Assessment of Long-term Energy Scenarios for New South Wales (NSW)

PhD Thesis

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CERTIFICATE OF AUTHORSHIP

I certify that the work in this thesis has not previously been submitted for a degree, nor has it been submitted as part of the requirements for a degree, except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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Shrestha, S., 2004. *"Long-Term Energy Scenarios for NSW: Energy, Economic and Environmental Impacts"*, AIE NSW and ACT Postgraduate Student Energy Awards 2004, Australian Institute of Energy, Sydney, December.

Shrestha, S., 2005. *"Long Term Energy Scenarios for NSW: Energy, Economic, and Environmental Impacts"*, Research Showcase Proceedings, University of Technology, Sydney, May.

Shrestha, S., and Sharma, D., 2006. *"Alternative Energy Supply Scenarios for New South Wales, Australia"*, Proceedings of a Conference on "Energy for Sustainable Development: Prospects and Issues for Asia", Organised by Asian Institute of Technology, Phuket, Thailand, 1–3 March.

ABBREVIATIONS

ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
ADV	Advanced Scenario
AEEI	Autonomous Energy Efficiency Improvement
AEPSOM	Australian Energy Planning System Optimisation Model
AGO	Australian Greenhouse Office
BAS	Base Scenario
BF	Blast Furnace
BOF	Blast Oxygen Furnace
CC	Combined cycle
CCS	Carbon capture and sequestration
CEF	"Clean Energy Future" Study
CGE	Computable General Equilibrium
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
COAG	Council of Australian Governments
CRS	Constant returns to scale
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSM	Coal Seam Methane
DRI	Direct Reduced Iron
EAF	Electric Arc Furnace
ESAA	Electricity Supply Association of Australia
FD	"Future Dilemmas" Study
GAMS	General Algebriac Modelling System
GDP	Gross Domestic Product
GEM	General Equilibrium Model
GHG	Greenhouse Gas
GRIT	Generation of Regional Input–output Tables
GTEM	Global Trade and Environment Model
GW	Gigawatt
GWh	Gigawatt hour
HVAC	Heating, Ventilating and Air-conditioning

IEA	International Energy Agency
IGCC	Integrated Gasification Combined Cycle
IPCC	Intergovernmental Panel on Climate Change
kWh	Kilowatt-hour
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LTW	"Living in Turbulent World" Study
MJ	Mega Joules
MOD	Moderate Scenario
MRET	Mandated Renewable Energy Technology
MW	Megawatt
NatHERS	Nationwide House Energy Rating Scheme
NEM	National Electricity Market
NGCC	Natural Gas Combined Cycle
NOx	Nitrogen Oxides
NSW	New South Wales
NT	Northern Territory
OECD	Organisation for Economic Co-operation and Development
OFD	Other final demand
OPEC	Organization of Petroleum Exporting Countries
OVA	Other Value Added
PJ	Petajoules
PM	Particulate Matter
PNG	Papua New Guinea
ppm	Parts per Million
PV	Photovoltaic
QLD	Queensland
R&D	Research and Development
RES	Reference Energy System
SA	South Australia
SEDA	Sustainable Energy Development Authority
SESSWG	Strategic Energy Supply and Security Working Group
SMHES	Snowy Mountains Hydro-electric Scheme
SO_2	Sulphur Dioxide

TAS	Tasmania
TJ	Terajoule
TWh	Terra Watt-hour
US	United States
UK	United Kingdom
VIC	Victoria
WA	Western Australia

ABSTRACT

This research analyses the economy-wide impacts of three energy scenarios (Base, Moderate and Advanced) for NSW for the period 2000–2040. These scenarios represent a suite of energy policy measures that the state could adopt in order to achieve its energy, environmental and economic goals. The Base scenario largely reflects the continuation of the current policy trends. In the Moderate and Advanced scenarios, CO_2 emissions, in the year 2040, are restricted to 8 percent above, and 25 percent below, the 1990 levels, respectively.

The scenario impacts are analysed in this research using a modelling framework that combines an optimisation-based energy sector model (MARKAL model) and an energy-oriented input–output economic model. The energy impacts are analysed in terms of how the state's primary and final energy requirements would evolve in response to alternative scenario-specific policies. And, the economic impact analysis focuses on how would such evolution affect sectoral outputs, wages and salaries, employment, and energy and CO_2 intensities.

The analysis suggests that a continuation of current policy trends (Base scenario) would result, by 2040, in a doubling of primary energy requirements, 80 percent increase in CO_2 emissions, and a markedly increased dependency on imported oil. The CO_2-restricting policies specific to the Moderate and Advanced scenarios could however result in significantly lower primary energy requirements – approximately 17 and 28 percent, respectively, below the Base level. Further, the economy wide impacts of these reduced energy requirements are likely to be minimal at the aggregate (State) level. For example, the Gross State Product, wages and salaries, and employment in 2040 would be lower by merely 0.28, 0.09 and 0.003 percent, respectively, in the Moderate scenario as compared with the Base scenario. These impacts at disaggregated (sectoral) levels would, however, be rather significant and mixed. The main beneficiaries, for example, in terms of wages and salaries and employment, would be the agriculture, other equipment, and construction sectors, and the main losers would be electricity, coal, and petroleum sectors. This shows the importance – in a policy context – of undertaking disaggregated analysis and the pitfalls of basing policy decisions on aggregate analyses

alone. Such disaggregate analysis also makes transparent the inter- and intra-sectoral linkages and provides more robust bases for developing trade-offs and compromises to achieve desirable policy outcomes.

1. Introduction

1.1 Background and Problem Statement

The state of New South Wales is the largest energy-consuming state in Australia.[1] (see Table 1-1), responsible for nearly a third of the total national energy consumption. The state's energy consumption grew by 1.7 percent per year over the period 1991–2000 (ABARE 2004). The energy supply in the state has historically been dominated by two types of fossil energy sources, namely, coal and petroleum products. In 2000, for example, these two fuels accounted for nearly 86 percent of the total primary energy consumption (coal 50 percent and petroleum products 36 percent) (Dickson, Akmal & Thorpe 2003). While this energy system (coal-dominant) provided cheaper energy services to help fuel the state's economic growth in the past, some of its consequences are that the state now produces the largest amount of greenhouse gas (GHG) emissions in the country (30 percent of the total) and depends upon imported petroleum products for about 45 percent of its petroleum needs (MOEU 2000b). This dependence on coal and oil is likely to continue in the future, thereby increasing the potential for even higher CO_2 emissions. In the next 20 years (by 2020), primary energy requirements in NSW will increase by 40 percent, 80 percent of which would be contributed by coal and oil (coal 44 percent, oil 38 percent) ABARE (2003). Similarly, CO_2 emissions from energy combustion would increase by 33 percent compared to 2000 levels. Thus, continuing with the current coal- and oil- dominated energy supply system is likely to pose challenges in terms of the environment and supply security in the coming decades.

Table 1-1: Energy Consumption and CO_2 Emissions (2000)

	New South Wales	Victoria	Queensland	Australia
Energy consumption (PJ)	1,426	1,346	1,010	4,971
Electricity	249	171	162	757
Coal	714	672	447	2,032
Gas	143	237	74	924
Petroleum Products	532	433	384	1,778
CO_2 emission, kton	106	102	70	350
Population, '000	6,894	4,804	3,629	19,413

Sources: Dickson et al. (2003); ABS (2004)

[1] Australia has eight states and territories – New South Wales, Australian Capital Territory, Victoria, South Australia, Northern Territory, Western Australia, Tasmania, and Queensland.

In recent years, the Australian energy sector has witnessed the emergence of several key issues that have the potential to challenge the continuation of the traditional energy system. Three such issues worth noting, for example, are: the reform of the electricity and gas sectors, which is changing the way energy services are provided; increasing pressure to reduce CO_2 emissions, which is affecting the decisions made on technology and fuel choices; and geopolitical developments (particularly since the World Trade Center disaster in the United States in 2001), which is increasing the concern to reduce dependency on imported oil. In the following sections, these issues are elaborated further in the context of their implications for NSW.

Reform in electricity and gas sectors. The reform in the electricity and gas industries, which began in the early 1990s, is providing the state of NSW with more options to meet its energy needs. NSW became a part of the National Electricity Market (NEM) in 1998. Since then it has became convenient for the state to purchase electricity from other states in the network, if it is cheaper to do so. Similarly, the reform in the gas sector has facilitated the state to purchase gas from the other states, as the reform has removed restrictions on interstate trade. The reforms are now being extended to include renewable technologies and services in all states and territories, which have potential to affect the state's energy sector even more.

With the reform in the electricity sector, a key challenge for the state would be to attract the private sector to invest in power plants that would provide not only electricity to meet increasing demand, but at the same time produce less GHG emissions. NSW's generation capacity, which is surplus at present (at about 12,800 MW), is expected to become insufficient by the end of this decade to meet the increasing electricity demand, and the state would be seeking to install more generating capacity (see NSW Government 2004)[2]. Adding power plants requires a considerable amount of time, from

[2] It is worth noting here the announcement made by the NSW government recently (May 2007) to establish an "Inquiry into Electricity supply in NSW" to review the feasibility of various base load generation options for the state (NSW Government 2007). The inquiry released its final report in September 2007. Some key recommendations made by the inquiry to the government include: (i) NSW would need to be in position where base load generation can be operational by 2013-14 to avoid potential energy shortfalls (10,500 GWh); (b) Coal-based (Ultra-supercritical Pulverised Fuel) or gas-based (Combined Cycle Gas Turbine) plant will be able to meet the emerging generation needs; (c) The

planning to construction, hence, the investors need appropriate signals in time in terms of how they are to consider environmental requirements. There is a need to assess various types of options that would be available for NSW in terms of power-plant technology and fuel choices.

Another important effect of the reform is that states and territories are becoming connected at a greater level, mainly due to the expansion of electricity interconnection and gas pipelines. As a result, the policy-making process in any state needs to take into account the options (such as electricity import) that may become available from other states. The greater integration across the states, and a need to address the climate change issues, collectively, is prompting the federal government and state governments to come together, to seek a national energy strategy for the long term. The Council of Australian Government (COAG), for example, has initiated an agreement between the commonwealth and the states and territories on a national policy framework to guide future decisions. NSW, being the largest energy-consuming state in Australia, has a higher stake in such a national strategy.

CO_2 emission reduction challenges. On the environmental front, the coming into effect of the Kyoto Protocol, after ratification by Russia in 2004, has increased pressure on the major CO_2 emitting countries to develop GHG reduction policies[3]. NSW is the largest CO_2 emitting state in Australia, mainly because of its heavy reliance on coal for

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Commonwealth Government should give regulatory certainty on emission trading scheme; (d) To secure investments in generation, the NSW government should transfer its retail and generation interests to private sector; and (e) Encourage and support energy efficiency initiatives where possible (Owen 2007).

[3] In 2006, publication of the Stern Review and release of documentary film "An Inconvenient Truth" presented by the former US Vice President Al Gore generated significant public interest in climate change issues that are bound to put pressure on the Australian governments to act. The Stern Review concluded that the benefit of strong and early action to reduce greenhouse gas emissions would outweigh the economic cost of not acting. The review, for example, estimated that inaction could cost 5%-20% of global GDP per year, while the cost of action could be limited to around 1% of global GDP. The review suggested that emissions would need to be reduced to at least 25% below current levels (2007) or more by 2050. The documentary film, on the other hand, attempted to educate the public about possible consequences of global warming, such as collapse of ice sheets in Greenland, Antarctica, rise of global sea levels, flooding in coastal areas. It also presented a review of various scientific opinions on climate change and discussions on politics and economics of global warming.

its energy needs, coal being the most carbon intensive fossil fuel. Reducing GHG emissions from the energy sector would be a significant challenge in the NSW energy sector's development. The NSW government recognises the threats and challenges of climate change, and in fact supports the ratification of the Kyoto Protocol (NSW Government 2004), contrary to the view held by the federal government – the White Paper made it clear that the federal government would not ratify the Kyoto Protocol (Commonwealth of Australia 2004)[4].

This calls for a long-term strategy that would be able to provide a signals to investors about the abatement challenges ahead. There is a need to examine key policy choices that can enhance the state's economic competitiveness and still lead to a significant reduction of GHGs. NSW has, in recent years, developed some innovative climate-change policies. These policies are, however, short term in nature and focus mainly on the electricity sector. The NSW government, for example, has introduced the NSW GHG Benchmark Scheme, which targets electricity sectors to reduce their emissions to 5 percent below 1990 emission level (or 7.27 tonnes per capita) by 2007 and to continue at that level until 2012[5].

Dependency on imported oil. The World Trade Center disaster in the United States in 2001 and subsequent geopolitical developments (such as war in Iraq) has made the world oil market very unstable in terms of supply and price. This has added concerns in oil-importing countries, including Australia, and pressure is building in these countries to reduce their dependency on imported oil. It is particularly important for Australia because the country's oil reserves are not sufficient for the long term. At the current rate

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[4] Instead of ratifying the Kyoto Protocol, Australia established the Asia-Pacific Partnership on Clean Development and Climate (AP6) on January 2006. The partnership also includes the United States, China, India, Japan, the Republic of Korea. It aimed at tackling climate change issues through technical cooperation, technology development and deployment such as solar power, carbon capture and sequestration. Australia's policy shifted dramatically in favour of Kyoto Protocol with the recent election of the Labour Party at the federal level. The new government ratified the Kyoto Protocol on 3 December 2007 (Commonwealth of Australia 2007).

[5] On October 2006, the NSW government extended the NSW GHG Benchmark Scheme to 2020 (from the previously set target of 2012) (DEUS 2006a). When scenarios were being developed in this research (in 2002–03), the Scheme was scheduled for the period of 2007 to 2012.

of production (1430 PJ/yr), the current reserves (16,800 PJ) can last for the next 11 years only. The oil production in Australia is expected to decline in the future. The situation is particularly alarming for NSW, since the state does not produce oil and relies solely on imports from interstate and overseas. In 2000, for example, NSW supplied 45 percent of its oil needs from overseas imports (MOEU 2000b). It is highly likely that NSW's dependence on imported oil will increase.

Meeting the transport fuel demand will be a challenge for NSW's energy sector. The forecasts by Dickson, Akmal and Thorpe (2003) and Apelbaum (1997) indicate that the demand for oil, which is mainly used in transport, will rise rapidly in NSW (for example, from 515 PJ in 2000 to 757 PJ in 2020, equivalent to 46 percent increase). The transportation energy need is linked with energy security. If the dependency on imported oil increases, the economy would become exposed to the risk of the politically volatile Middle East market, and its cartel-like behaviour through the OPEC. Thus, reducing its dependency on imported oil would be economically and politically desirable for NSW. To develop a strategy for transport, there is a need to assess various options that may be available including, for example, improving vehicle fuel efficiency, and increasing alternative transportation fuels as a means to reduce GHG emissions and dependence on oil imports.

The emergence of these issues and associated challenges implies that NSW needs to assess various strategies that would assist in developing a long-term energy strategy for the state. Some of them, for example, include:

- What options (in terms of energy resources) would be available for NSW to meet with its long-term energy requirement? How could the diversity in the energy mix be increased, which currently is dominated by coal and oil?
- Would the state face constraints on supplying alternative energy sources, such as, natural gas, biomass?
- What options would be suitable to reduce the dependency on imported oil?
- How would the emerging technologies affect the development of future energy system?

- What options would be useful to reduce CO_2 emissions, and how would they impact upon economy?

A sustainable energy strategy should be able to guide the state towards an energy pathway that would provide energy services with reduced GHG emissions, and also maintain economic growth and living standards. The state currently stands at the crossroads of choosing an appropriate energy pathway. The state government recognises the need for the state to move towards a carbon constrained energy path (see NSW government's "Energy Directions Green Paper", NSW Government, 2004). However, it has not set a clear goal yet (such as in the UK[6]). The current energy policies in the state are focused primarily on streamlining the energy market reform and reducing GHG emissions from power generation. The key shortcomings in the current policies are that they focus on a short range, in a range of 10–15 years, and they are not part of an integrated and unified view of the possible future direction. Being the largest energy-consuming state in Australia, how the state of New South Wales responds in developing an energy strategy will have impacts not only for the state, but also for the nation.

In examining various types of energy strategies, it is important that they are analysed from a long-term perspective. This is because energy technologies and infrastructures (such as power plants) have long useful economic lives, in the range of 30–40 years, and hence policy decisions need to consider their long-term consequences. Furthermore, some of the challenges faced by the energy sector, such as climate change, need a long-term strategy. The stabilisation of GHGs in the atmosphere, for example, needs a long term period, in the order of 100 years.

A difficulty associated with long-term analysis is that how the energy system evolves into the future is inherently uncertain. The energy system which provides energy services to consumers (such as heating, lighting, cooling, transport, etc.) is made up of a

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[6] The UK, for example, has set a goal to reduce emissions from energy use by 60% from the current level (1997) by 2050, following a recommendation made by the Royal Commission on Environmental pollution (RCEP) (RCEP 2000). At the time when scenarios were being developed for this research (in 2002–03), no state level target had been set for CO_2 emissions reduction. On October 2006, however, the NSW government brought out a policy paper (DEUS 2006a) which states that state's GHG emissions are to be reduced to the 2000 level of emissions by 2025 and further below 60% by 2050.

complex network of extraction (for example, mining), conversion (for example, power plants), transmission, distribution and end-use segments. How these segments evolve into the future over a long time frame is inherently uncertain. Various forces may play a role in shaping their evolution in the future. Different types of priorities may emerge and influence the way energy system evolves in the future. Combating the threat of climate change, for instance, may become urgent, if compelling new scientific evidences emerges[7], or finding alternatives to imported oil may become crucial, if supply of oil becomes volatile. Similarly, how energy technologies evolve in the future can also affect how the development of energy sector takes place. The improvements in technologies such as clean coal, geo-sequestration, fuel cell driven cars, or photo-voltaic (PV) can significantly influence the future energy pathways. The introduction of nuclear energy could significantly change the dynamics of the game.

To deal with such uncertainties in the long term, identification of alternative energy pathways and the assessment of consequences of these pathways would be useful. Scenario analysis offers a useful methodological framework for this purpose.

There are only a select few studies that have been conducted in Australia on the basis of scenario analysis framework, for example, Foran et al. (2002) Turton et al.(2002); SESSWG (2003); and Saddler et al. (2004) . But most of these studies have focused at the national level. The studies generally lack in analysis relevant at the state level (see a review of the scenario studies in Chapter 2). This shortcoming is significant in the context of Australia, because the states differ considerably in terms of energy resource availability, use patterns and institutional dynamics. For example, NSW derives power mainly from black coal, Victoria from brown coal, Tasmania from hydro, and South Australia from natural gas. The differences in cost-effectiveness of these resources have played an important role in these states' power generation development strategies. The analysis focusing specifically at the state level is hence necessary in the Australian

[7] It is worth to note here that the IPCC's fourth assessment report, entitled "Climate Change 2007", released on November 2007, for example, concluded that global warming is "unequivocal" as evident by the rise in global average air and ocean temperatures, widespread melting of snow and ice, and rising average sea level. It also reported that increase in global GHG emissions caused by human activities since 1750 have contributed in this warming (IPCC 2007).

context. This is more important for NSW because, unlike other states, NSW does not have oil and gas resources (except for carbon-intensive coal resources), while it is the largest energy-consuming state in Australia. Furthermore, studies conducted at the national level usually come up with policy solutions that are best (that is, least cost, efficient) at the national level, but not necessarily best when viewed from the state perspective. This, given the state governments' constitutional power in energy matters within their jurisdictions, could render national level policy prescriptions inoperable. It is therefore important that energy scenarios be assessed in terms of how they would impact the state.

The assessment of such impacts would be meaningful only if energy scenarios are examined by taking into account all the components (on the supply, transformation and demand sides) that comprise the energy system. Because an energy system consists of a complex network of several components, involving extraction of resources, conversion and delivery to the final users, changes in any one component in the system could have impacts on other components in the network. For example, CO_2 emissions from the electricity sector can be reduced not just by focusing on the power generation but also by lowering demand for electricity at the end-use levels, such as the residential and commercial sectors, through improvements, for example, in efficiency. Similarly, a reduction in CO_2 emissions can be achieved not only from the electricity sector, but also from other sectors, such as the transport and industrial sectors. The current energy policy making process in NSW seems to concentrate on smaller components of the energy system rather than look into the complete system. For example, current CO_2 emission reduction strategies in NSW largely target reducing emissions from the electricity sector only, whereas other equally important sectors, such as transport, are being overlooked.

Similarly, assessment of impacts of energy developments on the economy would be useful if they could be examined in greater detail at the sectoral level. Past studies aimed at examining economic impacts mainly focused on the macro-level, such as GDP and employment, without going into details at sectoral levels. The economic approaches (such as general equilibrium, econometric approaches) which are applied in these studies have several limitations: they are weak in capturing technological innovations; the economic sectors in these models are presented generally in aggregated terms; and they rely too much on past trends (they rely, for example, on elasticity values derived from past data). The analysis based on these types of approaches usually shows that moving towards a less carbon-intensive energy system will necessarily restrict economic growth. For example, the Allen Consulting Group (2000) and Brown et al. (1999) report a loss of GDP in the range of 1.3 percent to 1.9 percent for Australia if the country meets the Kyoto Protocol target on GHG emissions. Since the modelling approaches used in these analysis are weak in incorporating technological changes, the results from such models generally understate the opportunities that are available but yet to be used. For example, the National Framework for Energy Efficiency (Sustainable Energy Authority Victoria 2003) shows that if half of the energy efficiency opportunities available for Australia with a payback period of four years are implemented, GDP would actually increase by $975 million a year and GHG emissions will reduce by 10 Mt a year.

To examine the long-term impacts of various scenarios both on energy and the economy, there is a need for a modelling approach which would be able to address both the energy and economic sectors in detail. A review of past modelling studies shows (see Chapter 2) that among the energy models, bottom-up models would be the most suitable to analyse the energy sector at the detailed level. These types of models are suitable because they are capable of taking into account a large number of energy supply, transformation and demand technologies. Similarly, among the various types of economic approaches, the input–output model would be the most suitable model for the purpose of analysing detailed economy-wide impacts. This type of model gives a higher level of representation for the economic sectors, thus enabling an examination of wider impacts. A framework needs to be developed that combines these two types of energy and economic models to analyse the scenarios. There are very few examples of such a framework in use, in which these two models are combined together to examine both energy and the economy. A combination of the two modelling approaches would make it possible to examine the impacts of the scenarios on energy and the economy in detail.

1.2 Research Objectives

Against the above backdrop, the main objective of this research is to assess the impacts of long-term energy supply scenarios for the state of New South Wales, with a view to contributing to the development of long-term energy policies and strategies for NSW.

Specific objectives include:

a) Review the existing status of energy scenario and energy modelling studies in Australia with a view to identifying their strengths and weaknesses and to use this information to select an appropriate method to assess the impacts of long-term energy supply scenarios.

b) Develop long-term energy scenarios for New South Wales, taking into account key factors that would have the potential to influence the state's energy policies in the future.

c) Develop an energy modelling framework and use the framework to evaluate the long-term energy impacts of various scenarios in terms of energy requirements, fuel mix, technology mix, generation mix and CO_2 emissions.

d) Develop an economic modelling framework and use the framework to assess the economic impacts of energy scenarios in terms of total outputs, employment, wages and salaries, and also total energy- and CO_2-intensities of various economic sectors.

e) Assess the policy significance of the impacts quantified above.

1.3 Scope of this Research

This research is limited to the analysis of energy-related issues within the state of New South Wales. The scenarios are assessed in terms of their long-term impacts on energy and the economy. The energy impacts include impacts in terms of primary energy requirements, electricity generation by fuel and technology types, and CO_2 emissions. The economic impacts are quantified in terms of sectoral economic outputs, wages and salaries, employment and energy and CO_2 intensities. The time period for the assessment of scenarios is limited to 40 years, starting from 2000 and ending in 2040. This selection of the time period is in recognition of the long life span of energy technologies such as power plants and refineries, and long-term implications of the investments in the energy sector. The discussion in this research on GHG emissions focuses exclusively on CO_2 emissions from combustion; CO_2 is the dominant GHG gas, accounting for 97 percent of total GHG emissions from energy use (AGO 2002).

1.4 Research Framework

The research framework used for this study is illustrated in Figure 1.1. The framework consists of four interrelated tasks: (a) review of energy scenario and energy modelling studies; (b) development of energy scenarios; (c) assessment of the energy impacts of scenarios; (d) assessment of the economic impacts of scenarios; and finally (e) assessment of policy implications. A brief description of each of these components is presented below. Further details are provided in respective chapters (Chapter 2, 3, 4, 5 and 6).

Review of energy scenario and energy modelling studies. The first task in this research is reviewing energy scenarios and energy modelling studies conducted in Australia. The purpose of the review is to develop an understanding of the strengths and shortcomings in the past studies: what are the key driving forces behind these scenarios; what methodological approaches are used, and their strengths and weaknesses; what are the key issues examined and what are ignored; and to find out to what extent these studies have been able to investigate the energy issues that concern the state of NSW. The intention of this review is to assess the appropriateness of these approaches for application in this research and to analyse emerging energy issues in the context of NSW.

Development of scenarios. The second task in this research is to develop long-term energy scenarios for NSW. The reasons for using scenarios in this research are explained earlier in Section 1.1. These scenarios take into account various factors which have the potential to influence the development of future energy systems. Such factors, for example, include energy diversity, energy security, CO_2 emissions, technological development and use of energy-efficient technologies. The extent of the influence of these factors, from low to high, defines – in the context of this research – the general title for each scenario, namely, the Base, Moderate and Advanced scenario. This is further explained in Chapter 3.

Assessment of energy impacts. To assess the long-term impacts, the above scenarios are quantitatively modelled using a linear programming based optimisation model – the MARKAL model (Fishbone et al. 1983). This model represents the energy sector in the form of a reference energy system that includes all energy flows and processes – resource extraction (such as coal-mining, gas extraction), transformation (such as refineries, power plants), end uses (such as industrial, residential, etc.). The model simulates competition among fuels and technologies, and chooses the most cost-efficient mix of technologies and fuels to meet exogenously determined sectoral energy demands in conformance with specified constraints (for example, emission limits). The MARKAL model minimises the total discounted cost of the energy sector over the entire planning horizon.

The choice of the MARKAL model is made for several reasons. First, this model has the capability to analyse the energy system at a disaggregated level, with detailed representation of technologies, which only a few other bottom-up models can do. Second, the model provides solutions that are cost optimal – a dominant criterion in present times. For example, the model can identify the least-cost CO_2 emission strategy, by minimising the total cost for the whole energy system (reducing CO_2 emission is one of the key factors in scenarios in this research), while many other models, such as simulation models, can only test the strategies proposed by the user, which may not be an optimal strategy. Third, this model provides an equilibrium solution (unlike econometric models), where supply and demand are balanced. Fourth, the model minimises the total discounted cost of the energy system over the long term; such costs comprise investment and operating costs for all sectors. This is identical to maximising the net social surplus (that is, the sum of supplier and consumer surpluses) – a socially optimal objective.

Assessment of economic impacts. The energy impacts assessed (above) are next translated into economic impacts. These economic impacts are assessed with the assistance of an energy oriented input–output model that is developed specifically in this research. This approach enables the determination of the economic impacts by taking into account the interrelationships that exist between economic sectors. The outputs from the energy modelling (in the previous task in this research) are used to investigate how they would impact various economic sectors. For example, how changes in primary energy mix, technology mix, (obtained from the energy sector model) would change total outputs, wages and salaries, and employment across different economic sectors in NSW.

There are several reasons for using input–output model in this research. The input–output model can investigate complex interrelationship between energy, environment and economy. The strength of this model is that it captures linkages across a large number of economic sectors, which makes it possible to examine direct and indirect impacts. It offers a practical approach to general equilibrium analysis, allowing the assessment of complex and indirect repercussions of economic changes. Unlike other economic models which focus on macro levels only, this model is appropriate both at macro level, and sectorally disaggregated micro levels. Input–output approach is particularly useful because it contains a higher degree of sectoral details than dynamic optimization model, macroeconomic model and computable general equilibrium model (Zhang & Folmer 1998).

Most of the previous studies relied upon macro economic approaches, such as, general equilibrium modelling (GEM). These approaches have been unable to provide a detailed representation for energy technologies. This is a significant shortcoming because of the multi-faceted composition of the energy sector (power plants, refineries, boilers, furnaces, appliances, etc.), and evolving nature of these technologies.

In this study, detailed representations of technologies are accounted for in the energy modelling part, thus overcoming a major drawback posed by economic models. With the use of input–output approach, this research makes it possible to examine the economy wide impacts on a large number of economic sectors. Input–output approach deals with smaller parts of an economy compared to the macroeconomic approach and it places emphasise on individual sectors. In this way, this research is able to examine impacts at greater level of details both for energy and economic sectors. The methodology is further elaborated in Chapter 5 in detail.

Assessment of policy implications. Finally, the results of the scenario impacts on energy and economy obtained from the energy model and the input–output model are reviewed to draw implications for energy policy for the state. It draws these implication by weighing these impacts against historical trend (for example, in coal use) and current policy settings (for example, on reducing CO_2 emissions); by comparing the impacts obtained for the three policy scenarios (that is, Base, Moderate and Advanced); and by considering limitations and constrains that may arise in pursuing these policies.

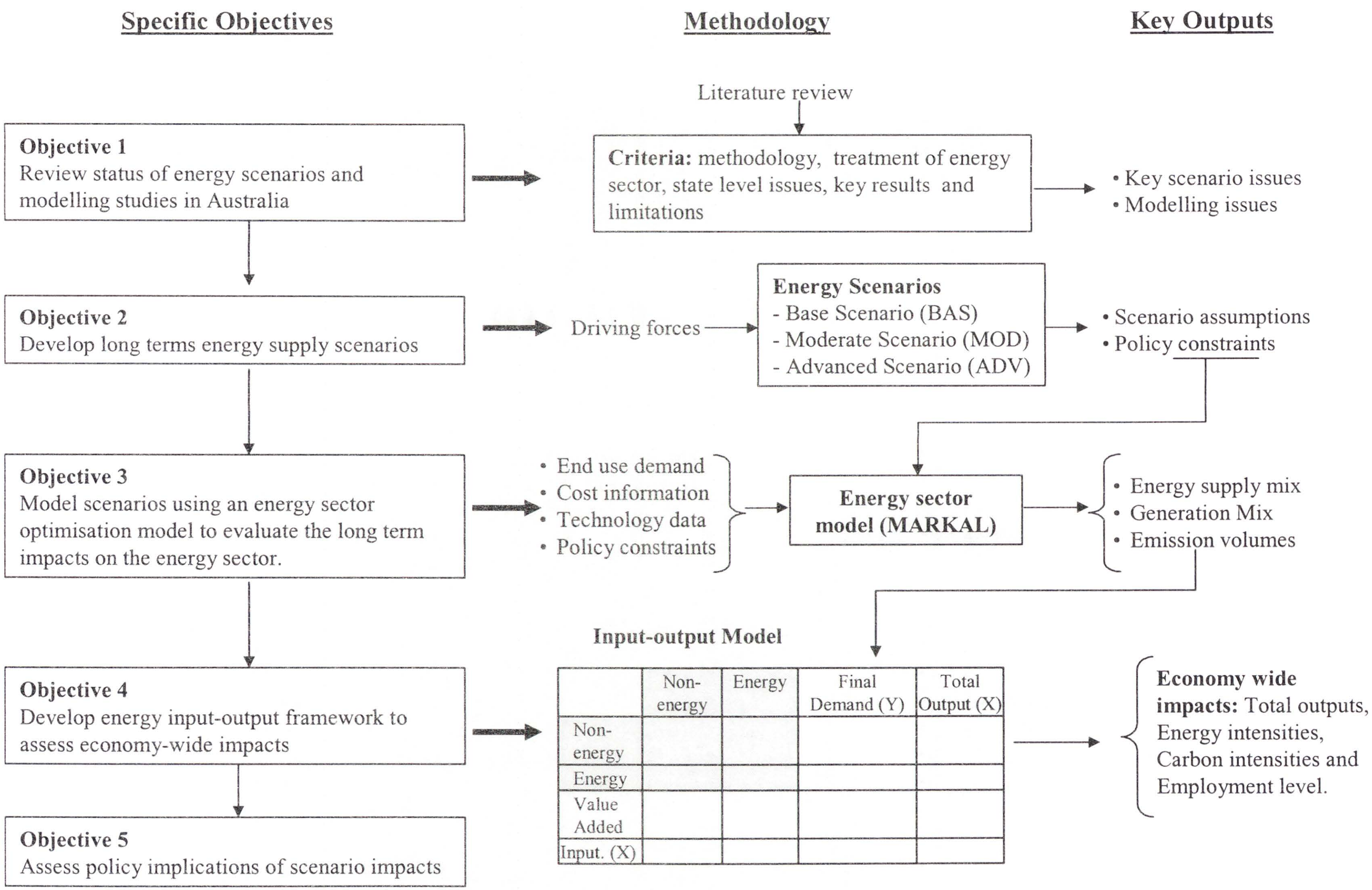

Figure 1.1: Research Framework: An Overview

1.5 Data Considerations

As explained in the previous section, the research framework developed in this research combines two types of models, the energy sector and the input–output model. Among the two models, the energy sector model, being a bottom up type of model, is characterised by a need for extensive data. The key data required by this model include: projection of end-use services, the availability of various types of energy resources, energy balance for the base year (2000), energy prices, emission factors, and detailed technology- specific data (such as efficiency, availability factor, life). A large amount of data is also required to build the input–output model. These include: the basic input–output table, energy consumption by different sectors, and emission factors by fuel types. This section briefly outlines the sources of data and methods used to assemble data for this research. Further details on data preparation are provided in the respective chapters (Chapters 4 and 5).

To estimate the demand for end-use energy services for NSW for the study period, this research uses ABARE's projections (Dickson, Akmal & Thorpe 2003) of final energy consumption at the sectoral level for the state. In using ABARE's data in this research, however, two difficulties were encountered: First, the data available was in aggregated form and not detailed by different levels of end-uses, for example, within the residential sector, data was not available at the level of end use services such as cooking, air-conditioning, etc. Second, the projections made by ABARE were limited to year 2020 only, while this research requires data up to 2040. The first shortcoming was overcome by disaggregating data on sectoral energy consumption using assumptions which are collected from various other sources. The sources of assumptions, for example, include: for the residential sector and commercial sector, from the Department of Minerals and Energy (1991), AGO (1999); for the transport sector, data are used from ABS (2001); for the iron and steel industry, and the aluminium industry, data are taken from NSW Department of Energy (1998) and Ferber (2002). The second shortcoming in the ABARE data set is overcome with the use of simplified extrapolation of ABARE's data beyond 2020: by assuming a constant growth rate for energy consumption beyond 2020 at the same rate as in the last period (2015–2020) of the ABARE's projection. In the absence of the availability of energy demand projections for NSW, this simplistic approach is more reasonable, because the economic growth assumed beyond 2020 in this research is constant and has the same values as in 2015–2020. For the base year, 2000, data are also checked and matched with the data available at the state level from respective state government publications (such as the Ministry of Energy and Utilities, 2001).

Data on fossil energy resources (coal, oil and natural gas) come from Geoscience Australia (2002), (2004), and on biomass resources from SEDA (2001). Energy prices data are taken from Dickson, Akmal and Thorpe (2003). Data on the electricity sector (capacity, fuel mix, generation in base year 2000) come from the Electricity Australia (ESAA 2002). Data on the cost of power plants are taken from various published sources in Australia, for example, Jones, Peng and Naughten (1994), Naughten (2003) and data for the future periods, when they are not readily available for Australia, are taken from other published sources, such as IWG (2000); Marsh et al. (2002); IEA (2003); MIT (2003); and IEA (2005). The data on emission factors by different fuel types CO_2 emission come from Dickson et al. (2003) and AGO (2004).

The energy-oriented input–output model developed in this research is based on the regionalised economic input–output table initially developed for NSW by Powell (2004). This regionalised input–output table is developed by using the GRIT method (Generation of Regional Input–output Tables, see Jensen and West, (1986)). This method uses the national input–output table of ABS (2001a) together with state specific data. While the table for NSW consists of 106 economic sectors, as in the national input–output table, the energy sectors are represented in aggregated form, for example, coal, oil, and gas sectors are placed in the same row. The energy sectors in this input–output table are disaggregated for the purpose of this research by using data on energy sectors collected from Dickson, Akmal and Thorpe (2003).

Table 1-2: Data Sources

Data Types	Sources
Socio-economic	GSP: Dickson, Akmal and Thorpe (2003) Population: ABS (1998)
Energy resources	Fossil (Coal, Gas, Oil): Geoscience Australia (2004) (2002) Renewables (Biomass): SEDA (2001)
End-use services	Residential: ABS (2002), AGO (1999b), Fiebig and Woodland (1994) Commercial: AGO (1999a) DOE (1996) Industrial: DISR (2000; 2002) Transport: ABS (2001c) Apelbaum (1997)
Emission factor	CO_2: AGO (2004) Dickson, Akmal and Thorpe (2003)
Technology specific data (For example, cost, life, efficiency, capacity factor)	Power Plants: ESAA (2002) IWG (2000) Jones, Peng and Naughten (1994) Marsh et al. (2002) MIT (2003) Naughten (2003) Transport: (IEA 2004a; Short & Dickson 2004)
Input–output table	Powell (2004), ETSU (1998), Dickson, Akmal and Thorpe (2003), ABS (2001a)

1.6 Significance of This Research

This research study makes contributions in a number of ways as outlined below:

NSW - focused Scenario Study. This research provides an assessment of energy scenarios that specifically focus on the state of NSW. The past scenario studies (Foran & Poldy 2002; Saddler, Diesendorf & Denniss 2004; SESSWG 2003) in Australia have been conducted mostly with interest at the national level. These studies are generally found to be inadequate for examining state-specific issues. Because these past studies treated Australia as a single region in their analysis (that they were lacking in disaggregating the country into various states), they could not to capture the diversity that existed across the states. The states in Australia vary widely in terms of resource availability and energy needs, which a single-region treatment would have difficulty to capture sufficiently in detail. In this research, by concentrating on a single state, it has been possible to treat the state-specific issues in detail and to take into account the state's potential and limitations (for example, limitations of energy resources, such as natural gas and petroleum products).

Energy Focused. Another significant feature of this research (again compared with other scenario studies in Australia) is that the scenarios in this research are driven by factors that are concerned with the energy-related issues for NSW. The scenarios take into account challenges faced by the energy sector in NSW, and also various types of options that are available or may become available in the future to deal with these challenges. For example, a need to reduce CO_2 emissions from energy use is one of the key driving forces in scenarios in this research. This contrasts with other scenario studies in Australia, for example, Foran and Poldy (2002) is more concerned with different sizes of population and their effects on infrastructure, resources and environment, and SESSWG (2003) is more concerned with the effects of a range of global political developments on the Australian energy sector (energy security). An important shortcoming in these two past scenario studies is that they fail to consider a future scenario wherein a large reduction in CO_2 emissions (given the carbon-intensive energy system in NSW), such as to below 1990 emission level, might become necessary (see Chapter 3).

Methodological Framework. Another major contribution made by this research relates to the development of a modelling framework that combines an energy model (optimisation model) and an economic model (input–output model) to analyse the scenarios. This framework is valuable because it allows one to examine the energy and economic sectors at a higher level of sectoral details. The energy-sector model captures details of the energy system both on the supply and demand side with the use of reference energy system. The input–output model provides higher level of sectors details (32 non-energy sectors and 16 energy sectors) and is able to capture interrelationships across these sectors. In this way this research is able to analyse both the energy and economic impacts in greater level of detail. This was not possible in the frameworks used by other major scenario studies conducted in Australia, such as, Foran and Poldy (2002) and SESSWG (2003).

Research Outcomes. This research provides an assessment of three scenarios for NSW in terms of how energy requirements in the state would be met in the next forty years and their potential impacts on energy, economy and the environment. The scenario outcomes provide important information for the long term, for example, information about primary and final energy mix, power-plant-technology mix, the share of renewable energy sources, the amounts of CO_2 emissions, and also information on economy-wide impacts in terms of total outputs, wages and salaries, employment, energy and CO_2 intensities. A comparison of the results across the scenarios provides important insights for the policy analysts and policy makers. The scenario results, for example, suggest that without long-term, concerted energy policy measures (that is, if the current trends are allowed to continue over the next forty years), the energy requirements would double and CO_2 emissions would increase by 80 percent compared with their current levels, and the dependency on imported oil would increase significantly, potentially inviting energy insecurity for the state. It also suggests that the alternative scenarios (called Moderate and Advanced in this research) have the potential to reduce energy consumption by as much as 28 per cent below the Base level by 2040, and reduce CO_2 emissions by 25 percent below the 1990 levels. It shows a need for a fundamental shift in the energy sector from a largely coal- and oil-based system to one which is diverse in energy resources, uses efficient technologies, and includes a greater level of energy conservation practices.

Relevance to Other States. While the states in Australia vary widely in terms of resource availability and energy requirements, some of the lessons learnt in this research could be useful for some of the states that show similar characteristics as in NSW, particularly, for Victoria and Queensland. For example, energy consumption characteristics of these two states (they are also the next largest energy-consuming states in Australia after NSW), to some extent, match with NSW's own energy consumption characteristics. In all of these three states, for example, coal is the dominant source of energy, contributing more than 50 percent of the total energy consumption, natural gas plays a minor role, and, petroleum products are the second most important energy source. Because of these similarities in energy consumption characteristics, the lessons that could be learned for NSW would be to some extent valuable for Victoria and Queensland as well.

1.7 Structure of the Thesis

The thesis consists of six chapters in total.

Chapter 2 provides a review of major energy scenario and energy modelling studies conducted in Australia. This chapter develops an understanding of strengths and shortcomings in the past studies. In particular, it sheds lights on the methodological approaches used, the focus of issues examined, how the energy sector is accounted for, and their ability to address issues at the state level, particularly NSW. This review provides the basis for establishing a research framework for this research.

Chapter 3 develops three energy scenarios for the study, taking into account the five key scenario variables that have potential to shape the energy sector in NSW. The chapter describes the scenarios in detail, and also provides a brief discussion on the modelling framework to be used in scenario assessment.

Chapter 4 develops an energy modelling framework to assess the three scenarios quantitatively. It provides assessment of these scenarios in terms of their impacts on energy requirements (quantity and fuel mix), technology mix, and CO_2 emissions.

Chapter 5 develops an energy oriented input–output model to assess economy wide impacts of the scenarios. The scenarios are assessed in terms of their impacts on total sectoral outputs, wages and salaries, employment, total energy intensity and CO_2 intensity.

Chapter 6 assesses energy and economic impacts for the three scenarios (as analysed in Chapter 4 and Chapter 5) from policy perspective.

Finally, Chapter 7 presents key conclusions of the scenario impacts and their implications for policy, limitations of this research, and recommendations for future research.

2. A Review of Energy Scenario and Modelling Studies in Australia

2.1 Introduction

This chapter reviews the status of the energy-scenario and energy-modelling studies in Australia. The objective of this review is to assess the strengths and weaknesses of these studies and their appropriateness for analysing the wider impacts of alternative energy-environmental pathways for NSW.

As illustrated in Figure 2.1, the review is divided into two groups: "energy-scenario studies" and "energy-modelling studies". The "energy-modelling studies" are further divided into two sub-groups: engineering- and economic-based studies (models). While it is difficult to separate energy-scenario and modelling studies (because an analysis of energy scenarios often involves energy modelling), in the context of this thesis, the distinction is made based upon the dominant focus of these studies.

The energy-scenario studies are reviewed in terms of their focus, key driving forces behind the scenarios, methodological approaches used for analysis, and the level of geographical disaggregation (that is, national or state level). The energy-modelling studies are reviewed in terms of their underlying methodological approaches, application areas (for example, climate change policy, energy forecast), how energy sectors are treated (level of sectoral disaggregation, technological representation), and also their ability to address issues at the state level.

This chapter is organised as follows. Section 2.2 reviews the three major energy-scenario studies conducted in Australia. This is followed by a review of energy-modelling studies (Section 2.3). This section is further divided into two subsections. Subsection 2.3.1 presents discussions on engineering-based modelling studies (that is optimisation and simulation models), and subsection 2.3.2, on economic models (that is general equilibrium and input–output models). Section 2.4 presents the major findings of the review.

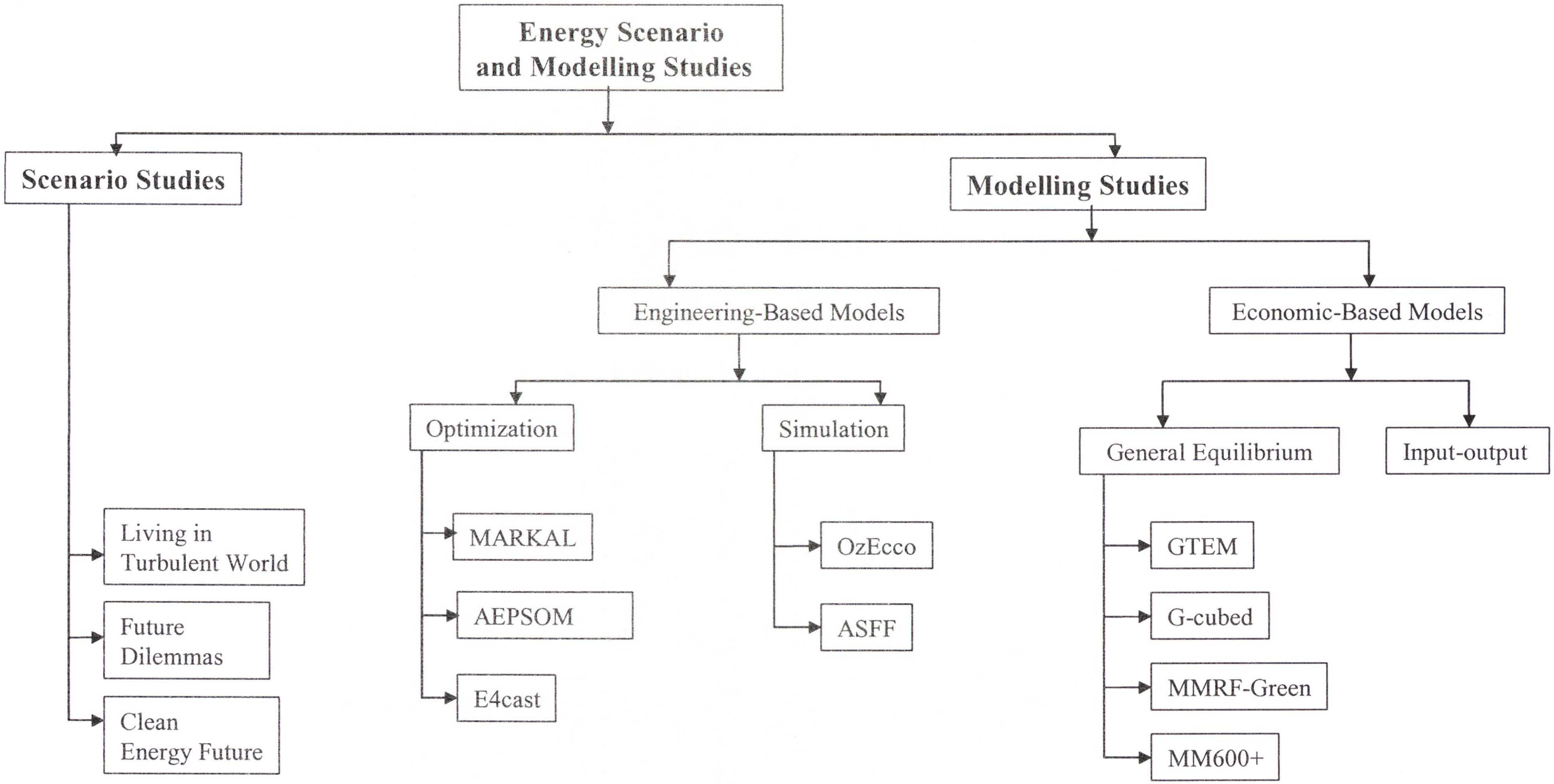

Figure 2.1: Energy-scenario and Energy-modelling Studies: a Classification for Review

2.2 Energy-scenario Studies

This section provides a review of major scenario studies conducted in Australia. It provides a brief description of the three scenario studies, followed by a comparative discussion to highlight differences across these studies. The discussion focuses on driving forces behind the scenarios, methodological approaches used to develop and analyse scenarios, and key outcomes from the scenarios, particularly on energy requirement and CO_2 emissions.

While several energy-modelling studies have been conducted in Australia in the last three decades, the practice of conducting long-term scenario analysis is rather recent. The most prominent energy scenario studies (also analysed in this chapter) include "Living in a Turbulent World (LTW)" (SESSWG 2003), "Future Dilemmas (FD)" (Foran & Poldy 2002), and "Clean Energy Future (CEF)" (Saddler, Diesendorf & Denniss 2004).

(a) The Living in a Turbulent World (LTW) Study

This study is perhaps the most comprehensive scenario study conducted for Australia in recent times. This study is quite similar to the ones conducted in the United Kingdom (Marsh et al. 2002) and Canada (OETF 2002). This scenario study was conducted by a team of consultants[8], for the Strategic Energy Supply and Security Working Group (a working group of the Ministerial Council on Energy). The main objective of this study is to examine how global geopolitical developments would affect Australia in terms of the security of energy supply. Selected features of this study are presented below.

Scenarios. This study developed four different scenarios: "Global Convergence", "Fortress World", "It's a Green World", and "Muddling Through". The Global Convergence scenario represents increased globalisation in the future, typified by increased open trade and investment, and dominance by multilateral companies in the investment market. This scenario is used by the authors as the reference scenario,

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[8] The project team comprised four consultants: NIEIR (National Institute of Economic and Industry Research), Houston Energy Group, Southern Pacific Consulting Group, and Resource Connections.

against which other scenarios are compared. The Fortress World assumes that the world economy would be contained by increased protectionism. The third scenario, It's a Green World, portrays a future in which significant technological advances and significant deployment of alternative energy technologies would take place. The final scenario, Muddling Through, represents a future with moderate economic growth, and a mix of other characteristics drawn from scenarios two and three.

Driving Forces. The scenarios in this study are mainly driven by how different contexts of the global economic situation, for example, increased globalisation, protectionism, environmental issues, become dominant, and how these aspects would impact on the security (particularly the dependence on imported oil) and reliability of energy supply for Australia.

Methodology. This study develops four scenarios mainly by relying upon the broad outlines provided by SESSWG under its Terms of Reference. It does not therefore follow the traditional approach[9] commonly used in a scenario development process. To analyse scenarios quantitatively, the study uses an econometric model. In this model, the world is divided into 30 countries/regions. Australia is further divided in detail at the state and territory levels. This allows the model to examine the scenario results detailed at state levels. The model estimates energy demand functions (for industrial, household and transport sectors) for all the countries. An important distinction in these demand functions from the traditional demand function is that in these functions a new parameter is introduced which takes into account how energy technologies across the countries progress and converge towards the best efficiency level of the benchmark countries (which are Japan, Germany and the United States). Energy demand is assumed in these scenarios to be a function of GDP (or household consumption for the household sector), and the price of energy.

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[9] Under the traditional approach, different analysts specify alternative assumptions for economic policy, technologies, political change and cultural factors. These are then developed into different sets of consistent assumptions. A number of scenarios are developed around these sets of assumptions, and finally the most plausible or desirable scenarios are selected for analysis (SESSWG 2003).

Results. The key outcomes from the study include estimates for primary energy requirements and CO_2 emissions for the Australian states up to the year 2030 (see Table 2-1 for selected results). The study finds that primary energy requirements for Australia would increase, as compared with 2000 levels, by 48, 52, 43 and 63 percent by 2030 for the Global Convergence, Fortress World, Green World, and Muddling Through scenarios, respectively. Coal and natural gas provide the largest share in this energy requirement, contributing nearly 75 percent in all scenarios. The scenarios witness gas consumption rising (from 18 percent in 2000 to 37–47 percent by 2030) and oil consumption declining (from 34 percent in 2000 to 11 to 20 percent in 2030). A similar trends are also observed for NSW. Coal continues to constitute a large share of the energy mix; from a share of 41 percent in 2000 to 38, 37, 30 and 33 percent in 2030 for the four scenarios. Even in the environmentally aggressive Green scenario, coal occupies 30 percent of the share in the total energy mix. CO_2 emissions increase by 26–31 percent above the 2000 level across the scenarios (except for the Green World scenario, in which the rise is only about 1.2 percent).

Table 2-1: Living in a Turbulent World Study: Some Results (2030)

	For 2000	Global Convergence	Fortress World	Green World	Muddling Through
(a) Australia					
GDP growth rate, % per yr		2.8	2.3	3.2	3
CO_2, Mt	331.5	420	433	337	435
Primary energy, PJ	4,850	7,201	7,378	6,923	7,928
(b) NSW (annual growth rate, % (2000-2030))					
GSP		2.3	1.9	2.6	2.4
Primary energy		0.7	1	0.2	0.8
Coal		1.2	1	0.3	0.6
Gas		2.1	3.3	3.5	3.8
Oil		-0.7	-0.1	-2.4	-0.5
Electricity		2.2	2.3	2	2.3
Renewables		0.6	0.6	1.3	0.7

Source: Compiled from SESSWG (2003)

(b) The Future Dilemmas (FD) Study

The Future Dilemmas (FD) study (Foran & Poldy 2002) was conducted by the CSIRO Sustainable Ecosystems, for the Commonwealth Department of Immigration and Multicultural and Indigenous Affairs (DIMIA). Unlike the previous Living in Turbulent World scenario study, the objective of this study is to assess the impacts of different sizes of population (a result of different levels of immigration) on infrastructure, resources and environment in Australia until the year 2050.

Scenarios. This study examines three scenarios which reflect three different population sizes for Australia in the future. The first scenario assumes that the net immigration would be zero. The second scenario, which represents a base scenario, assumes a rate of immigration at 70,000 a year. The third scenario assumes the flow of immigration at the rate of 0.67 percent per year of the population of 2000.

Driving Forces. In the Future Dilemma (FD) study, the key driving forces behind the scenarios are three different population sizes by 2050 (that is, 20, 25 and 32 million) for Australia.

Methodology. This study examines the scenarios using a modelling approach that is based on the physical economy rather than the conventional monetary economy of the country. In this method the Australian economy is represented in terms of the physical economy[10]. This method uses an accounting method of stocks and flows of materials as they undergo various processes over time and simulates the impacts of various scenarios.

Table 2-2: Future Dilemmas Study: Some Results (2050)

	2000	Zero Scenario 2050	Base Scenario 2050	0.67% pa Scenario 2050
Population, million		20	25	32
Primary Energy, PJ	4810	6000	7000	8300
CO_2, Mt	331.5	475	541	651

Source: Compiled from Foran et al. (2002).

[10] Physical economy describes a chain of physical transactions that take place to produce economic outputs (GDP). (Also see subsection 2.3.1 (c) for details on this type of methodology.)

Results. This study provides impacts on the energy sector, in terms of energy requirements and GHG emissions (see Table 2-2). Primary energy requirements increase by 25, 46, and 75 percent for the three scenarios, and, CO_2 emissions rise by 43, 63 and 96 percent, compared to 2000 emission levels. Fossil energy sources continue to dominate the primary energy mix, with coal (41 percent), oil (34 percent) and gas (23 percent) as the dominant fuels.

(c) The Clean Energy Future (CEF) Study

This study (Saddler, Diesendorf & Denniss 2004) was conducted by Energy Strategies for the Clean Energy Future Group. The study is designed to explore the potential for deep cuts in CO_2 emissions (that is, 50 percent below the 2001 level) in Australia. The scenarios place strong emphasis on energy efficiency and reliance on renewable energy in energy supply, to achieve their goal of reducing CO_2 emissions.

Scenarios. This study examines four different scenarios. Scenario 1 represents the baseline scenario. Scenario 2 corresponds to a scenario that would reduce CO_2 emissions 50 percent below the 2001 level. Scenario 3 represents a situation wherein coal plants are entirely phased out, replaced by natural gas and biomass plants. Scenarios 2 and 3 also assume an enhanced use of energy efficiency, which reduces final energy demand in these scenarios significantly below that of Scenario 1. Scenario 4 represents a mix drawn from the previous scenarios; it assumes final energy demand to remain the same as in the Baseline scenario, but the energy supply mix is assumed to be similar to that in Scenario 3.

Driving Forces. In this study, the key driving force behind the scenarios is a concern for reducing CO_2 emissions. The scenarios in this study are driven by an objective of reducing CO_2 emissions by 50 percent below the 2001 emission level.

Methodology. This study develops scenarios based on different types of requirements for CO_2 emissions reduction. It assumes one population size and one economic growth rate for all the scenarios studied. The study uses "scenario back-casting" approach to examine these scenarios. This method involves first forecasting energy demand and CO_2 emissions for the next 40 yrs, based on certain assumptions of economic growth (at

GDP growth rate at 2.4 percent per year). Next, it explores using the full potential of new and efficient technologies to cut back on demand and CO_2 emissions. This type of method is used, as the study notes, to overcome the drawback posed by traditional econometric approaches that rely largely on past relationships which tend to make them unable to describe the future that could be different from the continuation of the past.

Results. The scenario outcomes include the amount of energy requirements (primary and final energy) for Australia and CO_2 emissions over the next 40 years (see Table 2-3). Primary energy requirements increase by 33 percent in Scenario 1, but reduce by 8 percent in Scenario 2, compared with 2001 levels. Final energy consumption increases for Scenarios 1 and 2 by 57 percent and 25 percent, respectively. Scenario 2 shows a significant improvement in the overall energy efficiency, for example, the ratio of final to primary energy consumption improves from 53 percent in 2001, to 71 percent in 2040. CO_2 emissions in the Scenario 1 increase by 20 percent from the 2001 level, but decrease by 50, 55 and 42 percent for Scenarios 2, 3, and 4 respectively. A significant reduction in CO_2 emissions is achieved with a combination of measures that include improvements in energy efficiency, and a switch towards renewable and clean energy sources. The scenario outcome in this study shows a radically different energy and technology mix in power generation. The scenarios utilise the maximum potential of using renewables for power generation that can be achieved, thus deriving nearly 60 percent (biomass 28 percent, hydro 7.5 percent, solar 4.5 percent, and wind 20 percent) of total electricity generation from renewable energy sources.

Table 2-3: Clean Energy Future Study: Some Results (2040)

	2001	**Scenario 1 (Base)**	**Scenario 2 (CEF)**	**Scenario 3 (CEF + no coal)**	**Scenario 4**
Primary Energy (PJ)	3605	4795	3317		
Final Energy (PJ)	2943	4620	3679	3679	4620
CO_2, Mt	262	317	131	118	152

Source: Compiled from Saddler et al. (2004)

(d) Comparisons of Scenario Studies

A closer look across these three energy scenario studies finds key differences in three main areas: (a) the driving forces behind the scenarios; (b) the methodological approaches used for quantitative modelling; and (c) the scenario outcomes, particularly in terms of energy consumption and CO_2 emissions.

Key Driving Forces. The driving forces across these studies show important differences. The scenarios in the Living in a Turbulent World (LTW) study are mainly driven by the global economic situation (such as increased globalisation, protectionism, environmental issues becoming dominant). In the Future Dilemma (FD) study, the key driving forces are three different population sizes (20, 25 and 32 million) by 2050 for Australia. And, in the Clean Energy Future (CEF) study, the key driving force is the concern to reduce CO_2 emissions (by 50 percent below the 2001 emission level). The differences in the driving forces reflect differences in objectives in these studies.

Methodological Approaches. To develop scenarios for analysis, the LTW study uses a relatively more comprehensive methodological approach than the two other studies. This study, for example, develops scenarios under different sets of assumptions (of economic growth, technological advancement, etc.), based on the broad scenario outlines provided by SESSWG, and also in consultation with a wide range of stakeholders from Australia and overseas. In comparison, the development of scenarios in the FD study is simplistic because the three scenarios in this study are based on the three population sizes. Similarly, the CEF study also does not use any specific approach to develop scenarios; they are simply defined based on the extent at which CO_2 emission reductions would be sought.

To examine the scenarios, these three studies use approaches which are significantly different from each other. The approach used by LTW study to quantitatively analyse the scenarios is based upon an econometric approach. The model divides the world into 30 countries/regions. Australia is further divided into states and territories. This allows the model to examine the scenario results detailed at state level. The FD study uses an analytical framework which represents the Australian economy in terms of physical economy. This method uses an accounting method of stocks and flows of materials as they undergo various processes over time and simulates the feasibility of various scenarios. The CEF study uses the "scenario back-casting" approach. The method involves forecasting the energy demand first, based on certain assumptions of economic growth (at a GDP growth rate of 2.4 percent per year) and energy intensity. Then it uses a back-casting method by using the full potential of new and efficient technologies to cut back on demand.

Scenario Outcomes. In all the three studies, the key results of the modelling include estimates of primary energy requirements and CO_2 emissions for the next 30 to 50 years (see Tables 2-1, 2-2 and 2-3). However, comparison across the scenarios shows huge differences in these estimates. The LTW study, for example, finds that primary energy requirements in the next 30 years would increase by more than 40 percent. The FD study finds comparatively much lower estimates for energy requirements. The energy requirement in the Base scenario in this study increases by 45 percent from the 2000 level, but in the next fifty years (the comparable increase in the LTW study in the next 50 years for its reference scenario, the Global Convergence scenario, would be 90 percent, considering its annual growth rate of 1.3 percent). Compared to the previous two studies, the CEF study provides very contrasting estimates. In this study, the primary energy requirements (it excludes the transport sector energy demand) in the next forty years is actually less than the amount consumed in 2001.

Another striking difference between the three scenario studies is in their estimates of CO_2 emissions. The two studies, LTW, and FD, show a significant increase in CO_2 emissions at the end of the study period from the base year emission level (2000). This suggests that reducing CO_2 emissions has not attracted serious attention in these two scenario studies. Both of these studies seem to have ignored the likelihood of a future scenario in which CO_2 emissions would have to be reduced significantly below the 1990 emission levels. The CEF study, on the other hand, is overly concerned with reducing CO_2 emission, wherein CO_2 emissions are reduced by 50 percent below the 2001 emissions level.

Both studies, LTW and FD, show a primary energy mix that is dominated by fossil energy sources, with coal occupying a significant share. In the LTW scenarios, for example, the share of coal in the total primary mix is in a range of 30–38 percent, which is only slightly lower than the share in 2000 (at 41 percent). In the FD scenarios also, coal continues to provide nearly 40 percent of the total energy supply in 2050. The primary energy mix in the FD scenarios in 2050 does not change much from the mix in 2000. In the CEF study, the share of coal is reduced to a minimum. For example, the coal's share in total electricity supply reduces from 78 percent in 2001, to 9 percent in 2040 in Scenario 2.

In the LTW study, the share of oil reduces significantly, reflecting the underlying concerns about energy supply security. The share of oil in the primary energy mix drops from 34 percent in 2000, to 10–20 percent in 2030 in the four scenarios investigated in this study. However, in the FD study, the share of oil continues to remain large – at about 34 percent in 2050. This large share of oil results due to the assumptions of lower efficiency in transport technologies in this study. The CEF study limits its focus on the energy consumption by stationary sources, and excludes the transport sector.

Some Further Observations

Based upon the above discussion, some further observations could be made as follows:

- The three energy-scenario studies conducted in Australia, while provide valuable information on energy requirements, and CO_2 emissions in the long term, generally focus on the national level only. These studies therefore do not provide such information at the state level. Only the LTW study provides some estimates of energy requirements for NSW. It does not, however, provide corresponding CO_2 emissions, details on fuel and technology mix for power generation, etc. for NSW.

- Despite concerns about CO_2 emissions, these studies (with the exception of the CEF study) do not place adequate emphasis on reducing CO_2 emissions. The FD and LTW studies, for example, do not even envision a future scenario where a reduction in CO_2 emissions below the 1990 emission level would become necessary.

- Some of the assumptions in the CEF study (for example, widespread use of advanced technologies), while technically feasible, appear overly optimistic from practical considerations. This study assumes, for example, a widespread use of solar thermal preheating in all boilers in all end-use sectors (except in the iron and steel industry), substitution of natural gas for coal in combustion (such as in boilers and kilns used in alumina, nickel, and cement production) and increased use of cogeneration in almost all sectors. These measures would undoubtedly help in reducing CO_2 emissions significantly, but their practical implementation to the extent envisaged in this study remains questionable. Further, this study shows a radically different energy and technology mix in power generation, with renewables contributing nearly 60 percent of total electricity generation. Such a large share of renewables appears unrealistic, especially when one takes notice of the high cost of this technology, and their intermittent characteristics (wind and solar), and resource availability (biomass and wind).

- These studies are lacking in an examination of the impacts of alternative energy pathways on the wider economy, both at macro- (such as on GDP, employment) and micro- levels, (such as outputs and employment in different economic sectors).

- The methodologies applied in these studies are not based on any optimisation approach. They therefore cannot be said to have resulted in the determination of optimum outcomes – particularly in terms of the supply side.

2.3 Energy Modelling Studies

The previous section presented a review on the status of the energy-scenario studies in Australia. This section reviews some selected energy-modelling studies in Australia. This review focuses on the underlying methodological approaches adopted in the models, their application areas, the treatment of the energy sector within the model, and finally, how capable each of these models is of addressing energy issues for New South Wales.

In Australia, the use of quantitative models for energy analysis, like in many other industrialised countries, began in response to the oil crisis of the 1970s. The concerns about the security of supply motivated the development of energy models. The emphasis was to identify alternative energy strategies to meet energy demand in an oil-constrained world. The first notable event in this regard was a workshop, sponsored by the National Energy Advisory Committee in 1977. The workshop was organised to identify energy models for potential development in Australia. It reviewed three different types of energy models for this purpose: a general equilibrium model (of the Hudgen-Jorgenson type), an energy economic input–output model, and an optimisation model (BESOM model). This workshop produced two outcomes. One, it initiated the development of an optimisation-based engineering model. In 1979, for example, Australia joined the International Energy Agency (IEA) and gained access to the MARKAL model (a dynamic version of the BESOM model). This model was adapted to the Australian context and named MENSA (for Multiple Energy Systems of Australia) model (Stocks & Musgrove 1984). The second outcome was the development of an input–output based model (known as MERG).

James (1980) lists some of the earliest energy-modelling studies conducted in Australia. They include, for example, the Department of National Development's (1978) study that projected primary energy demand; Mula's (1977) development of systems models; Maher and Stocks' (1979) development of a linear-programming-based model AUSTESTM; Brain's (1977) model of similar type; and Folie and Ulph's (1976) macroeconomic model. James (1980) also made a note that the quantitative models in Australia during those periods were still in a state of infancy in view of evaluating energy policies.

The major energy models developed in Australia can be broadly grouped into two types: (a) engineering based, and (b) economy based. The engineering-based models can be further divided into two categories: optimisation models and simulation models. The economic models are also of two different types: general equilibrium models and input–output models. The following sections provide discussion on these models in detail.

2.3.1 Engineering-based Models

(a) Optimisation Models

There are three types of optimisation-based energy models in use in Australia: MARKAL (Fishbone et al. 1983), AEPSOM (Islam 1995) and E4CAST (Dickson et al.

2001). These models are characterised by their ability to represent energy systems in terms of details in energy demand and supply technologies. These models optimise energy systems to identify the most cost-efficient mix of technologies and fuels. Table 2-4 lists key features of these models.

MARKAL Model

MARKAL is an energy-sector optimisation model, developed by the International Energy Agency (IEA), in the late 1970s (Fishbone & Abilock 1981). Stocks and Musgrove (1984) applied the MARKAL model for the first time in Australia in a study that investigated the feasibility of electricity interconnections and interchanges across the states in the country. In the earlier version of the MARKAL model, electricity and low-temperature district heat were modelled as a single grid. This made the MARKAL model unable to accurately model the situation prevailing in Australia. Australia has six states and two federal territories with different characteristics in terms of electricity and natural gas systems. This posed challenges for the model to be used in the Australian context. To suit the model to the Australian environment, it was modified, mainly in terms of the introduction of regional structure in the model. This allowed the model to represent the electricity sector in terms of several electricity grids in place of a single electricity grid used in the earlier version of the model. The multi-regional model thus developed was named MENSA-MARKAL (MENSA, for Multiple Energy Systems of Australia). The MENSA-MARKAL was applied to study the feasibility of interconnections between three Australian states, New South Wales, Victoria and South Australia (Stocks & Musgrove 1984).

Table 2-4: Salient Features of Optimisation Models

Model Names	Description	Selected studies/applications
1. MENSA-MARKAL	**Main Characteristics** - linear-programming-based optimisation model - technological details – supply and demand side **Use** - to examine policy options for GHG emission - to assess competitiveness of energy technologies **Limitations** - lacks feedback to macro-economy	Jones et al. (1994) – examined policy implication of GHG emissions reduction in Australia; Daziell et al.(1993) – evaluated benefits of interstate gas and electricity connections; Naughten (2002) – simulated mandated target for renewable electricity in Australia; and Naughten (2003) – assessed combined cycle gas turbines in Australia.
2. AEPSOM	**Main Characteristics** - multi level optimisation - two sets of objective functions and constraints **Use** - to examine viability of renewable energy resources and technologies in Australia **Limitations** - lacks consideration of environmental issues - single period	Islam (1995) – determined viability of renewable energy resources and technologies in Australia.
3. E4CAST	**Main Characteristics** - optimisation model - demand function from econometric derived **Use** - to forecast medium-term energy demand forecast by state. **Limitations** - not suitable to examine policy scenarios - lacks technological details on demand side	Dickson et al. (2001) – projected consumption and production of energy in Australia for the period upto 2019 – 2020

The MENSA-MARKAL model represented the Australian energy system in the form of a reference energy system (RES), consisting of several energy demand and supply activities and technologies, over a given planning period (30–50 years). The RES represents energy flows in the systems, beginning with the extraction of primary energy resources, which are then transformed into a variety of secondary energy sources (such as petroleum products, electricity, heat), by various supply technologies (such as power plants, refineries). The secondary energy sources are finally consumed by end-use demand devices to satisfy the final energy demand of different economic sectors (such as residential, industrial). In this way, the demand for energy services is linked with primary energy resources through a chain of processes, conversion and demand technologies. The energy-supply and end-use technologies used in this model belonged to four different categories, namely, extraction, process, conversion and demand technologies.

In the 1990s, the MENSA model went through several modifications that included updating its database and improvements in the structure of the model to enhance its capabilities (Matthewson et al. 1998). ABARE later developed a Windows version interface (called ANSWER) for the MARKAL model in 1998 (see (ABARE 2002)). Several studies have been carried out using this version, for example, analysis of the policy implications of GHG emissions reduction (Jones, Peng & Naughten 1994); evaluation of the benefits of interstate gas and electricity connections (Daziell, Noble & Ofei-Menash 1993); analysis of the impacts of constraints of natural gas supply to the east-coast regions (such as New South Wales, Victoria) (Fainstein, Harman and Dickson (2002)); examination of how the Australian government's mandated target for renewable electricity can be achieved at least cost (Naughten 2002); and, more recently, an assessment of the impacts of introducing combined cycle gas turbines in the power sector (Naughten 2003). The majority of these studies have focused on examining a small segment of the energy system or issue, for example, renewable electricity technologies, interconnection of gas and electricity, or a particular kind of power plant. Further, these studies have typically examined energy issues from a national perspective. None of these studies have comprehensively focused on examining energy issues at the state level.

AEPSOM Model

The Australian Energy Planning System Optimisation Model (AEPSOM) was developed by Islam (1995). This model uses a multilevel optimisation (MLO) approach for energy planning. The MLO approach represents the energy system in a hierarchical structure, in which there can be more than one objective function. The hierarchical structure, for example, may include federal government, state government, and local government, each maximising (or minimising) its own respective objective function. The main purpose of developing the AEPSOM model was to overcome limitations posed by energy-modelling studies in that period. Energy models in that period considered one level of optimisation only, which meant that these models could not represent policy interactions between government and economic agents. Islam (1995) noted that energy models in that period were unable to analyse energy policies encompassing energy technology and economic policy settings.

In the AEPSOM model, an energy sector in a market economy is characterised by the existence of two levels of hierarchical decision-making systems – policy makers (that is, the government) and economic agents (that is, producers and consumers of energy). These two decision-makers optimise their goals subject to constraints, and their decisions are inter-related. The policy-makers at the upper level of the hierarchy, for example, influence the behaviour of energy-producers and -consumers, by taxes and subsidies. The modelling framework thus consists of two objective functions and two sets of constraints, one for policy and another for behaviour. The first objective function involves minimisation of policy objectives such as energy import, total energy use subject to constraints such as limits on changes in taxes and subsidies, and budget constraints. The second objective function (of the behavioural model - a cost minimisation linear-programming model) involves minimisation of the total cost of producing, supplying and using energy. Islam (1995) used the AEPSOM model to assess energy resources and technologies in Australia. This study identified optimal energy systems for Australia for two periods 1979–80 and 1989–90. This study found that imported crude oil was more attractive than domestic crude oil. The results also observed substantial changes that occurred in the energy situation between the periods of 1979–80 to 1989–90. For example, solar energy which was not found viable in 1979–80 appeared viable in 1989–90; the share of natural gas in the energy mix rose significantly in 1989–90; and also the share of biomass began to increase. Results obtained from the study supported the Australian energy technology development strategy of that period which emphasised the increasing market penetration of renewable energies such as solar, biomass and methanol. Islam (1997) used the AEPSOM model in another study that examined changes in the relative price structure in the energy sector and the deregulation of the energy market.

The AEPSOM model suffers from several limitations. First, it can not take into account emissions (such as CO_2) in its energy analysis. This limits the model's ability to assess greenhouse emissions-related policy issues. The model cannot, for example, estimate CO_2 emissions and hence cannot examine policy options on an emissions-constrained environment. Second, the model is not suitable for examining future energy systems (for example, energy scenarios). Islam used the model to examine past energy issues, for 1979–80, and 1989–90 to draw lessons for the future. Third, this model can be used for a single period only, hence it cannot analyse energy systems in a dynamic environment (on a multi-period basis). And, fourth, the model treats the energy system of the country as a single system only, that is, it cannot disaggregate the country at state and territorial levels, and hence cannot address policy issues relevant at the state level.

E4cast Model

E4cast (Dickson et al. 2001) is an energy forecasting model, which was developed by ABARE, to project long-term trends in energy consumption and production (by fuel and by industries) in Australia. The model uses an optimisation approach; the objective function maximises pure profits (which is equal to the difference between multiplications of price and quantity demanded, and price and quantity supplied) by satisfying the constraints of quantities and price. At the optimum level, a competitive equilibrium is obtained and pure profits become zero. The demand for different types of fuels in the model are computed from demand functions which are estimated econometrically, and incorporate effects owing to own-price elasticity, cross-price elasticity, income, activity and technical change. The model treats electricity production and consumption as separate sub-modules. The model can project end-use demands across twenty different sectors. The model was used by ABARE to project consumption and production of energy in Australia for a period up to 2019–2020 (Dickson, Akmal &

Thorpe 2003; Dickson et al. 2001). This study finds that total energy consumption in Australia will grow on average by 2 per cent per year over the projection period 1998–99 to 2019–20. The other use of model (apart from the regular use for projecting energy demand and supply), includes Donaldson and Dickson's (2003) application of the model to assess the availability of Liquefied Petroleum Gas to meet Australia's future domestic needs.

(b) Comparison of Optimisation Models

Structure. A key characteristic in all the optimisation models discussed here includes having one or two objective functions which are subject to constraints. How these objective functions are specified, however, differs significantly across these models. The AEPSOM model, for example, has two levels of objective functions, whereas the two other models (MARKAL and E4cast) have only one level of objective function. The objective function in the AEPSOM model focuses on minimising policy objectives (such as energy import, total energy consumption) at one level and minimising the total cost of the energy system at another level. The objective function in MARKAL minimises the total cost of the energy system only, and, the E4cast model minimises the pure profit as its objective function for projecting energy consumption.

In terms of geographical disaggregation, the E4cast model, and the later version of the MARKAL model, can accommodate the regional structure of the country; thus they can provide analyses at the state level. However, the AEPSOM model is not capable of incorporating such a regional structure.

Among the three models, the E4cast model addresses both the supply and demand sides of the energy system. The MARKAL model places more emphasis on the supply side of the energy system. Being a demand-driven model, the end-use services in this model need to be input exogenously.

Model Applications. The models differ from each other in terms of their applications – while MARKAL and AEPSOM models are more suitable for use in policy studies, E4Cast is suitable for projecting energy demand and supply (for Australia). As mentioned earlier, the MARKAL model has been used in many policy studies in

Australia. It has been used, for example, to assess GHG reduction policy issues, the benefits of interstate gas and electricity connections, mandated renewable energy targets, and assessment of combined-cycle gas turbines. The AEPSOM model has also been used to analyse policy issues, that included for example, assessing the viability of renewable energy technologies for Australia. The E4cast model, on the other hand, has been used mainly to project periodic energy supply and demand for Australia, from 2000 onwards.

The models' suitability for use in energy studies also depends upon how environmental issues could be accounted for in the model. The MARKAL and E4cast models, for example, take into account emissions of air pollutants and GHGs in its analysis. The MARKAL model is particularly useful to assess environmental issues such as reducing emissions (GHGs, other air pollutants), because of its ability to optimise the energy system in an emission-constrained environment. The AEPSOM model, on the contrary, does not take air emissions into account and is hence less suitable when environmental issues need to be examined.

Among the three models, only the E4cast model has been used for state level analyses. This model projects energy supply and demand for Australia and its seven states and territories. The studies based on MARKAL and AEPSOM have focused on analysing energy issues at national level only.

Some Further Observations

Followings are some further observations on the optimisation-based models discussed above:

- The main advantage of using an engineering-based optimisation model is that these models are capable of analysing energy systems at very disaggregated levels, by taking into account the details of technologies. Furthermore, the optimising makes these models suitable for analysing policy issues from the viewpoint of least-cost strategy. These models, for example, are useful to assess cost-effective CO_2 emission strategies that take into account costs of the whole energy system for over a long period (30–40 years).

- Among the three optimisation models discussed here, MARKAL has some distinguishable features that makes it more suitable than the other two for use in energy policy studies; this model is suitable for examining energy issues from the policy viewpoint (for example, GHG-related policy issues by placing constraints on CO_2 emissions), whereas E4cast is primarily useful in projecting energy supply and demand (it does not assess different types of scenarios); this model has a greater level of technological details, both on the supply and demand sides; (E4cast does not consider demand technologies in detail); and this model is available as a software package for researchers, whereas E4cast is not available for use by others (except for its developer, ABARE).

- A key shortcoming in the optimisation-based models is that they have a weak link with the rest of the economy. For example, in the MENSA-MARKAL model used in the Australian context, there is no provision for assessing the impacts of changes in prices on demand for energy services. (A recent upgrade of the MARKAL model, such as MARKAL-MICRO, can address these issues, but this has not been used in Australia.)

- Data requirements in the optimisation models are comparatively large in terms of volume and level of detail (for example, data are required on efficiencies, availability factors, costs per unit, etc., for each technology). Very often, such data would not be available, especially at local levels (for example, at regional, state level). This requires that some assumptions be made to fill such a data shortage. This could compromise the quality of data inputs, which could in turn affect the usefulness of the modelling outcomes. Diesendorf (1998), for example, makes note of differences that resulted in the outcomes from the MENSA-MARKAL model in the Australian context. Diesendorf notes that the thermal efficiencies of some of the technologies such as boilers were previously overestimated, which thus showed reduced potential for energy efficiency improvements. Similarly, for the residential sector, a greater role for efficient energy use was realised after improved energy efficiency data became available.

- Another drawback in the use of optimisation models is that they have a tendency to overestimate technological potential and generally underestimate the influence of social, political and institutional constraints (see Sutherland 1991).

(c) Simulation Models

There are two simulation-based models in use in Australia. They are the OzECCO model and the ASFF model. These models were developed in CSIRO's research study - Future Dilemmas (Foran & Poldy 2002). This study examined Australia's environmental future out to 2050. Both these models use physical economy[11] approach instead of the conventional monetary economy approach. In the physical economy approach, stocks and flows of materials are represented in physical units (for example, in PJ) as they undergo various processes over time. The OzEcco model represents an aggregated top-down approach, and the ASFF model a detailed bottom-up approach. Table 2-5 lists key features of these models.

OzEcco Model

The OzEcco model uses a systems dynamics approach and represents Australia's economy in terms of an embodied energy-economy. The OzECCO model was developed based on the ECCO (Enhancement of Carrying Capacity Options) model, developed by Slesser (1992). In this model, all goods and services are expressed in terms of their embodied energy content (energy included or embodied in goods and services), and economic activities are expressed as energy flows, in terms of energy units (for example,, PJ) instead of monetary units. The access to and transformation of energy (typically stocks of fossil fuel) are determinants of physical growth in a modern industrial economy (Foran & Poldy 2002). The embodied energy gets accumulated as fixed capital, for example, during investment in different sectors, such as agriculture (machines), or domestic housing, whereas it is dissipated during personal consumption. All capital stocks in the economy are expressed as stocks of embodied energy.

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[11] "Physical economy" describes the economy as a chain of physical transactions that take place to produce economic outputs (GDP).

Table 2-5: Salient Features of Simulation Models

Model	Features
1. OzECCO	**Main Characteristics** - top-down approach representation of Australian economy in physical economy - economic activities are represented in terms of energy flows - goods and services are seen in terms of their embodied energy content **Use** - to examine long-term impacts of three population scenarios on infrastructure, energy **Limitations** - inability to capture effects of economic variables, such as prices - difficulty in converting economic information available in monetary terms to physical flow in energy units.
2. ASFF	**Main Characteristics** - bottom-up representation of Australian economy in physical economy - the physical processes are represented by a series of calculators (32 nos) **Use** - to examine long-term impacts of three population scenarios on infrastructure, energy **Limitations** - inability to capture effects of economic variables such as prices - exogenous setting of 300 control variables depends on modeller's expertise

This model has been used to investigate the impacts on GDP and CO_2 emissions under three different scenarios for Australia. The key findings of the study include GDP multiplying by a factor of two and half, and CO_2 emissions increasing by nearly three times by 2050 under a business-as-usual scenario. The study also examines two alternative scenarios, wherein a reduction of CO_2 emissions was found to reduce GDP significantly. In one scenario it reduces by 34 percent below the BAU scenario.

ASFF Model

The ASFF model is a bottom-up model representing the Australian economic system in physical terms. The Australian economic system is represented in terms of stocks and flows, where stocks include resources such as people, livestock, energy, trees. The flows include processes wherein these stocks undergo changes. A series of calculators

(32 in total) are used to represent such physical processes, for example, the process of demography, consumption, building, transport, manufacturing and so on.

The model emphasises the exploration of possibilities rather than a prediction of the future. The concern in the model is not with what is likely to happen but with how desirable futures can be attained. The model starts with a vision of desirable futures (such as GHG emissions to an acceptable level), and works backwards to the present in order to identify measures required to reach it. The highly disaggregated simulation framework enables keeping track of all physically significant stocks and flows in the Australian socio-economic system.

(d) Comparison of Simulation Models

The following provides some observation on the simulated models:

- Important limitation in these physical-economy-based models is their inability to capture the effects of economic variables such as prices, and to allow for switching between various types of fuels. The models do not take into account the economic behaviour of systems, and they do not seek economically optimal solutions. Hence, projections made by the model may not be economically efficient projections.

- These models rely heavily upon the expertise of the model user, because the user is required to make important decisions for producers and consumers. For example, the ASFF model requires estimating 300 control variables (such as person per household, litre of gasoline per km, etc.) separately and input exogenously, which may be influenced by the model user's biases.

- The physical-flow-based models, such as OzECCO, require information in terms of physical flows (in energy units, for example), whereas most information in an economy is available in terms of monetary flows. Hence, this information needs to be converted into physical flows, which becomes a tricky task.

- These models have analysed energy issues at the national level. The analysis of impacts at the state levels is missing.

2.3.2 Economic Models

(a) General Equilibrium Models

There are four different types of general-equilibrium-based models[12] in use in Australia; two of these models, MMRF-GREEN (Adams, Horridge & Parmenter 2000) and MM600+ (Murphy 2000) focus on the Australian economy, and the other two GTEM (Brown et al. 1999) and G-cubed (McKibbin & Wilcoxen 1999) are more global in nature. These models have primarily been used to analyse the climate-change-related policy issues, such as carbon tax and emission trading. Table 2-6 lists key features of these models.

GTEM Model

The Global Trade and Environment Model (GTEM) is a computable general equilibrium, developed by the Australian Bureau of Agricultural and Resources Economics (ABARE). This model's development relied upon two previous models, ABARE's general equilibrium model, MEGABARE (ABARE 1996) and the GTAP model (Hertel 1997). The GTEM model improves MEGABARE in three respects: it extends GHG beyond CO_2 by including CH_4 and N_2O; it allows interfuel substitution, and it also includes an emission-response function for non-combustion GHG gases.

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[12] Computable General Equilibrium (CGE) models operate by simulating markets for energy, non-energy and other sectors, primary factors based on the optimisation behaviour of individual firms and households.

Table 2-6: Salient Features of General Equilibrium Models

Model Names	Descriptions	Applications
1. GTEM	**Main Characteristics** - global model, Australia is treated as one of the 24 regions - energy sectors are treated in detail - electricity and iron and steel industry are treated separately **Use** - to examine impacts of climate change policies on economy **Limitations** - lacks detail at state and territory levels	Brown et al. (1999) – to examine two types of greenhouse gas abatement policies, independent abatement and international emission-trading, to comply with the Kyoto Protocol.
2. G-cubed	**Main Characteristics** - global model, Australia is treated as one of the 8 regions - use a combination of macroeconomic modelling and general equilibrium modelling approaches **Use** - to examine climate change policy issues, such as emission-trading **Limitations** - lacks detail at state and territorial levels - energy sectors are represented in comparatively less detailed levels	Applied to examine impacts of carbon tax on Australian economy. (See McKibbin (1994), Mickibbin and Pearce (1993, 1995, 1996), and Mckibbin, Pearce and Stoeckel (1994).

Table 2-6 continued in next page

Table 2-6 continued from previous page

3. MMRF-GREEN	**Main Characteristics** - Australia is represented at state and territorial levels - energy sectors are treated in detail - energy-intensive products are treated separately **Use** - used to examine policy issues related to climate change, such as impacts of Kyoto Protocol on economy (employment) **Limitations** - technical progress, which reflects energy efficiency improvement is considered the same for both base and policy cases	Allen Consulting (2000) investigated the economic impacts of emission-trading policies designed to meet Australia's Kyoto target.
4. MM600+	**Main Characteristics** - Australia is represented at state and territorial levels - treats transport sector in detail through freight bundle - includes a large number of economic sectors (108 sectors) **Use** - used to examine effects of tax in transport sector to reduce GHG emissions **Limitations** - lacks detailed treatment of energy sectors	Econtech (2000) – analysed impacts of transport tax in reducing GHG emissions.

The general equilibrium approach in the GTEM model divides the world into 45 regions, with 50 economic sectors. The economic agents consist of consumers, producers, investors and governments. The producers operate in perfectly competitive markets using constant return to scale technologies. This means that the prices of products from industries are set to cover the costs of input materials and primary factors, with zero economic profit at all times (Brown et al. 1999). Each region has one representative household, that owns all factors of production and receives payment for the factors, tax revenues, and net interregional income transfers. The consumers maximise the current period utility by choosing consumption levels for each consumption good.

In this model, energy-related sectors are treated with special emphasis. It treats the electricity sector and the iron and steel industry (an energy-intensive industry) separately from other industries. Production in these industries is modelled using a "technology bundle" approach. In this approach, a number of known production technologies producing homogenous outputs for these two sectors are provided, which can substitute with each other in response to their costs. For example, electricity can be generated from coal, petroleum, gas, nuclear, hydro or renewable-based technologies; and iron and steel can be produced from blast furnaces and electric-arc furnaces. The production technique is represented by a Leontief production function[13].

The GTEM model has been used by ABARE in numerous studies. Tulpule et al (1998) and Brown (1999) used the model to examine the impacts of two types of policy options designed to meet Kyoto Protocol targets: one, independent abatement by Annex B[14] countries through domestic polices, and two, through international emissions-trading. The results show that GDP for Australia in 2010 would reduce by 1.3 percent in independent abatement and by 0.1% in Annex B trading. In other studies in the global context, the model is used to analyse the economic impacts of stabilising CO_2 concentration in the atmosphere and to examine the role of carbon capture and storage technologies in the electricity sector under such a scenario (Matysek et al. 2005). In a study by Heaney et al. (2005), this model is used to examine the role of advanced types

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[13] A production function that allows no substitution between inputs (that is, elasticity of substitution = 0).

[14] Countries listed in Annex B of the Kyoto Protocol.

of energy technologies in the electricity and iron and steel sectors in reducing the future growth of energy consumption and greenhouse gas emissions in APEC economies.

G-cubed Model

The G-cubed model developed by McKibbin et al. (1992) is also a general-equilibrium model for the global economy. The model is dynamic in nature and is a multi-country, multi-sectoral, inter-temporal general-equilibrium model of the global economy. It draws from both computable general-equilibrium models and macroeconomic models and attempts to integrate the better features of both approaches. The model combines the macroeconomic modelling approach of MSG2 model (McKibbin & Sachs 1991) with the general-equilibrium modelling approach of Jorgenson et al. (1991). This model has been used to analyse policy questions related to environmental regulation, tax reforms, monetary and fiscal policies and international trade.

The G-cubed model divides the world economy into eight autonomous regions, which interact through bilateral trade flows. Each region is represented by its own multi-sectoral econometric general equilibrium model. Production is broken down into 12 industries (five energy sectors and seven non-energy sectors) and each is represented by an econometrically estimated cost function (general equilibrium approach). Each economy or region consists of several economic agents, which includes households, the government, and the financial sectors. Each of the 12 sectors is represented as a price-taking firm which chooses variable inputs and its level of investment in order to maximise its stock value. Each firm's production technology is represented by a constant elasticity of substitution (CES) function[15]. Households maximise an inter-temporal utility function subject to life-time budget constraint, which determines the levels of savings, and firms choose investments to maximise the stock-market value of their equity (macro-economic approach).

Unlike in the GTEM model, energy sectors are not treated separately in the G-cubed model. Energy appears as an energy bundle, and substitution is allowed across five

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[15] A production function with constant elasticity of substitution.

energy types (electricity, gas, petroleum, coal and crude oil), and also between energy and other production inputs.

In the Australian context, the G-cubed model has been applied to examine GHG issues particularly related to carbon tax (McKibbin 1994; McKibbin & Pearce 1995; McKibbin, Pearce & Stoeckel 1994). These studies found that a carbon tax in Australia would lead to a significant reduction in economic outputs. The studies also showed Australia, being a large coal- exporting country, would benefit more from a global tax on the production of fossil fuels than a global tax on the use of these fuels, because it would allow Australia to keep tax revenue. Other studies related to greenhouse gas policies using this model include McKibbin et al. (1993), McKibbin (1997), and McKibbin (1998).

MMRF-Green Model

The MMRF-GREEN model (Adams, Horridge & Parmenter 2000) is a general-equilibrium model that focuses on the overall Australian economy. It is a dynamic, multi-regional, multi-sectoral model of the Australian economy. The model was developed into a dynamic version from the previous static version - the MMR model, by using the dynamic mechanisms from another model - a MONASH model (Dixon & Rimmer 2000). The general-equilibrium core of MMR is based on the ORANI model, a single-region model of Australia (Dixon et al. 1982).

The model divides Australia into six states and two territories. However, it can provide results at a much greater detailed level than this division, for example, at the sub-state level. The model can disaggregate the state-level results for output, employment and greenhouse gas emissions into 56 sub-state levels.

The model consists of five different economic agents: industries, capital creators, households, governments, and foreigners. There are 37 different sectors in this model. For each sector in each region there is an associated capital creator. The sectors produce a single commodity and the capital creators produce units of capital that are specific to the associated sector. Each region has a single household and regional government. There is also a federal government. The supplies and demand of commodities in each region are determined through optimising behaviour. It also determines demands for labour and capital in each industry. Labour supply is determined at the national level, based on demographic factors, and capital supply is determined based on rates of return. Supply and demand behaviour is coordinated through market-clearing equations which comprise the general-equilibrium core of the model.

Energy is considered explicitly in two places, one in electricity generation and another in production (or firm). The electricity sector is treated separately; it consists of different types of generators using different types of fuels, such as coal, gas oil and hydro. The electricity-supply industry in each state purchases electricity from these generators and sells to industries and final users (in some states they can sell directly to heavy consumers, such as aluminium and alumina refineries). The model allows substitution between different types of fuel inputs in electricity generators, based on prices represented by a constant elasticity of substitution (CES) production function, which provides scope for emission reductions. The model also allows improvements in energy efficiency, in terms of technical progress. These values are imposed exogenously and are the same for both the base-case and emission-policy scenario. This is a shortcoming in the model, because the emission policy scenario should naturally use more efficient technologies than the base scenario. At the production level, energy is made distinct by separating commodities made by using energy-intensive inputs and non-energy-related inputs. For a commodity produced using energy-intensive inputs, substitution is possible across the inputs, with the use of a CES production function. Substitution is possible for construction industry, for example, between cement and labour or other materials. For commodities produced from non-energy-intensive industries, the substitution possibilities are made zero, with the use of the Leontief production function. The model also takes into account the GHG emissions for all 37 industries considered.

This model has been used by the Allen Consulting Group (2000) to investigate the domestic economic impacts of GHG abatement policies such as international emission trading designed to meet Australia's Kyoto target. The modelling results show that complying with the Kyoto Protocol will reduce Australia's GDP by up to 1.9 percent a year. The results also showed that complying with the Kyoto Protocol will reduce the country's employment level by 2.5 percent annually.

MM600+ Model

The Murphy Model 600 Plus (MM600+) is a general-equilibrium model developed by Econtech (see Murphy (2000)) that also focuses on the overall Australian economy. Econtech developed this model by upgrading its previous model, MM303, under a contract with the Australian Competition and Consumer Commission.

The model divides Australia into states and territories, and industries are divided into 108 different sectors, which produce 672 different products. The economic agents in this model include producers, consumers, government, and foreign purchasers and sellers.

In this model, production function is represented by a Leontief function, which consists of inputs made up of a primary factor bundle, an energy bundle, a freight bundle and other intermediate bundle. While energy is not represented in as much detail as in the MMRF model, the model uses a different approach to deal with energy-related issues. In this model, the inputs to the production process include an energy bundle and a freight bundle. The energy bundle consists of a CES combination of primary energy inputs (such as black coal, brown coal, natural gas and LPG). Firms can substitute between these primary energy resources. The freight bundle allows firms to substitute between different modes of transport, for example, between road and rail freight transports, depending on the price of fuel such as diesel; thus the model has ability to affect the overall demand for diesel in response to price changes. This model is therefore more useful for investigating the transport sector in more detail. The household sector can also respond to changes in energy prices by substituting different types of energy sources (gas, electricity and other fuels) and also different modes of passenger transport (vehicles, railway). The treatment of taxation is particularly detailed in this model, with the inclusion of 24 different types of indirect taxes.

The model has been used to analyse GHG issues for various types of CO_2 taxes in the transport sector and also different forms of energy (Econtech 2000).

(b) Comparison of General Equilibrium Models

A review of general equilibrium models (above) used for energy policy analysis in Australia shows differences across the models in four key areas: in geographical coverage; in the level of importance given to the energy sector; in substitution possibilities between various forms of energy with other inputs; and in the representation of energy technologies.

Geographical Coverage. Among the four general equilibrium models reviewed here, two models, MMRF-GREEN and MM600+, represent Australia at a greater level of disaggregation, which makes these models suitable to examine impacts of domestic policies at state and territory levels. The MMRF-GREEN model, for instance, can provide results at 56 sub-state levels. The two other models, GTEM and G-cubed models, are global in geographic coverage, in which Australia is represented as one zone without domestic disaggregation. These models are, hence, suitable for analysing impacts of policies of global concerns, such as emission-trading. In GTEM, the world is divided into 24 regions, and in G-cubed, into eight regions.

In terms of the detailed representation of economic sectors, the MM600 model allows for a greater level of detail. It consists of 108 economic sectors, compared to 37 sectors in the MMRF-GREEN model. GTEM has 37 economic sectors, while the G-cubed has 12 sectors.

Treatment of Energy Sector. How the energy sector is treated within the model differs significantly across the four GEM models. The GEM approaches use energy as one of the several inputs. However, the level of disaggregation of the energy sector, and the representation of substitution between different energy types and with other inputs, vary significantly across these models. Among the four models, MMRF has the most detailed representation of energy sector, whereas the G-cubed has the least.

Among the two national-level models, the MMRF-Green model treats the energy sector at a higher level of details. It considers energy explicitly in two places, one in electricity generation and another in production (or firm). The electricity sector consists of different types of generators using different types of fuels, such as coal, gas, oil and hydro. The model is particularly suitable for examining country-specific energy and environmental issues. In the MM600+ model, while energy is not represented in as much detail as in the MMRF-Green model, the model's use of the energy bundle and a freight bundle provides some interesting scope for analysis. The freight bundle allows firms to substitute between different modes of transport, for example, substitution between road and rail freight, depending upon the prices of fuels such as diesel, thus it allows for the analyses of price response on overall demand. Thus this model is more useful for investigating the transport sector in more detail.

Among the two global GEM models, GTEM treats the energy sectors in more detail. The model treats the electricity sector and the energy-intensive iron and steel industry separately. Electricity is modelled using a "technology bundle" approach. Hence, a number of known production technologies producing homogenous outputs for these two sectors are provided, which can substitute with each other in response to their costs. For example, electricity can be generated from coal, petroleum, gas, nuclear, hydro or renewable-based technologies; and iron and steel can be produced from blast furnaces and electric-arc furnaces. In the G-cubed model, although energy sectors are not treated separately, energy appears as an energy bundle, and substitution is allowed across five energy types (electricity, gas, petroleum, coal and crude oil), and also substitution is allowed between energy and other production inputs.

Substitution Possibilities. The models differ in terms of how substitution possibilities (between different energy types and between energy and other factors of input) are accounted for. All the models, except for the GTEM, allow capital–energy substitution at the margin even if technology is currently infeasible (Pezzey & Lambie 2001).

The MMRF model allows substitution between different energy types (petroleum, natural gas and electricity), and also between energy and other primary factor inputs (such as capital, labour and land). In the electricity-supply industry, it allows substitution between electricity generated from different energy sources (black coal, brown coal, gas, oil products and renewables). In the MM600+ model, substitution between various energy types (black coal, brown coal, natural gas and LPG, except for petroleum products) is allowed, but substitution is not allowed between energy and other inputs (capital and labour). In GTEM, substitutions across different energy types (coal, gas, petroleum products and electricity) are allowed within an energy bundle, and also between energy with other factor of inputs (capital, labour, land). GTEM treats electricity sector and the iron and steel industry separately, and uses a technology bundle to represent production technology. Substitution between different technologies is allowed, for example, substitution is possible between generation technologies based on coal, oil, gas, nuclear, hydro and renewables. In the G-cubed model, substitution for energy is allowed at two stages, first across five different energy types (electricity, gas, petroleum, coal and crude oil) within an energy bundle; next between energy and other production inputs.

Representation of Technologies. The energy sector is characterised by a wide range of technologies, both on the supply and demand sides. Hence, how well these technological details are captured in the model is also important. The GTEM model is the only model that contains a greater level of technological detail, with the use of a technology bundles for the electricity sector and iron and steel industry. The MMRF model lacks explicit technology representation, however, it treats the electricity sector separately by identifying electricity production from different energy sources.

Some Further Observations

Some further observations on the general equilibrium-based models are provided below:

- GEM models, in general, use one average aggregate function to represent energy sector, which does not do justice to the diverse range of technologies typically employed in this sector. For example, specifying one equation for electricity production may yield a very different result than would be the case in reality, since electricity production depends on load characteristics, production technologies and generation mix (Bhattacharya 1996).

- Elasticity is a key parameter in general equilibrium models – this parameter is used to account for substitution possibilities. Its values, for example, can affect abatement costs for CO_2 emissions. The assumption of elasticity values used in these models also raises concerns, because consensus is generally lacking in the choice of their values. Diesendorf (1998) notes that in the Australian context there is little data available which can be used to derive elasticity values that could take into account large changes in energy demand and energy supply technologies. The general equilibrium models also unrealistically assume that elasticities values are time independent; experience however shows that their values change with time. The geographical characteristics of Australia also pose some challenges for substitution between various energy forms. For example, most of the loads for electricity are concentrated in the coastal regions in the southeast, where power is generated largely from coal, because of its availability in abundance. Australia's gas resources are located far from these load centres, hence substitution of coal with gas is not easy and the elasticity values should be able to capture these limitations.

(c) Input–output Model

The input–output model[16] has been applied in a number of studies in Australia to examine energy policy issues (such as CO_2 emissions, energy intensities) and their implications on the economic sectors. The advantage of using input–output approaches, compared to optimisation models or general equilibrium models, is that they make it possible to analyse the impacts of policy issues at a higher level of sectoral detail. Table 2-8 lists key features of these models.

[16] The input–output model, developed by Leontief (1966), represents the economic structure of the economy in a tabular form to illustrate inter-industry transactions, outputs produced and inputs absorbed by various sectors (see also Miller et al. (1985); Proops et al. (1993)).

Table 2-7: Salient Features of Input–output Models

Model Names	Descriptions
1. James (1980)	**Main Characteristics** - an 11-sector input–output table is developed from a 109-sector table - the input–output table consists of absorption matrix and make matrix **Use** - first use of input–output table for the analysis of energy issues - demonstrates the use of traditional input–output table for use in energy sector analysis **Limitations** - high level of aggregation (11 sectors in total) - disaggregation of energy sectors not sufficient
2. Karunaratne (1981)	**Main Characteristics** - a 21-sector matrix is developed from the 109-sector input–output table - a Leontief inverse of 21 sectors together with direct sectoral energy consumption is used to develop a sectoral energy matrix - a framework is developed to analyse interactions between energy conservation and macroeconomic goals **Use** - computes total demand for energy, which includes direct and indirect demand - examines macroeconomic policy issues **Limitations** - insufficient disaggregation of energy sectors (gas and electricity lumped in power sector) - primary energy is not divided into fuel types
3. Common and Salma (1992)	**Main Characteristics** - a 27 matrix is constructed from a 108-sector table - additional C and F matrices is used to account for energy consumed by industrial sectors and final demand - CO_2 emission factors by fuel types are used **Use** - examines GHG emissions from energy use and contributing factors **Limitations** - insufficient disaggregation of energy sectors (coal, oil and gas are represented by one sector)
4. Lenzen (1998)	**Main Characteristics** - extends GHG coverage to include CH_4 and N_2O - sectoral details are large, 45 sectors - carbon intensity of imports is also accounted for - energy transactions are represented in energy units **Use** - computes energy intensity **Limitations** - fuel use data are presented in an aggregated form

An early attempt in Australia at using input–output model to investigate energy related issues was made by James (1980). James developed an accounting framework, called AUSTIOM, based on the input–output model, to gather data on energy and economy systematically and to use such data for energy modelling studies. The purpose of these modelling studies was to illustrate how an input–output model that specifically focused on the energy sector can be developed from the traditional input–output table published by the Australian Bureau of Statistics (ABS). This model attempted to overcome the inadequacies experienced in energy data during that period. James (1980) noted that the ABS input–output table of 1968–69 period did not disaggregate energy sectors in sufficient detail, which made its use in energy modelling somewhat difficult. This problem continues until today. For example, the most recent input–output table available for 1999, combines the three important energy sectors (coal, oil and gas) into one sector.

James' (1980) input–output table aggregates 109 industrial sectors into 11 economic sectors, five of which are classified as energy sectors (coal and crude petroleum, petroleum and coal products, electricity, gas and iron and steel). In this input–output model, the matrices and vectors are partitioned into two, energy industries and commodities, and non-energy industries and commodities. This input–output table consists of an absorption matrix and a make matrix. The absorption matrix links the row of commodities with the column of industries, with each typical element "x_{ij}" in the matrix showing the absorption (input) of the i^{th} commodity by the j^{th} industry. It represents flows of 21 energy commodities to 11 industrial sectors and also to the final demand sectors. The make matrix links the rows of industries with the columns of commodities, with typical element "m_{ij}" in the matrix showing production of the j^{th} commodity by the i^{th} industry. From these matrices, the author computes an 11-sector coefficient matrix (industry by industry) derived from the industry technology assumptions. The author then suggests a number of applications for such a coefficient matrix, for example, to calculate a complete set of inter-sectoral energy flows, to calculate a Leontief inverse matrix, which can then be applied to determine the total sectoral outputs required to meet specified sets of final demands.

Karunaratne (1981) later used the input–output model to analyse the structure of energy demand in Australia and its relation to macro-policy issues. The main focus of his analysis was to illustrate the importance of considering the total demand (direct demand plus indirect demand) for energy instead of direct demand (as was usually practised) to analyse the interaction between the macro-economy and energy conservation. Karunaratne's (1981) input–output analysis aggregated the economic sectors into 21 sectors from the 109 X 109 sector input–output table for 1974–75. The weak point in this construction was insufficient disaggregation of the energy sectors. The energy sector was represented, for example, by one sector only (the Power sector).

In this input–output analysis, total output is equated to input demanded for intermediate and final demand uses. Then, in conjunction with the sectoral intensity for each of energy, income growth, employment, capital use and pollution, separate matrices are generated for intersectoral flows for each of them. Inter-sector models are outlined in terms of a Leontief inverse for the inter-sectoral flow of energy, income, employment, capital and pollution. The total effects are normalised, using total energy coefficients, to determine the trade-offs between income–energy, employment–energy, capital–energy and pollution–energy. The study illustrated interdependence across 21 sectors in terms of primary energy. The analysis found that the direct energy intensity coefficients underestimated total energy use by an average of 54 percent.

The study computed total sectoral energy, income, capital and pollution generated per unit of final demand. The effects are ranked according to the macro-objectives of energy conservation, which are of four types, minimisation of energy use, maximisation of income, maximisation of employment and minimisation of capital. It observed that the aims of maximising employment and income are compatible. Also, energy conservation and growth maximisation, capital economy and pollution abatement are found to be consistent with their objectives. The strongest correlations were observed between energy conservation and employment, thus implying energy as a substitute for labour.

In the 1990s, the application of input–output tables began to focus on environmental issues, mainly on greenhouse gas emissions related to energy use. The use of input–output tables in these analyses required modifying the input–output tables available from ABS to account for energy consumption and sources of emissions. These analyses primarily used three data sources: input–output tables, published regularly by ABS; sectoral energy consumption data available primarily from ABARE; and emission factors (such as CO_2 emission) from the Australian Greenhouse Office (AGO). These studies, however, continued to encounter difficulty in disaggregating the energy sectors, as was the case in earlier studies.

The first application of the input–output table to examine CO_2 emissions was Common and Salma (1992). This study used the input–output table of 1986–87 to compute CO_2 emission intensities (in tonnes/\$A) and total emissions for 27 sectors. The authors further used input–output tables from two periods (from 1974–75 to 1986–87) to trace the changes in CO_2 emissions over time to three contributing factors, namely, changes in final demand, changes in fuel mix and changes in technology. An important conclusion from the analysis was that while total emissions increased over time in a steady manner, the factors that contributed to emissions were found to be fluctuating over different sub-periods. For example, emissions due to changes in fuel mix and technologies were positive in one period and negative in other periods.

The application of input–output tables to examine GHG emissions was further extended by Lenzen (1998). This analysis extended the GHG coverage by including two additional GHG gases (CH_4 and N_2O), in units of CO_2 equivalent. The previous study on GHG emissions by Common and Salma (1992) was limited to CO_2 emissions only. Lenzen (1998) used the 1992–1993 input–output table to examine direct and indirect primary energy and greenhouse gas requirements for a given level of final consumption in Australia. This study calculated energy intensities (in MJ/A\$) and greenhouse gas intensities (in kg CO_2/A\$) for 45 industry sectors in Australia. It also estimated balances of primary energy consumption and greenhouse gas emissions by industry sectors. The authors reported the lack of sufficient disaggregation of fuel-use data as an important shortcoming in the input–output table, as noted first by James (1980).

Cornwell (1996) used input–output table based minimum disruption approach[17], to find out changes required in the structure of final demand, fuel mix and efficiency, and inter-industry trading to reduce Australia's CO_2 emissions by 20 per cent below 1989–90 level by the year 2004–05, while maintaining GDP growth and level of employment at the specified level of 2 percent per year. The study identified sectors which needed the largest reduction in final demand, they were construction (-7.97 percent), electricity (-7.81 percent), and petroleum and coal products (-7.58 percent) sectors. And, the sectors that needed largest increase in final demand were service sectors, mainly, wholesale and retail (4.32 percent), and ownership of dwellings services (4.23 percent). Similarly, the changes in the fuel mix required are in oil use (-2.46 percent) by petroleum and coal products sector, and black coal (-2.14 percent) and brown coal (-1.19 percent) by electricity sector.

The application of the input–output table in analysing energy consumption in the transportation sector of Australia can be found in Lenzen (1999). Lenzen calculated direct and indirect requirements in energy consumption and greenhouse gas emissions in the transport sector. Direct requirements refer to the fuel consumption by passenger and freight transport services, and indirect requirements refer to the embodied energy in the goods and services in the transport sector (such as vehicles and infrastructures). The study found that indirect requirements form a significant component in the total energy and greenhouse gas required for a given transport task. Depending upon the mode of transports, its share could be in a range of 10–50 percent for freight transport, and 25–65 percent for passenger transport.

In another study, Lenzen and Dey (2002) used the input–output method to compute the direct and indirect requirements of energy and associated greenhouse gases for different aspects of living styles in Australia. This analysis considered direct energy consumption by households and energy and greenhouse gases embodied in the consumer items

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[17] The minimum disruption approach, developed by Proops, Faber and Wagenhals (1993), uses input–output table to determine the minimum level of changes that would be required in the industrial structure (in terms of final demand, fuel mix and efficiency, and inter-industry trading) to achieve a target level of emissions reduction, while maintaining the desired level of macroeconomic variables, such as GDP and employment.

purchased by households. The study finds that direct consumption of fuels and electricity accounts for about 30 percent of the total energy expenditure and 17 percent of the total greenhouse gas expenditure of Australian households, and the consumption of non-energy commodities, through purchases, accounts for the remainder.

(d) Comparison of Input–output Models

The application of input–output approaches in these studies has been to examine total GHG-intensive and energy-intensive economic sectors by taking into account direct and indirect energy use. The use of input–output approaches has been particularly useful in analysing the consequences of climate change policies (such as carbon tax) on various sectors and outputs. This approach has also been used to determine contributing factors behind changes in CO_2 emissions over time. These factors include changes in final demand, fuel mix and technology (Common & Salma 1992). The input–output approach was used by Cornwell (1996) to find out how the structure of the Australian industrial sectors needs to change if a certain percentage of CO_2 emissions are needed to be reduced, while maintaining GDP growth and employment at the pre-specified levels.

The majority of the studies that used the input–output model have limited their analysis to one year only. Common and Salma (1992), however, used input–output tables for a longer time period (1974–75 and 1986–87), in order to examine the impacts of changes in CO_2 emissions. One of the key limitations in using input–output model is that these models are suitable for short-term analysis only. Further, none of the studies attempted to examine energy issues for long-term future.

When using the input–output model in energy–related studies, an important difficulty comes from the lack of disaggregation of energy sectors in the input–output table available for Australia. Common and Salma (1992) were unable to analyse at a higher level of disaggregation for energy sectors, due to the lack of disaggregated input–output data. Lenzen's (1998) input–output analysis disaggregates the economic sectors into 45 sectors, however, the number of energy sectors was still limited to three, similar to the Common and Salma (1992) study.

Some Further Observations

Some further observations on input–output models reviewed above include:

- In studies reviewed above, since a national input–output table was used, the results are valid for the analysis of of energy policy issues at the national level only. These results were inadequate to analyse policies at the state level. The analysis made at the national level may not accurately capture issues at state level. One of the reasons for this is that the primary energy mix at the state level (for example, NSW) differs significantly from the primary energy mix at the national level. In the input–output model, this difference in primary energy mix gets reflected in total energy intensity, and total CO_2 emissions intensity for different sectors. For example, the share of coal in the NSW's energy mix is relatively higher than the corresponding share in the national energy mix. This means that the total carbon intensity of an economic sector at the state level will be comparatively higher than the intensity computed for the same sector at the national level. Hence, the conclusions drawn from results at the national level have the potential to become erroneous when applied at the state level.

2.4 Selection of Energy and Economy Models for this Research

On the basis of the review of energy models in the previous sections in this chapter, it can be argued that the most suitable model to address the questions raised in this research are: the MARKAL model for the analysis of energy impacts, and energy oriented input–output model for the assessment of economy-wide impacts. The following discussion provides justification for this selection.

Energy Model. The MARKAL model would be suitable for following reasons:

- The energy scenarios in this research (as will be described in detail in Chapter 3) are characterised by various types of energy technologies including for example, existing and emerging power plants; transport (passenger driven by gasoline, natural gas, biofuel, or hybrid types of cars). The MARKAL model, as explained in the previous sections, can take into account these technologies at a very disaggregated level. Thus this model would be useful in investigating the competitiveness of these technologies under various scenarios and assessing the impacts of technological pathways on the total energy system.

- This model is able to identify the least-cost strategy for meeting energy needs, specific to various scenarios. For example, the model would be able to determine cost-effective GHG emission strategy by optimising the whole system (reducing CO_2 emission is one of the key factors in the scenarios considered in this research), while many other models, such as simulation models, can only test the strategies proposed by the user, which may not be an optimal strategy. This is so because the objective function of the MARKAL minimises the total discounted cost of energy system for the entire planning horizon. The total cost of the system consists of the cost of technologies (for example, investment cost, fixed cost and variable cost of power plants, refineries, heaters, appliances, etc.), costs of energy types (for example, coal, gas, electricity, etc.), and costs of energy imports (for example, oil, gas), etc.

- The minimisation of the total discounted cost of energy system over the long term (as noted above) is identical to maximising the net social surplus (that is, the sum of producer and consumer surpluses).

- Unlike econometric models, this model provides an equilibrium solution. In the MARKAL model, exogenously specified end-use demands must be satisfied for all time periods in order to have a feasible solution. The end-use demands are represented in terms of different end-use tasks, such as demand for heating (in PJ) by the residential sector, demand for personal transportation (in vehicle km), demand for steel and aluminium (in tonnes), etc. Each type of demand is satisfied by one or many types of end-use devices and fuels.

- Unlike other energy models, this model is made available by International Energy Agency (IEA) for general research purposes and has been used across the world for a variety of energy policy studies (the use of both of the other models discussed, namely AEPSOM and E4cast is limited to the model developers and they are not known to be available for use by other researchers).

Economic Model. To determine the economic impacts of different types of energy consumption trends for the three scenarios in this research, the input–output model would be the most suitable. The use of the input–output model would be suitable for the following reasons:

The review of economic models in the earlier sections illustrated that the majority of the economic models (such as general equilibrium models (GEM)) exhibit two key weaknesses for the purposes of this research. First, since they represent the economy at an aggregated level, their analysis would be limited to macro-level only, that is, they would fail to provide insights of scenario impacts detailed at sectoral levels. Second, these models represent energy technologies poorly. For the energy sector, this would be a critical issue because various scenarios in this research are characterised by a large number of energy technologies (such as power plants, refineries, boilers, furnaces, appliances, etc.) which evolve throughout the study period. For the purpose of this research, using input–output model in combination with the energy model, the MARKAL model could resolve these two problems. The energy model (MARKAL) would take into account detailed representations of technologies, thus overcoming a major drawback posed by economic models. In addition, the input–output model, since it captures linkages across a large number of economic sectors including energy sectors, would make it possible to examine the impacts of three scenarios on a large number of economic sectors. One of the major attractions of input–output model is that it has a higher level of disaggregation of economic sectors than any other economic model. The input–output model deals with smaller parts of an economy by placing emphasis on individual sectors (unlike the macroeconomic approach). It therefore becomes possible to examine the economy-wide impacts, specific to a larger number of economic sub-sectors. Unlike other economic models which focus on the macro-level only, the input–output model can be operated both at macro- and also at sectoral disaggregated micro-levels. In this way, a combination of energy model and input–output model would make it possible to examine impacts at a greater level of detail both in the energy and economic sectors.

2.5 Conclusions

This chapter reviewed the status of the energy-scenario and energy-modelling studies conducted in Australia. Following are the key conclusions of this review:

- The three **energy-scenario studies** reviewed in this chapter provided insights into the estimation of energy requirements and associated CO_2 emissions for Australia for the next 30 to 50 years. A closer examination of these studies revealed that significant differences exist in these studies in terms of, for example, driving forces behind the scenarios, methodological approaches used for analysis, and scenario outcomes. The scenarios in the Living in a Turbulent World (LTW) study, for example, are mainly driven by global economic situation; in the Future Dilemma (FD) study, they are driven by different population sizes; and in the Clean Energy Future (CEF) study, they are driven by a concern for reducing CO_2 emissions. The studies were found to be strikingly different in terms of the importance given to CO_2 emission reduction. For example, the CEF study envisages a 50 percent reduction in CO_2 emissions, compared with 2001 emission levels, while the two other studies fail to consider a future scenario wherein a large reduction in CO_2 emissions below the 2000 emission level would become necessary.

- The **energy-modelling studies** in Australia broadly belong to two types: one, using engineering-based optimisation or simulation models, and two, using economic models (general equilibrium or input–output). Amongst the engineering models, the MARKAL model is found to be suitable for analysing energy policy issues (in the context of this research), because it can analyse energy system by taking into account all segments of the system, with a detailed representation of technologies on both the supply and demand sides. The weakness in this type of model, however, is that it does not provide meaningful linkages between technology and economy at aggregated or disaggregated levels. This weakness can however be overcome by employing an energy-oriented input–output model.

- The majority of scenario and modelling studies in Australia have focused on energy issues from a national perspective; and state level analyses are therefore largely missing. Since the Australian states vary considerably in terms of energy resources availability and use patterns, the failure to consider such differences could provide erroneous results. This research attempts to overcome this shortcoming by focusing its analysis at state specific level.

3. Development of Long-term Energy Scenarios for NSW

3.1 Introduction

In the previous chapter, a review of energy scenario and energy modelling studies in Australia was presented. The review revealed that the majority of these studies were conducted at the national level, which made these studies unable to analyse state-specific issues in sufficient detail. In order therefore to examine energy related challenges specific to NSW, a scenario study specifically focusing on this particular state is required. This chapter develops three long-term energy scenarios for NSW. These scenarios are developed by taking into account major factors that have the potential to influence the development of future energy systems and policies in NSW. The energy and economic impacts of these scenarios will be assessed in Chapters 4 and 5, respectively.

This chapter is divided into three sections. Section 3.2 briefly explains the scenario development process in general. Section 3.3 provides a discussion on key driving forces behind the scenarios for NSW. Section 3.4 provides descriptions about the three scenarios. The main features of these scenarios are summarised in Section 3.5.

3.2 Scenario Development Process

A scenario development process generally involves developing a set of alternative storylines around a set of assumptions (developed by taking into account various of driving forces) that envision how the future might unfold. The scenarios are then modelled quantitatively to examine their impacts on energy, the environment, and the economy.[18]

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[18] Studies that used the scenario-based approach include, for example, IPCC (2000), IWG (2000), Marsh et al. (2002), and in the context of Australia, Diesendorf and Denniss (2004) and SESSWG (2003).

The methods used for constructing scenarios vary considerably, depending of course upon the purpose of the questions under analysis. The traditional approach used in Australia, as suggested by SESSWG (SESSWG 2003), for example, first involves different analysts specifying alternative assumptions for economic policy, technologies, political change and cultural factors. These assumptions are then developed into different sets of consistent assumptions. A number of scenarios are then developed around these assumptions, and finally the most plausible or desirable scenarios are selected for analysis. The methodology recommended by Schwartz (1992) involves following six steps: first, defining a focal issue; second, listing important forces in the environment; third, evaluating forces by importance and uncertainty; fourth, selecting a scenario logic; fifth, developing scenarios around uncertainties; and sixth, considering implications of the scenarios. In IPCC (2000), scenarios are constructed by following these five steps: first, review of existing scenarios in literatures; second, analyse their main characteristics and driving forces; third, formulate narrative "storylines" to describe alternative futures; fourth, quantify storylines with different modelling approaches; and fifth, an "open" review process of emission scenarios and their assumptions.

In this research, scenarios are constructed following these three steps: First, five key types of scenario variables are identified, which would be of interest from policy viewpoint and which have the potential to shape the future energy development processes in NSW. Their selection is influenced by their potential to deal with the challenges that could be faced by the energy sector in NSW (as explained in Chapter 1). Second, alternative scenarios are then constructed by developing a logically consistent set of assumptions about these variables and a set of policy constraints. Finally, the scenarios are modelled quantitatively using MARKAL model (energy model), and the energy-oriented input–output model (economic model) to assess their impacts on energy and the economy.

3.3 Explanatory Variables for the Scenarios

The five key variables that will be important from the policy viewpoint and which could influence the future development of the energy systems and policies in NSW are explained below:

Energy Diversity. Energy diversity in the primary energy mix is likely to be an important issue in the context of NSW. At present, the primary energy mix in the state lacks diversity; it is dominated by two types of fossil fuels, namely, coal and petroleum products. In 2000, for example, these two fuels constituted 86 percent of the total primary energy consumption (coal, 50 percent and petroleum products, 36 percent) (Dickson, Akmal & Thorpe 2003). The scenarios in this research assume that diversifying the energy mix, away from these two energy sources, would become important in order to reduce the risks associated with overwhelming dependence on few energy sources. For example, significant dependence on oil could be risky because its supply comes from the relatively unstable Middle East regions. And, over reliance on coal, which although is an indigenous energy resources, could be troublesome, particularly, if a global reduction of CO_2 emissions becomes imperative in the future. The diversification of fuels would be even more important in power generation, wherein coal currently provides nearly 90 percent of total power generation and is also a major source of CO_2 emissions. The ongoing energy market reform in the electricity and gas sectors would facilitate the diversification in fuel, as gas becomes attractive for private investors for electricity generation and as access to gas supply becomes easier with the removal of cross-border tariffs and access to gas pipelines. Fuel diversification would not be confined just to fossil fuels (for example, coal, gas, and oil), but would also include renewable energy sources, through their use in power generation, household applications (for example, solar water heating) and in the transport sector (for example, CNG, methanol, ethanol).

Oil Dependency. The urgency of reducing the dependency on imported oil is another important factor that could shape the future energy pathways. NSW does not have oil resources, but oil products have remained a major component of energy demand in the state, mainly because of its use in the transport sector. As mentioned earlier in Chapter

1, the world oil market has become very unstable recently in terms of supply and price, mainly after the World Trade Center disaster in the United States in 2001 and subsequent geopolitical developments (such as the war in Iraq). Reducing the dependency on imported oil is becoming important for countries like Australia. The country's oil reserves are not sufficient for the long term. At the current rate of production, one estimate show that the reserves can last only for next eleven years (Geoscience Australia 2002). The situation is particularly worrying for NSW, since the state does not produce oil and relies solely on imports from interstate and overseas. In 2000, for example, NSW supplied 45 percent of its oil need from overseas imports. The need to reduce dependency on imported oil is an important factor consideration in this research. This would be both economically and politically desirable for NSW. Reducing oil consumption could be achieved through increased efficiency of transport vehicles and the introduction of alternative transport fuels.

CO_2 Emissions. The need to reduce CO_2 emissions is an important consideration in the scenarios developed in this research. Reducing CO_2 emissions is emerging as a major issue in energy policy debate in most of the countries in the world. This has become even more important with the ratification of the Kyoto Protocol by Russia in 2004. NSW is the largest CO_2 emitting state in Australia (responsible for about 30 percent of the total), mainly because of the state's heavy reliance on carbon-intensive coal. The state government of NSW and the federal government, however, hold somewhat inconsistent views towards the Kyoto Protocol. The state government supports a ratification of the Kyoto Protocol (NSW Government 2004), but it is opposed by the federal government (Commonwealth of Australia 2004). Both governments, though, recognise the threats and challenges of climate change.

Advancement of Technologies. How energy technologies, such as advanced types of coal technologies, carbon capture and sequestration (CCS), wind power, PV, and road transport vehicles would improve in terms of cost and efficiency in the future will be key factor in future energy development. Technologies such as Integrated Gasification Combined Cycle (IGCC), CCS, hybrid cars, at present, are in demonstration or prototype phases, and not yet available commercially. The abilities of the state to deal with the climate-change challenges will very much depend upon how these technologies would progress in the future. For example, the long-term prospect for coal will depend upon how coal combustion technologies and carbon sequestration technologies would develop.

Social Factors. And, finally, how the society becomes environmentally conscious and begins to accept more efficient and environmentally friendly appliances, such as solar water heaters, hybrid vehicles, and alternative fuels in transportation, would play a role in defining these scenarios.

Three scenarios are developed in this research around the five variables (discussed above) (Figure 3.1). The level at which these variables may influence, from low, moderate, or high, defines the three scenarios, Base Scenario (BAS), Moderate Scenario (MOD), and Advanced Scenario (ADV).

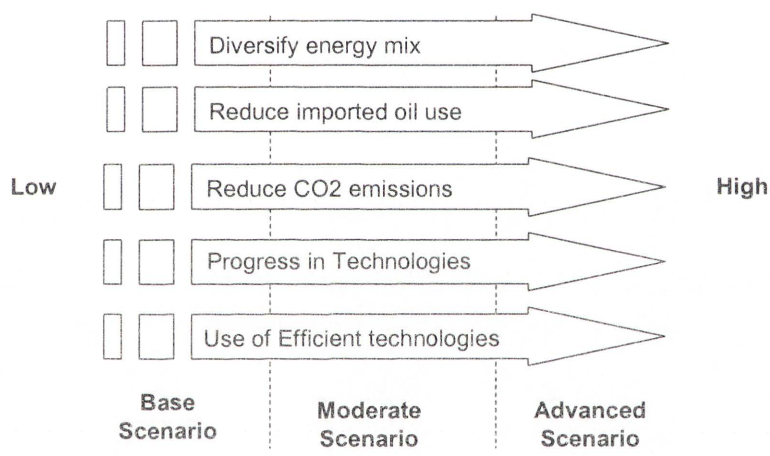

Figure 3.1: Key Scenario Variables

3.4 Scenario Descriptions

This research develops three energy supply scenarios, which attempt to represent three different energy pathways for NSW. The scenarios emphasise both the supply side of the energy system and also the key energy consuming end-use activities, such as energy intensive industries, road transport, heating and cooling in residential and commercial sectors, etc. The Base scenario or reference scenario represents the continuation of current trends in terms of policies and technologies. The two other scenarios (Moderate and Advanced scenarios) assume that significant changes in technological development and use could occur in the future.

All three scenarios assume the same end-use services, which are developed based on the energy demand projections made by ABARE for NSW (Dickson, Akmal & Thorpe 2003). ABARE's projection of energy demand assumes average economic growth for NSW at 3.1 per cent per year. This value is, however, lower than the historical average (3.6 percent) for NSW between 1995 to 2003 (ABS 2003).

The population is assumed to grow at annual rate of 1.1 percent during the first twenty years (similar to ABARE's estimate) and at 0.5 percent for the remaining twenty years (based on ABS forecast for 2021–2051, Series 1), with the total population of the state reaching 8.5 million by 2040. The discount rate of 8 percent is used to discount the costs over the study period of forty years.[19]

3.4.1 Base Scenario

Overview. The Base scenario (BAS) reflects the continuation of the current trends[20] in energy policy without any major changes taking place. The characteristics of this scenario include no restriction on coal use as a source of energy (in power generation, and in industries); no specific commitment to promote renewable energy sources (except for the existing MRET[21] scheme); no restriction on the total amount of CO_2 emissions, except for the restriction imposed in the electricity sector under the NSW GHG Benchmark Scheme (NSW Government 2001); and the continuation of this scheme beyond the current target year of 2012[22]. Table 3-1 lists key characteristics of Base scenario.

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[19] This value is taken from Naughten (2003).

[20] "Current trends" here reflects the trends during 2002 – 03, the period when the scenarios for this research were constructed.

[21] MRET – The Mandated Renewable Energy Technology scheme is a nationwide scheme that targets an additional 9500 GWh of electricity from renewable-based plants by 2010.

[22] At the time when scenarios were being developed for this research (in 2002 – 03), no state level target had been set for CO2 emissions reduction, and the NSW GHG Benchmark Scheme was scheduled to be implemented for the period of 2007 to 2012. In October, 2006, however, the state government brought out

Table 3-1: Characteristics of the Base Scenario

1. Energy resources

a. Current trend of coal use will continue with no specific policy to discourage coal use.
b. Natural gas supply will be available from the reserves in the eastern states and also from other sources during the study period
c. Renewable energy policy will remain the same with no specific policy to expand it further.
d. No policy to promote alternative fuels in transport.
e. There will be no immediate concern towards reducing oil dependency.

2. Electricity supply

a. There will be no restriction on generating power from conventional coal plants.
b. No specific policies to promote renewable-based plants except to comply with MRET scheme.

3. End-use sectors

Industrial sector

a. Technologies for steel production will remain the same as in present state.
b. In aluminium industry, technology will not change much from the present state.

Residential and commercial

a. No specific policy to promote solar-based water heaters.
b. Dwellings will remain the same as in 2000.
c. Energy consumption in HVAC in commercial buildings will remain much the same.

Transport

a. No specific policy to promote alternative fuels and technologies in the transport sector.

4. CO_2 emissions

a. No restriction on CO_2 emissions, except that CO_2 emissions from electricity supply will have to comply with the current NSW GHG Benchmark Scheme beyond the current target year of 2012.

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a policy paper (DEUS 2006a) which states that the NSW GHG Benchmark Scheme would be extended to 2020 (from 2012), and also that state's GHG emissions are to be reduced to the 2000 level of emissions by 2025 and further below 60% by 2050. It should be noted however that these GHG emissions in the policy paper include economy-wide emissions, that is, they include emissions from land-use changes in addition to emissions from energy use (whereas GHG emissions in this research are limited to CO2 from energy use).

Energy Resources. In this scenario, NSW would face no constraints on the availability of black coal[23] to meet its energy needs, particularly for power generation and industrial use. In the absence of any specific target on restricting the total amount of CO_2 emissions (except for the NSW GHG Benchmark Scheme which targets the electricity sector only), the state's energy supply mix would have the flexibility to rely on coal as a major source of energy. No specific commitment would be made to increase the use of other cleaner energy sources, such as natural gas and renewables (except under the MRET scheme)[24]. For gas supply, NSW would continue to rely on the Cooper Basin (Moomba) in South Australia and on the Gippsland Basin in Victoria.[25] As gas resources available in these eastern regions deplete in future, the supply would be sought from other sources (such as Carnarvon and Browse Basin in Western Australia, Bonaparte Basin in Northern Territory or from overseas, Papua New Guinea (PNG)). Alternatively, coal seam methane (CSM) could be available for use (NSW has huge deposits of CSM, of the order of 97,250 PJ). However, the cost of CSM production would continue to remain high, which might make it less competitive.[26]

The state would face no immediate urgency to reduce oil consumption; it would continue to be an important fuel in NSW, primarily for use in the transport sector. NSW would continue to source oil through imports from other states and also from overseas. NSW's dependence on imported oil may rise, as the reserves available in Australia deplete.[27] This study assumes that a third of the reserves available in Australia will be available for NSW.

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[23] Coal has been a major source of energy in NSW. The state has the largest reserves of coal in Australia estimated at 7.6 billion tonnes.

[24] A commitment to increase natural gas exists in Queensland, for example. The state's "13% Gas Scheme" requires electricity retailers and other liable parties to source at least 13% of their electricity from gas-based plants (Queensland Treasury 2002).

[25] At present NSW's gas supply comes from the Cooper Basin (Moomba) in South Australia (about 85% of the total) and from the Gippsland Basin in Victoria (about 15%). The pipelines have current capacities of 217 PJ/yr (Cooper 152PJ/yr and Gippsland 65 PJ/yr).

[26] The cost of CSM production is in average \$1–2 above natural gas prices (Fainstein, Harman & Dickson 2002).

[27] In 2001, Australia's reserves of crude oil amounted to 1,129 Mbbl (6,641PJ) and condensate, 1,735 Mbbl (10,206 PJ), which have 11 years of remaining life at the production rate of 2000 (Geoscience Australia 2002).

Electricity. In the electricity sector, there would be no specific policy to restrict the share of generation from coal-based plants.[28] However, the NSW GHG Benchmark Scheme could place coal plants in an unfavourable position. New clean coal technologies, such as integrated gasification combined cycle (IGCC) would be expected to enter from 2010 onwards, and begin to compete with other conventional plants, such as the current pulverised coal fired plants. With the GHG benchmark scheme in place, these advanced technologies would gain some advantages, since they offer better efficiency and produce less CO_2 emissions per kWh. The IGCC plants, which are still in development stages currently are comparatively expensive, however, the cost of these plants is expected to decline in the future, which is accounted for in the modelling work in this research (see Table 4-1 in Chapter 4).

This scenario expects that natural gas would be available for use in power generation, as a result of reforms in the the gas market and expansion in gas pipelines. Natural gas would be attractive from environmental considerations as well. The efficiency of combined cycle power plants would also increase, while cost declines (for details see Table 4-1 in Chapter 4).

The share of power generation from renewable energy sources based power plants will remain in the range of the government's target in 2000 (that is, 4 percent of the total generation by 2010) and no specific policy to expand its share throughout the planning period. There will be no specific commitment made to increase the share of renewable based power generation, except to comply with the MRET scheme.

End-use Sectors. This scenario assumes that the energy intensive industries, such as iron and steel[29], and aluminium, would not see significant changes in their technologies from the present state. Similarly, the transport sector, mainly road transports would also continue to rely on petroleum-based technologies.

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[28] In NSW, coal plants contributed about 90% of the total electricity generation in 2000.

[29] Steel production technologies in NSW currently include the Blast Furnace and Blast Oxygen Furnace in Port Kembla of 5000 kt/yr capacity and the Electric Arc Furnace of Onesteel and Smorgen of 725 kt/yr capacity.

The energy consumption pattern in the residential and commercial sectors would follow the current trends. The share of solar water heaters, for example, would remain the same as in 2000.

CO_2 Emissions. On the environmental side, this scenario will see no restrictions imposed on the total amount of CO_2 emissions, assuming that the present reluctance by the federal government to ratify the Kyoto Protocol will continue. This scenario, however, incorporates the current NSW GHG Benchmark Scheme, which restricts CO_2 emissions from power generation to 7 tonnes per capita by 2007, and to be maintained until 2012. This scenario assumes that this scheme would be maintained beyond 2012 throughout the study period (that is, up to 2040).

3.4.2 Moderate Scenario

Overview. The Moderate Scenario (MOD) reflects a future in which there would be a moderate level of urgency to increase energy diversity, reduce oil consumption, and limit CO_2 emissions.[30] This could result due to several possibilities: the government could bring in changes in its energy policies, particularly related to GHG emissions; pressure from the international community could rise as OECD countries begin to adopt to less carbon intensive energy paths; and new scientific evidence on climate change could emerge. This scenario expects some initiatives to be taken to shift the fuel mix of the state towards less carbon intensive fuels, mainly with increased use of gas and renewable energy sources. Also there would be a moderate level of uptake in advanced and energy efficient technologies in end-use sectors. Table 3-2 lists key characteristics of the Moderate scenario.

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[30] The quantification of these characteristics (that is, the level at which energy diversity would increase with the change in fuel mix, or percentage reduction in oil consumption) is not known at this point of discussion in this Chapter. These values are estimated by the model in Chapter-4. The objectives of this scenario are achieved by imposing various constraints in the energy model (for example, constraints on share of coal in electricity generation), while the least-cost solution of the model would determine the final results.

Table 3-2: Characteristics of the Moderate Scenario

1. Energy resources

a. Coal will be discouraged and use of natural gas will increase.
b. Natural gas supply will be available from the reserves in the eastern states and also from other sources during the study period
c Some use of coal seam methane.
d. Dependency on imported oil will be reduced.
e. Moderate use of renewable (biomass, PV, and wind).
f. Moderate use of alternative fuels (CNG, hydrogen, and methanol) in transport.

2. Electricity supply

a. Coal power plant would contribute to not more than 70% to total generation from 2020 onwards.
b. Renewable-based power plants would contribute at least 15% to total generation from 2020 onwards.
c. Share of PV in the total of renewables at least 10%.
d. Share of wind in the total of renewable at least 20%.

3. End-use sectors

Industrial Sectors

a. Share of steel production from DRI with EAF technology increase to 20% of total steel production by 2010, 30% by 2020, 40% by 2030, and 50% by 2040.
b. In aluminium industry, average energy consumption will improve in the electrolysis process to at least to half of the potential that can be achieved with the technology available at present. Similarly, energy consumption in the non-electrolysis process will improve at least to half of the potential achievable, compared to the most efficient smelter in Australia.

Residential and commercial

a. Share of solar-based water heaters contribute at least 20% of total water heating by 2010, 30% by 2020, 40% by 2030, and 50% by 2040.
b. New dwellings will shift to the 3.5 Energy star level, in terms of heating and cooling energy consumption.
c. Average energy consumption in refrigerators will be 800kWh/yr.
d. Average energy consumption for lighting in household will be restricted to 700kWh/yr.
e. Energy consumption in HVAC in commercial buildings will reduce by 10%, due to building code, improvement in technologies.

Transport

a. In passenger vehicles, CNG-based vehicles would contribute at least 5%, hydrogen-based at least 2% and methanol-based at least 3%.
b. In light commercial vehicles, CNG-based vehicles would contribute at least 5%, hydrogen-based at least 2% and methanol-based at least 3%.
c. In rigid trucks, CNG-based trucks would contribute at least 6%, and hydrogen-based at least 4%.
d. In articulated trucks, CNG-based trucks would contribute at least 6%, and hydrogen based at least 4%.

4. CO_2 emissions

a. Total CO_2 emissions from energy consumption will be restricted to 8% above 1990 emission level (equivalent to Kyoto Protocol).
b. CO_2 emissions from electricity supply will have to comply with the current NSW GHG Benchmark Scheme beyond the current target year of 2012.

Energy Resources. In this scenario natural gas would be increasingly available with an increase in pipeline capacities and access to the gas resources such as Carnarvon and Browse Basin in Western Australia, Bonaparte Basin in Northern Territory or from overseas, Papua New Guinea (PNG).[31] The use of gas would increase in electricity generation, in industrial sectors, and also in transportation. The concerns for the environment, particularly climate change, will also make gas more attractive.[32] In the transport sector, alternative fuels derived from natural gas, such as CNG, methanol, and hydrogen will be promoted increasingly, to reduce dependence on imported oil.

Electricity Sector. This scenario expects that the share of coal-based generation would be restricted to a maximum of 70 percent of total generation.[33] The advanced coal technologies, such as IGCC, would be available and begin to compete with conventional technologies. Gas-based technologies such as combined cycle will also become increasingly competitive with their prices falling and efficiency improving.

This scenario also assumes that there would be a mandatory requirement of renewable-based power generation (excluding hydropower) to 15 per cent of the total.[34] In this

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[31] The basis for the assumption is the size of gas pipeline projects which are currently being proposed in Australia. Fainstein (2002), for example, lists seven major projects under consideration that have a combined capacity of 1030 PJ/yr. The list of projects includes, for example, Darwin to Mt Isa, Moomba (200 PJ/yr), Papua New Guinea to Brisbane (300 PJ/yr), and Bayu Undan to Darwin (250PJ/yr).

[32] The report of the Council of Australian Government's Independent Review of Energy Market Directions, for example, states, "the panel believes that the introduction of greenhouse gas emission reduction measures such as emission trading regime may increase the penetration of natural gas – particularly as a fuel for electricity generation" (Parrer 2002).

[33] The basis for this constraint (which is imposed in the energy model) is that coal consumption would need to be reduced in this scenario to reduce CO2 emissions and also to allow space for other energy sources such as natural gas and renewables to play roles in the energy mix, thereby to increase energy diversity. The quantitative values for these would be determined by the energy model (discussed later in Chapter 4).

[34] At the time when scenarios for this research were being constructed (in 2002 – 03), no state level mandatory renewable energy target had been in place in NSW (except for the federal level scheme, MRET). In 2007, the NSW government announced that it would introduce the NSW Renewable Energy Target (NRET) (DEUS 2006a); this has however not been taken into account in the scenarios in this research. This new scheme would require energy retailers in NSW to source their electricity supply from renewable sources – 10% by 2010, and 15% by 2020. The 15% target would be maintained until 2030.

scenario, renewable energy resources, such as biomass, wind and solar, would be encouraged to play important roles in power generation. Biomass-based plants using bagasse, straw, pruning, stalks, etc., would be increasingly installed. Similarly, this scenario assumes the maximum growth rate at which wind energy in NSW could increase is 25 percent per year for the next 20 years, which is also the average growth rate in the world (IEA 2004c). This scenario also assumes that power generation from PV would also rise.

End-use Sectors. In this scenario, alternative production technologies in the iron and steel industry, such as Direct Reduced Iron (DRI) technology would be increasingly used. There would be a gradual shift in technologies from the current Blast Furnace (BF) and Basic Oxygen Furnace (BOF) technology to DRI technology. The BF/BOF technology produces large amounts of CO_2 emissions, because this technology uses coal to produce coke in the coke oven to produce iron. The EAF technology use electricity to produce steel but can use only the scrap materials. The DRI technology produces sponge iron that can be used in the Electric Arc Furnace (EAF) to produce steel. This technology mainly uses natural gas as the main source of fuel, and hence results in significant lower CO_2 emissions as compared to the conventional BF/BOF technology.

In the aluminium industry (an energy intensive industry), no significant technological change is expected to occur.[35] However, the level of efficiency in the electrolysis process will steadily shift to achieve the best efficiency level that can be achieved, which remains at the level of 47,000 MJ/t, as reported in Energetics (2003). In the non-electrolytic process there would be improvements in energy efficiency to the level of the most efficient sites in operation in Australia currently, which are at the level of 6,331 MJ/t. These improvements in efficiency could be achieved by improving smelter fume

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The target set in this research differs from the NRET target in two respects: In NRET, renewables are allowed to be sourced from generators which are located outside NSW (that is anywhere in the NEM). In this research, however, renewable electricity is generated within the state itself. Second, the NRET scheme includes all types of renewable energy sources to meet the target, this research treats hydropower separately, and excludes it in the % target. This is done because the hydro has very little potential for growth in future, and also because if existing hydropower is included, the percentage share of renewables in this research will be significantly higher.

[35] The aluminium industries in Australia use pre-bake technology for smelting (DISR 2000).

systems, improved compressor air systems, improved anode plant operations, etc. (DISR 2000).

Residential and commercial sectors in this scenario would witness improvements in energy efficiency in space heating and cooling, water heating, and refrigeration. These two sectors are important electricity consuming sectors. Buildings to be constructed will be regulated more strictly to follow the new building codes with 3.5 Energy Star rating. According to the Nationwide House Energy Rating Scheme (NatHERS), buildings with a star rating of 3.5 star will consume 180MJ/m2.yr for heating and cooling (AGO 1999b). The changes in building stocks would also affect the energy consumption level in the future. Energy use in the space heating and cooling depends not only on the efficiencies of the appliances in use, but also on the thermal performance of the building shells. For water heating, the residential sector will use more solar water heaters, to utilise the abundance sunshine available in NSW throughout the year. There will be improvements in energy consumption in lighting as well. In the transport sector, cars driven by alternative fuels such as CNG, methanol, ethanol and hydrogen would increase.

CO_2 Emissions. Environmental protection will be moderate in this scenario, with the main focus on limiting CO_2 emission. The global pressure to limit CO_2 emissions will rise and the country will agree to limit the CO_2 emissions to the Kyoto Protocol level (that is, 8 percent above 1990 emission level) throughout the study period.[36]

3.4.3 Advanced Scenario

Overview. The Advanced Scenario (ADV) reflects a future in which there will be a higher level of urgency to diversify primary energy supply mix, reduce dependency on imported oil, increase the use of advanced technologies, and lower CO_2 emissions even further than in the case of Moderate scenario.[37] This scenario envisions the fuel mix

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[36] The NSW government, for example, has called for ratification of the Kyoto Protocol by the Australian Government and the establishment of a national emission trading schemes (NSW Government 2004).

[37] The basis for this scenario is the assumption that significant policy initiatives would be needed (more than in the Moderate scenario), for example, to reduce CO_2 emissions. This may result due to the pressure

shifting towards cleaner (that is, less carbon intensive) fuels with significant increases in the share of renewable energy sources. There would be more restrictions on CO_2 emissions and also on the share of coal-based technologies. The government, business, and public would pay increased attention to the environmental aspects of development. Table 3-3 summarises the main characteristics of this scenario, which are briefly explained in the following paragraphs. The rationales behind the assumptions developed in the Moderate scenario are also valid for this scenario.

Energy Resources. In this scenario, coal being the most carbon intensive fuel, would become unattractive for use in power generation and in industries, while natural gas, coal seam methane and renewable energy sources would become attractive and increasingly become available to replace coal.

Natural gas would be available with an increase in pipeline capacities and reform in the gas market.[38] The use of gas would increase in electricity generation, in industrial sectors, and in transportation. On the other hand, to reduce oil consumption, increased use of alternative fuels, derived from natural gas, such as CNG, methanol, and hydrogen in the transport sector, would be promoted.

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from the international community, as OECD countries begin to employ stringent measures to deal with the climate change challenges. The UK, for example, has set a goal to reduce emissions from energy use by 60% from the current level (1997), by 2050, following a recommendation made by the Royal Commission on Environmental Pollution (RCEP) (RCEP 2000). And, the European Council adopted the EU Emissions Trading Directive to establish a market for emissions in Europe in 2003 (European Community 2003).

[38] For reasons same as in the Moderate scenario.

Table 3-3: Characteristics of the Advanced Scenario

1. Energy resources

a. Greater use of natural gas. Natural gas supply will be available from the reserves in the eastern states and also from other sources during the study period.
b. Moderate use of coal seam methane.
c. Dependency on imported oil will be reduced.
d. Large use of renewable (biomass, PV and wind).
e. Large use of alternative fuels (CNG, hydrogen and methanol) in transport.

2. Electricity supply

a. Coal power plant contributes to not more than 50% of the total power generation from 2020 onwards.
b. Renewable-based power plants contributes at least 25% of the total power generation from 2020 onwards.
c. Share of PV in the total of renewables at least 10%.
d. Share of wind in the total of renewable-based plants at least 20%.
e. Coal seam methane-based power plants' share increase.

3. End-use sectors

Industrial Sectors:

a. Share of steel production from DRI with EAF technology increase to 30% of total steel production by 2010, 50% by 2020, 60% by 2030, and 70% by 2040.
b. Average energy consumption will improve in the electrolysis process to the full potential that can be achieved with the best technology available at present (47MJ/kg of Al). Similarly, energy consumption in the non-electrolysis process will improve to the level of the most efficient smelter in Australia.

Residential and commercial

a. Share of solar-based water heating to contribute at least 30% to total water heating by 2010, at least 50% by 2020, at least 60% by 2030, and at least 70% by 2040.
b. New dwellings will shift to the 5 Energy star level, in terms of heating and cooling energy consumption.
c. Average energy consumption in refrigerator will be 600kWh/yr.
d. Average energy consumption for lighting in house will be restricted to 700kWh/yr
e. Energy consumption in HVAC in commercial buildings will reduce by 15%, due to building codes, and improvement in technologies.

Transport

a. Passenger vehicles – CNG-based vehicles contribute at least 10%, hydrogen-based at least 5% and methanol-based at least 10%.
b. Light commercial vehicles – CNG-based vehicles contribute 10%, hydrogen-based 5% and methanol-based 10%.
c. Rigid trucks – CNG-based trucks contribute 20%, and hydrogen-based 5%.
d. Articulated trucks – CNG-based trucks contribute 20%, and hydrogen-based 5%.

4. CO_2 emissions

a. Total CO_2 emissions from energy consumption will be restricted to 25% below 1990 emissions level (Kyoto Protocol).
b. CO_2 emissions from electricity supply will have to comply with the current NSW GHG Benchmark Scheme beyond the current target year of 2012.

Electricity Sectors. In the electricity sector, the share of coal-based generation would not be allowed to exceed half of the total generation from 2020 onwards. This could benefit natural gas- and renewable-based plants. The advanced types of coal technologies, such as IGCC and carbon capture and sequestration, technologies would be available and begin to compete with conventional plant technologies.[39] Gas-based technologies such as combined cycle power plants will also become increasingly competitive, with their prices falling and efficiency improving (see Table 4-1, Chapter 4). The renewable-based generation would be required to provide at least 25 percent of total generation by 2040.

End-use Sectors. In the industrial sector, the iron and steel industry will shift towards natural gas-based Direct Reduction Iron (DRI) technology, as coal use is discouraged. The share of DRI technology in this scenario would be higher (contributing about 70 percent of total steel production) than in the Moderate scenario.

The society will evolve into being one with strong environmental values and environmental actions. The people will prefer energy efficient appliances (refrigerators, and lighting) and environmentally sound technologies (such as solar hot water, roof top PV). The use of solar water heaters in the residential sectors would increase significantly (supplying 70 percent of water heating needs in 2040).

In the transport sector, road vehicles will shift towards more efficient vehicles such as hybrid vehicles[40], and also alternative fuels such as CNG, methanol and hydrogen would be promoted.

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[39] For example, COAL 21, a national collaborative program involving government, industry and research organisations, recommended a list of policy and programs to the Australian Government in 2004, which included establishing an IGCC demonstration plant in Australia, and assessing the potential of CO_2 capture and geological storage in Australia (Coal 21 2004). CO2CRC, a government sponsored research organisation, for example, expects CO_2 geosequestration to be widely applied within 20 years (CO2CRC 2005).

[40] Hybrid cars use internal combustion engines in conjunction with electrical systems that can store electricity, capture breaking energy and use electric drive systems. CSIRO (Australia) has participated with Holden in the development of a hybrid Holden ECOmmodore (Williams 2002). The Holden hybrid

CO_2 Emissions. This scenario assumes a global consensus will emerge to stabilise CO_2 concentration levels at 550 ppm, with a target to limit cumulative global carbon emissions within 1990–2100 in a range of 870–990 GtC, as reported in IPCC (2000) emission scenarios. This will prompt the NSW government to set CO_2 emissions reduction target from the energy sector at 25 percent below the 1990 emission level by 2020. This value is equivalent to 32 percent below the 1999 level, which will result in per capita emissions to 9.5 tonnes (with population reaching 8.5 million by 2040). This may result in a reduction of total GHG emission (that is, including emissions from other sources such as agriculture and land use change as well) by more than 25 percent below the 1990 emission level, for example, if the emission reduction due to land clearing continues as now.

3.5 Summary

This chapter developed three energy scenarios for NSW, the Base, Moderate and Advanced. The energy scenarios are developed by taking into account five scenario variables that have the potential to influence the development of the future energy sector in NSW. They include energy diversity, oil dependency, CO_2 emissions, advancement of technologies, and social factors. The key features of the three scenarios are provided in Table 3-4.

The Base scenario (BAS) reflects the continuation of current trends in energy policy without any major changes taking place. This scenario is characterised by continued reliance on coal as the major source of energy (in power generation and industries), no specific commitment to promote renewable energy (except for the MRET scheme), and no restriction on total amount of CO_2 emissions except for the restriction imposed in the electricity sector under the NSW GHG Benchmark Scheme.

The Moderate scenario (MOD) reflects a future with a moderate level of urgency to increase energy diversity, reduce oil consumption, and limit CO_2 emissions. Also there

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vehicle uses 50% less fuel than a conventional family car and also reduces exhaust emissions dramatically.

would be a moderate level of uptake of advanced and energy efficient technologies in the end-use sectors.

The Advanced scenario (ADV) reflects a future in which there will be a higher level of urgency to increase diversity in primary energy supply, reduce dependency on imported oil, increase the use of advanced technologies, and lower CO_2 emissions even further than in the case of Moderate scenario. The government, business and public would pay increased attention to the environmental aspects of development.

In the next two chapters these scenarios are quantitatively modelled and their impacts on energy and economic sectors are assessed.

Table 3-4: Key Scenario Features

	Base Scenario	Moderate Scenario	Advanced Scenario
Energy resources	a. No restrictions on coal and oil b. No renewable polices (except MRET)	a. Moderate restriction on coal use b. Increased availability of natural gas c. Reduced dependency on imported oil d. Moderate use of renewable (biomass, PV, and wind)	a. Higher restriction on coal use b. Increased availability of gas c. Reduced dependency on imported oil d. Large use of renewable (biomass, PV, and wind)
Electricity	a. No restriction on conventional coal plants c. Except MRET no other target on renewable	a. Coal plants < 70% from 2020 onwards b. Renewable contributes > 15% by 2020	a. Coal plant <50% share from 2020 onwards b. Renewable plants contribute > 25% from 2020 onwards
End-uses	a. No major technological shift in energy intensive industries (steel, aluminium) b. No specific target set for solar-based water heaters c. Dwellings will remain same as now d. Energy consumption in HVAC remains same e. No specific target to promote alternative fuels and technologies	a. Steel production switches to DRI with EAF technology > 30% by 2020, and >50% by 2040 b. Aluminium production improves efficiency to at least half of maximum potential achievable c. Solar water heater contributes >30% by 2020, and >50% by 2040 d. New dwellings at 3.5 Energy star e. Moderate improvement in efficiency in refrigerator, lighting g. HVAC efficiency improves by 10% h. Moderate use of CNG, hydrogen, methanol, ethanol in road transport	a. Steel production switches to DRI with EAF technology >50% by 2020, and > 70% by 2040 b. Aluminium production improves efficiency to full potential achievable c. Share of solar water heater > 50% by 2020, and >70% by 2040 d. New dwellings at 5 Energy star level e High improvement in efficiency in refrigerators, lighting g. HVAC efficiency improves by 15% h. Higher use of CNG, hydrogen, methanol, ethanol in road transport i. Higher use of hybrid passenger cars
CO_2 emissions	a. No restriction on CO_2 emissions, except NSW GHG Benchmark Scheme to continue beyond 2012.	a. CO_2 emissions ~ 8% above 1990 emission level (~Kyoto Protocol). b. NSW GHG Benchmark Scheme continues beyond 2012	a. CO_2 emissions < 25% below 1990 emission level b. NSW GHG Benchmark Scheme continues beyond 2012

4. Assessment of Energy Impacts of Scenarios

4.1 Introduction

The previous chapter (Chapter 3) outlined three energy supply scenarios (Base, Moderate and Advanced) for the state of New South Wales (NSW). These scenarios are developed by taking into account five different scenario variables that have the potential to shape the future development of the energy sector in NSW. The objectives of this chapter are to quantitatively model these scenarios and to assess their medium- and long-term impacts on the energy sector in NSW, for example, in terms of primary energy supply and mix, electricity supply and generation technology mix, and CO_2 emissions. A linear programming based optimization model, the MARKAL model, is used in this research to model the scenarios and to conduct these assessments. This modelling framework represents the energy system of NSW as a network of energy flows, starting with the extraction of energy resources, through conversion and transformation processes and finally to end-use services. This framework allows the complex energy system to be represented in a coherent framework, taking into account all important segments of the energy system. It also allows the determination of the impacts (as noted above) of various levels of end-use demands under a specified set of policy constraints.

This chapter is divided into seven sections. The next three sections (Section 4.2, 4.3 and 4.4) explain the quantitative modelling process of the energy scenarios. It includes a brief description of the MARKAL model, the model setup, and descriptions of various components that constitute the reference energy system (RES). Section 4.5 presents discussions on scenario results. This is followed by a separate section (Section 4.6) that conducts sensitivity analysis of nuclear plants.[41] The final section (Section 4.7) summarises the main findings of this chapter.

[41] Nuclear debate in Australia began in 2005 when the major modelling component of this research was already in the advanced stages of completion. It was, however, decided – in view of the emerging debate on this topic in Australia – to include nuclear option in a separate scenario. Hence, this add-on.

4.2 Energy Sector Model: MARKAL model

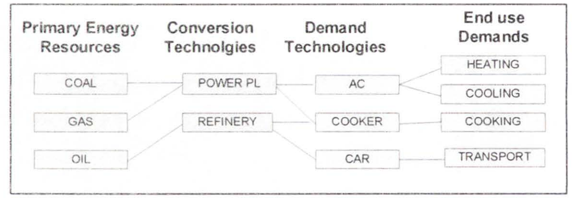
In this section a brief description of the MARKAL model is provided. A mathematical description of the objective function and constraints in the MARKAL model is explained in Appendix A (p 254). A fuller description of the MARKAL model in terms of attributes, sets, variables and equations of the system is available in Fishbone et al. (1981), Fishbone et al. (1983), and Loulou et al. (2004).

The MARKAL (MARKet ALlocation) model is a dynamic linear programming model. It is an energy/environmental planning model, developed by the International Energy Agency (IEA), in the late 1970s (Fishbone & Abilock 1981). This model seeks to determine feasible solution for an energy system at which equilibrium (optimality) is reached in every stage of the energy system – at the levels of primary energy, secondary energy, and energy services. At the optimum level, the model selects energy carriers and technologies that produce a least cost solution subject to a variety of constraints. Some of the underlying principles central to the MARKAL equilibrium are: outputs of a technology are a linear function of its inputs; total economic surplus is maximised over the entire time horizon; and energy markets are competitive, with perfect foresight.

A generic representation of the MARKAL modelling system employed in this research is shown in Figure 4-1. It has four main components – energy system topology and organisation, numerical database, mathematical structure, and scenarios and strategies. The "energy system topology and organisation" component represents the energy system of a country (or a state, NSW in this instance) as a network connecting various components of the system, such as energy procurement, conversion, processing, transmission, and end uses. This representation is called the Reference Energy System (RES). The building blocks of the RES are shown in Figure 4-2. Each component in the RES contains a large number of technologies that need to be described in terms of their technical and economic characteristics (including parameters).

Components of Energy System Model

1. **Energy system topology & organisation**



RES

2. **Numerical data**

	2000	2010	2030	2040
Investment Cost				
Fixed cost				
Variable Cost				
Efficiency				
Available Factor				

Time series

3. **Mathematical structure**
- transformation equation
- bounds, constraints
- user defined relations

Objective function,

Minimize $Z = \Sigma_i c_j X_i$

Subject to, $\Sigma_i a_{ij} X_i == b_j$**,and**

$X_i = 0$

GAMS Model

4. **Scenarios and strategies**

Base Scenario
Moderate Scenario
Advanced Scenario
Nuclear Scenario

Cases

Figure 4-1: Components in MARKAL Energy System (Source: Adapted from International Resources Group (2001))

In order to conduct energy analysis, these parameters require time series data, which is shown as second component ("numerical database") of the model. Time series data are also needed for user defined constraints, for example, if a constraint is imposed on CO_2 emissions for different time periods, or if certain sizes of capacities (for example, power plants such as renewable plants) must be installed. The third component, "mathematical structure", converts input data and user defined constraints into linear programming based mathematical equations and constraints and then solves them to find a feasible solution. This component is handled by the GAMS model. The final component, "scenarios and strategies", involves construction of scenarios within the model as required (for example, base scenario, environmental scenario, etc.). These scenarios will differ from each other in terms of assumptions on technical parameters, and constraints imposed – as required to reflect specified policy objectives.

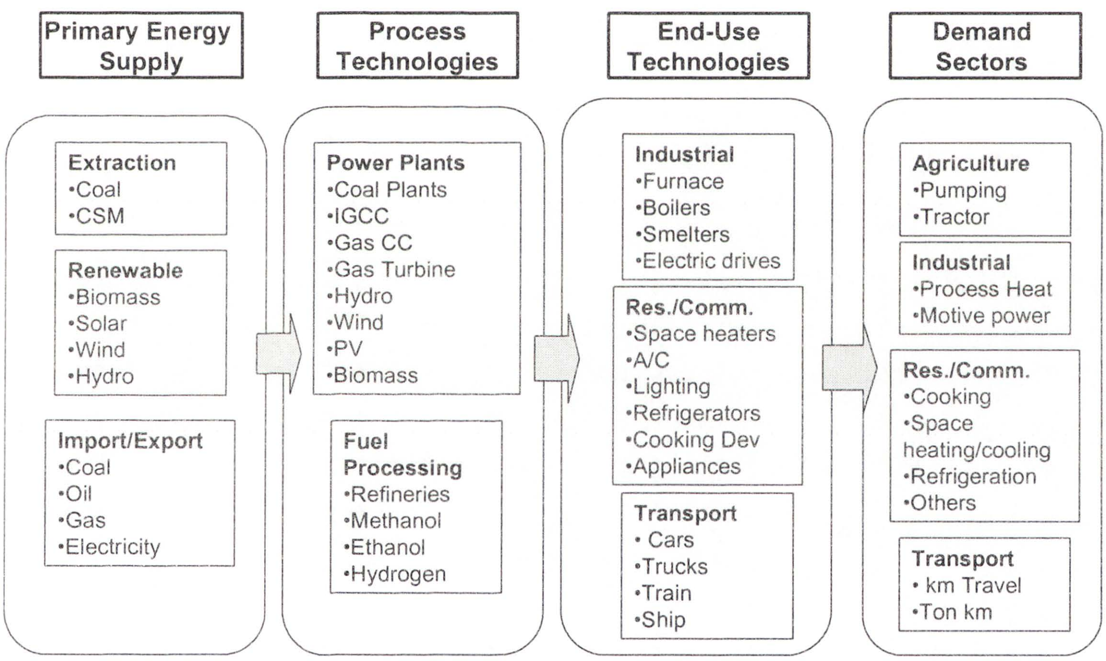


Figure 4-2: Building-blocks of Reference Energy System for NSW

The MARKAL model is a demand driven model. This means that the end-use demands in the model need to be specified exogenously, and they must be satisfied for all time periods in order to have a feasible solution. The end-use demands are represented in terms of different tasks of the end-users, such as demand for heating (in PJ) by the residential sector, demand for personal transportation (in vehicle km), demand for steel and aluminium (in tonnes), etc. Each type of demand is satisfied by one or many types of end-use devices (for example, electric or gas heater, bus or car, different types of steel production technologies).

In a mathematical form, the MARKAL is represented as (Fishbone & Abilock 1981):

Objective function,

$$\text{Minimise } Z = \Sigma_i \, c_j X_i$$

Subject to,

$$\Sigma_i \, a_{ij} \, X_i \lesseqgtr b_j, \text{ and } X_i \geq 0$$

"Z" is the objective function that represents the total discounted cost of the energy system for the entire study period. The coefficients "c_j" in the objective function and "a_{ij}" and "b_j" in the constraints are known as system parameters. They represent, for example, the unit costs of technologies (for example, investment cost of power plant in \$/kW), price of energy carriers (in \$/PJ), end-use demands (for example, space heating demand in PJ), etc. "X_j" refers to unknown quantities which are computed by the model. They include, for example, capacity of technologies (for example, power plants in MW), amounts of energy flows (coal, electricity in PJ), etc.

The model minimises the total discounted cost of the energy system while satisfying a number of specified constraints. The total cost of the system consists of the cost of technologies (for example, investment cost, fixed cost and variable cost of power plants, refineries, heaters, appliances, etc.), cost of energy resources (for example, coal, gas, electricity, etc.), cost of energy imports (for example, oil, gas), cost of emissions (for example, carbon tax), less salvage value and export revenue. In minimising total cost, the model chooses a mix of fuels (mined or imported), process and demand technologies, by taking into account their costs of installation and operation over the optimisation period.

The constraints that the model must meet while minimising total cost include:

- **Energy service demand constraints:** the model must satisfy end-use service demands, which are given exogenously for each time period.

- **Capacity transfer constraints:** the available capacity at any period is the sum of the residual capacities (that is, the capacity already existing before the start of optimisation period) plus installed new capacities still within its lifetime.

- **Capacity use constraints:** the activity in each technology must not exceed the availability of that technology which depends upon the installed capacity and the availability factor.

- **Electricity peak constraints:** installed capacity of electricity producing technologies must meet peak demand multiplied by a reserve factor.

- **Base load constraints:** the operation of base load technologies must not fluctuate from day to night in a given season.

- **Emission constraints:** the sum of emissions of certain pollutants, for example, CO_2, from all the emission sources, such as energy carrier resource activities, production of electricity from power plants, activities of process technologies, and final energy input to demand devices, must not exceed specified limits of total emissions for each time period or cumulative emissions.

- **Balance for commodities:** in each time period, the production plus import must be at least as much as the amount consumed and exported.

4.3 Model Setup

To quantitatively model the scenarios in this research, the model was set up and run in the Windows-based interface of the MARKAL model, known as ANSWER (Ver.5), developed by ABARE (2002). The ANSWER interface provides a user friendly platform to handle data and analyse the scenarios effectively.[42] Figures 4-3 and 4-4 illustrate the data input and results handling interfaces of this model.

The task of modelling the scenarios first included the construction of the Reference Energy System (RES) for NSW (discussed in detail in Section 4.4) in ANSWER. Each component in the RES is characterised by certain parameters for which data are need to be input. They include, for example, technical parameters (residual capacity, efficiency, life, availability), cost parameters (investment cost per unit, fixed cost, variable cost), emission characteristics, etc. Also, various policy constraints (such as constraints on CO_2 emissions, maximum growth rate that would need to be allowed for technologies, such as wind plants) are specified as required by the scenarios. The database for the alternative scenarios (MOD and ADV) uses the general database structure of the Base scenario, with some modifications to reflect policy constraints required by these scenarios.

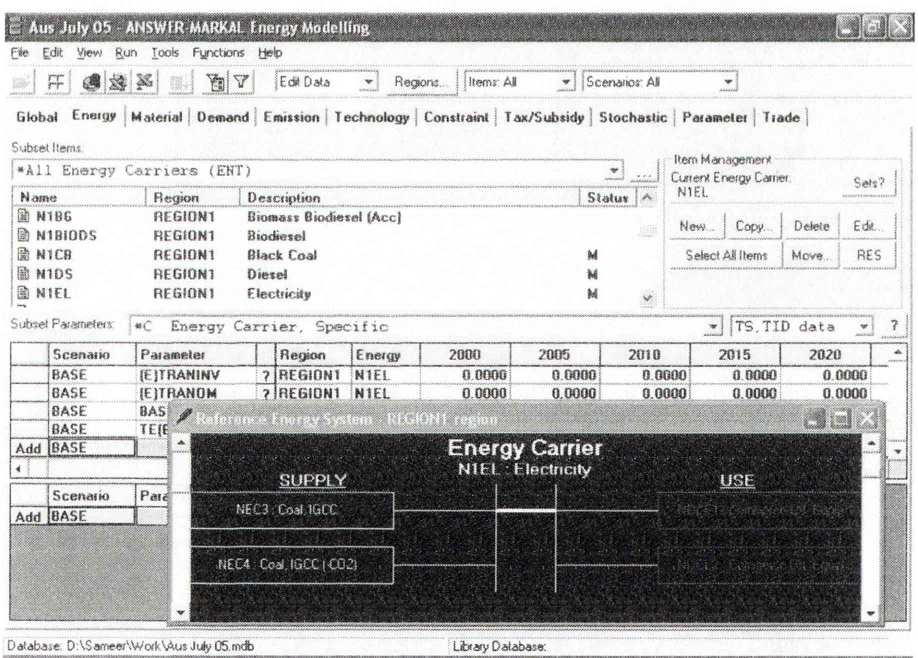


Figure 4-3: Database and RES Screen in ANSWER

[42] Before ANSWER became available, MUSS (MARKAL User's Support System) provided similar data handling and analysis support shell for the MARKAL. ANSWER provides a number of enhancements over MUSS, such as data editing capabilities via 'direct cell editing' similar to a spreadsheet (International Resources Group 2001).

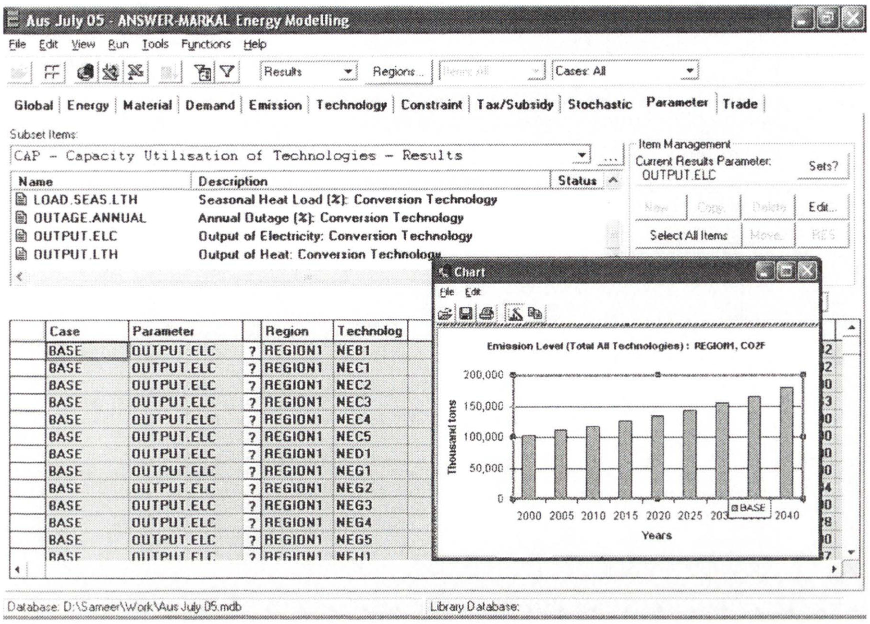


Figure 4-4: Results Screen in ANSWER

The Windows-based interface, ANSWER V5, translates input data and policy constraints into a linear programming (LP) problem with an objective function and constraints comprising a number of variables. To solve the optimisation problem, the interface uses the solver, GAMS (General Algebraic Modelling System), developed by Alexander Meeraus and Anthony Brooke of the World Bank (Brooke, Kendrick & Meeraus 1992).

In this research, the model is run for the Base scenario first, and then for alternative scenarios (Moderate and Advanced). The model provides solutions for all time periods (for example, 2000, 2010, 2020, 2030, and 2040) simultaneously. The model run solves the LP problem – to determine the combination of technologies and fuels that represent the most cost effective means of satisfying the specified levels of energy services. The model generates a report file, which provides details on the modelling outcomes. The present version of the model cannot generate the report in a customised form according to the user's need, hence results from the report need to be reassembled by the user for the purpose of presentation.

4.4 Reference Energy Systems for NSW

The Reference Energy System (RES) developed in this research in the MARKAL model represents the energy system for NSW as a network that includes primary energy resources, conversion and process technologies, demand technologies and end-use demand sectors. Energy is extracted at the primary resource level (for example, by mining or import), then undergoes transformation through conversion and process technologies (such as power plants and refineries), and is delivered to the demand technologies (such as space heaters, furnaces), which finally satisfy end-use services (space heating, kilometres travel, etc.) as demanded by various economic sectors. The RES diagram for NSW is presented in Figure 4-5.

4.3.1 Energy Resources

On the left hand side of the RES, the methods of acquiring energy carriers (that is, methods by which primary energy is extracted and supplied) are represented. They include, for example, mining of coal, import of gas and petroleum products. The primary energy resources considered in the RES include coal, natural gas, oil, and biomass. Coal and coal seam methane (CSM) are the only fossil energy resources that are available in abundance in the state itself (see Table 4-1). In the RES, coal is mined and supplied mainly to the power generation and industrial sectors, such as the iron and steel industry.

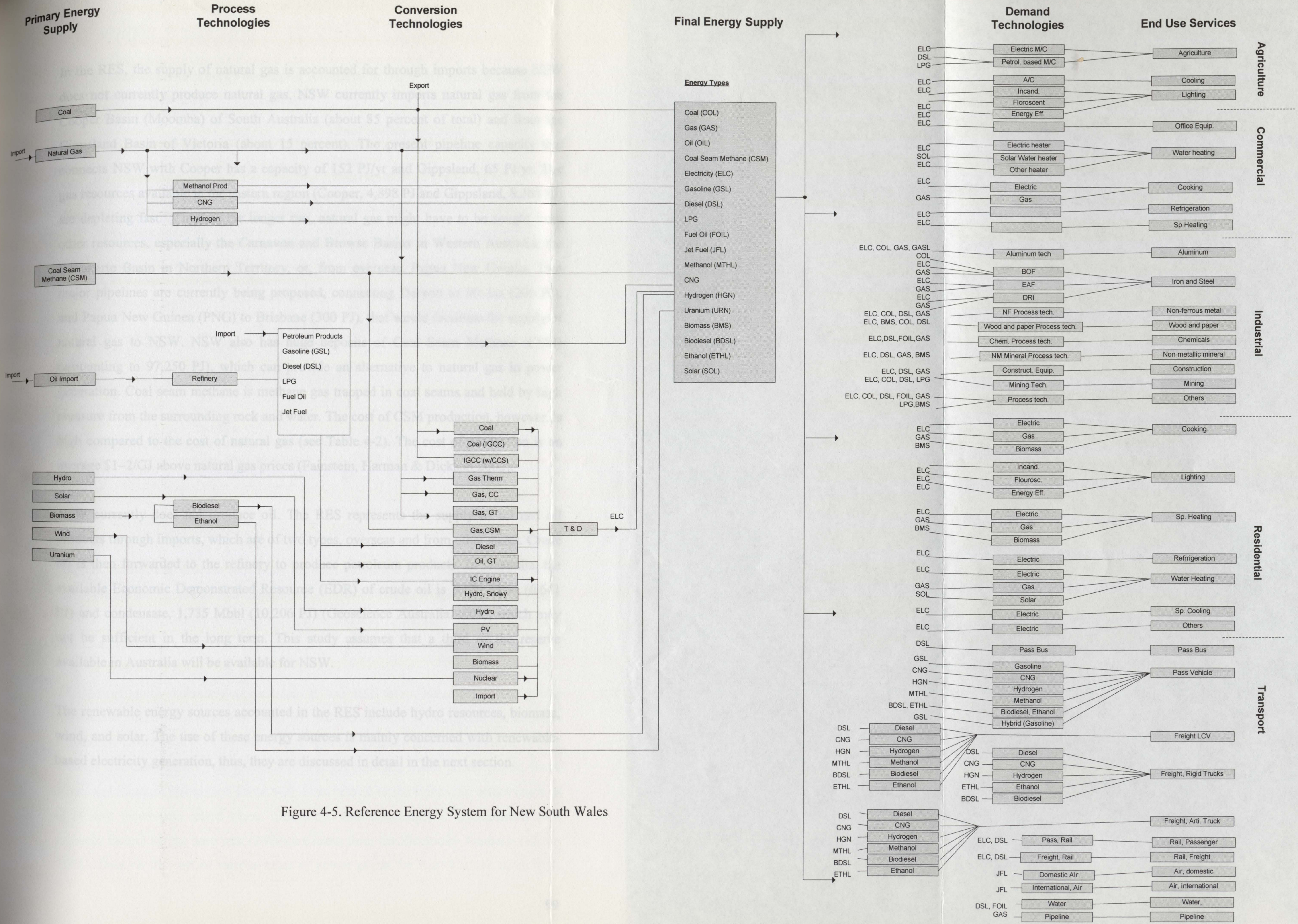


Figure 4-5. Reference Energy System for New South Wales

In the RES, the supply of natural gas is accounted for through imports because NSW does not currently produce natural gas. NSW currently imports natural gas from the Cooper Basin (Moomba) of South Australia (about 85 percent of total) and from the Gippsland Basin of Victoria (about 15 percent). The present pipeline capacity that connects NSW with Cooper has a capacity of 152 PJ/yr and Gippsland, 65 PJ/yr. The gas resources available in the eastern region (Cooper, 4,898 PJ and Gippsland, 8,368 PJ) are depleting fast. Thus, in the longer run, natural gas might have to be sought from other resources, especially the Carnavon and Browse Basins in Western Australia, the Bonaparte Basin in Northern Territory, or, from overseas, Papua New Guinea. Two major pipelines are currently being proposed, connecting Darwin to Mt Isa (200 PJ), and Papua New Guinea (PNG) to Brisbane (300 PJ), that would facilitate the supply of natural gas to NSW. NSW also has huge deposits of Coal Seam Methane (CSM) (amounting to 97,250 PJ), which can provide an alternative to natural gas in power generation. Coal seam methane is methane gas trapped in coal seams and held by high pressure from the surrounding rock and water. The cost of CSM production, however, is high compared to the cost of natural gas (see Table 4-2). The cost of production is on average \$1–2/GJ above natural gas prices (Fainstein, Harman & Dickson 2002).

NSW currently does not produce oil. The RES represents the supply of oil and oil products through imports, which are of two types, overseas and from other states. Crude oil is then forwarded to the refinery to produce petroleum products. In Australia, the available Economic Demonstrated Resource (EDR) of crude oil is 1,129 Mbbl (6,641 PJ) and condensate, 1,735 Mbbl (10,206 PJ) (Geoscience Australia 2002), which may not be sufficient in the long term. This study assumes that a third of the reserve available in Australia will be available for NSW.

The renewable energy sources accounted in the RES include hydro resources, biomass, wind, and solar. The use of these energy sources is mainly concerned with renewable-based electricity generation, thus, they are discussed in detail in the next section.

Table 4-1: Fossil Energy Resources Available in NSW and Australia (PJ)

	New South Wales	Australia	Remarks
Coal	436,620	1,091,550	Total resources (EDR) for Australia in 2003 = 38.3 Gt, of which 40% belongs to NSW.
Oil	None	16,840	Includes crude oil (6,640 PJ) and condensate (10,200 PJ)
Gas	None	33,694	Does not include non-commercial resources estimated at 95,386PJ.
CSM	97,240	249,240	Of the Australian total, 152,000 PJ is in Queensland

Source: Geoscience Australia (2004).
Note: [1] EDR: Economic Demonstrated Resources.

Table 4-2: Energy Prices

	\$/GJ (2000 price)
Black coal	1.25
Oil	7.3
LPG	10
Biomass	0.25
Natural Gas	2.55
Coal Seam Methane	3.8

Source: Dickson et al. (2003).

4.3.2 Conversion Technologies

The conversion and process sectors in the RES include process technologies such as power plants and refineries that transform one form of energy to another. Power plants, for example, transform coal and natural gas to electricity, and refineries convert crude oil to various forms of petroleum products (for example, gasoline, diesel, and fuel oil).

The power plant technologies included in the RES are conventional coal plants (pulverised fuel fired), advanced types of coal plants such as Integrated Gasification Combined Cycle (IGCC) with and without Carbon Capture and Sequestration (CCS), Natural Gas Combined Cycle (NGCC) plants, gas turbines, hydro power plants, wind, solar, and biomass plants (see Table 4-3). Data related to the electricity sector (such as electricity generation, plant types, efficiency, fuel consumption, transmission loss, capacity factor) for the base year (2000) are taken from the Electricity Australia (ESAA 2002). Data on the cost of various types of power plants for Australia are taken from

(Jones, Peng & Naughten 1994; Naughten 2003), and for the advanced technologies (such as IGCC plants) where local data are not available, they are taken from published sources such as IWG (2000); Marsh et al. (2002); IEA (2003); MIT (2003); and IEA (2005). At present, power plant technologies in NSW are dominated by coal based plants that use pulverised coal fired boilers. These power plants, for example, supplied about 90 percent of the state's power supply in 2000. The advanced coal plants, such as IGCC, included in the RES offer better efficiency, thus would produce less CO_2 emissions per kWh. In these plants, coal is not burned directly, but reacts with oxygen and steam in a gasifier to produce syngas (a composition of carbon monoxide and hydrogen). The syngas is used first to drive a gas turbine generating electricity, and the exhaust from the gas turbine is reused in a boiler to produce steam to drive a steam turbine, producing additional electricity. The IGCC plant is still in the developing stages and several demonstration plants have been installed in the United States, Europe and Japan. The flue gas from IGCC contains CO_2 in a more concentrated stream than in a conventional pulverised coal fired plant, which facilitates CO_2 capture more efficiently and in a less expensive way. The cost of IGCC is expected to decline in the future (at a faster rate for the Moderate and Advanced scenarios), which is accounted for in the modelling in this research (see Table 4-3).

Table 4-3: Power Plant Technologies

Plants	Year	Inv. Cost ($/kW)	Fix. Cost ($/kW)	Var. Cost ($/GJ)	Eff.	Life (yr)
Black Coal	2000	1200	15	0.56	0.35	40
	2040	1200	15	0.56	0.40	40
Brown Coal	2000	2000	18	0.67	0.28	40
IGCC	2010	1490	50	0.56	0.48	25
	2040	1490	25	0.56	0.55	25
	2040[1]	1200	25	0.56	0.60	25
IGCC (+geo seq)	2015	1490	50	0.56	0.49	25
	2040	1250	50	0.56	0.55	25
AFBC	2000	1430	15	0.56	0.35	40
Diesel	2000	1000	39	0.56	0.30	40
Natural Gas Therm	2000	800	20	0.79	0.38	40
Natural Gas CC	2000	820	10.5	0.79	0.4	25
	2040	820	10.5	0.79	0.55	25
	2040[1]	820	10.5	0.79	0.65	25
Gas (GT)	2000	500	9	0.5	0.32	25
Hydro	2000	2000	5	-	1	40
Oil (Therm)	2000	850	24	0.26	0.35	35
PV	2000	10500			1	30
	2040	3000			1	30
Wind	2000	1400	25	2	1	30
	2040	1100		2	1	30
Biomass	2000	1500	100		0.33	30
CSM CC	2000	820	10.5	0.79	0.4	25
	2040	820	10.5	0.79	0.55	25
	2040[1]	820	10.5	0.79	0.65	25

Sources: IWG (2000); Marsh et al. (2002); Naughten (2003); IEA (2005).

Note: [1]For Moderate and Advanced Scenarios only. All costs are in 2000 $.

The gas-based power plants in the RES include gas turbine and combined cycle power plants. The combined cycle power plants offer higher efficiency and are more likely to be used in the future.

The RES also includes hydropower plants, which mainly represents the share of NSW in the Snowy Mountains Hydro-electric Scheme (SMHES), as well as other small hydro plants already existing. The share of electricity generated by the SMHES for NSW is assumed to be 72 percent (Energy Authority of NSW 1986). Currently, hydropower is the next major source of power in NSW after coal, though it contributes only about 6 percent of the total. The capacities of hydropower plants has remained stagnant for many years and is expected to remain so in future because of the lack of feasible sites.

The RES also includes other renewable-based plants, mainly biomass, wind and solar. The major sources of biomass energy for NSW are agriculture by-products, such as bagasse, straw, prunings, stalks, etc. (SEDA 2001). Saddler, Diesendorf and Denniss (2004) estimate that the potential for electricity generation from agriculture crops to be 169 PJ for Australia, which is based on Kelleher's (1997) estimation of available crop residues. This research assumes that about one third of these resources will be available for NSW. The biomass potential from plantations is not considered, because of the limits on arable land in Australia and also due to water supply constraints.

The RES also includes power generation from wind. At present, NSW has about 17 MW of wind power installed, and 50 MW are in proposal phase. AUSWEA (2003) reported that NSW would have about 1,000 MW of wind power plants in the planning phase by 2005. The contribution of wind power in Australia is growing strongly, mainly because of the MRET scheme. Saddler, Diesendorf and Denniss (2004) estimate that about 20 GW of wind technology can be installed in Australia, if the sites with 7m/s of annual mean speed are considered. In this research, the maximum potential for wind energy in NSW is assumed to be limited by the maximum growth rate – 25 percent per year for the next 20 years, which is also the average growth rate of wind technology in the world (IEA 2004c).

Though NSW is blessed with plenty of solar radiation, the PV has not been exploited much, mainly due to the higher cost of this technology compared to other alternatives. At present, total installed capacity of PV amounts to only 1.2 MW. PV has the potential for use as rooftop installations (with increased public interest in green power), and also as small grid connected power stations. One of the advantages associated with PV is that it produces electricity during the day time when the peak load occurs.

It should be noted that with the creation of the National Electricity Market (NEM), it is now possible for NSW to import or export electricity from the network. The maximum amount of electricity that could be imported is, however, limited to not more than 10 percent of total consumption.

Aside from various types of power plants, the conversion technologies represented in the RES include fuel-processing technologies, such as refineries, methanol, ethanol production, etc. NSW currently has two refineries, the Clyde refinery (capacity 86,000bbl/d), and the Kurnell refinery (capacity 116,000bbl/d).

Table 4-4 provides the retirement schedule for existing power plants in NSW. It shows that the largest capacity retirements (5,280 MW) would occur around the year 2025.

Table 4-4: Retirement Schedule of Existing Power Plants

Year	Plants to be retired
2000	- none
2005	- 50 MW of gas turbine plant (Northern Plant)
2010	- 600 MW of coal thermal plant (Munmorah Plant: 300MW *2)
2015	- 2000 MW of coal thermal plant (Liddell Plant: 500 MW*4) - 100 MW of gas turbine plant (Broken Hill: 50 MW, and Hunter Valley: 50MW)
2020	- 2320 MW of coal thermal plant (Vales Point B Plant: 660MW*2, and Wallerawang C Plant: 500 MW*2) - 162 MW of Gas CC plant (Smithfield Plant)
2025	- 5280 MW of coal plant (Eraring Plant: 660MW*4, and Bayswater Plant: 660 MW*4)
2030	- none
2035	- 1320 MW of coal plant, (Mt Piper : 660 MW*2)
2040	- 150 MW of coal plant, (Redbank Plant: 150 MW)

Note: Computed based on commissioning dates from ESAA (2002).

4.3.3 End-use Demand Sectors

The RES, in this research, divides the end-use demand sectors into five different types: agriculture, residential, commercial, transport and industrial. The agricultural sector consumes a small amount of energy (about 1.5 percent of total in 2000) (Dickson, Akmal & Thorpe 2003). Hence, demand technologies in this sector are not treated in detail in this research.

The demand for end-use services for most of the sectors are estimated based on the long-term energy demand projections made by ABARE (Dickson, Akmal & Thorpe 2003). Since this study requires projections of end-use energy services beyond the ABARE's projection period of 2020, data required beyond 2020 are extrapolated by assuming the same growths rate as for the last period (2015–2020) of the ABARE's projection period. In the absence of availability of the projections, this simplistic approach should be reasonable, because the assumptions of economic growth beyond

2020 made in this research are similar to the economic growth assumptions made by ABARE for the 2015–2020 period. For the base year (2000), data are also checked and matched with the data available at the state level, from respective state government publications, for example, Ministry of Energy and Utilities (2000a; 2000b).

Residential and Commercial Sectors

The following end-use services demanded by the residential sector are considered in this research: space-heating, water-heating, lighting, cooking, cooling, refrigeration, and others. These services are provided by several end-use technologies. However, projections of energy consumption by the residential sector, estimated by ABARE, are available in an aggregated form (in PJ) by different types of energy sources (for example, electricity, gas, biomass), but not by end use types (for example, cooking, heating). Hence, data from ABARE are disaggregated into various types of end-use services based on assumptions given in Table 4-5. These assumptions are developed from different published sources (ABS 2002; AGO 1999b; Fiebig & Woodland 1994).

Table 4-5: Final Energy Consumption by End-use Services in Residential Sector

Energy use	% share
Electric appliances	26.5
Water heating	24.5
Cooking	3.9
Space heating and cooling	45.1

Sources: Fiebig et al. (1994); AGO (1999b); ABS (2002)

Table 4-5 shows that the key energy consuming applications in the residential sector are space-heating, water-heating and electrical appliances, and, within the electric appliances, refrigerators are the major energy consuming appliance. This study hence places more emphasis on these energy intensive applications. Energy use in space heating and cooling depends not only on the efficiencies of the appliances in use, but also on the thermal performance of the building shells. For example, according to the Nationwide House Energy Rating Scheme (NatHERS), a buildings with a star rating of 3.5 will consume approximately 180 MJ/m^2.yr, and one with a 5 star rating will consume 90 MJ/m^2.yr in NSW (AGO 1999b). If the new buildings are regulated more strictly to follow the energy star ratings, how the building stocks change will also affect the demand for heating and cooling in the future. Table 4-6 provides estimates of heating and cooling demand under different energy star ratings. Regarding water-heating, assumptions are more focused on how the residential sector will shift towards solar water heaters, since NSW receives an abundance of sunshine throughout the year. This research also focuses on energy consumption for lighting purposes. It assumes that the lighting energy need will be limited to varying amounts as specified in the scenarios under study. The projections of end-use services demands for the residential sector are provided in Table 4-12.

Table 4-6: Estimation of Dwellings, Floor Area, and Heating and Cooling Demand

	2000	2005	2010	2015	2020	2025	2030	2035	2040
No. of dwellings ('000)									
Total Houses[1]	2,501	2,620	2,691	2,769	2,847	2,911	2,975	2,993	3,012
New Houses [2]	55	215	430	645	860	1,075	1,290	1,505	1720
Floor area[3] ('000 m^2)									
Total Floor area	287,713	301,309	309,478	318,473	327,469	334,835	342,202	344,295	346,389
New Floor area	6,348	24,725	49,450	74,175	98,900	123,625	148,350	173,075	197,800
Heating and cooling demand (***unconstrained*** [4])									
3.5 Star (PJ)[5]	170	170	165	160	155	149	143	134	125
5 Star (PJ)[6]	170	170	110	106	101	97	92	85	78
(***constrained***[4])									
3.5 Star (PJ)	54	55	53	51	50	48	46	43	40
5 Star (PJ)	54	55	35	34	32	31	29	27	25

Notes:

[1] – computed based on population growth projection (series II) of (ABS 1998) and occupancy rate of 2.7 per household.

[2] – from 2005 onwards new dwellings will be constructed at the rate of 43,000 per year.

[3] – ratio of non-detached to total = 0.3, average floor area for detached = 130m^2/house; for non-detached = 80m^2/house (AGO 1999b).

[4] – unconstrained refers to energy demand required to maintain an entire dwelling at a high level of human comfort continuously during normal waking hours, 365 days a year. Constrained takes into account user behaviours, such as reducing the hours of heating and cooling depending upon occupancy, conditioning only part of their homes, etc.

[5] – new houses are 3.5 star (180MJ/m^2/yr), old house continue with 1 star (600MJ/m^2/yr)

[6] – from 2010 onwards, new houses will have 5 stars (90MJ/m^2/yr), old houses will have 2 star (405MJ/m^2/yr)

The end-use services demanded by the commercial sectors are space heating, air conditioning, lighting, cooking, office equipment, refrigeration, and others. The commercial sector is diverse in nature; it consists of establishments such as public administration and community services, retail and wholesale trade, finance, business services, recreation, etc. The energy consumption by the commercial sector in 2000 was about 7 percent of the total consumption. The major source of energy in this sector was electricity (about 59 percent in 2000) (MOEU 2000b), which was used for lighting, heating, cooling and other office equipment. After electricity, gas was the main fuel for space heating, water heating and cooking. The assumptions to disaggregate energy consumption by application types are developed based on information available from the DOE (1996); AGO (1999a). Table 4-7 provides breakdown of energy consumption in the commercial sector. The AGO (1999a) report identifies the priority areas in which to reduce GHG emissions by mainly reducing electricity consumption in lighting and building applications belonging to the public administration and community services, and retail, offices and hospitals. The projections of end-use services demand for the commercial sector are provided in Table 4-12.

Table 4-7: Energy Consumption in Commercial Sector by Fuel and End-use Types (1994) (% share)

Application	Electricity	Gas	Coal	Petroleum	Total
Lighting	0.34	0.00	0.00	0.00	0.20
Heating	0.07	0.43	0.54	0.71	0.23
Hot water	0.05	0.22	0.46	0.29	0.13
Cooking	0.04	0.32	0.00	0.00	0.13
Office equip.	0.20	0.00	0.00	0.00	0.12
Cooling	0.08	0.00	0.00	0.00	0.05
Refrigeration	0.07	0.00	0.00	0.00	0.04
Others	0.15	0.04	0.00	0.00	0.10
	1.00	1.00	1.00	1.00	1.00

Source: DOE (1996).

Industrial Sector

The NSW industrial sector is divided in this research into iron and steel industry, basic non-ferrous industry (aluminium and other), chemical, construction, mining, wood and paper, non-metallic, and other (food, etc.). The end-use services demanded by the industrial sector mainly include process heat and electromotive power.

Table 4-8 provides specific energy consumption for various types of steel production technologies. The assumptions for the iron and steel industry such as unit energy consumption, efficiency and advanced technologies are taken from Energetics (1997); Worrell et al. (1997); DISR (2002); Bluescope Steel (2005). The end-use demand of the iron and steel industry is expressed in tonnes of steel. This estimate of steel production is taken from ABARE's projections; according to these projections steel production is expected to increase at 1.2 percent per year until 2005, and at 2.8 percent after 2005. Steel demanded would be produced from a variety of technologies, for example, blast oxygen furnace (BOF), electric-arc furnace (EAF) or direct reduction iron (DRI) with electric-arc furnace.

Table 4-8: Specific Energy Consumption in Steel Production

Production Technologies	GJ/t
Blast Oxygen Furnace (BOF)	
Coal	23.92
Electricity	1.04
Gas	1.04
Total	26.00
Electric Arc Furnace (EAF)	
Gas	0.79
Electricity	1.52
Total	2.31
Direct Reduction Iron (DRI) with EAF	
Gas	14.00
Electricity	1.52
Total	15.52

Sources: Worrell et al. (1999); Bluescope Steel (2005).

At present, the iron and steel industry in NSW mainly consists of the Blast Furnace (BF) and Blast Oxygen Furnace (BOF) technology. The current steel production capacity includes 5,000 kt of BF/BOF in Port Kembla and 725 kt of EAF owned by Onesteel and Smorgen (DISR 2002). The BF/BOF technology is coal intensive because it requires coal to produce coke in the coke oven to produce iron; hence this technology results in large amounts of CO_2 emissions. The EAF technology uses scrap materials to produce steel. In this process, scrap is melted and refined using strong electricity. The alternative technology to produce iron is the Direct Reduced Iron (DRI) technology, which produces sponge iron that can be used in the EAF to produce steel. This technology mainly uses natural gas as the main source of fuel and hence results in significantly less CO_2 emissions, compared to the BF/BOF technology.

The demand for aluminium is specified in this research in ktons. The projections for aluminium are taken from Dickson et al. (2003). According to these projections, aluminium demand is projected to grow at 2.1 percent per year until 2005, and 1.6 percent thereafter. The assumptions on technical parameters (see Table 4-9) for the aluminium industry are based on DISR (2000) and AACL (2001). At present, the aluminium industry in NSW consists of two major plants that use the Hall-Heroult Process for smelting. The average energy consumption in the Australian smelting sector is 78,400 MJ/t of aluminium (DISR 2000). The electrolytic process is the major energy consuming process, consuming about 52,000 MJ/t, and energy consumption in the form of coke and pitch is about 18,000 MJ/t. In this research, in the Advanced scenario, it is assumed that the electrolysis process will achieve the best possible outcome in terms of energy consumption, that is, 47,000 MJ/t, as reported in Energetics (1997). The DISR (2000) study finds non-electrolytic energy consumption is 8,400 MJ/t, but some of the efficient sites have achieved energy consumption levels of 6,331 MJ/t. These improvements in efficiency are achieved by improving smelter fume systems, air-compression systems, anode plant operations, etc.

Table 4-9: Specific Energy Consumption in Aluminium Industry

	MJ/ton of Al
Electricity	52,000
Coke (Black Coal)	18,000
Gas	2,343
Others (petroleum prod)	6,057
Total	78,400

Source: DISR (2000).

The chemical industry is the third major energy consuming sector in NSW. In the chemical industry, the major energy consuming process is the steam-cracking of hydrocarbon feed-stock to produce ethylene and propylene. Feed-stocks that are used in cracking are ethane, LPG, and naphtha. The Orica plant of NSW previously used LPG shipped from Bass strait, and naphtha from the Kurnell Refinery as a feed-stock. However, after the construction of the 1,400 km pipeline from South Australia to bring ethane, the feed stock has shifted to ethane. In this research, it is assumed that there will be an increase in ethane use, due to the availability of abundant natural gas in the neighbouring states and also due to the possibility of using ethane in place of other traditionally used feed-stocks, such as naphtha and LPG. For example, in Saudi Arabia, ethane contributes more than 70 percent of the feed stock. Thus we assume that the use of natural gas will increase significantly in the chemical industry.

Transport Sector

The transport sector is the largest energy consuming sectors in NSW, consuming on average about one third of the total energy (Dickson, Akmal & Thorpe 2003). Since NSW does not produce oil, the energy consumed by this sector is either imported from other states (Victoria, South Australia) or from overseas (MOEU 2000b).

The transport sector is divided, in this research, into road (passenger, freight), water, rail and air. The end-use services demanded by the road transport sector are, for example, vehicle kilometres for passenger vehicles and tonne kilometres for freight transporting vehicles.

Among various transport modes within the transport sector, road transport is represented in greater detail in this research in terms of technologies. This is because not only does this sub-sector consume the largest amount of energy within the transport sector (75 percent of total transport) (Dickson, Akmal & Thorpe 2003), but it also provides relatively greater flexibility for fuel switching, compared with other transport sub-sectors. The road transport is of two types, passenger and freight. The two major sources of data for the transport sector are Apelbaum (1997) and ABS (2001c). Table 4-10 provides end use services provided by various types of road transports per unit of energy consumption used in this research. These values are developed based on specific energy consumption for different types of road transport vehicles based on the road transport survey conducted by ABS for NSW, which provides data, such as distance travelled, tonnes carried and fuel consumed by different types of road transport (ABS 2001c). For other types of transport (such as road, rail, water, air), fuel consumption data are estimated from Apelbaum (1997).

Table 4-10: End-use Service per Unit of Energy Consumption in Road Transport

Vehicle types	Energy
Passenger vehicle, Mkm/PJ	277.8
Bus, Mkm/PJ	99.80
Light commercial vehicle, Mton-km/PJ	44.83
Rigid trucks, Mton-km/PJ	366.29
Articulated trucks, Mton-km/PJ	923.46

Source: ABS (2001).

The alternative fuels for transport considered in this research are of two types; namely, based on fossil fuel sources (of three types – CNG, hydrogen, and methanol), and based on biofuels (two types, ethanol and biodiesel). The fossil-based alternative fuels will mainly use natural gas available in the country. The promising sources of biofuels are ethanol produced from waste starch and bio-diesel produced from waste cooking oil. The technological parameters for alternative fuels for transport are estimated based on the UK study by Marsh et al. (2002), and IEA (2000).

Table 4-11 : Alternative Fuels for Passenger Vehicles

Vehicle types	Investment Cost	Efficiency	Life
	$/km.yr	Mkm/PJ	Yr
Gasoline	1.84	278	10
CNG	2.33	278	10
Methanol	2.17	278	10
Hydrogen	8.33	909	10
Hybrid	2.20	800	10
Ethanol	2.03	278	10

Source: ABS (2001c); Marsh et al.(2002).

Table 4-12 : End-use Demand Estimates

	Unit	2000	2005	2010	2015	2020	2025	2030	2035	2040
1. Agriculture	PJ	14.30	14.90	15.80	17.00	18.30	19.70	21.21	22.83	24.57
2. Residential										
Elect. Appliances	PJ	32.30	35.30	38.51	42.55	47.19	52.34	58.06	64.40	71.43
Water heating	PJ	29.78	32.55	35.51	39.23	43.51	48.26	53.53	59.38	65.86
Cooking	PJ	4.72	5.16	5.63	6.22	6.89	7.65	8.48	9.41	10.44
Space heat./cool.	PJ	54.89	59.99	65.45	72.31	80.20	88.96	98.67	109.44	121.39
3. Commercial										
Lighting	PJ	14.38	16.43	17.85	19.66	21.71	23.97	26.47	29.23	32.27
Heating	PJ	16.45	18.80	20.43	22.50	24.84	27.43	30.29	33.44	36.93
Hot water	PJ	9.04	10.33	11.23	12.36	13.65	15.07	16.65	18.38	20.29
Cooking	PJ	9.19	10.50	11.41	12.57	13.88	15.32	16.92	18.68	20.63
Office equip.	PJ	8.75	9.99	10.86	11.96	13.20	14.58	16.10	17.78	19.63
Cooling	PJ	3.56	4.06	4.42	4.86	5.37	5.93	6.55	7.23	7.98
Refrigeration	PJ	3.11	3.56	3.87	4.26	4.70	5.19	5.73	6.33	6.99
Others	PJ	7.12	8.13	8.83	9.73	10.74	11.86	13.10	14.46	15.97
4. Industrial										
Construction	PJ	8.06	8.63	9.83	10.56	11.29	12.08	12.92	13.82	14.78
Wood paper and printing	PJ	15.50	19.75	28.08	30.48	32.60	34.86	37.29	39.89	42.66
Chemical	PJ	72.23	71.35	78.91	83.41	89.21	95.42	102.06	109.16	116.76
Non-metallic mineral prod.	PJ	25.92	27.80	31.74	34.28	36.66	39.21	41.94	44.86	47.98
Steel production	kton	5550	5769	7052	8096	9295	10671	12251	14065	16147
Aluminum Prod.	kton	600	666	721	780	845	914	990	1072	1160
Other metal products	PJ	29.00	30.28	34.03	36.38	38.91	41.62	44.52	47.61	50.93
Others	PJ	35.22	38.36	44.63	48.73	52.12	55.75	59.63	63.78	68.22
5. Transport										
Road										
Passenger vehicle	M-km	48633	51464	54460	57631	60986	64536	68293	72269	76476
Bus	M-km	587	621	657	695	736	778	824	872	922
Light commercial vehicle	Mt-km	1993	2294	2640	3039	3497	4025	4633	5332	6137
Rigid trucks	Mt-km	10145	11676	13439	15467	17802	20490	23583	27142	31240
Articulated Truck	Mt-km	39173	45086	51891	59725	68740	79117	91060	104805	120626
Rail										
Passenger	PJ	2.76	2.93	3.21	3.38	3.81	4.28	4.81	5.41	6.08
Freight	PJ	7.64	8.09	8.88	9.36	10.52	11.83	13.30	14.96	16.82
Air										
Domestic	PJ	23.16	27.90	33.08	44.18	49.67	55.85	62.79	70.59	79.37
International	PJ	61.74	74.65	93.79	107.44	120.79	135.81	152.69	171.68	193.02
Water	PJ	21.40	23.44	24.66	25.50	28.67	32.24	36.24	40.75	45.82

Source: Estimated based on energy demand projection from ABARE (Dickson, Akmal & Thorpe 2003)

4.5 Results and Discussions

This section presents the results indicating the energy impacts of the three scenarios. The energy impacts are quantified in this research in terms of primary and final energy requirements, electricity generation fuel mix, plant capacity requirements, and CO_2 emissions for NSW for the next 40 years. These estimates are obtained from the application of MARKAL model as presented in Sections 4.2 and 4.3 of this chapter, under a set of assumptions as described in Section 4.4.

4.5.1 Primary and Final Energy Consumption

Primary Energy

The results suggest that energy consumption in NSW would rise in all scenarios, though at lower levels for the Moderate (MOD) and the Advanced (ADV) scenarios (see Figure 4-6). For example, in the Base (BAS) scenario, the total primary energy requirement more than doubles in the next forty years, from 1,400 PJ in 2000 to 2,900 PJ by 2040. In the Moderate scenario, which represents a modest increase in energy efficiency and places modest constraints on CO_2 emissions, the primary energy requirements increase by 66 percent in the next forty years. In the Advanced scenario, which envisages higher CO_2 emission reductions, primary energy requirements increase by only 47 percent to the year 2040. The increased economic activity, population growth, transportation needs are major contributors to these increased demands in all three scenarios. The alternative scenarios, Moderate and Advanced, show relatively lower requirements for primary energy, mainly due to the increased use of efficient plants in power generation, improvements in end-use efficiency in the transport, industrial sectors, and residential sectors.

The average annual growth rate of primary energy requirements for the next forty years in the Base, Moderate and Advanced scenarios are 1.8, 1.3 and 0.9 per cent respectively. In the Base scenario, the growth rate in the first half of the period (that is, 2000–2020) is slightly higher (1.9 percent) than for the next half of this period (that is, 2020–2040) (1.7 percent).

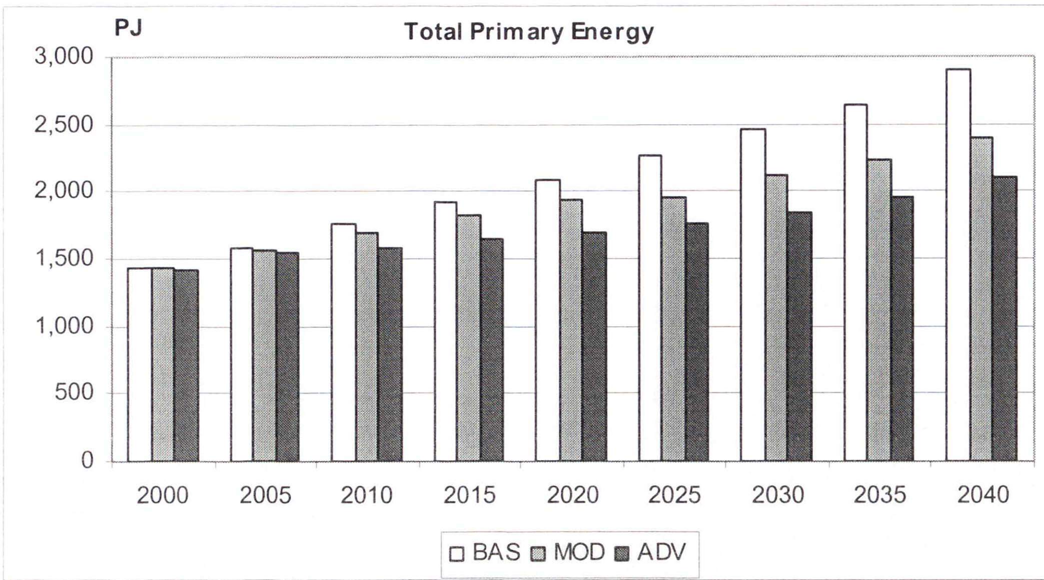


Figure 4-6: Primary Energy Requirements

The annual growth rate in the Base scenario (1.8 percent) for the period 2000-2040, is slightly higher compared to the rate (1.7 percent) experienced in the last decade (1991–2000). Further, in the last decade, the annual growth rate of primary energy for NSW was significantly lower than the national average (2.3 percent) (Dickson, Akmal & Thorpe 2003). This was mainly due to the reduced energy demand in the manufacturing sector. During the period 1991–2000, the energy consumption in the manufacturing sector declined by 0.2 percent per year, while in all other sectors, such as the transport, commercial, residential sectors, energy consumption grew at more than 2.5 percent. The manufacturing sector has an important share (about 38 percent in 2000) in the total energy consumption in NSW (Dickson, Akmal & Thorpe 2003), within the manufacturing sector, metal industries such as the iron and steel industry have the large shares. In NSW, steel production declined sharply with the shut-down of the Newcastle steel-works in 2000. In this research, steel production is assumed to grow in the future (see Table 4-12). This explains the rise in energy consumption at a rate greater than the historical trend.

Table 4-13: Primary Energy Mix under Three Scenarios (PJ)

Base Scenario

Energy Types	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
Black Coal	710	782	727	744	756	779	815	841	893
	(49.3)	(49.6)	(41.4)	(38.7)	(36.1)	(34.5)	(33.1)	(31.8)	(30.7)
Oil	525	577	647	719	794	875	971	1,073	1,193
	(36.4)	(36.5)	(36.8)	(37.5)	(37.9)	(38.7)	(39.4)	(40.5)	(41.0)
Natural Gas	110	118	213	288	349	400	455	515	560
	(7.7)	(7.5)	(12.1)	(15.0)	(16.7)	(17.7)	(18.5)	(19.4)	(19.2)
Coal Seam Methane	6	0	28	11	20	19	18	0	0
	(0.4)	(0.0)	(1.6)	(0.6)	(0.9)	(0.8)	(0.7)	(0.0)	(0.0)
Elect. Import(FEQ)[1]	31	35	38	42	46	51	57	63	69
	(2.2)	(2.2)	(2.2)	(2.2)	(2.2)	(2.3)	(2.3)	(2.4)	(2.4)
Renewable	58	67	105	117	127	135	149	157	194
	(4.0)	(4.3)	(6.0)	(6.1)	(6.1)	(6.0)	(6.0)	(5.9)	(6.7)
Total	**1,440**	**1,578**	**1,757**	**1,920**	**2,092**	**2,259**	**2,464**	**2,649**	**2,908**
	(100)	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**

Moderate Scenario

	2000	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
Black Coal	707	761	725	752	690	556	556	449	356
	(49.2)	(48.7)	(42.8)	(41.0)	(35.7)	(28.4)	(26.3)	(20.1)	(14.9)
Oil	525	577	580	632	669	741	775	859	944
	(36.5)	(36.9)	(34.2)	(34.5)	(34.6)	(37.8)	(36.6)	(38.5)	(39.5)
Natural Gas	112	127	221	247	329	388	457	515	578
	(7.8)	(8.1)	(13.0)	(13.5)	(17.0)	(19.8)	(21.6)	(23.1)	(24.2)
Coal Seam Methane	6	0	6	0	0	16	30	54	78
	(0.4)	(0.0)	(0.4)	(0.0)	(0.0)	(0.8)	(1.4)	(2.4)	(3.3)
Elect. Import(FEQ)	31	35	38	42	46	51	57	63	69
	(2.2)	(2.2)	(2.3)	(2.3)	(2.4)	(2.6)	(2.7)	(2.8)	(2.9)
Renewable	57	63	124	159	197	209	241	290	367
	(4.0)	(4.1)	(7.3)	(8.7)	(10.2)	(10.7)	(11.4)	(13.0)	(15.3)
Total	**1,439**	**1,563**	**1,693**	**1,832**	**1,935**	**1,960**	**2,115**	**2,230**	**2,392**
	(100)	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**

Advanced Scenario

	2000	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
Black Coal	707	722	531	381	287	260	226	234	316
	(49.6)	(46.7)	(33.6)	(23.2)	(16.9)	(14.7)	(12.3)	(12.0)	(15.0)
Oil	513	561	577	615	643	666	684	721	792
	(35.9)	(36.3)	(36.5)	(37.4)	(37.9)	(37.8)	(37.0)	(36.9)	(37.7)
Natural Gas	112	129	236	317	389	441	503	543	529
	(7.8)	(8.2)	(14.0)	(17.3)	(20.1)	(22.5)	(23.8)	(24.3)	(22.1)
Coal Seam Methane	6	0	23	46	71	67	63	47	27
	(0.4)	(0.0)	(1.5)	(2.8)	(4.2)	(3.8)	(3.4)	(2.4)	(1.3)
Elect. Import(FEQ)	31	35	38	42	46	51	57	63	69
	(2.2)	(2.2)	(2.4)	(2.6)	(2.7)	(2.9)	(3.1)	(3.2)	(3.3)
Renewable	57	100	177	242	261	278	315	345	369
	(4.0)	(6.5)	(11.2)	(14.7)	(15.4)	(15.8)	(17.0)	(17.7)	(17.5)
Total	**1,427**	**1,546**	**1,583**	**1,643**	**1,697**	**1,763**	**1,848**	**1,952**	**2,102**
	(100)	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**

Source: This Research.

Notes:

[1] Electricity imports are converted into primary energy in terms of Fossil Equivalent (FEQ) value of 3.125. FEQ corresponds to the reciprocal of the average efficiency of fossil-fuel power plants, which is assumed as 32 percent in this case.

[2] Numbers in parenthesis represent percentage shares.

Coal. The results show that the dominant role of coal in the state's total energy mix will diminish in the coming decades. The energy mix in the Base scenario, for example, shows that coal remain the dominant fuel during the first half of the study period (49 percent in 2000, and 39 percent in 2015) only (see Table 4-13). In the following periods, the share of coal reduces (to 31 percent in 2040) as natural gas and renewables begin to replace coal in power generation. Coal's continued dominancy in the first half of the study period reflects the inertia to change of the coal dominant NSW energy system, which was developed in the past to utilise the domestically available cheap coal, particularly in power generation (coal plants, for example, provided 90 percent of the power in 2000), and in industries such as coal intensive iron and steel industries. However, with growing concerns about climate change, coal's contribution is expected to decline in the future. The scenario results show that the share of coal reduces significantly in later periods (see Figure 4-7). As the existing coal plants retire, they are increasingly replaced by natural gas and renewable-based plants. This results mainly due to the impacts of the NSW GHG Benchmark Scheme (NSW Government 2001) – the scheme requires the electricity retailers to reduce their CO_2 emissions to a specified level (7ton/person), thus electricity generation switches to other less carbon intensive energy sources.

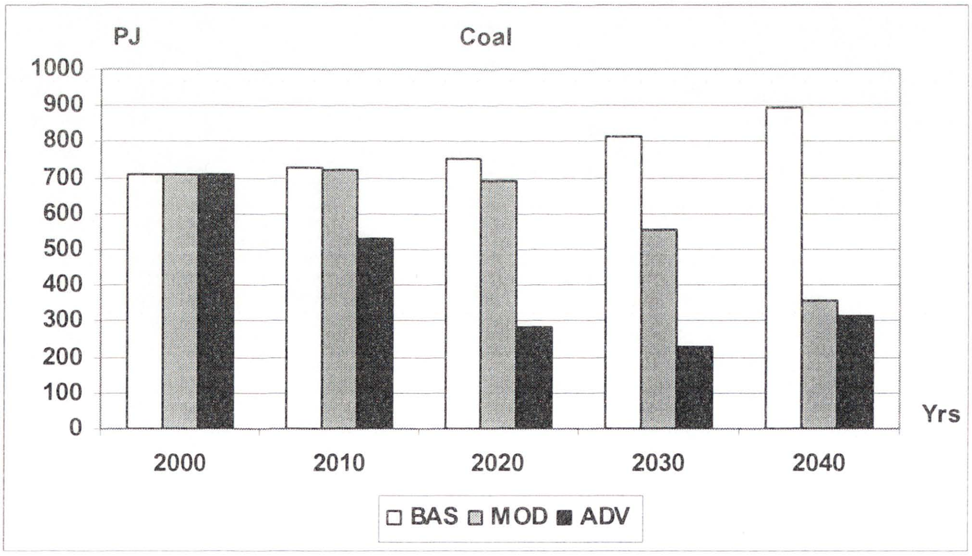


Figure 4-7: Coal Requirements

In the alternative scenarios (Moderate and Advanced), the shares of coal in the total energy mix reduce further, mainly because of the rising concerns about CO_2 emissions, and also because of other energy sources becoming competitive. In the year 2020, for example, the share of coal in the Moderate scenario reduces to 35.6 percent, and in the Advanced scenario, to 16.9 percent. At the end of the study period (2040), the share of coal reduces to 15 percent for both Moderate and Advanced scenarios. The huge reduction in the shares of coal in these scenarios is due to the uptake of alternative energy resources, mainly natural gas, and renewables.

Gas. With the share of coal declining in the total energy mix, the role of gas increases (from 8 percent in 2000, to 19 percent in 2040, for the Base scenario) in the NSW energy scene. Natural gas produces fewer CO_2 emissions compared to coal, which makes it increasingly attractive as a fuel for power generation. The increased availability of gas with the progress in gas market reform, and efficiency improvements in gas-based technologies such as combined-cycle plants would make gas increasingly attractive.

Gas is consumed in greater quantities in all three scenarios, primarily due to its increased use in power generation and industries such as iron and steel. In all three scenarios, the amounts of natural gas that will be required at the later periods are in the range of 550 PJ, which is nearly five times the consumption level in 2000. This indicates that there would be a need to increase the pipeline capacity by about three times from the current capacity of 200 PJ. Natural gas reserves in the eastern states are limited, hence, increase in demand for gas means gas supply would need to be sought from other resources such as the Carnarvon and Browse Basins of Western Australia, the Bonaparte Basin of the Northern Territory, and from overseas (for example, Papua New Guinea).

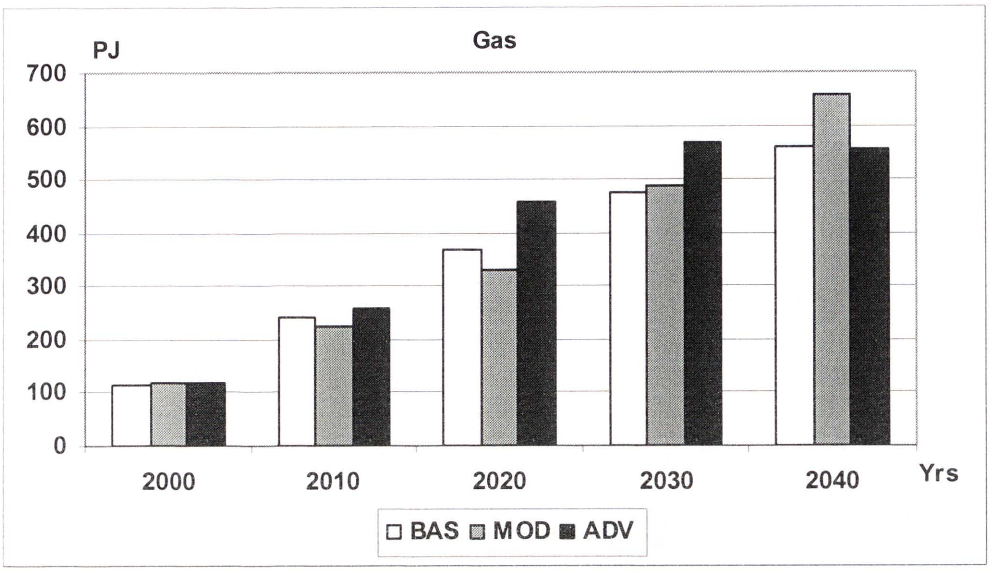


Figure 4-8: Gas Requirements

Oil. Oil would continue to occupy an important share in the total energy mix of NSW. With the increase in transportation activity, the demand for oil would rise. In all three scenarios, the demand for oil increases (see Figure 4-9). Oil consumption, over the period of 2000-2040, grows at 2 percent/yr in the Base scenario, 1.5 percent/yr in Moderate and 1.1 percent/yr in the Advanced scenario. If the present trend continues, as the Base scenario shows, the demand for oil would increase twofold by 2040, from 525 PJ in 2000, to 1,200 PJ in 2040. However, oil reserves in Australia are limited (16,850 PJ in 2001), and also oil production is expected to gradually decline in the near future from the current production rate of 1,430 PJ/yr (Dickson, Akmal & Thorpe 2003). These limited reserves and declining domestic production rates mean NSW would increasingly depend on imported oil, which might expose the state to the unstable world oil market (such as the Middle East, Russia and Central Asia).

In the Moderate and Advanced scenarios oil consumption in 2040 is lower, (944 PJ and 792 PJ, respectively) than in the case in the Base scenario (1,193PJ). This is due mainly to the efficiency improvements in the road transport sector (for example, use of efficient hybrid cars) and the increase in the use of CNG, methanol, and ethanol fuel.

Further, interestingly, in the year 2040, with the share of coal declining, oil (which is mainly consumed in the transport sector), previously the second most dominant energy source emerges as the most significant energy source in 2040; its shares increases from nearly 36 percent in 2000, to 41, 40, and 38 percent in the Base, Moderate, and Advanced scenarios, respectively.

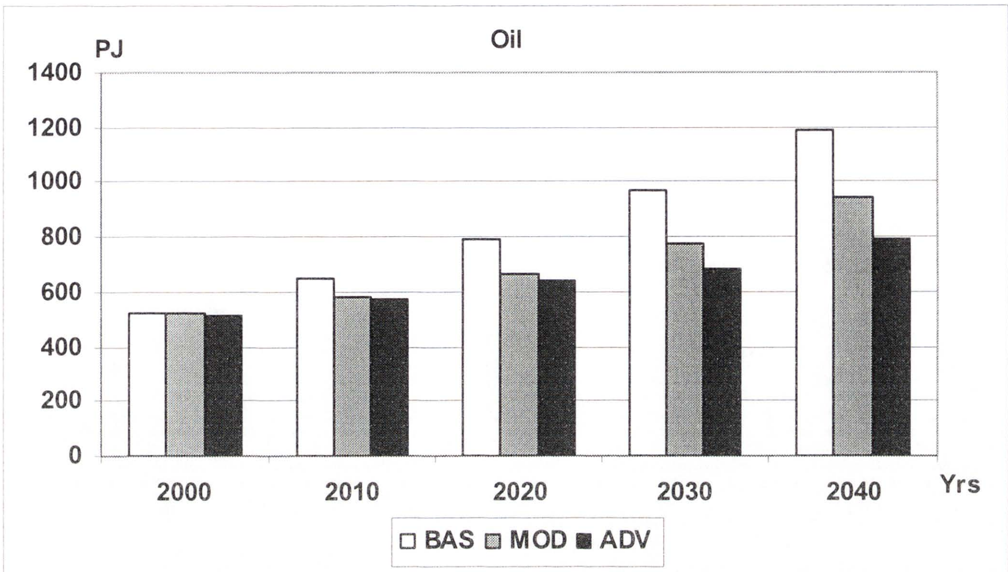


Figure 4-9: Oil Requirements

Renewable energy. The renewable energy resources, in the context of this research, mainly consist of hydropower, biomass, solar and wind. The share of renewable energy sources in the total energy mix increases from 4 percent in 2000 to 6, 10 and 15 percent in 2020 for the Base, Moderate and the Advanced scenarios respectively. The share increases further to 7, 15 and 18 percent in 2040. The annual growth rate of the renewable energy consumption is comparatively larger than other energy sources, mainly because it grows from a low base. The annual growth rate of renewable energy in the total energy mix is 3, 4.7 and 4.8 percent for the Base, Moderate and Advanced scenarios, respectively. In the renewable energy mix, while the share of hydro power remains stagnant, there is significant increase in the shares of biomass, wind, and to some extent solar energy (mainly in water-heating applications in the residential sector).

Energy intensity. The scenario results show there would be a constant improvement in the primary energy intensity (which measures energy required to produce a unit of economic output, represented as MJ/$) in NSW, across all scenarios, to the year 2040 (see Figure 4-10). This figure also shows that there has been a constant improvement in the primary energy intensity since 1990; this improvement accelerates after 1997. One explanation for this is that the economy began to shift from energy-intensive economic sectors towards less energy-intensive service sectors, such as finance, property and business, etc.

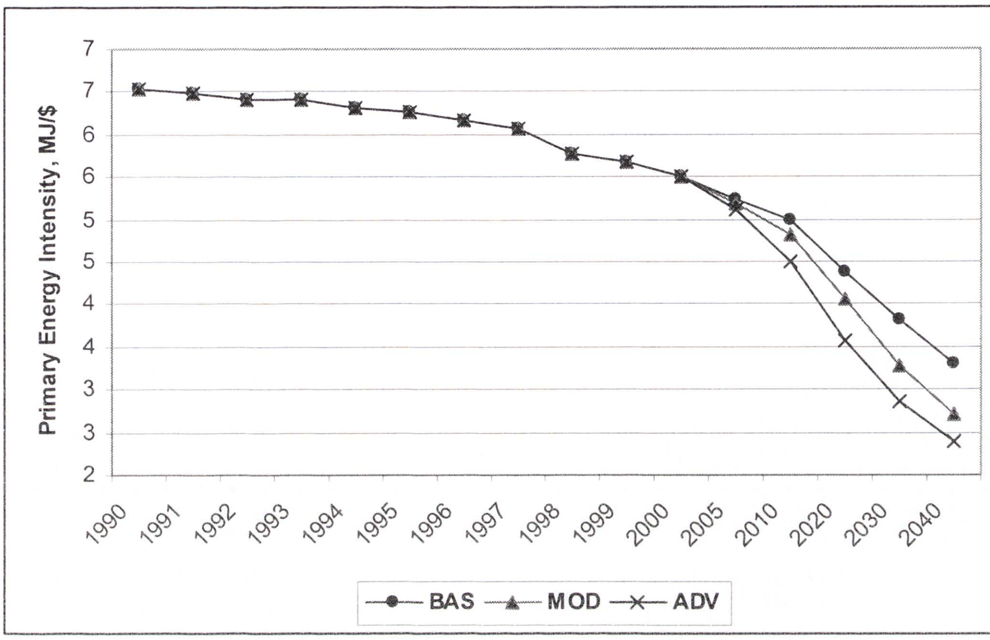


Figure 4-10: Primary Energy Intensity (MJ/\$)

Per Capita Energy Consumption. Per capita energy consumption (in GJ/person) for NSW gradually increases in all three scenarios, but at relatively lower rates in the Moderate and Advanced scenarios (see Figure 4-11 below). NSW is characterised by lower per capita energy consumption as compared to other states even though it is the largest energy consuming state in Australia. The per capita energy consumption for NSW is lower than the national average and is significantly lower when compared with the states of Victoria (VIC) and Queensland (QLD) (See Table 4-14). The table also compares the per capita energy consumption of Australia with that of selected countries. It illustrates that the per capita energy consumption for Australia, while lower than the US, is significantly higher than the OECD average and Japan. The result from the Advanced scenario shows that per capita energy consumption in NSW, in 2040, remains very close to the current national average (see Figure 4-11).

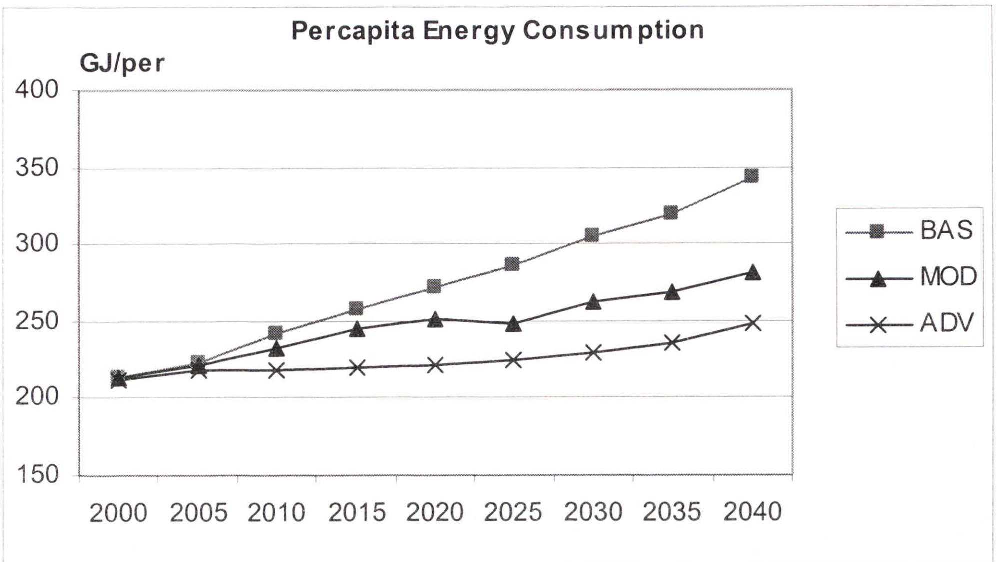


Figure 4-11: Per Capita Energy Consumption

Table 4-14: Energy Consumption per Capita in 2000

Country/ State	Energy consumption per capita (GJ/person)
US	350
Japan	173
OECD	198
Australia	241
NSW	207
VIC	280
QLD	278

Source: IEA (2002), Dickson et al. (2003).

Energy diversity (Herfindahl Index)

The diversity of fuels in primary energy mix across the scenarios under study are measured in this research with the help of Herfindahl index. The Herfindahl or diversification index (H) is given as follows (Hove 1993):

$$H = \Sigma (X_i)^2 \qquad (i = 1, 2, .., n)$$

where X_i is the percentage share of energy source "i" in total primary energy supply. For a given number of energy sources, "H" increases as the dispersion of their market shares increases. A lower index means a greater diversification in primary energy supply. When all energy sources have equal market shares "H" equals "1/n", and when one energy source satisfies the entire energy demand, "H" equals "1".

Table 4-15 shows Herfindahl indices for the three scenarios for NSW for 2020 and 2040. The table also provides index values for Australia and NSW for 2000 for the purpose of comparison. The table illustrates that the index values for both Australia and NSW in 2000 is significantly higher than 0.25 (value that will be attained if each of the four fuels had an equal share). The table also shows that the energy diversity in NSW (0.40) is lower than the diversity at the national level (0.33). This is mainly because NSW's primary energy supply mix is dominated by two types of fuels (coal and oil). In the later periods, as the share of coal decreases and the share of natural gas and renewable increases, the energy diversity increases – as reflected by the declining index values. The index improves significantly in the Advanced scenario for 2020 and 2040, as compared to the Base scenario.

Table 4-15: Energy Diversity across Scenarios

	Fraction of total (Xi)							
	Australia	New South Wales						
Energy Types	2000	2000	2020			2040		
		BAS	BAS	MOD	ADV	BAS	MOD	ADV
Black Coal	0.407	0.504	0.369	0.366	0.174	0.314	0.153	0.155
Oil	0.347	0.372	0.388	0.355	0.389	0.420	0.407	0.390
Natural Gas	0.192	0.083	0.180	0.175	0.279	0.197	0.282	0.273
Renewable	0.054	0.041	0.062	0.105	0.158	0.068	0.158	0.181
Herfindahl index, $H = \Sigma(X_i)^2$	**0.326**	**0.401**	**0.323**	**0.301**	**0.285**	**0.319**	**0.293**	**0.284**

Source: This research.

Final Energy Consumption

Figure 4-12 illustrates the trend in final energy requirements under the three different scenarios. Final energy consumption grows at 2.1 percent per year in the Base scenario, and at lower rates, of 1.7 and 1.4 percent, in the Moderate and Advanced scenarios. The total final energy requirements at the end of the study period (2040) declines by 13 percent in the Moderate and by 26 percent in the Advanced scenarios compared to the Base scenario.

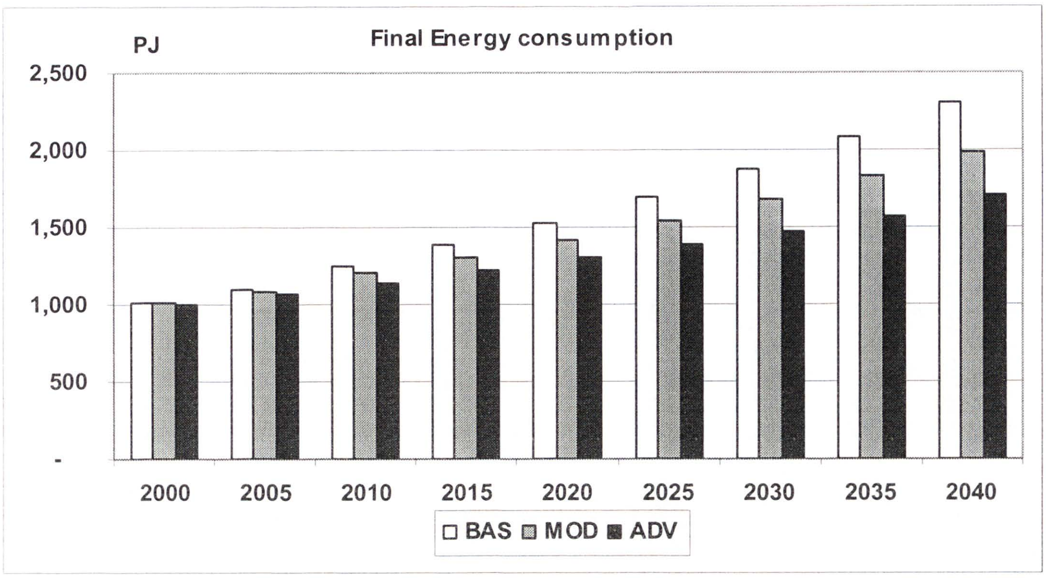


Figure 4-12: Final Energy Requirements

Figure 4-13 presents final energy requirement by different end-use sectors for the three different scenarios (see Table C-2, p 264, Appendix C, for details about data used to compute these values). In all three scenarios, the transport and industrial sectors emerge as the two major energy consuming sectors. Together, these two sectors account for nearly 80 percent of the total final energy requirements in all scenarios. Both of these sectors show improvements in energy requirements in the Moderate and Advanced scenarios, as compared to the Base scenario. The iron and steel, and aluminium industries are the major energy-consuming industries within the manufacturing sector. Energy consumption in the industrial sectors reduces mainly due to energy efficiency improvements in these two sub-sectors. In Moderate and Advanced scenarios, coal-based technologies in iron and steel industry, such as BF/BOF technologies, are phased out and natural gas-based DRI technologies (that produces sponge iron for use in electric arc furnaces) are introduced. In addition, energy requirements in the transport sector reduce due to the improvements in vehicle efficiency. Particularly in the Advanced scenario, energy requirements in the transport sector reduces significantly, due to the increased use of hybrid vehicles, which are twice as efficient as conventional vehicles. Energy requirements decline in the residential and commercial sectors in the Moderate and Advanced scenarios as energy efficiency improves in space heating (with increased use of insulation, following 3.5 star and 5 star building designs), ventilation and air conditioning.

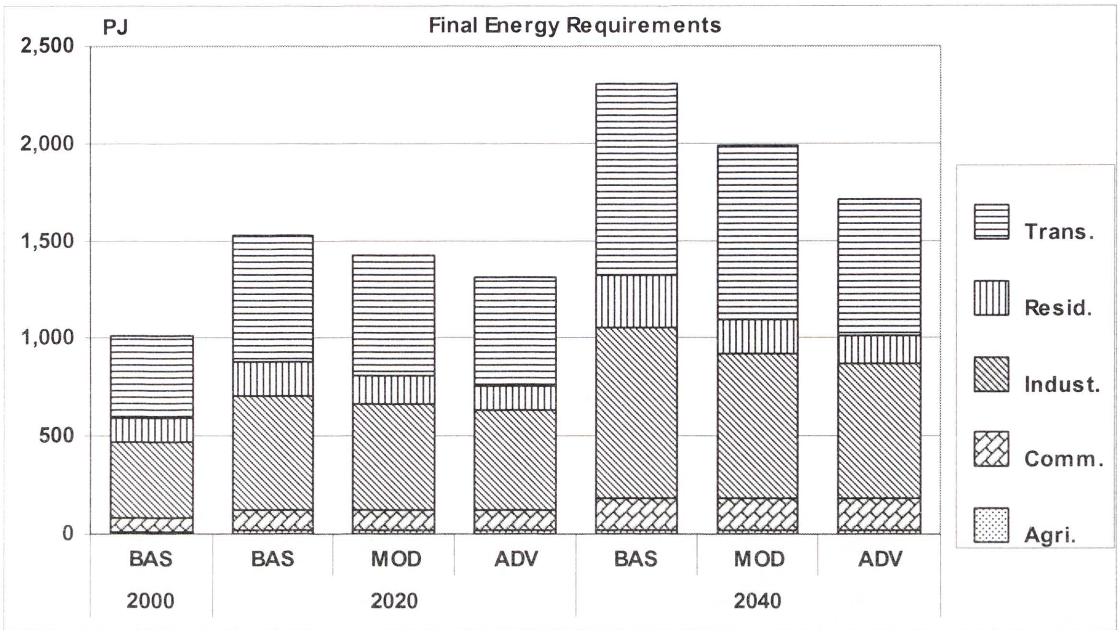


Figure 4-13: Final Energy Requirements by End-use Sectors

4.5.2 Electricity Supply

Electricity accounted for nearly 20 percent of total final energy consumption in NSW in 2000. The main electricity consuming end-use sectors in NSW include the industrial sector (for example, electricity-intensive industries, such as aluminium industries) and residential and commercial sectors (for example, thermal heating and cooling, water heating, and electric appliances, such as refrigerators). The residential and commercial sectors together consume about half of the total electricity consumed. The scenario results show that electricity consumption would grow, over the period 2000–2040, at an annual rate of 1.9 percent in the Base, 1.4 percent in the Moderate and 1.2 percent in the Advanced scenario. These growth rates are lower than the historical growth rate of 3 percent per year (1980–2001). This indicates an improvement in electricity intensity (MJ/$) of the economy (similar to the improvement energy intensity mentioned in the previous section). The electricity generation are lower in the Moderate and Advanced scenarios, by 17 and 24 percent in 2040, respectively, due to the decline in demand for electricity – a result of energy efficiency improvements in end-use sectors (for example, space heating and cooling, electric appliances, etc.).

Fuel types. Electricity is generated in NSW mainly from coal and natural gas, and to some extent renewable sources, such as, hydro power, biomass and wind. The scenario outcomes show that the level of fuel mix among these energy resources varies significantly across the three scenarios. The contribution of hydro remains constant, mainly because of the lack of potential sites for further development.

The scenario results show that the generation mix in NSW in the near future would go through a significant change from the historical trend (see Figure 4-14, and Table C-3, p 267 in Appendix C). The generation mix in NSW has historically been dominated by coal-based plants; these plants contributed, for example, nearly 90 percent to total electricity generation in 2000. The availability of cheap coal and a lack of concern about CO_2 emissions in the past have contributed to this large expansion of coal-based plants in NSW. The results for the Base scenario show that the share of coal plants decreases to 72 percent by 2010, 57 percent by 2020 and 47 percent by 2040. The share of coal-based generation decreases mainly due to the impacts of the NSW GHG Benchmark Scheme, which requires electricity retailers to limit CO_2 emission to 7.29 ton per capita by 2007. Coal being the most carbon intensive fuel, the electricity producers switch to less carbon intensive fuels such as natural gas and renewable. Although at reduced level, coal's share in this scenario continues to remain important.

In the Moderate scenario, the share of electricity from coal-based plants reduces to 20 percent of total generation by 2040, and the share of electricity from natural gas based plants and renewables, such as biomass and wind, increases. In the Advanced scenario, the share of power from coal-based plant declines further, to 13 percent by 2030, but recovers to 27 percent by 2040. This is so because this scenario imposes a higher level of restriction on CO_2 emissions; this results in the introduction of clean coal plants such as IGCC with carbon capture and sequestration (CCS) in greater numbers, thus increasing the share of coal.

In all three scenarios, natural gas based generation displaces coal-based generation. In the later periods (2020 onwards), clean coal plants, such as IGCC, begin to contribute more, as existing aging coal plants retire. These plants, with high levels of efficiency, contribute to the resurgence of coal in electricity generation in the later years (from 2025 onwards).

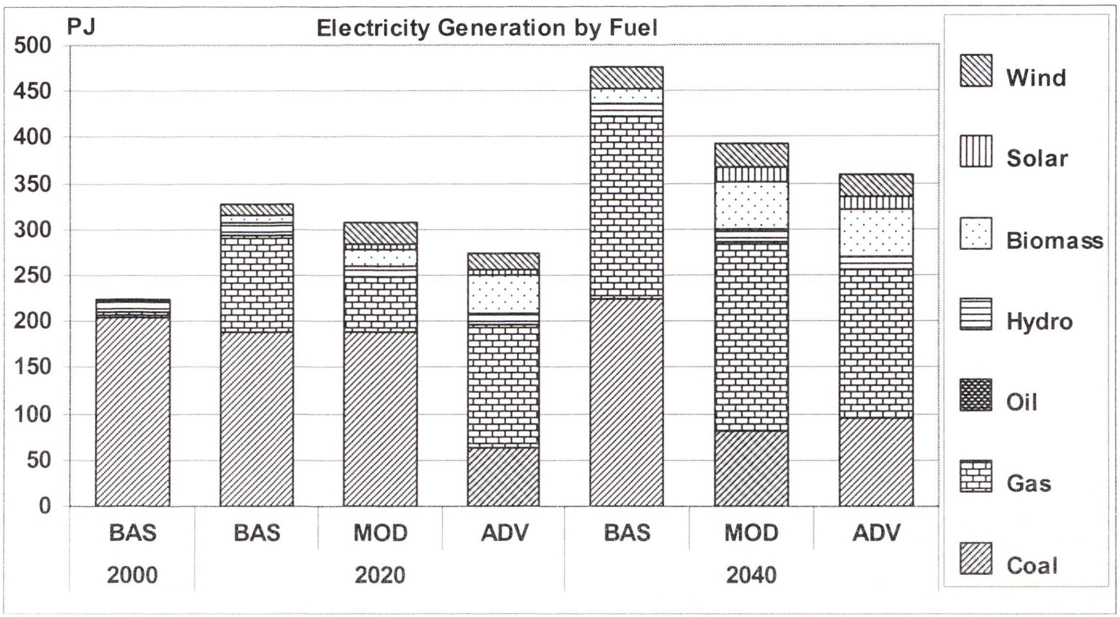


Figure 4-14: Electricity Generation by Fuel

Renewable-based Generation. Renewable-based power generation increases in NSW in all three scenarios. In the Base scenario, its share increases from 5.5 percent in 2000 to 10.3 percent and 11.4 percent in 2020 and 2040, respectively. In the Moderate and Advanced scenarios, the contribution rises to 19 and 28 percent, respectively, by 2020 and to 27 and 29 percent by 2040. The major sources of renewable generation NSW are hydro, biomass, and wind. Renewable-based generation increases for two reasons, namely, the NSW GHG Benchmark Scheme (a state scheme); and the MRET target (a national scheme).

Plant Capacities. Figure 4-15 shows power plants capacities, by technology, for all three scenarios. As can be seen, the share of conventional (pulverised) coal-based plants gradually declines along the time horizon in all scenarios, and, the IGCC plants, which are about two times more efficient than conventional plants, are added increasingly. With CO_2 emissions control becoming necessary, as existing conventional coal plants retire, IGCC plants become competitive and attractive for replacement. A large capacity of IGCC is added during 2025, when significant coal capacity (5,280 MW) is retired. This research assumes that during this period, two major coal power plants, the Eraring and the Baywater plants, with a combined capacity of 5,280 MW, which were commissioned in early 1980s, will retire. The IGCC plants, which are currently in demonstration phases, are expected to be commercially available by then. The IGCC plants would also be attractive if NSW decides to implement CO_2 capture and sequestration (CCS) as a measure to reduce CO_2 emissions. In the Advanced scenario, for example, where CO_2 emissions are restricted at a greater level, IGCC plants with CCS are installed in larger amounts in the second half of the period. CO_2 sequestration is likely to be implemented only after 2015 (based on a study by Passey and MacGill (2003)). The IGCC with CCS makes it possible for coal to play an important role in the Advanced scenario, while maintaining low levels of CO_2 emissions. The potential geo-sequestration sites in NSW are, however, located at considerable distances (above 500 km) from emission sources – spanning the Newcastle–Sydney–Wollongong area (Bradshaw et al. 2002).

The combined cycle gas-based plants are installed at greater levels in all three scenarios (see Figure 4-15). They become attractive due to the need to displace coal-based plants in order to reduce CO_2 emissions. Coal seam methane is also increasingly used, as gas plants are constrained by the upper bound in the model.

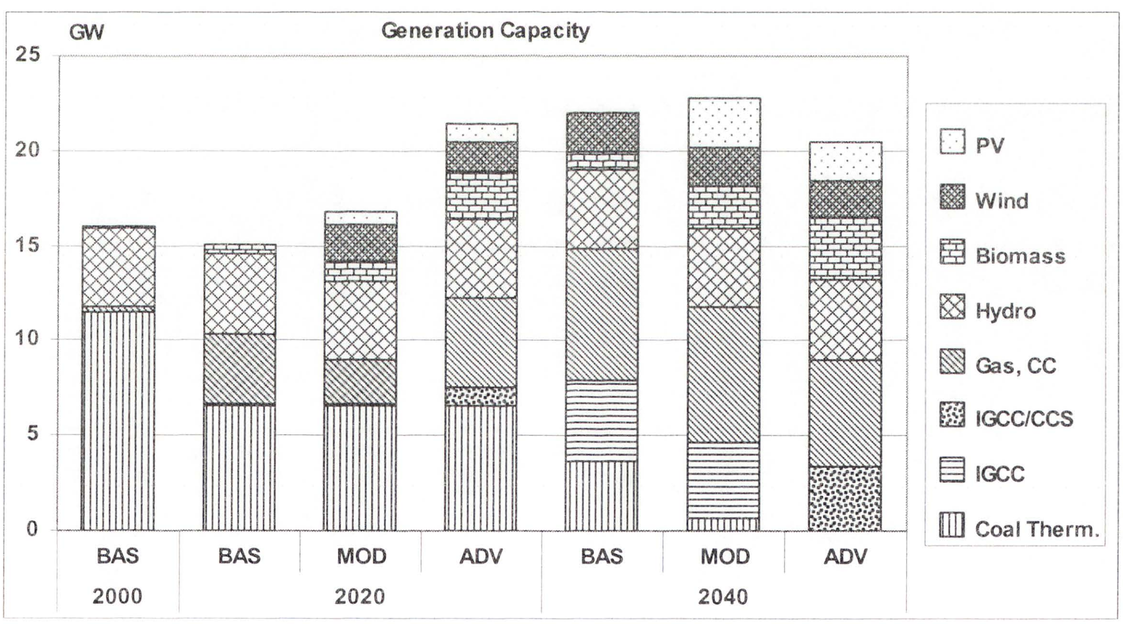


Figure 4-15: Generation Capacities

In all scenarios, renewable-based plants such as biomass, wind and solar PV are increasingly added. Of the three, biomass and wind are competitive with fossil-based plants, while PV provides the smallest share because of higher cost.

4.5.3 CO_2 Emissions

New South Wales is the largest GHG emitting state in Australia. In 1990, energy-related GHG emissions from NSW amounted to 109 Mt of CO_2 equivalent (which equals 36 percent of the total Australian emissions). The GHG emissions had increased to 119 Mt by 1999 (AGO 2002).

Reducing CO_2 emissions is one of the critical challenges faced by NSW today. The NSW government has initiated some important policy measures aimed at reducing CO_2 emissions. The NSW GHG Benchmark Scheme is one such measure; it seeks to reduce CO_2 emissions per capita from power generation to 7.29 ton by 2007 (equivalent to 5 percent below the 1990 emission level) (NSW Government 2001).

The main sources of CO_2 emissions are the consumption of fossil fuels such as coal and oil, which represents 87 percent of the state's total consumption. Coal is mainly consumed in power generation, and oil in transportation.

The scenario results show that, by 2040, CO_2 emission in the Base scenario would increase by nearly 80 percent above the 2000 emission levels. The main sources of emissions are electricity generation (from coal and natural gas plants), the industrial sector (iron and steel industry), and the transport sector (road transport). This rise in total CO_2 emission results even when emission from electricity generation are restricted to the specified level as required by the NSW Greenhouse Benchmark Scheme. This is because, while the scheme restricts emissions from the electricity sector, emissions from the transport sector continue to rise and this sector emerges as the main source of CO_2 emissions (see Table 4-16).

Table 4-16: CO_2 Emissions in NSW (in kton)

	2000	2005	2010	2015	2020	2025	2030	2035	2040
Base Scenario									
Electricity	50,680	56,434	54,213	55,844	57,300	58,316	60,170	60,019	61,619
	(49.4)	(50.3)	(46.3)	(44.4)	(42.4)	(40.4)	(38.5)	(36.0)	(34.1)
Agriculture	870	909	963	1,036	1,115	1,200	1,292	1,391	1,497
	(0.8)	(0.8)	(0.8)	(0.8)	(0.8)	(0.8)	(0.8)	(0.8)	(0.8)
Commerce	1,435	1,639	1,781	1,962	2,166	2,391	2,641	2,916	3,220
	(1.4)	(1.5)	(1.5)	(1.6)	(1.6)	(1.7)	(1.7)	(1.7)	(1.8)
Industrial	20,983	21,823	25,623	28,685	32,091	35,934	40,282	45,199	50,764
	(20.5)	(19.5)	(21.9)	(22.8)	(23.8)	(24.9)	(25.8)	(27.1)	(28.1)
Residential	953	1,035	1,125	1,254	1,390	1,544	1,711	1,896	2,094
	(0.9)	(0.9)	(1.0)	(1.0)	(1.0)	(1.1)	(1.1)	(1.1)	(1.2)
Transport	27,588	30,354	33,371	37,087	40,928	45,025	50,074	55,331	61,639
	(26.9)	(27.1)	(28.5)	(29.5)	(30.3)	(31.2)	(32.1)	(33.2)	(34.1)
Total	**102,509**	**112,194**	**117,076**	**125,868**	**134,990**	**144,410**	**156,170**	**166,752**	**180,833**
	(100)	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**
Moderate Scenario									
Electricity	50,756	56,275	54,163	55,689	51,782	41,345	42,422	34,606	28,192
	(50.0)	(51.2)	(49.1)	(47.8)	(44.4)	(36.8)	(36.1)	(29.7)	(24.1)
Agriculture	870	909	755	551	654	1,200	883	1,391	1,497
	(0.9)	(0.8)	(0.7)	(0.5)	(0.6)	(1.1)	(0.8)	(1.2)	(1.3)
Commerce	1,435	1,639	1,692	1,863	2,056	2,271	2,508	2,770	3,058
	(1.4)	(1.5)	(1.5)	(1.6)	(1.8)	(2.0)	(2.1)	(2.4)	(2.6)
Industrial	20,005	19,686	22,413	24,312	26,376	28,472	30,648	32,881	35,139
	(19.7)	(17.9)	(20.3)	(20.9)	(22.6)	(25.4)	(26.1)	(28.2)	(30.0)
Residential	953	989	1,015	1,064	1,107	1,166	1,233	1,297	1,361
	(0.9)	(0.9)	(0.9)	(0.9)	(0.9)	(1.0)	(1.0)	(1.1)	(1.2)
Transport	27,588	30,354	30,197	32,937	34,614	37,806	39,818	43,742	47,951
	(27.2)	(27.6)	(27.4)	(28.3)	(29.7)	(33.7)	(33.9)	(37.5)	(40.9)
Total	**101,607**	**109,852**	**110,235**	**116,416**	**116,589**	**112,260**	**117,512**	**116,687**	**117,198**
	(100)	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**
Advanced Scenario									
Electricity	50,752	52,795	40,823	28,128	22,219	20,247	18,576	15,890	12,515
	(50.4)	(50.1)	(43.3)	(33.3)	(27.7)	(25.2)	(23.2)	(19.8)	(15.3)
Agriculture	870	909	963	1,036	1,115	1,200	1,292	1,391	1,497
	(0.9)	(0.9)	(1.0)	(1.2)	(1.4)	(1.5)	(1.6)	(1.7)	(1.8)
Commerce	1,435	1,639	1,653	1,820	2,010	2,218	2,450	2,706	2,987
	(1.4)	(1.6)	(1.8)	(2.2)	(2.5)	(2.8)	(3.1)	(3.4)	(3.7)
Industrial	20,005	19,686	21,285	22,403	23,344	24,932	26,520	28,071	29,541
	(19.8)	(18.7)	(22.6)	(26.6)	(29.1)	(31.1)	(33.1)	(35.0)	(36.2)
Residential	951	988	854	906	956	1,016	1,084	1,154	1,227
	(0.9)	(0.9)	(0.9)	(1.1)	(1.2)	(1.3)	(1.4)	(1.4)	(1.5)
Transport	26,784	29,306	28,809	30,050	30,661	30,614	30,246	30,894	33,834
	(26.6)	(27.8)	(30.5)	(35.6)	(38.2)	(38.2)	(37.7)	(38.6)	(41.5)
Total	**100,797**	**105,323**	**94,387**	**84,343**	**80,305**	**80,227**	**80,168**	**80,106**	**81,601**
	(100)	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**	**(100)**

Note: Figures in parenthesis are in percentage shares.

Unlike the electricity sector, the transport sector has relatively less flexibility in terms of technological and fuel switching. Hence it is comparatively difficult to reduce CO_2 emissions from this sector unless (politically difficult) restrictions are placed on the use of personal transport. However, if a more aggressive reduction of CO_2 emissions becomes necessary, this particular sector would need to be targeted. The large volume of emissions in the Base scenario also indicates the extent to which emissions would need to be reduced in future, if more aggressive CO_2 reductions strategy becomes urgent. For example, in order to maintain the 1990 emission levels, the transportation sector would have to reduce its emissions by 80 percent by the year 2040. This also suggests that reduction strategy would need to be expanded beyond the electricity sector (where most current polices seem to focus on) to other sectors, particularly, the transport and industrial sectors.

The two alternative scenarios illustrate how CO_2 emission reductions can be achieved. In the Moderate scenario, the emission level is constrained at about 8 percent above the 1990 level, which corresponds with the Kyoto protocol limits (the Kyoto Protocol, however, includes emissions from other sources as well, such as land use, in addition to from energy combustion). In the Advanced scenario, the emission level is constrained at 25 percent below the 1990 level.

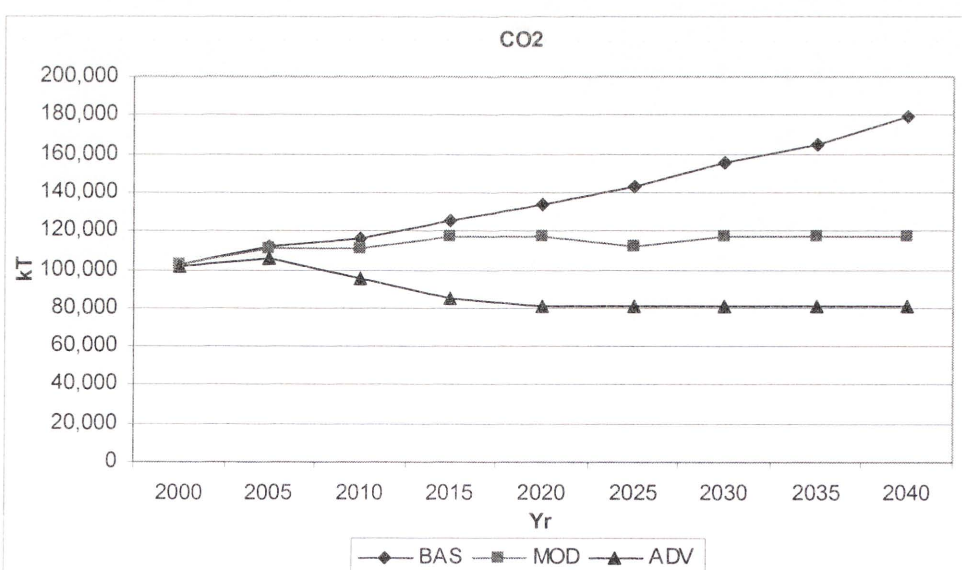


Figure 4-16: CO_2 Emissions

A large reduction in CO_2 emissions is achieved in the Moderate scenario mainly as a result of the use of cleaner fuels (natural gas, renewables), penetration by efficient plants in power generation (such as IGCC), efficiency improvement in end-use technologies, and fuel switching in the transport sector. Emissions from the power sector, for example, reduce by more than 60 percent in 2040 compared to the Base scenario. This result shows the potential for emission reduction in NSW if appropriate policies that promote energy efficiency and efficient plants could be implemented. It also shows how renewables can contribute in power generation, and hence help in reducing CO_2 emissions. While the huge reductions in CO_2 emissions could be achieved in power generation, the next important sectors that could contribute significantly in reducing CO_2 emissions are industry and transport.

In the Advanced scenario, CO_2 emissions are constrained, for the year 2040, to 25 percent below the 1990 level. This could be achieved with all the efficiency measures applied in the Moderate scenario plus further efficiency improvements in the transport sector, with increased uptake of hybrids vehicles, and also through carbon sequestration in the year 2015 and beyond. The emissions from the transport sector reduce to nearly half as compared to the Base scenario, mainly due to the efficiency improvements in road transport.

4.5.4 Comparison with the 'LTW' study

In this section, the scenario outcomes from this research are compared with the results for NSW from the "Living in Turbulent World (LTW)" study (SESSWG 2003). As mentioned in Chapter 2, the LTW study is the only study that provides some results detailed at the state level. Table 4-17 provides a comparison of key results.

Table 4-17 : Comparison of Results from This Research with the "LTW" Study

	2000	This Research BAS	This Research MOD	This Research ADV	LTW Study Global	LTW Study Fortress	LTW Study Green	LTW Study Muddling
		Annual Growth Rate (%) (2000-2030)						
GSP	259071[1] (M$)	3.1	3.1	3.1	2.3	1.9	2.6	2.4
Primary Energy	1,424 (PJ)	1.8	1.3	0.9	0.7	1	0.2	0.8
Energy Intensity	5.51 (MJ/$[1])	3.8	3.3	2.8	3.4	4.2	2.7	3.4
		Primary Energy Mix (%)						
Coal	50	31	15	15	58	51	52	48
Oil	36	41	39	38	23	25	16	24
Gas	10	19	27	23	15	19	26	24
Renewable	4	7	15	18	4	4	6	4

Source: This research and SESSWG (2003).

Notes: [1] – 2002–03 prices

The table suggest followings:

- The two studies show different growth rates for primary energy requirements over the period (2000-2030). This research suggests a relatively higher growth rates (0.9–1.8 percent) than the LTW study (0.2–1 percent). This is mainly due to the differences in assumptions of GSP growth rates in the two studies. Energy consumption is directly linked with economic growth, hence lower economic growth would also result in lower energy requirements. A better indicator to compare the two studies would be energy intensity, which represents the amount of energy required for a unit of economic output. The comparison of energy intensities between these two studies shows some similarities. For example, energy intensities in the Advanced scenario of this research and the "Green" scenario of the LTW study[43] are very close, 2.8 and 2.7 respectively, while growth rate for primary energy requirements are significantly different, by about four times (see Table 4-17). The energy intensity in the Moderate scenario of this research is closer to the energy intensity of the Global Convergence and Muddling Through scenarios of the LTW study. The energy intensity in the Base scenario (3.8 MJ/$) of this research is lower than in the Fortress scenario (4.2

[43] These two scenarios are essentially similar – driven by concern about CO_2 emissions. They both incorporate measures to improve energy efficiency in order to achieve CO_2 emission reduction.

MJ/$) of the LTW study, which illustrates that the Base scenario, which represents the current trend in this research, is more energy efficient than the Fortress scenario of the LTW study.

- Another stark difference between these two studies is in the composition of primary energy mix. In the LTW study, coal continues to play a dominant role in all four scenarios, occupying more than a 50 percent share in three of the four scenarios. In this research, the share of coal declines significantly to 15 percent in the Advanced scenario, for example. This reflects differences in the approaches considered in the two studies to reduce CO_2 emissions. The LTW study places relatively lower emphasis on CO_2 emissions (as evident from the amount of CO_2 emissions for Australia, which is higher than the 1990 emission level in all scenarios[44]). However, in this research, CO_2 emission reduction is one of the key factor that drives the scenarios (for example, in the Moderate and Advanced scenarios, CO_2 emissions are restricted to 108 percent and 75 percent of the 1990 emission level, respectively).

- In the LTW study, the share of oil reduces significantly, reflecting its concern towards oil supply security in this study. In this research, however, the share of oil continues to be comparatively high. This is because, in this research, oil demand in road transport reduces significantly, but demand in air transport continues to rise.

- Unlike coal and oil, the share of natural gas in total energy mix shows a lower level of differences. For example, the share of natural gas in the Base scenario (19 percent) is similar to the share in the Fortress scenario of the LTW study (19 percent). Similarly, the shares in the Moderate and Advanced scenarios are similar to the corresponding shares in the Green and the Muddling scenarios.

- Another difference across the scenarios is in how renewables play a role in the total energy mix. The LTW study shows that renewables would not emerge as a major sources of energy, for example, the share of renewables in 2030 remains

[44] The LTW study does not provide details on CO2 emissions at the state level.

the same as in the base year 2000 (except in the Green scenario, where it increases slightly to 6 percent), whereas in this research the share of renewables rises significantly, up to 18 percent in the advanced scenario.

4.6 Sensitivity Analysis on Nuclear Plants

The scenarios discussed so far have not considered nuclear plants as an option for power generation in NSW. This is due to the fact that at the start of this research, nuclear was not considered as a serious contender because of government regulations and general public sentiment towards nuclear power. The *Uranium Mining and Nuclear Facilities (Prohibitions) Act 1986 No 194* of the NSW Government, for example, prohibits the construction and operation of nuclear reactors for the purpose of generating electricity or any other form of energy (NSW Government 1986). Neither the federal government's White Paper (Australian Government 2004) nor the NSW government's Green Paper (NSW Government 2004) have considered nuclear plants as an option in the near future. The earlier scenario studies conducted in Australia (as discussed in Chapter 2) have also excluded nuclear plants, which reflects prevailing unacceptability of nuclear plants in the country. Some of the arguments against nuclear in these studies include: higher capital costs of construction and decommission; costly electricity compared to the conventional coal plant; long-term environmental and geo-strategic impacts of nuclear proliferation; and the anticipated difficulty in developing political consensus.

Recently, however, with heightened concerns for climate change, nuclear power debate has resurfaced. In Australia, for example, the Prime Minister of Australia appointed a taskforce to review nuclear energy in June 2006. In the US, MIT (MIT 2003) conducted a study to examine nuclear power as an option to reduce carbon emissions. The study examined four critical problems associated with a large expansion of nuclear power: cost, safety, waste and proliferation.

In Australia, the debate in nuclear power began in 2005 with Prime Minister John Howard welcoming a debate on the issue (Koutsoukis 2005). By the time this debate began, much of the modelling exercise in this research had been completed. In view, however, of the relevance of this issue in the current climates it was decided in this research that a separate sensitivity analysis for nuclear plants would be insightful. Three types of nuclear plants are considered in this research. Their costs are shown in Table 4-18. These costs are developed on the basis of select international reviews. For example, a survey conducted by the International Energy Agency (IEA) on nuclear power plants across the world reports the construction costs of nuclear plants vary between 1,000 US$/kW in Czech Republic to 2,500 US$/kW in Japan (IEA 2005). The cost varies for many reasons: the duration of the construction period, safety measures, size of plants and technology types. For the purpose of analysis in this research, a nuclear plant of Light Water Reactor type is added in the Advanced scenario. The light-water reactors (pressurised water reactors, PWR) are the most common reactors in the world (Percebois 2003). The Advanced scenario is chosen because this scenario has higher CO_2 emission constraints, hence, it is most appropriate for consideration of nuclear plant.

Table 4-18: Cost Data for Nuclear Plant

	Case 1	**Case2**	**Case 3**
Investment cost, $/kW	4000	3500	3000
Fixed Cost, $/kW	60	60	60
Variable cost, $/GJ	5	5	5
Life, yrs	40	40	40

Sources: MIT (2003) , IEA (IEA 2005)

The sensitivity analysis shows that if the investment cost of nuclear technology is $4,000/kW (Case 1), nuclear is not a cost-viable option (Figure 4-17). However, as the cost of plants falls to $3,500/kW, nuclear becomes competitive as compared to IGCC plants with CCS and begins to contribute in the technology mix. It therefore displaces IGCC plants with CCS under the assumption that CCS would cost $50/Ton of CO_2 removed. As a consequence of this, power generation from coal plants reduces – in the modelling in this research – to zero, after 2015. In Case 3, where the cost of nuclear power plant reduces further ($3,000/kW), the share of power from nuclear increases. In this case, some of power generation during the period 2015 – 2030 shifts from coal seam methane (CSM) based gas plants to coal thermal plants. Since nuclear plants do not emit CO_2, the increase in power generation from nuclear plants creates some space for other plants to emit CO_2 (while maintaining the total CO_2 emission at the constrained level, as specified for this scenario, that is, 25 percent below 1990 emission levels). The result of this is an increase in generation from cheaper but higher CO_2 emitting plants, such as coal thermal plants in place of the next expensive generating plants, which in this case are CSM-based plants.[45]

The following conclusions can be drawn from above analysis:

- In a situation where a large reduction in CO_2 emissions becomes necessary (as represented by the Advanced scenario), the nuclear option may become a viable option. In such a situation it would compete with the next costly plant, which in this case are the IGCC plants with CCS. These plants' competitiveness will increase further if an even larger reduction in CO_2 emissions becomes necessary, that is, beyond the current value imposed in the Advanced scenario, that is, 25 percent below of 1990 emissions level.

- The choice between nuclear and IGCC with CCS plants will depend very much upon how the capital costs of these plants improve in the future. The competitiveness of nuclear plant would increase if their capital cost declines below \$3,500/kW, and IGCC's competitiveness would increase if the cost of CO_2 sequestration in NSW reduces from the value assumed in this research (\$50/t CO_2).

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[45] **Comparison with the Nuclear Review Taskforce Report:** the sensitivity analysis on nuclear plants in this thesis was performed in 2005, the period when debate on nuclear power had just begun in Australia. In June 2006 the Prime Minister of Australia appointed a taskforce to review nuclear energy in Australia. The report from the taskforce came out in December 2006 (see Commonwealth of Australia (2006)). The key results of the taskforce report seem to support results derived in this research. These include, for example: (i) The taskforce finds nuclear power to be competitive only if the cost of greenhouse emissions is recognised (otherwise they would be 20% to 50% more costly than new coal-fired plants). This research finds nuclear power becoming competitive in the Advanced scenario only when CO_2 emissions are constrained at the highest levels (25% below the 1990 levels) (ii) The taskforce report finds the time period when nuclear electricity could be delivered to be around 2015. The results in this research also find nuclear power entering in the technology mix in 2015. (iii) The taskforce report finds nuclear power producing about a third of electricity by 2050. This research finds nuclear contributing about 25% of the total power in 2040.

- However, both of these technologies (that is, nuclear and IGCC with CCS) are characterised by many uncertainties at present – in the nuclear plants, for example, the cost of safe waste disposal, and, in the IGGC with CCS, the risks associated with long-term disposal of CO_2.

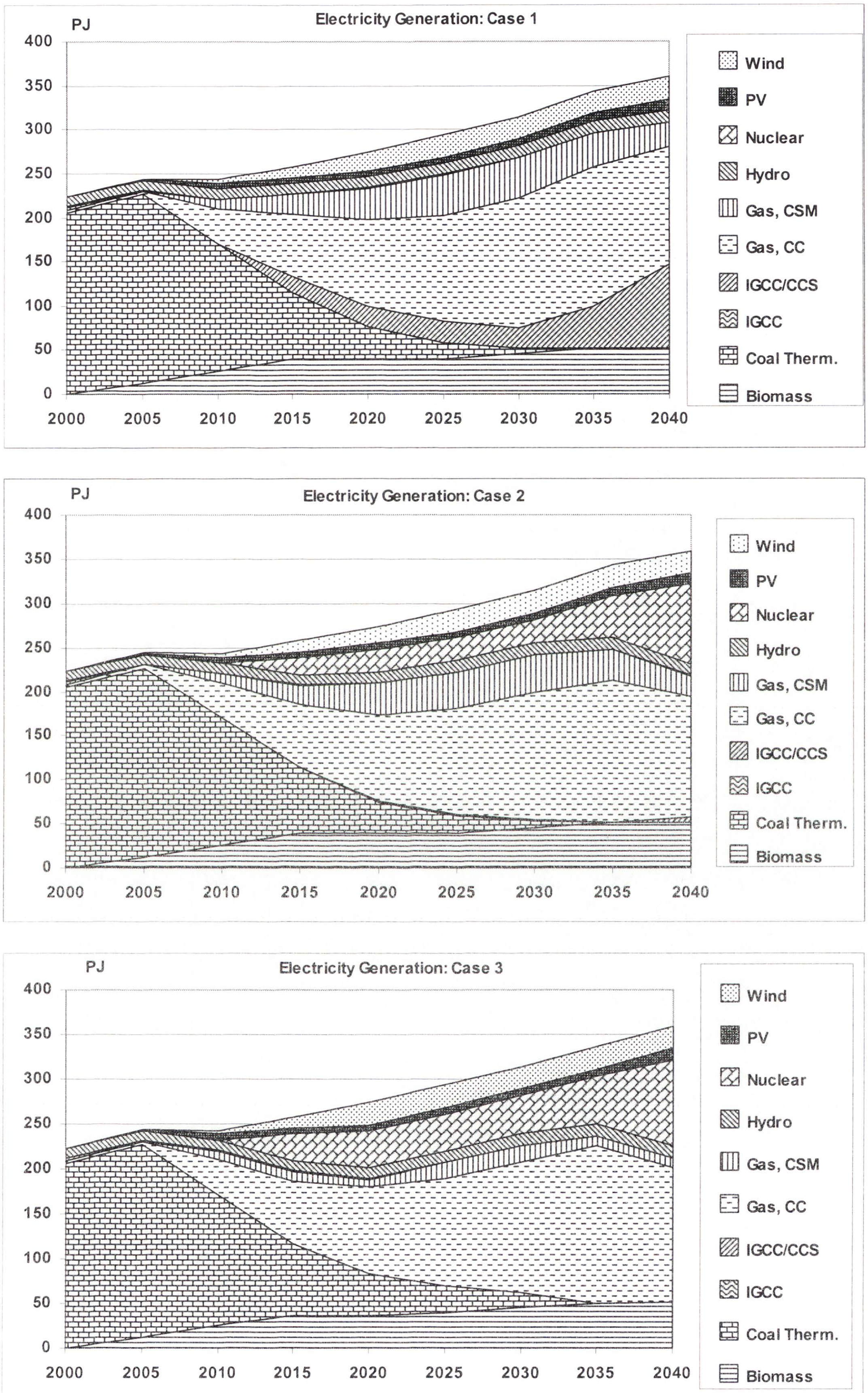

Figure 4-17: Electricity Generation: A Nuclear Scenario

There are five key concerns regarding the nuclear power development:

- First, the concern about the lengthy construction time and larger size required in nuclear plants. Nuclear plants have traditionally required a long period for construction, in a range of ten years, and the optimal size of capacity is normally of the order of 1,000 MW (unlike combined cycle gas plants, which could range between 300 to 400 MW). In reformed (restructured and increasingly privatised) energy market in NSW (and in Australia), as decision on power plants are made based on market profitability, nuclear may be disadvantaged. In one of the studies conducted in the UK, for example, Pena-Torres and Pearson (2000) find that privately owned reactors are very unlikely to win market place within a liberalised market, even with a consideration of possible carbon taxation and weighted political feasibility.

- Second, the concern about substantial uncertainties relating to the final waste disposal route. While geological disposable is technically feasible, it is yet to be executed and demonstrated anywhere in the world. In Australia, the debate about placing a nuclear dump in the South Australian deserts has been continuing for the past ten years, without any resolution (see Hogarth 1999).

- Third, if share of nuclear power increases, so would the risk of proliferation. There is a distinct possibility that nuclear technology/materials could be misused – to develop nuclear weapons.

- Fourth, how the public perceives nuclear plants would be a critical factor in its development. The public is generally sceptical about nuclear plants, due mainly concerns about safety and toxic waste disposal. While climate change is one of the key arguments being used to revive the nuclear debate, public response in this particular issue is generally found to be less than enthusiastic. For example, in Australia, while 95 percent of Australian electricity consumers have access to Green Power (electricity from renewable plants with negligible GHG emissions), only 1 percent of customers purchase Green Power, which amounts to less than half per cent of the total electricity sales in the country (MacGill, Outhred & Nolles 2006). In a survey conducted in the US, for example, the concern for global warning did not increase public preference for nuclear power development (MIT 2003). This shows that the argument about the perceived advantages of nuclear in combating climate change challenge is likely to have very little impact on improving its acceptability by public in general.

- Fifth, the equipment for the capital intensive nuclear plants would need to be imported from abroad, and, unlike fossil fuel plants, the cost of fuel in nuclear plant is not a significant cost. Thus a large share in the cost structure of nuclear would rely on imported goods; this could have negative implication for the balance-of-payment account (and the country's) balance of payment (see Uranium Information Centre Ltd. 2005). Nuclear plants are found to be most suitable for countries like Japan, Korea, and France, which lack fossil energy sources, and building capital intensive nuclear plants has the effect of stimulating local industries that build plant and at the same time minimises long term commitment to buying fuels from abroad.

4.7 Summary and Conclusions

This chapter analysed the energy implications of three possible energy pathways (scenarios) for NSW using an energy sector optimisation model (the MARKAL model). Table 4-19 provides a summary of key results. The analysis suggests the following:

- Without long-term policy measures in place – that is if the current trends in energy policy are allowed to continue – in the next forty years, the energy requirements in NSW will double, dependency on imported oil will increase significantly, potentially inviting energy insecurity, and CO_2 emissions will rise by about 80 percent. The Moderate and Advanced scenarios, underpinned by workable energy policies, demonstrate alternative pathways that could reduce energy consumption by as much as 28 percent below the base level, and CO_2 emissions up to 25 percent below the 1990 emission levels.

Table 4-19: Key Results from Scenarios

	BASE			MOD		ADV	
	2000	**2020**	**2040**	**2020**	**2040**	**2020**	**2040**
1. Primary energy							
Total, PJ	1,440	2,092	2,908	1,935	2,392	1,697	2,102
Growth (%/yr)	-	1.88	1.77	1.49	1.28	0.82	0.95
Coal	(49.3)	(36.1)	(30.7)	(35.7)	(14.9)	(16.9)	(15.0)
Oil	(36.4)	(38.0)	(41.0)	(34.6)	(39.5)	(37.9)	(37.7)
Gas	(7.7)	(17.6)	(19.3)	(17.0)	(27.4)	(24.3)	(23.4)
Ren	(4.0)	(6.1)	(6.7)	(10.2)	(15.3)	(15.4)	(17.6)
Per capita (PJ/per)	213	272	342	251	281	221	247
Diversity index	0.401	0.323	0.319	0.301	0.293	0.285	0.284
2. Electricity							
Total, PJ	223	328	477	307	393	274	360
Coal	(91.8)	(57.3)	(46.9)	(61.6)	(20.9)	(23.0)	(26.7)
Gas	(2.7)	(32.4)	(41.7)	(19.2)	(51.6)	(48.7)	(44.3)
Ren	(5.3)	(10.4)	(11.4)	(19.2)	(27.5)	(28.4)	(29.0)
3. Final energy							
Total, PJ	1,010	1,530	2,304	1,423	1,990	1,308	1,710
Agriculture	(1.4)	(1.2)	(1.1)	(1.3)	(1.2)	(1.4)	(1.4)
Commercial	(7.1)	(7.1)	(7.0)	(7.4)	(7.9)	(8.0)	(9.1)
Industrial	(38.2)	(37.9)	(37.6)	(38.0)	(37.2)	(39.4)	(40.3)
Residential	(12.1)	(11.6)	(11.7)	(10.0)	(8.7)	(9.2)	(8.6)
Transport	(41.2)	(42.2)	(42.7)	(43.2)	(45.0)	(42.0)	(40.6)
4. CO_2							
Total, Mtonnes	102.4	134.1	179.2	117.5	117.4	81.0	81.0
Per capita, ton	15.16	17.43	21.1	15.28	13.83	10.53	9.53
Per GSP, kg/$	0.395	0.281	0.204	0.246	0.134	0.169	0.092

Sources: Results of this research.

Note: Figures in parentheses are percentage shares of the total.

- The energy mix would go through a significant change over the study period (2000–2040). Historically, the energy mix in NSW has been dominated by two types of energy sources, coal and oil. The share of coal in the energy mix reduces in all scenarios, more significantly in the Moderate and Advanced scenarios (for example, from 49 percent in 2000, to 15 percent in 2040 in Advanced scenario), while the shares of natural gas, coal seam methane and renewable energy resources increase. The need to reduce CO_2 emissions plays a key role in prompting such shifts in the energy mix. The increased demand for natural gas would necessitate increasing the pipeline capacity by about three times the current capacity, and also access to the natural gas resources other than from eastern Australia.

- NSW would become increasingly dependent on imported oil if the current trends in oil consumption are allowed to continue. This would expose the state to increasing oil supply risks, especially as oil reserves in Australia decline (at the current rate of production, oil would last only for the next eleven years). An increased use of alternative fuels (CNG, methanol, and ethanol) in road transport and improvement in vehicle efficiencies, with the use of hybrid vehicles, could significantly reduce demand for imported oil. For example, oil import requirement could be reduced by 14 percent in the Moderate and by 42 percent in Advanced scenarios, by 2040.

- The electricity sector is likely to undergo a significant shift in the fuel and technology mix (with increased use of gas in place of coal), compared with the historical trends. These shifts would be mainly driven by the need to reduce CO_2 emissions. In the Base scenario, which is not constrained in terms of total CO_2 emissions, the NSW GHG Benchmark Scheme would play a key role in facilitating this shift. And, in other two scenarios, the shift results mainly from constraints on CO_2 emissions imposed in this research. These reductions in emission would be achieved through fuel switching, from coal to cleaner fuels such as natural gas and renewables (biomass, wind) and through the adoption of more efficient plants. The increased use of efficient IGCC plants would help coal to continue to play a long term role in power generation. This could however change if the cost of nuclear falls below $3,000/kW.

- The share of renewables in power generation would increase from 5 percent in 2000, to 19 percent and 28 percent in the Moderate and Advanced scenarios. The largest increment would occur in biomass and wind plants, contributing about 14 percent and 7 percent, respectively, in 2040 in the Advanced scenario. The increase in these shares would result from a direct commitment in these scenarios to expand renewable electricity.

- The transport and industrial sectors would continue to be the two major energy consuming sectors in all three scenarios. These two sectors would consume about 80 percent of the total final energy consumption in 2040, in all three scenarios. These sectors also provide large opportunities to reduce energy consumption and CO_2 emissions. The phasing-out of the coal intensive production technology in the iron and steel industry, such as Blast Oxygen Furnace (BOF) and the introduction of Direct Reduction Iron (DRI) technology which uses natural gas, would help significantly in reducing coal consumption and CO_2 emissions from industrial sectors. Similarly, oil consumption could be substantially reduced with improvements in vehicle efficiencies and the use of alternative fuels in the road transport. The residential and commercial sectors are relatively minor consumers of final energy, but are significant electricity consumers. Measures such as improving building envelope design, expansion of solar water heating, and efficiency improvement in refrigerators and lighting could reduce energy demand by up to 70 percent for the residential sector, thus resulting in significantly lower CO_2 emissions.

- CO_2 emissions are likely to increase significantly in the Base scenario. For example, by the year 2040, CO_2 emissions are expected to be 80 percent above the 2000 emission level. The power generation and transportation sectors are the two major sources of CO_2 emissions in NSW, currently responsible for 52 percent and 27 percent of total emissions respectively. The increase in CO_2 emissions, over the period 2000–2040, occurs even with the implementation of the current GHG Benchmark Scheme of NSW. The scheme helps in containing CO_2 emissions from power generation, but the emissions from the transport sector would rise, making this sector the largest emitting sector in 2040, contributing about 34 percent to total emissions in 2040. This suggests that more attention would need to be paid to the transport sector if a large reduction in CO_2 emissions is to be achieved. Similarly, increased attention would need to be paid to the industry sector in general, iron and steel industry in particular, in order to reduce CO_2 emissions.

5. Assessment of Economy-wide Impacts

5.1 Introduction

In the previous chapter (Chapter 4), the energy impacts of the three energy scenarios for NSW (developed in Chapter 3) have been assessed using an energy sector model (MARKAL model). This modelling provided estimates about the likely energy outcomes (impacts) over the next forty years. These impacts were expressed in terms of primary energy supply mix, final energy requirements (by fuel), power generation (by fuel and technological mix), and CO_2 emissions. Further, this modelling suggested that the energy impacts are likely to differ considerably across the three scenarios. Because of the linkages between energy and economy, these energy impacts are therefore likely to impact the economy of NSW to varying degrees. Also, these impacts would be felt by both the energy and non-energy sectors of the economy, because of the direct and indirect links between energy and non-energy sectors (for example, non-energy sectors consume energy produced by energy sectors and they in turn provide inputs needed by the energy sectors). It would be useful, from a policy perspective, therefore, to develop a deeper understanding about these impacts. For example, it would be useful to know how the implementation of policies intended to guide energy sector towards carbon constrained energy pathways (as represented by the Moderate and Advanced scenarios in this research) would impact different economic sectors, for example, in terms of changes in their total outputs, wages and salaries, employment, etc. Such information would assist the policy makers to determine which sectors would benefit and which sectors would suffer as a result of implementing a specific policy. This chapter aims to examine these economy-wide impacts for the three energy scenarios.

To examine these impacts, this chapter develops and applies an energy oriented input–output model. As explained in Chapter 2, the main advantage of using an input–output model is that it helps in capturing linkages across a large number of economic sectors. Unlike other economic models, such as macro-economic and general-equilibrium, input–output model has the capacity to examine the impacts on smaller segments of the economy, in response to individual sector-specific policies. In the energy modelling component of this research (described in Chapter 4), a detailed representation of various energy technologies considered in this research is provided. If such representation could be incorporated into input–output modelling, it would overcome a major drawback of economic models[46]. In this research, the economic input–output model is combined with the detailed energy model; this makes it possible to examine impacts at greater levels of detail, both for the energy and economic sectors. The impacts on the economic sectors are examined, in this research, in terms of changes in the total sectoral outputs (M$), wages and salaries (M$), employment levels (number of persons), total energy intensities (energy (MJ)/$ of economic output) and CO_2 intensities (CO_2 emission (kg)/$ of economic output).

This chapter is organised as follows: Section 5.2 describes the basic input–output framework and its extension, to include the energy sectors. Section 5.3 explains the method of combining the outputs obtained in energy modelling (Chapter 4) with the input–output analysis. Section 5.4 presents a brief overview of data related issues, in particular the basis for the aggregation of economic sectors, extension of the economic input–output table to take into account the energy sectors in detail, and forecasting of technical coefficients to the year 2040. Section 5.5 presents results of input–output modelling. Section 5.6 summarises the key findings of this chapter.

5.2 Input–output Framework

Basic input–output model

An input–output model represents an economy (of the state or other geographic economic unit) in a tabular form that contains production sectors, intermediate and final consumption sectors, and value added sectors. The table shows all transactions between these sectors in a particular year. These transactions can be represented in monetary or physical units. Each sector's production is consumed by intermediate sectors, and by final demand sectors (households, government, investment and exports).

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[46] The economic models (such as the general equilibrium model) generally suffer from a poor representation of energy technologies. This limitation is critical for analysing energy related issues because energy sector is characterized by a diverse types of technologies (such as power plants, refineries, boilers, furnaces, appliances, etc.) which are constantly evolving.

The basic balance equation of the input–output table is defined as,

$$X_i = \Sigma X_{ij} + Y_i \text{ .... } (5.1)$$

Where, X_i is the total output (X_i) produced by sector "i". "X_{ij}" represents the share of output of sector "i" consumed by sector "j" (also known as intermediate demand), and "Y_i" is the share of output of sector "i", consumed by the final demand categories (that is, household, government, investment and export).

Let, $a_{ij} = X_{ij}/X_j$.

Where, "X_j" is the total outputs of the sector "j". The coefficient a_{ij} thus represents the ratio of outputs (X_{ij}) delivered from sector "i" to sector "j" divided by the total output (X_j) of that sector "j". This ratio is known as the technical coefficient (or direct requirement coefficient); it shows the technical dependence between the two entities.

Equation (5.1) can be rewritten as follows,

$$X_i = \Sigma a_{ij} X_j + Y_i. \quad \text{.....} (5.2)$$

In an abbreviated, vector matrix format, the equation becomes,

$$X = AX+Y,$$

$$\text{or, } X = (I-A)^{-1} Y. \quad \text{....} (5.3)$$

Where, "A" is the matrix of technical coefficients (or direct requirement coefficients), and "I" is the unit matrix.

Equation (5.3) is the core of fundamental matrix representation of input–output analysis. It shows that the value of total output (X), depends upon the value of final demand (Y) and technical coefficients (A). The inverse matrix $(I-A)^{-1}$ is known as the Leontief inverse matrix (see Leontief 1966). The elements in the inverse matrix are known as "total requirement coefficients"; they represent total amount (direct and indirect) of the product that needs to be produced to meet a unit increment of final demand.

This research examines three different energy scenarios (Base, Moderate and Advanced). The expression (5.3) for the Base scenario can be written as follows,

$$X_{Base} = (I - A_{Base})^{-1} \, Y_{Base} \quad \ldots\ldots\ldots (5.4)$$

For the Moderate and Advanced scenarios, the values for final demand (Y) and technical coefficients are related to changes in energy inputs (as explained in Section 5.2). Thus the total outputs in these two scenarios can be computed as follows:

$$X_{MOD} = (I - A_{MOD})^{-1} \, Y_{MOD} \quad \ldots\ldots (5.5)$$

$$X_{ADV} = (I - A_{ADV})^{-1} \, Y_{ADV} \quad \ldots\ldots (5.6)$$

Where,

X_{Base}, X_{MOD} and X_{ADV} = Total outputs for Base, Moderate and Advanced scenarios;

A_{Base} A_{MOD} A_{ADV} = Technical coefficients for Base, Moderate and Advanced scenarios;

Y_{Base} Y_{MOD} Y_{ADV} = Final demands for Base, Moderate and Advanced scenarios.

From equations (5.4), (5.5) and (5.6), the differences in the outputs between alternative scenarios (Moderate and Advanced) and the Base scenario can be computed as follows:

$X_{MOD} - X_{Base}$ = Difference in total outputs between Moderate and Base scenarios.

$X_{ADV} - X_{Base}$ = Difference in total outputs between Advanced and Base scenarios.

Wages and salaries and employment levels are directly proportional to total outputs; thus changes in outputs across the scenarios also provide estimates of changes in wages and salaries and employment levels.

Energy oriented input–output approach

In the basic input–output table, the flows across the economic sectors (including energy sectors) are normally represented in monetary values (that is, in '000 \$). To apply input–output table for energy analysis (as proposed in this research), energy sectors need to be represented in greater detail. Two approaches are commonly practiced for such purpose. One approach is to leave the intermediate transaction table of the input–output table intact (that is, keeping all flows in monetary terms), and adding extra rows below the transaction table to account for each type of energy source consumed by the economic sectors. This approach is found to be useful in computing direct and indirect energy requirements of economic sectors. This approach could be further extended for the assessment of emissions (such as CO_2, SO_2, particulate matters) from energy activities by adding extra rows for each of these pollutants. In this approach, since energy is accounted for outside the intermediate transaction table, the flows from the non-energy sectors to energy sectors could not be accounted for.

Another approach for developing energy oriented input–output model involves a modification of the transaction table itself, to allow for the flows from the energy sector, expressed in energy units, PJ (see Casler & Wilbur 1984; Meier 1984; Miller & Blair 1985). This is illustrated in Figure 5-1. First, the economic sectors within the transaction table are separated into non-energy and energy sectors, usually allocating non-energy sectors in the upper rows and energy sectors in lower rows of the transaction table. At first, the flows in this transaction table would still be in monetary units. In the next step, data on energy consumption (by volume and energy type) are collected for each sector for the required year from various published sources, such as energy statistics. This energy data is then input into the energy sector rows to replace the flows that are previously presented in monetary units. Thus in this modified energy oriented input–output table, energy flows are now represented in energy units (PJ) and non-energy flows, in monetary units ('000 \$). The technological coefficients matrix (A), in such a table would take the form as shown in Figure 5-1, where these coefficients would be represented by four types of transactions, namely, from non-energy to non-energy sectors in '000 \$/'000 \$, from non-energy to energy sectors in '000 \$/PJ, from energy to non-energy in PJ/'000\$, and from energy to energy sectors in PJ/PJ.

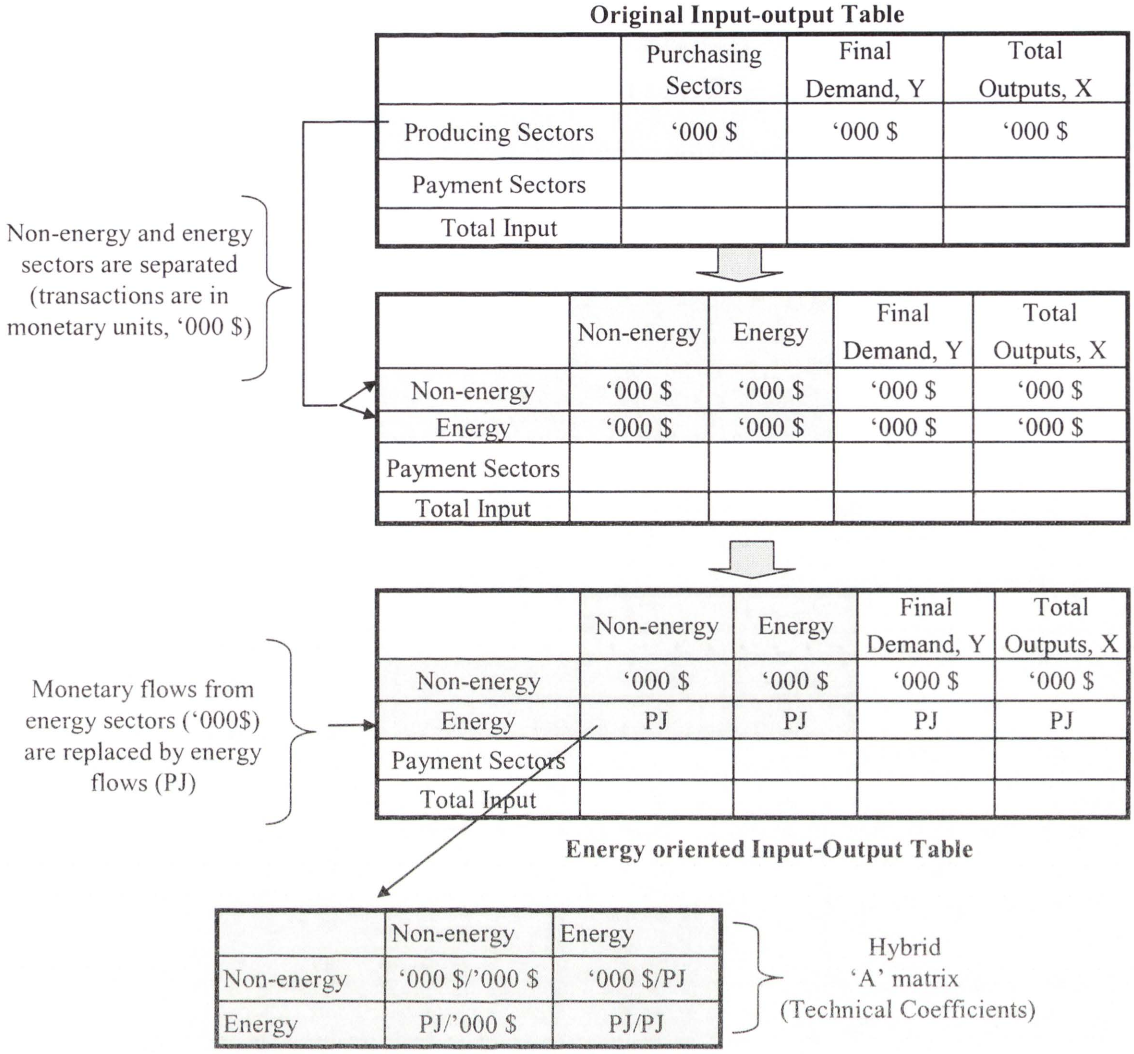

Figure 5-1: Energy Oriented Input–output Model: A Schematic Diagram

5.3 Input-output Table, Drivers of Impacts and Types of Impacts Analysed

Input-output Table. The input–output model employed in this research is adapted from the economic input–output table for NSW, for the year 2000-01. This table was developed at the Centre for Agricultural and Regional Economics, Armidale, NSW (Powell 2004), using the GRIT method (Generation of Regional Input–output Tables) (for details on GRIT method see Jensen and West, (1986)). This method used the national input–output table produced by the Australian Bureau of Statistics (ABS 2001a), together with state specific data. Figure 5-2 illustrates the structure of this input–output table. It has 106 intermediate sectors (similar to the national table) consisting 102 non-energy and 4 energy sectors. The primary inputs are divided into three components – household income, other value added and imports. The household income represents wages and salaries paid in each sector and imputed income for employers and self employed persons. For the purpose of clarity in this research, the term "wages and salaries" is used in place of the term "household income", as originally used in the NSW input–output table developed by Powell. The Other Value Added (OVA) includes rest of the primary inputs (except import), that is, it includes gross operating surplus, taxes less subsidies on products, and other indirect taxes less subsidies on production. The final demand is divided into three types – household, the other final demand (OFD) (which consists of government expenditure, capital expenditure of government, private and public and change in stocks) and exports.

		Purchasing Sectors			Final Demand			
		Non-energy Sectors	Energy Sectors	*Intermediate Outputs*	Household Demand	Other Final Demand	Export	Total Outputs
Producing Sector	Non-energy Sectors	102x102	102x4					C
	Energy Sectors	4x102 B	4x4 B		B			
	Intermediate inputs							
Primary inputs	Household income	C	C					
	Other Value added							
	Imports							
	Total inputs							
	Employment	C	C					

Transaction matrix, from which, 'A' matrix and $(I\text{-}A)^{-1}$ matrix are derived

B Drivers of Impacts: energy consumption values as derived from the energy model

C Impacts analysed in this research: Total outputs, wages and salaries (household income), and employment of production sectors.

Figure 5-2: Input-output Table

Drivers of Impacts. The economy wide impacts examined in this research (that is, impacts in terms of changes in total outputs, wages and salaries and employment in energy and non-energy sectors), arise as a result of the differences in energy consumption characteristics (for example, energy consumption levels, energy mix and technology mix as discussed in Chapter 4) of various economic sectors across the three scenarios. For use in the input–output model, these energy characteristics could be grouped into two types - direct and indirect energy consumption (These are shown in Figure 5-2 as shaded area, 'B'):

- **Direct energy consumption.** It includes energy consumed directly by the final consumers, which are accounted for as final demand in the input–output table. These include, for example, energy (electricity, gas, transport fuels) consumed by households and energy resources that are exported. The direct energy consumption (or final demand) vary across the scenarios, mainly due to the differences in consumer preferences for energy types (such as electricity, gas, or renewable in cooking), appliances (such as refrigerators, lightings, or solar water heaters), and energy conservation practices (such as insulating buildings envelope to reduce heating and cooling demand, using efficient transportation).

- **Indirect energy consumption.** Indirect energy consumption includes energy consumed by various intermediate (or production) sectors (for example, electricity, iron and steel, transport sectors), in order to produce various goods and services. They are accounted for in the inter-industry transaction matrix in the input–output table. As most of the energy in an economy is consumed by intermediate sectors rather than final demand sectors, indirect consumption is a critical component of input–output analysis.

  The scenario results (in Chapter 4) showed significant variation in indirect energy consumption across the three scenarios. The electricity sector, for example, showed differences in terms of fuel mix (for example, shares of coal, natural gas and renewables), and technology mix (for example, power plants shifts from coal plants to natural gas plants, and renewable-based plants, such as wind, biomass and PV). In 2020, for example, the share of coal, gas and biomass plants in the total electricity generation are 57, 32, and 8 percent, respectively, in the Base scenario, and 23, 48, and 14 percent, respectively, in the Advanced scenario.

  The level of indirect energy consumption by various sectors (such as industrial, transport, service, etc.) also showed significant differences across the scenarios. For example, the iron and steel industry showed fuel switching taking place from coal to gas, as steel production shifted from the coal-based Blast Furnace and

Blast Oxygen Furnace technology to gas-based Direct Reduced Iron (DRI) technology (for example, the share of steel production in 2020 from the DRI technology is 20 percent of the total in the Moderate scenario, compared with its share of zero percent in the Base scenario). Similarly, in transport sectors, alternative fuels, such as bio-fuels and natural gas replace petroleum products to some extent. Furthermore, improvement in energy efficiency in these sectors also results in reduced demand for energy, such as in electricity and other energy sources like coal, gas and renewables. Energy consumption in road transport, for example, declines significantly, with the use of efficient hybrid vehicles.

Economic Impacts. The differences in energy consumption across the three scenarios (as discussed in Chapter 4) would result in different levels of sectoral economic activities. For example, when electricity sector switches fuel from coal to gas, its immediate impact would be felt by the coal sector, in the form of reduced demand for coal output. As outputs from the coal sector decline, this sector would need less input from other economic sectors (such as, service to mining, rail transport). Hence, outputs of these economic sectors (from which the coal sector purchase its inputs) would also decline. The repercussions of such decline would then flow to other related sectors. Also, as more gas is used (instead of coal) there would be not only an increase in the outputs in the gas sector, but also in other economic sectors from which the gas sector purchases its inputs. In the input–output model, these economy-wide impacts could be examined at disaggregated levels.

In this research, the economic impacts are examined in terms of the changes in total sectoral outputs, wages and salaries, and employment levels (as represented by area "C" in the Figure 5-2) in the Moderate and Advanced scenarios in comparison with the corresponding values for the Base scenario. Further, impacts on energy and CO_2 intensities of the economic sectors (that show the relationship between energy consumption and CO_2 emissions with economic outputs) are also examined. These impacts are analysed in this research using an input–output framework as explained in Section 5.2.

5.4 Model Setup, Data Preparation and Computation

This section explains how the input–output model employed in this research was setup for analysis. In particular, it provides an explanation for the adjustments made to the basic model in terms of aggregation and disaggregation of various economic sectors, representation of energy technologies, and the projection of technical coefficients for future periods.

Model setup

The input–output model in this research is set-up in Microsoft Excel spreadsheet for the purposes of various computations. This input–output model essentially consists of a transaction table from which various matrices (for example, technical coefficients (A), Leontief inverse matrix $(I\text{-}A)^{-1}$) are derived through a series of matrix computations (matrix inverse, and multiplications) using Microsoft Excel software.

Aggregation and disaggregation of economic sectors

The original input–output table for NSW, for the year 2000–01, consists of 106 intermediate sectors. Of this, 102 are non-energy sectors and 4 are energy sectors. In this research, this input–output table is modified in two respects: the non-energy sectors are aggregated into 32 sectors, and energy sectors are disaggregated into 16 sectors (see Figure 5-3).

A. Original Input-output Table

Original table consists of 106 intermediate sectors (102 non-energy and 4 energy): all transactions are in monetary unit ('000 $)

	Non-energy Sectors (102)	Energy Sector (4)	Final Demand, Y	Total Outputs, X
Non-energy Sectors (102)	102 x 102	102 x 4		
Energy Sectors (4)	4 x 102	4 x 4		
Primary Inputs				
Total Input				
Employment[1]				

B. Aggregated Input-Output Table (36X36 sectors)

The economic sectors are aggregated to 36 sectors (based on two digit level ANZAC code): 32 non-energy, and 4 energy sectors.

	Non-energy Sectors (32)	Energy Sector (4)	Final Demand, Y	Total Outputs, X
Non-energy Sectors (32)	32 x 32	32 x 4		
Energy Sectors (4)	4 x 32	4 x 4		
Primary Inputs				
Total Input				
Employment[1]				

C. Energy oriented Input-Output Table

Energy sectors are further disaggregated into 16 sectors and represented in energy unit (PJ).

	Non-energy Sector (32)	Energy Sectors (16)	Final Demand, Y	Total Outputs, X
Non-energy Sectors (32)	Quadrant 1 (32x32) ('000 $/'000 $)	Quadrant 2 (32x16) ('000 $/PJ)		
Energy Sectors (16)	Quadrant 3 (16x32) (PJ/'000 $)	Quadrant 4 (16x16) (PJ/PJ)		
Primary Inputs				
Total Input				
Employment[1]				

Note: [1] Employment here refers to the number of employed persons

Figure 5-3: Development of Energy Oriented Input–output Table

The aggregation of non-energy sectors follows ANZSIC classification (ABS 1993), to a two digit level of classification (see Table D-1, p 275, Appendix D). Further, those sectors which are important from energy consumption viewpoint (that is, those that are energy intensive) are treated separately. For example, 'service to mining sector' is treated separately instead of aggregating it with the mining sector. This is because 'service to mining' sector provides a major input to the 'coal sector'. The coal sector constitutes a major mining activity in NSW, accounting for nearly 74 percent of mining income in NSW in 2000 (ABS 2001b). If the 'service to mining' sector is combined with 'other mining' sectors (such as copper, lead, zinc), the purchases made by the coal mining sector may appear as if it is purchasing from the 'other mining' sectors (that is, copper, lead, etc.) as well, which could present a distorted picture. Similarly, energy intensive basic metal sectors such as iron and steel and basic nonferrous are treated separately instead of treating them as one basic metal sector.

The input–output table available for NSW does not represent energy sectors in detail (this shortcoming is also evident in the national input–output table). Since this research is more interested in analysis of energy related issues, the energy sector needs to be represented comparatively in more detail. This is accomplished by disaggregating these 4 energy sectors into 16 energy sectors, to include sectors, such as, energy mining, power generation, fuel processing, etc. (see Table D-2, p. 277, Appendix D).

Energy technologies

The input–output model developed in this research makes an effort to represent energy technologies which are considered in the three energy scenarios, in order to investigate the economic impacts of responses to policy-induced changes in technology-mix. While it is not possible to represent each energy technology in the input–output table at the same level of detail as is possible in the energy sector model (that is, MARKAL), all energy-significant technologies have been included in this research. These technologies mainly belong to two groups, namely, technologies that generate electricity, and technologies that produce alternative fuels for transportation. For example, electricity could be generated from alternative plants such as wind and solar, which have quite different characteristics in terms of inputs required as compared to the conventional power plants, such as coal. These renewable plants do not require fuel inputs, and major purchases made by these plants include equipment, fabricated metals, construction services, which are usually capital intensive inputs. The general trend in input–output analysis has been to treat hydro as a proxy for all renewable-based technologies (see, for example, Proops et al. (1993)). This could be erroneous because inputs required by different types of renewable technologies vary widely. For example, inputs required by hydropower plants are typically dominated by civil construction materials, whereas the inputs required by wind power plants are dominated by fabricated metals. Thus by treating various renewable-based plants separately would increase the accuracy of analysis. However, data at that level of detail are not readily available. In this research, these estimates (that is, inputs needed by renewable plants) have been developed from several sources (see Appendix D, p. 278, Table D-3) -- for wind and biomass, they are from the UK study (ETSU 1998) and IEA (2003), and for the PV from Redding Energy Management (1999) and from Gaffney (2005). This research assumes that these data are valid for Australia as well.

In the input–output table, the capital expenditure by a plant is treated as an intermediate demand rather than final demand. This assumption would introduce conservatism in the estimates of various impacts, as not only these plants buy inputs from other economic sectors, but also sells their outputs (such as electricity) to other sectors. The rationale for treating capital expenditure as part of the intermediate demand can be found in Miller et al. (1985) and Lenzen (1998). It is also explained in Miller and Blair (1985) in the context of the development of dynamic input–output models.

The technical coefficients for various plants are computed, in this research, on the basis of the purchases that would be made by these plants per MWh of electricity generation. The purchases are then converted into annuities (annual purchases), taking into account the economic life spans of plants. There are two reasons for treating them as annual purchases. First, if these purchases are accounted for the year when the plants are actually installed, there would be a surge in economic activity for that particular year only (that year may not necessarily be the year of publication of the input–output table), and for other years the energy from these plants would be available at no costs. This would clearly distort results if one's interest is to analyse the impacts of a long run nature. Second reason: because wind and PV plants are available in smaller capacities (compared with the conventional thermal plants), the installation of wind and PV plants can be assumed as if these plants are installed in an incremental order, with small units installed every year (rather than a huge capacity installed in a one or two year period). Thus the inputs associated with such incremental increase in capacity will not differ much from the inputs associated with the capacity spread over its life time. A similar example can also be found in Lenzen and Dey (2002), where the authors use average values of the capital cost of a solar thermal plant over its life time of 25 years, in order to compare its impacts with that of a typical fossil-based thermal plant. Thus the coefficients computed on the basis of the above noted assumption represent annualized inputs that would be purchased by various plants per unit of energy produced. In reality, when the plants are installed, the purchases are made during the construction period, typically about 3 years.

Projecting technical coefficients into the future

Much of the input–output analysis is typically based on the assumption that technical coefficient are fixed (constant), that is, they do not change over time, in response to changes in final demand or other policy stimuli. This, argue some, implies that input–output framework is valid for short-term analysis only. Others argue that fixed proportionality of coefficients does not significantly compromise the quality of long-term analysis based on input–output framework. For example, Isard (1960) offers an interesting perspective on the use of input–output approach for future study: *"We may grant that the input–output technique cannot incorporate into its framework unforeseeable technological change (and new products). But neither can any other existing social science techniques.... It can be argued that we are less likely to overlook important possibilities for technological change when we construct the projection within the detailed systematic, and consistent framework of an input–output table"* (Isard 1960). There are several studies where input–output framework has been used to analyse long-term future scenarios. These studies have used largely fixed technical coefficients, or coefficients with minor modifications, such as modifying the energy input coefficients, to account for changes in energy inputs. Proops, Faber and Wagenhals (1993), for example, used this method to explore a number of scenarios spanning 20 years, for Germany and the UK – to investigate the effects of changes in final demand, energy efficiency, and interfuel substitution on CO_2 emissions. Murthy, Panda and Parikh (1997) used input–output model to analyse CO_2 emission scenarios for India upto 2005, using constant technical coefficients, derived from the 1990 input–output table. They also examined the effects of minor modifications in the coefficients that are related to energy inputs (coal, oil and electricity), by reducing the coefficients, somewhat arbitrarily, by 10 percent, to account for energy conservation. Lei (2000) applied input–output table of 1992 to forecast various energy scenarios for China upto 2020, using constant (1992) technical coefficients. Cruz (2002) also applied input–output table of 1992 to conduct scenario analysis upto 2010 for Portugal using constant technical coefficients.

In reality, however, technical coefficients are likely to change overtime. This could be due, for example, to changes in technology, fuel-mix, production-mix and production volumes. A challenge in input–output analyses is – how to accommodate these changes in technical coefficients? There are several methods to achieve this. For example, "Trends and Extrapolation" (Tilanus, 1966); "Marginal Input Coefficients" (Tilanus, 1967); "Best Practice Firms" (Miernyk, 1965); and "RAS" method (Stone, 1961).

This research adopts the RAS method to develop longer term projection of technical coefficients. A brief description of this method and the justification for its application in this research is provided in the next section.

The RAS method. The RAS method was developed by Stone (1961). This method assumes that changes in technical coefficients can be summarized by biproportional relationships in which each industry is characterized by a substitution multiplier (R), and a fabrication multiplier (S). These multipliers are assumed to operate uniformly over the rows and columns of the matrix. The substitution multiplier (R) measures how a particular commodity has been substituted by other commodities. It refers to the emergence of substitutes as production inputs, for example, the use of plastic products in place of metals. The fabrication multiplier (S) measures how the absorption of intermediate inputs as a proportion of the total input changes. It refers to the changes in the proportion of value added items in a sector's total purchase.

The RAS approach involves finding a set of values for "R" and "S", which when applied to the base year coefficient matrix, provides a matrix whose elements comply with the observed totals of intermediate outputs and inputs, by industry, for the year for which an updated matrix is required.

To use the RAS approach, three parameters are needed for the target year for which forecast of coefficients are to be made. They are, total outputs (X); intermediate demands (U); and intermediate supply (V). Normally these values are known for the past years from national accounts but not for future. If technical coefficients are to be forecasted for future years, it requires estimating these values for the target year (see Miller & Blair 1985, p. 283).

Thus, to project coefficients for the year 2040, before applying the RAS approach, we need first to estimate X (40), U (40) and V(40) for the year 2040. In this research, the approach suggested by Watanabe and Shishido (1970) is followed to estimate these three parameters. First, we estimate total outputs, X(40), for the year 2040 for each sector, relying upon energy demand of each sector as input in the MARKAL model for the reference scenario. With X(40) known, we then estimate tentative intermediate inputs U(40), and intermediate supply V(40) for the year 2040, by multiplying A(01) matrix of 2001 year with X(40) of 2040.

Next, based on the three input–output tables available for NSW (1992–93, 1995–96, and 2000–01), we compute adjustment factors (C and D), for intermediate demand and intermediate supply as follows. These adjustment factors take into account the evolution of intermediate demand and supply between different input–output tables.

U(96) = C1.U(93), V(96) = D1.V(93), and
U(01) = C2.U(96), V(01) = D2.V(96).

The values of C and D computed above are then compared with the adjustment factors computed based on U(01) and V(01) for 2001, and tentative U(40), V(40) for 2040. Wherever discrepancies are observed they are revised to develop a revised series of C and D. Finally, U (40) and V(40) for the target year are calculated as follows:

U (40) =C.U(01), V (40) =D.V(01).

Now, with X (40), U (40) and V (40) known, the RAS approach is used to compute coefficients for 2040 as follows,

$A(40) = R.\ A(01).\ S$

The values of R and S are computed by numerous iterations, as follows:

The first iteration begins with the computation of U^1, which is given by,

$U^1 = [A(01)\ .\ X(40)]\ .\ I$, where I is an identity matrix.

R^1 is then computed as, $R^1 = U(01)/U^1$

The first adjusted matrix is computed as, $A^1 = R^1\ A(01)$

The elements of R^1 assure that the row sum of $A^1.X(40)$ equals U(40). The next step is to adjust the column sum of A1.X(40) to match with V(40).

$V^1 = I'.\ [A^1.X(40)]$.

Then S^1 is computed as, $S^1 = V(40)/V^1$

It gives the second adjustment matrix, A^2, as,

$A^2 = A^1.S^1$

The procedure is repeated again, that is, U^2 is computed next, followed by V^2 and so on.

The iteration is continued for "n" number of times until $U(40)\text{-}U^n = 0.001$, $V(40)\text{-}V^n = 0.001$.

From the above discussion it is noticed that this method is attractive in terms of operational simplicity, mathematical clarity, and requirement of a minimum set of data. This method is "*...perhaps the best known and most widely used technique for revising or projecting input–output relationships given only the bare minimum of information...*"

(Allen 1970). This method is used in Australia, for example, by Australian Bureau of Statistics to develop national input–output tables (see ABS, 1997). The other techniques, such as 'trends and extrapolation', 'marginal input coefficient method', have been found to provide results which are, in some cases, worse than those obtained by using constant coefficients (Tilanus 1966).

Model-Run

The computation process in the input–output modelling involves representing input–output table in a matrix form and then performing matrix operations. The handling of large matrices could be a complex and time consuming process. A Microsoft Excel program was used in this research to perform various matrix operations. The results of these computations are organised in this research in terms of total sectoral outputs, wages and salaries, employment, total energy intensities, and total CO_2 intensities. The next section presents these results.

5.5 Results and Discussions

Tables 5-1 and 5-2 provide results of input–output modelling carried out in this research (as explained in Sections 5.2, 5.3 and 5.4).

5.5.1 Total Sectoral Outputs

The total output of an economic sector (for example, agriculture, mining), in an input–output table, is the sum of the outputs that are consumed by the intermediate sectors and by final consumption sectors (that is, households, government, investments and exports sectors). Tables 5-1 and 5-2 show, for the years 2020 and 2040, respectively, the impacts on sectoral outputs associated with different levels of energy outcomes (for example, consumption, technology and fuel mix) specific to Moderate and Advanced scenarios. These impacts are expressed in these tables in terms of the differences between the output values for Moderate/Advanced and Base scenarios (The outputs for the Base scenario are also shown in the table). Further, the energy input–output framework used in this research is defined in hybrid units (M$, and PJ). Hence, the outputs generated are also provided in two types of units, namely, monetary units (in M$) for the non-energy sectors, and in physical units (PJ) for the energy sectors. Some major results are presented below:

- The sectors that exhibit comparatively high values of total outputs in the Moderate and Advanced scenarios (as compared with the Base case scenario) are the agriculture, other equipment, construction, and fabricated metal. The total output of the agriculture sector, for example, is $273 million (2.2 percent) and $288 million (2.3 percent) higher, respectively, in 2020, for Moderate and Advanced scenarios, respectively – as compared with the Base scenario. The higher values of total outputs in the Moderate and Advanced scenarios are due to the increased use of agricultural products in biomass-based power generation, and also for producing alternative transport fuels (such as ethanol). Electricity generation from biomass plants, for example, is 17.6 and 39.8 PJ in the Moderate and Advanced scenarios, respectively, which is significantly higher as compared with the Base scenario (8.3 PJ). Further, the total requirement coefficients[47] in the $(I-A)^{-1}$ matrix, for the Moderate scenario, in 2020 (see, D-13, p. 288, Appendix-D) also show that the total outputs (that is, direct plus indirect) required from the agriculture sector are significantly higher for the biomass plant (835.6 thousand $/PJ) than for the coal (7.6 thousand $/PJ) and gas plants (5.4 thousand $/PJ).

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[47] Total requirement coefficient represents the cumulative (that is direct and indirect) outputs that must be produced by a sector in response to one unit increase in the final demand for the output of that sector (see Section 5-2).

Table 5-1: Economic Impacts of Alternative Scenarios for 2020

	Sectors	BAS			MOD			ADV		
					Differences in[1]			Differences in[1]		
		Total Outputs (M$)	Wages and salaries (M$)	Employment (Persons)	Total Outputs ('000$)	Wages and salaries ('000$)	Employment (Persons)	Total Outputs ('000$)	Wages and salaries ('000$)	Employment (Persons)
	Non-energy sectors									
1	Agri., hunting and trapping	12,549	3,892	89,907	273,201	84,727	1,957	288,327	89,418	2,066
					(2.18)[2]	*(2.18)*	*(2.18)*	*(2.30)*	*(2.30)*	*(2.30)*
2	Forestry and fishing	1,254	295	5,190	493	116	2	-3	-1	0
3	Mining	3,274	345	4,778	444	47	1	-1,201	-126	-2
4	Services to mining	679	104	1,196	-792	-121	-1	-5,969	-912	-11
5	Meat and diary prod.	11,065	1,099	22,480	1,166	116	2	395	39	1
6	Other food prod.	19,222	1,969	36,751	8,136	834	16	7,802	799	15
7	Beverage and tobacco	16,196	791	13,418	-118	-6	0	-1,155	-56	-1
8	Textile, clothing, leather	17,729	2,511	47,630	784	111	2	-784	-111	-2
9	Wood, paper, printing	40,338	6,320	122,796	4,019	630	12	-8,717	-1,366	-27
10	Basic chemical	3,040	171	2,703	-2,620	-147	-2	-15,286	-860	-14
11	Other chem., rubber, plastic	16,457	1,327	23,676	3,426	276	5	-15,219	-1,227	-22
12	Non-metalic mineral	7,614	950	14,876	1,805	225	4	-6,080	-758	-12
13	Iron and steel	20,450	1,785	29,273	14,825	1,294	21	3,879	339	6
					(0.07)	*(0.07)*	*(0.07)*	*(0.02)*	*(0.02)*	*(0.02)*
14	Basic non-ferrous	11,260	801	11,485	4,795	341	5	2,187	156	2
15	Fabricated metal	4,547	742	14,583	24,631	4,021	79	1,770	289	6
					(0.54)	*(0.54)*	*(0.54)*	*(0.04)*	*(0.04)*	*(0.04)*
16	Transport equip.	10,743	940	18,907	-814	-71	-1	-5,208	-456	-9
17	Other equip., manufacturing	37,567	3,262	77,473	214,149	18,596	442	166,224	14,434	343
					(0.57)	*(0.57)*	*(0.57)*	*(0.44)*	*(0.44)*	*(0.44)*
18	Water and sewerage	4,326	445	6,951	-4764	-491	-8	-11,390	-1,173	-18
19	Construction	25,285	8,818	191,145	44,865	15,646	339	36,109	12,592	273
					(0.18)	*(0.18)*	*(0.18)*	*(0.14)*	*(0.14)*	*(0.14)*

Table 5-1 continued on next page

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	Sectors	BAS			MOD			ADV		
					Differences in[1]			Differences in[1]		
		Total Outputs (M$)	Wages and salaries (M$)	Employment (Persons)	Total Outputs ('000$)	Wages and salaries ('000$)	Employment (Persons)	Total Outputs ('000$)	Wages and salaries ('000$)	Employment (Persons)
	Non-energy sectors									
20	Trade and repair	72,740	22,189	600,074	804	245	7	-48,284	-14,729	-398
					(0.00)	*(0.00)*	*(0.00)*	*(-0.07)*	*(-0.07)*	*(-0.07)*
21	Accomodation, café	20,849	4,362	157,044	-3,022	-632	-23	-14,401	-3,013	-108
22	Road transport	16,013	3,901	82,927	2,767	674	14	-16,579	-4,039	-86
23	Rail, pipeline	2,422	750	11,135	-5,363	-1,660	-25	-16,713	-5,174	-77
24	Water transport	3,504	293	4,142	-14,145	-1,182	-17	-30,244	-2,526	-36
25	Air and space travel	14,624	3,051	31,723	-2,891	-603	-6	-10,812	-2,255	-23
26	Services to transport	2,082	308	5,860	-5,055	-749	-14	-20,525	-3,040	-58
27	Communication	16,222	3,921	60,435	-2,918	-705	-11	-17,030	-4,117	-63
28	Finance and insurance	39,181	10,544	145,921	-17,719	-4,768	-66	-68,000	-18,300	-253
					(-0.05)	*(-0.05)*	*(-0.05)*	*(-0.17)*	*(-0.17)*	*(-0.17)*
29	Property and business	123,680	19,875	368,090	-29,347	-4,716	-87	-74,069	-11,903	-220
					(-0.02)	*(-0.02)*	*(-0.02)*	*(-0.06)*	*(-0.06)*	*(-0.06)*
30	Govt. admin and defence	19,197	6,818	113,013	-1,176	-418	-7	-4,761	-1,691	-28
31	Edu., health, community	41,984	23,011	490,261	-1,588	-870	-19	-9,773	-5,357	-114
32	Personal and other services	25,583	8,752	182,670	-1,817	-621	-13	-8,789	-3,007	-63
					(-0.01)	*(-0.01)*	*(-0.01)*	*(-0.03)*	*(-0.03)*	*(-0.03)*

Table 5-1 continued on next page

Table 5-1 continued from previous page

	Energy Sectors	Total Outputs (PJ)	Wages and salaries (M$)	Employment (Per)	Differences in[1]			Differences in[1]		
					Total Outputs (PJ)	Wages and salaries ('000$)	Employment (Persons)	Total Outputs (PJ)	Wages and salaries ('000$)	Employment (Persons)
1	Electricity[3]	317.47	997	12175	-20	-61,701	-753	-50	-155,670	-1,900
					(-6.19)	*(-6.19)*	*(-6.19)*	*(-15.61)*	*(-15.61)*	*(-15.61)*
2	Gas supply	385.34	213	2454	-49	-27,046	-311	86	47,875	551
					(-12.68)	*(-12.68)*	*(-12.68)*	*(22.44)*	*(22.44)*	*(22.44)*
3	Petroleum Product	748.59	214	2386	-117	-33,642	-374	-143	-41,011	-456
					(-15.69)	*(-15.69)*	*(-15.69)*	*(-19.12)*	*(-19.12)*	*(-19.12)*
4	Coal	3647.10	1,029	8693	-65	-18,377	-155	-470	-132,674	-1,121
					(-1.79)	*(-1.79)*	*(-1.79)*	*(-12.89)*	*(-12.89)*	*(-12.89)*
5	Others[4]	95.41	-	-	112	19,690	219	142	11,608	129
					(117.39)			(148.83)		

Source: Results obtained from input–output modelling in this research (the methodology for this modelling is explained in sections 5.3 and 5.4).

Notes:
1 These values show differences in comparison with the Base scenario values.
2 Values in the parentheses represent percentage differences from the corresponding values for the Base scenario. These percentages are provided in this table for select key sectors only (that is, for those that experience significant impacts, as also discussed in the text).
3 Electricity includes eight different energy technologies for power generation (such coal plant, gas plant, etc.).
4 Others include five different energy sectors characterised by energy types, namely, biomass, methanol, ethanol, CNG, and biodiesel.

Table 5-2: Economic Impacts of Alternative Scenarios for 2040

	Sectors	BAS			MOD			ADV		
					Differences in[1]			Differences in[1]		
		Total Outputs (M$)	Wages and salaries (M$)	Employment (Persons)	Total Output ('000$)	Wages and salaries ('000$)	Employment (Persons)	Total Output s ('000$)	Wages and salaries ('000$)	Employment (Persons)
	Non-Energy Sectors									
1	Agri., hunting and trapping	18629	5777	94,337	483,394	149,913	2,448	480,767	149,099	2,435
					(2.59)	*(2.59)*	*(2.59)*	*(2.58)*	*(2.58)*	*(2.58)*
2	Forestry and fishing	1860	437	5,444	353	83	1	69	16	0
3	Mining	5691	599	5,871	-114	-12	0	-1,913	-201	-2
4	Services to mining	1180	180	1,470	-5,282	-807	-7	-5,738	-877	-7
5	Meat and diary prod.	16004	1589	22,982	1,127	112	2	469	47	1
6	Other food prod.	27802	2848	37,573	9,141	937	12	8,521	873	12
7	Beverage and tobacco	23426	1144	13,718	-297	-14	0	-1,213	-59	-1
8	Textile, clothing, leather	25635	3630	48,679	419	59	1	-1,158	-164	-2
9	Wood, paper, printing	58324	9138	125,493	3,082	483	7	-12,490	-1,957	-27
10	Basic chemical	4393	247	2,761	1,079	61	1	-30,091	-1,693	-19
11	Other □hem.., rubber, plastic	23794	1918	24,196	-3,143	-253	-3	-23,927	-1,929	-24
12	Non-metallic mineral	10998	1372	15,187	-2,575	-321	-4	-10,712	-1,336	-15
13	Iron and steel	39188	3420	39,650	12,027	1,050	12	1,399	122	1
					(0.03)	*(0.03)*	*(0.03)*	*(0.00)*	*(0.00)*	*(0.00)*
14	Basic non-ferrous	16818	1197	12,125	4,325	308	3	1,302	93	1
15	Fabricated metal	6755	1103	15,312	11,488	1,875	26	-16,736	-2,732	-38
					(0.17)	*(0.17)*	*(0.17)*	*(-0.25)*	*(-0.25)*	*(-0.25)*
16	Transport equip.	15535	1360	19,324	-2,352	-206	-3	-4,737	-415	-6
17	Other equip., manufacturing	54323	4717	79,185	443,824	38,539	647	254,283	22,081	371
					(0.82)	*(0.82)*	*(0.82)*	*(0.47)*	*(0.47)*	*(0.47)*
18	Water and sewerage	7106	732	8,071	-9,305	-958	-11	-18,663	-1,922	-21
19	Construction	36568	12752	195,390	95,767	33,397	512	45,591	15,899	244
					(0.26)	*(0.26)*	*(0.26)*	*(0.12)*	*(0.12)*	*(0.12)*

Table 5-2 continued in next page

Table 5-2 continued from previous page

	Sectors	BAS			MOD			ADV		
					Differences in[1]			Differences in[1]		
		Total Outputs (M$)	Wages and salaries (M$)	Employment (Persons)	Total Output ('000$)	Wages and salaries ('000$)	Employment (Persons)	Total Output s ('000$)	Wages and salaries ('000$)	Employment (Persons)
	Non-Energy Sectors									
20	Trade and repair	119502	36453	696,816	-24,033	-7,331	-140	-73,437	-22,401	-428
					(-0.02)	*(-0.02)*	*(-0.02)*	*(-0.06)*	*(-0.06)*	*(-0.06)*
21	Accomodation, café	34256	7168	182,385	-7,211	-1,509	-38	-21,393	-4,476	-114
22	Road transport	30723	7484	112,463	-2,574	-627	-9	-24,934	-6,074	-91
23	Rail, pipeline	4199	1300	13,647	-15,267	-4,726	-50	-24,386	-7,549	-79
24	Water transport	6038	504	5,044	-9,383	-784	-8	-45,558	-3,805	-38
25	Air and space travel	25825	5387	39,597	-5,646	-1,178	-9	-15,612	-3,257	-24
26	Services to transport	2296	340	4,569	-6,432	-953	-13	-26,420	-3,913	-53
27	Communication	26646	6441	70,167	-10,540	-2,548	-28	-23,788	-5,750	-63
28	Finance and insurance	64363	17321	169,430	-51,955	-13,982	-137	-94,134	-25,333	-248
					(-0.08)	*(-0.08)*	*(-0.08)*	*(-0.15)*	*(-0.15)*	*(-0.15)*
29	Property and business	203143	32645	427,336	-49,647	-7,978	-104	-136,713	-21,970	-288
					(-0.02)	*(-0.02)*	*(-0.02)*	*(-0.07)*	*(-0.07)*	*(-0.07)*
30	Govt. admin and defence	31549	11206	131,277	-2,169	-771	-9	-6,477	-2,300	-27
31	Edu., health, community	69000	37819	569,523	-8,046	-4,410	-66	-10,902	-5,976	-90
32	Personal and other services	42041	14382	212,178	-5,908	-2,021	-30	-10,279	-3,516	-52
					(-0.01)	*(-0.01)*	*(-0.01)*	*(-0.02)*	*(-0.02)*	*(-0.02)*

Table 5-2 continued in next page

Table 5-2 continued from previous page

Sectors		BAS			MOD			ADV		
					Differences in[1]			Differences in[1]		
	Energy Sectors	Total Outputs (M$)	Wages and salaries (M$)	Employment (Persons)	Total Outputs (PJ)	Wages and salaries ('000$)	Employment (Persons)	Total Outputs (PJ)	Wages and salaries ('000$)	Employment (Persons)
1	Electricity[3]	462	1450	12512	-77 *(-16.59)*	-240,561 *(-16.59)*	-2,076 *(-16.59)*	-108 *(-23.29)*	-337,744 *(-23.29)*	-2,914 *(-23.29)*
2	Gas supply	581	322	2615	75 *(12.94)*	41,615 *(12.94)*	338 *(12.94)*	-15 *(-2.58)*	-8,289 *(-2.58)*	-67 *(-2.58)*
3	Petroleum Product	1124	322	2532	-234 *(-20.82)*	-67,027 *(-20.82)*	-527 *(-20.82)*	-378 *(-33.64)*	-108,305 *(-33.64)*	-852 *(-33.64)*
4	Coal	4635	1308	7810	-537 *(-11.59)*	-151,619 *(-11.59)*	-905 *(-11.59)*	-578 *(-12.46)*	-163,001 *(-12.46)*	-973 *(-12.46)*
5	Others[4]	145	-	-	249 *(172.6)*	35,536	279	194 *(133.92)*	21,816	172

Source: Results obtained from input–output modelling in this research (the methodology for this modelling is explained in Section 5.3 and 5.4).

Notes:

[1] These values show differences in comparison with the Base scenario values.

[2] Values in the parentheses represent percentage differences from the corresponding values for the Base scenario. These percentages are provided in this table for select key sectors only (that is, for those that experience significant impacts, as also discussed in the text).

[3] Electricity includes eight different energy technologies for power generation (such coal plant, gas plant, etc.).

[4] Others include five different energy sectors characterised by energy types, namely, biomass, methanol, ethanol, CNG, and biodiesel.

- The other equipment sector (which consists of industries such as electronic equipment, electrical equipment, other machinery and equipment) also shows comparatively higher values of total outputs in the Moderate and Advanced scenarios as compared with the Base scenario. The output of the other equipment sector, for example, is about $214 million (0.57 percent) higher in the Moderate scenario, and about $166 million (0.44 percent) higher in the Advanced scenario in 2020 – in comparison with the Base case scenario. Similarly, the outputs of the construction sector is $45 millions (0.18 percent) higher in the Moderate and 36 millions (0.14 percent) higher in the Advanced scenario. These higher values are largely due to the increased demand for their outputs by the renewable plants – there is a considerable expansion of renewable power generation in the Moderate and Advanced scenarios. The contribution from renewable plants, for example, increases from 127 PJ in the Base scenario to 197 PJ in the Moderate, and 261 PJ in the Advanced scenario in 2020 (see Table 4-13, Chapter 4).

- Other sectors such as fabricated metal and iron and steel also show comparatively higher values of outputs in the Moderate and Advanced scenarios as compared with the Base scenario (although much lower than the differences in the agriculture sector – as above). The output of the fabricated metal sector, in the Moderate scenario, is approximately $25 million (0.54 percent) higher as compared with the output in the Base scenario, in the year 2020. This is mainly due to increased requirements for fabricated metal, by natural gas and renewable-based electricity generation sectors. Interestingly, however, the gap between the economic output of fabricated metal sector in the Advanced and Base scenarios is much lower (~ $ 1.7 million) in the year 2020. This could be due to comparatively lower amount of electricity generation need from wind-based plants in the Advanced scenario (18.6 PJ, see Table C-3, p. 267, Appendix-C) as compared with the Moderate scenario (23.8 PJ), because of the decline in electricity demand in the Advanced scenario. In 2020, for example, electricity generation declines from 328 PJ in the Base, to 306 PJ in the Moderate, and 274 PJ in the Advanced scenario, respectively (see Table C-3, p. 267, Appendix–C).

- In the year 2040 too, higher outputs are observed for the agriculture, other equipment, and construction sectors. In the Moderate scenario, for example, the outputs of these sectors are \$483 (2.59 percent), \$444 (0.82 percent), and \$96 million (0.26 percent) higher, respectively, as compared with the outputs in the Base scenario. And, in the Advanced scenario, the outputs of these sectors are higher by \$481 (2.58 percent), \$254 (0.47 percent) and \$45 millions (0.12 percent), respectively, as compared with the Base scenario. These impacts are for 2040 significantly higher than for 2020. This reflects further increases in the use of biomass in power generation in the years between 2020 and 2040 and in the production of bio-fuels for transport and also increased penetration by renewable-based plants, such as wind and PV. However, the total output of fabricated metal sector in 2040, while higher in the Moderate scenario by \$11 million (0.17 percent), is lower in the Advanced scenario by about \$17 million (0.25 percent) – as compared with the Base scenario. This could be due to the reduced volume of gas used in the Advanced scenario (529 PJ) as compared with the Base (560 PJ) and Moderate scenarios (578 PJ). The impact on total outputs of the fabricated metal sector in 2040 is lower than in 2020 (unlike in the agriculture, other equipment and construction sectors, as mentioned earlier).

- The sectors that show comparatively lower values of total outputs are property and business and finance and insurance sectors. The impact on total outputs of these sectors is higher in the Advanced scenario than in the Moderate scenario. For example, in 2020, the total outputs of these sectors are lower by \$29 million (0.02 percent) and \$18 million (0.05 percent), respectively, in the Moderate scenario and by \$74 million (0.06 percent) and \$68 million (0.17 percent), respectively, in the Advanced scenario – as compared with the Base scenario. Similarly, in 2040, the total outputs of the 'property and business' and 'finance and insurance' sectors are lower in the Moderate scenario by \$49 million (0.02 percent) and \$52 million (0.08 percent), respectively, and in the Advanced scenario, by \$137 million (0.07 percent) and \$94 million (0.15 percent), respectively. These reductions in total outputs could be due to the reduced levels of energy consumption in the Moderate and Advanced scenarios, as compared with the Base scenario, and the ensuing decline in the purchase of the outputs of these sectors by the energy sectors. Interestingly, in 2020, the total outputs of the trade and repair sector, while marginally higher ($0.8 million, that is less than 0.01 percent) in the Moderate scenario, is significantly lower in the Advanced scenario ($48 million; 0.07 percent). In 2040, the total output of this sector is ever lower – $24 million (0.02 percent) in the Moderate, and by $73 million (0.06 percent) in the Advanced scenario.

- Among the energy sectors, the total outputs (in PJ) of the petroleum product and coal sectors are significantly lower. In 2020, for example, the total outputs of these two sectors are lower by 117 PJ (that is, by 15.69 percent) and 65 PJ (1.79 percent), respectively, in the Moderate scenarios, and by 143 PJ (19.12 percent) and 470 PJ (12.89 percent), respectively, in the Advanced scenario – in comparison with the Base scenario values. Similarly, in 2040, the total outputs of these two sectors are lower by 234 PJ (20.82 percent) and 537 PJ (11.59 percent), respectively, in the Moderate scenario, and by 378 PJ (33.64 percent) and 578 PJ (12.46 percent) in the Advanced scenario. These declines reflect reductions in the consumption of these energy types (as discussed in Section 4.5, Chapter 4) – the consumption of petroleum products, for example, reduces due to the improvements in vehicle efficiencies and the use of alternative transport fuels (such as CNG, ethanol) in road transport; and the consumption of coal reduces due to the decline in coal use in electricity generation and in iron and steel industry. The decline in coal consumption in the Moderate and Advanced scenarios also affects the services to mining sector (though marginally), for example, by reducing its output in the Advanced scenario by about $6 million in 2020 (that is, by 0.88 percent) and $6 million in 2040 (0.49 percent), as compared with the Base scenario.

- The total output of the electricity sector is lower in the both Moderate and Advanced scenarios. In 2020, it is lower by 20 PJ (that is, by 6.19 percent) and 50 PJ (15.61 percent), respectively. And, in 2040, by 77 PJ (16.59 percent) and 108 PJ (23.29 percent), respectively, compared with the Base scenario. These lower values are due to the improvements in the efficiency of electricity use (for example, in heating and cooling in the residential and commercial sectors).

- In 2020, the total output of the gas supply sector is lower in the Moderate scenario by 49 PJ (12.68 percent), but higher in the Advanced scenario by 86 PJ (22.44 percent). This reflects a reduced level of gas consumption in the Moderate scenario, due to the decline in electricity generation from gas-based plants, and expansion of, renewable-based plants. In the Advanced scenario, however, gas consumption is higher (in electricity generation and in the iron and steel industry) mainly for environmental reasons (that is, due to stringent constraints on CO_2 emissions). However, in 2040, the total output of the gas supply sector is higher by 75 PJ (12.94 percent) in the Moderate scenario, but is lower by 15 PJ (2.58 percent) in the Advanced scenario. This reflects lower level of gas consumption in 2040 in the Advanced scenario, as compared with the Moderate scenario, because of the increase in clean coal technologies such as IGCC with CCS for electricity generation, over the period 2020-2040.

- The total output of the other energy sectors (which comprise mainly biomass, methanol, ethanol, and CNG) is higher in the both Moderate and Advanced scenarios. In 2020, it is higher by 112 PJ (that is, by 116.9 percent) and 142 PJ (148.3 percent) respectively; and in 2040, by 249 PJ (172.6 percent) and 194 PJ (133.9 percent). These high values suggest increased use of these energy types in these scenarios, starting from the lower base in the Base scenario.

5.5.2 Wages and Salaries [48]

In the input–output model employed in this research, wages and salaries are directly proportional to sectoral outputs[49]. Hence, as output of an economic sector changes in

[48] It refers to payments made by producers to their employees for services rendered and imputed income for employers and self employed persons (that is for non-wage and salary earners) (Powell, Chalmers & Bailey 1999).

[49] The analysis of impacts of energy outcomes of various scenarios, on wages and salaries, in this research, is based on an open type of input–output table (that is, household sector is kept exogenous). Hence, it does not take into account further effects of changes in income on consumption. Such effects could be analysed in a closed type of input–output model. In this model, the consumer (household) sector is treated as a production sector inside the transaction matrix itself. Since, consumption is closely related

response to the changes in energy consumption, it would also impact wages and salaries of that sector. The absolute values of these impacts would, however, depend on not only the volume of the outputs itself, but also on the ratio of wages and salaries to outputs of these sectors. Hence, for the same level of impacts on total outputs, sectors that have a high value of this ratio would show large changes in the wages and salaries (these sectors, for example, include construction, agriculture, personal and other services, etc.) compared to the sectors that have a lower value of this ratio (such as, iron and steel, and other equipment). Tables 5-1 and 5-2 provide an overview of the impacts of energy outcomes, for various scenarios, on wages and salaries, as analysed in these research. The impacts on wages and salaries for some key sectors are shown in Figures 5-4 and 5-5. These figures show differences in the wages and salaries for Moderate and Advanced scenarios, in comparison with the corresponding values in the Base scenario. Some major findings are discussed below:

- The impacts on wages and salaries are most significant for agriculture, construction, fabricated metals and other equipment sectors. The total wages and salaries paid in the agriculture sector in the Moderate and the Advanced scenario, for example, are higher by \$85 million (that is, by 2.18 percent) and \$89 million (2.3 percent), respectively, in 2020, and by \$150 million (2.59 percent) and \$149 million (2.58 percent), respectively, in 2040 (in comparison with the Base scenario). This is due to the increased use of agri-products as energy sources, mainly in biomass plants, and for the production of biofuels. The wages and salaries in the construction sector in the Moderate and Advanced scenarios are higher by \$15 million (0.18 percent), and 12 million (0.14 percent), respectively, in 2020 and by \$33 million (0.26 percent), and \$16 million (0.12 percent), respectively, in 2040. Similarly, the wages and salaries in the other equipment sector in the Moderate and Advanced scenarios are higher by \$18 million (that is, by 0.57 percent) and \$14 million (0.44 percent), respectively, in 2020 and by \$38 million (0.82 percent) and \$22 million (0.47 percent), respectively, in 2040. These higher values are mainly due to the increase in the uptake of renewable-based power plants.

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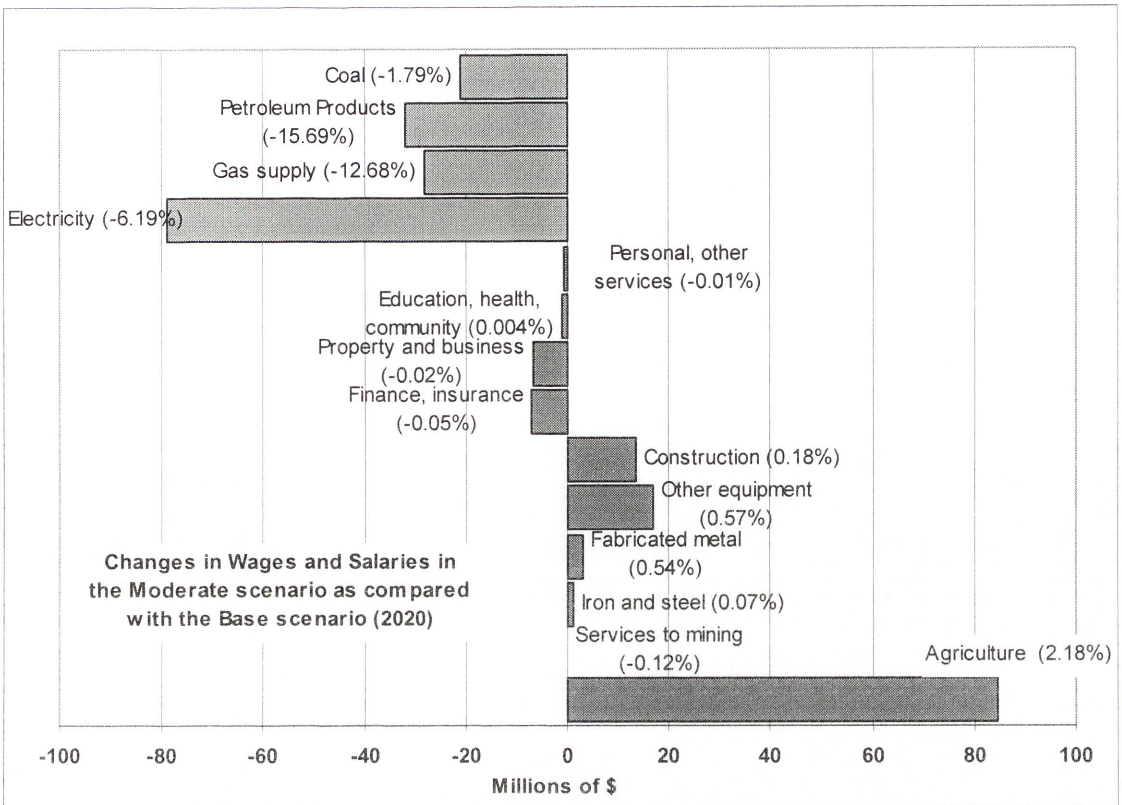
to personal income, changes in personal income will induce changes in consumption. This process would generate another round of impacts on outputs, personal income and consumption.

(a) Impacts for 2020



(b) Impacts for 2040

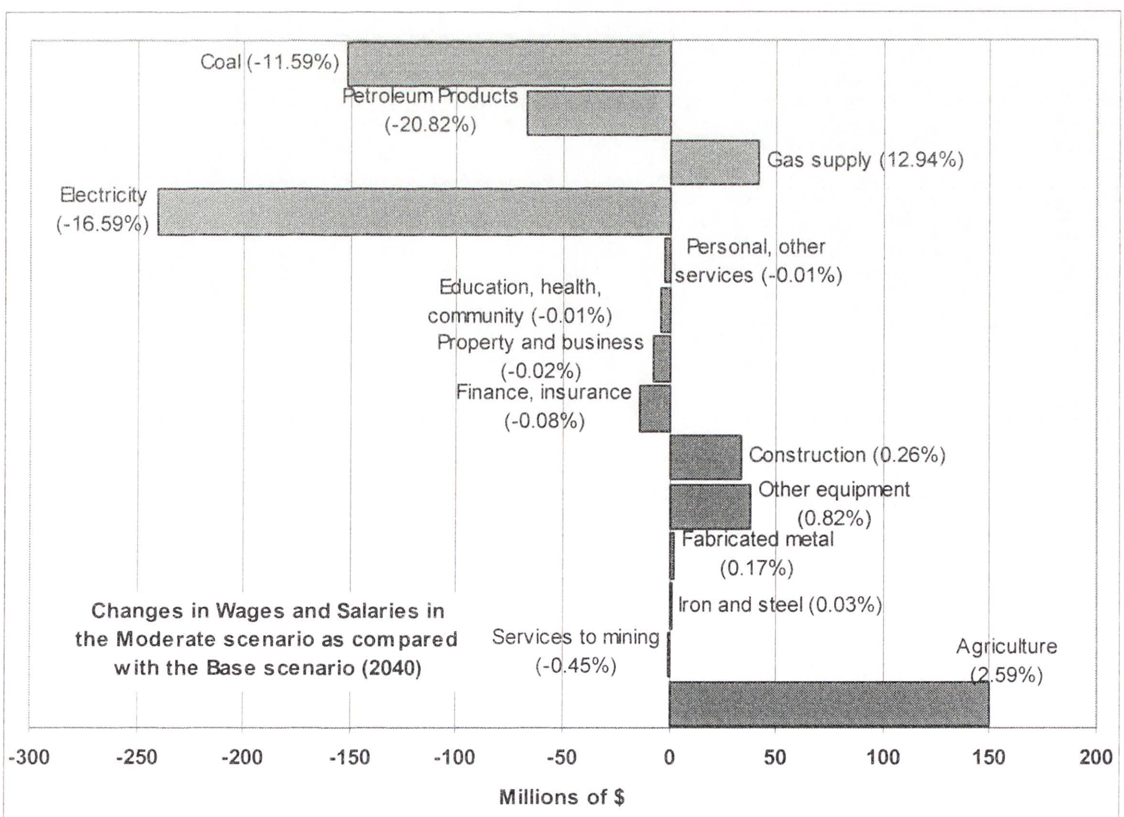
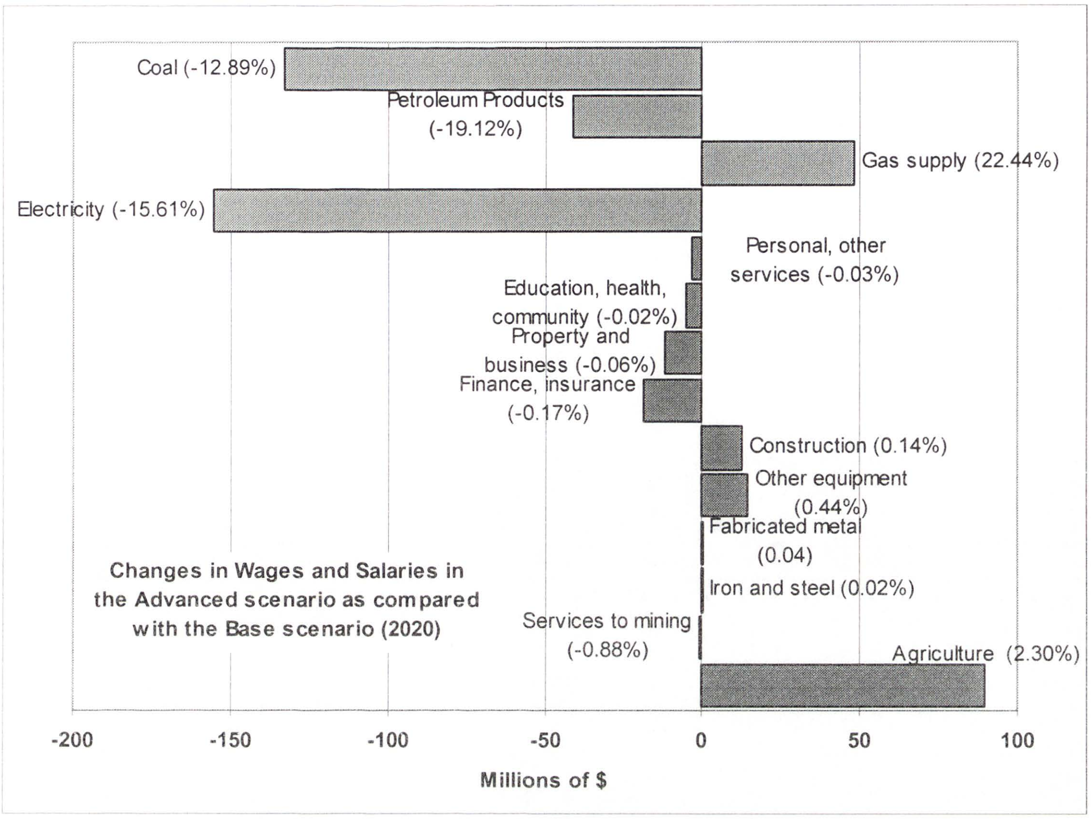


Figure 5-4: Income Impacts in Moderate Scenario

(a) Impacts for 2020



(b) Impacts for 2040

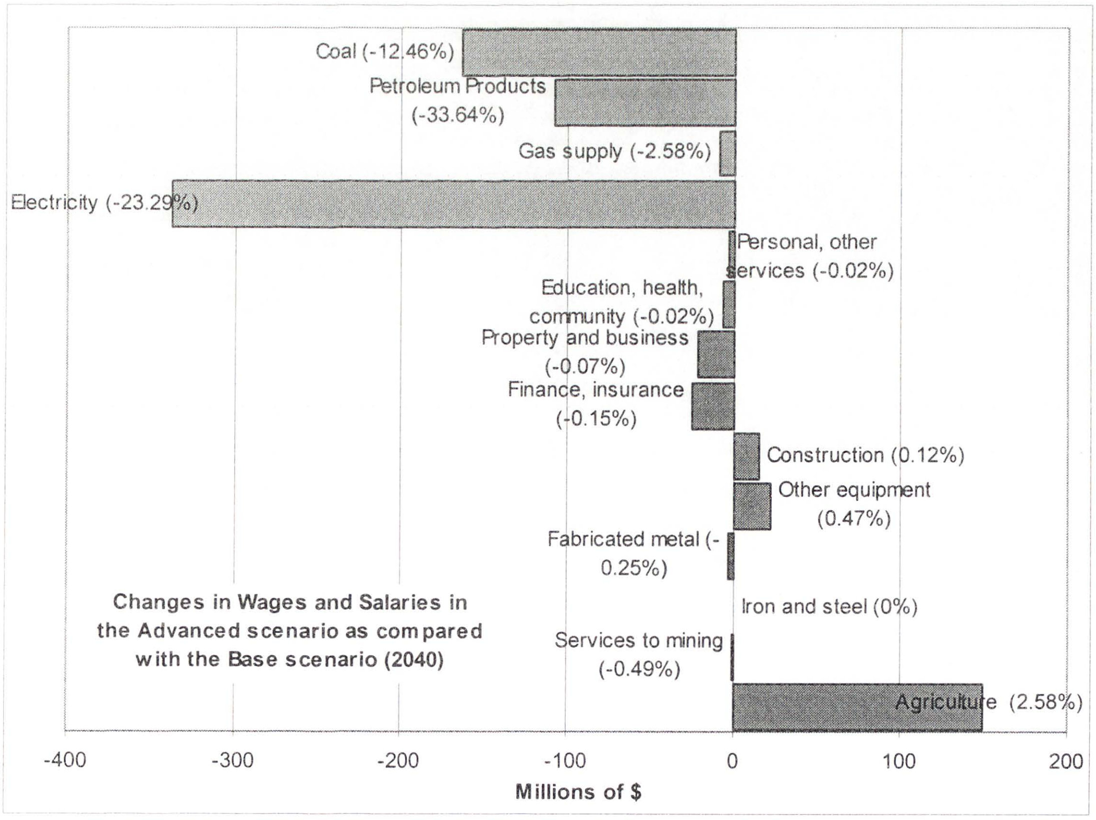


Figure 5-5: Income Impacts in Advanced Scenario

- The sectors that are likely to experience decline in the total amount of wages and salaries payment in the two scenarios are trade and repair, finance and insurance, and property and business. Such declines are most significant in 2040 in the Advanced scenarios. In this scenario, for example, wages and salaries paid in the trade and repair sector is \$22 million (0.06 percent) lower, \$25 million (0.15 percent) lower in the finance and insurance sector and \$22 millions (by 0.07 percent) lower in the property and business sector – as compared with the Base scenario. These declines in the wages and salaries reflect an overall decrease in total energy requirements in the three scenarios – for example, total primary energy requirement reduces from 2,908 PJ in the Base scenario, to 2,392 PJ in the Moderate scenario, and to 2,102 PJ in the Advanced scenario in 2040.

- The energy sectors experience considerable impact in terms of wages and salaries in both scenarios, because they bear the brunt of energy policy changes envisaged in the two scenarios. For example, in 2020, the wages and salaries for the electricity, coal, petroleum products sectors in the Moderate scenario is \$62 million (6.2 percent), \$18 million (1.8 percent), and \$34 million (15.7 percent) lower, respectively – as compared with the wages and salaries in the Base scenario. And, in the Advanced scenario, they are \$156 million (15.6 percent), \$133 million (12.9 percent), and \$41 million (19.1 percent) lower, respectively. In 2040, the wages and salaries for these sectors are lower even more – by \$240 million (16.6 percent), \$152 million (11.6 percent), and \$42 million (20.8 percent) in the Moderate scenario, respectively, and by \$338 million (23.3 percent), \$163 million (12.5 percent), and \$108 million (33.6 percent) in the Advanced scenario, respectively. These lower values of wages and salaries are due to the declines in electricity, coal, and petroleum consumption in the two scenarios. These declines, in turn, are due to envisaged efficiency improvements in the electrical appliances in the residential sectors, the replacement of coal by gas and renewables in electricity production, and improvements in vehicle efficiencies and the penetration by alternative fuels (natural gas, and biofuels) in the transport market. The wages and salaries, however, in the gas supply sector, while decreasing by \$27 million (12.68 percent) in the Moderate scenario, increases by \$48 million (22.44 percent) in the Advanced scenario, in 2020. On the contrary, in 2040, it increases by \$41 million (12.94 percent) in the Moderate scenario but decreases by \$8 million (2.58 percent) in the Advanced scenario. These fluctuations reflect the differences in the amounts of gas used in these scenarios for the given periods (as discussed earlier, in Sub-section 5.5.1, in p. 156).

- The wages and salaries paid in the coal and electricity sectors are comparatively lower in the Advanced scenario as compared to the Moderate scenario in 2020. This occurs due to the large reductions in coal consumption in the Advanced scenario (287 PJ) compared with the Moderate scenario (690 PJ); and also reduction in electricity consumption in the Advanced scenario (274 PJ) compared with the Moderate scenario (307 PJ).

- While the total amounts of wages and salaries generally decline in the conventional energy sectors (that is, coal, gas, petroleum products, and electricity), they increase in the others sector (which is comprised of biomass, methanol, ethanol, and CNG). For example, the wages and salaries of the other sector in the Moderate and Advance scenarios are higher by \$19 million (116.9 percent) and \$11 million (148.3 percent) in 2020, and by \$35 million (172.6 percent) and \$22 million (133.9 percent) in 2040, respectively. These results reflect increased use of these energy types in the Moderate and Advanced scenarios, for example, biomass is increasingly used in electricity generation sector, and ethanol and methanol in the transport sector.

5.5.3 Employment

The impact of energy outcomes (specific to the three scenarios) on employment[50] in various economic sectors arises mainly from the differences in sectoral economic activities (as represented by the changes in total outputs) in these scenarios. As explained in Section 5.2, these changes in total outputs are the outcomes of changes in energy settings in the two scenarios. The impacts on employment for each economic sector is computed, in this research, based on the ratio of employees per unit of the total output of the sector, taking into account future changes in annual labour productivities.

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[50] Employment here represents the number persons employed in a given sector.

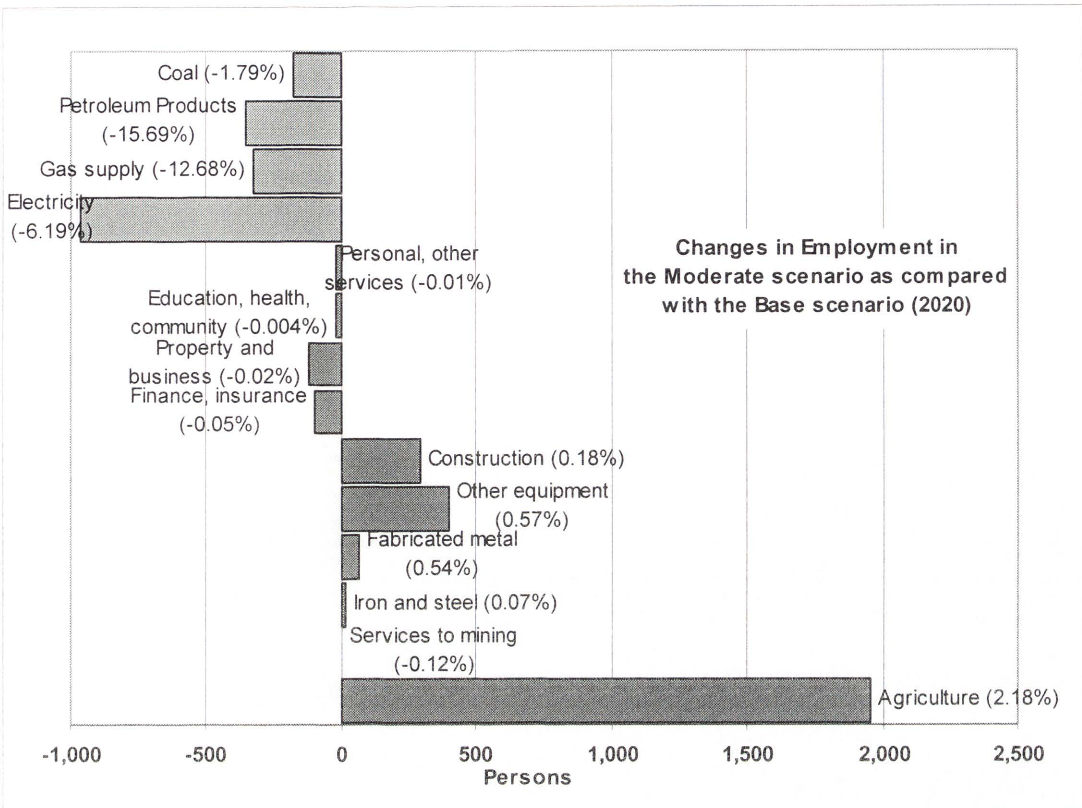
The labour productivity is assumed to improve at the rate of 1.75 percent per year over the period 2000–2040, which is based on the Intergenerational Report (Commonwealth of Australia 2002). The average annual improvement in labour productivity during the past 30 years (1970–2000) was 1.75 percent; it was 2 percent during the 1990s, and 1.2 percent during 1980s. Tables 5-1 and 5-2 show the employment impacts across various economic sectors for 2020 and 2040, respectively. Figures 5-6 and 5-7 present these impacts for selected key sectors. Some major findings are discussed below:

- It is observed that agriculture, other equipment, and construction sectors show higher level of employment in both Moderate and Advanced scenarios relative to the Base scenario. For example, the agriculture sector employs additional 1,957 persons (that is, 2.18 percent more) and 2,066 persons (~2.30 percent) in the Moderate and Advanced scenarios in 2020, respectively. In 2040, employment in this sector is higher by 2,448 persons (2.59 percent) and 2,435 persons (2.58 percent) in the Moderate and Advanced scenarios, respectively, – in comparison with the employment in the Base scenario. The employment in the construction sector in the Moderate and Advanced scenarios is higher by 339 persons (0.18 percent) and 273 persons (0.14 percent), respectively, in 2020, and by 512 persons (0.26 percent) and 244 persons (0.12 percent), respectively, in 2040. Similarly, employment in the other equipment sector in the Moderate and Advanced scenarios is also higher, by 442 persons (0.57 percent) and 343 persons (0.44 percent), respectively, in 2020 and by 647 persons (0.82 percent) and 371 persons (0.47 percent), respectively, in 2040. The agriculture sector, being the most labour intensive sector, experiences increase in employment. The other equipment sector, which experiences comparatively higher amount of total outputs (as discussed in Section 5.5.1), however, generates lower levels of additional employment in both scenarios. This is because this sector is comparatively less labour intensive than the agriculture sector.

- The trade and repair, finance and insurance, and property and business sectors experience declines in employment. For example, in the Advanced scenarios, in 2040, employment is lower by 428 persons (0.06 percent) in the trade and repair sector, by 248 persons (0.15 percent) in the finance and insurance sector, and by

288 persons (0.07 percent) in the property and business sector – in comparison with the Base scenario values.

(a) Impacts for 2020



(b) Impacts for 2040

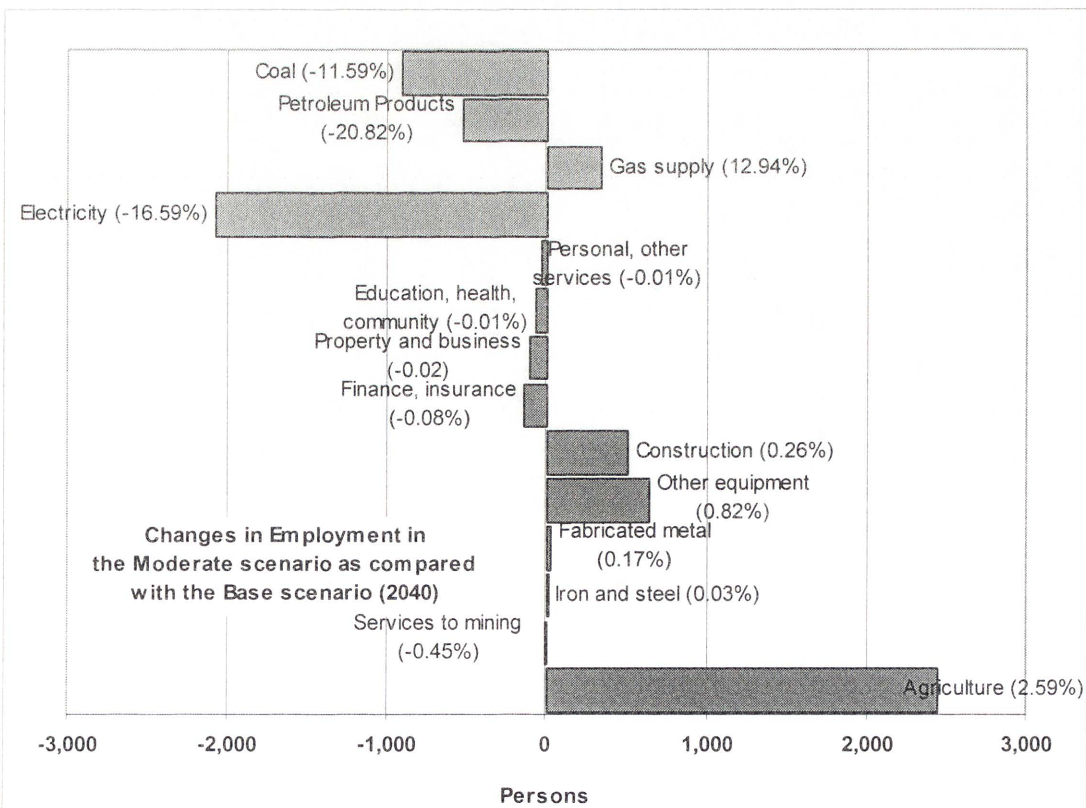
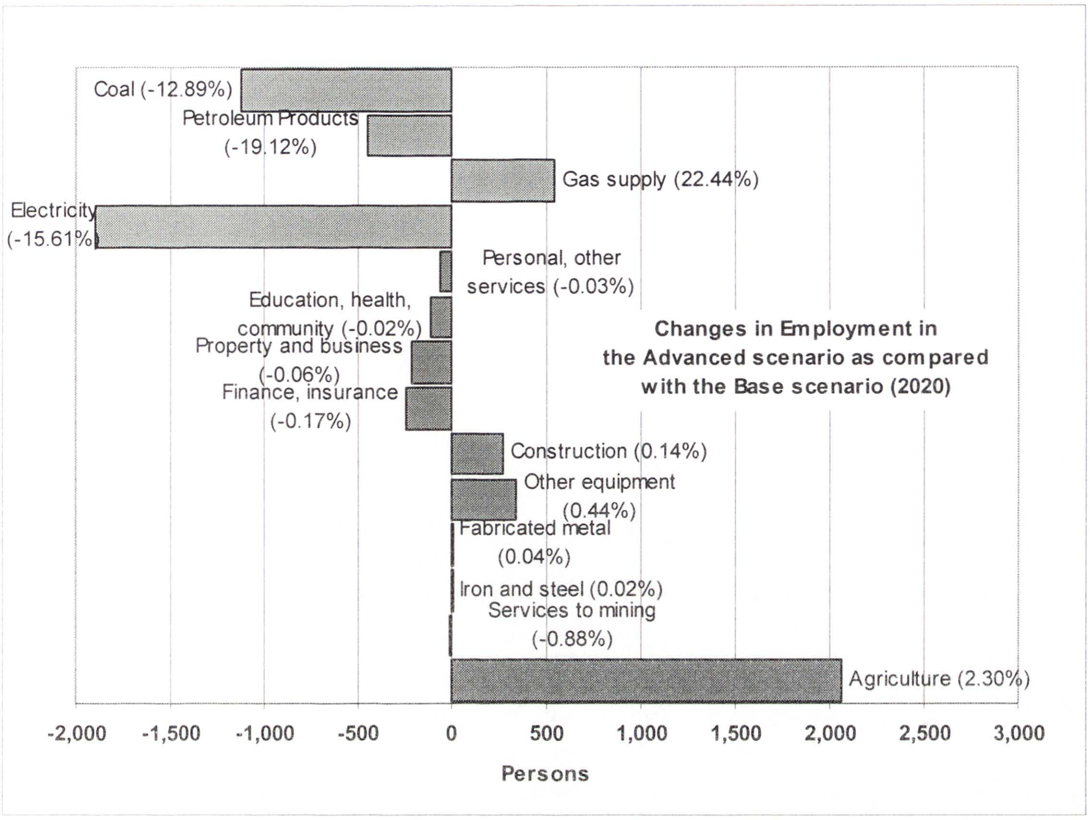


Figure 5-6: Impacts on Employment in the Moderate Scenario

(a) Impacts for 2020



(b) Impacts for 2040

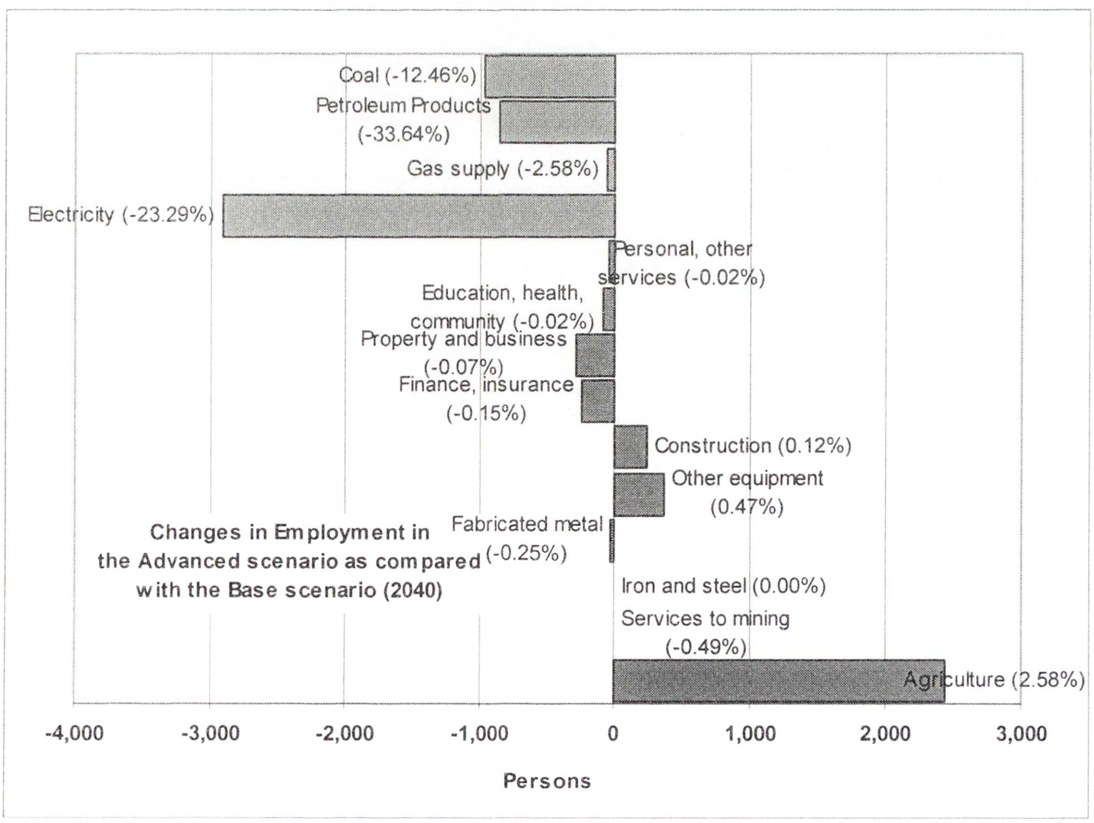


Figure 5-7: Impacts on Employment in the Advanced Scenario

- Among the energy sectors, the electricity, petroleum products and coal sectors experience decline in employment, in both the Moderate and the Advanced scenarios. For example, in 2020, employment in the electricity, coal, petroleum products sectors in the Moderate scenario are 753 persons (6.2 percent), 155 persons (1.8 percent), and 374 persons (15.7 percent) lower, respectively, as compared with the employment in the Base scenario. And, in the Advanced scenario, it is 1,900 persons (15.6 percent), 1,121 persons (12.9 percent) and 456 persons (19.1 percent) lower, respectively. In 2040, the employment in these sectors declines further – by 2,076 persons (16.6 percent), 905 persons (11.6 percent) and 527 persons (20.8 percent) in the Moderate scenario, and by 2914 persons (23.3 percent), 973 persons (12.5 percent) and 852 persons (33.6 percent) in the Advanced scenario, respectively. The employment in the gas supply sector, in 2020, is 311 persons (12.7 percent) lower in the Moderate scenario, but 551 persons (22.4 percent) higher in the Advanced scenario. On the contrary, in 2040, the employment is higher by 338 persons (12.9 percent) in the Moderate scenario but is lower by 67 persons (2.6 percent) in the Advanced scenario. These variations are due to the differences in the amount of gas use in these two scenarios for the given periods. The employment in the others sector is higher both in Moderate and Advanced scenarios, for 2020 and 2040. The most significant impact is in 2020 in the Moderate scenario, when 279 additional jobs are created in this sector.

- It can be observed from tables Table 5-1 and 5-2 that employment in the energy sectors generally declines in both scenarios, whereas for the non-energy sectors, they show an increasing trend. In the Moderate scenario in 2020, for example, there is a net decrease in employment in the energy sectors of 1,375 persons (5.34 percent), and a net increase in the non-energy sectors by 2,607 persons (0.09 percent), as compared with the Base scenario. These trends in employment are likely due to the switch in power generation, from fossil-based plants to renewable-based plants (such as wind, PV, and biomass) in the two scenarios. The renewable-based plants are generally highly capital and labour intensive, hence they would generate more employment. The increase in renewable technology therefore causes employment generation in various other sectors from which it draws its inputs. For example, as more wind plants are installed, more inputs from construction and fabricated metal sectors would be required; hence more employment would be generated in these sectors as well.

5.5.4 Primary Energy Intensities

Table 5-3 presents direct and total (that is, direct and indirect) primary energy intensities (MJ/$) estimated in this research on the basis of the input–output analysis. The total intensity takes into account both direct and indirect energy consumption. It indicates the total energy (MJ) needed to produce one dollar worth of output by a particular sector. Major findings are discussed below:

- The total energy intensities across the sectors in 2000 show wide variations. The most energy intensive sectors in that year are the basic chemical (41.45 MJ/$), basic non-ferrous (30.18 MJ/$), and iron and steel (18.92 MJ/$). And, the least energy intensive sectors include education, health and community (1.22 MJ/$), finance and insurance (1.26 MJ/$), and services to transport (1.34 MJ/$). The share of direct energy in the total energy intensity is also found to vary significantly across the sectors. For example, the shares of direct energy in the road transport (with an intensity of 14.41 MJ/$) and basic chemicals (with an intensity of 29.08 MJ/$) are 84 and 70 percent of their total energy intensities, respectively. But the share in the transport equipment (0.22 MJ/$) and other equipment sectors (0.22 MJ/$) is only 7.4 and 8.9 percent, respectively. In the basic non-ferrous sector – the second highest energy intensive sector in terms of total energy intensity – the share of direct energy intensity (11.17 MJ/$) is less than half (about 37 percent) of its total energy intensity (30.18 MJ/$). Similarly in the fabricated sector, the share of direct energy intensity (1.03 MJ/$) is only 13.5 percent of its total energy intensity (7.65 MJ/$).

- The total energy intensities of the economic sectors show declining trends to the years 2020 and 2040, for both the Moderate and Advanced scenarios. This reflects a declining trend in total primary energy consumption in the Moderate and Advanced scenarios, as compared with the Base scenarios (the total primary energy consumption in the Base, Moderate and Advanced scenarios are 2,092, 1,935 and 1,697 PJ, respectively, in 2020 and 2,908, 2,392, and 2,102 PJ, respectively, in 2040, see Table 4-13 in Chapter-4). The decline in the total energy intensities in the iron and steel, fabricated metal, road transport sectors are among the largest. In 2020, for example, the total energy intensity in the iron and steel sector (14.23 MJ/$) is lower by 13.7 percent in the Moderate scenario, and by 24.7 percent (12.43 MJ/$) in the Advanced scenario – as compared with the energy intensity in the Base scenario (16.50 MJ/$). Similarly, the energy intensity in the fabricated metal sector is lower, as compared with the Base scenario (6.23 MJ/$), by 8.8 percent in the Moderate scenario (5.68 MJ/$) and by 19 percent in the Advanced scenario (5.05 MJ/$). The decline in the total energy intensity in the fabricated metal sector is largely due to the improvement in indirect energy intensity (this sector is characterised by having a largest share of indirect intensity ~84 percent), reflecting improvement in the energy embodied inputs to this sector (such as iron and steel).

- The total energy intensity in the road transport is lower in the Moderate and Advanced scenarios by 8.7 and 17.5 percent, respectively in 2020, and by 15.9 and 30.7 percent, respectively in 2040 – in comparison with the energy intensity in the Base scenario. This is largely due the reduction in direct energy requirements in road transport because of efficiency improvements.

- The total energy intensities of the service sectors, such as communication, finance and insurance, property and business, personal and other services is lower in both the Advanced and Moderate scenarios in 2020 and 2040. In 2020, for example, the total energy intensity of the communication sector in the Moderate scenario (1.42 MJ/$) and the Advanced scenario (1.29 MJ/$) is 4.9 and 13.5 percent lower than the intensity in the Base scenario (1.49 MJ/$). Similarly, in 2040, the total energy intensity of this sector declines in the Moderate and Advanced scenarios by 13.2 and 15.6 percent, respectively. These declines in energy intensities reflect improvements in energy efficiency in these sectors.

- The share of direct and indirect energy in the total primary energy intensity provides valuable insights for policy analysts. It suggests, for example, that energy efficiency measures will be more effective if they are directed at sectors which have dominant shares of direct energy. These sectors include, for example, iron and steel, road transport, and basic chemical. And, for those sectors, where indirect energy dominates, policy should target to reduce the inputs of energy intensive materials. Otherwise, even if a sector uses the efficient appliances, the total energy consumption will not improve significantly, as the share of indirect energy will continue to be higher. These sectors, for example, include fabricated metals, construction, and service sectors.

Table 5-3: Primary Energy Intensities (MJ/$)

Sectors	2000		2020						2040					
			BAS		MOD		ADV		BAS		MOD		ADV	
	Direct	Total[1]	Direct	Total	Direct	Total	Direct	Total	Direct	Total	Direct	Total	Direct	Total
1 Agri., hunting and trapping	1.44	4.70	1.33	3.88	1.33	3.78	1.33	3.57	1.20	2.53	1.20	2.35	1.20	2.33
2 Forestry and fishing	1.44	4.02	1.33	3.30	1.33	3.77	1.33	2.97	1.20	2.11	1.20	1.93	1.20	1.92
3 Mining	2.53	7.21	2.29	5.70	2.29	5.49	2.29	5.02	2.07	3.75	2.07	3.31	2.07	3.33
4 Services to mining	2.53	7.61	2.29	6.08	2.29	5.83	2.29	5.32	2.07	3.90	2.07	3.43	2.07	3.42
5 Meat and diary prod.	0.87	5.07	0.83	4.20	0.83	4.23	0.83	3.73	0.75	2.44	0.75	2.19	0.75	2.10
6 Other food prod.	0.87	3.71	0.83	3.04	0.83	2.98	0.83	2.71	0.75	1.85	0.75	1.67	0.75	1.63
7 Beverage and tobacco	0.87	3.23	0.83	2.64	0.83	2.57	0.83	2.35	0.75	1.66	0.75	1.49	0.75	1.46
8 Textile, clothing, leather	0.96	3.69	1.67	3.09	1.67	3.07	1.67	2.93	1.51	2.23	1.51	2.15	1.51	2.13
9 Wood, paper, printing	0.51	3.39	0.81	2.62	0.81	2.54	0.81	2.35	0.73	1.65	0.73	1.50	0.73	1.48
10 Basic chemical	29.08	41.45	25.75	34.40	25.75	34.02	25.75	32.97	23.29	28.26	23.29	27.22	23.29	27.38
11 Other chem., rubber, plastic	0.40	3.44	0.36	2.38	0.36	2.33	0.36	2.22	0.32	1.37	0.32	1.30	0.32	1.29
12 Non-metallic mineral	5.12	11.63	4.83	9.71	4.83	9.44	4.83	8.87	4.37	7.03	4.37	6.52	4.37	6.42
13 Iron and steel	12.16	18.92	11.03	16.50	9.30	14.23	8.15	12.43	9.98	12.27	6.87	8.52	5.63	7.12
						(-13.7)		*(-24.7)*				*(-30.6)*		*(-42.0)*
14 Basic non-ferrous	11.17	30.18	9.05	22.38	8.78	20.95	8.54	18.37	8.17	15.33	7.92	12.90	7.69	12.80
15 Fabricated metal	1.03	7.65	0.81	6.23	0.78	5.68	0.76	5.05	0.73	3.37	0.71	2.70	0.69	2.53
						(-8.8)		*(-19.0)*				*(-19.7)*		*(-24.8)*
16 Transport equip.	0.22	2.98	0.20	2.42	0.20	2.22	0.20	1.98	0.18	1.23	0.18	0.98	0.18	0.92
17 Other equip., manufacturing	0.22	2.47	0.20	2.00	0.20	1.84	0.20	1.64	0.18	1.07	0.18	0.86	0.18	0.81
18 Water and sewerage	0.90	4.22	0.80	3.24	0.78	3.05	0.77	2.74	0.73	1.93	0.71	1.62	0.70	1.63
19 Construction	0.50	3.24	0.45	2.72	0.45	2.58	0.45	2.40	0.41	1.47	0.41	1.32	0.41	1.27
20 Trade and repair	0.28	2.14	0.27	1.72	0.27	1.63	0.26	1.48	0.25	0.89	0.24	0.77	0.24	0.75
21 Accommodation, café	0.28	1.92	0.27	1.51	0.27	1.46	0.26	1.30	0.25	0.77	0.24	0.66	0.24	0.66
22 Road transport	14.41	17.20	13.03	15.09	11.86	13.78	10.71	12.45	11.79	12.67	9.88	10.65	8.12	8.78
						(-8.7)		*(-17.5)*				*(-15.9)*		*(-30.7)*
23 Rail, pipeline	6.72	11.15	5.78	9.10	5.91	10.33	5.78	8.32	5.18	6.89	5.18	6.35	5.18	6.41
24 Water transport	9.68	13.80	8.76	12.40	8.76	12.37	8.15	11.50	7.92	9.52	7.92	9.50	6.66	8.02

Table 5-3 continued in next page

Table 5-3 continued from previous page

Sectors	2000		2020						2040					
			BAS		MOD		ADV		BAS		MOD		ADV	
	Direct	Total[1]	Direct	Total	Direct	Total	Direct	Total	Direct	Total	Direct	Total	Direct	Total
25 Air and space travel	12.89	14.76	11.66	13.28	11.66	13.26	11.41	12.93	10.55	11.29	10.55	11.27	10.04	10.73
26 Services to transport	0.32	1.34	0.48	1.13	0.48	1.10	0.48	1.04	0.44	0.84	0.44	0.79	0.44	0.76
						(-3.2)		*(-8.1)*				*(-6.2)*		*(-9.8)*
27 Communication	0.28	1.86	0.27	1.49	0.27	1.42	0.26	1.29	0.25	0.80	0.24	0.70	0.24	0.68
						(-4.9)		*(-13.5)*				*(-13.2)*		*(-15.6)*
28 Finance and insurance	0.28	1.26	0.27	0.97	0.27	0.92	0.26	0.83	0.25	0.56	0.24	0.48	0.24	0.48
						(-5.0)		*(-14.8)*				*(-15.0)*		*(-14.5)*
29 Property and business	0.28	1.58	0.27	1.24	0.27	1.18	0.26	1.06	0.25	0.67	0.24	0.58	0.24	0.57
30 Govt. admin and defence	0.28	1.97	0.27	1.56	0.27	1.49	0.26	1.36	0.25	0.82	0.24	0.71	0.24	0.70
31 Edu., health, community	0.28	1.22	0.27	0.95	0.27	0.90	0.26	0.81	0.25	0.57	0.24	0.48	0.24	0.48
						(-5.2)		*(-14.6)*				*(-14.8)*		*(-15.0)*
32 Personal and other services	0.28	1.80	0.27	1.43	0.27	1.36	0.26	1.23	0.25	0.76	0.24	0.66	0.24	0.65
						(-4.9)		*(-13.8)*				*(-13.8)*		*(-15.2)*

Source: Results obtained from input–output modelling in this research.

[1] Total energy intensity is the sum of the direct and indirect energy intensities.

[2] Values in the parentheses represent percentage changes in relation to the corresponding values for the Base scenario. These changes are shown in this table for selected key sectors only (that is, for those sectors that experience significant intensity impacts).

5.5.5 CO_2 emission Intensities

The total CO_2 emissions (expressed in thousand tons) for the Base, Moderate and Advanced scenarios are estimated in Section 4.5 (Chapter 4). These estimates are developed at the sectoral levels, such as for electricity, residential, commercial, agriculture, and transport sectors. In this section, CO_2 emissions of various economic sectors are examined in relation with their economic outputs. Table 5-4 presents direct and total CO_2 emission intensities (kg of CO_2/\$) for various economic sectors. The total CO_2 intensities are computed by taking into account both direct and indirect CO_2 emissions. Direct CO_2 emissions for an economic sector refer to the emissions that result from the direct consumption of fossil energy sources by the sectors. Indirect emissions are emissions associated with the energy embodied in goods and services input to these sectors. Some major findings of analysis in this research are discussed below:

- The total CO_2 intensities in 2000 vary widely across the economic sectors. For example, from 0.102 kg/\$ (education, health and community sector) to 2.57 kg/\$ (basic chemical sector). Other sectors with large values of CO_2 intensities in 2000 are basic non-ferrous (2.56 kg/\$), iron and steel (1.66 kg/\$), and road transport (1.26 kg/\$). In some of these (high CO_2–intensive) sectors, the share of direct CO_2 intensities is however small. For example, in the basic non-ferrous sector, the direct intensity (0.44 kg/\$) is only 17 percent of the total CO_2 intensity. This is because this sector includes industries (such as aluminium) that use large amounts of electricity in the smelting process. While the use of electricity does not produce CO_2 emissions directly (as reflected in the lower direct CO_2 intensity for these sectors), it could, however, result in large amount of emissions at the source of electricity generation (that is, at the power plant). Hence, a higher value of total CO_2 intensity for this sector. In the road transport sector, the share of direct CO_2 intensity (1.05 kg/\$) is about 83 percent of the total CO_2 intensity, which reflects large amount of direct consumption of fossil energy sources (petroleum products) in this sector.

- Sectors with low values of total CO_2 intensities include education, health and community (0.102 kg/\$), finance and insurance (0.106 kg/\$), services to transport

(0.106 kg/$), and personal and other services (0.15 kg/$). The share of direct intensities in these sectors are very low, for example, 4.3 percent (0.004 kg/$) in education, health and community, 4.1 percent (0.004 kg/$) in finance and insurance, 12.3 percent (0.013 kg/$) in services to transport, and 3.3 percent in (0.004 kg/$) in personal and other services. The low values of direct CO_2 intensities in these sectors reflect smaller shares of fossil energy sources (and a large share of electricity) in their energy consumption fuel-mix.

- The total CO_2 emission intensities for the economic sectors are generally lower in both Moderate and Advanced scenarios, as compared to the Base scenario in 2020 and 2040. This is due to the reduced level of energy consumption in these scenarios, in particular reduced levels of coal consumption. For example, in 2020, the total CO_2 intensities for the iron and steel sector in the Moderate (1.14 kg/$) and in Advanced scenarios (0.88 kg/$) are 19.7 percent and 38.1 percent lower than the corresponding intensity in the Base scenario (1.42 kg/$). In 2040, the intensities decreases further; they are 41.4 percent lower in the Moderate scenario (0.62 kg/$) and 56.2 percent lower in the Advanced scenarios (0.46 kg/$) – as compared with the intensity in the Base scenario (1.06 kg/$). The decline in total CO_2 emission intensities in the iron and steel sector is mainly due to the reduction in coal consumption by this sector, as this sector shifts from the coal-based Blast Furnace/Blast Oxygen Furnace to natural gas-based Direct Reduced Iron technology.

- The total CO_2 intensities for the sectors such as fabricated metal, transport equipment, and other equipment (which take large inputs from the iron and steel industry) also decline in the Moderate and Advanced scenarios. In the Advanced scenario, for example, the total CO_2 intensities, in 2020, are 35.1 percent lower for the fabricated metal (0.31 kg/$), 34.9 percent for the transport equipment (0.12 kg/$) and 34.6 percent for the other equipment (0.10 kg/$) sectors – as compared with the corresponding values in the Base scenario.

- The basic non-ferrous sector shows interesting results in terms of the movements in its total CO_2 intensities. For example, in 2020, while the total CO_2 intensity in the Moderate scenario (1.57 kg/$) declines by 5.8 percent, the decline in the

Advanced scenario (1.04 kg/$) is very large – 37.6 percent, compared to the intensity in the Base scenario (1.67 kg/$). This could be due to the differences in the rates at which fuel switching (for example, from coal to gas and renewables) takes place in the electricity generation sectors. In 2040, the intensities for the basic non-ferrous sector decline by 34.4 and 33.3 percent in the Moderate and Advanced scenarios, respectively.

- The total CO_2 intensities for the service sectors, such as communication, finance and insurance, property and business, personal and other services decline in both the Advanced and Moderate scenarios in 2020 and 2040. The decline is more significant however in the Advanced than the Moderate scenario. In 2020, for example, in the communication sector, the intensity in the Advanced scenario (0.077 kg/$) is 28.7 percent lower, but in the Moderate scenario (0.102 kg/$), it is only 6.3 percent lower, as compared to the value in the Base scenario (0.108 kg/$). Similarly, for the finance and insurance sector, the intensity in 2020 is 34.3 percent lower in the Advanced (0.046 kg/$), but only 4.7 percent lower, in the Moderate scenario (0.067 kg/$), as compared to the value in the Base scenario (0.071 kg/$). Electricity is the main type of energy consumed by these service sectors, and as CO_2 emissions from the electricity sector decrease (from 57.3 Mtons in the Base scenario to 51.7, and 22.2 Mtons in the Moderate and Advanced scenarios, respectively, in 2020, see Table 4-16, Chapter-4), the total CO_2 intensities in the service sectors also decline.

- The sectors, such as air and space travel, and water transport show marginal improvements in their CO_2 intensities in both scenarios. In 2020, for example, the total CO_2 intensities of these two sectors decline by 0.4 each in the Moderate, and, 3.4 and 8.2 percent in the Advanced scenario, respectively, compared with their values in the Base scenario (0.97, 0.91 kg/$, respectively).

Table 5-4: CO_2 Emissions Intensities (kg of CO_2/\$ of sectoral outputs)

	Sectors	2000		2020						2040					
				BAS		MOD		ADV		BAS		MOD		ADV	
		Direct	Total[1]	Direct	Total	Direct	Total	Direct	Total	Direct	Total	Direct	Total	Direct	Total
1	Agri., hunting and trapping	0.079	0.363	0.075	0.277	0.075	0.267	0.075	0.225	0.068	0.177	0.068	0.148	0.068	0.148
2	Forestry and fishing	0.079	0.325	0.075	0.243	0.075	0.279	0.075	0.188	0.068	0.151	0.068	0.123	0.068	0.123
3	Mining	0.097	0.599	0.089	0.424	0.089	0.406	0.089	0.302	0.080	0.266	0.080	0.194	0.080	0.198
4	Services to mining	0.097	0.636	0.089	0.458	0.089	0.435	0.089	0.326	0.080	0.281	0.080	0.204	0.080	0.205
5	Meat and diary prod.	0.038	0.393	0.028	0.289	0.028	0.285	0.028	0.220	0.025	0.160	0.025	0.123	0.025	0.117
6	Other food prod.	0.038	0.291	0.028	0.205	0.028	0.196	0.028	0.154	0.025	0.117	0.025	0.089	0.025	0.087
7	Beverage and tobacco	0.038	0.255	0.028	0.177	0.028	0.169	0.028	0.131	0.025	0.104	0.025	0.079	0.025	0.077
8	Textile, clothing, leather	0.023	0.305	0.074	0.182	0.074	0.178	0.074	0.155	0.067	0.123	0.067	0.109	0.067	0.109
9	Wood, paper, printing	0.001	0.283	0.014	0.161	0.014	0.153	0.014	0.117	0.013	0.091	0.013	0.066	0.013	0.066
10	Basic chemical	1.371	2.570	1.422	1.945	1.422	1.944	1.422	1.647	1.286	1.530	1.286	1.348	1.286	1.374
11	Other chem., rubber, plastic	0.023	0.249	0.020	0.160	0.020	0.156	0.020	0.134	0.018	0.089	0.018	0.077	0.018	0.077
12	Non-metallic mineral	0.263	0.889	0.261	0.686	0.261	0.655	0.261	0.550	0.236	0.481	0.236	0.399	0.236	0.395
13	Iron and steel	1.031	1.663	0.937	1.416	0.717	1.138	0.571	0.877	0.847	1.059	0.494	0.620	0.352	0.464
							(-19.7)		*(-38.1)*				*(-41.4)*		*(-56.2)*
14	Basic non-ferrous	0.437	2.562	0.270	1.670	0.263	1.574	0.256	1.041	0.243	1.080	0.236	0.708	0.230	0.720
							(-5.8)		*(-37.6)*				*(-34.4)*		*(-33.3)*
15	Fabricated metal	0.044	0.636	0.024	0.481	0.023	0.423	0.023	0.312	0.022	0.249	0.021	0.162	0.020	0.147
							(-12.1)		*(-35.1)*				*(-34.8)*		*(-41.1)*
16	Transport equip.	0.005	0.253	0.003	0.189	0.003	0.167	0.003	0.123	0.003	0.093	0.003	0.059	0.003	0.054
							(-11.9)		*(-34.9)*				*(-36.1)*		*(-42.3)*
17	Other equip., manufacturing	0.005	0.210	0.003	0.155	0.003	0.137	0.003	0.101	0.003	0.080	0.003	0.051	0.003	0.047
							(-11.2)		*(-34.6)*				*(-35.6)*		*(-41.1)*
18	Water and sewerage	0.010	0.354	0.007	0.237	0.007	0.224	0.007	0.154	0.007	0.134	0.006	0.085	0.006	0.088
19	Construction	0.036	0.256	0.033	0.200	0.033	0.184	0.033	0.154	0.029	0.106	0.029	0.085	0.029	0.081
20	Trade and repair	0.004	0.175	0.006	0.124	0.006	0.116	0.005	0.088	0.005	0.062	0.005	0.043	0.005	0.042
21	Accommodation, café	0.004	0.158	0.006	0.108	0.006	0.103	0.005	0.074	0.005	0.052	0.005	0.036	0.005	0.036

Table 5-4 continued in next page

Table 5-4 continued from previous page

	Sectors	2000		2020						2040					
				BAS		MOD		ADV		BAS		MOD		ADV	
		Direct	Total[1]	Direct	Total	Direct	Total	Direct	Total	Direct	Total	Direct	Total	Direct	Total
22	Road transport	1.051	1.261	0.955	1.104	0.718	0.904	0.670	0.812	0.864	0.927	0.553	0.665	0.466	0.542
23	Rail, pipeline	0.386	0.900	0.308	0.668	0.242	0.767	0.308	0.523	0.277	0.490	0.277	0.399	0.277	0.407
24	Water transport	0.707	1.015	0.642	0.906	0.642	0.902	0.598	0.831	0.581	0.695	0.581	0.691	0.488	0.583
							(-0.4)		*(-8.2)*				*(-0.6)*		*(-16.2)*
25	Air and space travel	0.941	1.082	0.855	0.971	0.855	0.968	0.836	0.938	0.773	0.826	0.773	0.822	0.736	0.782
							(-0.4)		*(-3.4)*				*(-0.5)*		*(-5.3)*
26	Services to transport	0.013	0.106	0.025	0.072	0.025	0.067	0.025	0.059	0.022	0.051	0.022	0.043	0.022	0.041
27	Communication	0.004	0.152	0.006	0.108	0.006	0.102	0.005	0.077	0.005	0.056	0.005	0.040	0.005	0.039
							(-6.3)		*(-28.7)*				*(-28.7)*		*(-30.1)*
28	Finance and insurance	0.004	0.106	0.006	0.071	0.006	0.067	0.005	0.046	0.005	0.039	0.005	0.025	0.005	0.026
							(-4.7)		*(-34.3)*				*(-34.3)*		*(-32.3)*
29	Property and business	0.004	0.131	0.006	0.090	0.006	0.085	0.005	0.061	0.005	0.046	0.005	0.032	0.005	0.032
							(-5.4)		*(-31.9)*				*(-32.1)*		*(-31.3)*
30	Govt. admin and defence	0.004	0.161	0.006	0.113	0.006	0.107	0.005	0.081	0.005	0.056	0.005	0.040	0.005	0.040
31	Education, health, community	0.004	0.102	0.006	0.069	0.006	0.065	0.005	0.046	0.005	0.039	0.005	0.026	0.005	0.026
32	Personal and other services	0.004	0.148	0.006	0.103	0.006	0.097	0.005	0.072	0.005	0.052	0.005	0.036	0.005	0.036
							(-6.0)		*(-30.4)*				*(-30.8)*		*(-31.0)*

Source: Results obtained from input–output modelling in this research.

[1] Total energy intensity is the sum of the direct and indirect energy intensities.

[2] Values in the parentheses represent percentage changes in relation to the corresponding values for the Base scenario. These changes are shown in this table for selected key sectors only (that is, for those sectors that experience significant intensity impacts).

5.6 Overall Impacts

In Section 5.5, the economy wide impacts of energy settings in Moderate and Advanced scenarios are presented – detailed at sectoral levels. This section presents these impacts at the aggregate level, that is, at the level of the state of NSW. This section also draws some inferences based on a comparative analysis of these impacts.

Total Output. In sub-section 5.5.1, it was observed that there is a considerable variation in outputs across individual sectors for the Moderate and Advanced scenarios. The total outputs, aggregate at the state level, are presented in Table 5-5.

Table 5-5: Total Outputs at State Level

Non-energy Sectors

	BAS	MOD			ADV		
	Total Outputs (M$)	**Total Outputs (M$)**	**Δ Total Outputs[1] (M$)**	**(%)**	**Total Outputs (M$)**	**Δ Total Outputs (M$)**	**(%)**
2020	661,673	662,179	506	0.076	661,769	96	0.014
2040	1,053,610	1,054,454	844	0.080	1,053,761	151	0.014

Energy Sectors

	Total Outputs (PJ)	**Total Outputs (PJ)**	**Δ Total Outputs (PJ)**	**(%)**	**Total Outputs**	**Δ Total Outputs (PJ)**	**(%)**
2020	5,194	5,054	-140	-2.69	4,759	-435	-8.37
2040	6,946	6,423	-523	-7.53	6,062	-885	-12.73

Source: This table is assembled from values contained in Tables 5.1 and 5.2.

Note: [1] Change in total output as compared with the corresponding value for the Base scenario.

The major points are summarised below:

- Despite significant variations in sector-specific outputs (as shown in Tables 5.1 and 5.2), the overall outputs of the non-energy sectors of NSW do not appear to change appreciably in response to the energy outcomes associated with the two scenarios, in the medium (2020) and longer terms (2040). For example, for the years 2020 and 2040, in the case of the Moderate scenario, the total outputs of the non-energy sectors, are respectively, merely 0.076 percent (that is $506 million) and 0.080 percent ($844 million) higher than the corresponding values for the Base scenario. Further this small difference becomes ever smaller in the Advanced scenario. In this scenario, the total outputs of the non-energy sectors, in 2020 and 2040, are merely 0.014 percent higher than the total outputs in the Base scenario.

- The total outputs of the energy sectors (in PJ), however, are noticeably lower both in the Moderate and Advanced scenarios, with respect to the Base scenario. For example, total outputs of the energy sectors in the Moderate and Advanced scenarios are lower by 140 PJ (2.7 percent) and 435 PJ (8.4 percent) in 2020 and by 523 PJ (7.5 percent) and 885 PJ (12.7 percent) in 2040, respectively, compared with the corresponding values for the Base scenario. The large decline in the energy sectors reflects reduced level of energy consumptions in the Moderate and Advanced scenarios.

Wages and Salaries. The impacts on wages and salaries at individual sector level were discussed in sub-section 5.5.2. Table 5-6 provides an overview of these impacts, aggregated to the state level. The table also shows impacts in terms of the Gross State Product (GSP). The GSP here refers to the sum of Other Value Added (OVA)[51] and wages and salaries, which could be considered as a proxy for the actual GSP[52]. From the table it can be observed that:

- The wages and salaries at the aggregated level are only marginally lower both for the Moderate and Advanced scenarios. In the Moderate and Advanced scenarios, for example, they are lower by \$11 million (~0.01 percent) and \$238 million (0.15 percent) in 2020 and by \$207 million (0.45 percent) and \$537 million (0.36 percent) in 2040.

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[51] The Other Value Added (OVA) in represents the remaining primary inputs except imports, for example, gross operating surplus, taxes on products and production (as explained in Section 5.3).

[52] The sum here accounts for intermediate sectors only, that is, it does not include the purchase of 'other value added' by the final demand sectors (that is, households, OFD, and export). Hence, this sum (GSP*) would actually be lower than the true GSP. However, since this value represents the bulk of the total GSP (for example, 90% in 2000-01), the impacts assessed in terms of this indicator could be considered as a justifiable proxy for the changes in GSP.

Table 5-6: Impacts on Wages and Salaries at Aggregated Level

	2020			2040		
	Wages and Salaries (M$)	Other Value Added (M$)	GSP* (M$)	Wages and Salaries (M$)	Other Value Added (M$)	GSP* (M$)
BAS	146,796	164,576	311,372	236,014	264,159	500,173
MOD	146,785	164,223	311,008	235,807	262,959	498,766
ADV	146,558	163,638	310,195	235,477	262,012	497,489
Change with respect to the Base Scenario						
MOD	-11	-353	-364	-207	-1,200	-1,407
	(-0.007)	*(-0.215)*	*(-0.117)*	*(-0.088)*	*(-0.454)*	*(-0.281)*
ADV	-238	-939	-1177	-537	-2148	-2685
	(-0.155)	*(-0.356)*	*(-0.261)*	*(-0.140)*	*(-0.359)*	*(-0.255)*

Source: Results obtained from input–output modelling in this research.

Note: Values in parentheses are percentage changes, in comparison with the Base scenario.

- The state GSP in the Moderate and Advanced scenarios are respectively $364 million (0.12 percent) and $1,177 million (0.26 percent) lower than the Base scenario in the year 2020. For the year 2040, these values are lower by $1,407 million (0.28 percent) and $2,685 million (0.25 percent), respectively. Figure 5-8 illustrates these impacts for the Moderate and Advanced scenarios, using a value of 100 for the Base scenario GSP*. It shows that the reduction in the state GSP* is likely to be larger in 2040 than in 2020.

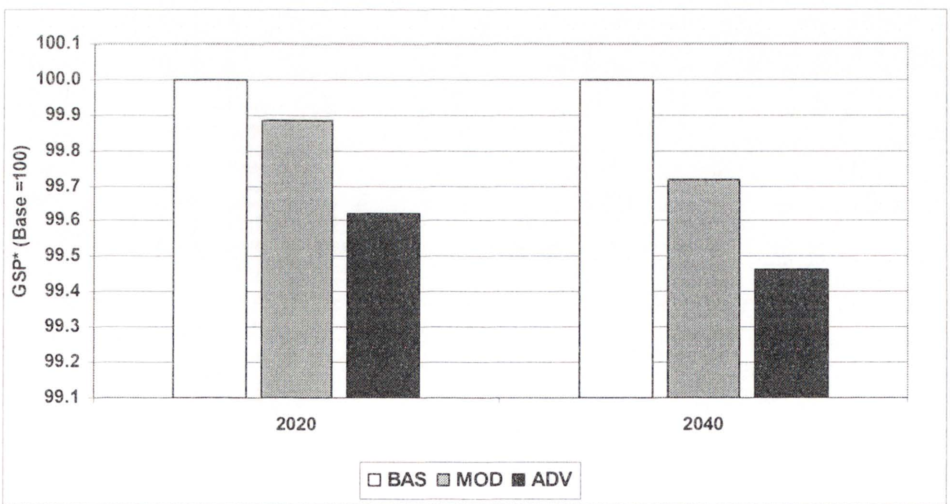

Figure 5-8: Impacts on GSP*

Employment. Table 5-7 presents state level employment impacts (the impacts on employment at individual sectors are discussed in sub-section 5.5.3):

- The employment levels in the Moderate scenario are only marginally higher – 0.041 percent (1,233 persons) for 2020 and 0.003 percent (112 persons) for 2040 – than the Base scenario employment levels. In the Advanced scenario, these levels, for 2020 and 2040, are lower by 0.057 (1,732 persons) and 0.097 percent (3,328 persons), respectively.

Table 5-7: Impacts on Employment at Aggregate Level

Year	BAS (persons)	MOD (persons)	Change from BAS (persons)	(%)	ADV (persons)	Change from BAS (persons)	(%)
2020	3,014,222	3,015,455	1,233	*0.041*	3,012,490	-1,732	*-0.057*
2040	3,426,670	3,426,783	112	*0.003*	3,423,343	-3,328	*-0.097*

Source: Results obtained from input–output modelling in this research.

The discussion above illustrates that impacts of energy outcomes of various scenarios (which are analysed in this research in terms of changes in total output, wages and salaries and employment) are not particularly significant at the aggregate level (considering they are not more than 0.3 percent in any case). However, the discussion in Section 5.5 has illustrated that these impacts are comparatively higher at individual sectoral levels, particularly for some sectors such as agriculture. Two important conclusions can be drawn from this observation: First, adopting the Moderate and Advanced scenarios would not result in any significant overall losses in total outputs, wages and salaries and employment, even while these scenarios would help achieve policy goals of reducing energy consumption and CO_2 emissions. Second, the disparities that exist between aggregate and individual sectoral level impacts indicate how policy recommendations made simply based upon analysis at the aggregate levels (often a normal practice in policy studies) could fail to represent the individual sector impacts, which could be significant.

Total Outputs vs. Energy and CO_2 intensities

Table 5-8 compares percentage differences in total outputs, energy intensities and CO_2 intensities for some major sectors (which were also discussed in Section 5.4), for the

Moderate and Advanced scenarios, as compared with the Base scenario. Figure 5-9 and 5-10 illustrate these values graphically. From the table and figures, it can be observed that:

- Among the nine sectors listed in the table, the agriculture sector, while exhibiting comparatively higher differences in total outputs, as compared with the Base scenario, however, shows smaller improvement in its total energy and CO_2 intensities. For example, in 2020, the total outputs of this sector is higher than the Base scenario outputs, by 2.2 and 2.3 percent for the Moderate and Advanced scenarios, respectively, while its energy and CO_2 intensities are lower by 2.5 and 3.7 percent, respectively, for the Moderate scenario and by 8.0 and 18.9 percent, respectively, for the Advanced scenario – in comparison with the corresponding intensities in the Base scenario. Figures 5-9 and 5-10 illustrate this in a clearer manner. For example, the plotting of this sector could be observed distinctly located at the upper right corner in these figures. As explained earlier in Section 5.5, the increase in economic outputs of this sector is due to the increased use of biomass for electricity generation and for producing bio-fuels. And, lower improvement in energy and CO2 intensities could be explained by the fact that the energy intensity (1.44 MJ/$ in 2000) of this sector is one of the lowest, thus it has comparatively lower room for improvement in energy efficiency.

- The iron and steel sector, on the other hand, showed smallest differences its total outputs, but the largest differences in its energy and CO_2 intensities. For example, in 2020, its energy and CO_2 intensities are lower by 13.7 and 19.7 percent for the Moderate scenario and by 24.7 and 38.1 percent for the Advanced scenario – in comparison with the Base scenario. For the same period, however, its total output is higher by only 0.07 percent for the Moderate scenario and by 0.02 percent for the Advanced scenario. This illustrates the fact that while the scenarios would not result in higher level of outputs in this sector, it could result in lowering energy intensity and CO_2 intensity significantly. This would result because of the technological shift that takes place in this sector across the scenarios, for example, from the coal-based Blast Furnace and Basic Oxygen Furnace to natural gas-based Direct Reduced Iron technology.

- For some of the sectors, such as other equipment and fabricated metal, total outputs are modestly higher and also their energy and CO_2 intensities are modestly lower. For example, the total outputs for the other equipment and fabricated metal sectors are higher by 0.57 and 0.54 percent respectively for the Moderate scenario in 2020 – as compared with the Base scenario. For the same period, the total energy intensities of these two sectors are lower by 7.9 and 8.8 percent, respectively, and CO_2 intensities decline by 11.2 and 12.1 percent, respectively.

From the above discussion, it can be observed that the alternative scenarios (Moderate and Advanced) would result in outputs that would be comparatively higher for those sectors which are characterised by having low energy and CO_2 intensities (such as the agriculture sector). The increase in outputs from these sectors would not hence result in significant increase in energy consumptions and CO_2 emissions. It is also observed that for energy intensive sectors (such as iron and steel), outputs would increase only marginally while their energy and CO_2 intensities reduce significantly. As a result of this, energy and CO_2 emissions from these sectors are also not likely to increase significantly.

Table 5-8: Percentage Differences[1] in Total Outputs, Energy and CO_2 Intensities

	2020						2040					
	MOD			ADV			MOD			ADV		
Sectors	Total Outputs	Energy Intensity	CO_2 Intensity	Total Outputs	Energy Intensity	CO_2 Intensity	Total Outputs	Energy Intensity	CO_2 Intensity	Total Outputs	Energy Intensity	CO_2 Intensity
A Agri., hunting and trapping	2.18	-2.53	-3.69	2.30	-8.00	-18.88	2.59	-7.08	-16.40	2.58	-7.82	-16.51
B Other equip., manufacturing	0.57	-7.95	-11.16	0.44	-17.93	-34.59	0.82	-19.44	-35.57	0.47	-23.82	-41.13
C Construction	0.18	-4.93	-7.83	0.14	-11.67	-23.06	0.26	-10.08	-19.25	0.12	-13.52	-23.02
D Fabricated metal	0.54	-8.82	-12.08	0.04	-19.04	-35.07	0.17	-19.66	-34.82	-0.25	-24.76	-41.12
E Finance and insurance	-0.05	-5.03	-4.65	-0.17	-14.83	-34.29	-0.08	-14.99	-34.27	-0.15	-14.47	-32.26
F Property and business	-0.02	-4.96	-5.36	-0.06	-14.20	-31.86	-0.02	-14.34	-32.07	-0.07	-14.76	-31.34
G Iron and steel	0.07	-13.74	-19.67	0.02	-24.70	-38.09	0.03	-30.61	-41.44	0.004	-42.00	-56.19
H Basic non-ferrous	0.04	-6.36	-5.77	0.02	-17.91	-37.65	0.03	-15.87	-34.42	0.01	-16.49	-33.32
I Road transport	0.02	-8.70	-18.14	-0.10	-17.54	-26.49	-0.01	-15.95	-28.22	-0.08	-30.72	-41.50

Source: Compiled from Tables 5-1, 5-2, 5-3, and 5-4.

Notes:

[1] -- The values here represent percentage differences for the Moderate (MOD) and Advanced (ADV) scenarios with respect to the corresponding values for the Base (BAS) scenario.

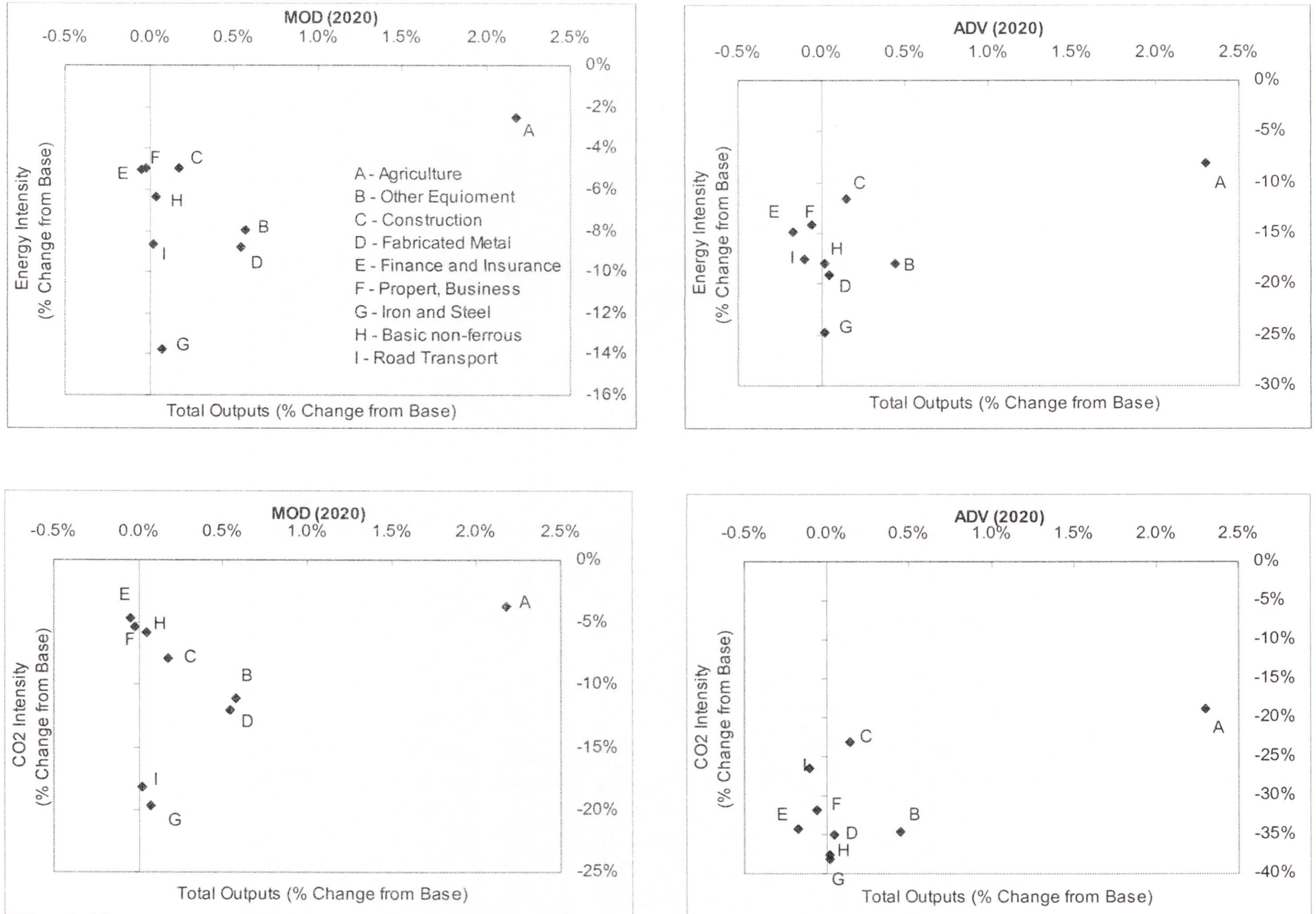

Figure 5-9: Total Outputs vs. Energy and CO_2 Intensities (2020)

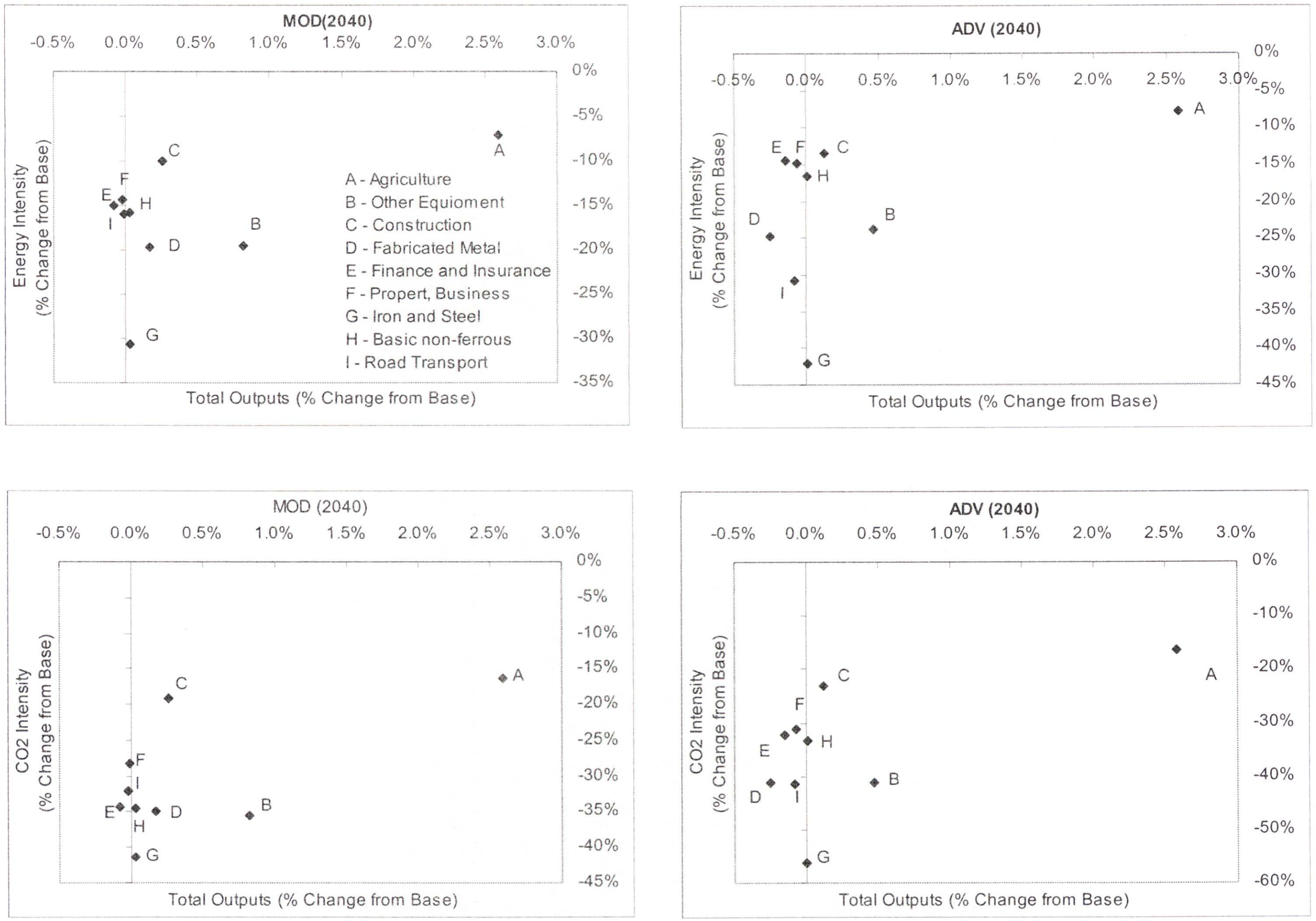

Figure 5-10: Total Outputs vs. Energy and CO_2 Intensities (2040)

5.7 Summary and Conclusions

This chapter examined the economy wide impacts of the changes in the structure of energy consumption in the Moderate and Advanced scenarios. These impacts are quantified in terms of the changes (from their corresponding values in the Base scenario) in total outputs, wages and salaries, employment level, primary energy intensities, and CO_2 emission intensities across the key economic sectors. A summary of main points and major conclusions are noted below.

Total Outputs

- The sectors that show comparatively higher values of total outputs in the Moderate and Advanced scenarios, as compared with the Base scenario, are agriculture, other equipment and construction. The total outputs of these sectors, for example, are higher by \$273 million (2.18 percent), \$214 million (0.57 percent), and \$44 million (0.18 percent) in the Moderate scenario, and by \$288 million (2.3 percent), \$166 million (0.44 percent) and \$36 million (0.14 percent) in the Advanced scenario in 2020 – in comparison with the corresponding values for the Base scenario. The use of renewable energy sources, such as biomass, wind and PV in power generation, and fuel switching from coal to natural gas are the major reasons behind these increases.

- The sectors that experience comparatively lower changes in total outputs are property and business, and finance and insurance. For example, in 2020, the total outputs from these sectors are lower by \$29 million (0.02 percent) and \$17 million (0.05 percent), respectively, in the Moderate scenario, and by \$74 million (0.06 percent) and \$68 million (0.17 percent), respectively, in the Advanced scenario – in comparison with the corresponding values in the Base scenario. These reductions in total outputs result from reduced levels of energy consumption in the Moderate and Advanced scenarios, as compared to the Base scenario.

- The total outputs (in PJ) of the energy sectors (electricity, petroleum product and coal) are lower than the outputs in the Base scenario in 2020 and 2040. In 2020, for example, the total outputs of these sectors are lower by 20 PJ (6.2 percent), 117 PJ (15.7 percent) and 65 PJ (1.8 percent), respectively, in the Moderate scenario, and by 50 PJ (15.6 percent), 470 PJ (12.9 percent), and 143 PJ (19.1 percent), respectively, in the Advanced scenario – as compared with the corresponding values in the Base scenario. These reflect reduction in electricity consumption due to the increased use of efficient appliances, petroleum products due to improvement in vehicle efficiency and use of alternative transport fuels; and coal consumption in electricity generation and in iron and steel industry. In 2020, the total output of the gas supply sector is lower in the Moderate scenario by 49 PJ (12.7 percent), but is higher in the Advanced scenario by 86 PJ (22.4 percent) – as compared with the Base scenario. This reflects reduced level of gas consumption in the Moderate scenario which is due to the decline in electricity generation and expansion of renewable-based plants.

Wages and Salaries

- The sectors that show higher values of wages and salaries are agriculture, construction, fabricated metals and other equipment sectors. The wages and salaries in the agriculture sector in the Moderate and the Advanced scenario, for example, are higher by $85 (2.18 percent) and $89 million (2.30), respectively in 2020. This is due to the increased use of agri-products, as energy sources, mainly in biomass plants, and in producing biofuels.

- The sectors that experience lower values of wages and salaries are trade and repair, finance and insurance, and property and business. In 2020, for example, the wages and salaries are lower in the Advanced scenarios, by $14 million (0.07 percent) in trade and repair, by $68 million (0.17 percent) in the finance and insurance and by $74 million (0.06 percent) in the property and business sectors – as compared with the Base scenario. These declines in wages and salaries in these sectors are a result of the overall decrease in total energy requirement in these scenarios.

- The energy sectors experience considerable changes in wages and salaries in both scenarios. For example, in 2020, the wages and salaries for the electricity, coal, petroleum products sectors in the Moderate scenario are lower by $61 million (6.2 percent), $18 million (1.8 percent), and $33 million (15.7 percent), respectively, as compared with the wages and salaries in the Base scenario. And, in the Advanced scenario, they are lower by $155 million (15.6 percent), $132 million (12.9 percent), and $41million (19.1 percent), respectively. This is because of the declines in electricity consumption, in response to efficiency improvements of electrical appliances in the residential sectors; reduced coal consumption, as coal is replaced by gas and renewables in electricity production; and reduced consumption of petroleum products, as vehicle efficiencies improve and as alternative fuels (natural gas, and biofuels) penetrate the transport market. The wages and salaries in the gas supply sector, however, while lower by $27 million (12.7 percent) in the Moderate scenario, are higher by $48 million (22.4 percent) in the Advanced scenario (in 2020).

- While wages and salaries are generally found to be declining in the traditional energy sectors (such as coal, gas, petroleum products, and electricity), they are found to be increasing in the 'others' sector (which comprises biomass, methanol, ethanol, and CNG). For example, the wages and salaries of the other sector in the Moderate and Advance scenario are higher by $19 and 11 million in 2020 as compared with the Base scenario. This reflects increased use of these energy types in the Moderate and Advanced scenarios, for example, biomass in electricity generation, and ethanol and methanol in the transport sector.

Employment

- Employment in the energy sectors is generally found to be declining while increasing in the non-energy sectors. In the Moderate scenario, in 2020, for example, there is a net decline in employment in the energy sectors of 1,375 persons, and a net increase in employment in non-energy sectors of 2,607. The shift in employment from energy to non-energy sectors could be largely due to the switch in power generation, from fossil-based plants to renewable-based plants (such as wind, PV, and biomass).

- The employment in agriculture, other equipment, and construction sectors is higher relative to the Base scenario in both Moderate and Advanced scenarios. In 2020, for example, the agriculture sector employs additional 1,957 (2.18 percent) and 2,066 persons (2.30 percent) in the Moderate and Advanced scenarios in 2020, respectively. The non-energy sectors, namely, trade and repair, finance and insurance, and property and business sectors experience comparatively larger reductions.

- The electricity, petroleum products and coal sectors experience large reductions in employment in both Moderate and the Advanced scenarios. For example, in 2020, employment in the electricity, coal, petroleum products sectors in the Moderate scenario is lower by 753 persons (6.2 percent), 155 persons (1.8 percent), and 374 persons (15.7), respectively, as compared with the employment in the Base scenario. And, in the Advanced scenario, it is lower by 1,900 persons (15.6 percent), 1,121 persons (12.9 percent) and 456 persons (19.1 percent), respectively. The employment in the gas supply sector, in 2020, is lower by 311 persons (12.7 percent) in the Moderate scenario, but is higher by 551 persons (22.4 percent) in the Advanced scenario.

Total Energy Intensities

- There exist wide variations in terms of total energy intensities across the economic sectors. The most energy intensive sectors in 2000, for example, are the basic chemical (41.45 MJ/$), basic non-ferrous (30.18 MJ/$), and iron and steel (18.92 MJ/$). And, the least energy intensive sectors are education, health and community (1.22 MJ/$), finance and insurance, 1.25 (MJ/$), and services to transport 1.33 (MJ/$).

- The total energy intensities of the economic sectors show a declining trend in the Moderate and Advanced scenarios. This reflects a declining trend in total primary energy consumption in the Moderate and the Advanced scenarios, as compared with the Base scenario. The reductions in the total energy intensity in the iron and steel, fabricated metal, road transport are the largest. In 2020, for example, the total energy intensity in the iron and steel sector is lower by 13.7 percent in the Moderate scenario (14.23 MJ/$) and by 24.7 percent in the Advanced scenario (12.4 MJ/$), as compared with the intensity in the Base scenario (16.50 MJ/$). Similarly, the energy intensity in the fabricated metal sector is 8.8 percent lower in the Moderate scenario (5.68 MJ/$) and 19 percent lower in the Advanced scenario (5.05 MJ/$). The lower values of total energy intensity in the fabricated metal sector is largely due to the improvement in indirect energy intensity, reflecting an improvement in the energy embodied inputs to this sector (such as inputs of iron and steel).

- The total energy intensity in the road transport sector is lower than the Base scenario intensity in the Moderate and Advanced scenario by 8.7 and 17.5 percent, respectively in 2020, and by 15.9 and 30.7 percent, respectively in 2040. This is largely due the reduction in direct energy requirements in road transport because of efficiency improvements.

- The total energy intensities of the service sectors, such as communication, finance and insurance, property and business, personal and other services are lower than the Base scenario in both Advanced and Moderate scenarios, in 2020 and 2040. In 2020, for example, the total energy intensity of the communication sector in the Moderate scenario (1.42 MJ/$) and the Advanced scenario (1.29 MJ/$) is 4.9 and 13.5 percent lower than the intensity in the Base scenario (1.49 MJ/$).

Total CO_2 Intensities

- The sectors that show largest values for CO_2 intensities in 2000 are basic chemical (2.57 kg/$), basic non-ferrous (2.56 kg/$), iron and steel (1.66 kg/$), and road transport (1.26 kg/$). The sectors that show lowest values for the total CO_2 intensities are education, health and community (0.10 kg/$), finance and insurance (0.11 kg/$), services to transport (0.11 kg/$), and personal and other services (0.15 kg/$).

- The total CO_2 emission intensities for the economic sectors are generally lower in both Moderate and Advanced scenarios, in comparison with the intensities in the Base scenario, in 2020 and 2040. This is due to reduced energy consumption in these scenarios, in particular reduced coal consumption. For example, in 2020, the total CO_2 intensities for the iron and steel sector in the Moderate (1.14 kg/$) and in Advanced (0.88 kg/$) scenarios are 19.7 and 38.1 percent lower than the intensity in the Base scenario (1.42 kg/$).

- The total CO_2 intensities for fabricated metal, transport equipment, and other equipment sectors (which take inputs from the iron and steel sector) also decline in the Moderate and Advanced scenarios in 2020 and 2040. In the Advanced scenario, for example, the total CO_2 intensities in 2020 in these sectors are lower by 35.1 percent for the fabricated metal (0.312 kg/$), by 34.9 percent for the transport equipment (0.123 kg/$) and by 34.6 percent for the other equipment (0.101 kg/$) sector, with respect to intensity in the Base scenario.

- The total CO_2 intensities of the service sectors, such as communication, finance and insurance, property and business, personal and other services are lower in both the Advanced and Moderate scenarios in 2020 and 2040 – in comparison with the Base scenario. In 2020, for example, in the communication sector, the intensity in the Advanced scenario (0.08 kg/$) is 28.7 percent lower, and in the Moderate scenario (0.10 kg/$) it is 6.3 percent lower, as compared with the values in the Base scenario (0.11 kg/$). Electricity is the main type of energy consumed by these service sectors, and as CO_2 emissions from the electricity sector decreases, it significantly lowers CO_2 intensities in the service sectors in the Advanced scenario.

Impacts at Aggregate (State) Level

- At the aggregate level, that is, at the state level, the total outputs of the non-energy sectors (in M$) are only modestly higher in both scenarios, in 2020 and 2040. For example, the total outputs of the non-energy sectors in 2020, for the Moderate and Advanced scenarios, are higher by $506 million (that is by 0.08 percent) and $96 million (0.014 percent), respectively, in comparison with the Base scenario. The higher level of total outputs in non-energy sectors is likely to be the result of higher level of outputs in agriculture, other equipment sectors resulting from increased use of renewable based energy plants (as discussed above).

- The total outputs of the energy sectors (in PJ), however, are lower both in the Moderate and Advanced scenarios, with respect to the Base scenario. For example, total outputs of the energy sectors in the Moderate and Advanced scenarios are lower by 140 PJ (2.7 percent) and 435 PJ (8.4 percent) in 2020, compared with the corresponding values for the Base scenario. The lower level of outputs in the energy sectors reflects reduced level of energy consumptions in the Moderate and Advanced scenarios.

- At the aggregate level, the wages and salaries are marginally lower both for the Moderate and the Advanced scenarios. In the Moderate and Advanced scenarios, for example, they are lower by \$11 million (~0.01 percent) and \$238 million (0.15 percent) in 2020, and by \$207 million (0.45 percent) and \$537 million (0.36 percent) in 2040.

- At the aggregate level, employment is marginally higher in the Moderate scenario but lower in the Advanced scenario, compared with the Base scenario. In 2020 and 2040, for example, employment in the Moderate scenario is higher by 1,233 persons (that is, by 0.041 percent) and 112 persons (0.003 percent), respectively. And, in the Advanced scenario, by 1,732 persons (0.057 percent) and 3,328 persons (0.097 percent), respectively – as compared with the corresponding values for the Base scenario.

- The economy wide impacts are more significant at individual sectoral levels (such as agricultural, other equipment sector) than at the aggregate level. This disparity between aggregate and individual sectoral level impacts indicates that policy recommendations made simply based upon analysis at the aggregate levels (often a normal practice in policy studies) could fail to represent individual sectoral level impacts, which could be significant.

- The agriculture sector, which experiences higher level of total outputs, shows small improvement in its total energy and CO_2 intensities. For example, in 2020, while its total outputs is 2.18 percent higher in the Moderate scenario as compared with the Base scenario, its energy and CO_2 intensities are 2.53 and 3.69 percent lower, respectively. The iron and steel sector, on the other hand, shows largest improvement in its energy and CO_2 intensity but smallest increase its total outputs. For example, in 2020, its energy and CO_2 intensities are 13.7 and 19.7 percent lower in the Moderate scenario, where, its total output is only 0.07 percent higher.

In summary, the alternative scenarios (Moderate and Advanced) would make marginal impacts on economy (on total outputs, wages and salaries and employment) at the aggregate level, even while these scenarios would help achieve policy goals of reducing energy consumption and CO_2 emissions. At the individual sectoral level, however, the impacts could be significant, for example, it could result in significantly lower income (wages and salaries) and employment in energy sectors but higher in the non-energy sectors. Also the loss of employment that would be experienced by the traditional energy sectors (coal, gas, electricity) could be compensated by the generation of additional employment in non-energy sectors from the increased use of renewable energy sources (such as biomass and wind). This employment generation resulting from the increased use of renewable energy sources could also benefit rural areas.

6. Energy Future for NSW: A Policy Perspective

6.1 Introduction

In Chapter 4 and Chapter 5, the energy and economic impacts associated with the Base, Moderate and Advanced scenarios were quantified, using the MARKAL (energy) and energy oriented input–output (economic) models, respectively. These chapters also provided some analysis, in particular, of the underlying reasoning, associated with such impacts. The energy impacts were quantified in terms of primary energy requirements, primary energy mix, fuel- and technology-mix in the electricity sector, and CO_2 emissions, for the period of 2000-2040. The economic impacts were quantified in terms of changes in total economic outputs, salaries and wages, employment, energy and CO_2 intensities. Figure 6-1 provides a summary of these scenario impacts grouped into three categories, namely, energy, environment and economy.

This chapter extends the analysis of scenario impacts, by providing a more complete policy perspective. This extension is achieved as follows: (i) key scenario impacts are reviewed in the context of historical trends (for example, in coal use) and current policy settings (for example, on reducing CO_2 emissions); (ii) an assessment is made to identify policy measures that would be needed to achieve these scenario outcomes, and (iii) a perspective is offered on the potential barriers to achieve such outcomes.

A. Base Scenario Estimates

1. Energy

PJ

	2000	2020	2040
Primary Energy	1,440	2,092	2,908
Coal	710	756	893
Gas	110	349	560
Oil	525	794	1,193
Renewables	58	127	194
Electricity	223.5	328	477

2. Environment

kton

	2000	2020	2040
CO2 emissions	102509	134,018	179,238

3. Economy

	2000	2020	2040
Outputs, M$	201,052	311,372	500,173
Wages & Salaries, M$	93,965	146,796	236,014
Employment, '000 Persons	2,741	3,014	3,427

Note:
MOD - Moderate Scenario, ADV - Advanced Scenario

B. Percentage Difference compared with Base Scenario in 2020

C. Percentage Difference compared with Base Scenario in 2040

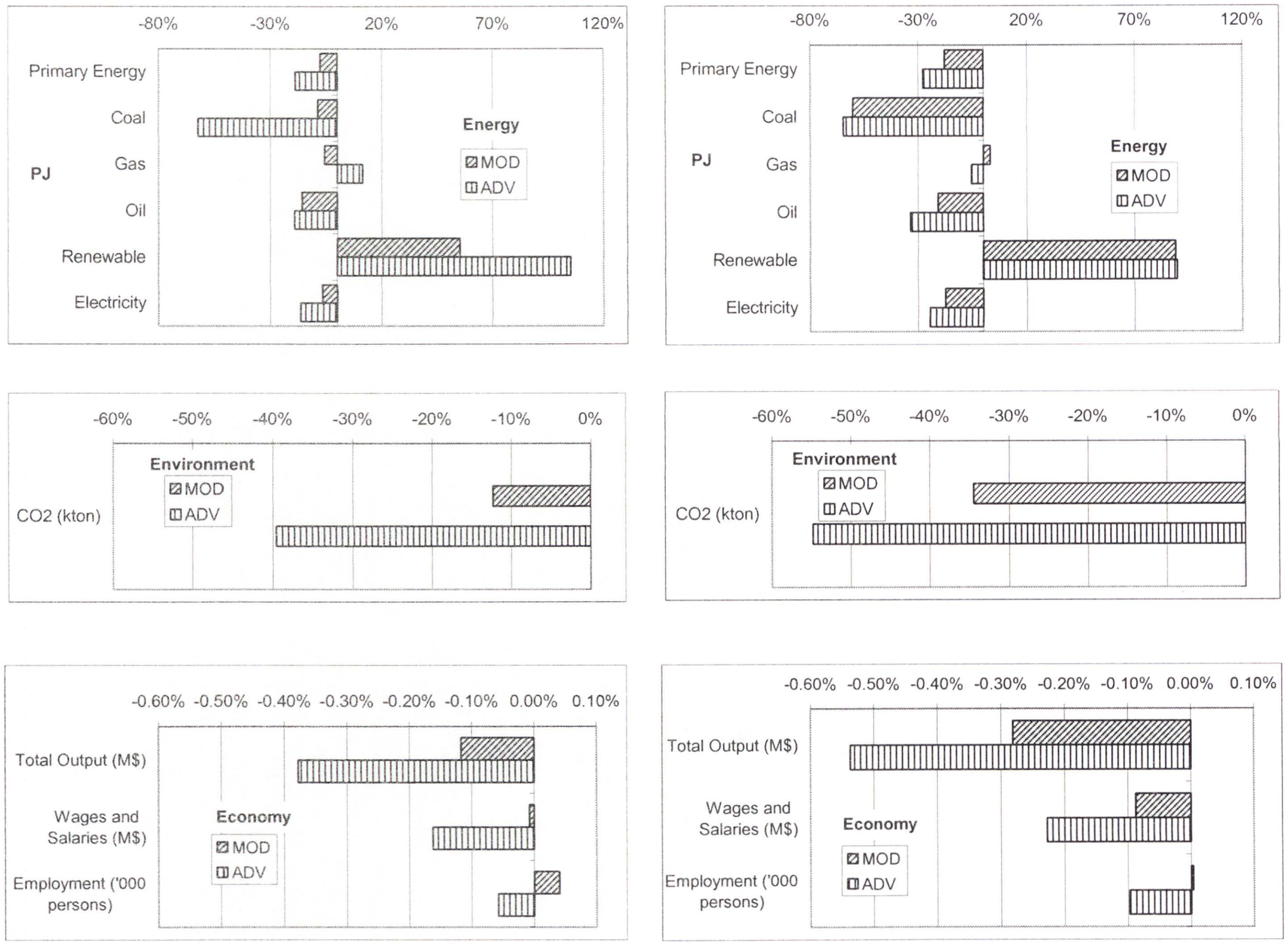

Figure 6-1: Summary of Scenario Impacts.

6.2 Key Policy Implications of Scenario Results

a. If the present energy policy trends continue, in the next forty years, NSW's primary energy requirements would double, CO_2 emissions would increase by about 80 percent and the state would depend upon imported oil for almost all of its oil needs. There is therefore an urgent need to diversify primary energy mix, improve efficiencies in both supply and demand sides, and increase the use of alternative technologies and fuels.

The scenario results suggest that the continuation of the current trends, as represented by the Base scenario in this research, could result in three major consequences in next forty years:

a) The primary energy requirements for NSW would double (from about 1,440 PJ in 2000, to 2,908 PJ in 2040). Nearly 60 percent of these energy requirements (which consist of natural gas (19 percent) and oil (41 percent)) would be met through imports from other states (especially, gas) or from overseas (mainly, oil).

b) The state would increasingly become dependent on imported oil, as the share, in the total primary energy mix, of oil imports increases from 36 percent in 2000, to 41 percent in 2040.

c) Energy related CO_2 emissions would increase from 102 Mt in 2000, to 181 Mt in 2040 – an increase of nearly 80 percent. This increase is primarily due to the fact that, in 2040, nearly 90 percent of the primary energy supply would be fossil fuel-based, with coal accounting for 31 percent, natural gas, 19 percent, and oil, 41 percent.

The Moderate and Advanced scenarios, developed in this research, have demonstrated how alternative energy paths could enable NSW to achieve reductions in primary energy requirements, by up to 17 and 28 percent of the Base scenario values, respectively, by the year 2040. And, the CO_2 emissions (Mt/year), in the two scenarios, in 2040 would respectively be 8 percent above the 1990 emission level (that is, the Kyoto Protocol level) and 25 percent below the 1990 emission level. Compared with the Base scenario emission levels, these volumes would be 35 percent lower for the Moderate scenario, and 55 percent lower for the Advanced scenarios, in 2040. In order to achieve these reductions, the state would need -- as the scenario outcomes in this research demonstrate -- the following policy strategies:

a) Shift its energy system from currently coal- and oil-based system, to the one which would be more diverse in energy resources (with increased use of low carbon energy sources, such as natural gas and renewables). For example, as the Moderate and Advanced scenarios indicate, the share of coal, gas, oil and renewables in the total energy would need to shift from 49.3, 7.7, 36.4, 4 percent in 2000, to 14.8, 24.1, 39.5, 15.3 percent, respectively, in the Moderate scenario, and to 15, 22.1, 37.7, 17.5 percent, respectively, in the Advanced scenario, in 2040.

b) Use advanced, efficient technologies widely (particularly in electricity generation and transportation). For example, there would be a need to increase the use of clean coal technologies such as IGCC plants in power generation and efficient hybrid cars in the road transport.

c) Improve end-use efficiencies in industrial and residential sectors. For example, in the industrial sector, there would be a need to switch towards natural gas based steel production technology such as Direct Reduced Iron, and in the residential sector there would be a need to improve efficiency in space heating and cooling and water heating (with use of solar water heaters).

The analysis in this research has indicated that the state would need to diversify its energy mix in the coming decades. Historically, NSW has relied upon two types of energy sources: coal, for most of its stationary energy needs (such as electricity generation and industrial use), and oil, for non-stationary energy needs (such as transport). However, this research has demonstrated that such reliance would not be desirable from an environmental or security of supply perspectives. The dominance of coal in the primary energy mix, for electricity generation and industrial use, would not be desirable because it would result in large amounts of CO_2 emissions[53]. It would be difficult for natural gas to become the dominant source of energy in NSW due to supply constraints and, to a lessor extent, CO_2 emissions (CO_2 emissions from natural gas, while lower than coal, are still significant). And, renewable energy sources are unlikely to become dominant sources of energy supply in NSW because of the limitation in resources (hydro, wind and biomass), higher costs (such as PV), and intermittent characteristics (such as wind, PV). Similarly, in the non-stationary sector, namely, transport, too much reliance on oil would be undesirable because its supply is linked with imports from a volatile oil market. Hence, it would be important for NSW to diversify energy mix both in the stationary and non-stationary sectors of the economy.

b. The alternative energy pathways (as represented by the Moderate and Advanced scenarios in this research) envisage a decline in the role of coal in the NSW's energy mix in the coming decades. The future of coal would depend upon the rate of adoption of advanced types of coal technologies.

In NSW, coal has historically been the dominant source of energy, accounting for about half of the total energy requirements in the past several decades. Its share in total primary energy consumption in 1970, 1980, 1990, and 2000, for example, was 51, 53, 53, and 50 percent, respectively (ABARE 2004). However, in the coming decades, as the concern about climate change increases, its share in the energy mix is likely to decrease. For example, in the Base scenario, the share of coal would decline from 50 percent in 2000 to 36 percent in 2020, and to 31 percent in 2040. Such decline, in the Base scenario, is due primarily to the impacts of the NSW Greenhouse Gas Benchmark Scheme.

In order for coal to maintain its role in the energy supply-mix, its use would need to become more competitive in terms of cost and efficiency in the coming decades. For example, as the current ageing power plants retire, they could be replaced by more efficient coal plants (such as IGCC), thus allowing coal to maintain role its role in power production. This would particularly be important after 2015 as more plant

[53] Carbon content in coal and natural gas, for example, are 90.6 and 51.3 kt/PJ, respectively (AGO 2004).

capacity would be needed (for example, the Base scenario shows that 1,550 MW of capacity would need to be added by 2015). The role of coal in the coming decades would hence very much depend upon how advanced types of clean coal technologies, particularly, IGCC and carbon capture and sequestration (CCS), penetrate the technology-mix, which, in turn would depend upon how these technologies evolve in the next few years in terms of cost, efficiency and applicability. The current status of these technologies is that the IGCC plant has been successfully demonstrated in the US, but carbon capture and sequestration technologies are yet to be proved successful. In Australia, neither of these technologies have yet been demonstrated (Coal 21 2004). It would be valuable for the Australian governments to undertake the feasibility studies of these technologies in the local context, particularly, with demonstration projects to gain some local experience. [54]

c. The share of natural gas in the NSW energy supply-mix would increase. This would necessitate increasing pipeline capacity, and also seeking supply of gas from sources other than the current sources of supply (that is Cooper and Gippsland Basins).

A key impact of CO_2 emission reduction initiatives across the scenarios (such as, the continuation of the GHG Benchmark Scheme in the Base scenario, and more stringent constraints imposed in the Moderate and Advanced scenarios) is that there would be a significant increase in natural gas demand in NSW. For example, the share of natural gas in the primary energy-mix would increase from 7 percent in 2000 to 19, 24 and 25 percent in 2040, for the Base, Moderate and Advanced scenarios, respectively. Natural gas produces lower amounts of CO_2 emissions as compared to coal, which would make it increasingly attractive for power generation. In the Moderate and Advanced scenarios, for example, natural gas consumption would rise as its use in power generation

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[54] At the time when policy implications in this research were being examined (in 2005-06), research and development in this area was limited to gasification of Australian coal by the CSIRO Energy Technology in conjunction with CRC for Coal in Sustainable Development (CCSD) (CSIRO 2006). This situation changed, however, in December 2006, as CO2CRC made announcement of a pilot project on geosequestration, which will involve injection of a mixture of CO_2 and methane into a geological formation at the Otway Basin of Victoria (CO2CRC 2006). It does not however intend capturing CO_2 released by power plants for sequestration purpose.

increases (mainly to comply with CO_2 emissions reduction requirements in this scenario) and also in the industrial sectors, such as the iron and steel. The analysis in this research suggests that, by 2040, gas consumption would increase by more than five times the consumption level in 2000.

This increased demand for natural gas would have three main implications:

a) It would require increasing pipeline capacity, by about three times, from the current capacity of 210PJ/yr, in next forty years.

b) It would be important for NSW to secure long term supply of gas from new sources (beyond the current sources of supply, namely, Cooper and Gippsland basins), such as Carnarvon and Browse basins in Western Australia, Bonaparte basin in Northern Territory, or from overseas, for example, Papua New Guinea (PNG). Among these three options, a PNG pipeline project is already under development. This could be a useful source of gas supply for NSW, possibly by the end of this decade[55].

c) It would be necessary for the state to develop coal seam methane (CSM) gas. The CSM, which is available in abundance in NSW (about 97,250 PJ), would be useful in easing the pressures to import natural gas.

These issues would need an immediate attention of the NSW government, as the current sources of supply decline[56].

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[55] The PNG Gas Project is developing a 3000 km pipeline (240 PJ/yr) to supply gas from Papua New Guinea (PNG) to Townsville, Gladstone and Mt Isa in Queensland (Exxon Mobil 2005). While Queensland would be the most attractive market for PNG gas, the project would also supply gas to South Australia, New South Wales and Victoria (ACIL Tasman 2004).

[56] Fainstein et al. (2002) estimates that by 2019-20, the reserve to production ratio of Cooper and Gippsland basins will reduce to 1 and 3 years, respectively.

d. Coal and gas would be two competing fossil fuels in the NSW primary energy-mix. The choice between these two fuels would depend upon several factors, such as resource availability, environmental characteristics, and cost competitiveness. These factors would need to be taken into consideration in policy decisions.

The analysis in this research has shown that coal and gas are the two key fossil energy sources that are likely to compete with each other in order to meet the future energy needs of NSW, particularly in power generation. For example, in the Base scenario, while the share of coal in power generation is expected to decline from 92 percent in 2000, to 47 percent in 2040, the corresponding share of gas would rise from 3 percent in 2000, to 42 percent in 2040. The actual substitution between these two fuels would depend upon several factors (as listed below), which would need to be taken into consideration in policy decisions:

a) Resource availability: In terms of supply, for example, coal could provide a certainty of supply for the long term because it is available in abundance (about 436,620 PJ) within the state itself. Whereas, for natural gas supply, NSW would have to depend upon imports from other states, or from overseas (such as PNG). As discussed earlier, the declining reserves in Victoria and South Australia could be a key limiting factor in gas supply for NSW.

b) Environment: In terms of reducing CO_2 emissions, gas could be preferred fuel because it contains nearly half of carbon compared to coal for the same energy content. Hence, if CO_2 emission reduction becomes a major concern (as in Moderate and Advanced scenarios), gas would be in an advantageous position.

c) Market reform: In view of the current energy market reform, and the implementation of the GHG Benchmark Scheme, gas fired plants could become comparatively attractive for private investors because of their shorter construction times (2 to 3 yrs), and lower up-front investment cost (~820$/kW in 2000). Moreover, gas plants could be installed in lower capacity blocks (for example, 300 MW).

e. The demand for oil would continue to rise in NSW. To reduce oil consumption, transport sector–focused measures would be necessary. These might include, for example, mandating higher vehicle efficiency standards, and promoting alternative vehicle technologies and alternative transport fuels.

NSW would continue to face challenges in meeting demand for oil in the coming decades as transportation activity increases. If the present trends continue, as the Base scenario indicates, the demand for oil in 2040 would double as compared with the 2000 consumption levels. While oil consumption rises in NSW, oil production in Australia is expected to gradually decline from the current rate of production because of limited availability of oil reserves[57]. It implies that NSW would increasingly become dependent upon imported oil from overseas, which could increase the exposure of the state to the unstable world oil market. In 2000, the state imported nearly 45 percent of its oil supply needs (MOEU 2000b). As the Australian oil production declines, the state's dependence on imported oil would rise, possibly reaching 100 percent by as early as 2015.

It is therefore important for NSW to introduce measures to reduce its dependency on imported oil. Petroleum products are mainly consumed in road transport (mainly passenger vehicles, and light commercial vehicles), and in air transport (domestic and international). The scenario results in this research have shown that demand for petroleum products in road transport could be significantly reduced through efficiency improvements, for example, with increased use of hybrid cars, and increased use of alternative fuels such as CNG, ethanol, methanol, etc. In the Moderate scenario, for example, these measures would reduce petroleum product consumption in road transport in 2020 and 2040 by 25 and 36 percent, respectively, as compared with the Base scenario. The corresponding reductions in the Advanced scenario would be 32 and 55 percent, respectively. The following measures could be helpful in reducing oil consumption in the road transport sector:

a) Set mandated fuel efficiency standard for road transport vehicles. The fuel efficiency level in road transport in NSW is very low at present. For example,

[57] ABARE estimates crude oil production in Australia to decline by 0.5% per year between 2000-01 to 2019-20 (Dickson, Akmal & Thorpe 2003).

the average rate of fuel consumption in NSW, in 2000, was 11.4 L/100km (ABS 2001c), which is relatively very high compared with fuel consumption level in the European Union (6.35 L/100km) and in Japan (5.07 L/km) (An & Sauer 2004). And, the current target set for efficiency improvement is set at 6.8 L/100km, by 2010, which is based on a voluntary code of practice (Department of Environment and Heritage 2003). Not only its voluntary nature is a matter of concern, equally worrisome is the fact that this level is less stringent than the mandatory targets set by other Asian countries, for example, Japan (4.9L/100km) and China (6.4L/100km) (An & Sauer 2004). Hence, it would be important for NSW to set fuel consumption target at least comparable with China, if not Japan.

b) Increase the use of alternative fuels such as CNG, ethanol, methanol, and hydrogen in the transport sector. The Moderate and Advanced scenarios in this research, for example, suggested that these fuels would need to contribute at least 20 to 25 percent of the total consumption by the road transport, by 2040.

c) Increase the uptake of advanced vehicle technologies, such as hybrid cars. Hybrid cars consume nearly half of the energy consumed by the conventional cars[58]. The hybrid vehicles offers not only a near term potential for energy and CO_2 emission reduction, the experience gained by its commercial success could also be beneficial in the long term, to transit towards hydrogen-based technologies.

f. Electricity sector would need to go through a significant transformation in the coming decades. The generation–mix would need to become more diverse, with decrease in the share of coal-based plants, and increase in the shares of natural gas- and renewable-based plants.

The electricity sector in NSW has historically been dominant with coal-based plants. In the coming decades, however, as this research has shown, this sector would need to go

[58] A prototype hybrid vehicle produced jointly by CSIRO, scientific research agency, with Holden Ltd., consumes fuel 50% less compared to the conventional gasoline driven cars (Holden Ltd 2006).

through a major transformation. The need to reduce CO_2 emission would be a key driver for this transformation. Since coal is the most carbon-intensive fuel, power generation would need to switch to less carbon-intensive fuels, such as natural gas and renewable. As more capacity is added to meet increasing electricity demand in the coming years, it would also provide more opportunities to increase the diversity of fuel- and technology-mix. Even in the Base scenario, for example, the share of generation from coal-based plants gradually decreases from 92 percent in 2000, to 72 percent by 2010, 57 percent by 2020, and 47 percent by 2040. The continuation of the GHG Benchmark Scheme would result in such a decline in the share of coal. In the Moderate and Advanced scenarios, the share of coal-based plants further reduces to 20 and 27 percent in 2040, respectively[59].

The electricity sector would need to increase the use of cleaner energy sources such as natural gas and renewables. In the Base scenario, for example, the share of electricity generation from natural gas plants would increase from 3 percent in 2000, to about 32 percent in 2020 and 41 percent in 2040. Natural gas would become attractive for electricity generation because of its clean characteristics and expected rise in efficiency level of gas-based plants (such as combined cycle). These plants, as they are available in smaller sizes (300–400 MW), could also become attractive for private builders. As noted earlier, the increase in gas use would cause concerns about its sources of supply; these concerns would need a careful consideration. Similarly, the share of renewable-based generation would also need to be increased in order to increase energy diversity (this issue is discussed separately in item (g) in this chapter).

While the share of coal-based plants declines, coal could still continue to play an important role in power generation. As the Moderate and Advanced scenarios have demonstrated, this would require coal-based technologies to shift from the current combustion-based technologies to more efficient gasification-based technologies, particularly after 2015. This is because, during that period, the existing coal plants

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[59] The share of coal based generation in the Advanced scenario is higher than in the Moderate scenario in 2040, because during this period, IGCC plants with carbon capture and sequestrations (CCS) are installed in the Advanced scenario, which allows the share of coal based generation to increase maintaining lower CO_2 emissions.

would begin to retire. This means that they could be replaced with more efficient advanced types of coal plants such as IGCC. Around 2025, for example, two major coal power plants, Eraring and Baywater plants, commissioned in early 1980s, with a combined capacity of 5,280 MW, are expected to retire. This could provide a good opportunity for replacing them with more efficient plants. In the longer term, for example, in the Advanced scenario, in 2040, with the increased use of efficient plants, such as IGCC with CCS, coal plants could maintain, even increase, their share in overall generation while maintaining low CO_2 emission level.

A separate analysis conducted in this research for nuclear plants, showed that nuclear plants at lower range of costs (~3000 $/kW), would become competitive with the IGCC plants with CCS only if large amount of CO_2 emission reduction is required (25 percent below 1990 emission level). At present, both of these plants (that is, IGCC with CCS and nuclear) have several uncertainties, particularly associated with environmental risks and costs.

On the end-use side, the residential and commercial sectors would offer large potential to reduce electricity consumption, through efficiency improvements. These two sectors, while consuming only about 20 percent of the total final energy, are however important when viewed in terms of their share in total electricity consumption (they consume nearly 60 percent of the total electricity). The scenario results have shown that improvement in building envelope design, expansion of solar water heating, and efficiency improvement in refrigerators and lighting could reduce electricity consumption in the residential sectors by 44 percent in the Moderate scenario and by 60 percent in the Advanced scenario in 2040, compared with the Base scenario. The key areas where electricity consumption could be reduced are in space heating and cooling, and water heating. The space heating demand could be reduced with improved building design, for example, requiring all new homes to have 3.5 to 5 Energy Star (NatHERs) ratings[60]. Also, there exists a large potential to increase solar water heating. At present only about 20 percent of the households use solar water heating.

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[60] Under the NatHERS (the Nationwide House Energy rating Scheme) star ratings, 3.5 star and 5 star building consume energy for heating and cooling at 180 and 90 MJ/m2.yr, respectively (AGO 1999b). This is different from the BASIX index (Eckstein & Palese 2005), which was introduced in July 2004,

g. The share of renewables in the energy-mix would need to be increased. This would need a state level commitment.

Despite the huge potential for renewable-based power generation in NSW, currently it provides a very small fraction of total electricity. The major sources of renewable generation in NSW are hydro, biomass, wind, and solar PV. In 2000, these sources provided about 5.5 percent of the total electricity[61] (ESAA 2002; MOEU 2000a, 2000b). If the share of hydro is excluded, the total share of remaining three – biomass, wind and solar – amounted to only 0.2 percent. Since there exists very little potential for further expansion of hydropower in NSW, the key renewable plants with the potential for future expansion are biomass, wind and solar PV.

To increase the share of renewables in power generation, there would be a need for a major policy commitment.[62] At present, two key policy measures are in place in NSW that favours renewable-based power generation[63]: (i) NSW Greenhouse Benchmark

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which requires new buildings to reduce energy consumption by 25% and water consumption by 40% compared to the average dwellings.

[61] The generation from hydro includes NSW's share (72%) in total generation from the Snowy Mountain Hydroelectric Scheme.

[62] At the time when policy implication were being examined in this research (in 2005 – 06), no state level mandatory renewable energy target had been in place in NSW (except for the federal level scheme, MRET). In 2007, the NSW government announced that it would introduce the NSW Renewable Energy Target (NRET) (DEUS 2006a, 2006b). This new scheme would require energy retailers in NSW to source their electricity supply from renewable sources – 10% by 2010, and 15% by 2020. The 15% target would be maintained until 2030. The target set in the Moderate and Advanced scenarios in this research differs from the NRET target in two respects: In NRET, renewables are allowed to be sourced from generators which are located outside NSW (that is anywhere in the NEM). In this research, however, renewable electricity is generated within the state itself. Second, the NRET scheme includes all types of renewable energy sources to meet the target, this research treats hydropower separately, and excludes it in the % target. This is done because the hydro has very little potential for growth in future. If existing hydropower is included, the percentage share of renewables in this research would be significantly higher.

[63] The Australian Government announced on September 2007 that it would introduce a national target "Clean Energy Target (CET)" of 30,000 GWh of electricity generation from low emissions technologies by 2020. The CET, which is planned to be implemented from January 2020 onwards, will not be limited to renewable energy sources but will also include other types of low emissions generation technologies

Scheme that require retailers to limit per capita CO_2 emissions to 7.29 tons by 2007. To comply with this scheme, retailers would need source their electricity from renewable-based power generation because they produce negligible CO_2 emissions. (ii) Mandated Renewable Energy Target (MRET) Scheme, which is being implemented at the federal level. Under this scheme, an additional 9,500 GWh of electricity needs to be generated from renewable-based plants nationwide by 2010.

However, these measures alone might not be sufficient to increase the share of renewables in NSW's energy-mix significantly. The commitment under the MRET, for example, is very low for NSW to bring about a rapid development of renewable-based generation. The nationwide target set at 9,500 GWh by 2010 in the MRET scheme falls below the previously intended target of 2 percent increase in renewable-based generation[64] (the 2 percent target was later scrapped in favour of 9,500 GWh). Even the 2 percent increase target is very low when compared with similar targets set by some European countries. Table 6-1 illustrates, for example, that many European Union member countries' targets for the share of renewable in electricity generation in 2010 is more than double their share in 2001 – Denmark is increasing from 16.4 to 29 percent, Germany from 6.2 to 12.5 percent, and United Kingdom from 2.5 to 10 percent (IEA 2004b). The MRET scheme is also criticized by some for its inability to provide significant market impetus required for high cost renewable technologies, such as PV (see MacGill, Outhred & Nolles 2006). Similar to the GHG Benchmark Scheme, hence, it would be important for NSW to set a state level target which is higher than the MRET level. The Moderate and Advanced scenarios in this research, for example, have shown that there would be a need to increase the share of generation from renewable-based plants (excluding hydro plants) to 19 and 28 percent respectively by 2020, and to 27 and 29 percent by 2040.

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that emit less than 200 gram of GHG per MWh, such as carbon capture and storage technologies (Australian Government 2007).

[64] In 1997, renewable based electricity generation was 16,000 GWh (after accounting for transmission losses), or 10.5% of total consumption in that year. In 2010, total renewable based generation would reach 25,500 GWh (by adding 9,500 GWh from MRET at 1997 level), while total electricity consumption would reach 229,000 GWh according to ABARE (Dickson, Akmal & Thorpe 2003). The share of renewables in 2010 hence will be 11.1% of the total consumption, which is 0.6% increase from the 1997 share, a third of the previous target of 2% increase.

Table 6-1: Percentage Share of Renewables in Electricity Production

Country	Share in 2001	Target for 2010
Australia	8.3	11.1[+]
Denmark	16.4	29
Germany	6.2	12.5
United Kingdom	2.5	10

Source: IEA (2004b)

Note: [+] Equals 25,500 GWh, including renewable-based generation in 1997 of 16,000 GWh and the mandated requirement under the MRET scheme of 9,500 GWh.

h. The extent to which the share of renewables in the primary energy-mix could be increased (thereby displacing fossil energy sources) would depend upon several factors, including resource availability, environment, cost, and employment generation. These factors would need to be taken into consideration in policy decisions.

Given that there would be a need to increase the share of renewables in the energy-mix (as discussed earlier in (g)), the choice between fossil and renewable energy sources would depend upon several factors (as listed below) that would need to be taken into consideration in policy decisions:

a) Resource availability: In terms of the availability of resources, renewables could face limitations. While much of the current biomass resources and wind potential in NSW has not been utilized yet, this potential is too limited to replace the fossil energy sources, which are available in abundance (particularly coal) in the state itself or can be obtained from other states such as Western Australia, Northern Territory.

b) Employment: In terms of employment generation, renewable-based plants have the advantage because they are generally employment intensive (see (j) also). This could be particularly beneficial in view of the declining trend of employment in the current fossil-based energy systems in NSW in recent years. For example, the employment in the electricity sector in NSW declined by 50 percent between 1991 and 1999, as a result of the electricity reform that began in early 1990s. Similarly, coal mining jobs (Australia wide) also reduced by 45 percent between the mid-1980s and 2004, due to the increase in automation in mining (Diesendorf 2005).

c) Cost: In terms of cost competitiveness, renewable based plants are in a disadvantaged position because their generation cost (0.06–0.40 \$/kWh) are high due to their relatively higher capital costs (for example, from 1400 \$/kW for wind plant to 10,500 \$/kW for PV). Electricity generation cost from fossil-based plants, on the other hand, are generally lower (0.03-0.04 \$/kWh) due to the lower investment cost (for example, 1200 \$/kW for coal plant) and fuel cost (~0.56 \$/GJ for coal).

d) Meeting Load Demand: The fossil-based plants are generally found to be suitable for both base (coal plants) and peak loads (gas turbine plants), whereas renewable plants have the characteristics of being intermittent (particularly wind and solar) in nature and hence limited in terms of their ability to meet any of these loads reliably.

i. CO_2 emissions would increase by about 80 percent in next forty years under the Base scenario. Reducing CO_2 emissions would need strategies that would target not only power generation but also the transport sector.

NSW is the largest CO_2 emitting state in Australia (responsible for about 30 percent of the country's total emissions) mainly because of its heavy reliance on fossil energy sources (particularly coal) for its energy needs. The two major sources of CO_2 emissions in NSW are electricity generation (about 52 percent of the total) and transportation (about 27 percent of the total). Electricity generation relies upon coal to the extent of 90 percent of its fuel needs. To control CO_2 emissions from power generation, NSW introduced the NSW GHG Benchmark Scheme in 2002. The Base scenario, in this research, suggests that even if this Scheme is continued to the year 2040, the total CO_2 emissions would still increase by nearly 80 percent as compared with the 2000 emission levels. This has two implications: First, it suggests that the NSW Greenhouse Gas Benchmark Scheme, which is scheduled to expire in 2012, would need to be extended beyond 2012[65]. Because, as the Base scenario has demonstrated, while the Scheme reduces emissions from the power sector, the total CO_2 emissions in NSW would still continue to rise significantly (mainly because of rise in emissions from the transport sector). This means if the Scheme were to be discontinued after 2012, the total CO_2 emissions would rise even further. Second, the CO_2 emissions reduction strategy would need to expand its coverage beyond the electricity sector, more specifically, it would need to include transport sector. The transport sector, being relatively inflexible in terms of technology and fuel switching, would need appropriate signals sooner, so that it could begin to take steps to improve efficiency and encourage changes in consumer habits.

If large reductions in CO_2 emissions become necessary, as envisaged in the Moderate and Advanced scenarios, there would be a need for developing policies aimed at achieving fuel switching (for example, coal to natural gas), efficiency improvements in power generation (for example, introduction of IGCC plants); improvement in end-use efficiencies; and wider use of efficient vehicles such as hybrid cars.

The electricity sector shows the largest potential for reducing CO_2 emissions. This is because, at present, coal is the major source of fuel in this sector (about 90 percent) which means that there is a large room for fuel switching to reduce CO_2 emissions, for example, by shifting towards cleaner energy sources such as natural gas and renewable (mainly biomass and wind).

In the industrial sector, energy intensive industries, particularly, iron and steel and aluminium, would need to be given priority from the view point of reducing CO_2 emissions. These two industries produce large emissions because of the process technologies they use, for example, the technology used by iron and steel industry is coal intensive, and that used by aluminium industry is electricity intensive (electricity being produced dominantly by coal based plants). To reduce CO_2 emissions, there

[65] When the scheme was introduced it was to be implemented for the period ending 2012. At the time when policy implication were being examined in this research (in 2005–06), the *Energy Directions Green Paper* of NSW was seeking suggestions on whether to extent the scheme beyond 2012 up to 2020 or not (See NSW Government 2004, p. 25). See footnote 22 on page 73 (Chapter 3) also.

would be a need to shift process technology in the iron and steel industry sector from the current coal based BF/BOF technology to DRI technology (which uses natural gas instead of coal). In the aluminium industry, while there is less scope for technology switch, emphasis should be upon improving energy efficiency. For example, there exists a potential for improving average energy consumption in the electrolysis process from the current level of 52 MJ/kg of Al, to the full potential that can be achieved with technology available at present (47 MJ/kg of Al). Energy consumption in non-electrolysis processes could also be improved to the level of most efficient smelter (6.3 MJ/kg of Al) in Australia. This research has demonstrated that these measures in the iron and steel and aluminium industries could result in total CO_2 emissions from the industrial sector to reduce to 35.1 Mt in the Moderate and 29.5 Mt in the Advanced scenario as compared with 50.7 Mt in the Base scenario in 2040.

The transport sector, which emerges as the key CO_2 emitting sector in the Base scenario (particularly after electricity sector's emissions reduce due to the NSW Benchmark Scheme), would need to be given priority from a policy view point. The scenario results have demonstrated that a significant CO_2 emissions reduction from this sector could be achieved by 2040 – 22 percent in Moderate and 45 percent in Advanced scenario, with a mix of policies that target increasing fuel efficiency standards for passenger and freight vehicles, and policies that support alternate vehicle technologies (such as hybrid vehicles) and alternative fuels (such as biofuels, natural gas-based fuels and even coal to liquid fuels).

j. Compared with the Base scenario, the Moderate and Advanced scenarios result in higher wages and salaries and employment in the non-energy sectors than in the energy sectors. It implies that adopting energy path-ways as represented by the Moderate and Advanced scenario would result in a transfer of wages and salaries and employment, from the energy to the non-energy sectors.

As discussed in Chapter 5, the differences in energy consumption characteristics across the three scenarios (in terms of quantity, fuel- and technology-mix) would result in economy-wide impacts (measured in terms of total sectoral outputs, wages and salaries and employment), both across the energy and non-energy sectors. A comparison of these impacts between the Moderate/Advanced and Base scenarios could provide valuable insights that would be of interest from a policy viewpoint, for example, to help understand the implications of adopting alternative energy paths in place of the current energy path (as represented by the Base scenario). Some potential implications of adopting policy strategies (as in the Moderate and Advanced scenarios) are listed below:

(a) Some key energy sectors would be disadvantaged as there would be a decline in wages and salaries and employment in these sectors.

Since the total outputs of the energy sectors in the Moderate and Advanced scenarios are lower as compared with the Base scenario (because of the reduced level of energy consumption in these scenarios), this would result in a decline in wages and salaries and employment in these energy sectors. In the Moderate scenario, for example, the total wages and salaries in the energy sectors would be $140 millions (that is, 5.7 percent) lower and total employment 1,604 persons (5.7 percent) lower, in comparison with the Base scenario in 2020.

Among the energy sectors that show significant differences are electricity, coal, and petroleum products. For example, in 2020, the wages and salaries in the electricity, coal, and petroleum products sectors in the Moderate scenario would be $62 million (that is, 6.2 percent), $18 million (1.8 percent), and $34 million (15.7 percent) lower, respectively, in comparison with the wages and salaries in the Base scenario. And, in the Advanced scenario, it would be lower by $156 million (15.6 percent), $133 million (12.9 percent), and $41million (19.1 percent), respectively. Similarly, employment in the electricity, coal, petroleum products sectors in the Moderate scenario in 2020 would be 753 persons (6.2 percent), 155 persons (1.8 percent), and 374 persons (15.7 percent) lower, respectively, in comparison with the employment in the Base scenario.

(b) The non-energy sectors in general would benefit as the wages and salaries and employment in these sectors rise.

While energy sectors would experience declines in their incomes and employment, the non-energy sectors would experience benefits. For example, in 2020, in the Moderate scenario, wages and salaries and employment in the non-energy sectors would be higher by $96.8 million (0.07 percent) and 2,339 persons (0.07 percent), respectively, as compared with the Base scenario. This suggests that if alternative scenarios are adopted, it would result in a transfer of income (wages and salaries) and employment from the energy to the non-energy sectors.

The key non-energy sectors that would experience such gain would be agriculture, construction, fabricated metals and other equipment. For example, the wages and salaries in these fours sectors in the Moderate scenario in 2020, would be higher by $84.7 million (that is by 2.3 percent), $15.6 million (0.28 percent), $4.02 million (0.5 percent) and $18.6 million (0.6 percent) in comparison with the Base scenario.

(c) Higher levels of outputs in some of the non-energy sectors could be favourable for the domestic economy.

The higher levels of outputs in the alternative scenarios for some of the non-energy sectors such as agriculture, construction, fabricated metals, and iron and steel could have positive impacts on the domestic economy because these sectors rely mostly on the inputs produced within the state itself. For example, import constitutes approximately only 9.7 percent of the purchases made by the agriculture and 5.7 percent by the construction sectors. The higher level of outputs in these sectors, in the Moderate and Advanced scenarios, means they would purchase more of domestically produced goods (instead of imported goods), thus helping domestic economy.

On the contrary, the higher outputs in the other equipment sector, in the Moderate and Advanced alternative scenarios, may not be desirable from an economic viewpoint, because this sector imports large share of its inputs. This share, for example, was 57 percent in 2000. Thus, as the output of this sector expands, as in the Moderate and Advanced scenarios, so would imports – that could worsen the balance of payments situation for the state.

(d) Increased use of renewable energy sources (such as biomass and wind), in the Moderate and Advanced scenarios, could generate additional employment that could compensate for the loss of employment in other traditional energy sectors.

The Moderate and Advanced scenarios show that there would be higher levels of employment in the non-energy sectors than in the Base scenario. In the Moderate scenario, for example, in 2020, job losses in the energy sectors are expected to be 1,604. In contrast, 2,339 new jobs would be created in the non-energy sectors in that year, thus resulting in a net gain overall gain in employment. One of the reasons for this is the increased use of labour-intensive renewable plants[66] in the Moderate and Advanced scenarios. This, in turn, is due to the fact that the manufacture of renewable plants generally involve light manufacturing sectors (such as fabricated metal, construction) which are known to be employment-intensive. The net effects on employment, as analysed in this research, are a result of employment generation in various economic sectors, from which these renewable plants purchase inputs. For example, as wind plants are added, more inputs are required from the construction and fabricated metal sectors, which results in more employment in these sectors. Such increase in employment could compensate for the loss of employment in the conventional energy sectors. The Moderate scenario, for example, shows no net loss in total employment both in 2020 and 2040, even when employment in the energy sector declines.

(e) Employment generation due to the increased use of renewable energy sources could benefit rural areas.

One of the advantages of increased use of renewable-based plants is that it could help generate employment in rural areas. For example, increased demand for biomass could generate employment in the rural-based agriculture sectors. Similarly, renewable-based plants such as wind are usually installed in rural areas. This could bring investment and jobs to these rural communities. This would be particularly beneficial for rural communities in NSW because they are known to suffer frequently from erratic weather conditions (Lloyd-Besson 2004). Light manufacturing sectors (such as fabricated metal, construction) that are needed for renewable-based plants are suitable to be located in

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[66] Diesendorf (Diesendorf 2005) reports, for example, in the Australian context, that coal fired electricity industry (including coal mining) provides about 63 job-years/TWh and wind power provides about 117–184 job-years/TWh.

rural areas. The capital expenditure on installation of these plants and their operation by the Australian contractors could provide many local jobs in the life of these plants[67].

k. Adopting policy strategies (as in the Moderate and Advanced scenarios) could help reduce energy intensities across the economic sectors.

This research has shown that alternative strategies (as in the Moderate and Advanced scenarios) could result in a significant lowering of energy intensities in the economic sectors, as compared with the intensities in the Base scenario. This would be due to the improvements in either direct intensity, or indirect intensity, or both. The sectors that would experience significant improvements in their energy intensities are iron and steel, fabricated metal, and road transport. In 2020, for example, the total energy intensity in the iron and steel industry is 13.7 percent lower in the Moderate scenario (14.23 MJ/$) and 24.7 percent lower in the Advanced scenario (12.4 MJ/$) than the corresponding intensity in the Base scenario (16.50 MJ/$). Similarly, the intensity in the fabricated metal sector is 8.8 percent lower in the Moderate scenario (5.68 MJ/$) and 19 percent lower in the Advanced scenario (5.05 MJ/$). The lower levels of total energy intensity in the fabricated metal sector is largely due to the improvements in indirect energy intensity, reflecting an improvement in the energy embodied inputs to this sector (such as iron and steel).

Further, the shares of direct and indirect energy in the total primary energy intensity could provide valuable insights for policy makers which could be useful for designing policy measures to improve energy efficiencies. For example, if direct energy is dominant in the total energy consumption, efficiency improvement in the production technology should be promoted. These sectors include, for example, iron and steel, road transport, and basic chemical. And, if indirect energy accounts for a major share, policy should be directed towards reducing the input of energy intensive materials. Otherwise, in such sectors, even if efficient appliances are used to improve efficiency, the total energy consumption would not improve significantly because the share of indirect energy consumption would continue to be higher. These sectors, for example, include

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[67] Diesendorf (2005) reports that renewable plants have higher Australian content in its cost structure (for example, 26% for coal fired and 44% for wind plant).

fabricated metals, construction, and service sectors. In fabricated metal, for example, indirect energy contributes about 95 percent to its total energy intensity, which illustrates the importance of indirect energy consumption in this particular sector.

l. Alternative strategies could result in a significant lowering of total CO_2 intensities across the economic sectors.

The total CO_2 emission intensities of various sectors in 2020 and 2040 for the Moderate and Advanced scenarios are found to be lower than the corresponding values in the Base scenario. This is due to the overall reduction in energy consumption in these alternative scenarios, and in particular due to the lower levels of coal consumption. Hence, by adopting alternative strategies, total CO_2 emission intensities for the economic sectors could be significantly lowered in 2020 and 2040. For example, in 2020, the total CO_2 intensities for the iron and steel sector in the Moderate (1.14 kg/$) and in Advanced scenarios (0.88 kg/$) is lower by 19.7 percent and 38.1 percent, respectively, than the Base scenario (1.42 kg/$). Similarly, total CO_2 intensities for the service sectors, such as communication, finance and insurance, property and business, personal and other services are lower both in the Advanced and Moderate scenarios in 2020 and 2040. In 2020, for example, in the communication sector, the intensity in the Advanced scenario (0.077 kg/$) is lower by 28.7 percent compared with the value in the Base scenario (0.108 kg/$). Electricity is the main type of energy consumed by these service sectors, and as CO_2 emissions from the electricity sector lowers, it results in a lower value of the total CO_2 intensities in the service sectors.

6.3 Conclusions

This chapter presented some policy perspectives associated with the two scenarios. Major conclusions include the following:

- If current energy policy trends continue, over the next forty years, NSW would experience a two-fold rise in primary energy requirements, 80 percent increase in CO_2 emissions and increased dependency on imported oil (possibly 100 percent). The severity of these impacts could however be reduced by NSW adopting a suite of policy measures (as described in the Moderate and Advanced scenarios) aimed at increasing the diversity of primary energy-mix, improving demand and supply-side efficiencies, and increasing the use of alternative technologies and fuels.

- With the concern about climate change increasing, the share of coal is likely to diminish from its historical trend, for example, from 50 percent in 2000, to 31, 15, and 15 percent in 2040 for the Base, Moderate and Advanced scenarios, respectively. For coal to maintain its importance in the energy supply-mix, it must improve its competitiveness in terms of cost and efficiency in the coming decades, for example, with the increased use of advanced types of clean coal technologies (such as IGCC plants and geo-sequestration).

- The share of natural gas in energy supply is likely to increase, for example, from 8 percent in 2000, to 19, 24 and 22 percent in 2040 for the Base, Moderate and Advanced scenarios, respectively. The increased demand for gas implies that there would be a need to increase pipeline capacity by about three times in next forty years, secure a long term supply of gas from alternative sources (beyond the current sources of supply, namely, Cooper and Gippsland basins), and develop domestically available coal seam methane gas.

- The demand for oil would continue to rise with increase in transportation activity, for example, contributing nearly 41 percent in the total primary energy mix in 2040 in the Base scenario (from 36.4 percent in 2000). Policies focusing on the transport sector would be necessary. Such policies could include, for example, higher vehicle efficiency standards, promoting alternative vehicle technologies such as hybrid cars, and alternative cleaner fuels, such as biofuels, CNG, methanol.

- The electricity sector would go through a significant transformation in the coming decades in terms of fuel- and technology-mix. As reducing CO_2 emissions from power generation becomes necessary, the generation mix would need to become more diverse, with decrease in the share of coal-based plants (from 92 percent in 2000, to about 21 percent in 2040 in the Moderate scenario, for example), and increase in the share of natural gas (from 2.7 percent in 2000, to 51 percent in 2040) and renewable-based plants (from 5.4 percent in 2000, to 27 percent in 2040).

- There is a need for political commitment to increase renewable-based technologies. The current renewable energy friendly policy measures, namely, the NSW Greenhouse Benchmark Scheme at state level, and the Mandated Renewable Energy Target (MRET) scheme at federal level, might not be sufficient to increase the share of renewables in NSW's energy-mix significantly. Hence, it would be important for NSW to set a state level target for renewable based generation which is higher than the MRET level, for example, to at least 25 percent of the total electricity generation by 2020[68].

- The continuation of current trends would result in a near doubling of CO_2 emissions in next 40 years. In order to contain these emissions, the NSW Greenhouse Gas Benchmark Scheme (which is scheduled to expire in 2012) needs to be extended beyond 2012[69]. Even this is unlikely to significantly reduce CO_2 emissions. What would be needed is to target not only power generation, but also transport sector because this sector would emerge as a key CO_2 emitting sector. In the industrial sector, energy intensive industries, particularly, iron and steel and aluminium, would need to be given priority from the view point of reducing CO_2 emissions.

- Adopting energy strategies, as considered in the alternative (Moderate and Advanced) scenarios, would result in a shift in wages and salaries and employment from the energy sectors to the non-energy sectors. In the Moderate scenario, for example, the total wages and salaries in the energy sectors are

[68] In 2007, the NSW government announced that it would introduce the NSW Renewable Energy Target (NRET). This new scheme would require energy retailers in NSW to source their electricity supply from renewable sources – 10% by 2010, and 15% by 2020. See also footnote 62 on page 222.

[69] In October, 2006, the NSW government brought out a policy paper (DEUS 2006a) which states that the NSW GHG Benchmark Scheme would be extended to 2020 (from 2012). See footnote 22 on page 73 also.

lower by $140 millions (that is by 5.7 percent) and total employment is lower by 1,604 persons (by 5.7 percent) in 2020, compared with the Base scenario. However, the wages and salaries and employment in the non-energy sectors would be higher by $96.8 millions (0.067 percent) and 2,339 persons (0.067 percent), respectively, compared with the Base scenario.

- The increased use of renewable energy sources (such as biomass and wind) could generate additional employment that could compensate for the loss of employment in the traditional energy sectors. In the Moderate scenario, for example, in 2020, while energy sectors lose employment by 1,604 persons, the non-energy sectors would gain employment by 2,339 persons, resulting in a net gain in employment.

- The alternative scenario could help reduce energy intensities of the economic sectors significantly. This would be due to the improvements in either direct intensity, or indirect intensity, or both. In 2020, for example, the total energy intensity in the iron and steel sector declines by 13.7 percent in the Moderate scenario (14.23 MJ/$) and by 24.7 percent in the Advanced scenario (12.4 MJ/$), compared with the intensity in the Base scenario (16.50 MJ/$).

- Alternative scenarios could help lower total CO_2 emission intensities for the economic sectors significantly in 2020 and 2040, as coal consumption in electricity sector and industrial sectors decline. For example, in 2020, the total CO_2 intensities for the iron and steel sector, in the Moderate (1.14 kg/$) and in Advanced scenarios (0.88 kg/$), would lower by 19.7 percent and 38.1 percent, compared with the Base scenario (1.42 kg/$).

It is clear from discussions in this chapter that NSW would need new long-term energy strategies – to avoid adverse consequences that might result from a continuation of the current energy policy trends. These new strategies, at a macro level, should emphasise a lowering of the total primary energy requirements, reducing dependency on imported oil, and reducing CO_2 emissions while minimising negative impacts on the economy. To achieve these macro level goals, however, it would require significant adjustments to be made at the micro level, that is, at individual sectoral levels including electricity, transport, industrial, residential and commercial. The Moderate and Advanced scenarios, assessed in this research, reflect the types of such adjustments. The assessment has shown, for example, that the electricity sector, a major source of CO_2 emissions in NSW, would need significant transformation in terms of – increasing diversity in fuel mix, technological shift and increased use of renewables. The transport sector – a strategically important sector from the consideration of reducing dependency on oil – would need mandated fuel efficiency standards and increased use of alternative fuels such as CNG, ethanol, methanol, and hydrogen and increased uptake of advanced vehicle technologies such as hybrid cars. The industrial sector would need increased focus on energy intensive metal industries, such as iron and steel and aluminium, because they provide greater opportunities for improvements in process technologies and efficiency. The residential and commercial sectors – relatively minor consumers of final energy, but significant electricity consumers – would need measures such as improving building envelope design, expansion of solar water heating, and efficiency improvements in refrigeration and lighting.

One key implication of above measures would be increased use of low carbon energy sources use such as natural gas and renewables. Increased use of natural gas means that NSW would need to secure long-term gas supply from new sources (beyond the current sources of supply, namely, from Cooper and Gippsland basins), such as Carnarvon and Browse basin in Western Australia, Bonaparte basin in Northern Territory or from overseas – Papua New Guinea (PNG). It also would mean that pipeline capacity would need to be expanded by about three times within next forty years. Increase in renewable energy sources would be possible only if a state level target is set, for example, to 25% of total generation by 2040. Coal, the only fossil fuel available domestically in abundance, would clearly be in a disadvantageous position. To continue to benefit from the availability of this domestic resource, its use would need to be made more competitive, in terms of cost and efficiency, by gradually shifting coal technologies from the current combustion-based technologies to efficient gasification-based technologies (IGCC), from 2015 onwards.

To achieve the policy goals as set in the alternative scenarios (Moderate and Advanced), the economy in the state would need to bear some positive and some negative impacts. The impacts at the aggregate level, measured in terms of changes in total outputs, wages and salaries, and employment would be marginally negative. At the individual sectoral level, however, some of the sectors, particularly energy sectors, would need to endure significant negative impacts in terms of loss in income (wages and salaries) and employment. Some of the non-energy sectors (agriculture, other equipment, construction) on the other hand would benefit. Hence, the loss of income and employment in the traditional energy sectors (coal, gas, electricity), could be compensated by generation of additional income and employment in non-energy sectors, mainly due to the increased use of renewable energy sources (such as biomass and wind). This indicates a significant transfer of income (wages and salaries) and employment, from the energy to the non-energy sectors (which do not show up at the aggregate level analyses). This additional employment resulting from the increased use of renewable energy sources could also benefit rural areas.

7. Conclusions and Recommendations

7.1 Summary and Conclusions

This research developed three energy scenarios (Base, Moderate and Advanced) – under different sets of policy strategies – for the state of New South Wales, for the next forty years (2000–2040). This research then assessed the energy and economic impacts associated with these scenarios. The objective of the assessment is to identify the long term energy policies and strategies that would be needed by the state to deal with energy challenges, particularly, to meet increasing future energy demand with reduced level of CO_2 emissions and dependency on imported oil, without compromising economic growth.

As backdrop to developing the above noted scenarios, this research reviewed energy scenario and energy modelling studies conducted in Australia. One of the main purposes of this review (in Chapter-2) was to ascertain if these studies, particularly the underpinning methodological frameworks employed by them, were suitable to analyse energy issues specific to NSW. The review revealed that majority of these studies focused on examining energy issues from a national perspective. By implication, the usefulness of these studies in terms of assisting with state level policy development was restricted, especially when viewed against the backdrop of significant differences in energy resource availability and use patterns across various Australian states, and considerable constitutional autonomy in energy and environmental domains enjoyed by various states. Further, on the basis of this review, and in view of the energy challenges facing NSW, this research decided to employ a methodology that comprised two main modelling components, namely, engineering-based optimisation model (the MARKAL model) – to determine primary resources requirements in the three scenarios, and an energy oriented input–output model – to determine economy-wide impacts of the scenarios.

The three scenarios developed in this research revolve around five key variables that have the potential to influence the development of NSW energy sector in future. These include: energy diversity, oil dependency, CO_2 emissions, advancement of technologies, and social factors. In addition, due consideration was given, in the development of scenarios, to the current policy setting, for example, relating to the NSW Greenhouse Benchmark Scheme, the Mandated Renewable Energy Target, the ongoing debate at the national and international levels (for example, CO_2 emission reduction strategies, nuclear plants), technological developments (for example, IGCC plants, carbon capture and sequestration), and anticipated advancements of other technologies (for example, photovoltaic, bio-fuels).

The salient features of the three energy scenarios include:

- The Base scenario (BAS) reflects the continuation of the current trends in energy policy typified, for example, by a continued reliance on coal use as the main source of energy in power generation and industrial processes, no specific commitment to promote renewable energy sources (except for the MRET scheme), and no restriction on CO_2 emissions besides those applicable for the electricity sector under the NSW GHG Benchmark Scheme.

- The Moderate Scenario (MOD) reflects a future where national and international pressures would necessitate an increase in energy diversity, reduced oil consumption, and limits CO_2 emissions, equivalent to 8 percent above the 1990 emission level (that is, the Kyoto Protocol level).

- The Advanced Scenario (ADV) reflects a future where national and global pressures would require the state to adopt policy measures that would encourage increased diversity in primary energy supply, reduced dependency on imported oil, increased use of advanced types of technologies, and a lowering of CO_2 emissions even further than in Moderate scenario (that is, 25 percent below 1990 emission level).

The following sections provide a summary of the major energy and economic impacts of the three scenarios. Select key impacts and their policy implications are also illustrated in Figure 7.1.

Energy impacts

(a) The continuation of the current trends, as represented by the Base scenario, would result – in the year 2040 – in a doubling of primary energy requirements (from about 1,440 PJ in 2000, to 2,908 PJ in 2040), 80 percent increase in CO_2 emissions (from 102 Mt in 2000, to 181 Mt in 2040) and increased dependency on imported oil. The Moderate and Advanced scenarios, on the other hand, show alternative energy paths for NSW that could achieve reduction in primary energy requirements by 17 and 28 percent, respectively, below the Base scenario level, by the year 2040. Similarly these scenarios would reduce CO_2 emissions to Kyoto Protocol level (that is, 8 percent above the 1990 emissions level) in the Moderate scenario, and to 25 percent below the 1990 emission level in the Advanced scenario (As compared with the Base scenario, these reductions would be 35 percent lower for the Moderate scenario and by 55 percent lower for the Advanced scenario).

(b) The concern about climate change, as reflected, for example, by the restrictions on CO_2 emissions due to the NSW Greenhouse Gas Benchmark scheme in the Base scenario, and stringent emission constraints imposed in the Moderate and Advanced scenarios, would reduce the share of coal in the total primary energy mix in all three scenarios. For example, the share of coal in the total energy mix would diminish from 49 percent in 2000, to 15 percent in both the Moderate and Advance scenarios in 2040, while the shares of natural gas and renewables would increase from 7.8 and 0.4 percent in 2000, to 24 and 15 percent, respectively, in the Moderate scenario in 2040.

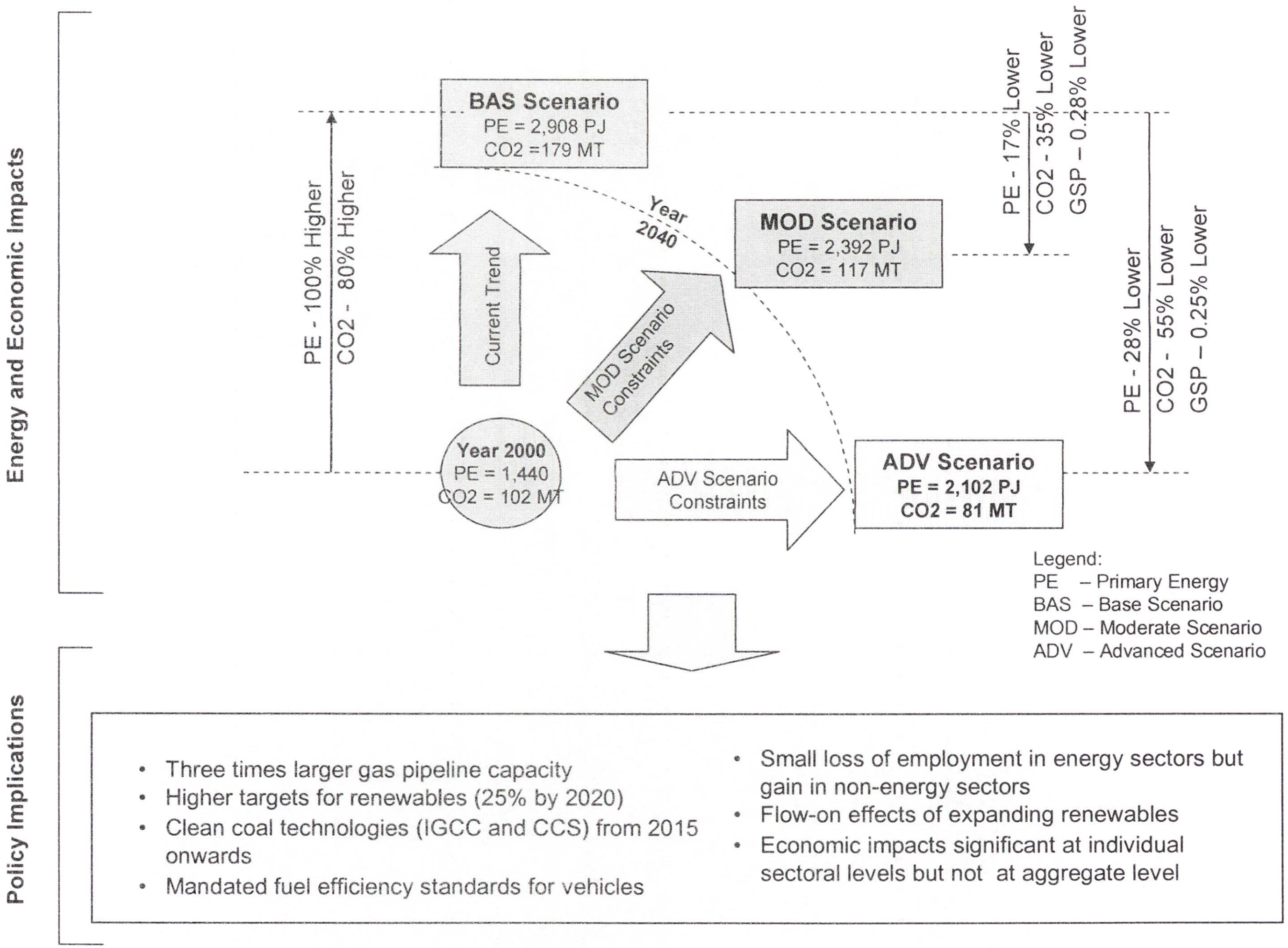

Figure 7-1: Summary of Energy and Economic Impacts and Policy Implications

In order for coal to ensure a longer-term survival, it would need to improve its competitiveness in terms of cost and efficiency. This could be achieved, for example, by replacing the retiring conventional coal plants by efficient plants (such as IGCC). This replacement would particularly be important after the year 2015; in the Base scenario, for example, an additional 1,550 MW of capacity would be needed by 2015. The role of coal in the coming decades would hence very much depend upon how the competitiveness of emerging advanced clean coal technologies, particularly IGCC, and carbon capture and sequestration (CCS) would improve. It would therefore be valuable for the NSW government to investigate the feasibility of these technologies in the context of the state.

(c) Given that the amount of gas consumption would increase, in 2040, by more than five times of the consumption level in 2000, there would be a need to increase the pipeline capacity, by approximately three times the current capacity (210 PJ/yr). With the dwindling of available gas in the current sources of supply, namely, Cooper and Gippsland, it would be important for NSW to secure a long term supply of gas from new sources, such as Carnarvon and Browse basin in Western Australia, Bonaparte basin in Northern Territory or from overseas Papua New Guinea (PNG). To ease the need of importing natural gas, the state would also need to develop coal seam methane (CSM) gas, which is available in abundance in the state itself (about 97,250 PJ).

(d) If current policy trends continue, the demand for oil would double by 2040, as compared with the demand in 2000. The oil reserves in Australia are declining, which means that domestic supply could fall further in the coming years. At the current rate of production (1,430 PJ/yr), the current reserves (16,800 PJ) can last for the next 11 years only. This would inevitably expose the state to the volatile world oil market (such as, the Middle East). For example, in 2000, NSW met 45 percent of its oil needs through imports (MOEU 2000b), while the corresponding share of imported oil in total oil consumption in Australia was 12 percent.

It would be important for NSW to introduce various measures to reduce dependency on imported oil. These may include, for example, setting mandated fuel efficiency standards for road transport vehicles, comparable, say, to China (6.4L/km) or Japan (4.9L/km); increase the use of alternative fuels such as CNG, ethanol, methanol, and hydrogen in the transport sector; and increase the uptake of advanced vehicle technologies, such as hybrid cars (Hybrid cars consume nearly half of the energy consumed by conventional cars). These measures could significantly slowdown the demand for petroleum products. In the Moderate scenario, for example, these measures could result in petroleum product consumption in road transport in 2020 and 2040 to be 25 and 36 percent, respectively, lower than the demand in the Base scenario.

(e) As reduction of CO_2 emissions becomes urgent in the coming decades, the electricity sector would need to go through a major transformation, away from the historically coal-dominant system, towards increased use of natural gas- and renewable-based systems. For example, the share of generation from coal-based plants would decrease from 92 percent in 2000, to 47, 20 and 27 percent in the Base, Moderate and Advanced scenarios, respectively, by 2040. Similarly, the share of electricity generation from natural gas plants would increase from 3 percent in 2000, to about 32 percent in 2020 and 41 percent in 2040 in the Base scenario. As more capacity is added to meet increasing electricity demand in the coming years, it would also provide more opportunities to increase the diversity of fuel- and technology-mix.

While the share of coal-based plants declines, coal could still continue to play an important role in power generation. As the Moderate and Advanced scenarios have demonstrated, this would require coal-based technologies to shift from the current combustion-based technologies to more efficient gasification-based technologies, particularly after 2015. This is because, during that period, the existing coal plants would begin to retire. This means that they could be replaced with highly efficient advanced types of coal plants such as IGCC. Around 2025, for example, two major coal power plants, Eraring and Baywater plants, commissioned in early 1980s, with a combined capacity of 5,280 MW are expected to retire. This could provide a good opportunity for replacing them with more efficient plants.

(f) The nuclear plants, at lower range of costs (~3000 \$/kW), would become competitive with the 'IGCC plants with CCS' only if significantly large amounts of CO_2 emission reductions, approximately 25 percent below 1990 emission level (as in the Advanced scenario), become necessary. At present, both of these plants (that is, IGCC with CCS, and nuclear) have many uncertainties in terms of environmental risks, and costs which would need to be resolved with continuous research and development.

(g) The major sources of renewable generation in NSW are hydro, biomass, wind, and solar PV. The share of renewables in power generation in the Moderate and Advanced scenarios would increase from 5 percent in 2000, to 19 and 28 percent, respectively, in 2020, and to 27 and 29 percent, respectively, in 2040. The largest increment would occur in biomass and wind plants, contributing about 14 and 7 percent, respectively, in 2040, in the Advanced scenario.

The promotion of renewable-based power generation would need a policy commitment by the state. Despite the huge potential for renewable-based power generation in NSW, currently, they provide a very small fraction of electricity generated in NSW (less than 1 percent, if hydro is excluded). At present, two key policy measures that favour renewable-based power generation include: (i) NSW Greenhouse Benchmark Scheme; (ii) Mandated Renewable Energy Target (MRET) scheme which is being implemented at the federal level. However, these measures might not be sufficient to increase the share of renewables in NSW's energy-mix significantly. Similar to the GHG Benchmark Scheme, hence, it would be important for NSW to set a state level target which is higher than the MRET level. The Moderate and Advanced scenarios in this research, for example, have shown that there would be a need to increase the share of generation from renewable-based plants from less than 1 percent (excluding hydro plants) to 19 and 28 percent respectively by 2020, and to 27 and 29 percent by 2040.

(h) On the end-use side, the residential and commercial sectors offer large potential to reduce electricity consumption through efficiency improvements. These two sectors, while consuming only about 20 percent of the total final energy consumption, are important when viewed in terms of their shares in total electricity consumption (they account for nearly 60 percent of total electricity consumption). The key areas where electricity consumption could be reduced in these sectors include space heating and cooling, and water heating. The scenario results have shown that improvement in building envelope design, expansion of solar water heating, and efficiency improvement in refrigerators and lighting could reduce electricity consumption in the residential sectors by 44 percent in the Moderate scenario and by 60 percent in the Advanced scenario in 2040, as compared with the Base scenario.

(i) The Base scenario has indicated that CO_2 emissions would increase by about 80 percent in next forty years under the current policy trend. The NSW Greenhouse Gas Benchmark Scheme (which is scheduled to expire in 2012) would need to be extended beyond 2012[70]. As the Base scenario has demonstrated, even with the Scheme in place, the total amount of CO_2 emissions in NSW would continue to rise significantly (mainly because of rise in emissions from the transport sector). If the Scheme were to be discontinued after 2012, the total CO_2 emissions would rise even further. The CO_2 emissions reduction strategy would need to expand its coverage beyond electricity sector, more specifically, it would need to include transport sector. The transport sector, being relatively inflexible in terms of technological and fuel switching, would need appropriate signals sooner, so that it could begin to take steps to improve efficiency and encourage changes in consumer habits.

In the industrial sector, energy intensive industries, particularly, iron and steel and aluminium, would need to be given priority from the view point of reducing CO_2 emissions. These two industries produce large emissions because of the process technologies they use, for example, the technology used by iron and steel industry is coal intensive, and that used by aluminium industry is electricity intensive (electricity being produced dominantly by coal based plants). To reduce CO_2 emissions, there would be a need to shift process technology in the iron and steel industry sector from the current coal based BF/BOF technology to DRI technology (which uses natural gas instead of coal). In the aluminium industry, while there is less scope for technology switch, emphasis should be upon improving energy efficiency. For example, there exists a potential for improvement in average energy consumption in the electrolysis process from the current level of 52 MJ/kg of Al to the full potential that can be achieved with technology available at present (47 MJ/kg of Al). Energy consumption in non-electrolysis processes could also be improved to the level of most efficient smelter (6.3 MJ/kg of Al) in Australia. This research has demonstrated that these measures in the iron and steel and aluminium industries could result in total CO_2 emissions from the industrial sector to reduce by 35.1 Mt in the Moderate and 29.5 Mt in the Advanced

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[70] It is reassuring to know that the NSW GHG Benchmark Scheme has now been extended to 2020 – also a key recommendation made in this research (see also footnote 22, p 73).

scenarios, in comparison with 50.7 Mt in the Base scenario, in 2040.

The transport sector, which emerges as the key CO_2 emitting sector in the Base scenario (particularly after reduction in emissions from electricity sector due to the NSW Benchmark Scheme) would need to be given priority from a policy view point. The scenario results have demonstrated that significant CO_2 emissions reduction from this sector could be achieved by 2040 – 22 percent in Moderate and 45 percent in Advanced scenario, with a mix of policies that target increasing fuel efficiency standards for passenger and freight vehicles, and policies that support alternate vehicle technologies (such as hybrid vehicles) and alternative fuels (such as biofuels, natural gas-based fuels and even coal to liquid fuels).

The policy implications identified in this research would require designing and implementing a set of regulatory measures (for example, vehicle efficiency standards and mandated target for renewable energy technologies at the state level) underpinned by transparency, effective communication and continual review.

Economic impacts

(a) The agriculture, other equipment and construction sectors would experience noticeable increase in their economic outputs in the Moderate and Advanced scenarios, as compared with the Base scenario. In 2020, for example, the total outputs of these sectors in the Moderate scenario are higher by $273 million (that is, by 2.2 percent), 214 million (0.6 percent), and 44 million (0.2 percent), respectively, and in the Advanced scenario, by $288 million (2.3 percent), 166 million (0.44 percent) and 36 million (0.14 percent), respectively. The use of renewable energy sources, such as biomass, wind and PV in power generation, and fuel switching from coal to natural gas are the major reasons behind such increases in sectoral outputs.

On the other hand, 'property and business' and 'finance and insurance' sectors would experience modestly negative economic impacts in the two scenarios. For example, in 2020, the total outputs of these sectors in the Moderate scenario would be $29 million

(0.02 percent) and 17 million (0.05 percent) lower, respectively, as compared with the Base scenario.

The higher level of total outputs for some of the non-energy sectors such as, agriculture, construction, fabricated metals, and iron and steel in the alternative scenarios could have positive impacts on the domestic economy because these sectors rely mostly on the inputs produced within the state itself. For example, import constitutes approximately only 9.7 percent of the purchases made by the agriculture and 5.7 percent by the construction sectors. The higher levels of outputs in these sectors, in the Moderate and Advanced scenarios, means that they would purchase more of domestically produced goods (instead of imported goods), thus helping domestic economy.

Among the energy sectors, total outputs (in PJ) would be lower for the electricity, petroleum product and coal sectors, both in the Moderate and Advanced scenarios, as compared with the Base scenario, in 2020 and 2040. In 2020, for example, the total outputs of these sectors would be lower by 20 PJ (that is, 6.2 percent), 117 PJ (15.7 percent) and 65 PJ (1.8 percent), respectively, in the Moderate scenario, and by 50 (15.6 percent), 143 PJ (19.1 percent), and 470 PJ (12.9 percent), respectively, in the Advanced scenario. These lower outputs reflect lower levels of electricity consumption, that, in turn, are due to the increased use of efficient appliances; lower levels of petroleum products consumption, improvements in vehicle efficiency and use of alternative transport fuels; and due to a decline in coal use in electricity generation and in the iron and steel industry.

(b) The agriculture, construction, fabricated metals and other equipment sectors would experience higher levels of wages and salaries in the Moderate and Advanced scenarios, as compared with the Base scenario. The wages and salaries in the agriculture sector in the Moderate and the Advanced scenarios, for example, would be $85 million (that is 2.2 percent) and 90 million (2.3 percent) higher, respectively, in 2020. This is due to the increased use of agri-products as energy sources, mainly for power generation and biofuel production.

The trade and repair, finance and insurance, and property and business sectors, on the other hand, would experience some decline in the wages and salaries. In 2020, for example, in the Advanced scenario, the wages and salaries in the trade and repair would lower (in comparison with the Base scenario) by $14 million (that is, 0.07 percent), the corresponding value for the finance and insurance, and property and business sectors would be $68 million (0.17 percent) and $74 million (0.06 percent), respectively.

Among the energy sectors, electricity, coal, and petroleum products would be significantly disadvantaged as there would be a decline in wages and salaries and employment in these sectors. For example, in 2020, the wages and salaries in the electricity, coal, and petroleum products sectors in the Moderate scenario are $62 million (that is, 6.2 percent), $18 million (1.8 percent), and $34 million (15.7 percent) lower, respectively, in comparison with the amount of wages and salaries in the Base scenario.

(c) The employment in agriculture, other equipment, and construction sectors would be higher, both in Moderate and Advanced scenarios, relative to the Base scenario. In 2020, for example, the agriculture sector would employ additional 1,957 persons (that is, 2.18 percent) and 2,066 persons (2.3 percent) in the Moderate and Advanced scenarios, respectively. The employment in trade and repair, finance and insurance, and property and business sectors would be comparatively lower in the Moderate and Advanced scenarios.

The electricity, petroleum products and coal sectors would experience higher job losses, both in Moderate and Advanced scenarios, as compared with the Base scenario. For example, in 2020, the electricity, coal, petroleum products sectors in the Moderate scenario would employ 753 (6.2 percent), 155 (1.8 percent), and 374 less persons (15.7 percent), respectively, as compared with the Base scenario. In the Advanced scenario, the corresponding values would be 1,900 (15.6 percent), 1,121 (12.9 percent) and 456 persons (19.1 percent), respectively.

The policy strategies reflected in alternative scenarios would generally result in a loss of employment in the energy sectors and increase in the non-energy sectors. For example, in 2020, job losses in the energy sectors are expected to be 1,604 in the Moderate scenario. In contrast, 2,339 new jobs would be created in the non-energy sectors in that year, thus resulting in a net overall gain in employment. The shift in employment from energy to non-energy sectors could be largely due to the switch in power generation, from low labour-intensive fossil-based plants to relatively more labour intensive renewable-based plants (such as wind, PV, and biomass). Such increase in employment could compensate for the loss of employment in the conventional energy sectors. The Moderate scenario, for example, shows no net loss in total employment in 2020 and 2040, even when employment in energy sector decreases. Further, employment generation due to the increased use of renewable energy sources could help generate employment in rural areas. For example, increased demand for biomass could generate employment in the rural-based agriculture sectors. Similarly, renewable-based plants such as wind are usually installed in rural areas. This could bring investment and jobs to these rural communities.

(d) The Moderate and Advanced scenarios suggest that the energy intensities of all economic sectors are generally experiencing a declining trend. This is due to the decline in primary energy consumption in these scenarios, a result of improvement in either direct intensity, or indirect intensity or both. The sectors that would experience significant decline in their energy intensities are the iron and steel, fabricated metal, and road transport. In 2020, for example, the total energy intensity in the iron and steel industry is 13.7 percent lower in the Moderate scenario (14.2 MJ/$) and 24.7 percent lower in the Advanced scenario (12.4 MJ/$) than the corresponding intensity in the Base scenario (16.5 MJ/$).

The shares of direct and indirect energy in the total primary energy intensity could provide useful insights into what types of energy efficiency measures would be more effective. For example, if the direct energy is dominant in the total energy consumption, policies should target improving energy efficiency in the industrial process technologies. These sectors include, for example, iron and steel, road transport, and basic chemical. And, if indirect energy accounts for a major share, policy should be directed towards reducing the input of energy intensive materials. Otherwise, in such sectors, even if efficient appliances are used, the total energy consumption would not improve significantly, because the share of indirect energy consumption would continue to be higher. These sectors, for example, include fabricated metals, construction, and service sectors. In the fabricated metal sector, for example indirect energy contributes about 95 percent to its total energy intensity, which illustrates the importance of indirect energy consumption in this particular sector.

(e) The total CO_2 intensities for various economic sectors would be lower in both Moderate and Advanced scenarios, in comparison with the Base scenario, in 2020 and 2040. This is due to the lower levels of energy consumption in these scenarios, in particular, lower level of coal consumption. For example, in 2020, the total CO_2 intensities for the iron and steel sector in the Moderate (1.1 kg/$) and in Advanced scenarios (0.88 kg/$) would be 19.6 and 38 percent lower than the Base scenario (1.4 kg/$).

The total CO_2 intensities of the service sectors, such as communication, finance and insurance, property and business, personal and other services, would be lower in both the Advanced and Moderate scenarios, in 2020 and 2040. In 2020, for example, in the communication sector, the intensity in the Advanced scenario (0.08 kg/$) would be lower by 32.2 percent, and in the Moderate scenario (0.10 kg/$) by 5.5 percent, compared with the corresponding value in the Base scenario (0.11 kg/$). Electricity is the main type of energy consumed by these service sectors, and as CO_2 emissions from the electricity sector decrease, so do CO_2 intensities.

(f) The economy wide impacts are found to be more significant at individual sectoral levels (such as agricultural, other equipment sector) than at the aggregate level. For example, in the Moderate and Advanced scenarios, the wages and salaries at an aggregate level would be lower by approximately ~0.01 and 0.15 percent in 2020, respectively. At the sectoral level, however, in the case of the agricultural sector, the wages and salaries would be higher by 2.2 and 2.3 percent, respectively, in 2020. This disparity between aggregate and individual sector level impacts indicates that policy recommendations made simply based upon analysis at the aggregate level (often a normal practice in policy studies) could fail to represent individual sectoral impacts, which could be significant.

7.2 Limitations of this Research and Recommendations for Further Research

This section presents some limitations of this research and recommends possible directions for future research. Some of these limitations are due to the very nature of the research methods applied, while others are due to the constraints in time and resources, and the unavailability of required information. A number of areas exist where this research could be extended.

Energy Impact Assessment

Strengthening of end-use demand estimates. This research used ABARE's energy demand projections for NSW (Dickson, Akmal & Thorpe 2003) to estimate end-use service demands. Energy demand projections made by ABARE are available at an aggregated level (for example, energy demand for the entire residential sector) but not detailed at various levels of end-use services (such as cooking, air conditioning services) -- as required by the MARKAL model. This research made adjustments in ABARE's projections to suit the requirement of the MARKAL model, by using assumptions collected from a variety of published sources (discussed in Section 4.4, Chapter 4). Further, ABARE's projections are available for up to the year 2020, whereas this research considers a time frame that extends to the year 2040. To fill this gap in data for the period 2020 to 2040, this research applied an extrapolation method. These adjustments, made in the process of data preparation, while a common practice in modelling exercises of this nature, may have compromised the assessment of true impacts at micro-levels of the economy. The future research could consider improving this aspect -- this would require a separate energy demand modelling exercise that would be able to generate end-use data at various levels of end use services exclusively to feed into the MARKAL model framework developed in this research.

Endogenisation of end-use demands. In this research, as required by the MARKAL model, demands for end-use services are input exogenously. An implication of this is that price effects on demand are ignored. Future research could consider endogenising the end-use demands.

Refinement in technological database. The energy modelling framework developed in this research has placed specific emphasis on key energy intensive end-use sectors, that is, they constitute core of technologies/sectors considered in the Reference Energy System (RES). Such technologies/sectors include, for example, iron and steel, aluminium, road transport. It is recommended that this RES be expanded to include other end-use technologies including non energy intensive technologies. This would also enable one to capture more comprehensively the interactions between various technologies in the analysis of various policy questions. In addition, the RES developed in this research is extendable to include other conversion, transport and resource industries. These would considerably enhance the analytical scope of the model. For example, by including nuclear, carbon capture and sequestration and desalination, one could analyse several of the emerging policy questions in the NSW context.

Expansion of coverage beyond NSW. The modelling framework developed in this research could be extended to include other Australian states. Of particular interest would be the inclusion of the National Energy Market (NEM) states, namely, Victoria, Queensland, South Australia, and Tasmania. This extended framework could then be used to examine issues such as the impact of energy trade and emission trading across the NEM states.

Economic Impact Assessment

Regionalisation of input–output table. The input–output tables in Australia are developed by the Australian Bureau of Statistics (ABS), usually at intervals of 3 to 5 years. These tables are, however, in aggregated form, that is they represent the entire nation. They therefore are not amenable for analysis of issues at the state level. In the absence of a state level input–output table for NSW from ABS, this research has instead used a state level table developed by Powell (2004). Although the disaggregation of economic sectors in this table corresponds with the national classification, this table was not independently developed through surveys, rather extrapolated from ABS table, using the GRIT method (Generation of Regional Input–output Tables, see Jensen and West (1986). This method uses the national input–output table of ABS (2001a), together with state specific data. While this method claims to provide a generally accurate representation of the state's economy, it does not guarantee accuracy of any particular cell (Powell, Chalmers & Bailey 1999). It is possible hence that this could have compromised some of the results in this research.

Extension of Energy sector. An implication of the aggregated nature of the input–output table (as discussed above) is that it is incapable of considering energy resources/sectors at disaggregated levels. Hence its analytical power gets somewhat restricted. This research has made considerable progress in overcoming this limitation/ for example, by including energy consumption data and technology specific data from various other sources (as discussed in Chapter 5). Significant scope however still exists for further extension of this table.

Ensuring Compatibility between energy and input–output frameworks. The classification of sectors used in the input–output table is different from the classification in the energy model (MARKAL model). This is because, in the MARKAL model, the sectors are classified based on their end-uses requiring energy as outputs, regardless of the nature or magnitude of their economic output, whereas in the input–output table, the sectors are classified based on the nature/magnitude of economic outputs (usually expressed in terms of product types and aggregated in \$). This creates difficulties in making a consistent link between the two modelling approaches. This research has attempted to overcome this drawback by including a detailed representation of energy intensive industries (e.g., electricity, iron and steel, road transport) in the input–output framework. This however was not possible for all energy industries. Further research should pay increasing attention to the issue.

Introducing dynamism in the projection of Input-output coefficients. One of the challenges in a study of a long term nature, using economic approach, is to realistically estimate and represent the evolution of economic sectors over extended time period. The input–output model also suffers from this shortcoming, because of its reliance on fixed technical coefficients (The technical coefficients in the input–output analysis represent relationship between various inputs and outputs within an economy at a specific time). This research used input–output model for a period extending 40 years into the future. The technical coefficients were updated in the research based on the well established RAS method. However, economic sectors represented in the input–output table are diverse in nature, which may go through significant changes over such a long period. These changes are unlikely to have been satisfactorily captured in the RAS method. This is another area for potential future research.

Applying closed type of input–output table. The current research has used an open type of input–output table, that is, household sector has been kept as exogenous. In future, this could be extended by using a closed type of input–output table. In the closed type of input–output table, the household sector is treated as a production sector within the transaction table. This allows one to examine the impacts of the changes in personal income (that is wages and salaries) on the total outputs, income and employment.

APPENDICES

Appendix A. Description of MARKAL Model

This appendix provides a simplified description the objective function and constraints that constitutes the MARKAL model. The more formal mathematical descriptions are available in Loulou (2004).

Objective function

$$Z = minimize \sum_{t=1}^{t=NPER} [(1+r)^{NYRS.(1-t)} \times ANNCOST_t \times \sum_{m=1}^{m=NYRS} (1+r)^{1-m}]$$

$$ANNCOST_t = \sum [Annualized\ Investment_{t,k} \times INV_{t,k} + Fixom_{t,k} \times CAP_{t,k} +$$

$$Varom_{t,k} \times \sum ACT_{t,k,s} + \sum [Delivcost_{t,k,c} \times Input_{t,k,c} \times \sum ACT_{t,k,s}] + \sum$$

$$[Mining\ cost_{t,c,l} \times mining_{t,c,l} + Importprice_{t,c,l} \times Import_{t,c,l} -$$

$$Exportprice_{t,c,l} \times export_{t,c,l}] + \sum [Tax_{t,p} \times ENV_{t,p}].$$

The objective function minimizes the total discounted costs of the energy system, which is the present value of the annual costs incurred in each year of the horizon.

The total annual cost is the sum of annualized investments, annual fixed costs, annual variable costs, fuel delivery costs, cost of extracting, cost of importing, minus revenue from exported energy carriers, plus taxes on emissions.

Constraints

1. Demand balance constraint

Sum {over all end-use technologies k, such that k supplies service d} of $CAP_{t,k}$ $\geq D_{t,d}$

This constrain ensures that the sum of outputs from all end use technologies (k) that are providing services to particular demand category (d) is greater than or equal to the specified demand.

2. Capacity transfer constraint

$$CAP_{t,k} = Sum\ of\ INV_{t,k} + RESID_{t,k}.$$

The capacity available in any period is equal to the sum of capacities installed in the past periods, which are still available for use in the current period within its lifetime, capacities installed in the current period, and the residual capacities which are in place before the start of the optimization.

3. Capacity use constraint

$$ACT_{t,k,s} \leq AF_{t,k,s} \times CAPUNIT \times CAP_{t,k}$$

The outputs from any technology must not exceed its availability.

4. Energy balance constraint

$$Sum\ of\ output_{t,k,c} \times ACT_{t,k,s} + Sum\ of\ MINING_{t,c,l} + Sum\ of\ IMP_{t,c,l}$$

$$\geq$$

$$Sum\ of\ EXP_{t,c,l} + Sum\ of\ Input_{t,k,c} \times ACT_{t,k,c,s}$$

This constrain ensures that the amount of energy carrier available to the system must be greater than or equal to the amount of energy consumed by the system.

5. Electricity peak reserve constraint

$$Sum\ of\ CAPUNIT \times Peak_{t,k,c} \times FR_s \times CAP_{t,k} + FR_s \times IMPORT_{t,c}$$

$$\geq$$

$$[1 + ERESERVE_{t,c}] \times [Sum\ of\ Input_{t,k,c} \times FR_s \times ACT_{t,k,s} + FR_s \times EXPORT_{t,c}.$$

This constrain requires the system to install capacities so that it could meet demand during the season of peak demand.

6. Emission constraint

$$ENV_{t,p} \leq ENV\_Limit_{t,p}$$

$$ENV_{t,p} = Sum\ [Eminv_{t,p,k} \times INV_{t,k} + Emcap_{t,k,p} \times CAP_{t,k} + Emact_{t,k,p} \times ACT_{t,k,s}].$$

The total amount of emissions must not exceed the limit imposed.

7. Electricity base load constraint

Sum {over all technologies k consuming electricity c at night of : $input_{t,k,c} \times Baseload_{t,c} \times ACT_{t,k,'N'}\}$

$$\geq$$

Sum {over all baseload technologies k producing electricity c at night of : $Output_{t,k,c} \times ACT_{t,k,'N'}\}$.

Baseload plants shall produce the same amount electricity in the night as in the day time.

r = discount rate

t = time period

k = technology

s = time slice

c = energy carrier

$INV_{t,k}$ = new capacity installed for technology k, in period t,

$CAP_{t,k}$ = installed capacity of technology k, in period t,

$ACT_{t,k,s}$ = output level of technology k, in period t,

$MINING_{t,c,l}$ = quantity of energy carrier, c, extracted at price level l in period t,

$IMPORT_{t,c,l,}$ = quantity of energy carrier, c, imported at price level l, in period t,

$EXPORT_{t,c,l}$ = quantity of energy carrier, c, exported at price level l, in period t,

$D_{t,d}$ = demand for end use d, in period t,

$ENV_{t,p}$ = emission of pollutant p in period t,

$Annualized\ Investment_{t,k}$ = annual equivalent of the unit investment cost,

$= INVCOST_{t,k} \times [r \times (1+r)^n/\{(1+r)^n-1\}]$ (n= plant life in yr).

$INVCOST_{t,k}$ = unit investment cost of technology k, in period t,

$Fixom_{t,k}$ = fixed cost of technology k, in period t,

$Varom_{t,k}$ = variable cost of technology k, in period t,

$Delivcost_{t,k,c}$ = delivery cost per unit of energy carrier c to technology k in period t,

$Input_{t,k,c}$ = the amount of energy carrier c required to operate one unit of technology k, in period t,

$Miningcost_{t,c,l}$ = the cost of mining energy carrier c at price level l, in period t,

$Imporprice_{t,c,l}$ = import price of energy carrier c, in period t,

$Exportprice_{t,c,l}$ = export price of energy carrier c, in period t,

$Tax_{t,p}$ = emission tax for pollutant p, in period t,

$RESID_{t,k}$ = residual capacity of technology k, which were installed prior to the optimisation and still available in period t,

$AF_{t,k,s}$ = availability factor of technology k, in time period t, in time slice s,

FR_s = fraction of year covered by time slice s (equals to 1 for non-seasonal energy carrier),

$ERESERVE_{t,c}$ = reserve coefficient for energy carrier c, in time t,

$Peak_{t,k,c}$ = fraction of technology k's capacity for a period t for electricity c that is allowed to contribute to the peak load,

Eminv, Emcap, Emact = emissions coefficients for pollutant p linked respectively to the construction, the capacity, and the operation of technology

$ENV\_LIMIT_{t,p}$ = is the upper limit set for the total emissions of pollutant p in period t,

$Baseload_{t,c}$ = maximum share of the night demand for electricity c in period t,

Appendix B. Data and assumptions

Table B-1: Population and gross state product (GSP)

	2000	2010	2020	2030	2040
Population[1] ('000)	6,755	7,266	7,688	8,034	8,083
GSP[2] ($M, 2000price)	237,379	322,128	437,135	593,202	804,987

Sources: (ABS 1998, 2003)

Notes: [1] Based on Series II projections by ABS (1998).

[2] Annual growth rate of 3.1%.

Table B-2: Calorific values and emissions factors

Energy types	Calorific value, GJ/unit	Emissions factors, kg/GJ
Black coal	28.5GJ/t	90.6
Oil	37MJ/L	73
Natural gas	54.4GJ/t	51.3

(AGO 2004; Dickson, Akmal & Thorpe 2003)

Appendix C. Energy Impact Results

Table C-1: Primary Energy Requirement by Fuel Types (PJ)

Base Scenario

Energy types	2000	2005	2010	2015	2020	2025	2030	2035	2040	Growth rate
Black Coal	710	782	727	744	756	779	815	841	893	(0.58)
	(49.3)	(49.6)	(41.4)	(38.7)	(36.1)	(34.5)	(33.1)	(31.8)	(30.7)	
Oil	525	577	647	719	794	875	971	1,073	1,193	(2.07)
	(36.4)	(36.5)	(36.8)	(37.5)	(37.9)	(38.7)	(39.4)	(40.5)	(41.0)	
Natural Gas	110	118	213	288	349	400	455	515	560	(4.14)
	(7.7)	(7.5)	(12.1)	(15.0)	(16.7)	(17.7)	(18.5)	(19.4)	(19.2)	
Coal Seam Methane	6	0	28	11	20	19	18	0	0	-
	(0.4)	(0.0)	(1.6)	(0.6)	(0.9)	(0.8)	(0.7)	(0.0)	(0.0)	
Elect. Import (FEQ)[1]	31	35	38	42	46	51	57	63	69	(2.00)
	(2.2)	(2.2)	(2.2)	(2.2)	(2.2)	(2.3)	(2.3)	(2.4)	(2.4)	
Renewable	58	67	105	117	127	135	149	157	194	(3.07)
	(4.0)	(4.3)	(6.0)	(6.1)	(6.1)	(6.0)	(6.0)	(5.9)	(6.7)	
Total	**1,440**	**1,578**	**1,757**	**1,920**	**2,092**	**2,259**	**2,464**	**2,649**	**2,908**	**(1.77)**

Moderate Scenario

	2000	2005	2010	2015	2020	2025	2030	2035	2040	
Black Coal	707	761	725	752	690	556	556	449	356	(-1.70)
	(49.2)	(48.7)	(42.8)	(41.0)	(35.7)	(28.4)	(26.3)	(20.1)	(14.9)	
Oil	525	577	580	632	669	741	775	859	944	(1.48)
	(36.5)	(36.9)	(34.2)	(34.5)	(34.6)	(37.8)	(36.6)	(38.5)	(39.5)	
Natural Gas	112	127	221	247	329	388	457	515	578	(4.19)
	(7.8)	(8.1)	(13.0)	(13.5)	(17.0)	(19.8)	(21.6)	(23.1)	(24.2)	
Coal Seam Methane	6	0	6	0	0	16	30	54	78	(6.49)
	(0.4)	(0.0)	(0.4)	(0.0)	(0.0)	(0.8)	(1.4)	(2.4)	(3.3)	
Elect. Import (FEQ)	31	35	38	42	46	51	57	63	69	(2.00)
	(2.2)	(2.2)	(2.3)	(2.3)	(2.4)	(2.6)	(2.7)	(2.8)	(2.9)	
Renewable	57	63	124	159	197	209	241	290	367	(4.75)
	(4.0)	(4.1)	(7.3)	(8.7)	(10.2)	(10.7)	(11.4)	(13.0)	(15.3)	
Total	**1,439**	**1,563**	**1,693**	**1,832**	**1,935**	**1,960**	**2,115**	**2,230**	**2,392**	**(1.28)**

Advanced Scenario

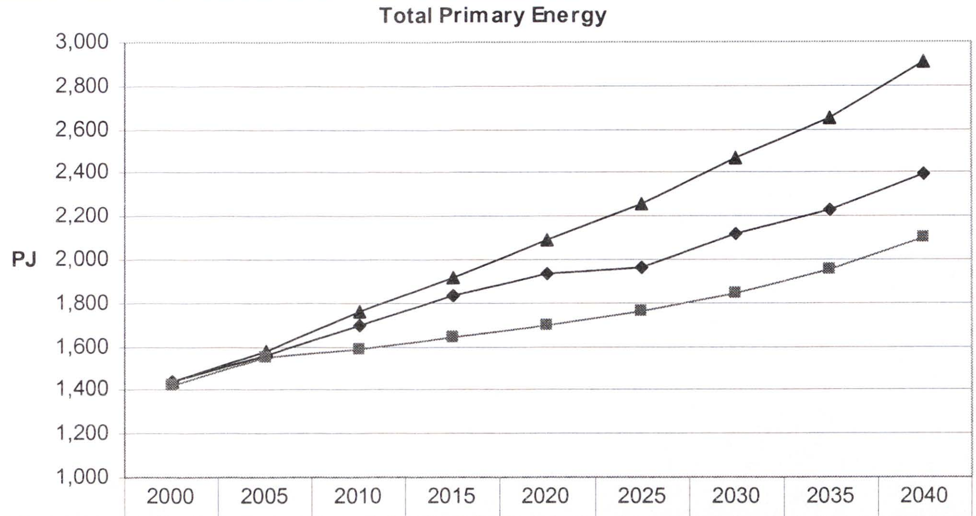
	2000	2005	2010	2015	2020	2025	2030	2035	2040	
Black Coal	707	722	531	381	287	260	226	234	316	(-2.00)
	(49.6)	(46.7)	(33.6)	(23.2)	(16.9)	(14.7)	(12.3)	(12.0)	(15.0)	
Oil	513	561	577	615	643	666	684	721	792	(1.10)
	(35.9)	(36.3)	(36.5)	(37.4)	(37.9)	(37.8)	(37.0)	(36.9)	(37.7)	
Natural Gas	112	129	236	317	389	441	503	543	529	(3.96)
	(7.8)	(8.2)	(14.0)	(17.3)	(20.1)	(22.5)	(23.8)	(24.3)	(22.1)	
Coal Seam Methane	6	0	23	46	71	67	63	47	27	(3.70)
	(0.4)	(0.0)	(1.5)	(2.8)	(4.2)	(3.8)	(3.4)	(2.4)	(1.3)	
Elect. Import (FEQ)	31	35	38	42	46	51	57	63	69	(2.00)
	(2.2)	(2.2)	(2.4)	(2.6)	(2.7)	(2.9)	(3.1)	(3.2)	(3.3)	
Renewable	57	100	177	242	261	278	315	345	369	(4.76)
	(4.0)	(6.5)	(11.2)	(14.7)	(15.4)	(15.8)	(17.0)	(17.7)	(17.5)	
Total	**1,427**	**1,546**	**1,583**	**1,643**	**1,697**	**1,763**	**1,848**	**1,952**	**2,102**	**(0.97)**

Source: Results obtained from the energy model in this research as discussed in Chapter 4.

Notes:

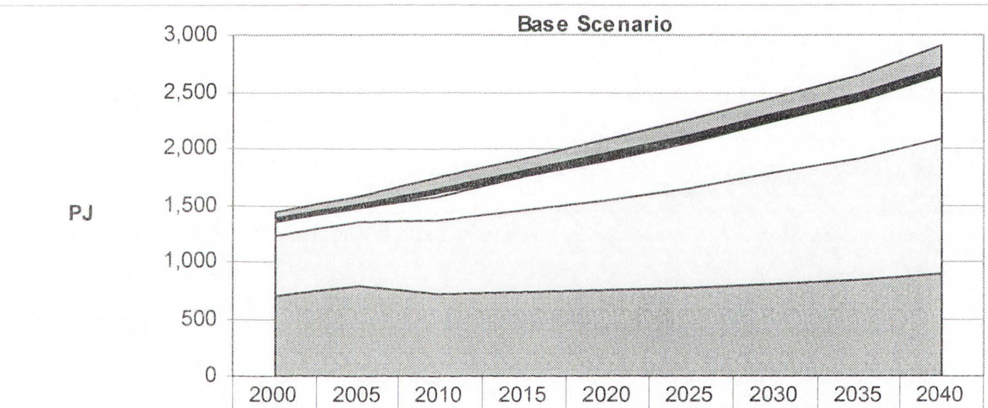
[1] Electricity import is converted into primary energy in terms of Fossil Equivalent (FEQ) value of 3.125. FEQ corresponds to reciprocal of the average efficiency of fossil fuel power plants, which is assumed as 32% in this case.

- Values in parenthesis are percentage of the total.



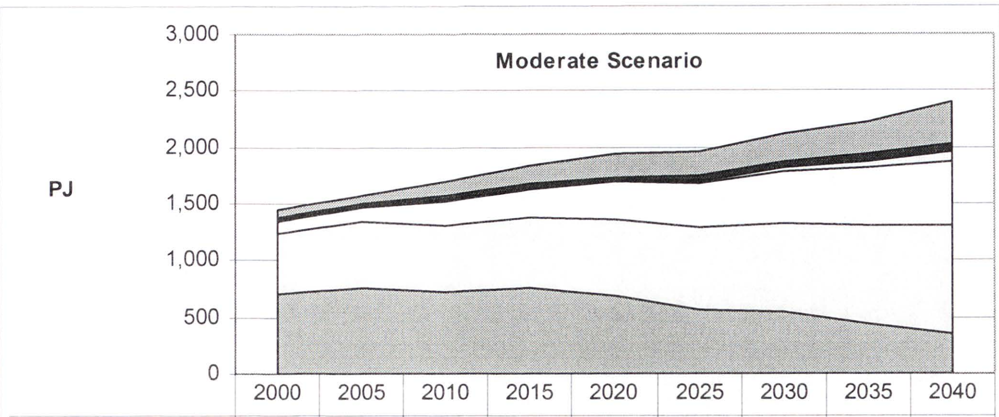
	2000	2005	2010	2015	2020	2025	2030	2035	2040
BAS	1,440	1,578	1,757	1,920	2,092	2,259	2,464	2,649	2,908
MOD	1,439	1,563	1,693	1,832	1,933	1,960	2,115	2,230	2,392
ADV	1,427	1,547	1,583	1,643	1,697	1,763	1,848	1,952	2,102

Figure C-18: Primary Energy Requirement



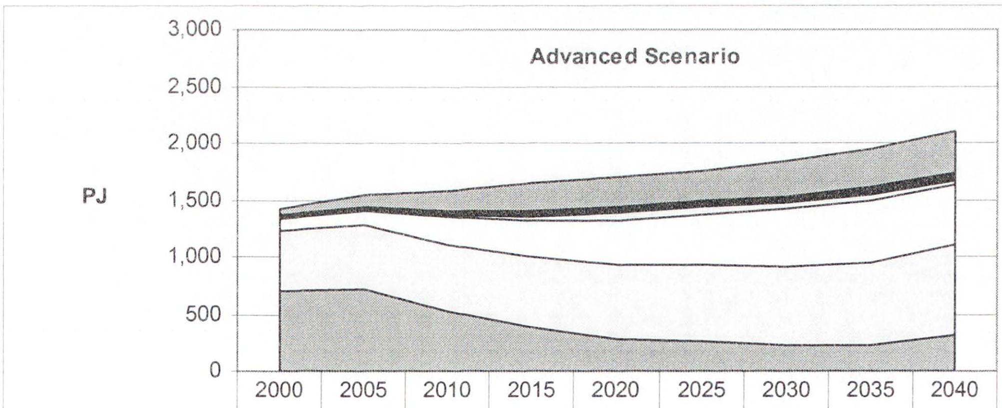
	2000	2005	2010	2015	2020	2025	2030	2035	2040
Hydro+Ren	58	67	105	117	127	135	149	157	194
Elect Import(FEQ)	31	35	38	42	46	51	57	63	69
Coal Seam Methane	6	0	28	11	20	19	18	0	0
Natural Gas	110	118	213	288	349	400	455	515	560
Oil	525	577	647	719	794	875	971	1,073	1,193
Black Coal	710	782	727	744	756	779	815	841	893

Figure C-19: Primary Energy Requirements by Fuel Types: Base Scenario



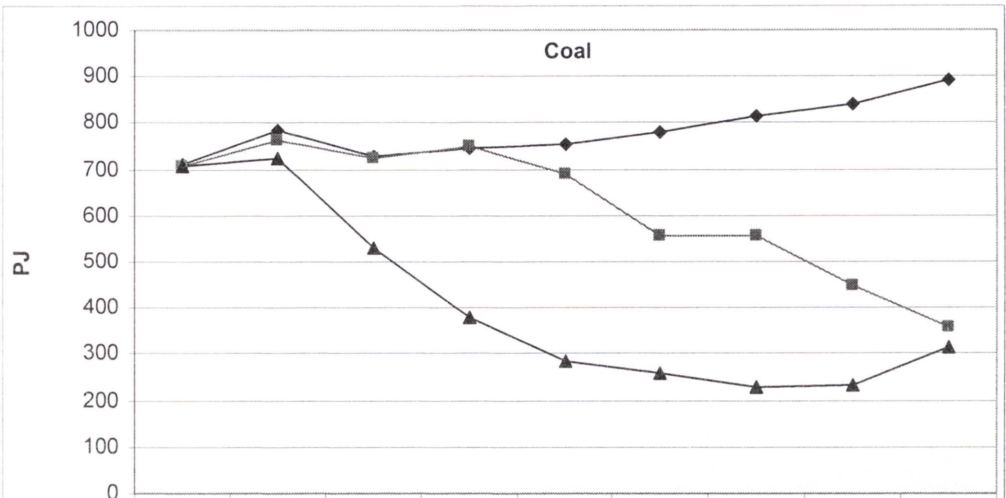
	2000	2005	2010	2015	2020	2025	2030	2035	2040
Hydro+Ren	57	63	124	159	197	209	241	290	367
Elect Import(FEQ)	31	35	38	42	46	51	57	63	69
Coal Seam Methane	6	0	6	0	0	16	30	54	78
Natural Gas	112	127	221	247	329	388	457	515	578
Oil	525	577	580	632	669	741	775	859	944
Black Coal	707	761	725	752	690	556	556	449	356

Figure C-20: Primary Energy Requirement by Fuel Types: Moderate Scenario



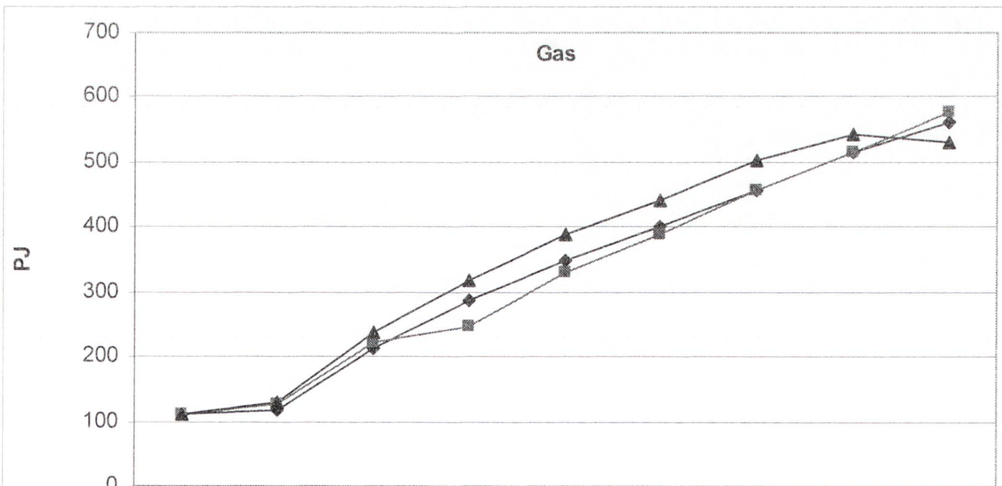
	2000	2005	2010	2015	2020	2025	2030	2035	2040
Hydro+Ren	57	100	177	242	261	278	315	345	369
Elect Import(FEQ)	31	35	38	42	46	51	57	63	69
Coal Seam Methane	6	0	23	46	71	67	63	47	27
Natural Gas	112	129	236	317	389	441	503	543	529
Oil	513	561	577	615	643	666	684	721	792
Black Coal	707	722	531	381	287	260	226	234	316

Figure C-21: Primary Energy Requirement by Fuel Types: Advanced Scenario



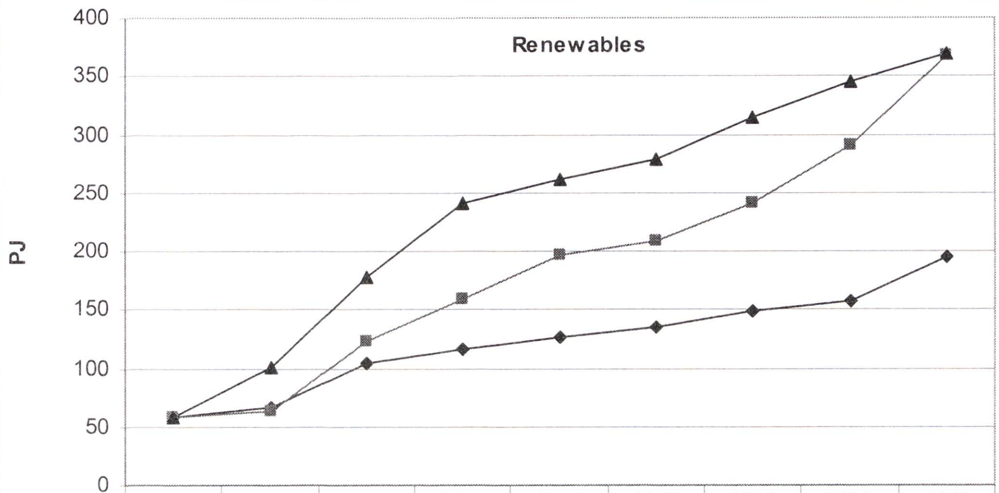
	2000	2005	2010	2015	2020	2025	2030	2035	2040
BAS	709.5	782.4	727	744	755.8	779.1	814.7	841.2	892.5
MOD	707.4	761	725.3	751.9	690.3	556.3	555.7	448.9	355.8
ADV	707.3	722.3	531.3	381.2	286.6	259.7	226.4	234	315.7

Figure C-22: Coal Requirements



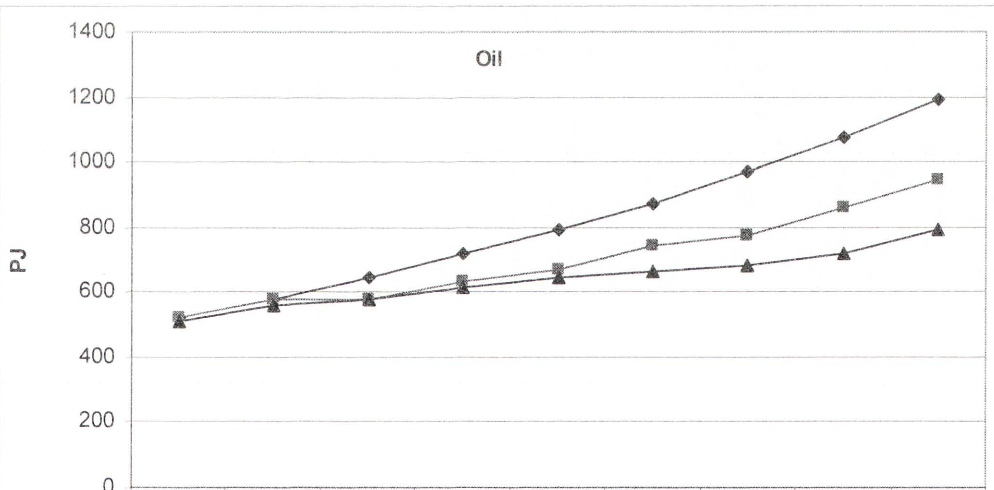
	2000	2005	2010	2015	2020	2025	2030	2035	2040
BAS	110.3	117.7	212.5	287.9	349.2	399.8	455	515.1	559.8
MOD	111.9	127.3	220.6	246.6	329.3	387.5	456.5	514.7	577.6
ADV	111.9	128.7	236.3	317.2	388.9	441.2	503.4	542.9	529.4

Figure C-23: Gas Requirements



	2000	2005	2010	2015	2020	2025	2030	2035	2040
BAS	58	67.1	105.1	116.5	127.1	134.7	148.9	157.1	194.3
MOD	57.4	63.3	123.6	159	197.4	209	241	290.3	367
ADV	57.4	100.2	177.1	241.8	260.9	277.9	314.8	344.6	368.8

Figure C-24: Renewable Energy Requirement



	2000	2005	2010	2015	2020	2025	2030	2035	2040
BAS	524.7	576.7	646.8	719.3	793.9	874.6	970.80	1,073.00	1,192.70
MOD	524.7	576.7	579.5	632.2	669.1	740.5	774.7	859	944.3
ADV	512.5	561.2	577.2	615.2	642.6	665.8	683.7	721.1	792.4

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Figure C-25: Oil Requirements

Table C-2: Final Energy Requirement by Sectors (PJ)

Base Scenario

	2000	2005	2010	2015	2020	2025	2030	2035	2040	Growth rate
Agriculture	14	15	16	17	18	20	21	23	25	(1.36)
	(1.4)	(1.4)	(1.3)	(1.2)	(1.2)	(1.2)	(1.1)	(1.1)	(1.1)	
Commercial	72	82	89	98	108	120	132	146	161	(2.04)
	(7.1)	(7.4)	(7.1)	(7.1)	(7.1)	(7.1)	(7.0)	(7.0)	(7.0)	
Industrial	386	408	477	526	580	640	707	783	867	(2.04)
	(38.2)	(37.0)	(38.2)	(38.0)	(37.9)	(37.8)	(37.7)	(37.7)	(37.6)	
Residential	122	133	145	160	178	197	219	243	269	(2.00)
	(12.1)	(12.1)	(11.6)	(11.6)	(11.6)	(11.7)	(11.7)	(11.7)	(11.7)	
Transport	416	464	522	583	645	716	794	883	982	(2.17)
	(41.2)	(42.1)	(41.8)	(42.1)	(42.2)	(42.3)	(42.4)	(42.5)	(42.6)	
Total	**1010**	**1102**	**1249**	**1384**	**1530**	**1692**	**1874**	**2077**	**2304**	**(2.08)**

Moderate Scenario

	2000	2005	2010	2015	2020	2025	2030	2035	2040	Growth rate
Agriculture	14	15	16	17	18	20	21	23	25	(1.36)
	(1.4)	(1.4)	(1.3)	(1.3)	(1.3)	(1.3)	(1.3)	(1.2)	(1.2)	
Commercial	72	82	87	96	106	117	129	142	157	(1.98)
	(7.1)	(7.5)	(7.2)	(7.3)	(7.4)	(7.5)	(7.7)	(7.8)	(7.9)	
Industrial	385	400	458	499	541	587	635	687	741	(1.65)
	(38.1)	(36.7)	(38.1)	(38.0)	(38.0)	(38.0)	(37.8)	(37.6)	(37.2)	
Residential	122	128	131	137	143	150	157	164	172	(0.87)
	(12.1)	(11.7)	(10.9)	(10.4)	(10.0)	(9.7)	(9.3)	(9.0)	(8.7)	
Transport	416	464	512	563	615	673	740	813	895	(1.93)
	(41.3)	(42.7)	(42.5)	(43.0)	(43.2)	(43.6)	(44.0)	(44.5)	(45.0)	
Total	**1009**	**1088**	**1204**	**1311**	**1423**	**1546**	**1682**	**1829**	**1990**	**(1.71)**

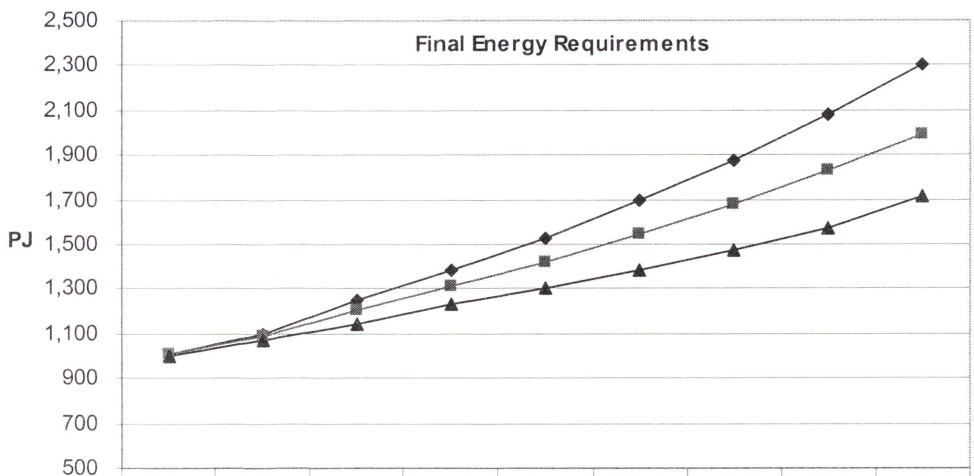
Advanced Scenario

	2000	2005	2010	2015	2020	2025	2030	2035	2040	Growth rate
Agriculture	14	15	16	17	18	20	21	23	25	(1.36)
	(1.4)	(1.4)	(1.4)	(1.4)	(1.4)	(1.4)	(1.4)	(1.4)	(1.4)	
Commercial	72	82	86	94	104	115	127	140	155	(1.95)
	(7.2)	(7.6)	(7.5)	(7.7)	(8.0)	(8.3)	(8.6)	(8.9)	(9.1)	
Industrial	385	400	448	481	515	556	598	642	688	(1.47)
	(38.6)	(37.2)	(39.2)	(39.2)	(39.4)	(40.1)	(40.6)	(40.8)	(40.3)	
Residential	122	127	110	115	120	127	133	140	148	(0.48)
	(12.2)	(11.8)	(9.6)	(9.3)	(9.2)	(9.1)	(9.0)	(8.9)	(8.6)	
Transport	405	450	484	521	550	569	594	629	694	(1.36)
	(40.6)	(41.9)	(42.3)	(42.4)	(42.0)	(41.0)	(40.3)	(39.9)	(40.6)	
Total	**997**	**1073**	**1144**	**1229**	**1308**	**1386**	**1474**	**1575**	**1710**	**(1.36)**

Source: Results obtained from energy model in this research.

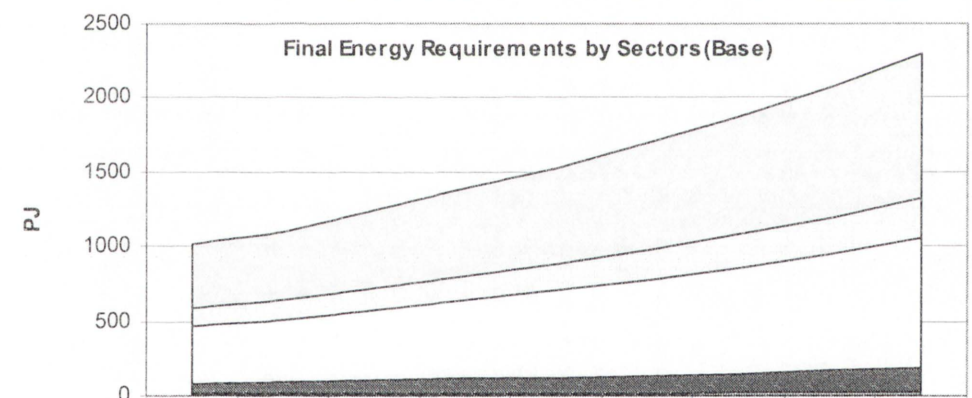
Notes:

Values in parenthesis are percentage of the total.



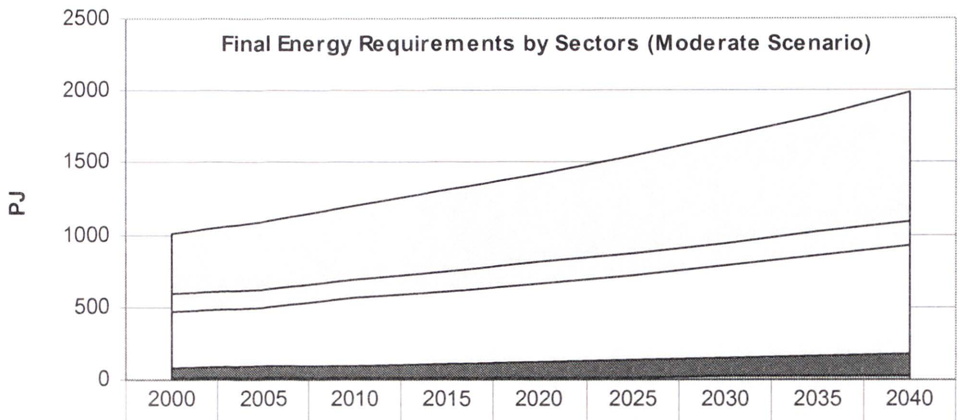
	2000	2005	2010	2015	2020	2025	2030	2035	2040
BAS	1,010	1,102	1,249	1,384	1,530	1,692	1,874	2,077	2,304
MOD	1,009	1,088	1,204	1,311	1,423	1,546	1,682	1,829	1,990
ADV	997	1,073	1,144	1,229	1,308	1,386	1,474	1,575	1,710

Figure C-26: Final Energy Requirements



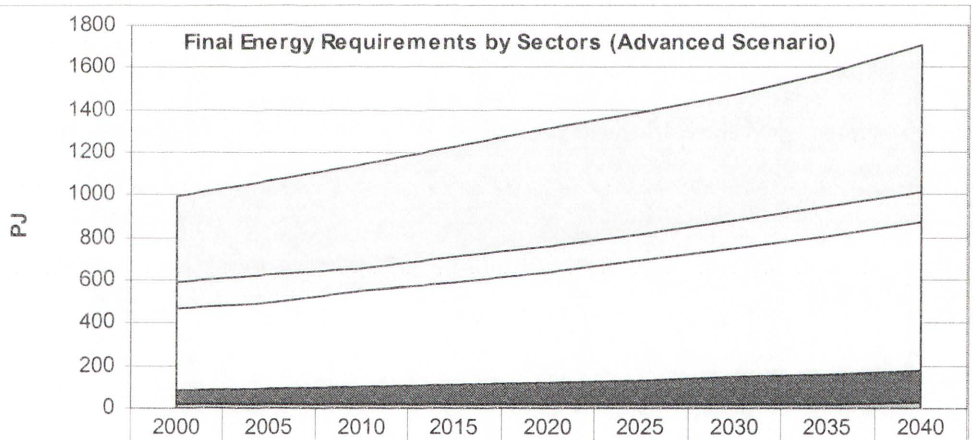
	2000	2005	2010	2015	2020	2025	2030	2035	2040
Transport	416	464	522	583	645	716	794	883	982
Residential	122	133	145	160	178	197	219	243	269
Industrial	386	408	477	526	580	640	707	783	867
Commercial	72	82	89	98	108	120	132	146	161
Agriculture	14	15	16	17	18	20	21	23	25

Figure C-27: Final Energy Requirement by Sectors: Base Scenario



	2000	2005	2010	2015	2020	2025	2030	2035	2040
Transport	416	464	512	563	615	673	740	813	895
Residential	122	128	131	137	143	150	157	164	172
Industrial	385	400	458	499	541	587	635	687	741
Commercial	72	82	87	96	106	117	129	142	157
Agriculture	14	15	16	17	18	20	21	23	25

Figure C-28: Final Energy Requirement by Sectors: Moderate Scenario



	2000	2005	2010	2015	2020	2025	2030	2035	2040
Transport	405	450	484	521	550	569	594	629	694
Residential	122	127	110	115	120	127	133	140	148
Industrial	385	400	448	481	515	556	598	642	688
Commercial	72	82	86	94	104	115	127	140	155
Agriculture	14	15	16	17	18	20	21	23	25

Figure C-29: Final Energy Requirement by Sectors: Advanced Scenario

Table C-3: Power Generation by Fuel Types (PJ)

Base Scenario

	2000	2005	2010	2015	2020	2025	2030	2035	2040	Growth rate
Coal	205.1	230.2	197.8	194.3	188.0	200.1	200.1	220.5	223.9	(0.22)
	(91.8)	(93.4)	(72.5)	(64.9)	(57.3)	(55.1)	(50.6)	(50.5)	(46.9)	
Gas	6.1	3.6	51.4	75.2	106.3	128.9	155.0	176.1	198.7	(9.10)
	(2.7)	(1.5)	(18.8)	(25.1)	(32.4)	(35.5)	(39.2)	(40.3)	(41.7)	
Hydro	11.8	11.8	12.1	12.5	12.8	13.2	13.6	14.1	14.5	(0.51)
	(5.3)	(4.8)	(4.4)	(4.2)	(3.9)	(3.6)	(3.4)	(3.2)	(3.0)	
Biomass	0.3	0.3	8.6	8.5	8.3	8.3	8.3	8.0	14.6	(10.39)
	(0.1)	(0.1)	(3.2)	(2.8)	(2.5)	(2.3)	(2.1)	(1.8)	(3.1)	
Solar	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.06	0.07	(4.99)
	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	
Wind	0.2	0.6	3.0	8.7	12.8	12.6	18.4	18.0	25.2	(13.00)
	(0.1)	(0.2)	(1.1)	(2.9)	(3.9)	(3.5)	(4.6)	(4.1)	(5.3)	
Total	**223.5**	**246.4**	**272.9**	**299.3**	**328.3**	**363.2**	**395.5**	**436.7**	**476.9**	**(1.91)**

Moderate Scenario

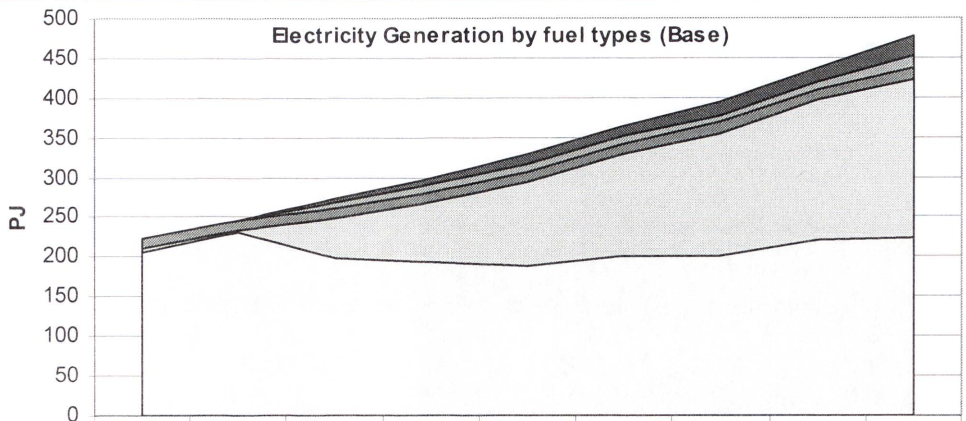
	2000	2005	2010	2015	2020	2025	2030	2035	2040	Growth rate
Coal	205.4	229.5	209.9	215.5	189.0	167.8	167.8	130.3	82.0	(-2.27)
	(91.9)	(93.7)	(80.0)	(75.0)	(61.6)	(52.6)	(47.4)	(35.3)	(20.9)	
Gas	6.1	3.6	27.3	30.6	58.8	90.2	119.3	158.4	203.1	(9.16)
	(2.7)	(1.5)	(10.4)	(10.7)	(19.2)	(28.3)	(33.7)	(42.9)	(51.6)	
Hydro	11.8	11.8	12.1	12.5	12.8	13.2	13.6	14.1	14.5	(0.51)
	(5.3)	(4.8)	(4.6)	(4.3)	(4.2)	(4.1)	(3.9)	(3.8)	(3.7)	
Biomass	0.1	0.1	8.2	15.0	17.6	17.9	22.5	34.6	52.0	(17.23)
	(0.0)	(0.0)	(3.1)	(5.2)	(5.7)	(5.6)	(6.4)	(9.4)	(13.2)	
Solar	0.0	0.0	1.3	2.9	4.6	4.8	5.3	6.6	16.4	(20.33)
	(0.0)	(0.0)	(0.5)	(1.0)	(1.5)	(1.5)	(1.5)	(1.8)	(4.2)	
Wind	0.2	0.2	3.6	10.9	23.8	25.2	25.2	24.9	25.2	(13.0)
	(0.0)	(0.0)	(1.4)	(3.8)	(7.8)	(7.9)	(7.1)	(6.7)	(6.4)	
Total	**223.4**	**245.1**	**262.4**	**287.3**	**306.6**	**319.1**	**353.8**	**368.8**	**393.2**	**(1.42)**

Advanced Scenario

	2000	2005	2010	2015	2020	2025	2030	2035	2040	Growth rate
Coal	205.4	215.2	144.6	94.0	63.0	52.8	40.0	48.8	95.9	(-1.89)
	(91.9)	(88.1)	(59.5)	(36.4)	(23.0)	(18.0)	(12.7)	(14.5)	(26.6)	
Gas	6.1	3.6	49.8	92.4	133.5	156.0	182.2	190.0	159.4	(8.50)
	(2.7)	(1.5)	(20.5)	(35.8)	(48.7)	(53.1)	(57.9)	(56.4)	(44.3)	
Hydro	11.8	11.8	12.1	12.5	12.8	13.2	13.6	14.1	14.5	(0.51)
	(5.3)	(4.8)	(5.0)	(4.8)	(4.7)	(4.5)	(4.3)	(4.2)	(4.0)	
Biomass	0.1	11.7	26.0	40.0	39.8	39.8	45.5	50.6	52.0	17.23)
	(0.0)	(4.8)	(10.7)	(15.5)	(14.5)	(13.6)	(14.5)	(15.0)	(14.5)	
Solar	0.0	1.5	6.2	6.2	6.5	7.2	7.9	8.4	12.7	(19.56)
	(0.0)	(0.6)	(2.5)	(2.4)	(2.4)	(2.4)	(2.5)	(2.5)	(3.5)	
Wind	0.2	0.6	4.3	13.1	18.6	24.6	25.2	25.2	25.2	(13.00)
	(0.0)	(0.2)	(1.8)	(5.1)	(6.8)	(8.4)	(8.0)	(7.5)	(7.0)	
Total	**223.4**	**244.4**	**243.0**	**258.1**	**274.2**	**293.6**	**314.3**	**337.1**	**359.7**	**(1.20)**

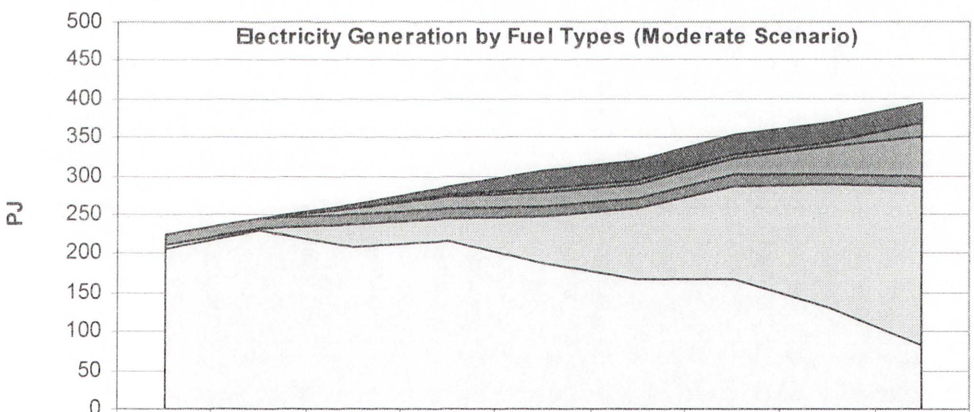
Source: Results obtained from energy model in this research.

Note: Values in parenthesis represent percentage shares of the total power generation.



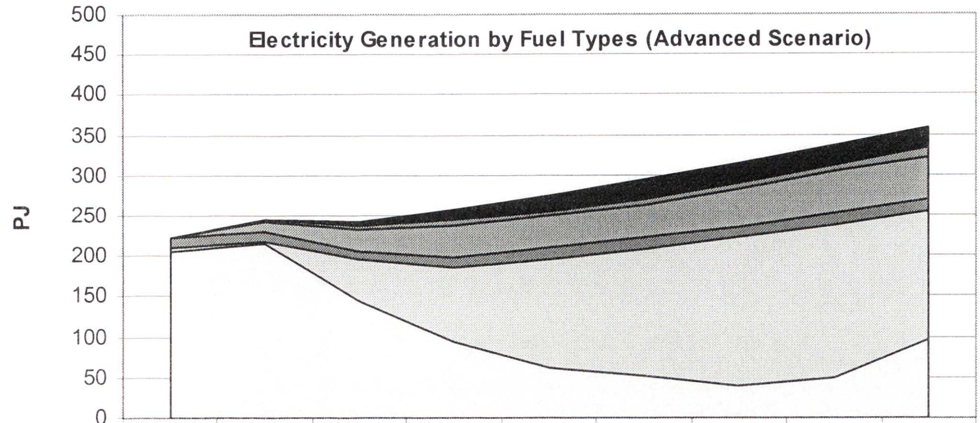
	2000	2005	2010	2015	2020	2025	2030	2035	2040
Wind	0.19	0.57	2.99	8.71	12.79	12.61	18.35	17.97	25.23
Solar	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.06	0.07
Biomass	0.28	0.3	8.6	8.48	8.32	8.32	8.32	8.04	14.6
Hydro	11.8	11.8	12.1	12.47	12.84	13.24	13.63	14.05	14.47
Gas	6.1	3.6	51.38	75.24	106.32	128.87	155.02	176.05	198.68
Coal	205.11	230.16	197.82	194.33	187.95	200.11	200.11	220.49	223.87

Figure C-30: Electricity Generation by Fuel Types: Base Scenario



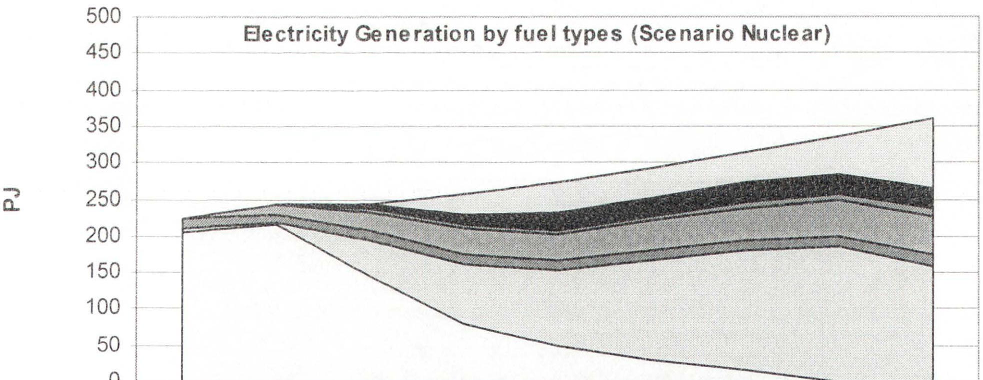
	2000	2005	2010	2015	2020	2025	2030	2035	2040
Wind	0.19	0.19	3.62	10.91	23.84	25.23	25.23	24.85	25.23
Solar	0.01	0.01	1.31	2.87	4.6	4.79	5.31	6.6	16.43
Biomass	0.09	0.12	8.18	14.95	17.55	17.85	22.53	34.57	52
Hydro	11.8	11.8	12.1	12.47	12.84	13.24	13.63	14.05	14.47
Gas	6.1	3.6	27.26	30.63	58.77	90.2	119.28	158.35	203.07
Coal	205.42	229.54	209.94	215.48	189	167.8	167.8	130.34	82.03

Figure C31: Electricity Generation by Fuels Types: Moderate Scenario



	2000	2005	2010	2015	2020	2025	2030	2035	2040
Wind	0.2	0.6	4.3	13.1	18.6	24.6	25.2	25.2	25.2
Solar	0.0	1.5	6.2	6.2	6.5	7.2	7.9	8.4	12.7
Biomass	0.1	11.7	26.0	40.0	39.8	39.8	45.5	50.6	52.0
Hydro	11.8	11.8	12.1	12.5	12.8	13.2	13.6	14.1	14.5
Gas	6.1	3.6	49.8	92.4	133.5	156.0	182.2	190.0	159.4
Coal	205.4	215.2	144.6	94.0	63.0	52.8	40.0	48.8	95.9

Figure C 32: Electricity Generation by Fuels Types: Advanced Scenario



	2000	2005	2010	2015	2020	2025	2030	2035	2040
Nuclear	0	0	0	29.25	40.82	41.01	42.48	52.84	95.82
Wind	-	0.6	4.3	13.1	25.2	25.2	25.2	25.2	25.2
Solar	0.0	1.5	6.2	6.2	6.8	7.3	7.9	8.4	12.7
Biomass	0.1	11.7	26.0	35.9	35.8	40.1	45.5	50.4	52.0
Hydro	11.8	11.8	12.1	12.5	12.8	13.2	13.6	14.1	14.5
Gas	6.1	3.6	49.8	80.9	104.8	136.5	162.7	185.3	159.4
Coal	205.4	215.2	144.6	80.2	48.0	30.3	17.0	0.0	0.0

Figure C 33: Electricity Generation by Fuels Types: Nuclear Scenario

Table C-4: Installed Capacities by Plant Types (GW)

Base Scenario

Plant types	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
Biomass Pl.	0.02	0.04	0.55	0.54	0.53	0.53	0.53	0.51	0.93
	(0.1)	(0.2)	(3.1)	(3.1)	(3.3)	(3.1)	(2.8)	(2.5)	(4.2)
Coal Therm.	11.52	11.52	10.92	8.92	6.6	5.01	5.01	3.69	3.69
	(71.3)	(70.0)	(61.3)	(51.8)	(41.0)	(28.9)	(26.8)	(18.4)	(16.8)
Coal, IGCC	0	0	0	0	0.02	2.04	2.04	4.07	4.19
	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(11.8)	(10.9)	(20.3)	(19.0)
Coal, IGCC (CCS)	0	0	0	0	0	0	0	0	0
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Gas, CC	0.16	0.46	1.39	2.48	3.42	4.21	5.13	6.2	7
	(1.0)	(2.8)	(7.8)	(14.4)	(21.3)	(24.3)	(27.5)	(30.9)	(31.8)
Gas, CC, CSM	0.1	0.1	0.42	0.42	0.33	0.33	0.33	0	0
	(0.6)	(0.6)	(2.4)	(2.4)	(2.1)	(1.9)	(1.8)	(0.0)	(0.0)
Oil, GT	0.15	0.1	0.1	0	0	0	0	0	0
	(0.9)	(0.6)	(0.6)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Hydro	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
	(2.6)	(2.6)	(2.4)	(2.4)	(2.6)	(2.4)	(2.2)	(2.1)	(1.9)
Snowy, Hydro	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76
	(23.3)	(22.9)	(21.1)	(21.8)	(23.4)	(21.7)	(20.1)	(18.7)	(17.1)
Solar PV	0	0	0	0	0	0.01	0.01	0.01	0.01
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.06)	(0.05)	(0.05)	(0.05)
Wind	0.02	0.05	0.24	0.69	1.01	1	1.45	1.42	2
	(0.1)	(0.3)	(1.3)	(4.0)	(6.3)	(5.8)	(7.8)	(7.1)	(9.1)
Total	**16.15**	**16.45**	**17.80**	**17.23**	**16.09**	**17.31**	**18.68**	**20.08**	**22.00**

Moderate Scenario

Plant types	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
Biomass Pl.	0.02	0.02	0.52	0.95	1.11	1.13	1.43	2.19	3.3
	(0.1)	(0.1)	(3.0)	(5.6)	(6.6)	(6.6)	(7.7)	(11.2)	(13.8)
Coal Therm.	11.52	11.52	10.92	8.92	6.6	2.02	2.02	0.7	0.7
	(71.3)	(71.0)	(63.6)	(52.3)	(39.2)	(11.8)	(10.8)	(3.6)	(2.9)
Coal, IGCC	0	0	0	0	0.06	3.9	3.9	3.9	3.9
	(0.0)	(0.0)	(0.0)	(0.0)	(0.4)	(22.7)	(20.9)	(19.9)	(16.4)
Coal, IGCC (CCS)	0	0	0	0	0	0	0	0	0
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Gas, CC	0.16	0.25	0.86	1.58	2.27	2.88	3.59	4.41	5.36
	(1.0)	(1.5)	(5.0)	(9.3)	(13.5)	(16.8)	(19.3)	(22.5)	(22.5)
Gas, CC, CSM	0.1	0.1	0.1	0.1	0	0.3	0.68	1.17	1.8
	(0.6)	(0.6)	(0.6)	(0.6)	(0.0)	(1.7)	(3.6)	(6.0)	(7.5)
Oil, GT	0.15	0.1	0.1	0	0	0	0	0	0
	(0.9)	(0.6)	(0.6)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Hydro	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
	(2.6)	(2.6)	(2.4)	(2.5)	(2.5)	(2.4)	(2.3)	(2.1)	(1.8)
Snowy, Hydro	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76
	(23.3)	(23.2)	(21.9)	(22.1)	(22.3)	(21.9)	(20.2)	(19.2)	(15.8)
Solar PV	0	0	0.21	0.46	0.73	0.76	0.84	1.05	2.61
	(0.0)	(0.0)	(1.2)	(2.7)	(4.3)	(4.4)	(4.5)	(5.4)	(10.9)
Wind	0.02	0.05	0.29	0.86	1.89	2	2	1.97	2
	(0.1)	(0.3)	(1.7)	(5.0)	(11.2)	(11.6)	(10.7)	(10.1)	(8.4)
Total	**16.15**	**16.22**	**17.18**	**17.05**	**16.84**	**17.17**	**18.64**	**19.57**	**23.85**

(Table continues in next page)

(…contd Table C-4)

Advanced Scenario

Plant types	2000	2005	2010	2015	2020	2025	2030	2035	2040
Biomass Pl.	0.03	0.74	1.65	2.54	2.53	2.53	2.89	3.21	3.3
	(0.2)	(4.3)	(8.3)	(11.8)	(11.8)	(14.3)	(14.9)	(16.4)	(16.1)
Coal Therm.	11.52	11.52	10.92	8.92	6.6	1.32	1.32	0	0
	(71.3)	(66.2)	(54.8)	(41.4)	(30.8)	(7.5)	(6.8)	(0.0)	(0.0)
Coal, IGCC	0	0	0	0	0	0	0	0	0
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Coal, IGCC (CCS)	0	0	0	0.66	0.95	1.06	1.3	2.1	3.38
	(0.0)	(0.0)	(0.0)	(3.1)	(4.4)	(6.0)	(6.7)	(10.8)	(16.5)
Gas, CC	0.16	0.46	1.39	2.48	3.42	4.21	5.13	5.68	5.01
	(1.0)	(2.6)	(7.0)	(11.5)	(15.9)	(23.8)	(26.5)	(29.1)	(24.5)
Gas, CC, CSM	0.1	0.1	0.37	0.77	1.28	1.28	1.28	1.01	0.61
	(0.6)	(0.6)	(1.9)	(3.6)	(6.0)	(7.2)	(6.6)	(5.2)	(3.0)
Oil, GT	0.15	0.1	0.1	0	0	0	0	0	0
	(0.9)	(0.6)	(0.5)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Hydro	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
	(2.6)	(2.4)	(2.1)	(1.9)	(2.0)	(2.4)	(2.2)	(2.2)	(2.0)
Snowy, Hydro	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76
	(23.3)	(21.6)	(18.9)	(17.4)	(17.5)	(21.3)	(19.4)	(19.3)	(18.4)
Solar PV	0	0.24	0.98	0.98	1.03	1.13	1.25	1.34	2.01
	(0.0)	(1.4)	(4.9)	(4.5)	(4.8)	(6.4)	(6.5)	(6.9)	(9.8)
Wind	0.02	0.05	0.34	1.04	1.47	1.95	2	2	2
	(0.1)	(0.3)	(1.7)	(4.8)	(6.8)	(11.0)	(10.3)	(10.2)	(9.8)
Total	**16.16**	**17.39**	**19.93**	**21.57**	**21.46**	**17.66**	**19.35**	**19.52**	**20.49**

Source: Results obtained from energy modeling in this research.

Notes: Values in parenthesis are percentage shares of the total.

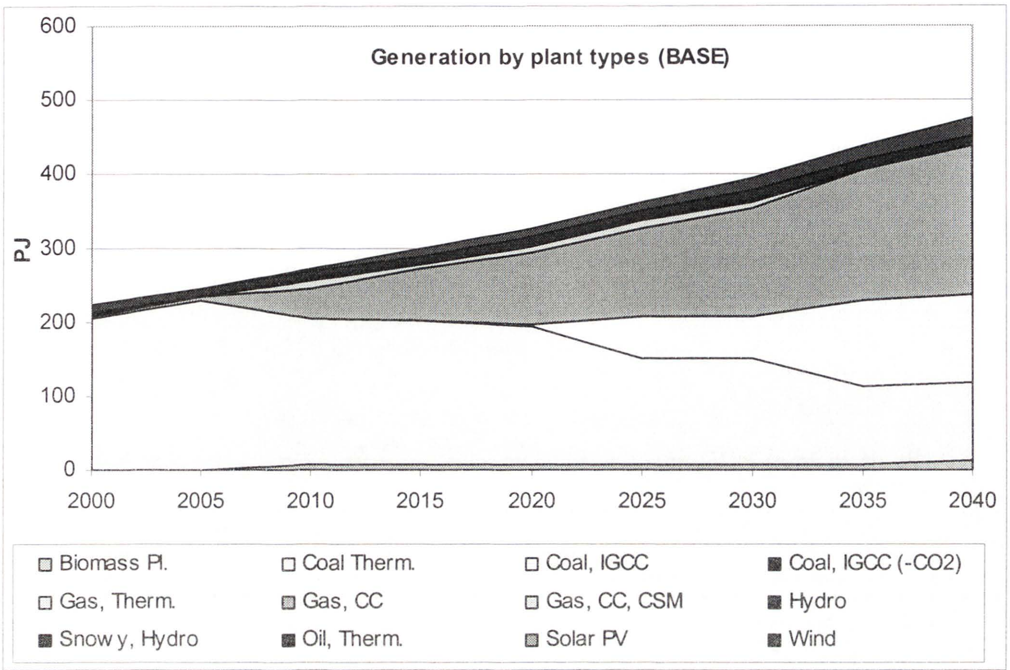


Figure C-34: Electricity Generation by Plant Types: Base Scenario

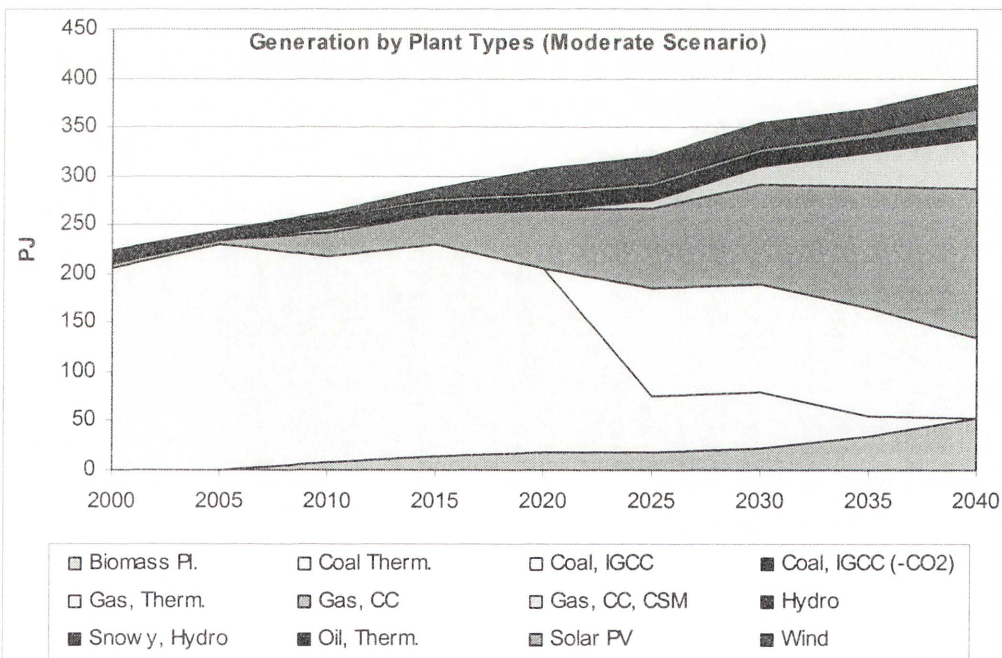


Figure C-35: Electricity Generation by Plant Types: Moderate Scenario

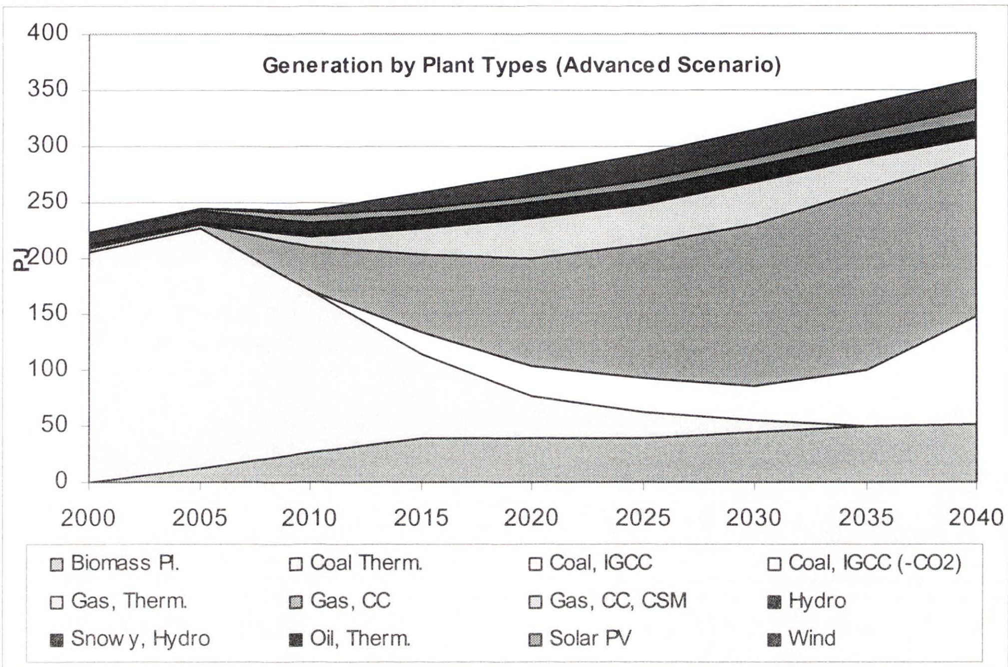
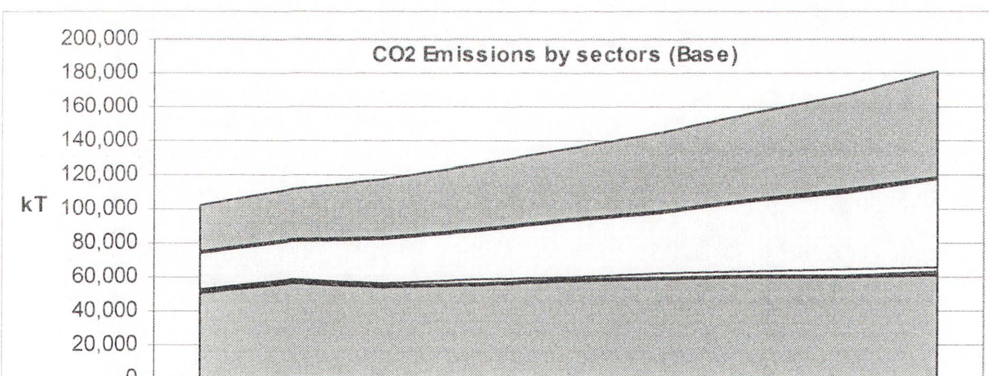


Figure C-36: Electricity Generation by Plant Types: Advanced Scenario



	2000	2005	2010	2015	2020	2025	2030	2035	2040
Transport	27588	30354	33371	37087	40928	45025	50074	55331	61639
Residential	953	1035	1125	1254	1390	1544	1711	1896	2094
Industrial	20983	21823	25623	28685	32091	35934	40282	45199	50764
Commerce	1435	1639	1781	1962	2166	2391	2641	2916	3220
Agriculture	870	909	963	1036	1115	1200	1292	1391	1497
Electricity	50680	56434	54213	55844	57300	58316	60170	60019	61619

Figure C-37: CO_2 emissions by Sectors: Base Scenario

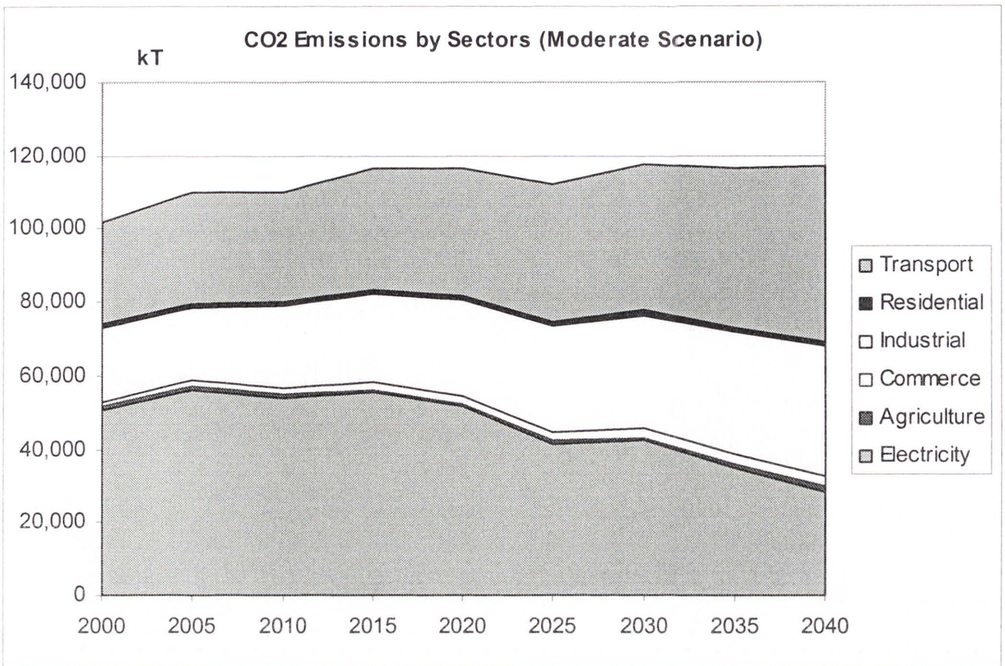


Figure C-38: CO_2 Emissions by Sectors: Moderate Scenario

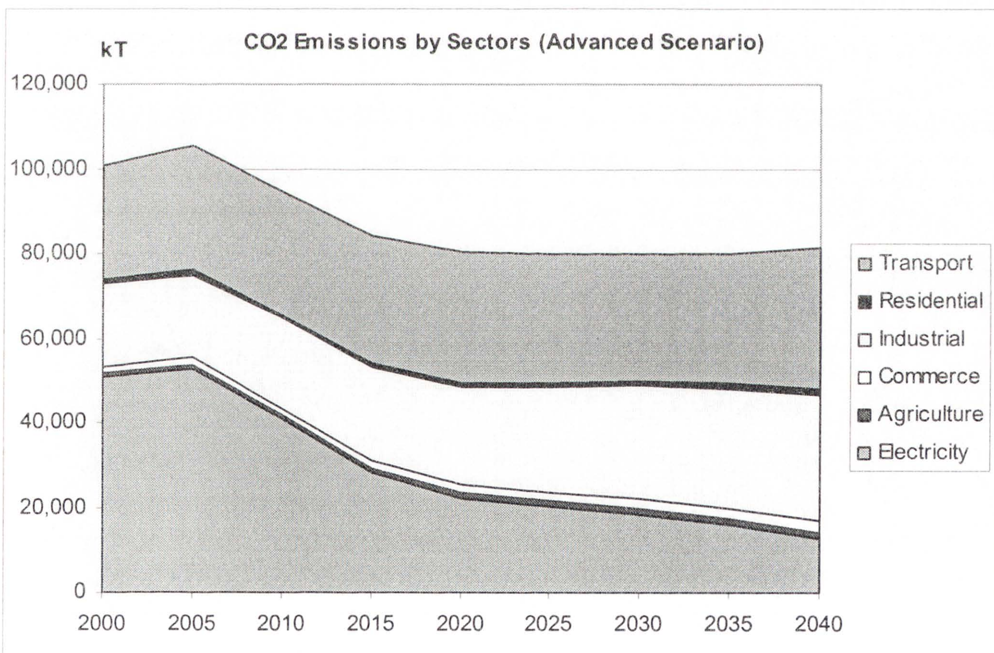


Figure C-39: CO_2 Emissions by Sectors: Advanced Scenario

Appendix D. Economic Impact Results

Table D-1: Aggregation of Sectors

1	**Agri., hunting and trapping**
	Sheep
	Grains
	Beef cattle
	Dairy cattle
	Pigs
	Poultry
	Other agriculture
	Services to agric.; hunting
2	**Forestry and fishing**
	Forestry and logging
	Commercial fishing
3	**Mining**
	Iron ores
	Non-ferrous metal ores
	Other mining
4	**Services to mining**
5	**Meat and diary prod.**
	Meat and meat products
	Dairy products
6	**Other food prod.**
	Fruit and vegetable products
	Oils and fats
	Flour and cereal foods
	Bakery products
	Confectionery
	Other food products
7	**Beverage and tobacco**
	Soft drinks, cordials, syrups
	Beer and malt
	Wine and spirits
	Tobacco products
8	**Textile, clothing, leather**
	Textile fibres, yarns etc
	Textile products
	Knitting mill products
	Clothing
	Footwear
	Leather and leather products
9	**Wood, paper, printing**
	Sawmill products
	Other wood products
	Paper bags and products
	Printing; services to printing
	Publishing; recorded media etc
10	**Basic chemical**
11	**Other chem., rubber, plastic**
	Paints
	Pharmaceuticals etc
	Soap and detergents
	Cosmetics and toiletries
	Other chemical products
	Rubber products
	Plastic products
12	**Non-metalic mineral**
	Glass and glass products
	Ceramic products
	Cement, lime and concrete slurry
	Plaster; other concrete products
	Non-metallic min. products nec
13	**Iron and steel**
14	**Basic non-ferrous**
15	**Fabricated metal**
	Structural metal products
	Sheet metal products
	Fabricated metal products
16	**Transport equip.**
	Motor vehicles and parts etc
	Ships and boats
	Railway equipment
	Aircraft
17	**Other equip., manufacturing**
	Scientific etc equipment
	Electronic equipment
	Household appliances
	Other electrical equipment
	Agri., mining etc machinery
	Other machinery and equipment
	Prefabricated buildings
	Furniture
	Other manufacturing
18	**Water and sewerage**
	Water, sewerage and drainage
19	**Construction**
	Residential building
	Other construction

(Table continues in next page)

Notes:
The sectors are aggregated following two digit level of ANZSIC classifications.

Table D-1: Aggregation of Sectors (.. contd)

20	**Trade and repair**
	Wholesale trade
	Retail trade
	Mechanical repairs
	Other repairs
21	**Accommodation, café**
22	**Road transport**
23	**Rail, pipeline**
24	**Water transport**
25	**Air and space travel**
26	**Services to transport**
27	**Communication**
28	**Finance and insurance**
	Banking
	Non-bank finance
	Insurance
	Services to finance etc
29	**Property and business**
	Ownership of dwellings
	Other property services
	Scientific research etc
	Legal, accounting etc services
	Other business services
30	**Govt. admin and defence**
	Government administration
	Defence
31	**Education, health, community**
	Education
	Health services
	Community services
32	**Personal and other services**
	Motion picture, radio etc
	Libraries, museums, arts
	Sport, gambling etc
	Personal services
	Other services
33	**Electricity**
34	**Gas**
35	**Petroleum**
36	**Coal; oil and gas**

Table D-2: Disaggregation of Energy Sectors

	Energy sectors
1	Electricity
2	Gas supply
3	Petroleum Product
4	Coal plant.
5	Gas Plant
6	Oil Plant.
7	Hydro
8	PV plant
9	Wind
10	Biomass Plant
11	Biomass
12	Coal
13	CNG
14	Methanol
15	Ethanol
16	Biodiesel

Note: The four energy sectors (Electricity, gas supply, petroleum products, and coal) as listed in the previous Table E-1 are disaggregated and expanded into 16 sectors. For example, the electricity sector now receives electricity generated by various power plants (such as, coal, gas, wind plants) and then supplies to other sectors.

Table D-3: Percentage Share of Purchases Made by Renewable Plants

Purchase made from sectors	PV Plant	Wind Plant	Biomass Plant
Fabricated metal	0.05	0.15	0.15
Other equipment	0.75	0.69	0.50
Construction	0.19	0.15	0.25
Finance and insurance	0.01	0.01	0.01
Property and business			0.09

Source: (CISS 2001; ETSU 1998; Gaffney 2005; IEA 2003; Redding Energy Management 1999)

Table D-4: Total Outputs in Base Scenario

	Non-energy Sectors	2000 (M$)	2020 (M$)	2040 (M$)
1	Agri., hunting and trapping	8,966	12,522	18,590
2	Forestry and fishing	897	1,253	1,860
3	Mining	1,989	3,269	5,687
4	Services to mining	413	678	1,180
5	Meat and diary prod.	5,288	11,064	16,004
6	Other food prod.	9,187	19,220	27,801
7	Beverage and tobacco	7,741	16,195	23,425
8	Textile, clothing, leather	5,315	17,724	25,631
9	Wood, paper, printing	14,899	40,296	58,288
10	Basic chemical	2,568	3,033	4,388
11	Other chem., rubber, plastic	13,916	16,432	23,773
12	Non-metalic mineral	5,100	7,581	10,966
13	Iron and steel	9,240	20,372	39,121
14	Basic non-ferrous	5,827	11,235	16,797
15	Fabricated metal	5,012	4,332	6,460
16	Transport equip.	7,272	10,740	15,533
17	Other equip., manufacturing	24,977	36,892	53,354
18	Water and sewerage	3,084	4,322	7,103
19	Construction	18,150	25,009	36,167
20	Trade and repair	47,645	72,677	119,448
21	Accomodation, café	13,661	20,838	34,247
22	Road transport	8,445	15,990	30,706
23	Rail, pipeline	2,025	2,417	4,196
24	Water transport	1,946	3,503	6,037
25	Air and space travel	7,108	14,616	25,819
26	Services to transport	7,378	2,070	2,288
27	Communication	10,624	16,205	26,634
28	Finance and insurance	25,657	39,137	64,323
29	Property and business	80,942	123,467	202,924
30	Govt. admin and defence	12,584	19,195	31,548
31	Education, health, community	27,522	41,982	68,999
32	Personal and other services	16,768	25,577	42,037
	Energy Sectors	**2000 (PJ)**	**2020 (PJ)**	**2040 (PJ)**
1	Electricity[1]	223	317	462
2	Gas supply	116	385	581
3	Petroleum Product	525	748	1124
4	Coal	710	3647	4635
5	Others[2]	58	95	145

Sources: Powell (2004); Dickson et al. (2003) and results obtained from the input–output model in this research.

Notes:

[1] Electricity includes eight different energy sectors related to power generation (such coal plant, gas plant, etc.).

[2] Others include energy sectors representing five different energy types such as biomass, methanol, ethanol, CNG, and biodiesel.

Table D-5: Total Outputs in Moderate Scenario

	Non-energy Sectors	2000 (M$)	2020 (M$)	2040 (M$)
1	Agri., hunting and trapping	8,966	12,823	19,113
2	Forestry and fishing	897	1,254	1,861
3	Mining	1,989	3,274	5,690
4	Services to mining	413	678	1,175
5	Meat and diary prod.	5,288	11,066	16,006
6	Other food prod.	9,187	19,230	27,811
7	Beverage and tobacco	7,741	16,196	23,426
8	Textile, clothing, leather	5,315	17,730	25,635
9	Wood, paper, printing	14,899	40,342	58,327
10	Basic chemical	2,568	3,037	4,394
11	Other chem., rubber, plastic	13,916	16,460	23,791
12	Non-metalic mineral	5,100	7,616	10,995
13	Iron and steel	9,240	20,465	39,200
14	Basic non-ferrous	5,827	11,265	16,822
15	Fabricated metal	5,012	4,572	6,767
16	Transport equip.	7,272	10,743	15,533
17	Other equip., manufacturing	24,977	37,781	54,766
18	Water and sewerage	3,084	4,321	7,096
19	Construction	18,150	25,330	36,663
20	Trade and repair	47,645	72,741	119,478
21	Accomodation, café	13,661	20,846	34,249
22	Road transport	8,445	16,015	30,720
23	Rail, pipeline	2,025	2,416	4,184
24	Water transport	1,946	3,490	6,028
25	Air and space travel	7,108	14,621	25,820
26	Services to transport	7,378	2,077	2,290
27	Communication	10,624	16,219	26,635
28	Finance and insurance	25,657	39,163	64,311
29	Property and business	80,942	123,650	203,093
30	Govt. admin and defence	12,584	19,196	31,547
31	Education, health, community	27,522	41,982	68,992
32	Personal and other services	16,768	25,581	42,035
	Energy Sectors	**2000 (PJ)**	**2020 (PJ)**	**2040 (PJ)**
1	Electricity[1]	223	298	385
2	Gas supply	116	336	656
3	Petroleum Product	525	631	890
4	Coal	710	3,582	4,098
5	Others[2]	58	207	394

Sources: Powell (2004); Dickson et al. (2003) and results obtained from the input–output model in this research.

Notes:

[1] Electricity includes eight different energy sectors related to power generation (such coal plant, gas plant, etc.).

[2] Others include five different energy sectors related to energy types such as biomass, methanol, ethanol, CNG, and biodiesel.

Table D-6: Total Outputs in Advanced Scenario

	Non-energy Sectors	2000 (M$)	2020 (M$)	2040 (M$)
1	Agri., hunting and trapping	8,966	12,838	19,110
2	Forestry and fishing	897	1,254	1,861
3	Mining	1,989	3,273	5,689
4	Services to mining	413	673	1,174
5	Meat and diary prod.	5,288	11,065	16,005
6	Other food prod.	9,187	19,229	27,811
7	Beverage and tobacco	7,741	16,195	23,425
8	Textile, clothing, leather	5,315	17,728	25,634
9	Wood, paper, printing	14,899	40,330	58,311
10	Basic chemical	2,568	3,024	4,363
11	Other chem., rubber, plastic	13,916	16,441	23,770
12	Non-metalic mineral	5,100	7,608	10,987
13	Iron and steel	9,240	20,454	39,189
14	Basic non-ferrous	5,827	11,262	16,819
15	Fabricated metal	5,012	4,549	6,738
16	Transport equip.	7,272	10,738	15,530
17	Other equip., manufacturing	24,977	37,733	54,577
18	Water and sewerage	3,084	4,314	7,087
19	Construction	18,150	25,321	36,613
20	Trade and repair	47,645	72,692	119,429
21	Accomodation, café	13,661	20,834	34,234
22	Road transport	8,445	15,996	30,698
23	Rail, pipeline	2,025	2,405	4,175
24	Water transport	1,946	3,474	5,992
25	Air and space travel	7,108	14,613	25,810
26	Services to transport	7,378	2,061	2,270
27	Communication	10,624	16,205	26,622
28	Finance and insurance	25,657	39,113	64,268
29	Property and business	80,942	123,605	203,006
30	Govt. admin and defence	12,584	19,193	31,543
31	Education, health, community	27,522	41,974	68,990
32	Personal and other services	16,768	25,574	42,031
	Energy Sectors	**2000 (PJ)**	**2020 (PJ)**	**2040 (PJ)**
1	Electricity[1]	223	268	354
2	Gas supply	116	472	566
3	Petroleum Product	525	605	746
4	Coal	710	3177	4057
5	Others[2]	58	237	338

Sources: Powell (2004); Dickson et al. (2003) and results obtained from the input–output model in this research

Notes:

[1] Electricity includes eight different energy sectors related to power generation (such coal plant, gas plant, etc.).

[2] Others include five different energy sectors related to energy types such as biomass, methanol, ethanol, CNG, and biodiesel.

Table D-7: Household Income in Base Scenario (thousand $)

	Non-energy Sectors	2000	2020	2040
1	Agri., hunting and trapping	2,781	3,892	5,777
2	Forestry and fishing	211	295	437
3	Mining	209	345	599
4	Services to mining	63	104	180
5	Meat and diary prod.	525	1,099	1,589
6	Other food prod.	941	1,969	2,848
7	Beverage and tobacco	378	791	1,144
8	Textile, clothing, leather	753	2,511	3,630
9	Wood, paper, printing	2,334	6,320	9,138
10	Basic chemical	145	171	247
11	Other chem., rubber, plastic	1,122	1,327	1,918
12	Non-metalic mineral	636	950	1,372
13	Iron and steel	806	1,785	3,420
14	Basic non-ferrous	415	801	1,197
15	Fabricated metal	818	742	1,103
16	Transport equip.	636	940	1,360
17	Other equip., manufacturing	2,169	3,262	4,717
18	Water and sewerage	318	445	732
19	Construction	6,329	8,818	12,752
20	Trade and repair	14,534	22,189	36,453
21	Accomodation, café	2,858	4,362	7,168
22	Road transport	2,057	3,901	7,484
23	Rail, pipeline	627	750	1,300
24	Water transport	163	293	504
25	Air and space travel	1,483	3,051	5,387
26	Services to transport	1,093	308	340
27	Communication	2,568	3,921	6,441
28	Finance and insurance	6,905	10,544	17,321
29	Property and business	13,007	19,875	32,645
30	Govt. admin and defence	4,469	6,818	11,206
31	Education, health, community	15,085	23,011	37,819
32	Personal and other services	5,736	8,752	14,382
	Energy Sectors			
1	Electricity[1]	731	997	1450
2	Gas supply	73	213	321
3	Petroleum Product	153	214	322
4	Coal	833	1029	1308
5	Others[2]	-	-	-

Source: Powell (2004); Dickson et al. (2003) and results obtained from the input-output model in this researchand this research.

Notes:

[1] Electricity includes eight different energy sectors related to power generation (such coal plant, gas plant, etc.).

[2] Others include five different energy sectors related to energy types such as biomass, methanol, ethanol, CNG, and biodiesel.

Table D-8: Household Income in Moderate Scenario (thousand $)

	Non-energy Sectors	2000	2020	2040
1	Agri., hunting and trapping	2,781	3,977	5,927
2	Forestry and fishing	211	295	437
3	Mining	209	345	599
4	Services to mining	63	104	180
5	Meat and diary prod.	525	1,099	1,589
6	Other food prod.	941	1,970	2,849
7	Beverage and tobacco	378	791	1,144
8	Textile, clothing, leather	753	2,511	3,630
9	Wood, paper, printing	2,334	6,321	9,138
10	Basic chemical	145	171	247
11	Other chem., rubber, plastic	1,122	1,327	1,918
12	Non-metalic mineral	636	950	1,371
13	Iron and steel	806	1,786	3,421
14	Basic non-ferrous	415	802	1,197
15	Fabricated metal	818	746	1,105
16	Transport equip.	636	940	1,360
17	Other equip., manufacturing	2,169	3,281	4,756
18	Water and sewerage	318	445	731
19	Construction	6,329	8,833	12,786
20	Trade and repair	14,534	22,189	36,446
21	Accomodation, café	2,858	4,362	7,166
22	Road transport	2,057	3,901	7,484
23	Rail, pipeline	627	748	1,295
24	Water transport	163	292	504
25	Air and space travel	1,483	3,050	5,386
26	Services to transport	1,093	308	339
27	Communication	2,568	3,921	6,438
28	Finance and insurance	6,905	10,539	17,307
29	Property and business	13,007	19,871	32,637
30	Govt. admin and defence	4,469	6,818	11,205
31	Education, health, community	15,085	23,010	37,815
32	Personal and other services	5,736	8,751	14,380
	Energy Sectors			
1	Electricity[1]	731	935	1,209
2	Gas supply	73	186	363
3	Petroleum Product	153	181	255
4	Coal	833	1,011	1,156
5	Others[2]	-	19	35

Source: Powell (2004) and this research.

Notes:

[1] Electricity includes eight different energy sectors related to power generation (such coal plant, gas plant, etc.).

[2] Others include five different energy sectors related to energy types such as biomass, methanol, ethanol, CNG, and biodiesel.

Table D-9: Household Income in Advanced Scenario (thousand $)

	Non-energy Sectors	2000	2020	2040
1	Agri., hunting and trapping	2,781	3,981	5,927
2	Forestry and fishing	211	295	437
3	Mining	209	345	599
4	Services to mining	63	103	179
5	Meat and diary prod.	525	1,099	1,589
6	Other food prod.	941	1,970	2,849
7	Beverage and tobacco	378	791	1,144
8	Textile, clothing, leather	753	2,511	3,630
9	Wood, paper, printing	2,334	6,319	9,136
10	Basic chemical	145	170	246
11	Other chem., rubber, plastic	1,122	1,326	1,917
12	Non-metalic mineral	636	949	1,370
13	Iron and steel	806	1,785	3,420
14	Basic non-ferrous	415	801	1,197
15	Fabricated metal	818	743	1,100
16	Transport equip.	636	940	1,359
17	Other equip., manufacturing	2,169	3,277	4,739
18	Water and sewerage	318	444	730
19	Construction	6,329	8,830	12,768
20	Trade and repair	14,534	22,174	36,431
21	Accomodation, café	2,858	4,359	7,163
22	Road transport	2,057	3,897	7,478
23	Rail, pipeline	627	745	1,292
24	Water transport	163	290	501
25	Air and space travel	1,483	3,048	5,384
26	Services to transport	1,093	305	336
27	Communication	2,568	3,917	6,435
28	Finance and insurance	6,905	10,526	17,295
29	Property and business	13,007	19,863	32,623
30	Govt. admin and defence	4,469	6,817	11,203
31	Education, health, community	15,085	23,006	37,813
32	Personal and other services	5,736	8,749	14,379
	Energy Sectors			
1	Electricity[1]	731	842	1112
2	Gas supply	73	261	313
3	Petroleum Product	153	173	213
4	Coal	833	896	1145
5	Others[2]	-	11	218

Source: Powell (2004) and this research.

Notes:

[1] Electricity includes eight different energy sectors related to power generation (such coal plant, gas plant, etc.).

[2] Others include five different energy sectors related to energy types such as biomass, methanol, ethanol, CNG, and biodiesel.

Table D-10: Employment in Base Scenario (persons)

	Non-energy Sectors	**2000**	**2020**	**2040**
1	Agri., hunting and trapping	90,876	127,198	188,825
2	Forestry and fishing	5,254	7,342	10,897
3	Mining	4,107	6,761	11,751
4	Services to mining	1,029	1,692	2,942
5	Meat and diary prod.	15,200	31,804	46,001
6	Other food prod.	24,850	51,995	75,206
7	Beverage and tobacco	9,073	18,983	27,458
8	Textile, clothing, leather	20,203	67,386	97,437
9	Wood, paper, printing	64,168	173,729	251,187
10	Basic chemical	3,231	3,824	5,527
11	Other chem., rubber, plastic	28,324	33,496	48,431
12	Non-metalic mineral	14,096	21,047	30,398
13	Iron and steel	18,713	41,415	79,363
14	Basic non-ferrous	8,409	16,249	24,269
15	Fabricated metal	22,742	20,632	30,649
16	Transport equip.	18,105	26,750	38,679
17	Other equip., manufacturing	72,874	109,607	158,496
18	Water and sewerage	7,011	9,834	16,155
19	Construction	194,118	270,427	391,093
20	Trade and repair	556,080	848,971	1,394,745
21	Accomodation, café	145,580	222,182	365,062
22	Road transport	61,875	117,324	225,105
23	Rail, pipeline	13,176	15,753	27,316
24	Water transport	3,254	5,860	10,097
25	Air and space travel	21,815	44,881	79,257
26	Services to transport	29,380	8,290	9,145
27	Communication	55,996	85,503	140,447
28	Finance and insurance	135,190	206,445	339,131
29	Property and business	340,816	520,765	855,354
30	Govt. admin and defence	104,806	159,888	262,764
31	Education, health, community	454,698	693,611	1,139,956
32	Personal and other services	169,385	258,437	424,694
	Energy Sectors			
1	Electricity[1]	12,635	12,175	12,511
2	Gas supply	1,189	2,454	2,615
3	Petroleum Product	2,405	2,386	2,532
4	Coal	9,959	8,693	7,809
5	Others[2]	-	-	-

Source: Powell (2004) and this research.

Notes:

[1] Electricity includes eight different energy sectors related to power generation (such coal plant, gas plant, etc.).

[2] Others include five different energy sectors related to energy types such as biomass, methanol, ethanol, CNG, and biodiesel.

Table D-11: Employment in Moderate Scenario (persons)

	Non-energy Sectors	2000	2020	2040
1	Agri., hunting and trapping	90,876	129,967	193,724
2	Forestry and fishing	5,254	7,345	10,899
3	Mining	4,107	6,761	11,751
4	Services to mining	1,029	1,690	2,929
5	Meat and diary prod.	15,200	31,808	46,005
6	Other food prod.	24,850	52,017	75,231
7	Beverage and tobacco	9,073	18,983	27,458
8	Textile, clothing, leather	20,203	67,389	97,438
9	Wood, paper, printing	64,168	173,746	251,200
10	Basic chemical	3,231	3,821	5,528
11	Other chem., rubber, plastic	28,324	33,503	48,425
12	Non-metalic mineral	14,096	21,052	30,391
13	Iron and steel	18,713	41,445	79,387
14	Basic non-ferrous	8,409	16,256	24,276
15	Fabricated metal	22,742	20,744	30,701
16	Transport equip.	18,105	26,748	38,674
17	Other equip., manufacturing	72,874	110,232	159,791
18	Water and sewerage	7,011	9,823	16,134
19	Construction	194,118	270,907	392,117
20	Trade and repair	556,080	848,980	1,394,464
21	Accomodation, café	145,580	222,150	364,985
22	Road transport	61,875	117,344	225,086
23	Rail, pipeline	13,176	15,718	27,216
24	Water transport	3,254	5,836	10,081
25	Air and space travel	21,815	44,872	79,239
26	Services to transport	29,380	8,270	9,119
27	Communication	55,996	85,487	140,391
28	Finance and insurance	135,190	206,352	338,858
29	Property and business	340,816	520,642	855,145
30	Govt. admin and defence	104,806	159,879	262,746
31	Education, health, community	454,698	693,585	1,139,823
32	Personal and other services	169,385	258,419	424,634
	Energy Sectors			
1	Electricity[1]	12,635	11,422	10,436
2	Gas supply	1,189	2,143	2,953
3	Petroleum Product	2,405	2,012	2,005
4	Coal	9,959	8,538	6,904
5	Others[2]	-	219	279

Source: Powell (2004) and this research.

Notes:

[1] Electricity includes eight different energy sectors related to power generation (such coal plant, gas plant, etc.).

[2] Others include five different energy sectors related to energy types such as biomass, methanol, ethanol, CNG, and biodiesel.

Table D-12: Employment in Advanced Scenario (persons)

	Non-energy Sectors	2000	2020	2040
1	Agri., hunting and trapping	90,876	130,121	193,698
2	Forestry and fishing	5,254	7,342	10,897
3	Mining	4,107	6,758	11,747
4	Services to mining	1,029	1,677	2,928
5	Meat and diary prod.	15,200	31,805	46,003
6	Other food prod.	24,850	52,016	75,229
7	Beverage and tobacco	9,073	18,982	27,457
8	Textile, clothing, leather	20,203	67,383	97,432
9	Wood, paper, printing	64,168	173,691	251,133
10	Basic chemical	3,231	3,805	5,489
11	Other chem., rubber, plastic	28,324	33,465	48,382
12	Non-metalic mineral	14,096	21,030	30,369
13	Iron and steel	18,713	41,423	79,366
14	Basic non-ferrous	8,409	16,252	24,271
15	Fabricated metal	22,742	20,640	30,573
16	Transport equip.	18,105	26,737	38,668
17	Other equip., manufacturing	72,874	110,092	159,238
18	Water and sewerage	7,011	9,808	16,112
19	Construction	194,118	270,813	391,581
20	Trade and repair	556,080	848,407	1,393,888
21	Accomodation, café	145,580	222,029	364,834
22	Road transport	61,875	117,202	224,922
23	Rail, pipeline	13,176	15,644	27,157
24	Water transport	3,254	5,809	10,020
25	Air and space travel	21,815	44,848	79,209
26	Services to transport	29,380	8,209	9,040
27	Communication	55,996	85,413	140,321
28	Finance and insurance	135,190	206,087	338,635
29	Property and business	340,816	520,454	854,779
30	Govt. admin and defence	104,806	159,849	262,710
31	Education, health, community	454,698	693,450	1,139,776
32	Personal and other services	169,385	258,349	424,590
	Energy Sectors			
1	Electricity[1]	12,635	10,275	9,597
2	Gas supply	1,189	3,004	2,547
3	Petroleum Product	2,405	1,929	1,680
4	Coal	9,959	7,573	6,836
5	Others[2]	-	129	171

Source: Powell (2004) and this research.

Notes:

[1] Electricity includes eight different energy sectors related to power generation (such coal plant, gas plant, etc.).

[2] Others include five different energy sectors related to energy types such as biomass, methanol, ethanol, CNG, and biodiesel.

Table D-13: Direct Requirement Coefficient Matrix 'A' in 2000

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
	Agri., hui	Forestry a	Mining	Services t	Meat and	Other foo	Beverage	Textile, c	Wood, pa	Basic che	Other che	Non-meta	Iron and s	Basic nor	Fabricate	Transport	Other equ	Water an	Construct	Trade an	Accomod	Road trar	Rail, pipe	Water tra	Air and sp	Services t
1 Agri., hunting and trapping	0.08561	0.00426	0.00001	0.00000	0.33582	0.05897	0.05258	0.03445	0.00002	0.00110	0.00315	0.00000	0.00000	0.00000	0.00002	0.00000	0.00037	0.00007	0.00044	0.00032	0.00254	0.00001	0.00004	0.00000	0.00000	0.00010
2 Forestry and fishing	0.00172	0.05597	0.00056	0.00001	0.00000	0.00025	0.00000	0.00000	0.00987	0.00042	0.00014	0.00000	0.00000	0.00022	0.00000	0.00000	0.00015	0.00001	0.00011	0.00068	0.00822	0.00005	0.00210	0.00000	0.00000	0.00002
3 Mining	0.00031	0.00049	0.01276	0.00692	0.00005	0.00206	0.00002	0.00003	0.00005	0.00388	0.00022	0.02488	0.00499	0.07012	0.00112	0.00008	0.00090	0.00170	0.00496	0.00012	0.00043	0.00012	0.00022	0.00022	0.00005	0.00011
4 Services to mining	0.00000	0.00000	0.05693	0.01135	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5 Meat and diary prod.	0.00363	0.00057	0.00002	0.00006	0.05119	0.02803	0.00020	0.00787	0.00000	0.00369	0.00162	0.00000	0.00001	0.00000	0.00004	0.00008	0.00004	0.00023	0.00010	0.00629	0.02707	0.00005	0.00041	0.00016	0.00006	0.00004
6 Other food prod.	0.02686	0.02519	0.00023	0.00117	0.00937	0.11036	0.00567	0.00007	0.00001	0.00310	0.00365	0.00001	0.00001	0.00001	0.00006	0.00003	0.00004	0.00017	0.00003	0.00349	0.01913	0.00008	0.00020	0.00010	0.00013	0.00007
7 Beverage and tobacco	0.00074	0.00140	0.00029	0.00031	0.00124	0.00240	0.04318	0.00054	0.00035	0.00058	0.00015	0.00011	0.00008	0.00003	0.00007	0.00014	0.00008	0.00044	0.00010	0.00044	0.05758	0.00018	0.00033	0.00013	0.00027	0.00020
8 Textile, clothing, leather	0.00148	0.00638	0.00107	0.00032	0.00141	0.00374	0.00100	0.09185	0.00164	0.00161	0.00232	0.00107	0.00190	0.00106	0.00650	0.00131	0.00210	0.00033	0.00205	0.00194	0.00727	0.00108	0.00594	0.00182	0.00045	0.00075
9 Wood, paper, printing	0.00451	0.00946	0.00340	0.01103	0.01451	0.01440	0.01880	0.01079	0.15911	0.00598	0.01348	0.00984	0.00388	0.00236	0.01301	0.00614	0.01628	0.00485	0.04974	0.04228	0.01988	0.00507	0.01308	0.00572	0.00358	0.00661
10 Basic chemical	0.02601	0.00092	0.01015	0.00492	0.00028	0.00090	0.00041	0.00521	0.00629	0.12956	0.04014	0.00481	0.00217	0.00523	0.00836	0.00342	0.00217	0.01421	0.00071	0.00010	0.00034	0.00013	0.00180	0.00007	0.00001	0.00005
11 Other chem., rubber, plastic	0.02603	0.02033	0.02043	0.00645	0.02709	0.02794	0.01655	0.01035	0.03509	0.03772	0.14418	0.01195	0.01441	0.00420	0.01371	0.02007	0.01260	0.02602	0.01402	0.00461	0.01025	0.00993	0.00398	0.00445	0.00411	0.00246
12 Non-metalic mineral	0.00001	0.01816	0.00245	0.00401	0.00002	0.00340	0.01430	0.00024	0.00133	0.00026	0.00178	0.12435	0.01014	0.00604	0.01013	0.00322	0.00317	0.01060	0.08481	0.00264	0.00102	0.00046	0.00009	0.00000	0.00001	0.00009
13 Iron and steel	0.00001	0.00051	0.00357	0.03127	0.00001	0.00003	0.00002	0.00058	0.00045	0.00024	0.00027	0.00632	0.19321	0.00370	0.14104	0.05034	0.04077	0.00246	0.01607	0.00064	0.00004	0.00007	0.00401	0.00013	0.00002	0.00005
14 Basic non-ferrous	0.00001	0.00008	0.00091	0.00022	0.00027	0.00024	0.00005	0.00073	0.00169	0.00118	0.00252	0.00169	0.02496	0.23173	0.04695	0.00837	0.01063	0.00035	0.00055	0.00021	0.00028	0.00003	0.00034	0.00001	0.00001	0.00004
15 Fabricated metal	0.00170	0.02602	0.01431	0.02336	0.00320	0.00532	0.02023	0.00306	0.00655	0.00343	0.00364	0.01380	0.00576	0.00128	0.08745	0.01526	0.01215	0.01805	0.04919	0.00325	0.00180	0.00540	0.05654	0.02499	0.00190	0.00308
16 Transport equip.	0.00083	0.00714	0.00328	0.00386	0.00007	0.00022	0.00009	0.00007	0.00020	0.00023	0.00016	0.00090	0.00063	0.00006	0.00036	0.17012	0.00124	0.00016	0.00029	0.00545	0.00120	0.01017	0.06990	0.01681	0.04074	0.00470
17 Other equip., manufacturing	0.00567	0.12059	0.07076	0.03059	0.00192	0.00469	0.00231	0.00630	0.00957	0.00310	0.00562	0.00494	0.00772	0.01293	0.01985	0.03795	0.07374	0.01225	0.05749	0.00836	0.02012	0.00880	0.02173	0.00308	0.00069	0.01557
18 Water and sewerage	0.00347	0.00046	0.00117	0.00015	0.00426	0.00207	0.00227	0.00141	0.00121	0.00194	0.00176	0.00134	0.00276	0.00104	0.00129	0.00096	0.00073	0.06793	0.00069	0.00057	0.00400	0.00003	0.00003	0.00238	0.00001	0.00002
19 Construction	0.00315	0.00047	0.00879	0.00148	0.00003	0.00006	0.00008	0.00008	0.00016	0.00013	0.00009	0.00020	0.00013	0.00004	0.00009	0.00014	0.00004	0.00035	0.00070	0.00073	0.00418	0.00038	0.01115	0.00062	0.00029	0.00130
20 Trade and repair	0.04741	0.13089	0.04798	0.04159	0.04544	0.06916	0.03454	0.05310	0.04555	0.04121	0.04327	0.02417	0.01561	0.01179	0.03723	0.02389	0.03442	0.04035	0.05268	0.04030	0.03553	0.08451	0.03934	0.01187	0.03158	0.02869
21 Accomodation, café	0.00773	0.00438	0.00422	0.03521	0.00072	0.00817	0.05037	0.00705	0.01021	0.00538	0.01029	0.00586	0.00358	0.00288	0.00964	0.00288	0.00291	0.00373	0.00429	0.01063	0.00275	0.00877	0.00268	0.00445	0.00713	0.00820
22 Road transport	0.02634	0.01046	0.02582	0.01221	0.07415	0.03630	0.02947	0.01038	0.01737	0.01204	0.01010	0.09553	0.01952	0.01019	0.01227	0.00301	0.00602	0.00410	0.01600	0.01718	0.00553	0.10522	0.00503	0.00142	0.00974	0.01425
23 Rail, pipeline	0.00349	0.00034	0.00182	0.00038	0.00299	0.00620	0.00309	0.00268	0.00101	0.00272	0.00271	0.01806	0.01380	0.01452	0.00168	0.00040	0.00093	0.00026	0.00132	0.00120	0.00138	0.00011	0.00093	0.00006	0.00157	0.00147
24 Water transport	0.00013	0.00128	0.00016	0.02467	0.00005	0.00097	0.00021	0.00083	0.00057	0.00059	0.00031	0.00096	0.00192	0.00472	0.00098	0.00008	0.00024	0.00003	0.00005	0.00027	0.00006	0.00008	0.00008	0.22948	0.00021	0.00005
25 Air and space travel	0.00238	0.00158	0.00465	0.01402	0.00033	0.00555	0.00201	0.00970	0.00921	0.00261	0.00432	0.00189	0.00174	0.00167	0.00369	0.00230	0.00352	0.00539	0.00069	0.01368	0.00205	0.00163	0.00043	0.00313	0.06096	0.00353
26 Services to transport	0.00697	0.00263	0.00152	0.00325	0.00471	0.01327	0.01318	0.00528	0.01491	0.01211	0.01004	0.00539	0.00611	0.00267	0.01130	0.00336	0.00114	0.00108	0.00334	0.02908	0.00520	0.01448	0.00225	0.13998	0.07006	0.03303
27 Communication	0.00909	0.00634	0.01427	0.01239	0.00601	0.00638	0.00410	0.00553	0.01025	0.00273	0.00517	0.00790	0.00303	0.00156	0.00853	0.00370	0.00585	0.00984	0.00295	0.03952	0.02092	0.03392	0.00819	0.00821	0.00916	0.02311
28 Finance and insurance	0.02571	0.02685	0.01841	0.02341	0.00663	0.02119	0.01175	0.00640	0.01113	0.00460	0.00772	0.00751	0.00614	0.00890	0.00817	0.00592	0.00366	0.06138	0.01794	0.03406	0.02818	0.01613	0.03368	0.01420	0.01499	0.01156
29 Property and business	0.02821	0.01508	0.02295	0.20642	0.03166	0.03429	0.03879	0.03511	0.06373	0.02994	0.07618	0.02976	0.06511	0.03419	0.04280	0.03403	0.02163	0.04407	0.08751	0.18904	0.11146	0.09321	0.10582	0.06679	0.07554	0.09111
30 Govt. admin and defence	0.00083	0.00256	0.00535	0.00140	0.00105	0.00220	0.00112	0.00038	0.00402	0.00120	0.00053	0.00066	0.00159	0.00029	0.00137	0.00129	0.00032	0.00221	0.00122	0.00173	0.00047	0.01565	0.00278	0.00045	0.00013	0.00868
31 Education, health, communi	0.00199	0.00060	0.00063	0.00143	0.00264	0.00087	0.00183	0.00371	0.00178	0.00065	0.00371	0.00074	0.00063	0.00047	0.00064	0.00087	0.00047	0.00087	0.00039	0.00080	0.00096	0.00084	0.00123	0.00101	0.00069	0.00248
32 Personal and other services	0.00061	0.00234	0.00095	0.00270	0.00225	0.00330	0.00460	0.00369	0.00601	0.00126	0.00472	0.00209	0.00050	0.00032	0.00284	0.00329	0.00141	0.00153	0.00056	0.00906	0.01401	0.00246	0.00108	0.00103	0.00131	0.00169
33 Electricity	0.00396	0.00227	0.01951	0.00101	0.01395	0.00784	0.00407	0.00452	0.00721	0.01103	0.00552	0.01526	0.02280	0.04340	0.00673	0.00444	0.00489	0.02126	0.00118	0.00476	0.01566	0.00237	0.02439	0.00065	0.00127	0.01195
34 Gas	0.00008	0.00003	0.00036	0.00000	0.00080	0.00078	0.00034	0.00036	0.00031	0.00163	0.00015	0.00498	0.00110	0.00212	0.00024	0.00017	0.00008	0.00000	0.00000	0.00032	0.00086	0.00001	0.00013	0.00000	0.00002	0.00005
35 Petroleum, coal prod.	0.01625	0.04253	0.03375	0.03680	0.00123	0.00171	0.00122	0.00045	0.00246	0.01344	0.00199	0.00468	0.01375	0.00741	0.00247	0.00037	0.00040	0.01006	0.00467	0.00503	0.00588	0.02980	0.00870	0.01846	0.10716	0.00600
36 Coal, oil and gas	0.00025	0.00023	0.00071	0.00028	0.00038	0.00102	0.00049	0.00075	0.00051	0.00803	0.00024	0.00513	0.00907	0.00453	0.00024	0.00016	0.00011	0.00004	0.00003	0.00037	0.00086	0.00021	0.00028	0.00012	0.00002	0.00006

Source: Direct requirement coefficients are computed in this research as described in Section 5-2 and 5-4 (Chapter 5)

(contd ...)

Table D-13: Direct Requirement Coefficient Matrix 'A' in 2000 (..contd)

		27	28	29	30	31	32	33	34	35	36
		Commun	Finance a	Property :	Govt. adr	Educatioı	Personal :	Electricity	Gas supp	Petroleun	Coal pl.
1	Agri., hunting an	0.00000	0.00006	0.00033	0.00079	0.00021	0.00334	0.00001	0.00000	0.00000	0.00000
2	Forestry and fish	0.00004	0.00005	0.00002	0.00002	0.00003	0.00013	0.00003	0.00000	0.00000	0.00026
3	Mining	0.00006	0.00004	0.00023	0.00042	0.00016	0.00128	0.00014	0.00020	0.00039	0.00079
4	Services to minir	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00718
5	Meat and diary p	0.00038	0.00022	0.00029	0.00010	0.00049	0.00059	0.00003	0.00005	0.00001	0.00001
6	Other food prod.	0.00024	0.00030	0.00021	0.00079	0.00041	0.00300	0.00004	0.00005	0.00003	0.00012
7	Beverage and tol	0.00054	0.00132	0.00020	0.00154	0.00029	0.00029	0.00011	0.00019	0.00008	0.00011
8	Textile, clothing,	0.00127	0.00018	0.00085	0.00275	0.00386	0.00461	0.00026	0.00025	0.00018	0.00045
9	Wood, paper, pri	0.02790	0.00826	0.01542	0.03712	0.00960	0.01906	0.00200	0.00306	0.00198	0.00230
10	Basic chemical	0.00019	0.00005	0.00074	0.00048	0.00111	0.00261	0.00105	0.00611	0.01114	0.00146
11	Other chem., rub	0.01005	0.00027	0.00546	0.01153	0.00890	0.01411	0.00464	0.01022	0.00430	0.01129
12	Non-metalic min	0.00007	0.00014	0.00172	0.00177	0.00060	0.00136	0.00651	0.00015	0.00000	0.00057
13	Iron and steel	0.00021	0.00001	0.00127	0.00075	0.00009	0.00040	0.00087	0.00063	0.00000	0.00340
14	Basic non-ferrou	0.00051	0.00001	0.00016	0.00189	0.00005	0.00031	0.00002	0.00008	0.00001	0.00004
15	Fabricated metal	0.00547	0.00021	0.00351	0.00438	0.00170	0.00433	0.00229	0.00405	0.00048	0.00478
16	Transport equip.	0.00217	0.00005	0.00022	0.01344	0.00022	0.00045	0.00030	0.00011	0.00011	0.00177
17	Other equip., ma	0.04407	0.00287	0.00919	0.01798	0.01705	0.02982	0.02149	0.00297	0.00054	0.02956
18	Water and sewer	0.00001	0.00033	0.00778	0.00254	0.00289	0.00222	0.00723	0.00715	0.00154	0.00040
19	Construction	0.00010	0.00026	0.00802	0.00870	0.00031	0.00023	0.00077	0.00121	0.00003	0.00090
20	Trade and repair	0.06680	0.00601	0.01243	0.01598	0.02271	0.02778	0.02486	0.01979	0.00786	0.02186
21	Accomodation, c	0.01264	0.01074	0.01115	0.01440	0.00355	0.01048	0.00468	0.00186	0.00356	0.00254
22	Road transport	0.01216	0.00039	0.00230	0.00525	0.00336	0.00894	0.00257	0.00116	0.00642	0.00933
23	Rail, pipeline	0.00177	0.00051	0.00101	0.00046	0.00054	0.00046	0.00614	0.01973	0.00110	0.01330
24	Water transport	0.00087	0.00000	0.00027	0.00107	0.00028	0.00038	0.00062	0.00081	0.01300	0.00046
25	Air and space tra	0.01757	0.00467	0.00714	0.01715	0.00295	0.00649	0.00300	0.00392	0.00229	0.00233
26	Services to trans	0.00855	0.00514	0.00953	0.01042	0.00180	0.00199	0.00046	0.00021	0.00532	0.00518
27	Communication	0.01884	0.01797	0.01563	0.03520	0.01388	0.02372	0.00837	0.00836	0.00103	0.00315
28	Finance and insu	0.01472	0.18195	0.03811	0.03751	0.01359	0.02174	0.03876	0.02897	0.00191	0.01396
29	Property and bus	0.05172	0.06332	0.17643	0.08778	0.04058	0.08665	0.02823	0.18487	0.00595	0.02212
30	Govt. admin and	0.00387	0.00065	0.00179	0.04783	0.00144	0.00090	0.00035	0.00013	0.00132	0.00160
31	Education, health	0.00130	0.00333	0.00169	0.00323	0.01041	0.00318	0.00134	0.00120	0.00042	0.00915
32	Personal and oth	0.00200	0.00445	0.01136	0.00605	0.00645	0.06115	0.00145	0.00154	0.00057	0.00483
33	Electricity	0.00459	0.00151	0.00479	0.00627	0.00584	0.00564	0.06872	0.00202	0.00495	0.01105
34	Gas	0.00018	0.00001	0.00006	0.00009	0.00020	0.00004	0.00499	0.01511	0.00034	0.00003
35	Petroleum, coal	0.00586	0.00013	0.00246	0.00278	0.00124	0.00323	0.00627	0.00188	0.03586	0.01311
36	Coal, oil and gas	0.00052	0.00003	0.00007	0.00043	0.00030	0.00015	0.04237	0.00000	0.18269	0.00481

Table D-14: Direct Requirement Coefficient Matrix 'A' for Base scenario in 2020

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
	Agri., hui	Forestry a	Mining	Services t	Meat and	Other foo	Beverage	Textile, c	Wood, pa	Basic che	Other che	Non-meta	Iron and s	Basic nor	Fabricate	Transport	Other equ	Water and	Construct	Trade and	Accomod	Road trar	Rail, pipe	Water tra	Air and sp	Services t
1 Agri., hunting and trapping	0.08562	0.00426	0.00001	0.00000	0.33581	0.05897	0.05258	0.03446	0.00002	0.00091	0.00260	0.00000	0.00000	0.00000	0.00002	0.00000	0.00037	0.00007	0.00044	0.00032	0.00254	0.00000	0.00004	0.00000	0.00000	0.00010
2 Forestry and fishing	0.00172	0.05598	0.00056	0.00001	0.00000	0.00025	0.00000	0.00000	0.00932	0.00035	0.00012	0.00000	0.00000	0.00020	0.00000	0.00000	0.00015	0.00001	0.00011	0.00068	0.00822	0.00004	0.00210	0.00000	0.00000	0.00002
3 Mining	0.00031	0.00049	0.01275	0.00691	0.00005	0.00206	0.00002	0.00003	0.00005	0.00320	0.00018	0.02486	0.00499	0.06319	0.00112	0.00008	0.00090	0.00170	0.00496	0.00012	0.00043	0.00010	0.00022	0.00022	0.00005	0.00011
4 Services to mining	0.00000	0.00000	0.05694	0.01135	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5 Meat and diary prod.	0.00363	0.00057	0.00002	0.00006	0.05119	0.02803	0.00020	0.00787	0.00000	0.00305	0.00133	0.00000	0.00001	0.00000	0.00004	0.00008	0.00004	0.00023	0.00010	0.00629	0.02707	0.00004	0.00041	0.00016	0.00006	0.00004
6 Other food prod.	0.02686	0.02519	0.00023	0.00117	0.00937	0.11036	0.00567	0.00007	0.00001	0.00256	0.00301	0.00001	0.00001	0.00001	0.00006	0.00003	0.00004	0.00017	0.00003	0.00349	0.01913	0.00006	0.00020	0.00010	0.00013	0.00007
7 Beverage and tobacco	0.00074	0.00140	0.00029	0.00031	0.00124	0.00240	0.04318	0.00054	0.00033	0.00048	0.00013	0.00011	0.00008	0.00003	0.00007	0.00014	0.00008	0.00044	0.00010	0.00044	0.05759	0.00015	0.00033	0.00013	0.00027	0.00020
8 Textile, clothing, leather	0.00148	0.00638	0.00107	0.00032	0.00141	0.00374	0.00100	0.09185	0.00155	0.00133	0.00191	0.00107	0.00190	0.00096	0.00650	0.00131	0.00210	0.00033	0.00205	0.00194	0.00727	0.00091	0.00594	0.00182	0.00045	0.00075
9 Wood, paper, printing	0.00451	0.00946	0.00340	0.01103	0.01451	0.01440	0.01880	0.01079	0.15019	0.00494	0.01113	0.00984	0.00388	0.00213	0.01301	0.00614	0.01629	0.00485	0.04974	0.04228	0.01988	0.00426	0.01308	0.00572	0.00358	0.00661
10 Basic chemical	0.02601	0.00092	0.01015	0.00492	0.00028	0.00090	0.00041	0.00520	0.00594	0.10694	0.03313	0.00481	0.00217	0.00472	0.00836	0.00342	0.00217	0.01421	0.00071	0.00010	0.00034	0.00011	0.00180	0.00007	0.00001	0.00005
11 Other chem., rubber, plastic	0.02603	0.02033	0.02044	0.00645	0.02709	0.02794	0.01655	0.01035	0.03312	0.03114	0.11899	0.01195	0.01442	0.00379	0.01370	0.02007	0.01260	0.02602	0.01402	0.00461	0.01025	0.00836	0.00398	0.00445	0.00411	0.00246
12 Non-metalic mineral	0.00001	0.01815	0.00245	0.00401	0.00002	0.00340	0.01430	0.00024	0.00126	0.00021	0.00147	0.12437	0.01015	0.00545	0.01013	0.00322	0.00317	0.01060	0.08481	0.00263	0.00102	0.00039	0.00009	0.00000	0.00001	0.00009
13 Iron and steel	0.00001	0.00051	0.00357	0.03126	0.00001	0.00003	0.00002	0.00058	0.00042	0.00020	0.00022	0.00632	0.19323	0.00333	0.14095	0.05033	0.04077	0.00246	0.01606	0.00064	0.00004	0.00006	0.00401	0.00013	0.00002	0.00005
14 Basic non-ferrous	0.00001	0.00008	0.00091	0.00022	0.00027	0.00024	0.00005	0.00073	0.00160	0.00098	0.00208	0.00169	0.02494	0.20879	0.04687	0.00836	0.01062	0.00035	0.00055	0.00021	0.00028	0.00002	0.00034	0.00001	0.00001	0.00004
15 Fabricated metal	0.00170	0.02601	0.01431	0.02336	0.00320	0.00531	0.02022	0.00306	0.00618	0.00283	0.00300	0.01380	0.00576	0.00115	0.08742	0.01527	0.01216	0.01805	0.04919	0.00325	0.00180	0.00454	0.05654	0.02499	0.00190	0.00308
16 Transport equip.	0.00083	0.00714	0.00328	0.00386	0.00007	0.00022	0.00009	0.00007	0.00018	0.00019	0.00013	0.00090	0.00063	0.00005	0.00036	0.17014	0.00124	0.00016	0.00029	0.00545	0.00120	0.00857	0.06990	0.01681	0.04074	0.00470
17 Other equip., manufacturing	0.00566	0.12058	0.07077	0.03058	0.00192	0.00469	0.00231	0.00630	0.00903	0.00256	0.00464	0.00495	0.00773	0.01167	0.01984	0.03796	0.07376	0.01225	0.05749	0.00836	0.02012	0.00741	0.02172	0.00308	0.00069	0.01557
18 Water and sewerage	0.00347	0.00046	0.00117	0.00015	0.00426	0.00207	0.00227	0.00141	0.00114	0.00160	0.00145	0.00134	0.00276	0.00094	0.00129	0.00096	0.00073	0.06793	0.00069	0.00057	0.00400	0.00002	0.00003	0.00238	0.00001	0.00002
19 Construction	0.00315	0.00047	0.00879	0.00148	0.00003	0.00006	0.00008	0.00008	0.00015	0.00011	0.00008	0.00020	0.00013	0.00004	0.00009	0.00014	0.00004	0.00035	0.00070	0.00073	0.00419	0.00032	0.01115	0.00062	0.00029	0.00130
20 Trade and repair	0.04741	0.13090	0.04799	0.04159	0.04543	0.06916	0.03453	0.05310	0.04300	0.03401	0.03571	0.02418	0.01562	0.01064	0.03723	0.02389	0.03443	0.04035	0.05269	0.04030	0.03553	0.07115	0.03934	0.01187	0.03158	0.02869
21 Accomodation, café	0.00773	0.00438	0.00422	0.03522	0.00072	0.00817	0.05037	0.00705	0.00964	0.00444	0.00849	0.00586	0.00358	0.00260	0.00964	0.00288	0.00291	0.00373	0.00429	0.01063	0.00275	0.00738	0.00268	0.00445	0.00713	0.00820
22 Road transport	0.02634	0.01046	0.02582	0.01221	0.07414	0.03629	0.02947	0.01038	0.01640	0.00994	0.00833	0.09555	0.01953	0.00919	0.01227	0.00301	0.00602	0.00410	0.01600	0.01717	0.00553	0.08859	0.00503	0.00142	0.00974	0.01425
23 Rail, pipeline	0.00349	0.00034	0.00182	0.00038	0.00299	0.00620	0.00309	0.00267	0.00095	0.00224	0.00224	0.01806	0.01380	0.01310	0.00168	0.00040	0.00093	0.00026	0.00132	0.00120	0.00138	0.00009	0.00093	0.00006	0.00157	0.00147
24 Water transport	0.00013	0.00128	0.00016	0.02467	0.00005	0.00097	0.00021	0.00083	0.00054	0.00048	0.00025	0.00096	0.00192	0.00426	0.00098	0.00008	0.00024	0.00003	0.00005	0.00027	0.00006	0.00007	0.00008	0.22945	0.00021	0.00005
25 Air and space travel	0.00238	0.00158	0.00465	0.01402	0.00033	0.00555	0.00201	0.00970	0.00869	0.00216	0.00357	0.00189	0.00174	0.00151	0.00369	0.00230	0.00352	0.00539	0.00069	0.01368	0.00205	0.00138	0.00043	0.00313	0.06096	0.00353
26 Services to transport	0.00697	0.00263	0.00152	0.00325	0.00471	0.01327	0.01318	0.00528	0.01407	0.01000	0.00828	0.00540	0.00611	0.00241	0.01130	0.00336	0.00114	0.00108	0.00334	0.02908	0.00520	0.01219	0.00225	0.13997	0.07006	0.03303
27 Communication	0.00909	0.00634	0.01428	0.01239	0.00601	0.00638	0.00410	0.00553	0.00967	0.00225	0.00427	0.00790	0.00303	0.00140	0.00853	0.00370	0.00585	0.00984	0.00295	0.03952	0.02092	0.02856	0.00819	0.00821	0.00916	0.02311
28 Finance and insurance	0.02571	0.02686	0.01842	0.02341	0.00663	0.02119	0.01175	0.00640	0.01050	0.00379	0.00638	0.00751	0.00614	0.00803	0.00817	0.00592	0.00367	0.06138	0.01794	0.03407	0.02819	0.01358	0.03368	0.01420	0.01500	0.01156
29 Property and business	0.02821	0.01508	0.02296	0.20643	0.03166	0.03429	0.03879	0.03511	0.06015	0.02472	0.06288	0.02977	0.06515	0.03085	0.04280	0.03404	0.02164	0.04407	0.08752	0.18905	0.11147	0.07848	0.10582	0.06678	0.07554	0.09111
30 Govt. admin and defence	0.00083	0.00256	0.00535	0.00140	0.00105	0.00220	0.00112	0.00038	0.00379	0.00099	0.00044	0.00066	0.00159	0.00026	0.00137	0.00129	0.00032	0.00221	0.00122	0.00173	0.00047	0.01317	0.00278	0.00045	0.00013	0.00868
31 Education, health, communi	0.00199	0.00060	0.00063	0.00143	0.00264	0.00087	0.00183	0.00371	0.00168	0.00053	0.00306	0.00074	0.00063	0.00042	0.00064	0.00087	0.00047	0.00087	0.00039	0.00080	0.00096	0.00070	0.00123	0.00101	0.00069	0.00248
32 Personal and other services	0.00061	0.00234	0.00095	0.00270	0.00225	0.00330	0.00460	0.00369	0.00567	0.00104	0.00389	0.00209	0.00050	0.00029	0.00284	0.00329	0.00141	0.00153	0.00056	0.00906	0.01401	0.00207	0.00108	0.00103	0.00131	0.00169
33 Electricity	3.0E-07	3.0E-07	1.1E-06	1.1E-06	2.4E-07	2.4E-07	2.4E-07	1.2E-07	2.7E-07	2.9E-06	4.0E-08	8.9E-07	4.9E-07	5.3E-06	3.8E-07	1.5E-07	1.5E-07	7.0E-07	5.2E-09	1.8E-07	1.8E-07	0.0E+00	1.5E-06	0.0E+00	0.0E+00	0.0E+00
34 Gas supply	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.9E-07	2.9E-07	2.9E-07	7.5E-07	0.0E+00	1.1E-05	1.6E-07	2.3E-06	4.7E-07	1.6E-06	3.3E-07	3.1E-08	3.1E-08	2.8E-08	7.6E-09	4.7E-08	4.7E-08	0.0E+00	4.1E-07	0.0E+00	0.0E+00	4.8E-07
35 Petroleum Product	1.0E-06	1.0E-06	1.2E-06	1.2E-06	4.9E-08	4.9E-08	4.9E-08	1.3E-07	6.7E-09	1.1E-05	1.6E-07	4.9E-08	0.0E+00	6.3E-07	9.4E-08	1.7E-08	1.7E-08	8.0E-08	4.4E-07	4.1E-08	4.1E-08	1.3E-05	3.9E-06	8.8E-06	1.2E-05	0.0E+00
36 Coal pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
37 GasPl	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
40 PV pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
41 Wind	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
42 Biomass Plant	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
43 Biomass	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.4E-07	1.4E-07	1.4E-07	3.8E-07	3.9E-07	0.0E+00	0.0E+00	5.5E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
44 Coal	0.0E+00	0.0E+00	3.3E-09	3.3E-09	1.1E-07	1.1E-07	1.1E-07	2.8E-07	1.5E-07	0.0E+00	0.0E+00	1.5E-06	1.0E-05	1.6E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.5E-09	4.5E-09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
45 CNG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
46 Methanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
47 Ethanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Source: Direct requirement coefficients are computed in this research as described in Section 5-2 and 5-4 (Chapter 5)

(contd ...)

Table D-14: Direct Requirement Coefficient Matrix 'A' for Base Scenario in 2020 (..contd)

	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
	Commun	Finance a	Property	Govt. adr	Educatioi	Personal	Electricit	Gas supp	Petroleun	Coal pl.	GasPl	Oil Pl.	Hydro	PV pl.	Wind	Biomass Pla	Biomass	Coal	CNG	Methanol	Ethanol	Biodiesel
1 Agri., hunting an	0.00000	0.00006	0.00033	0.00079	0.00021	0.00334	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	250.00	0.00	0.00	0.00	7758.62	16244.31
2 Forestry and fish	0.00004	0.00005	0.00002	0.00002	0.00003	0.00013	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.00	0.00
3 Mining	0.00006	0.00004	0.00023	0.00042	0.00016	0.00128	3.51	0.32	6.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.37	6.37	6.37	6.37	6.37
4 Services to minir	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.41	0.00	0.00	0.00	0.00
5 Meat and diary p	0.00038	0.00022	0.00029	0.00010	0.00049	0.00059	0.85	0.08	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.22	0.22	0.22	0.22
6 Other food prod.	0.00024	0.00030	0.00021	0.00079	0.00041	0.00300	1.05	0.08	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.44	0.44	0.44	0.44
7 Beverage and tol	0.00054	0.00132	0.00020	0.00154	0.00029	0.00029	2.67	0.30	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	1.34	1.34	1.34	1.34
8 Textile, clothing,	0.00127	0.00018	0.00085	0.00275	0.00386	0.00461	6.41	0.39	2.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.78	2.88	2.88	2.88	2.88
9 Wood, paper, pri	0.02790	0.00826	0.01542	0.03712	0.00960	0.01906	49.88	4.82	32.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.97	32.42	32.42	32.42	32.42
10 Basic chemical	0.00019	0.00005	0.00074	0.00048	0.00111	0.00261	26.21	9.62	184.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.52	182.07	182.07	182.07	182.07
11 Other chem., rub	0.01005	0.00027	0.00546	0.01153	0.00890	0.01411	115.49	16.09	71.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.52	70.35	70.35	70.35	70.35
12 Non-metalic min	0.00007	0.00014	0.00172	0.00177	0.00060	0.00136	162.04	0.23	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.06	0.06	0.06	0.06
13 Iron and steel	0.00021	0.00001	0.00127	0.00075	0.00009	0.00040	21.55	0.99	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.87	0.04	0.04	0.04	0.04
14 Basic non-ferrou	0.00051	0.00001	0.00016	0.00189	0.00005	0.00031	0.49	0.12	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.13	0.13	0.13	0.13
15 Fabricated metal	0.00547	0.00021	0.00351	0.00437	0.00170	0.00433	57.11	6.37	7.94	531.84	396.07	0.00	0.00	2253.36	1478.77	1267.51	0.00	8.26	7.86	7.86	7.86	7.86
16 Transport equip.	0.00217	0.00005	0.00022	0.01344	0.00022	0.00045	7.49	0.18	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.06	1.78	1.78	1.78	1.78
17 Other equip., ma	0.04407	0.00287	0.00918	0.01798	0.01704	0.02982	535.22	4.67	8.92	1772.79	1320.24	0.00	0.00	33800.39	6802.33	4225.05	0.00	51.08	8.82	8.82	8.82	8.82
18 Water and sewer	0.00001	0.00033	0.00778	0.00254	0.00289	0.00222	180.01	11.26	25.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	25.24	25.24	25.24	25.24
19 Construction	0.00010	0.00026	0.00802	0.00870	0.00031	0.00023	19.17	1.91	0.51	886.40	660.12	0.00	0.00	8562.77	1478.77	2112.52	0.00	1.55	0.51	0.51	0.51	0.51
20 Trade and repair	0.06681	0.00601	0.01243	0.01598	0.02271	0.02778	619.13	31.15	129.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	37.78	128.43	128.43	128.43	128.43
21 Accomodation, c	0.01264	0.01074	0.01115	0.01440	0.00355	0.01048	116.59	2.93	58.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.38	58.20	58.20	58.20	58.20
22 Road transport	0.01216	0.00039	0.00230	0.00525	0.00336	0.00894	63.97	1.82	106.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.12	104.95	104.95	104.95	104.95
23 Rail, pipeline	0.00177	0.00051	0.00101	0.00046	0.00054	0.00046	152.85	31.04	18.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.98	17.92	17.92	17.92	17.92
24 Water transport	0.00087	0.00000	0.00027	0.00107	0.00028	0.00038	15.52	1.28	214.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.79	212.50	212.50	212.50	212.50
25 Air and space tra	0.01757	0.00467	0.00714	0.01715	0.00296	0.00649	74.62	6.16	37.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.04	37.43	37.43	37.43	37.43
26 Services to trans	0.00855	0.00514	0.00953	0.01042	0.00180	0.00199	11.48	0.32	88.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.95	87.05	87.05	87.05	87.05
27 Communication	0.01884	0.01796	0.01563	0.03520	0.01388	0.02372	208.47	13.16	16.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.44	16.77	16.77	16.77	16.77
28 Finance and insu	0.01472	0.18195	0.03812	0.03752	0.01359	0.02175	965.52	45.60	31.51	35.46	26.40	0.00	0.00	450.67	95.58	84.50	0.00	24.13	31.17	31.17	31.17	31.17
29 Property and bus	0.05173	0.06331	0.17643	0.08779	0.04058	0.08665	703.23	291.02	98.39	319.10	237.64	0.00	0.00	0.00	0.00	760.51	0.00	38.23	97.32	97.32	97.32	97.32
30 Govt. admin and	0.00387	0.00065	0.00179	0.04784	0.00144	0.00090	8.84	0.21	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.77	21.66	21.66	21.66	21.66
31 Education, health	0.00130	0.00333	0.00169	0.00323	0.01041	0.00319	33.45	1.89	7.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.82	6.95	6.95	6.95	6.95
32 Personal and oth	0.00200	0.00445	0.01136	0.00605	0.00645	0.06115	36.15	2.42	9.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.34	9.32	9.32	9.32	9.32
33 Electricity	1.8E-07	1.8E-07	1.8E-07	1.8E-07	1.8E-07	1.8E-07	0.0E+00	0.0E+00	8.1E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.5E-03	9.5E-04	9.5E-04	9.5E-04	9.5E-04
34 Gas supply	4.7E-08	4.7E-08	4.7E-08	4.7E-08	4.7E-08	4.7E-08	0.0E+00	0.0E+00	3.1E-03	0.0E+00	2.1E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	1.0E+00	0.0E+00	0.0E+00
35 Petroleum Produ	4.1E-08	4.1E-08	4.1E-08	4.1E-08	4.1E-08	4.1E-08	0.0E+00	0.0E+00	3.1E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.7E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00
36 Coal pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.9E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
37 GasPl	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.1E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
40 PV pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	9.5E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
41 Wind	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.0E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
42 Biomass Plant	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.6E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
43 Biomass	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
44 Coal	4.5E-09	4.5E-09	4.5E-09	4.5E-09	4.5E-09	4.5E-09	0.0E+00	0.0E+00	0.0E+00	2.7E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.4E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00
45 CNG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
46 Methanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
47 Ethanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Table D-15: Total Requirement Coefficient Matrix '(I-A)-1' for Base scenario in 2020

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
	Agri., hui	Forestry a	Mining	Services t	Meat and	Other foo	Beverage	Textile, c	Wood, pa	Basic che	Other che	Non-meta	Iron and s	Basic nor	Fabricate	Transpon	Other equ	Water an	Construct	Trade and	Accomod	Road trar	Rail, pipe	Water tra	Air and sp	Services t
1 Agri., hunting and trapping	1.09864	0.00897	0.00089	0.00160	0.39043	0.08641	0.06254	0.04584	0.00124	0.00350	0.00491	0.00073	0.00065	0.00069	0.00118	0.00068	0.00100	0.00092	0.00141	0.00412	0.01961	0.00090	0.00120	0.00082	0.00067	0.00072
2 Forestry and fishing	0.00236	1.05987	0.00095	0.00075	0.00121	0.00101	0.00101	0.00048	0.01192	0.00072	0.00055	0.00044	0.00031	0.00059	0.00051	0.00028	0.00054	0.00030	0.00101	0.00158	0.00927	0.00043	0.00265	0.00034	0.00030	0.00033
3 Mining	0.00076	0.00190	1.01414	0.00812	0.00056	0.00279	0.00086	0.00033	0.00057	0.00410	0.00078	0.02938	0.00944	0.08163	0.00745	0.00198	0.00263	0.00262	0.00839	0.00056	0.00091	0.00048	0.00122	0.00085	0.00039	0.00033
4 Services to mining	0.00005	0.00012	0.05843	1.01198	0.00004	0.00017	0.00006	0.00003	0.00004	0.00030	0.00005	0.00174	0.00072	0.00487	0.00048	0.00013	0.00017	0.00017	0.00050	0.00004	0.00006	0.00003	0.00011	0.00005	0.00003	0.00002
5 Meat and diary prod.	0.00629	0.00322	0.00100	0.00203	1.05722	0.03496	0.00291	0.01029	0.00114	0.00450	0.00271	0.00083	0.00064	0.00060	0.00115	0.00073	0.00064	0.00110	0.00110	0.00791	0.03025	0.00124	0.00131	0.00096	0.00089	0.00078
6 Other food prod.	0.03416	0.03144	0.00114	0.00285	0.02383	1.12807	0.01028	0.00229	0.00130	0.00405	0.00474	0.00069	0.00055	0.00053	0.00092	0.00058	0.00054	0.00093	0.00085	0.00504	0.02376	0.00098	0.00094	0.00075	0.00080	0.00065
7 Beverage and tobacco	0.00189	0.00255	0.00117	0.00320	0.00248	0.00406	1.04881	0.00149	0.00154	0.00128	0.00110	0.00099	0.00074	0.00069	0.00121	0.00071	0.00054	0.00123	0.00097	0.00184	0.06119	0.00123	0.00111	0.00112	0.00123	0.00109
8 Textile, clothing, leather	0.00270	0.00909	0.00228	0.00199	0.00331	0.00583	0.00255	1.10189	0.00296	0.00239	0.00309	0.00241	0.00343	0.00225	0.00916	0.00268	0.00317	0.00120	0.00381	0.00327	0.00918	0.00201	0.00796	0.00369	0.00130	0.00150
9 Wood, paper, printing	0.01499	0.02903	0.01566	0.02802	0.03088	0.03118	0.03267	0.02187	1.18630	0.01430	0.02203	0.02160	0.01298	0.01097	0.02670	0.01599	0.02623	0.01465	0.07125	0.06308	0.03618	0.01765	0.02751	0.01865	0.01309	0.01587
10 Basic chemical	0.03436	0.00436	0.01431	0.00803	0.01471	0.00627	0.00438	0.00905	0.01034	1.12502	0.04317	0.00855	0.00515	0.00937	0.01309	0.00692	0.00423	0.01927	0.00425	0.00190	0.00273	0.00432	0.00516	0.00400	0.00366	0.00086
11 Other chem., rubber, plastic	0.03835	0.03340	0.02992	0.01592	0.05036	0.04443	0.02711	0.01815	0.04852	0.04481	1.14020	0.02172	0.02481	0.01254	0.02570	0.03260	0.01948	0.03599	0.02558	0.01297	0.02048	0.01600	0.01312	0.01279	0.01041	0.00647
12 Non-metalic mineral	0.00151	0.02449	0.00584	0.00769	0.00154	0.00573	0.01849	0.00120	0.00315	0.00207	0.00283	1.14372	0.01590	0.01105	0.01664	0.00663	0.00547	0.01439	0.09940	0.00471	0.00412	0.00171	0.00411	0.00163	0.00111	0.00113
13 Iron and steel	0.00215	0.01563	0.01610	0.04853	0.00268	0.00321	0.00575	0.00287	0.00406	0.00318	0.00233	0.01479	1.24377	0.01110	0.19514	0.08248	0.05819	0.00909	0.03536	0.00436	0.00363	0.00358	0.02496	0.00993	0.00511	0.00302
14 Basic non-ferrous	0.00085	0.00512	0.00449	0.00469	0.00144	0.00158	0.00223	0.00181	0.00369	0.00244	0.00375	0.00476	0.04044	1.26582	0.07213	0.01766	0.01756	0.00273	0.00683	0.00152	0.00161	0.00121	0.00688	0.00330	0.00132	0.00101
15 Fabricated metal	0.00503	0.03553	0.02208	0.03190	0.00793	0.01020	0.02619	0.00584	0.01082	0.00818	0.00584	0.02241	0.01212	0.01141	1.10086	0.02313	0.01641	0.02389	0.05939	0.00741	0.00701	0.00816	0.06789	0.03881	0.00530	0.00560
16 Transport equip.	0.00297	0.01162	0.00637	0.00783	0.00321	0.00331	0.00206	0.00206	0.00237	0.00192	0.00157	0.00546	0.00379	0.00325	0.00272	1.20625	0.00279	0.00157	0.00244	0.00906	0.00302	0.01316	0.08566	0.02859	0.05392	0.00723
17 Other equip., manufacturing	0.01334	0.14656	0.08897	0.04707	0.01235	0.01384	0.01047	0.01252	0.01964	0.01668	0.01066	0.01793	0.01953	0.04536	0.03455	0.05514	1.08467	0.02149	0.07115	0.01971	0.03097	0.01624	0.03913	0.01450	0.00884	0.02276
18 Water and sewerage	0.00533	0.00211	0.00275	0.00379	0.00773	0.00435	0.00424	0.00290	0.00294	0.00406	0.00313	0.00306	0.00528	0.00386	0.00369	0.00256	0.00179	1.07423	0.00284	0.00342	0.00658	0.00201	0.00247	0.00528	0.00177	0.00144
19 Construction	0.00480	0.00201	0.01112	0.00559	0.00287	0.00194	0.00184	0.00132	0.00183	0.00401	0.00145	0.00272	0.00253	0.00794	0.00230	0.00136	0.00097	0.00214	1.00257	0.00354	0.00618	0.00200	0.01425	0.00258	0.00177	0.00276
20 Trade and repair	0.06980	0.16558	0.06971	0.06440	0.08969	0.10267	0.05640	0.07257	0.06683	0.05416	0.05246	0.05040	0.03342	0.03386	0.06029	0.04146	0.04725	0.05639	0.07612	1.06158	0.05798	0.09435	0.05938	0.03442	0.04836	0.04063
21 Accomodation, café	0.01278	0.01103	0.01084	0.04324	0.00920	0.01512	0.05752	0.01140	0.01579	0.00933	0.01311	0.01136	0.00831	0.00775	0.01565	0.00687	0.00587	0.00841	0.01069	0.01787	1.01127	0.01378	0.00869	0.01213	0.01252	0.01211
22 Road transport	0.03777	0.02388	0.03522	0.02145	0.10312	0.05596	0.04238	0.01833	0.02585	0.01814	0.01460	0.12486	0.03205	0.02004	0.02569	0.00977	0.01187	0.01024	0.03480	0.02597	0.01672	1.10364	0.01216	0.00998	0.01704	0.01914
23 Rail, pipeline	0.00479	0.00222	0.00314	0.00243	0.00548	0.00829	0.00459	0.00372	0.00196	0.00444	0.00326	0.02184	0.01894	0.01906	0.00661	0.00251	0.00255	0.00143	0.00449	0.00227	0.00266	0.00104	1.00255	0.00129	0.00254	0.00202
24 Water transport	0.00100	0.00264	0.00296	0.03347	0.00096	0.00198	0.00077	0.00156	0.00125	0.00467	0.00084	0.00232	0.00374	0.00792	0.00273	0.00068	0.00081	0.00046	0.00092	0.00086	0.00050	0.00440	0.00171	1.30129	0.00403	0.00034
25 Air and space travel	0.00604	0.00740	0.00952	0.02066	0.00538	0.01092	0.00555	0.01420	0.01427	0.00589	0.00703	0.00552	0.00507	0.00540	0.00813	0.00552	0.00622	0.00935	0.00546	0.02020	0.00661	0.00655	0.00492	0.00859	1.06853	0.00691
26 Services to transport	0.01416	0.01293	0.00835	0.01761	0.01582	0.02407	0.02057	0.01203	0.02346	0.01783	0.01476	0.01288	0.01291	0.00846	0.02007	0.00877	0.00554	0.00675	0.01179	0.03905	0.01281	0.02216	0.00964	0.19440	0.08328	1.03867
27 Communication	0.01818	0.02005	0.02393	0.02583	0.02125	0.01909	0.01387	0.01342	0.01997	0.00975	0.01142	0.01939	0.01076	0.01025	0.01824	0.01022	0.01127	0.01834	0.01415	0.05235	0.03093	0.04143	0.01797	0.02210	0.01846	0.03071
28 Finance and insurance	0.04639	0.05215	0.03750	0.05417	0.03610	0.04671	0.03021	0.02024	0.02855	0.01986	0.01985	0.02500	0.02278	0.03268	0.02637	0.01824	0.01269	0.09131	0.03875	0.06313	0.05217	0.03355	0.05863	0.03781	0.03220	0.02589
29 Property and business	0.07726	0.08735	0.08507	0.30534	0.10510	0.10270	0.09382	0.08126	0.12368	0.07417	0.11417	0.08726	0.12819	0.08803	0.11141	0.08148	0.05625	0.09324	0.15660	0.27498	0.17649	0.14693	0.17240	0.15340	0.13406	0.13841
30 Govt. admin and defence	0.00233	0.00435	0.00707	0.00327	0.00391	0.00451	0.00276	0.00141	0.00593	0.00242	0.00148	0.00350	0.00333	0.00181	0.00318	0.00248	0.00114	0.00334	0.00306	0.00382	0.00191	0.01661	0.00431	0.00351	0.00206	0.01035
31 Education, health, commun	0.00297	0.00167	0.00153	0.00278	0.00451	0.00217	0.00283	0.00478	0.00280	0.00151	0.00408	0.00166	0.00169	0.00159	0.00167	0.00168	0.00098	0.00182	0.00141	0.00208	0.00215	0.00167	0.00232	0.00257	0.00164	0.00317
32 Personal and other services	0.00349	0.00686	0.00407	0.00901	0.00626	0.00762	0.00863	0.00681	0.01029	0.00378	0.00735	0.00531	0.00349	0.00301	0.00647	0.00642	0.00340	0.00459	0.00490	0.01508	0.01917	0.00621	0.00537	0.00503	0.00468	0.00469
33 Electricity	5.2E-07	5.2E-07	1.3E-06	1.3E-06	5.2E-07	4.4E-07	4.1E-07	2.5E-07	4.4E-07	3.4E-06	2.6E-07	1.2E-06	9.8E-07	6.9E-06	1.0E-06	4.0E-07	3.5E-07	9.1E-07	2.9E-07	3.3E-07	3.3E-07	1.2E-07	1.7E-06	1.3E-07	9.9E-08	7.5E-08
34 Gas supply	8.2E-07	5.6E-07	1.2E-06	1.1E-06	9.0E-07	7.8E-07	7.4E-07	1.1E-06	4.9E-07	1.5E-05	9.0E-07	3.7E-06	1.5E-06	7.1E-06	1.5E-06	5.2E-07	4.2E-07	9.8E-07	5.8E-07	3.7E-07	4.0E-07	2.2E-07	1.8E-06	3.2E-07	2.2E-07	5.9E-07
35 Petroleum Product	2.1E-06	1.6E-06	2.1E-06	2.2E-06	2.1E-06	1.2E-06	8.4E-07	7.5E-07	6.9E-07	1.3E-05	9.9E-07	2.0E-06	7.4E-07	1.5E-06	8.2E-07	3.4E-07	3.4E-07	5.9E-07	1.1E-06	6.9E-07	4.5E-07	1.5E-05	4.3E-06	1.2E-05	1.3E-05	3.7E-07
36 Coal pl.	3.1E-07	3.1E-07	7.8E-07	7.8E-07	3.1E-07	2.6E-07	2.4E-07	1.5E-07	2.6E-07	2.0E-06	1.5E-07	7.2E-07	5.8E-07	4.1E-06	6.2E-07	2.4E-07	2.1E-07	5.4E-07	1.7E-07	1.9E-07	2.0E-07	6.9E-08	9.8E-07	7.7E-08	5.9E-08	4.5E-08
37 GasPl	1.7E-07	1.7E-07	4.4E-07	4.4E-07	1.7E-07	1.5E-07	1.4E-07	8.4E-08	1.5E-07	1.1E-06	8.7E-08	4.1E-07	3.3E-07	2.3E-06	3.5E-07	1.4E-07	1.2E-07	3.1E-07	9.8E-08	1.1E-07	1.1E-07	3.9E-08	5.5E-07	4.3E-08	3.3E-08	2.5E-08
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	2.1E-08	2.1E-08	5.4E-08	5.3E-08	2.1E-08	1.8E-08	1.6E-08	1.0E-08	1.8E-08	1.4E-07	1.1E-08	4.9E-08	4.0E-08	2.8E-07	4.2E-08	1.6E-08	1.4E-08	3.7E-08	1.2E-08	1.3E-08	1.3E-08	4.7E-09	6.7E-08	5.2E-09	4.0E-09	3.1E-09
40 PV pl.	4.9E-11	4.9E-11	1.3E-10	1.2E-10	4.9E-11	4.1E-11	3.8E-11	2.4E-11	4.2E-11	3.2E-10	2.5E-11	1.2E-10	9.3E-11	6.5E-10	9.8E-11	3.8E-11	3.3E-11	8.7E-11	2.8E-11	3.1E-11	3.2E-11	1.1E-11	1.6E-10	1.2E-11	9.4E-12	7.1E-12
41 Wind	2.1E-08	2.1E-08	5.3E-08	5.3E-08	2.1E-08	1.8E-08	1.6E-08	1.0E-08	1.8E-08	1.4E-07	1.0E-08	4.9E-08	4.0E-08	2.8E-07	4.2E-08	1.6E-08	1.4E-08	3.7E-08	1.2E-08	1.3E-08	1.3E-08	4.7E-09	6.7E-08	5.2E-09	4.0E-09	3.0E-09
42 Biomass Plant	1.4E-08	1.4E-08	3.5E-08	3.5E-08	1.4E-08	1.2E-08	1.1E-08	6.5E-09	1.2E-08	8.9E-08	6.8E-09	3.2E-08	2.6E-08	1.8E-07	2.7E-08	1.1E-08	9.2E-09	2.4E-08	7.7E-09	8.6E-09	8.7E-09	3.1E-09	4.3E-08	3.4E-09	2.6E-09	2.0E-09
43 Biomass	5.4E-08	6.3E-08	1.1E-07	1.2E-07	2.1E-07	2.2E-07	2.0E-07	4.5E-07	5.0E-07	2.8E-07	3.2E-08	1.7E-07	8.6E-08	5.5E-07	9.8E-08	4.0E-08	4.0E-08	8.0E-08	5.8E-08	5.4E-08	6.1E-08	1.7E-08	1.5E-07	1.9E-08	1.4E-08	1.3E-08
44 Coal	8.6E-07	1.1E-06	2.3E-06	2.6E-06	9.9E-07	8.8E-07	8.6E-07	7.5E-07	9.4E-07	5.5E-06	4.6E-07	3.9E-06	1.4E-05	1.3E-05	3.8E-06	1.5E-06	1.2E-06	1.6E-06	1.0E-06	6.0E-07	6.1E-07	2.3E-07	2.9E-06	3.2E-07	2.2E-07	1.6E-07
45 CNG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
46 Methanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
47 Ethanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Source: Total requirement coefficients are computed in this research as described in Section 5-2 and 5-4 (Chapter 5)+A189

(contd ...)

Table D-15: Total Requirement Coefficient Matrix '(I-A)-1' for Base Scenario in 2020 (...contd)

	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
	Commun	Finance a	Property	Govt. adr	Educatioı	Personal	Electricity	Gas supp	Petroleun	Coal pl.	GasPl	Oil Pl.	Hydro	PV pl.	Wind	Biomass Pla	Biomass	Coal	CNG	Methanol	Ethanol	Biodiesel
1 Agri., hunting an	0.00108	0.00081	0.00126	0.00205	0.00103	0.00535	37.90	0.88	3.82	6.30	4.93	0.00	0.00	49.05	10.74	842.05	274.66	0.82	4.65	4.65	8527.71	17850.44
2 Forestry and fish	0.00070	0.00039	0.00048	0.00080	0.00029	0.00067	9.35	0.42	1.66	4.51	2.59	0.00	0.00	28.20	5.95	7.24	0.59	0.82	2.06	2.06	19.92	39.91
3 Mining	0.00042	0.00018	0.00065	0.00105	0.00035	0.00175	33.08	0.78	8.12	21.82	13.79	0.00	0.00	177.74	41.36	39.38	0.19	2.05	8.80	8.80	13.90	20.32
4 Services to minir	0.00003	0.00002	0.00004	0.00007	0.00003	0.00011	22.21	0.05	0.50	35.36	0.85	0.00	0.00	10.96	2.57	2.43	0.01	12.72	0.55	0.55	0.92	1.38
5 Meat and diary p	0.00159	0.00093	0.00113	0.00114	0.00103	0.00172	18.52	1.00	4.92	5.37	4.44	0.00	0.00	34.18	7.79	12.20	1.57	0.83	5.84	5.84	53.61	106.95
6 Other food prod.	0.00119	0.00096	0.00096	0.00182	0.00089	0.00448	16.24	0.85	4.39	5.09	3.71	0.00	0.00	27.89	6.35	31.92	8.54	0.95	5.18	5.18	269.38	559.28
7 Beverage and tol	0.00177	0.00271	0.00141	0.00314	0.00077	0.00144	22.02	1.23	6.60	5.59	4.86	0.00	0.00	30.38	7.13	8.58	0.47	0.96	7.74	7.74	21.21	37.29
8 Textile, clothing,	0.00231	0.00071	0.00176	0.00413	0.00474	0.00622	37.23	1.61	6.90	19.83	14.18	0.00	0.00	160.59	40.78	36.48	0.68	1.99	8.41	8.41	27.76	50.68
9 Wood, paper, pri	0.04293	0.01680	0.02785	0.05559	0.01650	0.03263	354.43	19.48	68.99	172.59	140.80	0.00	0.00	1564.41	324.87	329.14	3.75	14.53	87.51	87.51	184.29	311.45
10 Basic chemical	0.00174	0.00059	0.00218	0.00247	0.00224	0.00492	87.04	12.88	214.45	33.92	41.56	0.00	0.00	209.24	54.49	71.19	8.59	5.54	224.33	224.33	478.03	769.58
11 Other chem., rub	0.01671	0.00304	0.01121	0.02018	0.01288	0.02211	327.79	24.47	104.04	149.53	107.66	0.00	0.00	936.87	208.65	206.77	9.59	27.76	127.04	127.04	400.07	725.45
12 Non-metalic min	0.00134	0.00087	0.00409	0.00431	0.00139	0.00285	316.65	2.41	3.90	117.11	85.57	0.00	0.00	1073.98	208.91	258.52	0.38	3.37	6.30	6.30	15.59	28.40
13 Iron and steel	0.00523	0.00109	0.00454	0.00581	0.00215	0.00448	363.51	5.46	8.82	280.34	190.20	0.00	0.00	2710.02	736.82	573.10	0.54	15.02	14.20	14.20	25.44	43.71
14 Basic non-ferrou	0.00234	0.00038	0.00123	0.00409	0.00078	0.00181	105.34	1.58	3.66	83.21	59.93	0.00	0.00	814.68	236.24	181.65	0.21	2.69	5.20	5.20	10.19	17.38
15 Fabricated metal	0.00894	0.00179	0.00703	0.00873	0.00345	0.00775	823.32	12.47	26.53	711.49	525.16	0.00	0.00	3544.58	1827.53	1599.45	1.26	15.54	38.71	38.71	65.30	108.01
16 Transport equip.	0.00512	0.00092	0.00159	0.01906	0.00107	0.00202	64.28	4.26	16.80	28.77	15.85	0.00	0.00	121.63	26.68	23.91	0.74	7.29	20.83	20.83	39.60	64.80
17 Other equip., ma	0.05398	0.00840	0.01762	0.02946	0.02239	0.04073	2901.18	14.56	34.60	2195.75	1528.10	0.00	0.00	37353.02	7535.36	4801.08	3.33	68.69	49.08	49.08	138.00	251.19
18 Water and sewer	0.00131	0.00157	0.01073	0.00458	0.00394	0.00414	235.56	15.70	32.62	18.04	41.73	0.00	0.00	93.92	21.99	30.57	1.33	2.56	47.85	47.85	73.50	118.72
19 Construction	0.00146	0.00157	0.01044	0.01085	0.00118	0.00187	919.73	5.77	5.88	908.84	678.82	0.00	0.00	8623.56	1492.74	2136.67	1.20	5.12	11.69	11.69	43.13	83.83
20 Trade and repair	0.08283	0.01472	0.02538	0.03373	0.03086	0.04403	1117.75	48.14	191.67	342.50	245.46	0.00	0.00	2391.27	524.51	510.26	17.45	55.76	237.16	237.16	730.55	1322.83
21 Accomodation, c	0.01705	0.01570	0.01642	0.02036	0.00598	0.01551	230.93	10.35	74.85	59.14	47.37	0.00	0.00	332.45	80.41	90.74	3.20	9.30	84.15	84.15	172.98	281.44
22 Road transport	0.01841	0.00273	0.00657	0.01142	0.00618	0.01492	250.16	6.74	134.50	129.98	64.82	0.00	0.00	758.45	170.49	190.09	9.44	23.04	139.39	139.39	425.69	746.19
23 Rail, pipeline	0.00252	0.00102	0.00179	0.00140	0.00095	0.00126	239.73	32.04	21.21	78.58	77.65	0.00	0.00	139.99	33.85	33.72	1.20	24.42	52.90	52.90	58.05	98.72
24 Water transport	0.00153	0.00018	0.00066	0.00187	0.00056	0.00087	33.88	2.10	282.47	11.09	7.40	0.00	0.00	41.41	10.91	10.09	0.25	2.66	280.64	280.64	286.32	294.85
25 Air and space tra	0.02248	0.00810	0.01143	0.02318	0.00518	0.01085	169.86	11.90	51.97	45.44	43.32	0.00	0.00	279.07	63.21	62.09	1.51	7.89	63.13	63.13	98.10	149.37
26 Services to trans|	0.01617	0.00947	0.01555	0.01827	0.00495	0.00779	152.25	8.71	153.56	76.93	45.53	0.00	0.00	337.53	85.67	97.08	3.54	15.07	160.11	160.11	261.25	381.38
27 Communication	1.02772	0.02627	0.02436	0.04561	0.01840	0.03289	411.70	25.25	48.36	89.10	91.72	0.00	0.00	555.18	127.10	135.16	4.55	14.13	72.92	72.92	188.74	343.03
28 Finance and insu	0.03068	1.23076	0.06343	0.06201	0.02372	0.04094	1601.66	81.45	85.86	255.67	273.84	0.00	0.00	1374.99	300.29	356.30	11.60	44.77	166.10	166.10	444.59	838.26
29 Property and bus	0.10374	0.10812	1.24146	0.14813	0.06806	0.14192	2435.26	389.61	282.26	945.13	1349.50	0.00	0.00	3541.96	789.28	1721.50	19.32	91.59	667.09	667.09	876.93	1532.56
30 Govt. admin and	0.00523	0.00143	0.00299	1.05152	0.00208	0.00205	36.69	1.70	28.74	18.67	9.14	0.00	0.00	72.42	17.10	19.45	0.58	4.16	30.03	30.03	46.38	66.11
31 Education, healtl	0.00203	0.00453	0.00267	0.00437	1.01096	0.00419	79.24	3.23	10.05	50.57	10.52	0.00	0.00	51.18	11.69	13.92	0.74	16.91	13.14	13.14	32.98	58.21
32 Personal and oth	0.00532	0.00783	0.01631	0.01037	0.00862	1.06836	122.52	8.85	19.83	51.22	33.22	0.00	0.00	175.05	40.70	48.62	0.87	11.82	28.39	28.39	46.61	76.21
33 Electricity	2.8E-07	2.7E-07	3.0E-07	3.2E-07	2.4E-07	3.0E-07	1.0E+00	2.3E-04	1.7E-03	8.6E-03	1.6E-03	0.0E+00	0.0E+00	1.7E-02	4.4E-03	4.1E-03	1.3E-04	2.6E-03	2.1E-03	2.1E-03	5.9E-03	1.0E-02
34 Gas supply	3.1E-07	2.8E-07	3.3E-07	3.6E-07	2.7E-07	3.7E-07	7.2E-01	1.0E+00	7.0E-03	7.6E-03	2.1E+00	0.0E+00	0.0E+00	2.3E-02	6.0E-03	5.8E-03	2.0E-04	2.0E-03	1.0E+00	1.0E+00	1.0E-02	1.7E-02
35 Petroleum Produ	6.1E-07	2.1E-07	3.3E-07	5.5E-07	2.3E-07	4.7E-07	1.3E-02	5.6E-04	1.0E+00	1.1E-02	2.8E-03	0.0E+00	0.0E+00	2.3E-02	5.2E-03	6.7E-03	5.4E-04	3.4E-03	7.9E-03	7.9E-03	2.4E-02	4.2E-02
36 Coal pl.	1.7E-07	1.6E-07	1.8E-07	1.9E-07	1.4E-07	1.8E-07	6.0E-01	1.4E-04	1.0E-03	1.0E+00	9.7E-04	0.0E+00	0.0E+00	1.0E-02	2.6E-03	2.4E-03	7.7E-05	1.6E-03	1.2E-03	1.2E-03	3.5E-03	6.1E-03
37 GasPl	9.5E-08	9.1E-08	1.0E-07	1.1E-07	8.1E-08	1.0E-07	3.4E-01	7.7E-05	5.8E-04	2.9E-03	1.0E+00	0.0E+00	0.0E+00	5.6E-03	1.5E-03	1.4E-03	4.3E-05	8.8E-04	7.0E-04	7.0E-04	2.0E-03	3.4E-03
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	1.1E-08	1.1E-08	1.2E-08	1.3E-08	9.7E-09	1.2E-08	4.1E-02	9.2E-06	7.0E-05	3.5E-04	6.6E-05	0.0E+00	1.0E+00	6.8E-04	1.8E-04	1.6E-04	5.2E-06	1.1E-04	8.4E-05	8.4E-05	2.4E-04	4.2E-04
40 PV pl.	2.7E-11	2.6E-11	2.8E-11	3.0E-11	2.3E-11	2.9E-11	9.5E-05	2.2E-08	1.6E-07	8.2E-07	1.5E-07	0.0E+00	0.0E+00	1.0E+00	4.1E-07	3.8E-07	1.2E-08	2.5E-07	2.0E-07	2.0E-07	5.5E-07	9.7E-07
41 Wind	1.1E-08	1.1E-08	1.2E-08	1.3E-08	9.7E-09	1.2E-08	4.1E-02	9.2E-06	6.9E-05	3.5E-04	6.6E-05	0.0E+00	0.0E+00	6.8E-04	1.0E+00	1.6E-04	5.2E-06	1.1E-04	8.4E-05	8.4E-05	2.4E-04	4.1E-04
42 Biomass Plant	7.4E-09	7.1E-09	7.8E-09	8.4E-09	6.3E-09	8.0E-09	2.6E-02	6.0E-06	4.5E-05	2.3E-04	4.3E-05	0.0E+00	0.0E+00	4.4E-04	1.1E-04	1.0E+00	3.4E-06	6.9E-05	5.4E-05	5.4E-05	1.5E-04	2.7E-04
43 Biomass	4.1E-08	2.9E-08	3.6E-08	5.0E-08	2.8E-08	4.0E-08	8.0E-02	2.7E-05	1.7E-04	7.7E-04	2.0E-04	0.0E+00	0.0E+00	2.1E-03	5.0E-04	3.0E+00	1.0E+00	2.2E-04	2.1E-04	2.1E-04	6.0E-04	1.1E-03
44 Coal	5.3E-07	4.6E-07	5.4E-07	6.0E-07	4.2E-07	5.5E-07	1.6E+00	4.3E-04	2.9E-03	2.7E+00	4.8E-03	0.0E+00	0.0E+00	5.7E-02	1.5E-02	1.3E-02	2.2E-04	1.0E+00	3.5E-03	3.5E-03	9.8E-03	1.7E-02
45 CNG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00
46 Methanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	0.0E+00	0.0E+00
47 Ethanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	0.0E+00
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00

Table D-16: Direct Requirement Coefficient Matrix 'A' for Moderate Scenario in 2020

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
	Agri., hui	Forestry ε	Mining	Services t	Meat and	Other foo	Beverage	Textile, c	Wood, pε	Basic che	Other che	Non-metε	Iron and :	Basic nor	Fabricate	Transport	Other eqι	Water an	Construct	Trade an	Accomod	Road trar	Rail, pipe	Water tra	Air and sι	Services t
1 Agri., hunting and trapping	0.08562	0.00426	0.00001	0.00000	0.33581	0.05897	0.05258	0.03446	0.00002	0.00091	0.00260	0.00000	0.00000	0.00000	0.00002	0.00000	0.00037	0.00007	0.00044	0.00032	0.00254	0.00000	0.00004	0.00000	0.00000	0.00010
2 Forestry and fishing	0.00172	0.05598	0.00056	0.00001	0.00000	0.00025	0.00000	0.00000	0.00932	0.00035	0.00012	0.00000	0.00000	0.00020	0.00000	0.00000	0.00015	0.00001	0.00011	0.00068	0.00822	0.00004	0.00210	0.00000	0.00000	0.00002
3 Mining	0.00031	0.00049	0.01275	0.00691	0.00005	0.00206	0.00002	0.00003	0.00005	0.00320	0.00018	0.02486	0.00499	0.06319	0.00112	0.00008	0.00090	0.00170	0.00496	0.00012	0.00043	0.00010	0.00022	0.00022	0.00005	0.00011
4 Services to mining	0.00000	0.00000	0.05694	0.01135	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5 Meat and diary prod.	0.00363	0.00057	0.00002	0.00006	0.05119	0.02803	0.00020	0.00787	0.00000	0.00305	0.00133	0.00000	0.00001	0.00000	0.00004	0.00008	0.00004	0.00023	0.00010	0.00629	0.02707	0.00004	0.00041	0.00016	0.00006	0.00004
6 Other food prod.	0.02686	0.02519	0.00023	0.00117	0.00937	0.11036	0.00567	0.00007	0.00001	0.00256	0.00301	0.00001	0.00001	0.00001	0.00006	0.00003	0.00004	0.00017	0.00003	0.00349	0.01913	0.00006	0.00020	0.00010	0.00013	0.00007
7 Beverage and tobacco	0.00074	0.00140	0.00029	0.00031	0.00124	0.00240	0.04318	0.00054	0.00033	0.00048	0.00013	0.00011	0.00008	0.00003	0.00007	0.00014	0.00008	0.00044	0.00010	0.00044	0.05759	0.00015	0.00033	0.00013	0.00027	0.00020
8 Textile, clothing, leather	0.00148	0.00638	0.00107	0.00032	0.00141	0.00374	0.00100	0.09185	0.00155	0.00133	0.00191	0.00107	0.00190	0.00096	0.00650	0.00131	0.00210	0.00033	0.00205	0.00194	0.00727	0.00091	0.00594	0.00182	0.00045	0.00075
9 Wood, paper, printing	0.00451	0.00946	0.00340	0.01103	0.01451	0.01440	0.01880	0.01079	0.15019	0.00494	0.01113	0.00984	0.00388	0.00213	0.01301	0.00614	0.01629	0.00485	0.04974	0.04228	0.01988	0.00426	0.01308	0.00572	0.00358	0.00661
10 Basic chemical	0.02601	0.00092	0.01015	0.00492	0.00028	0.00090	0.00041	0.00520	0.00594	0.10694	0.03313	0.00481	0.00217	0.00472	0.00836	0.00342	0.00217	0.01421	0.00071	0.00010	0.00034	0.00011	0.00180	0.00007	0.00001	0.00005
11 Other chem., rubber, plastic	0.02603	0.02033	0.02044	0.00645	0.02709	0.02794	0.01655	0.01035	0.03312	0.03114	0.11899	0.01195	0.01442	0.00379	0.01370	0.02007	0.01260	0.02602	0.01402	0.00461	0.01025	0.00836	0.00398	0.00445	0.00411	0.00246
12 Non-metalic mineral	0.00001	0.01815	0.00245	0.00401	0.00002	0.00340	0.01430	0.00024	0.00126	0.00021	0.00147	0.12437	0.01015	0.00545	0.01013	0.00322	0.00317	0.01060	0.08481	0.00263	0.00102	0.00039	0.00009	0.00000	0.00001	0.00009
13 Iron and steel	0.00001	0.00051	0.00357	0.03126	0.00001	0.00003	0.00002	0.00058	0.00042	0.00020	0.00022	0.00632	0.19323	0.00333	0.14095	0.05033	0.04077	0.00246	0.01606	0.00064	0.00004	0.00006	0.00401	0.00013	0.00002	0.00005
14 Basic non-ferrous	0.00001	0.00008	0.00091	0.00022	0.00027	0.00024	0.00005	0.00073	0.00160	0.00098	0.00208	0.00169	0.02494	0.20879	0.04687	0.00836	0.01062	0.00035	0.00055	0.00021	0.00028	0.00002	0.00034	0.00001	0.00001	0.00004
15 Fabricated metal	0.00170	0.02601	0.01431	0.02336	0.00320	0.00531	0.02022	0.00306	0.00618	0.00283	0.00300	0.01380	0.00576	0.00115	0.08742	0.01527	0.01216	0.01805	0.04919	0.00325	0.00180	0.00454	0.05654	0.02499	0.00190	0.00308
16 Transport equip.	0.00083	0.00714	0.00328	0.00386	0.00007	0.00022	0.00009	0.00007	0.00018	0.00019	0.00013	0.00090	0.00063	0.00005	0.00036	0.17014	0.00124	0.00016	0.00029	0.00545	0.00120	0.00857	0.06990	0.01681	0.04074	0.00470
17 Other equip., manufacturing	0.00566	0.12058	0.07077	0.03058	0.00192	0.00469	0.00231	0.00630	0.00903	0.00256	0.00464	0.00495	0.00773	0.01167	0.01984	0.03796	0.07376	0.01225	0.05749	0.00836	0.02012	0.00741	0.02172	0.00308	0.00069	0.01557
18 Water and sewerage	0.00347	0.00046	0.00117	0.00015	0.00426	0.00207	0.00227	0.00141	0.00114	0.00160	0.00145	0.00134	0.00276	0.00094	0.00129	0.00096	0.00073	0.06793	0.00069	0.00057	0.00400	0.00002	0.00003	0.00238	0.00001	0.00002
19 Construction	0.00315	0.00047	0.00879	0.00148	0.00003	0.00006	0.00008	0.00008	0.00015	0.00011	0.00008	0.00020	0.00013	0.00004	0.00009	0.00014	0.00004	0.00035	0.00070	0.00073	0.00419	0.00032	0.01115	0.00062	0.00029	0.00130
20 Trade and repair	0.04741	0.13090	0.04799	0.04159	0.04543	0.06916	0.03453	0.05310	0.04300	0.03401	0.03571	0.02418	0.01562	0.01064	0.03723	0.02389	0.03443	0.04035	0.05269	0.04030	0.03553	0.07115	0.03934	0.01187	0.03158	0.02869
21 Accomodation, café	0.00773	0.00438	0.00422	0.03522	0.00072	0.00817	0.05037	0.00705	0.00964	0.00444	0.00849	0.00586	0.00358	0.00260	0.00964	0.00288	0.00291	0.00373	0.00429	0.01063	0.00275	0.00738	0.00268	0.00445	0.00713	0.00820
22 Road transport	0.02634	0.01046	0.02582	0.01221	0.07414	0.03629	0.02947	0.01038	0.01640	0.00994	0.00833	0.09555	0.01953	0.00919	0.01227	0.00301	0.00602	0.00410	0.01600	0.01717	0.00553	0.08859	0.00503	0.00142	0.00974	0.01425
23 Rail, pipeline	0.00349	0.00034	0.00182	0.00038	0.00299	0.00620	0.00309	0.00267	0.00095	0.00224	0.00224	0.01806	0.01380	0.01310	0.00168	0.00040	0.00093	0.00026	0.00132	0.00120	0.00138	0.00009	0.00093	0.00006	0.00157	0.00147
24 Water transport	0.00013	0.00128	0.00016	0.02467	0.00005	0.00097	0.00021	0.00083	0.00054	0.00048	0.00025	0.00096	0.00192	0.00426	0.00098	0.00008	0.00024	0.00003	0.00005	0.00027	0.00006	0.00007	0.00008	0.22945	0.00021	0.00005
25 Air and space travel	0.00238	0.00158	0.00465	0.01402	0.00033	0.00555	0.00201	0.00970	0.00869	0.00216	0.00357	0.00189	0.00174	0.00151	0.00369	0.00230	0.00352	0.00539	0.00069	0.01368	0.00205	0.00138	0.00043	0.00313	0.06096	0.00353
26 Services to transport	0.00697	0.00263	0.00152	0.00325	0.00471	0.01327	0.01318	0.00528	0.01407	0.01000	0.00828	0.00540	0.00611	0.00241	0.01130	0.00336	0.00114	0.00108	0.00334	0.02908	0.00520	0.01219	0.00225	0.13997	0.07006	0.03303
27 Communication	0.00909	0.00634	0.01428	0.01239	0.00601	0.00638	0.00410	0.00553	0.00967	0.00225	0.00427	0.00790	0.00303	0.00140	0.00853	0.00370	0.00585	0.00984	0.00295	0.03952	0.02092	0.02856	0.00819	0.00821	0.00916	0.02311
28 Finance and insurance	0.02571	0.02686	0.01842	0.02341	0.00663	0.02119	0.01175	0.00640	0.01050	0.00379	0.00638	0.00751	0.00614	0.00803	0.00817	0.00592	0.00367	0.06138	0.01794	0.03407	0.02819	0.01358	0.03368	0.01420	0.01500	0.01156
29 Property and business	0.02821	0.01508	0.02296	0.20643	0.03166	0.03429	0.03879	0.03511	0.06015	0.02472	0.06288	0.02977	0.06515	0.03085	0.04280	0.03404	0.02164	0.04407	0.08752	0.18905	0.11147	0.07848	0.10582	0.06678	0.07554	0.09111
30 Govt. admin and defence	0.00083	0.00256	0.00535	0.00140	0.00105	0.00220	0.00112	0.00038	0.00379	0.00099	0.00044	0.00066	0.00159	0.00026	0.00137	0.00129	0.00032	0.00221	0.00122	0.00173	0.00047	0.01317	0.00278	0.00045	0.00013	0.00868
31 Education, health, communi	0.00199	0.00060	0.00063	0.00143	0.00264	0.00087	0.00183	0.00371	0.00168	0.00053	0.00306	0.00074	0.00063	0.00042	0.00064	0.00087	0.00047	0.00087	0.00039	0.00080	0.00096	0.00070	0.00123	0.00101	0.00069	0.00248
32 Personal and other services	0.00061	0.00234	0.00095	0.00270	0.00225	0.00330	0.00460	0.00369	0.00567	0.00104	0.00389	0.00209	0.00050	0.00029	0.00284	0.00329	0.00141	0.00153	0.00056	0.00906	0.01401	0.00207	0.00108	0.00103	0.00131	0.00169
33 Electricity	7.3E-07	7.3E-07	1.1E-06	1.1E-06	2.4E-07	2.4E-07	2.4E-07	1.2E-07	2.7E-07	2.9E-06	4.0E-08	8.9E-07	5.3E-07	5.1E-06	3.7E-07	1.5E-07	1.5E-07	6.8E-07	5.2E-09	1.8E-07	1.8E-07	0.0E+00	2.5E-06	0.0E+00	0.0E+00	0.0E+00
34 Gas supply	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.9E-07	2.9E-07	2.9E-07	7.5E-07	0.0E+00	1.1E-05	1.6E-07	2.3E-06	2.0E-06	1.6E-06	3.2E-07	3.1E-08	3.1E-08	2.7E-08	7.6E-09	4.3E-08	4.3E-08	0.0E+00	4.1E-07	0.0E+00	0.0E+00	4.8E-07
35 Petroleum Product	6.0E-07	6.0E-07	1.2E-06	1.2E-06	4.9E-08	4.9E-08	4.9E-08	1.3E-07	6.7E-09	1.1E-05	1.6E-07	4.9E-08	0.0E+00	6.1E-07	9.1E-08	1.7E-08	1.7E-08	7.8E-08	4.4E-07	4.0E-08	4.0E-08	9.8E-06	3.0E-06	8.8E-06	1.2E-05	0.0E+00
36 Coal pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
37 GasPl	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
40 PV pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
41 Wind	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
42 Biomass Plant	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
43 Biomass	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.4E-07	1.4E-07	1.4E-07	3.8E-07	3.9E-07	0.0E+00	0.0E+00	5.5E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
44 Coal	0.0E+00	0.0E+00	3.3E-09	3.3E-09	1.1E-07	1.1E-07	1.1E-07	2.8E-07	1.5E-07	0.0E+00	0.0E+00	1.5E-06	6.8E-06	1.5E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.1E-09	4.1E-09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
45 CNG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	9.1E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
46 Methanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.0E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
47 Ethanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	9.6E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Source: Direct requirement coefficients are computed in this research as described in Section 5-2 and 5-4 (Chapter 5)

(contd ...)

Table D-16: Direct Requirement Coefficient Matrix 'A' for Moderate Scenario in 2020 (...contd)

	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
	Commun	Finance a	Property :	Govt. adr	Educatioı	Personal :	Electricit	Gas supp	Petroleun	Coal pl.	GasPl	Oil Pl.	Hydro	PV pl.	Wind	Biomass Pla	Biomass	Coal	CNG	Methanol	Ethanol	Biodiesel
1 Agri., hunting an	0.00000	0.00006	0.00033	0.00079	0.00021	0.00334	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	250.00	0.00	0.00	0.00	7758.62	16244.31
2 Forestry and fish	0.00004	0.00005	0.00002	0.00002	0.00003	0.00013	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.00	0.00
3 Mining	0.00006	0.00004	0.00023	0.00042	0.00016	0.00128	3.51	0.32	6.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.37	6.37	6.37	6.37	6.37
4 Services to minir	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.41	0.00	0.00	0.00	0.00
5 Meat and diary p	0.00038	0.00022	0.00029	0.00010	0.00049	0.00059	0.85	0.08	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.22	0.22	0.22	0.22
6 Other food prod.	0.00024	0.00030	0.00021	0.00079	0.00041	0.00300	1.05	0.08	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.44	0.44	0.44	0.44
7 Beverage and tot	0.00054	0.00132	0.00020	0.00154	0.00029	0.00029	2.67	0.30	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	1.34	1.34	1.34	1.34
8 Textile, clothing,	0.00127	0.00018	0.00085	0.00275	0.00386	0.00461	6.41	0.39	2.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.78	2.88	2.88	2.88	2.88
9 Wood, paper, pri	0.02790	0.00826	0.01542	0.03712	0.00960	0.01906	49.88	4.82	32.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.97	32.42	32.42	32.42	32.42
10 Basic chemical	0.00019	0.00005	0.00074	0.00048	0.00111	0.00261	26.21	9.62	184.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.52	182.07	182.07	182.07	182.07
11 Other chem., rub	0.01005	0.00027	0.00546	0.01153	0.00890	0.01411	115.49	16.09	71.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.52	70.35	70.35	70.35	70.35
12 Non-metalic min	0.00007	0.00014	0.00172	0.00177	0.00060	0.00136	162.04	0.23	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.06	0.06	0.06	0.06
13 Iron and steel	0.00021	0.00001	0.00127	0.00075	0.00009	0.00040	21.55	0.99	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.87	0.04	0.04	0.04	0.04
14 Basic non-ferrou	0.00051	0.00001	0.00016	0.00189	0.00005	0.00031	0.49	0.12	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.13	0.13	0.13	0.13
15 Fabricated metal	0.00547	0.00021	0.00351	0.00437	0.00170	0.00433	57.11	6.37	7.94	531.84	396.07	0.00	0.00	2253.36	1478.77	1267.51	0.00	8.26	7.86	7.86	7.86	7.86
16 Transport equip.	0.00217	0.00005	0.00022	0.01344	0.00022	0.00045	7.49	0.18	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.06	1.78	1.78	1.78	1.78
17 Other equip., ma	0.04407	0.00287	0.00918	0.01798	0.01704	0.02982	535.22	4.67	8.92	1772.79	1320.24	0.00	0.00	33800.39	6802.33	4225.05	0.00	51.08	8.82	8.82	8.82	8.82
18 Water and sewer	0.00001	0.00033	0.00778	0.00254	0.00289	0.00222	180.01	11.26	25.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	25.24	25.24	25.24	25.24
19 Construction	0.00010	0.00026	0.00802	0.00870	0.00031	0.00023	19.17	1.91	0.51	886.40	660.12	0.00	0.00	8562.77	1478.77	2112.52	0.00	1.55	0.51	0.51	0.51	0.51
20 Trade and repair	0.06681	0.00601	0.01243	0.01598	0.02271	0.02778	619.13	31.15	129.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	37.78	128.43	128.43	128.43	128.43
21 Accomodation, c	0.01264	0.01074	0.01115	0.01440	0.00355	0.01048	116.59	2.93	58.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.38	58.20	58.20	58.20	58.20
22 Road transport	0.01216	0.00039	0.00230	0.00525	0.00336	0.00894	63.97	1.82	106.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.12	104.95	104.95	104.95	104.95
23 Rail, pipeline	0.00177	0.00051	0.00101	0.00046	0.00054	0.00046	152.85	31.04	18.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.98	17.92	17.92	17.92	17.92
24 Water transport	0.00087	0.00000	0.00027	0.00107	0.00028	0.00038	15.52	1.28	214.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.79	212.50	212.50	212.50	212.50
25 Air and space tra	0.01757	0.00467	0.00714	0.01715	0.00296	0.00649	74.62	6.16	37.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.04	37.43	37.43	37.43	37.43
26 Services to trans	0.00855	0.00514	0.00953	0.01042	0.00180	0.00199	11.48	0.32	88.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.95	87.05	87.05	87.05	87.05
27 Communication	0.01884	0.01796	0.01563	0.03520	0.01388	0.02372	208.47	13.16	16.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.44	16.77	16.77	16.77	16.77
28 Finance and insu	0.01472	0.18195	0.03812	0.03752	0.01359	0.02175	965.52	45.60	31.51	35.46	26.40	0.00	0.00	450.67	95.58	84.50	0.00	24.13	31.17	31.17	31.17	31.17
29 Property and bus	0.05173	0.06331	0.17643	0.08779	0.04058	0.08665	703.23	291.02	98.39	319.10	237.64	0.00	0.00	0.00	0.00	760.51	0.00	38.23	97.32	97.32	97.32	97.32
30 Govt. admin and	0.00387	0.00065	0.00179	0.04784	0.00144	0.00090	8.84	0.21	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.77	21.66	21.66	21.66	21.66
31 Education, health	0.00130	0.00333	0.00169	0.00323	0.01041	0.00319	33.45	1.89	7.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.82	6.95	6.95	6.95	6.95
32 Personal and oth	0.00200	0.00445	0.01136	0.00605	0.00645	0.06115	36.15	2.42	9.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.34	9.32	9.32	9.32	9.32
33 Electricity	1.8E-07	1.8E-07	1.8E-07	1.8E-07	1.8E-07	1.8E-07	0.0E+00	0.0E+00	9.5E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.5E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00
34 Gas supply	4.3E-08	4.3E-08	4.3E-08	4.3E-08	4.3E-08	4.3E-08	0.0E+00	0.0E+00	3.7E-03	0.0E+00	2.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	1.0E+00	0.0E+00	0.0E+00
35 Petroleum Produ	4.0E-08	4.0E-08	4.0E-08	4.0E-08	4.0E-08	4.0E-08	0.0E+00	0.0E+00	3.7E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.8E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00
36 Coal pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
37 GasPl	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.0E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.3E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
40 PV pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.5E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
41 Wind	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	8.0E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
42 Biomass Plant	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.9E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
43 Biomass	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	0.0E+00
44 Coal	4.1E-09	4.1E-09	4.1E-09	4.1E-09	4.1E-09	4.1E-09	0.0E+00	0.0E+00	0.0E+00	2.7E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.6E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00
45 CNG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
46 Methanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
47 Ethanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Table D-17: Total Requirement Coefficient Matrix '(I-A)-1' for Moderate Scenario in 2020

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
	Agri., hui	Forestry :	Mining	Services t	Meat and	Other foo	Beverage	Textile, c	Wood, pa	Basic che	Other che	Non-meta	Iron and :	Basic nor	Fabricate	Transport	Other equ	Water anc	Construct	Trade anc	Accomod	Road trar	Rail, pipe	Water tra	Air and sp	Services t
1 Agri., hunting and trapping	1.09900	0.00922	0.00122	0.00182	0.39132	0.08690	0.06291	0.04601	0.00147	0.00375	0.00504	0.00182	0.00095	0.00103	0.00143	0.00077	0.00111	0.00103	0.00171	0.00435	0.01976	0.01019	0.00142	0.00090	0.00082	0.00088
2 Forestry and fishing	0.00236	1.05987	0.00095	0.00075	0.00121	0.00102	0.00101	0.00048	0.01192	0.00072	0.00055	0.00044	0.00031	0.00059	0.00051	0.00028	0.00054	0.00030	0.00101	0.00158	0.00927	0.00045	0.00266	0.00034	0.00030	0.00033
3 Mining	0.00077	0.00192	1.01414	0.00813	0.00057	0.00280	0.00087	0.00034	0.00057	0.00411	0.00078	0.02938	0.00944	0.08165	0.00745	0.00198	0.00263	0.00263	0.00840	0.00056	0.00091	0.00048	0.00126	0.00085	0.00039	0.00033
4 Services to mining	0.00007	0.00013	0.05843	1.01198	0.00005	0.00017	0.00006	0.00003	0.00005	0.00031	0.00005	0.00174	0.00067	0.00487	0.00047	0.00013	0.00016	0.00017	0.00050	0.00004	0.00006	0.00003	0.00013	0.00005	0.00003	0.00002
5 Meat and diary prod.	0.00629	0.00323	0.00100	0.00203	1.05723	0.03497	0.00292	0.01030	0.00114	0.00451	0.00271	0.00084	0.00064	0.00060	0.00115	0.00073	0.00064	0.00110	0.00110	0.00791	0.03025	0.00129	0.00133	0.00096	0.00089	0.00078
6 Other food prod.	0.03418	0.03145	0.00115	0.00286	0.02386	1.12808	0.01029	0.00230	0.00131	0.00406	0.00475	0.00072	0.00055	0.00054	0.00093	0.00059	0.00054	0.00093	0.00086	0.00504	0.02376	0.00126	0.00096	0.00076	0.00080	0.00066
7 Beverage and tobacco	0.00190	0.00256	0.00117	0.00320	0.00248	0.00406	1.04881	0.00149	0.00154	0.00128	0.00110	0.00099	0.00074	0.00069	0.00121	0.00071	0.00054	0.00123	0.00097	0.00184	0.06120	0.00124	0.00113	0.00112	0.00123	0.00109
8 Textile, clothing, leather	0.00272	0.00911	0.00229	0.00200	0.00332	0.00583	0.00255	1.10189	0.00296	0.00241	0.00309	0.00242	0.00343	0.00227	0.00916	0.00268	0.00317	0.00120	0.00381	0.00327	0.00918	0.00202	0.00801	0.00369	0.00130	0.00150
9 Wood, paper, printing	0.01516	0.02919	0.01571	0.02807	0.03096	0.03121	0.03269	0.02189	1.18632	0.01442	0.02204	0.02166	0.01302	0.01113	0.02673	0.01600	0.02624	0.01468	0.07127	0.06309	0.03619	0.01771	0.02791	0.01866	0.01310	0.01587
10 Basic chemical	0.03430	0.00430	0.01431	0.00804	0.01470	0.00627	0.00438	0.00904	0.01034	1.12503	0.04317	0.00855	0.00516	0.00936	0.01309	0.00692	0.00423	0.01927	0.00425	0.00190	0.00273	0.00434	0.00507	0.00400	0.00366	0.00086
11 Other chem., rubber, plastic	0.03848	0.03353	0.02995	0.01595	0.05043	0.04446	0.02714	0.01816	0.04854	0.04489	1.14021	0.02178	0.02479	0.01260	0.02571	0.03261	0.01949	0.03600	0.02560	0.01298	0.02049	0.01621	0.01342	0.01280	0.01041	0.00647
12 Non-metalic mineral	0.00168	0.02465	0.00587	0.00773	0.00161	0.00576	0.01851	0.00122	0.00316	0.00217	0.00284	1.14376	0.01594	0.01116	0.01667	0.00664	0.00548	0.01441	0.09941	0.00472	0.00413	0.00173	0.00450	0.00164	0.00111	0.00114
13 Iron and steel	0.00240	0.01586	0.01620	0.04863	0.00280	0.00326	0.00579	0.00290	0.00410	0.00344	0.00236	0.01490	1.24382	0.01152	0.19521	0.08251	0.05822	0.00915	0.03539	0.00438	0.00366	0.00360	0.02553	0.00994	0.00512	0.00302
14 Basic non-ferrous	0.00092	0.00519	0.00452	0.00472	0.00147	0.00160	0.00224	0.00182	0.00370	0.00252	0.00376	0.00479	0.04047	1.26595	0.07215	0.01767	0.01757	0.00274	0.00684	0.00153	0.00161	0.00122	0.00704	0.00330	0.00132	0.00102
15 Fabricated metal	0.00555	0.03603	0.02227	0.03208	0.00816	0.01030	0.02627	0.00589	0.01089	0.00866	0.00588	0.02260	0.01227	0.01216	1.10099	0.02318	0.01646	0.02400	0.05943	0.00746	0.00707	0.00820	0.06909	0.03883	0.00531	0.00561
16 Transport equip.	0.00299	0.01164	0.00638	0.00783	0.00322	0.00331	0.00206	0.00206	0.00238	0.00193	0.00157	0.00546	0.00378	0.00325	0.00272	1.20625	0.00279	0.00157	0.00244	0.00906	0.00302	0.01317	0.08572	0.02859	0.05392	0.00723
17 Other equip., manufacturing	0.01561	0.14876	0.09020	0.04829	0.01348	0.01441	0.01096	0.01283	0.02007	0.01983	0.01092	0.01914	0.02040	0.05089	0.03542	0.05550	1.08498	0.02225	0.07143	0.02002	0.03132	0.01645	0.04456	0.01462	0.00894	0.02284
18 Water and sewerage	0.00542	0.00220	0.00275	0.00378	0.00776	0.00436	0.00424	0.00291	0.00294	0.00406	0.00313	0.00307	0.00531	0.00380	0.00368	0.00256	0.00179	1.07422	0.00284	0.00342	0.00658	0.00203	0.00267	0.00528	0.00178	0.00144
19 Construction	0.00544	0.00263	0.01140	0.00586	0.00317	0.00209	0.00196	0.00139	0.00193	0.00473	0.00151	0.00300	0.00279	0.00914	0.00250	0.00145	0.00105	0.00231	1.00263	0.00361	0.00626	0.00207	0.01575	0.00261	0.00179	0.00278
20 Trade and repair	0.07030	0.16606	0.06980	0.06447	0.08992	0.10275	0.05646	0.07261	0.06687	0.05435	0.05248	0.05053	0.03341	0.03398	0.06031	0.04148	0.04727	0.05642	0.07614	1.06160	0.05801	0.09476	0.06051	0.03444	0.04837	0.04064
21 Accomodation, café	0.01286	0.01110	0.01085	0.04324	0.00923	0.01514	0.05753	0.01141	0.01579	0.00936	0.01312	0.01137	0.00832	0.00774	0.01565	0.00687	0.00588	0.00841	0.01069	0.01787	1.01127	0.01380	0.00888	0.01213	0.01252	0.01211
22 Road transport	0.03785	0.02395	0.03526	0.02148	0.10317	0.05599	0.04240	0.01834	0.02586	0.01821	0.01461	0.12491	0.03201	0.02012	0.02570	0.00978	0.01188	0.01025	0.03481	0.02598	0.01673	1.10379	0.01236	0.00998	0.01705	0.01914
23 Rail, pipeline	0.00489	0.00232	0.00314	0.00242	0.00552	0.00830	0.00460	0.00373	0.00196	0.00443	0.00326	0.02185	0.01891	0.01898	0.00660	0.00251	0.00255	0.00142	0.00449	0.00227	0.00266	0.00110	1.00277	0.00129	0.00254	0.00203
24 Water transport	0.00088	0.00252	0.00295	0.03346	0.00088	0.00195	0.00074	0.00155	0.00124	0.00467	0.00083	0.00227	0.00372	0.00790	0.00272	0.00068	0.00080	0.00045	0.00090	0.00085	0.00049	0.00404	0.00149	1.30129	0.00402	0.00033
25 Air and space travel	0.00610	0.00746	0.00952	0.02066	0.00541	0.01093	0.00555	0.01420	0.01427	0.00590	0.00703	0.00552	0.00507	0.00539	0.00813	0.00552	0.00622	0.00935	0.00546	0.02021	0.00662	0.00655	0.00506	0.00859	1.06853	0.00691
26 Services to transport	0.01416	0.01293	0.00835	0.01762	0.01582	0.02407	0.02057	0.01203	0.02346	0.01786	0.01476	0.01288	0.01287	0.00848	0.02007	0.00877	0.00554	0.00676	0.01178	0.03905	0.01282	0.02208	0.00968	0.19440	0.08328	1.03867
27 Communication	0.01837	0.02023	0.02395	0.02584	0.02133	0.01912	0.01389	0.01344	0.01998	0.00978	0.01142	0.01942	0.01078	0.01022	0.01825	0.01022	0.01128	0.01834	0.01416	0.05235	0.03094	0.04155	0.01837	0.02211	0.01846	0.03072
28 Finance and insurance	0.04714	0.05286	0.03753	0.05420	0.03641	0.04681	0.03028	0.02029	0.02857	0.01993	0.01987	0.02510	0.02286	0.03245	0.02637	0.01825	0.01271	0.09129	0.03877	0.06315	0.05219	0.03393	0.06025	0.03782	0.03222	0.02590
29 Property and business	0.07829	0.08833	0.08508	0.30535	0.10552	0.10282	0.09391	0.08132	0.12371	0.07415	0.11419	0.08738	0.12869	0.08742	0.11143	0.08151	0.05627	0.09319	0.15664	0.27500	0.17652	0.14769	0.17463	0.15341	0.13408	0.13843
30 Govt. admin and defence	0.00233	0.00436	0.00708	0.00327	0.00391	0.00451	0.00276	0.00141	0.00593	0.00243	0.00148	0.00350	0.00332	0.00182	0.00318	0.00248	0.00114	0.00334	0.00306	0.00382	0.00191	0.01660	0.00432	0.00351	0.00206	0.01035
31 Education, health, communi	0.00301	0.00170	0.00153	0.00278	0.00452	0.00217	0.00283	0.00478	0.00281	0.00152	0.00408	0.00167	0.00163	0.00159	0.00166	0.00168	0.00098	0.00182	0.00141	0.00208	0.00215	0.00169	0.00240	0.00257	0.00164	0.00317
32 Personal and other services	0.00354	0.00691	0.00407	0.00901	0.00628	0.00763	0.00863	0.00681	0.01030	0.00380	0.00735	0.00532	0.00347	0.00301	0.00647	0.00642	0.00340	0.00459	0.00490	0.01508	0.01917	0.00623	0.00549	0.00503	0.00468	0.00469
33 Electricity	9.9E-07	9.8E-07	1.3E-06	1.3E-06	6.9E-07	4.8E-07	4.4E-07	2.7E-07	4.5E-07	3.4E-06	2.6E-07	1.2E-06	1.0E-06	6.7E-06	1.0E-06	4.1E-07	3.5E-07	8.9E-07	3.0E-07	3.3E-07	3.4E-07	1.2E-07	2.7E-06	1.3E-07	1.0E-07	7.7E-08
34 Gas supply	8.7E-07	6.2E-07	8.1E-07	8.1E-07	9.1E-07	7.2E-07	6.7E-07	1.1E-06	3.8E-07	1.4E-05	8.3E-07	3.4E-06	3.1E-06	4.8E-06	1.5E-06	5.2E-07	4.1E-07	7.0E-07	5.7E-07	3.0E-07	3.2E-07	1.4E-06	1.7E-06	3.1E-07	2.2E-07	5.9E-07
35 Petroleum Product	1.6E-06	1.1E-06	2.0E-06	2.1E-06	1.6E-06	9.3E-07	6.7E-07	6.6E-07	6.0E-07	1.3E-05	9.4E-07	1.6E-06	6.1E-07	1.4E-06	7.3E-07	3.1E-07	3.0E-07	5.6E-07	9.7E-07	6.0E-07	3.8E-07	1.1E-05	3.3E-06	1.2E-05	1.3E-05	3.0E-07
36 Coal pl.	6.3E-07	6.2E-07	8.4E-07	8.4E-07	4.4E-07	3.1E-07	2.8E-07	1.7E-07	2.9E-07	2.2E-06	1.7E-07	7.9E-07	6.6E-07	4.3E-06	6.5E-07	2.6E-07	2.2E-07	5.7E-07	1.9E-07	2.1E-07	2.2E-07	7.8E-08	1.7E-06	8.4E-08	6.6E-08	4.9E-08
37 GasPl	2.0E-07	1.9E-07	2.6E-07	2.6E-07	1.4E-07	9.6E-08	8.7E-08	5.4E-08	8.9E-08	6.7E-07	5.2E-08	2.5E-07	2.0E-07	1.3E-06	2.0E-07	8.0E-08	7.0E-08	1.8E-07	5.9E-08	6.5E-08	6.8E-08	2.4E-08	5.3E-07	2.6E-08	2.1E-08	1.5E-08
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	4.3E-08	4.2E-08	5.7E-08	5.7E-08	3.0E-08	2.1E-08	1.9E-08	1.2E-08	1.9E-08	1.5E-07	1.1E-08	5.4E-08	4.5E-08	2.9E-07	4.4E-08	1.8E-08	1.5E-08	3.9E-08	1.3E-08	1.4E-08	1.5E-08	5.3E-09	1.2E-07	5.7E-09	4.5E-09	3.3E-09
40 PV pl.	1.5E-08	1.5E-08	2.1E-08	2.0E-08	1.1E-08	7.5E-09	6.8E-09	4.2E-09	6.9E-09	5.3E-08	4.1E-09	1.9E-08	1.6E-08	1.0E-07	1.6E-08	6.3E-09	5.4E-09	1.4E-08	4.6E-09	5.1E-09	5.3E-09	1.9E-09	4.2E-08	2.0E-09	1.6E-09	1.2E-09
41 Wind	8.0E-08	7.9E-08	1.1E-07	1.1E-07	5.6E-08	3.9E-08	3.5E-08	2.2E-08	3.6E-08	2.7E-07	2.1E-08	9.9E-08	8.3E-08	5.4E-07	8.2E-08	3.3E-08	2.8E-08	7.2E-08	2.4E-08	2.6E-08	2.8E-08	9.9E-09	2.2E-07	1.1E-08	8.3E-09	6.2E-09
42 Biomass Plant	5.9E-08	5.8E-08	7.8E-08	7.8E-08	4.1E-08	2.9E-08	2.6E-08	1.6E-08	2.7E-08	2.0E-07	1.6E-08	7.3E-08	6.1E-08	4.0E-07	6.1E-08	2.4E-08	2.1E-08	5.3E-08	1.7E-08	1.9E-08	2.0E-08	7.3E-09	1.6E-07	7.8E-09	6.1E-09	4.6E-09
43 Biomass	2.3E-07	2.2E-07	2.8E-07	2.7E-07	3.9E-07	3.2E-07	2.9E-07	4.9E-07	5.6E-07	6.3E-07	7.2E-08	4.1E-07	2.2E-07	1.2E-06	2.2E-07	8.9E-08	8.6E-08	1.8E-07	1.2E-07	1.1E-07	1.1E-07	1.1E-06	5.0E-07	4.2E-08	4.1E-08	3.9E-08
44 Coal	1.7E-06	1.8E-06	2.4E-06	2.6E-06	1.3E-06	1.0E-06	9.4E-07	8.1E-07	9.9E-07	5.9E-06	4.9E-07	4.0E-06	1.0E-05	1.3E-05	3.2E-06	1.3E-06	1.0E-06	1.6E-06	9.3E-07	6.2E-07	6.5E-07	2.5E-07	4.8E-06	3.1E-07	2.2E-07	1.6E-07
45 CNG	3.4E-08	2.2E-08	3.2E-08	2.0E-08	9.4E-08	5.1E-08	3.9E-08	1.7E-08	2.3E-08	1.7E-08	1.3E-08	1.1E-07	2.9E-08	1.8E-08	2.3E-08	8.9E-09	1.1E-08	9.3E-09	3.2E-08	2.4E-08	1.5E-08	1.0E-06	1.1E-08	9.1E-09	1.5E-08	1.7E-08
46 Methanol	7.4E-09	4.7E-09	6.9E-09	4.2E-09	2.0E-08	1.1E-08	8.3E-09	3.6E-09	5.0E-09	3.6E-09	2.9E-09	2.4E-08	6.2E-09	3.9E-09	5.0E-09	1.9E-09	2.3E-09	2.0E-09	6.8E-09	5.1E-09	3.3E-09	2.2E-07	2.4E-09	1.9E-09	3.3E-09	3.7E-09
47 Ethanol	3.6E-08	2.3E-08	3.4E-08	2.1E-08	9.9E-08	5.4E-08	4.1E-08	1.8E-08	2.5E-08	1.7E-08	1.4E-08	1.2E-07	3.1E-08	1.9E-08	2.5E-08	9.4E-09	1.1E-08	9.8E-09	3.3E-08	2.5E-08	1.6E-08	1.1E-06	1.2E-08	9.6E-09	1.6E-08	1.8E-08
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Source: Total requirement coefficients are computed in this research as described in Section 5-2 and 5-4 (Chapter 5)

(contd ...)

Table D-17: Total Requirement Coefficient Matrix '(I-A)-1' for Moderate Scenario in 2020 (...contd)

	27 Commun	28 Finance a	29 Property :	30 Govt. adr	31 Educatioı	32 Personal :	33 Electricit	34 Gas supp	35 Petroleun	36 Coal pl.	37 GasPl	38 Oil Pl.	39 Hydro	40 PV pl.	41 Wind	42 Biomass Pla	43 Biomass	44 Coal	45 CNG	46 Methanol	47 Ethanol	48 Biodiesel
1 Agri., hunting an	0.00124	0.00084	0.00132	0.00215	0.00109	0.00549	68.35	0.95	5.01	7.64	5.36	0.00	0.00	55.90	12.30	835.62	274.75	1.09	5.82	5.82	8806.37	17857.43
2 Forestry and fish	0.00070	0.00039	0.00048	0.00080	0.00029	0.00067	10.09	0.42	1.67	4.52	2.52	0.00	0.00	28.22	5.96	7.23	0.59	0.83	2.05	2.05	20.54	39.98
3 Mining	0.00042	0.00018	0.00065	0.00105	0.00035	0.00175	37.82	0.78	8.14	21.86	13.66	0.00	0.00	177.81	41.37	39.40	0.19	2.07	8.77	8.77	14.19	20.56
4 Services to minir	0.00003	0.00002	0.00004	0.00007	0.00003	0.00011	23.95	0.05	0.51	35.32	0.84	0.00	0.00	10.87	2.55	2.42	0.02	12.73	0.53	0.53	1.01	1.56
5 Meat and diary p	0.00159	0.00093	0.00113	0.00114	0.00103	0.00172	19.36	1.00	4.93	5.39	4.28	0.00	0.00	34.23	7.80	12.16	1.57	0.84	5.83	5.83	55.24	107.08
6 Other food prod.	0.00119	0.00096	0.00096	0.00182	0.00089	0.00448	17.72	0.86	4.43	5.14	3.58	0.00	0.00	28.10	6.40	31.72	8.54	0.96	5.20	5.20	278.08	559.57
7 Beverage and tot	0.00177	0.00271	0.00141	0.00314	0.00077	0.00144	22.60	1.23	6.61	5.60	4.65	0.00	0.00	30.40	7.13	8.58	0.48	0.96	7.72	7.72	21.73	37.40
8 Textile, clothing,	0.00232	0.00071	0.00176	0.00413	0.00474	0.00622	41.42	1.61	6.92	19.86	13.92	0.00	0.00	160.66	40.80	36.49	0.68	2.01	8.39	8.39	28.56	50.96
9 Wood, paper, pri	0.04294	0.01681	0.02786	0.05560	0.01651	0.03264	390.08	19.50	69.18	172.91	137.56	0.00	0.00	1565.00	325.02	329.28	3.79	14.65	87.24	87.23	189.12	313.95
10 Basic chemical	0.00174	0.00059	0.00218	0.00247	0.00224	0.00492	90.08	12.88	214.60	33.96	39.36	0.00	0.00	209.28	54.50	70.90	8.58	5.56	224.26	224.25	486.09	768.59
11 Other chem., rub	0.01672	0.00305	0.01122	0.02019	0.01289	0.02212	348.36	24.49	104.23	149.68	103.55	0.00	0.00	937.22	208.73	206.65	9.62	27.84	126.80	126.79	410.46	727.36
12 Non-metalic min	0.00135	0.00088	0.00410	0.00432	0.00140	0.00286	343.53	2.43	4.01	117.39	85.22	0.00	0.00	1074.43	209.02	258.74	0.42	3.47	6.05	6.04	17.10	30.96
13 Iron and steel	0.00525	0.00110	0.00456	0.00583	0.00216	0.00451	439.93	5.49	9.04	281.01	189.41	0.00	0.00	2711.22	737.13	573.52	0.60	15.25	13.96	13.96	27.66	47.39
14 Basic non-ferrou	0.00235	0.00038	0.00123	0.00410	0.00078	0.00182	128.80	1.59	3.73	83.43	59.70	0.00	0.00	815.07	236.34	181.78	0.23	2.76	5.14	5.14	10.90	18.46
15 Fabricated metal	0.00898	0.00182	0.00707	0.00877	0.00348	0.00779	962.81	12.53	26.96	712.80	523.31	0.00	0.00	3546.89	1828.11	1600.29	1.39	15.97	38.15	38.14	70.04	115.72
16 Transport equip.	0.00512	0.00092	0.00159	0.01906	0.00107	0.00202	66.94	4.26	16.83	28.78	15.12	0.00	0.00	121.63	26.68	23.91	0.75	7.30	20.77	20.77	40.49	65.15
17 Other equip., ma	0.05424	0.00864	0.01788	0.02974	0.02261	0.04101	3827.31	14.89	36.88	2204.09	1527.28	0.00	0.00	37368.19	7539.24	4805.93	3.90	71.37	47.57	47.56	157.65	286.18
18 Water and sewer	0.00131	0.00157	0.01073	0.00458	0.00394	0.00414	233.45	15.71	32.68	18.06	39.08	0.00	0.00	93.95	22.00	30.61	1.36	2.57	47.64	47.63	75.37	120.04
19 Construction	0.00152	0.00162	0.01050	0.01091	0.00123	0.00193	1129.98	5.85	6.45	910.83	678.24	0.00	0.00	8627.14	1493.65	2137.88	1.36	5.75	11.12	11.11	48.80	93.56
20 Trade and repair	0.08285	0.01474	0.02540	0.03375	0.03087	0.04405	1172.33	48.18	192.15	342.99	237.41	0.00	0.00	2392.19	524.72	510.30	17.58	55.99	236.28	236.26	751.09	1330.07
21 Accomodation, c	0.01706	0.01570	0.01642	0.02036	0.00598	0.01551	238.02	10.35	74.95	59.21	45.62	0.00	0.00	332.54	80.43	90.72	3.22	9.34	83.95	83.95	176.62	282.56
22 Road transport	0.01842	0.00274	0.00658	0.01142	0.00618	0.01492	271.53	6.75	134.68	130.13	63.71	0.00	0.00	758.72	170.55	189.93	9.46	23.12	139.20	139.20	435.58	747.31
23 Rail, pipeline	0.00252	0.00102	0.00179	0.00140	0.00095	0.00126	235.96	32.05	21.28	78.49	72.20	0.00	0.00	139.88	33.82	33.73	1.22	24.43	52.69	52.68	59.83	100.15
24 Water transport	0.00152	0.00018	0.00065	0.00187	0.00055	0.00087	34.55	2.10	282.59	11.06	7.00	0.00	0.00	41.11	10.84	9.92	0.22	2.66	280.55	280.55	285.46	292.68
25 Air and space tra	0.02248	0.00810	0.01143	0.02318	0.00518	0.01085	174.38	11.90	52.04	45.48	41.30	0.00	0.00	279.12	63.22	62.10	1.53	7.92	62.99	62.98	99.94	150.19
26 Services to trans|	0.01617	0.00948	0.01555	0.01827	0.00495	0.00779	160.84	8.71	153.68	76.96	44.05	0.00	0.00	337.51	85.67	96.97	3.54	15.10	159.97	159.97	264.69	381.33
27 Communication	1.02773	0.02627	0.02436	0.04562	0.01840	0.03290	420.31	25.27	48.50	89.21	87.47	0.00	0.00	555.40	127.15	135.21	4.59	14.19	72.59	72.58	194.40	345.66
28 Finance and insu	0.03069	1.23077	0.06343	0.06201	0.02372	0.04095	1617.71	81.50	86.31	255.98	260.11	0.00	0.00	1375.54	300.39	356.61	11.78	44.93	164.76	164.73	460.72	848.92
29 Property and bus	0.10375	0.10811	1.24145	0.14813	0.06805	0.14192	2420.48	389.68	283.14	945.29	1283.41	0.00	0.00	3543.09	789.52	1721.89	19.57	91.75	665.13	664.98	902.30	1547.07
30 Govt. admin and	0.00523	0.00143	0.00299	1.05153	0.00208	0.00205	38.62	1.70	28.76	18.67	8.86	0.00	0.00	72.41	17.09	19.44	0.58	4.17	30.00	30.00	46.96	66.16
31 Education, healtł	0.00203	0.00453	0.00267	0.00437	1.01096	0.00419	81.56	3.23	10.08	50.53	9.97	0.00	0.00	51.10	11.66	13.91	0.75	16.92	13.07	13.07	33.94	58.71
32 Personal and oth	0.00532	0.00783	0.01631	0.01037	0.00862	1.06837	125.81	8.85	19.87	51.22	31.72	0.00	0.00	175.05	40.70	48.64	0.89	11.84	28.29	28.29	47.79	76.95
33 Electricity	2.8E-07	2.7E-07	3.0E-07	3.2E-07	2.4E-07	3.0E-07	1.0E+00	2.6E-04	1.9E-03	8.8E-03	1.7E-03	0.0E+00	0.0E+00	1.7E-02	4.4E-03	4.4E-03	2.5E-04	2.7E-03	1.2E-03	1.2E-03	8.9E-03	1.7E-02
34 Gas supply	2.4E-07	1.9E-07	2.4E-07	2.8E-07	2.0E-07	2.9E-07	4.0E-01	1.0E+00	7.3E-03	5.4E-03	2.0E+00	0.0E+00	0.0E+00	2.2E-02	5.9E-03	5.7E-03	2.2E-04	1.2E-03	1.0E+00	1.0E+00	1.0E-02	1.7E-02
35 Petroleum Produ	5.5E-07	1.9E-07	3.0E-07	5.1E-07	2.1E-07	4.1E-07	1.3E-02	5.1E-04	1.0E+00	1.1E-02	2.4E-03	0.0E+00	0.0E+00	2.0E-02	4.6E-03	5.6E-03	3.9E-04	3.3E-03	7.4E-03	7.4E-03	1.9E-02	3.2E-02
36 Coal pl.	1.8E-07	1.7E-07	1.9E-07	2.0E-07	1.5E-07	1.9E-07	6.4E-01	1.7E-04	1.2E-03	1.0E+00	1.1E-03	0.0E+00	0.0E+00	1.1E-02	2.8E-03	2.8E-03	1.6E-04	1.7E-03	7.5E-04	7.5E-04	5.6E-03	1.1E-02
37 GasPl	5.6E-08	5.3E-08	5.9E-08	6.3E-08	4.7E-08	6.0E-08	2.0E-01	5.1E-05	3.8E-04	1.7E-03	1.0E+00	0.0E+00	0.0E+00	3.3E-03	8.7E-04	8.7E-04	4.9E-05	5.3E-04	2.3E-04	2.3E-04	1.8E-03	3.4E-03
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	1.2E-08	1.2E-08	1.3E-08	1.4E-08	1.0E-08	1.3E-08	4.4E-02	1.1E-05	8.2E-05	3.8E-04	7.1E-05	0.0E+00	1.0E+00	7.3E-04	1.9E-04	1.9E-04	1.1E-05	1.2E-04	5.1E-05	5.1E-05	3.8E-04	7.4E-04
40 PV pl.	4.4E-09	4.2E-09	4.6E-09	4.9E-09	3.7E-09	4.7E-09	1.6E-02	4.0E-06	2.9E-05	1.4E-04	2.6E-05	0.0E+00	0.0E+00	1.0E+00	6.8E-05	6.8E-05	3.8E-06	4.2E-05	1.8E-05	1.8E-05	1.4E-04	2.6E-04
41 Wind	2.3E-08	2.2E-08	2.4E-08	2.6E-08	1.9E-08	2.4E-08	8.1E-02	2.1E-05	1.5E-04	7.1E-04	1.3E-04	0.0E+00	0.0E+00	1.4E-03	1.0E+00	3.5E-04	2.0E-05	2.2E-04	9.4E-05	9.4E-05	7.1E-04	1.4E-03
42 Biomass Plant	1.7E-08	1.6E-08	1.7E-08	1.9E-08	1.4E-08	1.8E-08	6.0E-02	1.5E-05	1.1E-04	5.2E-04	9.8E-05	0.0E+00	0.0E+00	1.0E-03	2.6E-04	1.0E+00	1.5E-05	1.6E-04	6.9E-05	6.9E-05	5.2E-04	1.0E-03
43 Biomass	8.6E-08	5.8E-08	7.1E-08	9.2E-08	5.7E-08	8.4E-08	1.8E-01	6.1E-05	5.0E-04	1.8E-03	4.2E-04	0.0E+00	0.0E+00	4.5E-03	1.1E-03	3.0E+00	1.0E+00	5.1E-04	3.8E-04	3.8E-04	1.0E+00	4.0E-03
44 Coal	5.4E-07	4.8E-07	5.6E-07	6.2E-07	4.4E-07	5.7E-07	1.7E+00	5.0E-04	3.3E-03	2.7E+00	4.4E-03	0.0E+00	0.0E+00	5.1E-02	1.3E-02	1.2E-02	4.3E-04	1.0E+00	2.2E-03	2.2E-03	1.6E-02	3.0E-02
45 CNG	1.7E-08	2.5E-09	6.0E-09	1.0E-08	5.6E-09	1.4E-08	2.5E-04	6.1E-06	1.2E-04	1.2E-04	5.8E-05	0.0E+00	0.0E+00	6.9E-04	1.5E-04	1.7E-04	8.6E-06	2.1E-05	1.0E+00	1.3E-04	4.0E-04	6.8E-04
46 Methanol	3.6E-09	5.3E-10	1.3E-09	2.2E-09	1.2E-09	2.9E-09	5.3E-05	1.3E-06	2.6E-05	2.5E-05	1.2E-05	0.0E+00	0.0E+00	1.5E-04	3.3E-05	3.7E-05	1.8E-06	4.5E-06	2.7E-05	1.0E+00	8.5E-05	1.5E-04
47 Ethanol	1.8E-08	2.6E-09	6.3E-09	1.1E-08	5.9E-09	1.4E-08	2.6E-04	6.5E-06	1.3E-04	1.2E-04	6.1E-05	0.0E+00	0.0E+00	7.3E-04	1.6E-04	1.8E-04	9.1E-06	2.2E-05	1.3E-04	1.3E-04	1.0E+00	7.2E-04
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00

Table D-18: Direct Requirement Coefficient Matrix 'A' for Advanced Scenario in 2020

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
	Agri., hui	Forestry a	Mining	Services t	Meat and	Other foo	Beverage	Textile, c	Wood, pa	Basic che	Other che	Non-meta	Iron and s	Basic nor	Fabricate	Transport	Other equ	Water and	Construct	Trade and	Accomoc	Road trar	Rail, pipe	Water tra	Air and sp	Services t
1 Agri., hunting and trapping	0.08562	0.00426	0.00001	0.00000	0.33581	0.05897	0.05258	0.03446	0.00002	0.00091	0.00260	0.00000	0.00000	0.00000	0.00002	0.00000	0.00037	0.00007	0.00044	0.00032	0.00254	0.00000	0.00004	0.00000	0.00000	0.00010
2 Forestry and fishing	0.00172	0.05598	0.00056	0.00001	0.00000	0.00025	0.00000	0.00000	0.00932	0.00035	0.00012	0.00000	0.00000	0.00020	0.00000	0.00000	0.00015	0.00001	0.00011	0.00068	0.00822	0.00004	0.00210	0.00000	0.00000	0.00002
3 Mining	0.00031	0.00049	0.01275	0.00691	0.00005	0.00206	0.00002	0.00003	0.00005	0.00320	0.00018	0.02486	0.00499	0.06319	0.00112	0.00008	0.00090	0.00170	0.00496	0.00012	0.00043	0.00010	0.00022	0.00022	0.00005	0.00011
4 Services to mining	0.00000	0.00000	0.05694	0.01135	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5 Meat and diary prod.	0.00363	0.00057	0.00002	0.00006	0.05119	0.02803	0.00020	0.00787	0.00000	0.00305	0.00133	0.00000	0.00001	0.00000	0.00004	0.00008	0.00004	0.00023	0.00010	0.00629	0.02707	0.00004	0.00041	0.00016	0.00006	0.00004
6 Other food prod.	0.02686	0.02519	0.00023	0.00117	0.00937	0.11036	0.00567	0.00007	0.00001	0.00256	0.00301	0.00001	0.00001	0.00001	0.00006	0.00003	0.00004	0.00017	0.00003	0.00349	0.01913	0.00006	0.00020	0.00010	0.00013	0.00007
7 Beverage and tobacco	0.00074	0.00140	0.00029	0.00031	0.00124	0.00240	0.04318	0.00054	0.00033	0.00048	0.00013	0.00011	0.00008	0.00003	0.00007	0.00014	0.00008	0.00044	0.00010	0.00044	0.05759	0.00015	0.00033	0.00013	0.00027	0.00020
8 Textile, clothing, leather	0.00148	0.00638	0.00107	0.00032	0.00141	0.00374	0.00100	0.09185	0.00155	0.00133	0.00191	0.00107	0.00190	0.00096	0.00650	0.00131	0.00210	0.00033	0.00205	0.00194	0.00727	0.00091	0.00594	0.00182	0.00045	0.00075
9 Wood, paper, printing	0.00451	0.00946	0.00340	0.01103	0.01451	0.01440	0.01880	0.01079	0.15019	0.00494	0.01113	0.00984	0.00388	0.00213	0.01301	0.00614	0.01629	0.00485	0.04974	0.04228	0.01988	0.00426	0.01308	0.00572	0.00358	0.00661
10 Basic chemical	0.02601	0.00092	0.01015	0.00492	0.00028	0.00090	0.00041	0.00520	0.00594	0.10694	0.03313	0.00481	0.00217	0.00472	0.00836	0.00342	0.00217	0.01421	0.00071	0.00010	0.00034	0.00011	0.00180	0.00007	0.00001	0.00005
11 Other chem., rubber, plastic	0.02603	0.02033	0.02044	0.00645	0.02709	0.02794	0.01655	0.01035	0.03312	0.03114	0.11899	0.01195	0.01442	0.00379	0.01370	0.02007	0.01260	0.02602	0.01402	0.00461	0.01025	0.00836	0.00398	0.00445	0.00411	0.00246
12 Non-metalic mineral	0.00001	0.01815	0.00245	0.00401	0.00002	0.00340	0.01430	0.00024	0.00126	0.00021	0.00147	0.12437	0.01015	0.00545	0.01013	0.00322	0.00317	0.01060	0.08481	0.00263	0.00102	0.00039	0.00009	0.00000	0.00001	0.00009
13 Iron and steel	0.00001	0.00051	0.00357	0.03126	0.00001	0.00003	0.00002	0.00058	0.00042	0.00020	0.00022	0.00632	0.19323	0.00333	0.14095	0.05033	0.04077	0.00246	0.01606	0.00064	0.00004	0.00006	0.00401	0.00013	0.00002	0.00005
14 Basic non-ferrous	0.00001	0.00008	0.00091	0.00022	0.00027	0.00024	0.00005	0.00073	0.00160	0.00098	0.00208	0.00169	0.02494	0.20879	0.04687	0.00836	0.01062	0.00035	0.00055	0.00021	0.00028	0.00002	0.00034	0.00001	0.00001	0.00004
15 Fabricated metal	0.00170	0.02601	0.01431	0.02336	0.00320	0.00531	0.02022	0.00306	0.00618	0.00283	0.00300	0.01380	0.00576	0.00115	0.08742	0.01527	0.01216	0.01805	0.04919	0.00325	0.00180	0.00454	0.05654	0.02499	0.00190	0.00308
16 Transport equip.	0.00083	0.00714	0.00328	0.00386	0.00007	0.00022	0.00009	0.00007	0.00018	0.00019	0.00013	0.00090	0.00063	0.00005	0.00036	0.17014	0.00124	0.00016	0.00029	0.00545	0.00120	0.00857	0.06990	0.01681	0.04074	0.00470
17 Other equip., manufacturing	0.00566	0.12058	0.07077	0.03058	0.00192	0.00469	0.00231	0.00630	0.00903	0.00256	0.00464	0.00495	0.00773	0.01167	0.01984	0.03796	0.07376	0.01225	0.05749	0.00836	0.02012	0.00741	0.02172	0.00308	0.00069	0.01557
18 Water and sewerage	0.00347	0.00046	0.00117	0.00015	0.00426	0.00207	0.00227	0.00141	0.00114	0.00160	0.00145	0.00134	0.00276	0.00094	0.00129	0.00096	0.00073	0.06793	0.00069	0.00057	0.00400	0.00002	0.00003	0.00238	0.00001	0.00002
19 Construction	0.00315	0.00047	0.00879	0.00148	0.00003	0.00006	0.00008	0.00008	0.00015	0.00011	0.00008	0.00020	0.00013	0.00004	0.00009	0.00014	0.00004	0.00035	0.00070	0.00073	0.00419	0.00032	0.01115	0.00062	0.00029	0.00130
20 Trade and repair	0.04741	0.13090	0.04799	0.04159	0.04543	0.06916	0.03453	0.05310	0.04300	0.03401	0.03571	0.02418	0.01562	0.01064	0.03723	0.02389	0.03443	0.04035	0.05269	0.04030	0.03553	0.07115	0.03934	0.01187	0.03158	0.02869
21 Accomodation, café	0.00773	0.00438	0.00422	0.03522	0.00072	0.00817	0.05037	0.00705	0.00964	0.00444	0.00849	0.00586	0.00358	0.00260	0.00964	0.00288	0.00291	0.00373	0.00429	0.01063	0.00275	0.00738	0.00268	0.00445	0.00713	0.00820
22 Road transport	0.02634	0.01046	0.02582	0.01221	0.07414	0.03629	0.02947	0.01038	0.01640	0.00994	0.00833	0.09555	0.01953	0.00919	0.01227	0.00301	0.00602	0.00410	0.01600	0.01717	0.00553	0.08859	0.00503	0.00142	0.00974	0.01425
23 Rail, pipeline	0.00349	0.00034	0.00182	0.00038	0.00299	0.00620	0.00309	0.00267	0.00095	0.00224	0.00224	0.01806	0.01380	0.01310	0.00168	0.00040	0.00093	0.00026	0.00132	0.00120	0.00138	0.00009	0.00093	0.00006	0.00157	0.00147
24 Water transport	0.00013	0.00128	0.00016	0.02467	0.00005	0.00097	0.00021	0.00083	0.00054	0.00048	0.00025	0.00096	0.00192	0.00426	0.00098	0.00008	0.00024	0.00003	0.00005	0.00027	0.00006	0.00007	0.00008	0.22945	0.00021	0.00005
25 Air and space travel	0.00238	0.00158	0.00465	0.01402	0.00033	0.00555	0.00201	0.00970	0.00869	0.00216	0.00357	0.00189	0.00174	0.00151	0.00369	0.00230	0.00352	0.00539	0.00069	0.01368	0.00205	0.00138	0.00043	0.00313	0.06096	0.00353
26 Services to transport	0.00697	0.00263	0.00152	0.00325	0.00471	0.01327	0.01318	0.00528	0.01407	0.01000	0.00828	0.00540	0.00611	0.00241	0.01130	0.00336	0.00114	0.00108	0.00334	0.02908	0.00520	0.01219	0.00225	0.13997	0.07006	0.03303
27 Communication	0.00909	0.00634	0.01428	0.01239	0.00601	0.00638	0.00410	0.00553	0.00967	0.00225	0.00427	0.00790	0.00303	0.00140	0.00853	0.00370	0.00585	0.00984	0.00295	0.03952	0.02092	0.02856	0.00819	0.00821	0.00916	0.02311
28 Finance and insurance	0.02571	0.02686	0.01842	0.02341	0.00663	0.02119	0.01175	0.00640	0.01050	0.00379	0.00638	0.00751	0.00614	0.00803	0.00817	0.00592	0.00367	0.06138	0.01794	0.03407	0.02819	0.01358	0.03368	0.01420	0.01500	0.01156
29 Property and business	0.02821	0.01508	0.02296	0.20643	0.03166	0.03429	0.03879	0.03511	0.06015	0.02472	0.06288	0.02977	0.06515	0.03085	0.04280	0.03404	0.02164	0.04407	0.08752	0.18905	0.11147	0.07848	0.10582	0.06678	0.07554	0.09111
30 Govt. admin and defence	0.00083	0.00256	0.00535	0.00140	0.00105	0.00220	0.00112	0.00038	0.00379	0.00099	0.00044	0.00066	0.00159	0.00026	0.00137	0.00129	0.00032	0.00221	0.00122	0.00173	0.00047	0.01317	0.00278	0.00045	0.00013	0.00868
31 Education, health, communi	0.00199	0.00060	0.00063	0.00143	0.00264	0.00087	0.00183	0.00371	0.00168	0.00053	0.00306	0.00074	0.00063	0.00042	0.00064	0.00087	0.00047	0.00087	0.00039	0.00080	0.00096	0.00070	0.00123	0.00101	0.00069	0.00248
32 Personal and other services	0.00061	0.00234	0.00095	0.00270	0.00225	0.00330	0.00460	0.00369	0.00567	0.00104	0.00389	0.00209	0.00050	0.00029	0.00284	0.00329	0.00141	0.00153	0.00056	0.00906	0.01401	0.00207	0.00108	0.00103	0.00131	0.00169
33 Electricity	3.0E-07	3.0E-07	1.1E-06	1.1E-06	2.4E-07	2.4E-07	2.4E-07	1.2E-07	2.7E-07	2.9E-06	4.0E-08	8.9E-07	5.5E-07	4.9E-06	3.6E-07	1.5E-07	1.5E-07	6.7E-07	5.2E-09	1.8E-07	1.8E-07	0.0E+00	1.5E-06	0.0E+00	0.0E+00	0.0E+00
34 Gas supply	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.9E-07	2.9E-07	2.9E-07	7.5E-07	0.0E+00	1.1E-05	1.6E-07	2.3E-06	3.0E-06	1.6E-06	3.1E-07	3.1E-08	3.1E-08	2.6E-08	7.6E-09	4.1E-08	4.1E-08	0.0E+00	4.1E-07	0.0E+00	0.0E+00	4.8E-07
35 Petroleum Product	1.0E-06	1.0E-06	1.2E-06	1.2E-06	4.9E-08	4.9E-08	4.9E-08	1.3E-07	6.7E-09	1.1E-05	1.6E-07	4.9E-08	0.0E+00	5.9E-07	8.9E-08	1.7E-08	1.7E-08	7.7E-08	4.4E-07	4.0E-08	4.0E-08	9.1E-06	3.9E-06	8.2E-06	1.1E-05	0.0E+00
36 Coal pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
37 GasPl	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
40 PV pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
41 Wind	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
42 Biomass Plant	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
43 Biomass	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.4E-07	1.4E-07	1.4E-07	3.8E-07	3.9E-07	0.0E+00	0.0E+00	5.5E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
44 Coal	0.0E+00	0.0E+00	3.3E-09	3.3E-09	1.1E-07	1.1E-07	1.1E-07	2.8E-07	1.5E-07	0.0E+00	0.0E+00	1.5E-06	4.6E-06	1.4E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.9E-09	3.9E-09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
45 CNG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.2E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
46 Methanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
47 Ethanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	9.6E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Source: Direct requirement coefficients are computed in this research as described in Section 5-2 and 5-4 (Chapter 5)

(contd ...)

Table D-18: Direct Requirement Coefficient Matrix 'A' for Advanced Scenario in 2020 (...contd)

	27 Commun	28 Finance a	29 Property :	30 Govt. adr	31 Educatioi	32 Personal :	33 Electricit	34 Gas supp	35 Petroleun	36 Coal pl.	37 GasPl	38 Oil Pl.	39 Hydro	40 PV pl.	41 Wind	42 Biomass Pla	43 Biomass	44 Coal	45 CNG	46 Methanol	47 Ethanol	48 Biodiesel
1 Agri., hunting an	0.00000	0.00006	0.00033	0.00079	0.00021	0.00334	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	250.00	0.00	0.00	0.00	7758.62	16244.31
2 Forestry and fish	0.00004	0.00005	0.00002	0.00002	0.00003	0.00013	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.00	0.00
3 Mining	0.00006	0.00004	0.00023	0.00042	0.00016	0.00128	3.51	0.32	6.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.37	6.37	6.37	6.37	6.37
4 Services to minir	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.41	0.00	0.00	0.00	0.00
5 Meat and diary p	0.00038	0.00022	0.00029	0.00010	0.00049	0.00059	0.85	0.08	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.22	0.22	0.22	0.22
6 Other food prod.	0.00024	0.00030	0.00021	0.00079	0.00041	0.00300	1.05	0.08	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.44	0.44	0.44	0.44
7 Beverage and tol	0.00054	0.00132	0.00020	0.00154	0.00029	0.00029	2.67	0.30	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	1.34	1.34	1.34	1.34
8 Textile, clothing,	0.00127	0.00018	0.00085	0.00275	0.00386	0.00461	6.41	0.39	2.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.78	2.88	2.88	2.88	2.88
9 Wood, paper, pri	0.02790	0.00826	0.01542	0.03712	0.00960	0.01906	49.88	4.82	32.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.97	32.42	32.42	32.42	32.42
10 Basic chemical	0.00019	0.00005	0.00074	0.00048	0.00111	0.00261	26.21	9.62	184.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.52	182.07	182.07	182.07	182.07
11 Other chem., rub	0.01005	0.00027	0.00546	0.01153	0.00890	0.01411	115.49	16.09	71.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.52	70.35	70.35	70.35	70.35
12 Non-metalic min	0.00007	0.00014	0.00172	0.00177	0.00060	0.00136	162.04	0.23	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.06	0.06	0.06	0.06
13 Iron and steel	0.00021	0.00001	0.00127	0.00075	0.00009	0.00040	21.55	0.99	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.87	0.04	0.04	0.04	0.04
14 Basic non-ferrou	0.00051	0.00001	0.00016	0.00189	0.00005	0.00031	0.49	0.12	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.13	0.13	0.13	0.13
15 Fabricated metal	0.00547	0.00021	0.00351	0.00437	0.00170	0.00433	57.11	6.37	7.94	531.84	396.07	0.00	0.00	2253.36	1478.77	1267.51	0.00	8.26	7.86	7.86	7.86	7.86
16 Transport equip.	0.00217	0.00005	0.00022	0.01344	0.00022	0.00045	7.49	0.18	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.06	1.78	1.78	1.78	1.78
17 Other equip., ma	0.04407	0.00287	0.00918	0.01798	0.01704	0.02982	535.22	4.67	8.92	1772.79	1320.24	0.00	0.00	33800.39	6802.33	4225.05	0.00	51.08	8.82	8.82	8.82	8.82
18 Water and sewer	0.00001	0.00033	0.00778	0.00254	0.00289	0.00222	180.01	11.26	25.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	25.24	25.24	25.24	25.24
19 Construction	0.00010	0.00026	0.00802	0.00870	0.00031	0.00023	19.17	1.91	0.51	886.40	660.12	0.00	0.00	8562.77	1478.77	2112.52	0.00	1.55	0.51	0.51	0.51	0.51
20 Trade and repair	0.06681	0.00601	0.01243	0.01598	0.02271	0.02778	619.13	31.15	129.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	37.78	128.43	128.43	128.43	128.43
21 Accomodation, c	0.01264	0.01074	0.01115	0.01440	0.00355	0.01048	116.59	2.93	58.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.38	58.20	58.20	58.20	58.20
22 Road transport	0.01216	0.00039	0.00230	0.00525	0.00336	0.00894	63.97	1.82	106.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.12	104.95	104.95	104.95	104.95
23 Rail, pipeline	0.00177	0.00051	0.00101	0.00046	0.00054	0.00046	152.85	31.04	18.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.98	17.92	17.92	17.92	17.92
24 Water transport	0.00087	0.00000	0.00027	0.00107	0.00028	0.00038	15.52	1.28	214.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.79	212.50	212.50	212.50	212.50
25 Air and space tra	0.01757	0.00467	0.00714	0.01715	0.00296	0.00649	74.62	6.16	37.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.04	37.43	37.43	37.43	37.43
26 Services to trans|	0.00855	0.00514	0.00953	0.01042	0.00180	0.00199	11.48	0.32	88.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.95	87.05	87.05	87.05	87.05
27 Communication	0.01884	0.01796	0.01563	0.03520	0.01388	0.02372	208.47	13.16	16.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.44	16.77	16.77	16.77	16.77
28 Finance and insu	0.01472	0.18195	0.03812	0.03752	0.01359	0.02175	965.52	45.60	31.51	35.46	26.40	0.00	0.00	450.67	95.58	84.50	0.00	24.13	31.17	31.17	31.17	31.17
29 Property and bus	0.05173	0.06331	0.17643	0.08779	0.04058	0.08665	703.23	291.02	98.39	319.10	237.64	0.00	0.00	0.00	0.00	760.51	0.00	38.23	97.32	97.32	97.32	97.32
30 Govt. admin and	0.00387	0.00065	0.00179	0.04784	0.00144	0.00090	8.84	0.21	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.77	21.66	21.66	21.66	21.66
31 Education, health	0.00130	0.00333	0.00169	0.00323	0.01041	0.00319	33.45	1.89	7.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.82	6.95	6.95	6.95	6.95
32 Personal and oth	0.00200	0.00445	0.01136	0.00605	0.00645	0.06115	36.15	2.42	9.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.34	9.32	9.32	9.32	9.32
33 Electricity	1.8E-07	1.8E-07	1.8E-07	1.8E-07	1.8E-07	1.8E-07	0.0E+00	0.0E+00	9.9E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.8E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00
34 Gas supply	4.1E-08	4.1E-08	4.1E-08	4.1E-08	4.1E-08	4.1E-08	0.0E+00	0.0E+00	3.9E-03	0.0E+00	2.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00
35 Petroleum Produ	4.0E-08	4.0E-08	4.0E-08	4.0E-08	4.0E-08	4.0E-08	0.0E+00	0.0E+00	3.9E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.1E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00
36 Coal pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
37 GasPl	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.0E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.8E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
40 PV pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.4E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
41 Wind	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.9E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
42 Biomass Plant	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.5E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
43 Biomass	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	0.0E+00
44 Coal	3.9E-09	3.9E-09	3.9E-09	3.9E-09	3.9E-09	3.9E-09	0.0E+00	0.0E+00	0.0E+00	2.4E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	8.5E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00
45 CNG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
46 Methanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
47 Ethanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Table D-19: Total Requirement Coefficient Matrix '(I-A)-1' for Advanced Scenario in 2020

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
	Agri., hui	Forestry :	Mining	Services 1	Meat and	Other foo	Beverage	Textile, c	Wood, pa	Basic che	Other che	Non-meta	Iron and :	Basic nor	Fabricate	Transport	Other equ	Water and	Construct	Trade and	Accomod	Road trar	Rail, pipe	Water tra	Air and sp	Services t
1 Agri., hunting and trapping	1.09901	0.00923	0.00132	0.00191	0.39135	0.08692	0.06294	0.04602	0.00150	0.00400	0.00506	0.00191	0.00103	0.00149	0.00150	0.00080	0.00114	0.00109	0.00174	0.00437	0.01978	0.01020	0.00148	0.00091	0.00083	0.00089
2 Forestry and fishing	0.00236	1.05987	0.00095	0.00075	0.00121	0.00102	0.00101	0.00048	0.01192	0.00072	0.00055	0.00044	0.00031	0.00059	0.00051	0.00028	0.00054	0.00030	0.00101	0.00158	0.00927	0.00045	0.00265	0.00034	0.00030	0.00033
3 Mining	0.00076	0.00191	1.01414	0.00813	0.00057	0.00279	0.00086	0.00033	0.00057	0.00411	0.00078	0.02938	0.00944	0.08164	0.00745	0.00198	0.00263	0.00262	0.00839	0.00056	0.00091	0.00047	0.00123	0.00084	0.00039	0.00033
4 Services to mining	0.00005	0.00012	0.05841	1.01196	0.00004	0.00017	0.00005	0.00003	0.00004	0.00026	0.00005	0.00172	0.00062	0.00477	0.00045	0.00012	0.00016	0.00016	0.00049	0.00003	0.00006	0.00003	0.00008	0.00005	0.00002	0.00002
5 Meat and diary prod.	0.00629	0.00322	0.00100	0.00203	1.05723	0.03497	0.00292	0.01029	0.00114	0.00451	0.00271	0.00083	0.00064	0.00060	0.00115	0.00073	0.00064	0.00110	0.00110	0.00791	0.03025	0.00128	0.00131	0.00096	0.00089	0.00078
6 Other food prod.	0.03417	0.03144	0.00115	0.00286	0.02385	1.12808	0.01029	0.00230	0.00131	0.00407	0.00475	0.00073	0.00055	0.00055	0.00093	0.00059	0.00054	0.00094	0.00086	0.00504	0.02376	0.00126	0.00095	0.00075	0.00080	0.00066
7 Beverage and tobacco	0.00190	0.00255	0.00117	0.00320	0.00248	0.00406	1.04881	0.00149	0.00154	0.00128	0.00110	0.00099	0.00074	0.00068	0.00121	0.00071	0.00054	0.00123	0.00097	0.00184	0.06119	0.00123	0.00111	0.00111	0.00122	0.00109
8 Textile, clothing, leather	0.00270	0.00909	0.00229	0.00200	0.00331	0.00583	0.00255	1.10189	0.00296	0.00241	0.00309	0.00241	0.00343	0.00227	0.00916	0.00268	0.00317	0.00120	0.00381	0.00327	0.00918	0.00201	0.00797	0.00369	0.00130	0.00150
9 Wood, paper, printing	0.01501	0.02905	0.01572	0.02808	0.03090	0.03120	0.03268	0.02188	1.18631	0.01446	0.02204	0.02165	0.01302	0.01110	0.02672	0.01600	0.02624	0.01468	0.07126	0.06309	0.03619	0.01761	0.02759	0.01860	0.01308	0.01587
10 Basic chemical	0.03435	0.00436	0.01431	0.00804	0.01469	0.00626	0.00438	0.00904	0.01034	1.12505	0.04317	0.00853	0.00516	0.00937	0.01309	0.00692	0.00423	0.01927	0.00424	0.00189	0.00273	0.00407	0.00517	0.00383	0.00360	0.00086
11 Other chem., rubber, plastic	0.03835	0.03341	0.02993	0.01594	0.05037	0.04444	0.02712	0.01815	0.04853	0.04486	1.14020	0.02174	0.02474	0.01248	0.02568	0.03260	0.01948	0.03599	0.02559	0.01297	0.02048	0.01607	0.01314	0.01271	0.01038	0.00647
12 Non-metalic mineral	0.00153	0.02450	0.00588	0.00774	0.00156	0.00575	0.01850	0.00121	0.00317	0.00219	0.00284	1.14376	0.01595	0.01114	0.01667	0.00664	0.00548	0.01441	0.09941	0.00472	0.00413	0.00172	0.00416	0.00163	0.00111	0.00113
13 Iron and steel	0.00220	0.01567	0.01621	0.04864	0.00273	0.00325	0.00578	0.00289	0.00410	0.00347	0.00236	0.01490	1.24380	0.01149	0.19520	0.08251	0.05822	0.00916	0.03539	0.00438	0.00365	0.00359	0.02510	0.00993	0.00512	0.00302
14 Basic non-ferrous	0.00086	0.00514	0.00453	0.00472	0.00145	0.00159	0.00224	0.00182	0.00370	0.00254	0.00376	0.00479	0.04047	1.26595	0.07215	0.01767	0.01757	0.00275	0.00684	0.00153	0.00161	0.00121	0.00692	0.00330	0.00132	0.00102
15 Fabricated metal	0.00512	0.03561	0.02230	0.03211	0.00801	0.01026	0.02625	0.00588	0.01089	0.00874	0.00588	0.02260	0.01227	0.01211	1.10099	0.02319	0.01646	0.02401	0.05943	0.00746	0.00706	0.00816	0.06815	0.03881	0.00531	0.00561
16 Transport equip.	0.00297	0.01162	0.00637	0.00782	0.00321	0.00331	0.00205	0.00206	0.00237	0.00191	0.00157	0.00546	0.00376	0.00321	0.00271	1.20624	0.00278	0.00156	0.00243	0.00906	0.00302	0.01314	0.08566	0.02858	0.05391	0.00722
17 Other equip., manufacturing	0.01394	0.14715	0.09051	0.04859	0.01295	0.01435	0.01094	0.01280	0.02015	0.02066	0.01096	0.01935	0.02050	0.05164	0.03554	0.05558	1.08504	0.02242	0.07147	0.02007	0.03134	0.01641	0.04104	0.01461	0.00895	0.02285
18 Water and sewerage	0.00533	0.00211	0.00275	0.00379	0.00773	0.00435	0.00424	0.00290	0.00294	0.00408	0.00313	0.00307	0.00533	0.00379	0.00369	0.00256	0.00179	1.07423	0.00284	0.00342	0.00658	0.00198	0.00247	0.00525	0.00177	0.00144
19 Construction	0.00495	0.00216	0.01152	0.00598	0.00302	0.00207	0.00196	0.00139	0.00196	0.00503	0.00153	0.00308	0.00288	0.00947	0.00256	0.00148	0.00107	0.00237	1.00265	0.00363	0.00627	0.00206	0.01474	0.00261	0.00180	0.00278
20 Trade and repair	0.06982	0.16560	0.06977	0.06444	0.08972	0.10269	0.05642	0.07258	0.06685	0.05431	0.05247	0.05046	0.03331	0.03365	0.06025	0.04146	0.04725	0.05639	0.07612	1.06158	0.05799	0.09449	0.05945	0.03428	0.04831	0.04063
21 Accomodation, café	0.01278	0.01103	0.01084	0.04324	0.00919	0.01512	0.05752	0.01140	0.01579	0.00935	0.01311	0.01136	0.00830	0.00768	0.01564	0.00686	0.00587	0.00841	0.01069	0.01787	1.01126	0.01370	0.00870	0.01207	0.01250	0.01210
22 Road transport	0.03777	0.02388	0.03523	0.02145	0.10312	0.05596	0.04238	0.01833	0.02585	0.01817	0.01461	0.12487	0.03194	0.01997	0.02567	0.00977	0.01187	0.01023	0.03480	0.02597	0.01672	1.10361	0.01217	0.00987	0.01701	0.01914
23 Rail, pipeline	0.00479	0.00222	0.00313	0.00241	0.00547	0.00828	0.00459	0.00372	0.00196	0.00441	0.00325	0.02183	0.01888	0.01887	0.00658	0.00250	0.00254	0.00141	0.00449	0.00227	0.00265	0.00105	1.00253	0.00127	0.00253	0.00202
24 Water transport	0.00098	0.00262	0.00294	0.03345	0.00089	0.00194	0.00074	0.00154	0.00123	0.00466	0.00083	0.00223	0.00371	0.00787	0.00271	0.00068	0.00080	0.00045	0.00089	0.00084	0.00049	0.00368	0.00170	1.30107	0.00394	0.00032
25 Air and space travel	0.00604	0.00740	0.00952	0.02066	0.00538	0.01092	0.00555	0.01420	0.01427	0.00590	0.00703	0.00551	0.00507	0.00536	0.00813	0.00552	0.00622	0.00935	0.00546	0.02020	0.00661	0.00648	0.00493	0.00855	1.06852	0.00691
26 Services to transport	0.01415	0.01292	0.00834	0.01760	0.01579	0.02406	0.02055	0.01202	0.02345	0.01783	0.01475	0.01285	0.01283	0.00839	0.02005	0.00876	0.00553	0.00674	0.01177	0.03904	0.01281	0.02189	0.00963	0.19427	0.08323	1.03866
27 Communication	0.01819	0.02006	0.02395	0.02584	0.02126	0.01910	0.01387	0.01343	0.01997	0.00980	0.01142	0.01941	0.01078	0.01016	0.01824	0.01022	0.01128	0.01834	0.01415	0.05235	0.03093	0.04147	0.01799	0.02207	0.01845	0.03072
28 Finance and insurance	0.04641	0.05216	0.03754	0.05421	0.03613	0.04674	0.03023	0.02025	0.02856	0.01996	0.01986	0.02506	0.02287	0.03217	0.02633	0.01825	0.01270	0.09129	0.03876	0.06313	0.05217	0.03378	0.05867	0.03775	0.03219	0.02589
29 Property and business	0.07735	0.08744	0.08529	0.30557	0.10519	0.10277	0.09389	0.08130	0.12376	0.07474	0.11421	0.08748	0.12912	0.08800	0.11156	0.08158	0.05633	0.09331	0.15666	0.27502	0.17653	0.14714	0.17267	0.15320	0.13401	0.13842
30 Govt. admin and defence	0.00232	0.00435	0.00707	0.00327	0.00390	0.00450	0.00275	0.00141	0.00593	0.00242	0.00148	0.00349	0.00331	0.00179	0.00318	0.00248	0.00113	0.00334	0.00305	0.00382	0.00191	0.01656	0.00430	0.00348	0.00206	0.01035
31 Education, health, communi	0.00297	0.00166	0.00151	0.00275	0.00450	0.00216	0.00282	0.00477	0.00280	0.00146	0.00408	0.00164	0.00157	0.00146	0.00163	0.00167	0.00097	0.00180	0.00141	0.00207	0.00214	0.00167	0.00229	0.00256	0.00163	0.00317
32 Personal and other services	0.00349	0.00686	0.00406	0.00900	0.00625	0.00762	0.00863	0.00680	0.01029	0.00377	0.00735	0.00531	0.00344	0.00294	0.00645	0.00641	0.00340	0.00458	0.00489	0.01508	0.01916	0.00619	0.00536	0.00502	0.00467	0.00469
33 Electricity	5.2E-07	5.2E-07	1.3E-06	1.3E-06	5.2E-07	4.4E-07	4.0E-07	2.5E-07	4.4E-07	3.4E-06	2.6E-07	1.2E-06	1.0E-06	6.4E-06	1.0E-06	4.0E-07	3.5E-07	8.8E-07	2.9E-07	3.2E-07	3.3E-07	1.1E-07	1.6E-06	1.3E-07	1.0E-07	7.4E-08
34 Gas supply	9.8E-07	7.5E-07	1.6E-06	1.6E-06	1.1E-06	9.4E-07	8.8E-07	1.2E-06	6.3E-07	1.6E-05	9.8E-07	4.1E-06	4.9E-06	8.5E-06	2.3E-06	8.3E-07	6.6E-07	1.2E-06	7.6E-07	4.7E-07	4.9E-07	9.3E-07	2.3E-06	3.8E-07	2.8E-07	6.3E-07
35 Petroleum Product	2.0E-06	1.5E-06	2.0E-06	2.1E-06	1.7E-06	9.4E-07	6.7E-07	6.7E-07	5.9E-07	1.3E-05	9.3E-07	1.5E-06	5.9E-07	1.4E-06	7.0E-07	3.0E-07	2.9E-07	5.4E-07	9.5E-07	5.8E-07	3.8E-07	1.0E-05	4.2E-06	1.1E-05	1.2E-05	2.9E-07
36 Coal pl.	1.2E-07	1.2E-07	3.1E-07	3.1E-07	1.2E-07	1.0E-07	9.5E-08	5.8E-08	1.0E-07	8.0E-07	6.1E-08	2.9E-07	2.4E-07	1.5E-06	2.3E-07	9.4E-08	8.1E-08	2.1E-07	6.8E-08	7.5E-08	7.7E-08	2.7E-08	3.9E-07	3.0E-08	2.4E-08	1.7E-08
37 GasPl	2.6E-07	2.6E-07	6.6E-07	6.6E-07	2.6E-07	2.2E-07	2.0E-07	1.2E-07	2.2E-07	1.7E-06	1.3E-07	6.0E-07	5.1E-07	3.2E-06	5.0E-07	2.0E-07	1.7E-07	4.4E-07	1.4E-07	1.6E-07	1.6E-07	5.7E-08	8.2E-07	6.3E-08	5.0E-08	3.7E-08
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	2.5E-08	2.5E-08	6.3E-08	6.3E-08	2.5E-08	2.1E-08	1.9E-08	1.2E-08	2.1E-08	1.6E-07	1.2E-08	5.8E-08	4.9E-08	3.1E-07	4.8E-08	1.9E-08	1.7E-08	4.2E-08	1.4E-08	1.5E-08	1.6E-08	5.5E-09	7.9E-08	6.1E-09	4.8E-09	3.6E-09
40 PV pl.	1.3E-08	1.3E-08	3.2E-08	3.2E-08	1.3E-08	1.1E-08	9.8E-09	6.0E-09	1.1E-08	8.2E-08	6.3E-09	2.9E-08	2.5E-08	1.6E-07	2.4E-08	9.7E-09	8.4E-09	2.1E-08	7.0E-09	7.8E-09	7.9E-09	2.8E-09	4.0E-08	3.1E-09	2.4E-09	1.8E-09
41 Wind	3.6E-08	3.6E-08	9.2E-08	9.1E-08	3.6E-08	3.0E-08	2.8E-08	1.7E-08	3.0E-08	2.4E-07	1.8E-08	8.4E-08	7.1E-08	4.5E-07	6.9E-08	2.8E-08	2.4E-08	6.1E-08	2.0E-08	2.2E-08	2.3E-08	8.0E-09	1.1E-07	8.8E-09	6.9E-09	5.1E-09
42 Biomass Plant	7.7E-08	7.7E-08	2.0E-07	2.0E-07	7.7E-08	6.5E-08	6.0E-08	3.7E-08	6.5E-08	5.1E-07	3.8E-08	1.8E-07	1.5E-07	9.6E-07	1.5E-07	6.0E-08	5.1E-08	1.3E-07	4.3E-08	4.8E-08	4.9E-08	1.7E-08	2.5E-07	1.9E-08	1.5E-08	1.1E-08
43 Biomass	2.8E-07	2.8E-07	6.3E-07	6.2E-07	5.0E-07	4.3E-07	3.9E-07	5.6E-07	6.8E-07	1.5E-06	1.4E-07	7.3E-07	5.0E-07	2.9E-06	4.8E-07	2.0E-07	1.8E-07	4.1E-07	2.0E-07	2.0E-07	2.0E-07	1.1E-06	7.6E-07	7.5E-08	6.7E-08	5.9E-08
44 Coal	3.1E-07	4.2E-07	8.4E-07	1.0E-06	4.3E-07	4.1E-07	4.1E-07	4.8E-07	4.6E-07	1.9E-06	1.7E-07	2.5E-06	6.4E-06	5.5E-06	1.6E-06	6.5E-07	5.0E-07	5.7E-07	5.0E-07	2.3E-07	2.4E-07	9.1E-08	1.1E-06	1.3E-07	8.7E-08	6.3E-08
45 CNG	2.3E-08	1.5E-08	2.2E-08	1.3E-08	6.3E-08	3.4E-08	2.6E-08	1.1E-08	1.6E-08	1.1E-08	9.0E-09	7.7E-08	2.0E-08	1.2E-08	1.6E-08	6.0E-09	7.3E-09	6.3E-09	2.1E-08	1.6E-08	1.0E-08	6.8E-07	7.5E-09	6.1E-09	1.0E-08	1.2E-08
46 Methanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
47 Ethanol	3.6E-08	2.3E-08	3.4E-08	2.1E-08	9.9E-08	5.4E-08	4.1E-08	1.8E-08	2.5E-08	1.7E-08	1.4E-08	1.2E-07	3.1E-08	1.9E-08	2.5E-08	9.3E-09	1.1E-08	9.8E-09	3.3E-08	2.5E-08	1.6E-08	1.1E-06	1.2E-08	9.4E-09	1.6E-08	1.8E-08
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Source: Total requirement coefficients are computed in this research as described in Section 5-2 and 5-4 (Chapter 5)

(contd ...)

Table D-19: Total Requirement Coefficient Matrix '(I-A)-1' for Advanced Scenario in 2020 (...contd)

	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
	Commun	Finance a	Property :	Govt. adr	Educatioi	Personal :	Electricit	Gas supp	Petroleun	Coal pl.	GasPl	Oil Pl.	Hydro	PV pl.	Wind	Biomass Pla	Biomass	Coal	CNG	Methanol	Ethanol	Biodiesel
1 Agri., hunting an	0.00126	0.00086	0.00134	0.00218	0.00111	0.00551	142.72	0.96	5.15	8.01	5.47	0.00	0.00	57.09	12.61	835.79	274.75	1.33	5.90	4.93	8806.50	17857.62
2 Forestry and fish	0.00070	0.00039	0.00048	0.00080	0.00029	0.00067	9.81	0.42	1.67	4.28	2.52	0.00	0.00	28.21	5.95	7.23	0.59	0.83	2.05	1.63	20.50	39.91
3 Mining	0.00042	0.00018	0.00065	0.00105	0.00035	0.00175	37.68	0.78	8.14	21.28	13.66	0.00	0.00	177.78	41.36	39.38	0.19	2.08	8.77	7.99	14.07	20.32
4 Services to minir	0.00003	0.00001	0.00004	0.00006	0.00002	0.00010	9.34	0.05	0.48	31.41	0.81	0.00	0.00	10.55	2.46	2.34	0.01	12.69	0.51	0.47	0.85	1.24
5 Meat and diary p	0.00159	0.00093	0.00113	0.00114	0.00103	0.00172	19.75	1.00	4.93	5.16	4.28	0.00	0.00	34.22	7.80	12.16	1.57	0.85	5.83	4.84	55.19	106.97
6 Other food prod.	0.00119	0.00096	0.00096	0.00182	0.00089	0.00448	19.71	0.86	4.43	4.89	3.58	0.00	0.00	28.12	6.41	31.72	8.54	0.97	5.20	4.35	278.03	559.48
7 Beverage and tot	0.00177	0.00271	0.00141	0.00314	0.00077	0.00144	22.65	1.23	6.61	5.33	4.65	0.00	0.00	30.38	7.13	8.57	0.47	0.97	7.72	6.49	21.66	37.27
8 Textile, clothing,	0.00231	0.00071	0.00176	0.00413	0.00474	0.00622	41.76	1.61	6.92	19.30	13.91	0.00	0.00	160.64	40.79	36.47	0.68	2.02	8.38	6.77	28.43	50.69
9 Wood, paper, pri	0.04294	0.01681	0.02786	0.05560	0.01651	0.03264	401.07	19.49	69.20	168.96	137.54	0.00	0.00	1564.98	325.01	329.16	3.75	14.83	87.20	67.71	187.90	311.50
10 Basic chemical	0.00174	0.00059	0.00218	0.00247	0.00224	0.00491	95.61	12.88	214.58	32.57	39.36	0.00	0.00	209.16	54.48	70.91	8.59	5.68	224.19	211.31	486.44	769.37
11 Other chem., rub	0.01671	0.00304	0.01121	0.02018	0.01288	0.02211	342.10	24.47	104.21	141.64	103.50	0.00	0.00	936.83	208.63	206.47	9.59	27.96	126.73	102.25	409.42	725.29
12 Non-metalic min	0.00135	0.00088	0.00410	0.00432	0.00140	0.00286	352.38	2.42	4.03	116.66	85.20	0.00	0.00	1074.46	209.02	258.62	0.38	3.60	6.03	3.61	15.84	28.42
13 Iron and steel	0.00525	0.00111	0.00457	0.00583	0.00217	0.00451	450.76	5.48	9.06	276.86	189.39	0.00	0.00	2711.19	737.11	573.36	0.55	15.41	13.94	8.47	26.06	44.16
14 Basic non-ferrou	0.00235	0.00039	0.00123	0.00410	0.00078	0.00182	134.13	1.59	3.74	82.74	59.70	0.00	0.00	815.10	236.35	181.74	0.22	2.81	5.13	3.55	10.45	17.54
15 Fabricated metal	0.00898	0.00183	0.00707	0.00878	0.00348	0.00780	989.09	12.50	27.02	708.93	523.27	0.00	0.00	3546.96	1828.12	1599.97	1.28	16.34	38.10	25.60	66.58	108.72
16 Transport equip.	0.00512	0.00092	0.00159	0.01906	0.00107	0.00202	62.34	4.26	16.82	26.62	15.11	0.00	0.00	121.49	26.64	23.86	0.74	7.31	20.76	16.50	40.26	64.70
17 Other equip., ma	0.05429	0.00869	0.01794	0.02980	0.02265	0.04106	4079.24	14.82	37.40	2187.57	1527.30	0.00	0.00	37370.83	7539.89	4805.22	3.49	73.25	47.60	32.79	144.43	259.24
18 Water and sewer	0.00131	0.00157	0.01073	0.00458	0.00394	0.00414	241.16	15.70	32.70	17.55	39.07	0.00	0.00	94.00	22.01	30.55	1.33	2.67	47.62	31.92	74.62	118.52
19 Construction	0.00154	0.00164	0.01052	0.01094	0.00125	0.00195	1221.23	5.83	6.63	910.67	678.28	0.00	0.00	8628.29	1493.94	2137.76	1.24	6.35	11.15	5.31	44.96	85.73
20 Trade and repair	0.08283	0.01473	0.02539	0.03374	0.03086	0.04404	1163.50	48.15	192.13	327.16	237.29	0.00	0.00	2391.33	524.49	509.74	17.46	56.37	236.12	187.98	747.17	1322.21
21 Accomodation, c	0.01705	0.01570	0.01642	0.02036	0.00598	0.01551	237.56	10.35	74.94	56.64	45.60	0.00	0.00	332.37	80.39	90.62	3.20	9.44	83.91	73.57	175.94	281.21
22 Road transport	0.01841	0.00273	0.00657	0.01142	0.00618	0.01491	258.74	6.74	134.64	123.41	63.66	0.00	0.00	758.20	170.41	189.75	9.44	23.21	139.13	132.38	434.89	745.98
23 Rail, pipeline	0.00251	0.00102	0.00178	0.00139	0.00095	0.00125	228.35	32.04	21.27	71.32	72.17	0.00	0.00	139.60	33.75	33.59	1.20	24.48	52.65	20.61	58.96	98.39
24 Water transport	0.00151	0.00018	0.00065	0.00186	0.00055	0.00086	33.19	2.10	282.55	10.50	6.99	0.00	0.00	40.84	10.78	9.94	0.24	2.77	280.46	278.36	286.20	294.27
25 Air and space tra	0.02248	0.00810	0.01143	0.02318	0.00518	0.01085	175.38	11.90	52.04	43.29	41.29	0.00	0.00	279.03	63.19	62.03	1.51	7.99	62.96	51.06	99.44	149.19
26 Services to transı	0.01616	0.00947	0.01555	0.01826	0.00494	0.00778	152.91	8.70	153.65	72.62	44.01	0.00	0.00	337.14	85.57	96.88	3.54	15.18	159.90	151.20	264.51	381.03
27 Communication	1.02772	0.02627	0.02436	0.04561	0.01840	0.03289	425.56	25.26	48.52	85.35	87.44	0.00	0.00	555.30	127.12	135.05	4.55	14.34	72.54	47.29	192.97	342.78
28 Finance and insu	0.03068	1.23076	0.06343	0.06201	0.02372	0.04094	1631.10	81.45	86.35	243.86	260.00	0.00	0.00	1375.16	300.28	355.97	11.60	45.48	164.62	83.16	454.87	837.12
29 Property and bus	0.10378	0.10815	1.24149	0.14816	0.06808	0.14196	2600.15	389.64	283.50	921.39	1283.57	0.00	0.00	3545.48	790.14	1721.67	19.34	93.09	664.93	275.29	894.77	1531.81
30 Govt. admin and	0.00523	0.00143	0.00299	1.05152	0.00208	0.00205	35.69	1.70	28.75	17.45	8.85	0.00	0.00	72.30	17.07	19.41	0.58	4.18	29.98	28.29	46.89	66.02
31 Education, healtl	0.00203	0.00452	0.00266	0.00437	1.01096	0.00419	64.58	3.22	10.05	45.40	9.93	0.00	0.00	50.69	11.55	13.79	0.74	16.90	13.04	9.82	33.57	57.99
32 Personal and oth	0.00532	0.00783	0.01630	0.01037	0.00861	1.06836	119.42	8.85	19.86	47.74	31.70	0.00	0.00	174.84	40.64	48.55	0.87	11.86	28.26	19.42	47.34	76.05
33 Electricity	2.8E-07	2.7E-07	2.9E-07	3.1E-07	2.4E-07	3.0E-07	1.0E+00	2.2E-04	1.9E-03	8.7E-03	1.6E-03	0.0E+00	0.0E+00	1.7E-02	4.3E-03	4.0E-03	1.3E-04	3.0E-03	1.1E-03	8.9E-04	5.0E-03	9.3E-03
34 Gas supply	4.0E-07	3.4E-07	4.1E-07	4.6E-07	3.3E-07	4.5E-07	9.9E-01	1.0E+00	8.5E-03	1.1E-02	2.0E+00	0.0E+00	0.0E+00	3.4E-02	9.0E-03	8.3E-03	2.4E-04	3.1E-03	1.0E+00	3.6E-03	1.1E-02	1.9E-02
35 Petroleum Produ	5.3E-07	1.9E-07	3.0E-07	4.9E-07	2.0E-07	4.0E-07	9.8E-03	5.3E-04	1.0E+00	1.1E-02	2.4E-03	0.0E+00	0.0E+00	2.0E-02	4.4E-03	5.9E-03	5.0E-04	3.7E-03	7.2E-03	6.7E-03	2.3E-02	3.9E-02
36 Coal pl.	6.5E-08	6.3E-08	6.9E-08	7.4E-08	5.5E-08	7.0E-08	2.4E-01	5.3E-05	4.5E-04	1.0E+00	3.7E-04	0.0E+00	0.0E+00	3.9E-03	1.0E-03	9.3E-04	3.0E-05	7.0E-04	2.6E-04	2.1E-04	1.2E-03	2.2E-03
37 GasPl	1.4E-07	1.3E-07	1.5E-07	1.6E-07	1.2E-07	1.5E-07	5.0E-01	1.1E-04	9.5E-04	4.3E-03	1.0E+00	0.0E+00	0.0E+00	8.2E-03	2.1E-03	2.0E-03	6.4E-05	1.5E-03	5.5E-04	4.4E-04	2.5E-03	4.6E-03
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	1.3E-08	1.3E-08	1.4E-08	1.5E-08	1.1E-08	1.4E-08	4.8E-02	1.1E-05	9.1E-05	4.2E-04	7.5E-05	0.0E+00	1.0E+00	7.9E-04	2.1E-04	1.9E-04	6.2E-06	1.4E-04	5.3E-05	4.3E-05	2.4E-04	4.4E-04
40 PV pl.	6.7E-09	6.4E-09	7.1E-09	7.6E-09	5.7E-09	7.2E-09	2.4E-02	5.5E-06	4.6E-05	2.1E-04	3.8E-05	0.0E+00	0.0E+00	1.0E+00	1.0E-04	9.6E-05	3.1E-06	7.3E-05	2.7E-05	2.2E-05	1.2E-04	2.2E-04
41 Wind	1.9E-08	1.8E-08	2.0E-08	2.2E-08	1.6E-08	2.1E-08	7.0E-02	1.6E-05	1.3E-04	6.0E-04	1.1E-04	0.0E+00	0.0E+00	1.1E-03	1.0E+00	2.8E-04	9.0E-06	2.1E-04	7.7E-05	6.2E-05	3.5E-04	6.4E-04
42 Biomass Plant	4.1E-08	4.0E-08	4.3E-08	4.7E-08	3.5E-08	4.4E-08	1.5E-01	3.3E-05	2.8E-04	1.3E-03	2.3E-04	0.0E+00	0.0E+00	2.5E-03	6.4E-04	1.0E+00	1.9E-05	4.5E-04	1.7E-04	1.3E-04	7.5E-04	1.4E-03
43 Biomass	1.6E-07	1.3E-07	1.5E-07	1.8E-07	1.2E-07	1.6E-07	4.5E-01	1.2E-04	1.0E-03	4.1E-03	8.2E-04	0.0E+00	0.0E+00	8.8E-03	2.2E-03	3.0E+00	1.0E+00	1.4E-03	6.7E-04	5.5E-04	1.0E+00	5.1E-03
44 Coal	2.0E-07	1.7E-07	2.0E-07	2.3E-07	1.6E-07	2.1E-07	5.7E-01	1.6E-04	1.1E-03	2.4E+00	2.0E-03	0.0E+00	0.0E+00	2.5E-02	6.6E-03	5.6E-03	7.8E-05	1.0E+00	7.3E-04	5.7E-04	3.1E-03	5.7E-03
45 CNG	1.1E-08	1.7E-09	4.0E-09	7.0E-09	3.8E-09	9.2E-09	1.6E-04	4.2E-06	8.3E-05	7.6E-05	3.9E-05	0.0E+00	0.0E+00	4.7E-04	1.0E-04	1.2E-04	5.8E-06	1.4E-05	1.0E+00	8.1E-05	2.7E-04	4.6E-04
46 Methanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	0.0E+00	0.0E+00
47 Ethanol	1.8E-08	2.6E-09	6.3E-09	1.1E-08	5.9E-09	1.4E-08	2.5E-04	6.5E-06	1.3E-04	1.2E-04	6.1E-05	0.0E+00	0.0E+00	7.3E-04	1.6E-04	1.8E-04	9.0E-06	2.2E-05	1.3E-04	1.3E-04	1.0E+00	7.1E-04
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00

Table D-20: Direct Requiremnt Coefficient Matrix 'A' for Base Scenario in 2040

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
	Agri., hui	Forestry ;	Mining	Services t	Meat and	Other foo	Beverage	Textile, c	Wood, pa	Basic che	Other che	Non-meta	Iron and :	Basic nor	Fabricate	Transpon	Other equ	Water an	Construct	Trade anc	Accomoc	Road trar	Rail, pipe	Water tra	Air and s|	Services t
1 Agri., hunting and trapping	0.05767	0.00287	0.00000	0.00000	0.23216	0.04077	0.03635	0.02383	0.00001	0.00063	0.00180	0.00000	0.00000	0.00000	0.00001	0.00000	0.00026	0.00004	0.00031	0.00020	0.00154	0.00000	0.00002	0.00000	0.00000	0.00009
2 Forestry and fishing	0.00116	0.03771	0.00032	0.00000	0.00000	0.00018	0.00000	0.00000	0.00644	0.00024	0.00008	0.00000	0.00000	0.00013	0.00000	0.00000	0.00010	0.00001	0.00008	0.00041	0.00500	0.00002	0.00121	0.00000	0.00000	0.00002
3 Mining	0.00021	0.00033	0.00733	0.00397	0.00004	0.00142	0.00001	0.00002	0.00004	0.00221	0.00013	0.01719	0.00260	0.04227	0.00075	0.00006	0.00062	0.00103	0.00343	0.00007	0.00026	0.00005	0.00013	0.00013	0.00003	0.00010
4 Services to mining	0.00000	0.00000	0.03273	0.00653	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5 Meat and diary prod.	0.00245	0.00039	0.00001	0.00004	0.03539	0.01938	0.00014	0.00544	0.00000	0.00211	0.00092	0.00000	0.00000	0.00000	0.00003	0.00006	0.00003	0.00014	0.00007	0.00383	0.01647	0.00002	0.00024	0.00009	0.00004	0.00004
6 Other food prod.	0.01809	0.01697	0.00013	0.00067	0.00648	0.07629	0.00392	0.00005	0.00001	0.00177	0.00208	0.00001	0.00001	0.00000	0.00004	0.00002	0.00003	0.00011	0.00002	0.00213	0.01164	0.00003	0.00011	0.00006	0.00008	0.00006
7 Beverage and tobacco	0.00050	0.00094	0.00017	0.00018	0.00086	0.00166	0.02985	0.00037	0.00023	0.00033	0.00009	0.00008	0.00004	0.00002	0.00005	0.00010	0.00005	0.00027	0.00007	0.00027	0.03504	0.00008	0.00019	0.00008	0.00015	0.00018
8 Textile, clothing, leather	0.00100	0.00429	0.00062	0.00018	0.00098	0.00259	0.00069	0.06351	0.00107	0.00092	0.00132	0.00074	0.00099	0.00064	0.00436	0.00091	0.00145	0.00020	0.00142	0.00118	0.00442	0.00047	0.00342	0.00106	0.00026	0.00068
9 Wood, paper, printing	0.00304	0.00637	0.00195	0.00634	0.01003	0.00996	0.01300	0.00746	0.10383	0.00341	0.00769	0.00680	0.00202	0.00142	0.00872	0.00425	0.01126	0.00295	0.03440	0.02572	0.01210	0.00222	0.00754	0.00332	0.00202	0.00598
10 Basic chemical	0.01752	0.00062	0.00583	0.00283	0.00020	0.00062	0.00028	0.00360	0.00410	0.07391	0.02290	0.00333	0.00113	0.00316	0.00560	0.00236	0.00150	0.00865	0.00049	0.00006	0.00021	0.00006	0.00104	0.00004	0.00001	0.00004
11 Other chem., rubber, plastic	0.01753	0.01370	0.01175	0.00371	0.01873	0.01932	0.01144	0.00716	0.02290	0.02152	0.08225	0.00826	0.00751	0.00253	0.00919	0.01388	0.00871	0.01583	0.00970	0.00281	0.00624	0.00435	0.00229	0.00258	0.00233	0.00222
12 Non-metalic mineral	0.00001	0.01223	0.00141	0.00231	0.00001	0.00235	0.00988	0.00016	0.00087	0.00015	0.00102	0.08597	0.00528	0.00364	0.00679	0.00222	0.00219	0.00645	0.05864	0.00160	0.00062	0.00020	0.00005	0.00000	0.00000	0.00008
13 Iron and steel	0.00001	0.00034	0.00205	0.01797	0.00001	0.00002	0.00001	0.00040	0.00029	0.00014	0.00015	0.00437	0.10062	0.00223	0.09451	0.03480	0.02819	0.00150	0.01111	0.00039	0.00002	0.00003	0.00231	0.00007	0.00001	0.00004
14 Basic non-ferrous	0.00000	0.00006	0.00052	0.00013	0.00019	0.00017	0.00003	0.00050	0.00110	0.00067	0.00144	0.00117	0.01299	0.13966	0.03143	0.00578	0.00734	0.00021	0.00038	0.00013	0.00017	0.00001	0.00019	0.00001	0.00001	0.00004
15 Fabricated metal	0.00115	0.01752	0.00823	0.01343	0.00221	0.00367	0.01398	0.00212	0.00427	0.00196	0.00208	0.00954	0.00300	0.00077	0.05862	0.01056	0.00841	0.01098	0.03401	0.00198	0.00110	0.00237	0.03257	0.01450	0.00108	0.00279
16 Transport equip.	0.00056	0.00481	0.00189	0.00222	0.00005	0.00015	0.00006	0.00005	0.00013	0.00013	0.00009	0.00062	0.00033	0.00003	0.00024	0.11765	0.00086	0.00010	0.00020	0.00331	0.00073	0.00446	0.04027	0.00975	0.02306	0.00425
17 Other equip., manufacturing	0.00382	0.08122	0.04068	0.01758	0.00132	0.00325	0.00160	0.00436	0.00624	0.00177	0.00320	0.00342	0.00402	0.00780	0.01330	0.02624	0.05100	0.00745	0.03976	0.00509	0.01224	0.00386	0.01252	0.00179	0.00039	0.01408
18 Water and sewerage	0.00234	0.00031	0.00067	0.00009	0.00295	0.00143	0.00157	0.00098	0.00079	0.00111	0.00100	0.00093	0.00144	0.00063	0.00086	0.00067	0.00051	0.04133	0.00048	0.00035	0.00243	0.00001	0.00002	0.00138	0.00001	0.00002
19 Construction	0.00212	0.00031	0.00505	0.00085	0.00002	0.00004	0.00006	0.00006	0.00010	0.00008	0.00005	0.00014	0.00007	0.00003	0.00006	0.00010	0.00003	0.00021	0.00049	0.00045	0.00255	0.00017	0.00643	0.00036	0.00016	0.00118
20 Trade and repair	0.03193	0.08817	0.02758	0.02391	0.03141	0.04781	0.02387	0.03672	0.02973	0.02351	0.02468	0.01671	0.00813	0.00712	0.02496	0.01652	0.02380	0.02455	0.03643	0.02452	0.02162	0.03705	0.02266	0.00689	0.01788	0.02595
21 Accomodation, café	0.00521	0.00295	0.00243	0.02024	0.00050	0.00565	0.03482	0.00487	0.00666	0.00307	0.00587	0.00405	0.00187	0.00174	0.00647	0.00199	0.00201	0.00227	0.00297	0.00647	0.00168	0.00385	0.00155	0.00258	0.00404	0.00742
22 Road transport	0.01774	0.00705	0.01484	0.00702	0.05126	0.02509	0.02037	0.00717	0.01133	0.00687	0.00576	0.06605	0.01017	0.00615	0.00823	0.00208	0.00416	0.00249	0.01106	0.01045	0.00336	0.04613	0.00290	0.00082	0.00551	0.01289
23 Rail, pipeline	0.00235	0.00023	0.00104	0.00022	0.00206	0.00428	0.00213	0.00185	0.00066	0.00155	0.00155	0.01248	0.00719	0.00876	0.00113	0.00028	0.00065	0.00016	0.00091	0.00073	0.00084	0.00005	0.00053	0.00004	0.00089	0.00133
24 Water transport	0.00009	0.00087	0.00009	0.01418	0.00003	0.00067	0.00014	0.00057	0.00037	0.00033	0.00018	0.00067	0.00100	0.00285	0.00066	0.00005	0.00017	0.00002	0.00003	0.00016	0.00004	0.00004	0.00005	0.13314	0.00012	0.00004
25 Air and space travel	0.00160	0.00106	0.00267	0.00806	0.00023	0.00384	0.00139	0.00671	0.00601	0.00149	0.00247	0.00131	0.00091	0.00101	0.00248	0.00159	0.00244	0.00328	0.00048	0.00832	0.00125	0.00072	0.00024	0.00181	0.03451	0.00319
26 Services to transport	0.00470	0.00177	0.00088	0.00187	0.00326	0.00918	0.00911	0.00365	0.00973	0.00691	0.00573	0.00373	0.00318	0.00161	0.00757	0.00233	0.00079	0.00066	0.00231	0.01770	0.00316	0.00635	0.00129	0.08122	0.03966	0.02988
27 Communication	0.00612	0.00427	0.00821	0.00712	0.00415	0.00441	0.00283	0.00382	0.00669	0.00156	0.00295	0.00546	0.00158	0.00094	0.00572	0.00256	0.00405	0.00599	0.00204	0.02404	0.01273	0.01487	0.00472	0.00477	0.00519	0.02090
28 Finance and insurance	0.01732	0.01809	0.01059	0.01346	0.00458	0.01465	0.00813	0.00443	0.00726	0.00262	0.00441	0.00519	0.00320	0.00537	0.00547	0.00409	0.00253	0.03735	0.01240	0.02073	0.01715	0.00707	0.01940	0.00824	0.00849	0.01045
29 Property and business	0.01900	0.01016	0.01320	0.11866	0.02189	0.02370	0.02682	0.02428	0.04159	0.01708	0.04346	0.02058	0.03392	0.02064	0.02870	0.02354	0.01496	0.02682	0.06052	0.11503	0.06782	0.04087	0.06097	0.03875	0.04276	0.08242
30 Govt. admin and defence	0.00056	0.00172	0.00308	0.00080	0.00072	0.00152	0.00077	0.00026	0.00262	0.00069	0.00030	0.00046	0.00083	0.00018	0.00092	0.00090	0.00022	0.00134	0.00085	0.00105	0.00028	0.00686	0.00160	0.00026	0.00007	0.00785
31 Education, health, communi	0.00134	0.00040	0.00036	0.00082	0.00183	0.00060	0.00127	0.00256	0.00116	0.00037	0.00212	0.00051	0.00033	0.00028	0.00043	0.00060	0.00033	0.00053	0.00027	0.00049	0.00058	0.00037	0.00071	0.00058	0.00039	0.00224
32 Personal and other services	0.00041	0.00158	0.00055	0.00155	0.00156	0.00228	0.00318	0.00255	0.00392	0.00072	0.00269	0.00145	0.00026	0.00020	0.00191	0.00228	0.00097	0.00093	0.00039	0.00551	0.00853	0.00108	0.00062	0.00060	0.00074	0.00153
33 Electricity	2.7E-07	2.7E-07	9.8E-07	9.8E-07	2.2E-07	2.2E-07	2.2E-07	1.1E-07	2.4E-07	2.7E-06	3.7E-08	8.1E-07	4.4E-07	4.8E-06	3.4E-07	1.3E-07	1.3E-07	6.3E-07	4.7E-09	1.6E-07	1.6E-07	0.0E+00	1.3E-06	0.0E+00	0.0E+00	0.0E+00
34 Gas supply	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.6E-07	2.6E-07	2.6E-07	6.8E-07	0.0E+00	1.0E-05	1.4E-07	2.1E-06	4.2E-07	1.4E-06	3.0E-07	2.8E-08	2.8E-08	2.5E-08	6.9E-09	4.2E-08	4.2E-08	0.0E+00	2.4E-07	0.0E+00	0.0E+00	4.4E-07
35 Petroleum Product	9.3E-07	9.3E-07	1.1E-06	1.1E-06	4.4E-08	4.4E-08	4.4E-08	1.2E-07	6.0E-09	1.0E-05	1.4E-07	4.4E-08	0.0E+00	5.7E-07	8.5E-08	1.6E-08	1.6E-08	7.2E-08	4.0E-07	3.7E-08	3.7E-08	1.2E-05	3.6E-06	7.9E-06	1.1E-05	0.0E+00
36 Coal pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
37 GasPl	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
40 PV pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
41 Wind	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
42 Biomass Plant	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
43 Biomass	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.3E-07	1.3E-07	1.3E-07	3.4E-07	3.5E-07	0.0E+00	0.0E+00	5.1E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
44 Coal	0.0E+00	0.0E+00	2.8E-09	2.8E-09	9.8E-08	9.8E-08	9.8E-08	2.6E-07	1.4E-07	0.0E+00	0.0E+00	1.4E-06	9.1E-06	1.4E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.1E-09	4.1E-09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
45 CNG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
46 Methanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
47 Ethanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Source: Direct requirement coefficients are computed in this research as described in Section 5-2 and 5-4 (Chapter 5)

(contd ...)

Table D-20: Direct Requiremnt Coefficient Matrix 'A' for Base Scenario in 2040 (...contd)

	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
	Commun	Finance a	Property :	Govt. adr	Educatioı	Personal :	Electricit	Gas supp	Petroleun	Coal pl.	GasPl	Oil Pl.	Hydro	PV pl.	Wind	Biomass Pla	Biomass	Coal	CNG	Methanol	Ethanol	Biodiesel
1 Agri., hunting an	0.00000	0.00004	0.00020	0.00048	0.00013	0.00203	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	250.00	0.00	0.00	0.00	7758.62	16244.31
2 Forestry and fish	0.00002	0.00003	0.00001	0.00001	0.00002	0.00008	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00	0.00
3 Mining	0.00003	0.00002	0.00014	0.00026	0.00010	0.00078	2.41	0.21	4.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.08	6.37	6.37	6.37	6.37
4 Services to minir	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.76	0.00	0.00	0.00	0.00
5 Meat and diary p	0.00023	0.00013	0.00017	0.00006	0.00030	0.00036	0.59	0.05	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.22	0.22	0.22	0.22
6 Other food prod.	0.00015	0.00018	0.00013	0.00048	0.00025	0.00183	0.72	0.05	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.44	0.44	0.44	0.44
7 Beverage and tot	0.00033	0.00080	0.00012	0.00094	0.00018	0.00017	1.83	0.20	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	1.34	1.34	1.34	1.34
8 Textile, clothing,	0.00077	0.00011	0.00052	0.00167	0.00235	0.00281	4.41	0.26	1.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	2.88	2.88	2.88	2.88
9 Wood, paper, pri	0.01698	0.00502	0.00938	0.02259	0.00584	0.01160	34.29	3.20	21.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.12	32.42	32.42	32.42	32.42
10 Basic chemical	0.00012	0.00003	0.00045	0.00029	0.00068	0.00159	18.02	6.38	122.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.98	182.07	182.07	182.07	182.07
11 Other chem., rub	0.00611	0.00017	0.00332	0.00701	0.00541	0.00858	79.39	10.66	47.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.35	70.35	70.35	70.35	70.35
12 Non-metalic min	0.00005	0.00008	0.00105	0.00108	0.00037	0.00082	111.40	0.15	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.06	0.06	0.06	0.06
13 Iron and steel	0.00013	0.00001	0.00078	0.00045	0.00006	0.00024	14.81	0.66	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.62	0.04	0.04	0.04	0.04
14 Basic non-ferrou	0.00031	0.00000	0.00010	0.00115	0.00003	0.00019	0.34	0.08	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.13	0.13	0.13	0.13
15 Fabricated metal	0.00333	0.00013	0.00214	0.00266	0.00104	0.00264	39.26	4.22	5.29	531.84	396.07	0.00	0.00	2253.36	1478.77	1267.51	0.00	6.50	7.86	7.86	7.86	7.86
16 Transport equip.	0.00132	0.00003	0.00013	0.00818	0.00013	0.00028	5.15	0.12	1.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.41	1.78	1.78	1.78	1.78
17 Other equip., ma	0.02681	0.00174	0.00559	0.01094	0.01037	0.01814	367.93	3.09	5.94	1772.79	1320.24	0.00	0.00	33800.39	6802.33	4225.05	0.00	40.18	8.82	8.82	8.82	8.82
18 Water and sewer	0.00001	0.00020	0.00473	0.00154	0.00176	0.00135	123.74	7.46	16.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	25.24	25.24	25.24	25.24
19 Construction	0.00006	0.00016	0.00488	0.00529	0.00019	0.00014	13.18	1.27	0.34	886.40	660.12	0.00	0.00	8562.77	1478.77	2112.52	0.00	1.22	0.51	0.51	0.51	0.51
20 Trade and repair	0.04065	0.00365	0.00756	0.00972	0.01382	0.01690	425.61	20.65	86.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.72	128.43	128.43	128.43	128.43
21 Accomodation, c	0.00769	0.00653	0.00678	0.00876	0.00216	0.00638	80.15	1.94	39.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.45	58.20	58.20	58.20	58.20
22 Road transport	0.00740	0.00024	0.00140	0.00320	0.00204	0.00544	43.98	1.21	70.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.68	104.95	104.95	104.95	104.95
23 Rail, pipeline	0.00108	0.00031	0.00061	0.00028	0.00033	0.00028	105.07	20.58	12.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.08	17.92	17.92	17.92	17.92
24 Water transport	0.00053	0.00000	0.00016	0.00065	0.00017	0.00023	10.67	0.85	143.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	212.50	212.50	212.50	212.50
25 Air and space tra	0.01069	0.00284	0.00434	0.01043	0.00180	0.00395	51.30	4.09	25.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.17	37.43	37.43	37.43	37.43
26 Services to transן	0.00520	0.00313	0.00580	0.00634	0.00110	0.00121	7.89	0.22	58.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.04	87.05	87.05	87.05	87.05
27 Communication	0.01146	0.01093	0.00951	0.02142	0.00844	0.01443	143.31	8.72	11.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.28	16.77	16.77	16.77	16.77
28 Finance and insu	0.00896	0.11070	0.02319	0.02283	0.00827	0.01323	663.74	30.23	20.98	35.46	26.40	0.00	0.00	450.67	98.58	84.50	0.00	18.98	31.17	31.17	31.17	31.17
29 Property and bus	0.03147	0.03852	0.10735	0.05341	0.02469	0.05272	483.42	192.91	65.51	319.10	237.64	0.00	0.00	0.00	0.00	760.51	0.00	30.07	97.32	97.32	97.32	97.32
30 Govt. admin and	0.00235	0.00040	0.00109	0.02911	0.00088	0.00055	6.08	0.14	14.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.18	21.66	21.66	21.66	21.66
31 Education, health	0.00079	0.00203	0.00103	0.00196	0.00634	0.00194	23.00	1.25	4.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.45	6.95	6.95	6.95	6.95
32 Personal and oth	0.00122	0.00271	0.00691	0.00368	0.00393	0.03721	24.85	1.60	6.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.56	9.32	9.32	9.32	9.32
33 Electricity	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	0.0E+00	0.0E+00	7.0E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E-03	9.5E-04	9.5E-04	9.5E-04	9.5E-04
34 Gas supply	4.2E-08	4.2E-08	4.2E-08	4.2E-08	4.2E-08	4.2E-08	0.0E+00	0.0E+00	2.7E-03	0.0E+00	1.8E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	1.0E+00	0.0E+00	0.0E+00
35 Petroleum Produ	3.7E-08	3.7E-08	3.7E-08	3.7E-08	3.7E-08	3.7E-08	0.0E+00	0.0E+00	2.7E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.4E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00
36 Coal pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.9E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
37 GasPl	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.3E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.1E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
40 PV pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.5E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
41 Wind	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.5E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
42 Biomass Plant	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.2E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
43 Biomass	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
44 Coal	4.1E-09	4.1E-09	4.1E-09	4.1E-09	4.1E-09	4.1E-09	0.0E+00	0.0E+00	0.0E+00	2.1E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	8.8E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00
45 CNG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
46 Methanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
47 Ethanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Table D-21: Total Requiremnt Coefficient Matrix '(I-A)-1' for Base Scenario in 2040

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
	Agri., hui	Forestry a	Mining	Services t	Meat and	Other foo	Beverage	Textile, c	Wood, pa	Basic che	Other che	Non-meta	Iron and s	Basic nor	Fabricate	Transport	Other equ	Water and	Construct	Trade and	Accomod	Road trar	Rail, pipe	Water tra	Air and sp	Services t
1 Agri., hunting and trapping	1.06315	0.00466	0.00024	0.00040	0.25648	0.05274	0.04056	0.02883	0.00045	0.00170	0.00269	0.00022	0.00015	0.00028	0.00037	0.00020	0.00046	0.00029	0.00060	0.00156	0.00820	0.00019	0.00038	0.00020	0.00016	0.00033
2 Forestry and fishing	0.00139	1.03937	0.00043	0.00022	0.00047	0.00045	0.00039	0.00017	0.00756	0.00037	0.00024	0.00015	0.00007	0.00026	0.00017	0.00009	0.00025	0.00009	0.00043	0.00072	0.00537	0.00012	0.00138	0.00009	0.00008	0.00016
3 Mining	0.00037	0.00083	1.00775	0.00430	0.00020	0.00170	0.00033	0.00012	0.00021	0.00259	0.00035	0.01913	0.00381	0.04974	0.00305	0.00070	0.00126	0.00134	0.00484	0.00020	0.00040	0.00017	0.00039	0.00030	0.00014	0.00019
4 Services to mining	0.00002	0.00003	0.03321	1.00672	0.00001	0.00006	0.00002	0.00001	0.00001	0.00012	0.00001	0.00066	0.00023	0.00171	0.00012	0.00003	0.00005	0.00005	0.00016	0.00001	0.00002	0.00001	0.00003	0.00001	0.00001	0.00001
5 Meat and diary prod.	0.00349	0.00139	0.00028	0.00063	1.03791	0.02236	0.00118	0.00644	0.00040	0.00268	0.00145	0.00026	0.00015	0.00018	0.00039	0.00027	0.00023	0.00041	0.00040	0.00436	0.01764	0.00034	0.00049	0.00030	0.00027	0.00037
6 Other food prod.	0.02117	0.01957	0.00039	0.00117	0.01257	1.08414	0.00580	0.00091	0.00047	0.00236	0.00277	0.00021	0.00013	0.00015	0.00031	0.00020	0.00019	0.00034	0.00028	0.00263	0.01333	0.00027	0.00032	0.00022	0.00026	0.00032
7 Beverage and tobacco	0.00090	0.00132	0.00039	0.00108	0.00125	0.00226	1.03221	0.00071	0.00065	0.00061	0.00043	0.00035	0.00019	0.00021	0.00041	0.00027	0.00020	0.00049	0.00034	0.00069	0.03639	0.00036	0.00040	0.00034	0.00043	0.00060
8 Textile, clothing, leather	0.00145	0.00536	0.00099	0.00068	0.00167	0.00340	0.00128	1.06808	0.00161	0.00134	0.00178	0.00122	0.00138	0.00110	0.00535	0.00141	0.00186	0.00048	0.00208	0.00161	0.00509	0.00078	0.00410	0.00163	0.00052	0.00104
9 Wood, paper, printing	0.00662	0.01334	0.00559	0.01132	0.01565	0.01600	0.01811	0.01152	1.11901	0.00692	0.01171	0.01083	0.00422	0.00434	0.01333	0.00771	0.01503	0.00599	0.04275	0.03270	0.01746	0.00585	0.01205	0.00714	0.00491	0.01038
10 Basic chemical	0.02103	0.00192	0.00730	0.00385	0.00614	0.00269	0.00185	0.00516	0.00590	1.08236	0.02729	0.00478	0.00193	0.00493	0.00735	0.00372	0.00229	0.01049	0.00186	0.00061	0.00093	0.00202	0.00233	0.00168	0.00176	0.00039
11 Other chem., rubber, plastic	0.02240	0.01866	0.01483	0.00653	0.02801	0.02588	0.01555	0.01018	0.02922	0.02748	1.09146	0.01189	0.01028	0.00574	0.01329	0.01878	0.01134	0.01932	0.01412	0.00550	0.00970	0.00670	0.00530	0.00520	0.00447	0.00408
12 Non-metalic mineral	0.00055	0.01479	0.00258	0.00347	0.00048	0.00322	0.01162	0.00048	0.00156	0.00099	0.00150	1.09465	0.00684	0.00603	0.00910	0.00345	0.00303	0.00783	0.06503	0.00226	0.00171	0.00052	0.00146	0.00043	0.00030	0.00054
13 Iron and steel	0.00065	0.00597	0.00593	0.02298	0.00075	0.00101	0.00208	0.00114	0.00150	0.00125	0.00082	0.00728	1.11294	0.00490	0.11271	0.04648	0.03431	0.00364	0.01828	0.00144	0.00106	0.00090	0.00913	0.00286	0.00149	0.00140
14 Basic non-ferrous	0.00026	0.00188	0.00161	0.00140	0.00053	0.00060	0.00081	0.00088	0.00186	0.00123	0.00206	0.00224	0.01711	1.16295	0.04082	0.00917	0.00996	0.00097	0.00270	0.00050	0.00055	0.00030	0.00226	0.00092	0.00036	0.00047
15 Fabricated metal	0.00244	0.02139	0.01115	0.01650	0.00393	0.00554	0.01643	0.00317	0.00614	0.00501	0.00314	0.01315	0.00489	0.00631	1.06401	0.01374	0.01012	0.01325	0.03818	0.00337	0.00295	0.00336	0.03706	0.01877	0.00216	0.00402
16 Transport equip.	0.00125	0.00644	0.00279	0.00335	0.00101	0.00115	0.00069	0.00070	0.00084	0.00071	0.00055	0.00213	0.00110	0.00103	0.00091	1.13367	0.00137	0.00048	0.00085	0.00448	0.00125	0.00576	0.04601	0.01350	0.02758	0.00554
17 Other equip., manufacturing	0.00696	0.09218	0.04819	0.02418	0.00524	0.00677	0.00484	0.00678	0.01062	0.01082	0.00549	0.00921	0.00814	0.02717	0.01908	0.03343	1.05566	0.01143	0.04508	0.00905	0.01611	0.00629	0.02032	0.00554	0.00309	0.01778
18 Water and sewerage	0.00300	0.00083	0.00116	0.00121	0.00424	0.00223	0.00227	0.00150	0.00141	0.00223	0.00160	0.00154	0.00209	0.00189	0.00162	0.00119	0.00085	1.04354	0.00120	0.00123	0.00326	0.00062	0.00084	0.00225	0.00059	0.00066
19 Construction	0.00286	0.00094	0.00631	0.00267	0.00120	0.00081	0.00080	0.00055	0.00082	0.00294	0.00057	0.00147	0.00102	0.00559	0.00102	0.00058	0.00042	0.00113	1.00115	0.00144	0.00326	0.00061	0.00815	0.00094	0.00061	0.00188
20 Trade and repair	0.04034	0.10149	0.03449	0.03082	0.04826	0.06069	0.03207	0.04430	0.03898	0.03216	0.03115	0.02603	0.01279	0.01607	0.03284	0.02305	0.02857	0.02987	0.04505	1.03144	0.02913	0.04375	0.02938	0.01446	0.02362	0.03181
21 Accomodation, café	0.00701	0.00526	0.00444	0.02263	0.00354	0.00816	0.03761	0.00646	0.00896	0.00511	0.00759	0.00594	0.00305	0.00359	0.00846	0.00337	0.00304	0.00375	0.00527	0.00879	1.00463	0.00578	0.00348	0.00514	0.00591	0.00931
22 Road transport	0.02194	0.01193	0.01762	0.00965	0.06238	0.03267	0.02524	0.01015	0.01486	0.01025	0.00807	0.07742	0.01333	0.00999	0.01262	0.00432	0.00618	0.00446	0.01847	0.01327	0.00717	1.05050	0.00512	0.00388	0.00815	0.01521
23 Rail, pipeline	0.00287	0.00092	0.00149	0.00086	0.00307	0.00513	0.00273	0.00227	0.00104	0.00265	0.00195	0.01413	0.00863	0.01134	0.00278	0.00097	0.00120	0.00057	0.00217	0.00108	0.00127	0.00037	1.00110	0.00045	0.00124	0.00159
24 Water transport	0.00043	0.00136	0.00098	0.01684	0.00032	0.00101	0.00032	0.00083	0.00061	0.00240	0.00038	0.00112	0.00144	0.00415	0.00120	0.00023	0.00035	0.00015	0.00033	0.00033	0.00016	0.00216	0.00079	1.15518	0.00201	0.00016
25 Air and space travel	0.00285	0.00307	0.00412	0.01001	0.00189	0.00572	0.00260	0.00837	0.00807	0.00298	0.00370	0.00249	0.00172	0.00237	0.00391	0.00269	0.00338	0.00452	0.00214	0.01039	0.00266	0.00223	0.00165	0.00352	1.03694	0.00479
26 Services to transport	0.00727	0.00537	0.00281	0.00607	0.00715	0.01317	0.01185	0.00611	0.01331	0.01008	0.00817	0.00625	0.00487	0.00355	0.01052	0.00417	0.00230	0.00241	0.00532	0.02102	0.00560	0.00944	0.00361	0.09856	0.04439	1.03283
27 Communication	0.00927	0.00907	0.01105	0.01108	0.00941	0.00888	0.00631	0.00665	0.01043	0.00446	0.00549	0.00935	0.00348	0.00408	0.00889	0.00477	0.00593	0.00867	0.00597	0.02818	0.01583	0.01837	0.00773	0.00940	0.00825	0.02468
28 Finance and insurance	0.02444	0.02655	0.01621	0.02244	0.01473	0.02343	0.01444	0.00908	0.01338	0.00907	0.00890	0.01098	0.00737	0.01498	0.01106	0.00803	0.00542	0.04702	0.01929	0.02964	0.02447	0.01217	0.02719	0.01496	0.01351	0.01692
29 Property and business	0.03563	0.03446	0.03140	0.14805	0.04621	0.04728	0.04609	0.04058	0.06451	0.03685	0.06212	0.03976	0.04962	0.04156	0.05060	0.03961	0.02666	0.04213	0.08442	0.14256	0.08809	0.05921	0.08147	0.06585	0.06124	0.10531
30 Govt. admin and defence	0.00107	0.00233	0.00358	0.00134	0.00168	0.00234	0.00135	0.00062	0.00344	0.00128	0.00068	0.00139	0.00126	0.00069	0.00150	0.00130	0.00049	0.00169	0.00147	0.00176	0.00073	0.00789	0.00208	0.00146	0.00084	0.00874
31 Education, health, communi	0.00170	0.00077	0.00064	0.00123	0.00254	0.00108	0.00164	0.00299	0.00159	0.00078	0.00252	0.00084	0.00067	0.00075	0.00077	0.00089	0.00051	0.00084	0.00063	0.00090	0.00097	0.00065	0.00106	0.00112	0.00072	0.00259
32 Personal and other services	0.00135	0.00308	0.00140	0.00339	0.00281	0.00375	0.00460	0.00365	0.00559	0.00172	0.00393	0.00249	0.00101	0.00108	0.00305	0.00337	0.00164	0.00185	0.00188	0.00741	0.01016	0.00217	0.00191	0.00174	0.00175	0.00291
33 Electricity	3.9E-07	3.8E-07	1.1E-06	1.1E-06	3.6E-07	3.2E-07	3.0E-07	1.8E-07	3.3E-07	2.9E-06	1.6E-07	9.9E-07	6.5E-07	5.7E-06	6.8E-07	2.6E-07	2.4E-07	7.3E-07	1.5E-07	2.3E-07	2.3E-07	4.7E-08	1.4E-06	4.9E-08	4.3E-08	4.8E-08
34 Gas supply	5.5E-07	3.9E-07	9.5E-07	9.3E-07	6.4E-07	6.0E-07	5.7E-07	9.4E-07	3.5E-07	1.3E-05	5.8E-07	3.1E-06	1.1E-06	6.2E-06	1.1E-06	3.3E-07	2.9E-07	7.4E-07	3.2E-07	2.6E-07	2.7E-07	1.1E-07	1.4E-06	1.4E-07	1.1E-07	5.1E-07
35 Petroleum Product	1.5E-06	1.2E-06	1.5E-06	1.5E-06	1.1E-06	6.1E-07	4.5E-07	4.4E-07	3.6E-07	1.1E-05	5.9E-07	1.1E-06	3.0E-07	1.0E-06	4.2E-07	1.6E-07	1.7E-07	3.0E-07	6.9E-07	3.3E-07	1.9E-07	1.2E-05	3.8E-06	9.3E-06	1.1E-05	2.5E-07
36 Coal pl.	1.9E-07	1.8E-07	5.3E-07	5.2E-07	1.7E-07	1.5E-07	1.5E-07	8.5E-08	1.6E-07	1.4E-06	7.5E-08	4.8E-07	3.2E-07	2.8E-06	3.3E-07	1.3E-07	1.2E-07	3.6E-07	7.3E-08	1.1E-07	1.1E-07	2.3E-08	6.9E-07	2.4E-08	2.1E-08	2.3E-08
37 GasPl	1.7E-07	1.6E-07	4.7E-07	4.6E-07	1.6E-07	1.4E-07	1.3E-07	7.6E-08	1.4E-07	1.3E-06	6.7E-08	4.2E-07	2.8E-07	2.4E-06	2.9E-07	1.1E-07	1.0E-07	3.2E-07	6.5E-08	9.8E-08	9.9E-08	2.0E-08	6.1E-07	2.1E-08	1.8E-08	2.1E-08
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	1.2E-08	1.2E-08	3.4E-08	3.4E-08	1.1E-08	1.0E-08	9.5E-09	5.5E-09	1.0E-08	9.2E-08	4.9E-09	3.1E-08	2.1E-08	1.8E-07	2.1E-08	8.1E-09	7.5E-09	2.3E-08	4.7E-09	7.1E-09	7.2E-09	1.5E-09	4.5E-08	1.6E-09	1.3E-09	1.5E-09
40 PV pl.	5.9E-11	5.7E-11	1.6E-10	1.6E-10	5.5E-11	4.8E-11	4.6E-11	2.7E-11	5.0E-11	4.4E-10	2.4E-11	1.5E-10	9.9E-11	8.6E-10	1.0E-10	3.9E-11	3.6E-11	1.1E-10	2.3E-11	3.4E-11	3.5E-11	7.1E-12	2.2E-10	7.5E-12	6.5E-12	7.3E-12
41 Wind	2.1E-08	2.1E-08	5.9E-08	5.9E-08	2.0E-08	1.7E-08	1.7E-08	9.6E-09	1.8E-08	1.6E-07	8.5E-09	5.4E-08	3.6E-08	3.1E-07	3.7E-08	1.4E-08	1.3E-08	4.0E-08	8.3E-09	1.2E-08	1.3E-08	2.6E-09	7.8E-08	2.7E-09	2.3E-09	2.6E-09
42 Biomass Plant	1.2E-08	1.2E-08	3.4E-08	3.4E-08	1.1E-08	1.0E-08	9.6E-09	5.6E-09	1.0E-08	9.3E-08	4.9E-09	3.1E-08	2.1E-08	1.8E-07	2.1E-08	8.2E-09	7.5E-09	2.3E-08	4.8E-09	7.2E-09	7.3E-09	1.5E-09	4.5E-08	1.6E-09	1.4E-09	1.5E-09
43 Biomass	4.3E-08	4.6E-08	1.1E-07	1.1E-07	1.8E-07	1.8E-07	1.7E-07	3.9E-07	4.2E-07	2.8E-07	2.0E-08	1.5E-07	6.5E-08	5.5E-07	7.2E-08	2.8E-08	2.9E-08	7.3E-08	3.4E-08	3.5E-08	3.9E-08	7.0E-09	1.4E-07	7.9E-09	6.1E-09	8.8E-09
44 Coal	4.1E-07	4.8E-07	1.2E-06	1.3E-06	4.9E-07	4.6E-07	4.6E-07	4.7E-07	5.2E-07	3.1E-06	1.8E-07	2.6E-06	1.1E-05	7.6E-06	1.8E-06	7.1E-07	5.8E-07	8.1E-07	4.2E-07	2.6E-07	2.7E-07	6.0E-08	1.6E-06	8.1E-08	6.0E-08	6.7E-08
45 CNG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
46 Methanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
47 Ethanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Source: Total requirement coefficients are computed in this research as described in Section 5-2 and 5-4 (Chapter 5)

(contd ...)

Table D-21: Total Requiremnt Coefficient Matrix '(I-A)-1' for Base Scenario in 2040 (...contd)

	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
.	Commun	Finance a	Property :	Govt. adr	Educatioı	Personal :	Electricit	Gas supp	Petroleun	Coal pl.	GasPl	Oil Pl.	Hydro	PV pl.	Wind	Biomass Pla	Biomass	Coal	CNG	Methanol	Ethanol	Biodiesel
1 Agri., hunting an	0.00031	0.00024	0.00046	0.00085	0.00040	0.00270	30.69	0.24	1.13	2.43	1.70	0.00	0.00	21.62	4.59	809.47	265.79	0.34	1.90	1.90	8250.28	17271.88
2 Forestry and fishi	0.00025	0.00013	0.00016	0.00027	0.00010	0.00026	3.70	0.12	0.58	2.03	0.94	0.00	0.00	12.54	2.59	3.36	0.35	0.50	0.98	0.98	11.67	23.50
3 Mining	0.00013	0.00006	0.00027	0.00045	0.00015	0.00092	16.00	0.35	4.87	11.13	6.76	0.00	0.00	90.93	20.25	19.90	0.09	1.36	7.57	7.57	10.09	13.22
4 Services to minir	0.00001	0.00000	0.00001	0.00002	0.00001	0.00003	10.80	0.01	0.17	21.46	0.24	0.00	0.00	3.26	0.74	0.72	0.00	9.90	0.27	0.27	0.38	0.52
5 Meat and diary p	0.00062	0.00035	0.00043	0.00038	0.00047	0.00072	6.78	0.34	1.83	1.84	1.45	0.00	0.00	12.38	2.80	5.33	0.87	0.33	3.04	3.04	29.82	59.46
6 Other food prod	0.00044	0.00038	0.00035	0.00080	0.00040	0.00232	6.16	0.29	1.68	1.85	1.18	0.00	0.00	9.82	2.23	18.14	5.29	0.45	2.77	2.77	166.74	346.39
7 Beverage and tol	0.00072	0.00124	0.00050	0.00145	0.00032	0.00053	8.60	0.46	2.77	2.02	1.64	0.00	0.00	11.08	2.58	3.24	0.22	0.44	4.57	4.57	11.08	18.71
8 Textile, clothing,	0.00112	0.00027	0.00080	0.00213	0.00266	0.00336	18.90	0.66	3.32	10.70	7.34	0.00	0.00	92.80	23.65	20.76	0.36	1.15	5.58	5.58	16.16	28.45
9 Wood, paper, pri	0.02205	0.00767	0.01339	0.02885	0.00812	0.01603	172.74	8.00	34.09	92.38	71.29	0.00	0.00	907.48	185.90	186.54	1.65	7.58	58.46	58.46	101.78	157.92
10 Basic chemical	0.00062	0.00018	0.00090	0.00094	0.00106	0.00237	47.00	7.60	135.43	17.54	21.22	0.00	0.00	110.05	29.23	39.56	5.26	3.57	208.25	208.25	363.77	542.19
11 Other chem., rub	0.00834	0.00097	0.00516	0.00991	0.00678	0.01128	180.43	13.58	59.80	82.49	55.53	0.00	0.00	534.53	117.76	115.55	5.60	19.24	102.12	102.12	262.31	452.36
12 Non-metalic min	0.00044	0.00030	0.00185	0.00195	0.00063	0.00130	198.50	0.85	1.25	72.80	52.53	0.00	0.00	680.07	130.30	163.59	0.14	2.03	2.68	2.68	6.08	10.72
13 Iron and steel	0.00176	0.00028	0.00173	0.00201	0.00071	0.00152	193.97	1.98	2.41	155.85	106.03	0.00	0.00	1570.29	427.11	328.27	0.16	8.57	5.53	5.53	8.62	14.17
14 Basic non-ferrou	0.00090	0.00010	0.00040	0.00184	0.00026	0.00065	53.44	0.51	1.10	44.37	32.12	0.00	0.00	451.86	132.13	100.05	0.07	1.16	2.13	2.13	3.65	5.87
15 Fabricated metal	0.00454	0.00066	0.00335	0.00418	0.00167	0.00381	714.36	6.35	11.90	642.22	472.37	0.00	0.00	3066.89	1698.79	1476.52	0.61	10.97	23.90	23.90	36.45	57.13
16 Transport equip.	0.00224	0.00026	0.00052	0.01013	0.00038	0.00072	25.92	1.47	6.13	12.79	5.53	0.00	0.00	55.79	11.95	10.10	0.31	4.19	10.54	10.54	18.78	29.40
17 Other equip., ma	0.03049	0.00372	0.00859	0.01506	0.01244	0.02208	2574.37	6.43	15.95	2037.27	1444.89	0.00	0.00	36112.52	7276.22	4591.77	1.74	52.78	29.80	29.80	77.34	136.38
18 Water and sewer	0.00039	0.00057	0.00569	0.00218	0.00210	0.00195	148.13	9.02	19.42	8.48	20.34	0.00	0.00	43.06	10.03	14.85	0.75	1.50	37.74	37.74	52.02	77.49
19 Construction	0.00057	0.00066	0.00576	0.00608	0.00055	0.00075	893.81	2.66	2.60	900.13	668.07	0.00	0.00	8589.50	1484.92	2124.63	0.71	4.47	6.41	6.41	25.93	50.18
20 Trade and repair	0.04591	0.00634	0.01168	0.01552	0.01651	0.02218	666.79	26.25	108.42	193.76	131.18	0.00	0.00	1428.31	310.15	297.48	10.08	38.25	186.72	186.72	473.43	815.71
21 Accomodation, c	0.00908	0.00811	0.00846	0.01067	0.00294	0.00796	127.57	4.45	44.65	29.63	21.17	0.00	0.00	170.61	41.79	47.13	1.75	5.65	70.58	70.58	120.51	179.99
22 Road transport	0.00935	0.00091	0.00270	0.00512	0.00292	0.00729	125.62	2.71	80.39	68.42	30.96	0.00	0.00	395.93	88.11	99.88	5.49	15.67	121.81	121.81	289.35	475.57
23 Rail, pipeline	0.00132	0.00048	0.00086	0.00058	0.00047	0.00053	151.48	20.90	13.21	46.19	42.38	0.00	0.00	65.74	15.55	16.06	0.72	18.88	40.39	40.39	41.72	66.03
24 Water transport	0.00072	0.00005	0.00027	0.00089	0.00025	0.00037	17.76	1.11	166.33	5.11	3.23	0.00	0.00	17.24	4.62	4.22	0.11	1.63	247.55	247.55	249.78	253.43
25 Air and space tra	0.01226	0.00390	0.00568	0.01236	0.00251	0.00531	90.62	5.98	29.95	22.30	19.78	0.00	0.00	143.34	32.36	30.60	0.71	4.85	50.32	50.32	66.46	90.66
26 Services to trans	0.00767	0.00447	0.00771	0.00885	0.00209	0.00299	63.15	3.00	81.67	37.65	18.12	0.00	0.00	149.18	39.54	46.06	1.82	9.65	123.98	123.98	177.42	239.15
27 Communication	1.01431	0.01357	0.01227	0.02475	0.00989	0.01732	226.61	12.77	22.09	42.22	41.80	0.00	0.00	277.73	63.65	66.43	2.32	8.09	45.43	45.43	104.57	183.23
28 Finance and insu	0.01375	1.12682	0.03109	0.03040	0.01141	0.01906	942.65	42.19	38.35	143.07	138.19	0.00	0.00	881.25	192.86	215.06	6.11	28.35	98.75	98.75	246.17	453.55
29 Property and bus	0.04779	0.05243	1.12815	0.07231	0.03335	0.06993	1411.29	226.89	127.58	624.71	793.40	0.00	0.00	1761.72	386.20	1244.51	8.91	53.26	414.86	414.86	464.40	766.72
30 Govt. admin and	0.00279	0.00064	0.00148	1.03039	0.00108	0.00090	17.09	0.62	17.06	9.40	3.71	0.00	0.00	32.74	7.77	9.05	0.27	2.78	25.90	25.90	33.59	42.67
31 Education, healtl	0.00102	0.00242	0.00134	0.00234	1.00652	0.00226	44.26	1.70	5.74	30.09	4.87	0.00	0.00	25.29	5.74	6.95	0.42	12.96	10.20	10.20	21.68	36.10
32 Personal and oth	0.00224	0.00375	0.00848	0.00502	0.00461	1.03961	59.45	3.77	9.63	26.16	13.60	0.00	0.00	80.19	18.83	22.57	0.34	8.01	18.02	18.02	24.68	36.10
33 Electricity	2.1E-07	2.0E-07	2.1E-07	2.2E-07	1.9E-07	2.2E-07	1.0E+00	1.2E-04	1.2E-03	7.7E-03	9.5E-04	0.0E+00	0.0E+00	1.1E-02	2.9E-03	2.7E-03	9.7E-05	3.1E-03	1.8E-03	1.8E-03	4.7E-03	7.9E-03
34 Gas supply	2.3E-07	2.2E-07	2.4E-07	2.5E-07	2.1E-07	2.6E-07	7.9E-01	1.0E+00	5.1E-03	6.9E-03	1.8E+00	0.0E+00	0.0E+00	1.5E-02	4.0E-03	3.9E-03	1.4E-04	2.6E-03	1.0E+00	1.0E+00	7.7E-03	1.2E-02
35 Petroleum Produ	3.0E-07	1.0E-07	1.6E-07	2.6E-07	1.2E-07	2.2E-07	7.9E-03	2.8E-04	1.0E+00	9.3E-03	1.4E-03	0.0E+00	0.0E+00	1.3E-02	2.8E-03	4.0E-03	3.8E-04	3.8E-03	6.3E-03	6.3E-03	1.8E-02	3.1E-02
36 Coal pl.	1.0E-07	9.9E-08	1.0E-07	1.1E-07	9.2E-08	1.1E-07	4.9E-01	5.7E-05	5.8E-04	1.0E+00	4.6E-04	0.0E+00	0.0E+00	5.3E-03	1.4E-03	1.3E-03	4.7E-05	1.5E-03	8.7E-04	8.7E-04	2.3E-03	3.9E-03
37 GasPl	8.9E-08	8.8E-08	9.3E-08	9.7E-08	8.2E-08	9.4E-08	4.3E-01	5.0E-05	5.1E-04	3.3E-03	1.0E+00	0.0E+00	0.0E+00	4.7E-03	1.2E-03	1.1E-03	4.2E-05	1.4E-03	7.7E-04	7.7E-04	2.0E-03	3.4E-03
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	6.5E-09	6.4E-09	6.7E-09	7.1E-09	6.0E-09	6.8E-09	3.2E-02	3.7E-06	3.7E-05	2.4E-04	3.0E-05	0.0E+00	1.0E+00	3.4E-04	9.0E-05	8.3E-05	3.0E-06	9.9E-05	5.6E-05	5.6E-05	1.5E-04	2.5E-04
40 PV pl.	3.2E-11	3.1E-11	3.3E-11	3.4E-11	2.9E-11	3.3E-11	1.5E-04	1.8E-08	1.8E-07	1.2E-06	1.4E-07	0.0E+00	0.0E+00	1.0E+00	4.3E-07	4.0E-07	1.5E-08	4.8E-07	2.7E-07	2.7E-07	7.1E-07	1.2E-06
41 Wind	1.1E-08	1.1E-08	1.2E-08	1.2E-08	1.0E-08	1.2E-08	5.5E-02	6.4E-06	6.5E-05	4.2E-04	5.2E-05	0.0E+00	0.0E+00	6.0E-04	1.0E+00	1.5E-04	5.3E-06	1.7E-04	9.8E-05	9.8E-05	2.6E-04	4.3E-04
42 Biomass Plant	6.6E-09	6.5E-09	6.8E-09	7.1E-09	6.0E-09	6.9E-09	3.2E-02	3.7E-06	3.8E-05	2.4E-04	3.0E-05	0.0E+00	0.0E+00	3.5E-04	9.1E-05	1.0E+00	3.1E-06	1.0E-04	5.7E-05	5.7E-05	1.5E-04	2.5E-04
43 Biomass	2.8E-08	2.3E-08	2.6E-08	3.3E-08	2.2E-08	2.8E-08	9.7E-02	1.4E-05	1.3E-04	7.8E-04	1.2E-04	0.0E+00	0.0E+00	1.4E-03	3.6E-04	3.0E+00	1.0E+00	3.1E-04	2.0E-04	2.0E-04	5.2E-04	8.8E-04
44 Coal	2.4E-07	2.2E-07	2.5E-07	2.7E-07	2.1E-07	2.5E-07	1.0E+00	1.4E-04	1.3E-03	2.1E+00	2.1E-03	0.0E+00	0.0E+00	2.7E-02	7.3E-03	6.2E-03	1.0E-04	1.0E+00	1.9E-03	1.9E-03	5.0E-03	8.5E-03
45 CNG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00
46 Methanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	0.0E+00	0.0E+00
47 Ethanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	0.0E+00
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00

Table D-22: Direct Requirement Coefficient Matrix 'A' for Moderate Scenario in 2040

	1	2	3	4	5	6	7	8	9	10	11	12	13
	Agri., hui	Forestry a	Mining	Services t	Meat and	Other foo	Beverage	Textile, c	Wood, pa	Basic che	Other che	Non-meta	Iron and s
1 Agri., hunting and trapping	0.05767	0.00287	0.00000	0.00000	0.23216	0.04077	0.03635	0.02383	0.00001	0.00063	0.00180	0.00000	0.00000
2 Forestry and fishing	0.00116	0.03771	0.00032	0.00000	0.00000	0.00018	0.00000	0.00000	0.00644	0.00024	0.00008	0.00000	0.00000
3 Mining	0.00021	0.00033	0.00733	0.00397	0.00004	0.00142	0.00001	0.00002	0.00004	0.00221	0.00013	0.01719	0.00260
4 Services to mining	0.00000	0.00000	0.03273	0.00653	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5 Meat and diary prod.	0.00245	0.00039	0.00001	0.00004	0.03539	0.01938	0.00014	0.00544	0.00000	0.00211	0.00092	0.00000	0.00000
6 Other food prod.	0.01809	0.01697	0.00013	0.00067	0.00648	0.07629	0.00392	0.00005	0.00001	0.00177	0.00208	0.00001	0.00001
7 Beverage and tobacco	0.00050	0.00094	0.00017	0.00018	0.00086	0.00166	0.02985	0.00037	0.00023	0.00033	0.00009	0.00008	0.00004
8 Textile, clothing, leather	0.00100	0.00429	0.00062	0.00018	0.00098	0.00259	0.00069	0.06351	0.00107	0.00092	0.00132	0.00074	0.00099
9 Wood, paper, printing	0.00304	0.00637	0.00195	0.00634	0.01003	0.00996	0.01300	0.00746	0.10383	0.00341	0.00769	0.00680	0.00202
10 Basic chemical	0.01752	0.00062	0.00583	0.00283	0.00020	0.00062	0.00028	0.00360	0.00410	0.07391	0.02290	0.00333	0.00113
11 Other chem., rubber, plastic	0.01753	0.01370	0.01175	0.00371	0.01873	0.01932	0.01144	0.00716	0.02290	0.02152	0.08225	0.00826	0.00751
12 Non-metalic mineral	0.00001	0.01223	0.00141	0.00231	0.00001	0.00235	0.00988	0.00016	0.00087	0.00015	0.00102	0.08597	0.00528
13 Iron and steel	0.00001	0.00034	0.00205	0.01797	0.00001	0.00002	0.00001	0.00040	0.00029	0.00014	0.00015	0.00437	0.10062
14 Basic non-ferrous	0.00000	0.00006	0.00052	0.00013	0.00019	0.00017	0.00003	0.00050	0.00110	0.00067	0.00144	0.00117	0.01299
15 Fabricated metal	0.00115	0.01752	0.00823	0.01343	0.00221	0.00367	0.01398	0.00212	0.00427	0.00196	0.00208	0.00954	0.00300
16 Transport equip.	0.00056	0.00481	0.00189	0.00222	0.00005	0.00015	0.00006	0.00005	0.00013	0.00013	0.00009	0.00062	0.00033
17 Other equip., manufacturing	0.00382	0.08122	0.04068	0.01758	0.00132	0.00325	0.00160	0.00436	0.00624	0.00177	0.00320	0.00342	0.00402
18 Water and sewerage	0.00234	0.00031	0.00067	0.00009	0.00295	0.00143	0.00157	0.00098	0.00079	0.00111	0.00100	0.00093	0.00144
19 Construction	0.00212	0.00031	0.00505	0.00085	0.00002	0.00004	0.00006	0.00006	0.00010	0.00008	0.00005	0.00014	0.00007
20 Trade and repair	0.03193	0.08817	0.02758	0.02391	0.03141	0.04781	0.02387	0.03672	0.02973	0.02351	0.02468	0.01671	0.00813
21 Accomodation, café	0.00521	0.00295	0.00243	0.02024	0.00050	0.00565	0.03482	0.00487	0.00666	0.00307	0.00587	0.00405	0.00187
22 Road transport	0.01774	0.00705	0.01484	0.00702	0.05126	0.02509	0.02037	0.00717	0.01133	0.00687	0.00576	0.06605	0.01017
23 Rail, pipeline	0.00235	0.00023	0.00104	0.00022	0.00206	0.00428	0.00213	0.00185	0.00066	0.00155	0.00155	0.01248	0.00719
24 Water transport	0.00009	0.00087	0.00009	0.01418	0.00003	0.00067	0.00014	0.00057	0.00037	0.00033	0.00018	0.00067	0.00100
25 Air and space travel	0.00160	0.00106	0.00267	0.00806	0.00023	0.00384	0.00139	0.00671	0.00601	0.00149	0.00247	0.00131	0.00091
26 Services to transport	0.00470	0.00177	0.00088	0.00187	0.00326	0.00918	0.00911	0.00365	0.00973	0.00691	0.00573	0.00373	0.00318
27 Communication	0.00612	0.00427	0.00821	0.00712	0.00415	0.00441	0.00283	0.00382	0.00669	0.00156	0.00295	0.00546	0.00158
28 Finance and insurance	0.01732	0.01809	0.01059	0.01346	0.00458	0.01465	0.00813	0.00443	0.00726	0.00262	0.00441	0.00519	0.00320
29 Property and business	0.01900	0.01016	0.01320	0.11866	0.02189	0.02370	0.02682	0.02428	0.04159	0.01708	0.04346	0.02058	0.03392
30 Govt. admin and defence	0.00056	0.00172	0.00308	0.00080	0.00072	0.00152	0.00077	0.00026	0.00262	0.00069	0.00030	0.00046	0.00083
31 Education, health, communi	0.00134	0.00040	0.00036	0.00082	0.00183	0.00060	0.00127	0.00256	0.00116	0.00037	0.00212	0.00051	0.00033
32 Personal and other services	0.00041	0.00158	0.00055	0.00155	0.00156	0.00228	0.00318	0.00255	0.00392	0.00072	0.00269	0.00145	0.00026
33 Electricity	2.7E-07	2.7E-07	9.8E-07	9.8E-07	2.2E-07	2.2E-07	2.2E-07	1.1E-07	2.4E-07	2.7E-06	3.7E-08	8.1E-07	4.5E-07
34 Gas supply	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.6E-07	2.6E-07	2.6E-07	6.8E-07	0.0E+00	1.0E-05	1.4E-07	2.1E-06	2.2E-06
35 Petroleum Product	9.3E-07	9.3E-07	1.1E-06	1.1E-06	4.4E-08	4.4E-08	4.4E-08	1.2E-07	6.0E-09	1.0E-05	1.4E-07	4.4E-08	0.0E+00
36 Coal pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
37 GasPl	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
40 PV pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
41 Wind	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
42 Biomass Plant	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
43 Biomass	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.3E-07	1.3E-07	1.3E-07	3.4E-07	3.5E-07	0.0E+00	0.0E+00	5.1E-08	0.0E+00
44 Coal	0.0E+00	0.0E+00	2.8E-09	2.8E-09	9.8E-08	9.8E-08	9.8E-08	2.6E-07	1.4E-07	0.0E+00	0.0E+00	1.4E-06	4.2E-06
45 CNG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
46 Methanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
47 Ethanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

	14	15	16	17	18	19	20	21	22	23	24	25	26
	Basic nor	Fabricate	Transport	Other equ	Water and	Construct	Trade and	Accomoc	Road trar	Rail, pipe	Water tra	Air and sp	Services t
1 Agri., hunting and trapping	0.00000	0.00001	0.00000	0.00026	0.00004	0.00031	0.00020	0.00154	0.00000	0.00002	0.00000	0.00000	0.00009
2 Forestry and fishing	0.00013	0.00000	0.00000	0.00010	0.00001	0.00008	0.00041	0.00500	0.00002	0.00121	0.00000	0.00000	0.00002
3 Mining	0.04227	0.00075	0.00006	0.00062	0.00103	0.00343	0.00007	0.00026	0.00005	0.00013	0.00013	0.00003	0.00010
4 Services to mining	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5 Meat and diary prod.	0.00000	0.00003	0.00006	0.00003	0.00014	0.00007	0.00383	0.01647	0.00002	0.00024	0.00009	0.00004	0.00004
6 Other food prod.	0.00000	0.00004	0.00002	0.00003	0.00011	0.00002	0.00213	0.01164	0.00003	0.00011	0.00006	0.00008	0.00006
7 Beverage and tobacco	0.00002	0.00005	0.00010	0.00005	0.00027	0.00007	0.00027	0.03504	0.00008	0.00019	0.00008	0.00015	0.00018
8 Textile, clothing, leather	0.00064	0.00436	0.00091	0.00145	0.00020	0.00142	0.00118	0.00442	0.00047	0.00342	0.00106	0.00026	0.00068
9 Wood, paper, printing	0.00142	0.00872	0.00425	0.01126	0.00295	0.03440	0.02572	0.01210	0.00222	0.00754	0.00332	0.00202	0.00598
10 Basic chemical	0.00316	0.00560	0.00236	0.00150	0.00865	0.00049	0.00006	0.00021	0.00006	0.00104	0.00004	0.00001	0.00004
11 Other chem., rubber, plastic	0.00253	0.00919	0.01388	0.00871	0.01583	0.00970	0.00281	0.00624	0.00435	0.00229	0.00258	0.00233	0.00222
12 Non-metalic mineral	0.00364	0.00679	0.00222	0.00219	0.00645	0.05864	0.00160	0.00062	0.00020	0.00005	0.00000	0.00000	0.00008
13 Iron and steel	0.00223	0.09451	0.03480	0.02819	0.00150	0.01111	0.00039	0.00002	0.00003	0.00231	0.00007	0.00001	0.00004
14 Basic non-ferrous	0.13966	0.03143	0.00578	0.00734	0.00021	0.00038	0.00013	0.00017	0.00001	0.00019	0.00001	0.00001	0.00004
15 Fabricated metal	0.00077	0.05862	0.01056	0.00841	0.01098	0.03401	0.00198	0.00110	0.00237	0.03257	0.01450	0.00108	0.00279
16 Transport equip.	0.00003	0.00024	0.11765	0.00086	0.00010	0.00020	0.00331	0.00073	0.00446	0.04027	0.00975	0.02306	0.00425
17 Other equip., manufacturing	0.00780	0.01330	0.02624	0.05100	0.00745	0.03976	0.00509	0.01224	0.00386	0.01252	0.00179	0.00039	0.01408
18 Water and sewerage	0.00063	0.00086	0.00067	0.00051	0.04133	0.00048	0.00035	0.00243	0.00001	0.00002	0.00138	0.00001	0.00002
19 Construction	0.00003	0.00006	0.00010	0.00003	0.00021	0.00049	0.00045	0.00255	0.00017	0.00643	0.00036	0.00016	0.00118
20 Trade and repair	0.00712	0.02496	0.01652	0.02380	0.02455	0.03643	0.02452	0.02162	0.03705	0.02266	0.00689	0.01788	0.02595
21 Accomodation, café	0.00174	0.00647	0.00199	0.00201	0.00227	0.00297	0.00647	0.00168	0.00385	0.00155	0.00258	0.00404	0.00742
22 Road transport	0.00615	0.00823	0.00208	0.00416	0.00249	0.01106	0.01045	0.00336	0.04613	0.00290	0.00082	0.00551	0.01289
23 Rail, pipeline	0.00876	0.00113	0.00028	0.00065	0.00016	0.00091	0.00073	0.00084	0.00005	0.00053	0.00004	0.00089	0.00133
24 Water transport	0.00285	0.00066	0.00005	0.00017	0.00002	0.00003	0.00016	0.00004	0.00004	0.00005	0.13314	0.00012	0.00004
25 Air and space travel	0.00101	0.00248	0.00159	0.00244	0.00328	0.00048	0.00832	0.00125	0.00072	0.00024	0.00181	0.03451	0.00319
26 Services to transport	0.00161	0.00757	0.00233	0.00079	0.00066	0.00231	0.01770	0.00316	0.00635	0.00129	0.08122	0.03966	0.02988
27 Communication	0.00094	0.00572	0.00256	0.00405	0.00599	0.00204	0.02404	0.01273	0.01487	0.00472	0.00477	0.00519	0.02090
28 Finance and insurance	0.00537	0.00547	0.00409	0.00253	0.03735	0.01240	0.02073	0.01715	0.00707	0.01940	0.00824	0.00849	0.01045
29 Property and business	0.02064	0.02870	0.02354	0.01496	0.02682	0.06052	0.11503	0.06782	0.04087	0.06097	0.03875	0.04276	0.08242
30 Govt. admin and defence	0.00018	0.00092	0.00090	0.00022	0.00134	0.00085	0.00105	0.00028	0.00686	0.00160	0.00026	0.00007	0.00785
31 Education, health, communi	0.00028	0.00043	0.00060	0.00033	0.00053	0.00027	0.00049	0.00058	0.00037	0.00071	0.00058	0.00039	0.00224
32 Personal and other services	0.00020	0.00191	0.00228	0.00097	0.00093	0.00039	0.00551	0.00853	0.00108	0.00062	0.00060	0.00074	0.00153
33 Electricity	4.6E-06	3.3E-07	1.3E-07	1.3E-07	6.1E-07	4.7E-09	1.6E-07	1.6E-07	0.0E+00	1.3E-06	0.0E+00	0.0E+00	0.0E+00
34 Gas supply	1.4E-06	2.9E-07	2.8E-08	2.8E-08	2.4E-08	6.9E-09	3.9E-08	3.9E-08	0.0E+00	2.4E-07	0.0E+00	0.0E+00	4.4E-07
35 Petroleum Product	5.5E-07	8.3E-08	1.6E-08	1.6E-08	7.0E-08	4.0E-07	3.6E-08	3.6E-08	7.5E-06	3.6E-06	7.9E-06	1.1E-05	0.0E+00
36 Coal pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
37 GasPl	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
40 PV pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
41 Wind	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
42 Biomass Plant	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
43 Biomass	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
44 Coal	1.4E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.7E-09	3.7E-09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
45 CNG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.1E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00
46 Methanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.2E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
47 Ethanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.1E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Source: Direct requirement coefficients are computed in this research as described in Section 5-2 and 5-4 (Chapter 5)

(contd ...)

Table D-22: Direct Requirement Coefficient Matrix 'A' for Moderate Scenario in 2040 (...contd)

	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
	Commun	Finance a	Property :	Govt. adr	Educatioi	Personal :	Electricity	Gas supp	Petroleun	Coal pl.	GasPl	Oil Pl.	Hydro	PV pl.	Wind	Biomass Pla	Biomass	Coal	CNG	Methanol	Ethanol	Biodiesel
1 Agri., hunting an	0.00000	0.00004	0.00020	0.00048	0.00013	0.00203	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	250.00	0.00	0.00	0.00	7758.62	16244.31
2 Forestry and fish	0.00002	0.00003	0.00001	0.00001	0.00002	0.00008	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00	0.00
3 Mining	0.00003	0.00002	0.00014	0.00026	0.00010	0.00078	2.41	0.21	4.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.08	6.37	6.37	6.37	6.37
4 Services to minir	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.76	0.00	0.00	0.00	0.00
5 Meat and diary p	0.00023	0.00013	0.00017	0.00006	0.00030	0.00036	0.59	0.05	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.22	0.22	0.22	0.22
6 Other food prod.	0.00015	0.00018	0.00013	0.00048	0.00025	0.00183	0.72	0.05	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.44	0.44	0.44	0.44
7 Beverage and tot	0.00033	0.00080	0.00012	0.00094	0.00018	0.00017	1.83	0.20	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	1.34	1.34	1.34	1.34
8 Textile, clothing,	0.00077	0.00011	0.00052	0.00167	0.00235	0.00281	4.41	0.26	1.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	2.88	2.88	2.88	2.88
9 Wood, paper, pri	0.01698	0.00502	0.00938	0.02259	0.00584	0.01160	34.29	3.20	21.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.12	32.42	32.42	32.42	32.42
10 Basic chemical	0.00012	0.00003	0.00045	0.00029	0.00068	0.00159	18.02	6.38	122.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.98	182.07	182.07	182.07	182.07
11 Other chem., rub	0.00611	0.00017	0.00332	0.00701	0.00541	0.00858	79.39	10.66	47.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.35	70.35	70.35	70.35	70.35
12 Non-metalic min	0.00005	0.00008	0.00105	0.00108	0.00037	0.00082	111.40	0.15	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.06	0.06	0.06	0.06
13 Iron and steel	0.00013	0.00001	0.00078	0.00045	0.00006	0.00024	14.81	0.66	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.62	0.04	0.04	0.04	0.04
14 Basic non-ferrou	0.00031	0.00000	0.00010	0.00115	0.00003	0.00019	0.34	0.08	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.13	0.13	0.13	0.13
15 Fabricated metal	0.00333	0.00013	0.00214	0.00266	0.00104	0.00264	39.26	4.22	5.29	531.84	396.07	0.00	0.00	2253.36	1478.77	1267.51	0.00	6.50	7.86	7.86	7.86	7.86
16 Transport equip.	0.00132	0.00003	0.00013	0.00818	0.00013	0.00028	5.15	0.12	1.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.41	1.78	1.78	1.78	1.78
17 Other equip., ma	0.02681	0.00174	0.00559	0.01094	0.01037	0.01814	367.93	3.09	5.94	1772.79	1320.24	0.00	0.00	33800.39	6802.33	4225.05	0.00	40.18	8.82	8.82	8.82	8.82
18 Water and sewer	0.00001	0.00020	0.00473	0.00154	0.00176	0.00135	123.74	7.46	16.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	25.24	25.24	25.24	25.24
19 Construction	0.00006	0.00016	0.00488	0.00529	0.00019	0.00014	13.18	1.27	0.34	886.40	660.12	0.00	0.00	8562.77	1478.77	2112.52	0.00	1.22	0.51	0.51	0.51	0.51
20 Trade and repair	0.04065	0.00365	0.00756	0.00972	0.01382	0.01690	425.61	20.65	86.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.72	128.43	128.43	128.43	128.43
21 Accomodation, c	0.00769	0.00653	0.00678	0.00876	0.00216	0.00638	80.15	1.94	39.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.45	58.20	58.20	58.20	58.20
22 Road transport	0.00740	0.00024	0.00140	0.00320	0.00204	0.00544	43.98	1.21	70.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.68	104.95	104.95	104.95	104.95
23 Rail, pipeline	0.00108	0.00031	0.00061	0.00028	0.00033	0.00028	105.07	20.58	12.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.08	17.92	17.92	17.92	17.92
24 Water transport	0.00053	0.00000	0.00016	0.00065	0.00017	0.00023	10.67	0.85	143.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	212.50	212.50	212.50	212.50
25 Air and space tra	0.01069	0.00284	0.00434	0.01043	0.00180	0.00395	51.30	4.09	25.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.17	37.43	37.43	37.43	37.43
26 Services to trans|	0.00520	0.00313	0.00580	0.00634	0.00110	0.00121	7.89	0.22	58.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.04	87.05	87.05	87.05	87.05
27 Communication	0.01146	0.01093	0.00951	0.02142	0.00844	0.01443	143.31	8.72	11.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.28	16.77	16.77	16.77	16.77
28 Finance and insu	0.00896	0.11070	0.02319	0.02283	0.00827	0.01323	663.74	30.23	20.98	35.46	26.40	0.00	0.00	450.67	98.58	84.50	0.00	18.98	31.17	31.17	31.17	31.17
29 Property and bus	0.03147	0.03852	0.10735	0.05341	0.02469	0.05272	483.42	192.91	65.51	319.10	237.64	0.00	0.00	0.00	0.00	760.51	0.00	30.07	97.32	97.32	97.32	97.32
30 Govt. admin and	0.00235	0.00040	0.00109	0.02911	0.00088	0.00055	6.08	0.14	14.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.18	21.66	21.66	21.66	21.66
31 Education, healtl	0.00079	0.00203	0.00103	0.00196	0.00634	0.00194	23.00	1.25	4.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.45	6.95	6.95	6.95	6.95
32 Personal and oth	0.00122	0.00271	0.00691	0.00368	0.00393	0.03721	24.85	1.60	6.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.56	9.32	9.32	9.32	9.32
33 Electricity	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	0.0E+00	0.0E+00	8.9E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.4E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00
34 Gas supply	3.9E-08	3.9E-08	3.9E-08	3.9E-08	3.9E-08	3.9E-08	0.0E+00	0.0E+00	3.4E-03	0.0E+00	1.5E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	1.0E+00	0.0E+00	0.0E+00
35 Petroleum Produ	3.6E-08	3.6E-08	3.6E-08	3.6E-08	3.6E-08	3.6E-08	0.0E+00	0.0E+00	3.5E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.8E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00
36 Coal pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.1E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
37 GasPl	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.3E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.8E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
40 PV pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.3E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
41 Wind	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.6E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
42 Biomass Plant	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
43 Biomass	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	0.0E+00
44 Coal	3.7E-09	3.7E-09	3.7E-09	3.7E-09	3.7E-09	3.7E-09	0.0E+00	0.0E+00	0.0E+00	1.7E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	9.9E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00
45 CNG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
46 Methanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
47 Ethanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Table D-23: Total Requirement Coefficient Matrix '(I-A)-1' for Moderate Scenario in 2040

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
	Agri., hui	Forestry a	Mining	Services t	Meat and	Other foo	Beverage	Textile, c	Wood, pa	Basic che	Other che	Non-meta	Iron and	Basic nor	Fabricate	Transport	Other equ	Water an	Construct	Trade an	Accomod	Road trar	Rail, pipe	Water tra	Air and s	Services t
1 Agri., hunting and trapping	1.06338	0.00480	0.00049	0.00058	0.25708	0.05306	0.04082	0.02893	0.00061	0.00204	0.00278	0.00100	0.00032	0.00082	0.00054	0.00026	0.00054	0.00039	0.00078	0.00170	0.00828	0.00968	0.00054	0.00024	0.00024	0.00047
2 Forestry and fishing	0.00139	1.03937	0.00043	0.00022	0.00047	0.00045	0.00039	0.00017	0.00756	0.00037	0.00024	0.00015	0.00007	0.00026	0.00017	0.00009	0.00025	0.00009	0.00043	0.00072	0.00537	0.00013	0.00138	0.00009	0.00008	0.00016
3 Mining	0.00037	0.00084	1.00775	0.00431	0.00020	0.00170	0.00033	0.00012	0.00021	0.00260	0.00035	0.01914	0.00381	0.04976	0.00306	0.00070	0.00126	0.00134	0.00484	0.00020	0.00040	0.00017	0.00040	0.00030	0.00014	0.00019
4 Services to mining	0.00001	0.00003	0.03320	1.00671	0.00001	0.00006	0.00001	0.00001	0.00001	0.00010	0.00001	0.00065	0.00017	0.00167	0.00011	0.00003	0.00004	0.00005	0.00016	0.00001	0.00001	0.00001	0.00002	0.00001	0.00000	0.00001
5 Meat and diary prod.	0.00349	0.00139	0.00029	0.00063	1.03791	0.02236	0.00118	0.00644	0.00040	0.00268	0.00145	0.00026	0.00015	0.00018	0.00039	0.00027	0.00023	0.00041	0.00040	0.00436	0.01764	0.00037	0.00049	0.00030	0.00027	0.00037
6 Other food prod.	0.02118	0.01957	0.00039	0.00118	0.01258	1.08414	0.00581	0.00091	0.00048	0.00237	0.00277	0.00023	0.00013	0.00016	0.00031	0.00020	0.00019	0.00034	0.00029	0.00263	0.01333	0.00046	0.00032	0.00023	0.00026	0.00032
7 Beverage and tobacco	0.00090	0.00132	0.00039	0.00108	0.00126	0.00226	1.03221	0.00071	0.00065	0.00061	0.00043	0.00035	0.00019	0.00021	0.00041	0.00027	0.00020	0.00049	0.00034	0.00069	0.03639	0.00037	0.00040	0.00034	0.00043	0.00060
8 Textile, clothing, leather	0.00145	0.00536	0.00099	0.00068	0.00167	0.00340	0.00128	1.06808	0.00161	0.00135	0.00178	0.00122	0.00138	0.00112	0.00535	0.00141	0.00186	0.00048	0.00208	0.00161	0.00510	0.00079	0.00411	0.00163	0.00052	0.00104
9 Wood, paper, printing	0.00663	0.01336	0.00563	0.01136	0.01567	0.01602	0.01812	0.01152	1.11902	0.00704	0.01171	0.01088	0.00422	0.00452	0.01335	0.00772	0.01504	0.00601	0.04276	0.03271	0.01747	0.00589	0.01210	0.00714	0.00492	0.01038
10 Basic chemical	0.02103	0.00193	0.00730	0.00386	0.00614	0.00269	0.00186	0.00516	0.00590	1.08238	0.02729	0.00480	0.00193	0.00495	0.00736	0.00372	0.00229	0.01049	0.00186	0.00061	0.00094	0.00211	0.00234	0.00168	0.00176	0.00040
11 Other chem., rubber, plastic	0.02241	0.01867	0.01485	0.00655	0.02803	0.02589	0.01556	0.01019	0.02923	0.02752	1.09146	0.01192	0.01022	0.00579	0.01329	0.01878	0.01134	0.01933	0.01412	0.00550	0.00970	0.00687	0.00532	0.00520	0.00448	0.00409
12 Non-metalic mineral	0.00056	0.01480	0.00261	0.00351	0.00049	0.00323	0.01163	0.00049	0.00157	0.00108	0.00151	1.09468	0.00686	0.00617	0.00912	0.00346	0.00304	0.00785	0.06504	0.00226	0.00171	0.00053	0.00150	0.00043	0.00030	0.00054
13 Iron and steel	0.00068	0.00600	0.00601	0.02305	0.00078	0.00103	0.00210	0.00115	0.00152	0.00146	0.00083	0.00735	1.11295	0.00526	0.11275	0.04649	0.03432	0.00369	0.01829	0.00146	0.00108	0.00091	0.00923	0.00286	0.00149	0.00140
14 Basic non-ferrous	0.00027	0.00188	0.00163	0.00142	0.00054	0.00060	0.00082	0.00088	0.00187	0.00129	0.00207	0.00226	0.01712	1.16306	0.04084	0.00918	0.00997	0.00099	0.00270	0.00050	0.00056	0.00030	0.00229	0.00092	0.00036	0.00047
15 Fabricated metal	0.00250	0.02145	0.01134	0.01668	0.00399	0.00560	0.01648	0.00320	0.00619	0.00551	0.00317	0.01332	0.00496	0.00711	1.06411	0.01379	0.01016	0.01336	0.03821	0.00340	0.00299	0.00339	0.03731	0.01878	0.00217	0.00402
16 Transport equip.	0.00125	0.00644	0.00279	0.00335	0.00101	0.00115	0.00069	0.00070	0.00084	0.00071	0.00055	0.00213	0.00108	0.00102	0.00090	1.13367	0.00137	0.00048	0.00085	0.00448	0.00125	0.00577	0.04601	0.01350	0.02758	0.00554
17 Other equip., manufacturing	0.00760	0.09281	0.05001	0.02597	0.00585	0.00731	0.00534	0.00707	0.01117	0.01572	0.00574	0.01086	0.00896	0.03582	0.02011	0.03384	1.05604	0.01257	0.04533	0.00942	0.01648	0.00642	0.02269	0.00563	0.00317	0.01786
18 Water and sewerage	0.00300	0.00083	0.00116	0.00121	0.00424	0.00224	0.00227	0.00150	0.00141	0.00223	0.00160	0.00154	0.00210	0.00187	0.00162	0.00119	0.00085	1.04354	0.00121	0.00123	0.00326	0.00064	0.00084	0.00225	0.00059	0.00066
19 Construction	0.00302	0.00110	0.00676	0.00312	0.00135	0.00094	0.00093	0.00062	0.00096	0.00418	0.00064	0.00188	0.00128	0.00772	0.00128	0.00069	0.00052	0.00142	1.00121	0.00153	0.00335	0.00066	0.00874	0.00096	0.00063	0.00190
20 Trade and repair	0.04036	0.10151	0.03454	0.03087	0.04830	0.06072	0.03209	0.04431	0.03900	0.03231	0.03115	0.02609	0.01267	0.01619	0.03285	0.02305	0.02858	0.02989	0.04506	1.03145	0.02914	0.04405	0.02945	0.01447	0.02363	0.03181
21 Accomodation, café	0.00701	0.00527	0.00445	0.02263	0.00355	0.00816	0.03761	0.00646	0.00896	0.00512	0.00759	0.00595	0.00303	0.00360	0.00846	0.00337	0.00304	0.00376	0.00527	0.00879	1.00463	0.00581	0.00348	0.00514	0.00591	0.00931
22 Road transport	0.02195	0.01193	0.01763	0.00966	0.06240	0.03267	0.02525	0.01015	0.01486	0.01028	0.00808	0.07744	0.01326	0.01002	0.01262	0.00432	0.00618	0.00446	0.01847	0.01327	0.00717	1.05064	0.00513	0.00389	0.00815	0.01521
23 Rail, pipeline	0.00286	0.00091	0.00148	0.00085	0.00307	0.00513	0.00273	0.00227	0.00104	0.00263	0.00194	0.01412	0.00856	0.01126	0.00276	0.00096	0.00120	0.00057	0.00217	0.00108	0.00127	0.00042	1.00108	0.00045	0.00124	0.00159
24 Water transport	0.00043	0.00136	0.00098	0.01684	0.00031	0.00101	0.00032	0.00083	0.00061	0.00240	0.00038	0.00111	0.00144	0.00414	0.00120	0.00023	0.00034	0.00014	0.00033	0.00033	0.00016	0.00203	0.00079	1.15518	0.00201	0.00016
25 Air and space travel	0.00285	0.00308	0.00413	0.01001	0.00189	0.00572	0.00260	0.00838	0.00807	0.00300	0.00370	0.00250	0.00171	0.00238	0.00391	0.00269	0.00339	0.00452	0.00214	0.01039	0.00266	0.00224	0.00165	0.00352	1.03694	0.00479
26 Services to transport	0.00727	0.00537	0.00281	0.00607	0.00715	0.01317	0.01185	0.00611	0.01331	0.01009	0.00817	0.00625	0.00483	0.00354	0.01051	0.00417	0.00230	0.00241	0.00532	0.02102	0.00560	0.00944	0.00361	0.09856	0.04439	1.03283
27 Communication	0.00927	0.00907	0.01106	0.01109	0.00942	0.00888	0.00632	0.00665	0.01044	0.00449	0.00550	0.00936	0.00347	0.00409	0.00889	0.00477	0.00593	0.00867	0.00597	0.02819	0.01583	0.01845	0.00775	0.00940	0.00825	0.02469
28 Finance and insurance	0.02445	0.02656	0.01625	0.02247	0.01475	0.02345	0.01445	0.00909	0.01339	0.00915	0.00890	0.01103	0.00733	0.01494	0.01106	0.00804	0.00543	0.04702	0.01930	0.02965	0.02448	0.01241	0.02723	0.01496	0.01351	0.01692
29 Property and business	0.03567	0.03449	0.03149	0.14814	0.04627	0.04732	0.04613	0.04060	0.06454	0.03708	0.06214	0.03987	0.04986	0.04170	0.05064	0.03964	0.02669	0.04216	0.08444	0.14257	0.08810	0.05973	0.08158	0.06586	0.06126	0.10532
30 Govt. admin and defence	0.00107	0.00233	0.00358	0.00134	0.00168	0.00234	0.00135	0.00062	0.00344	0.00127	0.00068	0.00139	0.00125	0.00068	0.00150	0.00130	0.00049	0.00169	0.00147	0.00176	0.00073	0.00789	0.00208	0.00146	0.00084	0.00874
31 Education, health, communi	0.00170	0.00077	0.00063	0.00122	0.00254	0.00108	0.00164	0.00299	0.00159	0.00076	0.00252	0.00084	0.00060	0.00069	0.00076	0.00089	0.00050	0.00083	0.00063	0.00090	0.00097	0.00066	0.00105	0.00112	0.00072	0.00259
32 Personal and other services	0.00134	0.00308	0.00140	0.00339	0.00281	0.00375	0.00460	0.00365	0.00559	0.00172	0.00393	0.00249	0.00097	0.00107	0.00304	0.00336	0.00164	0.00185	0.00188	0.00741	0.01016	0.00218	0.00191	0.00174	0.00175	0.00291
33 Electricity	3.9E-07	3.8E-07	1.1E-06	1.1E-06	3.6E-07	3.2E-07	3.0E-07	1.7E-07	3.3E-07	2.9E-06	1.5E-07	9.8E-07	6.4E-07	5.5E-06	6.6E-07	2.6E-07	2.4E-07	7.1E-07	1.5E-07	2.2E-07	2.3E-07	4.8E-08	1.4E-06	5.0E-08	4.4E-08	4.7E-08
34 Gas supply	5.8E-07	4.2E-07	1.0E-06	1.0E-06	7.3E-07	6.5E-07	6.2E-07	9.5E-07	3.8E-07	1.4E-05	5.9E-07	3.3E-06	3.1E-06	6.2E-06	1.3E-06	4.2E-07	3.6E-07	7.6E-07	3.8E-07	2.8E-07	2.8E-07	1.5E-06	1.5E-06	1.6E-07	1.3E-07	5.3E-07
35 Petroleum Product	1.4E-06	1.1E-06	1.4E-06	1.5E-06	8.7E-07	4.8E-07	3.5E-07	3.9E-07	3.0E-07	1.1E-05	5.6E-07	8.1E-07	2.2E-07	9.4E-07	3.6E-07	1.4E-07	1.4E-07	2.8E-07	6.2E-07	2.7E-07	1.6E-07	8.0E-06	3.7E-06	9.3E-06	1.1E-05	1.9E-07
36 Coal pl.	8.2E-08	8.0E-08	2.3E-07	2.3E-07	7.7E-08	6.8E-08	6.4E-08	3.7E-08	7.0E-08	6.2E-07	3.3E-08	2.1E-07	1.4E-07	1.2E-06	1.4E-07	5.5E-08	5.0E-08	1.5E-07	3.2E-08	4.8E-08	4.8E-08	1.0E-08	3.0E-07	1.1E-08	9.5E-09	1.0E-08
37 GasPl	2.0E-07	2.0E-07	5.7E-07	5.7E-07	1.9E-07	1.7E-07	1.6E-07	9.2E-08	1.7E-07	1.5E-06	8.2E-08	5.2E-07	3.4E-07	2.9E-06	3.5E-07	1.4E-07	1.2E-07	3.8E-07	7.9E-08	1.2E-07	1.2E-07	2.5E-08	7.5E-07	2.7E-08	2.3E-08	2.5E-08
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	1.5E-08	1.4E-08	4.1E-08	4.0E-08	1.4E-08	1.2E-08	1.1E-08	6.6E-09	1.2E-08	1.1E-07	5.8E-09	3.7E-08	2.4E-08	2.1E-07	2.5E-08	9.7E-09	8.9E-09	2.7E-08	5.6E-09	8.4E-09	8.6E-09	1.8E-09	5.3E-08	1.9E-09	1.7E-09	1.8E-09
40 PV pl.	1.6E-08	1.6E-08	4.6E-08	4.6E-08	1.5E-08	1.4E-08	1.3E-08	7.5E-09	1.4E-08	1.3E-07	6.6E-09	4.2E-08	2.7E-08	2.3E-07	2.8E-08	1.1E-08	1.0E-08	3.0E-08	6.4E-09	9.6E-09	9.7E-09	2.0E-09	6.1E-08	2.2E-09	1.9E-09	2.0E-09
41 Wind	2.5E-08	2.5E-08	7.1E-08	7.1E-08	2.4E-08	2.1E-08	2.0E-08	1.1E-08	2.2E-08	1.9E-07	1.0E-08	6.5E-08	4.2E-08	3.6E-07	4.3E-08	1.7E-08	1.5E-08	4.7E-08	9.8E-09	1.5E-08	1.5E-08	3.1E-09	9.3E-08	3.3E-09	2.9E-09	3.1E-09
42 Biomass Plant	5.2E-08	5.1E-08	1.5E-07	1.5E-07	4.9E-08	4.3E-08	4.1E-08	2.4E-08	4.5E-08	4.0E-07	2.1E-08	1.3E-07	8.7E-08	7.4E-07	8.9E-08	3.5E-08	3.2E-08	9.6E-08	2.0E-08	3.0E-08	3.1E-08	6.5E-09	1.9E-07	6.8E-09	6.0E-09	6.4E-09
43 Biomass	1.9E-07	1.8E-07	4.6E-07	4.5E-07	3.6E-07	3.2E-07	2.9E-07	4.5E-07	5.4E-07	1.2E-06	7.7E-08	5.4E-07	2.8E-07	2.2E-06	2.9E-07	1.1E-07	1.1E-07	3.0E-07	1.0E-07	1.2E-07	1.2E-07	1.1E-06	5.9E-07	2.8E-08	2.9E-08	4.0E-08
44 Coal	1.4E-07	1.9E-07	4.2E-07	4.9E-07	2.4E-07	2.3E-07	2.4E-07	3.5E-07	2.8E-07	1.0E-06	6.6E-08	1.9E-06	4.9E-06	3.6E-06	7.8E-07	3.0E-07	2.5E-07	2.8E-07	2.3E-07	9.9E-08	1.0E-07	2.4E-08	5.5E-07	3.4E-08	2.4E-08	2.7E-08
45 CNG	2.3E-08	1.3E-08	1.9E-08	1.0E-08	6.6E-08	3.5E-08	2.7E-08	1.1E-08	1.6E-08	1.1E-08	8.6E-09	8.2E-08	1.4E-08	1.1E-08	1.3E-08	4.6E-09	6.6E-09	4.7E-09	2.0E-08	1.4E-08	7.6E-09	1.1E-06	5.4E-09	4.1E-09	8.6E-09	1.6E-08
46 Methanol	4.9E-09	2.7E-09	3.9E-09	2.2E-09	1.4E-08	7.3E-09	5.6E-09	2.3E-09	3.3E-09	2.3E-09	1.8E-09	1.7E-08	3.0E-09	2.2E-09	2.8E-09	9.6E-10	1.4E-09	1.0E-09	4.1E-09	3.0E-09	1.6E-09	2.3E-07	1.1E-09	8.7E-10	1.8E-09	3.4E-09
47 Ethanol	2.3E-08	1.3E-08	1.9E-08	1.0E-08	6.6E-08	3.5E-08	2.7E-08	1.1E-08	1.6E-08	1.1E-08	8.6E-09	8.2E-08	1.4E-08	1.1E-08	1.3E-08	4.6E-09	6.6E-09	4.7E-09	2.0E-08	1.4E-08	7.6E-09	1.1E-06	5.4E-09	4.1E-09	8.6E-09	1.6E-08
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Source: Total requirement coefficients are computed in this research as described in Section 5-2 and 5-4 (Chapter 5)

(contd ...)

Table D-23: Total Requirement Coefficient Matrix '(I-A)-1' for Moderate Scenario in 2040 (...contd)

	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
	Commun	Finance a	Property	Govt. adr	Educatioi	Personal	Electricit	Gas supp	Petroleun	Coal pl.	GasPl	Oil Pl.	Hydro	PV pl.	Wind	Biomass Pla	Biomass	Coal	CNG	Methanol	Ethanol	Biodiesel
1 Agri., hunting an	0.00041	0.00027	0.00050	0.00091	0.00044	0.00278	115.45	0.27	1.97	3.41	1.98	0.00	0.00	26.09	5.61	802.53	265.85	0.79	3.04	3.04	8520.52	17276.72
2 Forestry and fish	0.00025	0.00013	0.00016	0.00027	0.00010	0.00026	4.08	0.12	0.58	1.80	0.91	0.00	0.00	12.55	2.60	3.35	0.35	0.50	0.98	0.98	12.02	23.50
3 Mining	0.00013	0.00006	0.00027	0.00045	0.00015	0.00092	19.61	0.35	4.89	10.52	6.66	0.00	0.00	90.95	20.26	19.91	0.09	1.38	7.56	7.56	10.18	13.23
4 Services to minir	0.00001	0.00000	0.00001	0.00002	0.00001	0.00003	4.16	0.01	0.17	16.69	0.23	0.00	0.00	3.12	0.70	0.68	0.00	9.88	0.25	0.25	0.35	0.46
5 Meat and diary p	0.00062	0.00035	0.00043	0.00038	0.00047	0.00072	7.45	0.34	1.83	1.69	1.35	0.00	0.00	12.40	2.80	5.31	0.87	0.34	3.04	3.04	30.70	59.48
6 Other food prod.	0.00044	0.00038	0.00035	0.00080	0.00040	0.00232	8.01	0.29	1.70	1.66	1.10	0.00	0.00	9.91	2.25	18.00	5.29	0.47	2.79	2.79	172.12	346.48
7 Beverage and tot	0.00072	0.00124	0.00050	0.00145	0.00032	0.00053	8.93	0.46	2.78	1.82	1.51	0.00	0.00	11.08	2.58	3.23	0.22	0.45	4.56	4.56	11.30	18.71
8 Textile, clothing,	0.00112	0.00027	0.00081	0.00213	0.00266	0.00336	22.87	0.66	3.34	10.19	7.15	0.00	0.00	92.84	23.66	20.76	0.36	1.17	5.56	5.56	16.52	28.46
9 Wood, paper, pri	0.02206	0.00768	0.01340	0.02886	0.00812	0.01604	212.75	8.01	34.21	89.16	69.00	0.00	0.00	907.87	186.00	186.59	1.66	7.81	58.33	58.33	103.44	158.05
10 Basic chemical	0.00062	0.00018	0.00090	0.00094	0.00106	0.00237	51.91	7.60	135.55	16.01	19.02	0.00	0.00	110.12	29.25	39.42	5.26	3.67	208.21	208.21	369.06	542.22
11 Other chem., rub	0.00834	0.00097	0.00516	0.00992	0.00678	0.01128	195.45	13.58	59.92	73.56	51.59	0.00	0.00	534.62	117.78	115.41	5.60	19.39	101.98	101.98	267.87	452.37
12 Non-metalic min	0.00044	0.00031	0.00186	0.00196	0.00063	0.00130	230.97	0.85	1.34	72.18	52.31	0.00	0.00	680.38	130.38	163.66	0.14	2.22	2.52	2.52	6.15	10.75
13 Iron and steel	0.00177	0.00029	0.00174	0.00203	0.00072	0.00153	266.58	1.99	2.55	152.37	105.52	0.00	0.00	1570.99	427.29	328.44	0.17	8.90	5.40	5.40	8.88	14.50
14 Basic non-ferrou	0.00090	0.00010	0.00041	0.00185	0.00026	0.00065	75.45	0.51	1.14	44.00	32.00	0.00	0.00	452.09	132.19	100.10	0.07	1.26	2.10	2.10	3.75	5.98
15 Fabricated metal	0.00458	0.00069	0.00339	0.00421	0.00170	0.00385	886.51	6.37	12.29	638.62	470.67	0.00	0.00	3068.61	1699.23	1476.91	0.63	11.87	23.37	23.37	37.05	57.66
16 Transport equip.	0.00224	0.00026	0.00052	0.01013	0.00038	0.00072	25.88	1.47	6.14	10.81	5.10	0.00	0.00	55.76	11.94	10.09	0.31	4.20	10.52	10.52	19.07	29.38
17 Other equip., ma	0.03082	0.00405	0.00894	0.01542	0.01274	0.02243	4254.85	6.62	18.75	2025.18	1444.48	0.00	0.00	36129.97	7280.73	4595.93	1.90	59.74	28.75	28.75	83.02	145.62
18 Water and sewer	0.00039	0.00057	0.00569	0.00218	0.00210	0.00195	149.78	9.02	19.47	7.89	17.73	0.00	0.00	43.08	10.04	14.83	0.75	1.57	37.60	37.60	52.64	77.37
19 Construction	0.00065	0.00074	0.00585	0.00617	0.00063	0.00083	1317.16	2.71	3.35	901.46	667.67	0.00	0.00	8593.94	1486.07	2125.68	0.76	6.32	5.92	5.92	27.40	52.28
20 Trade and repair	0.04592	0.00635	0.01169	0.01553	0.01652	0.02219	714.22	26.25	108.73	176.32	123.59	0.00	0.00	1428.64	310.22	297.26	10.09	38.73	186.16	186.16	483.20	815.54
21 Accomodation, c	0.00908	0.00811	0.00846	0.01068	0.00294	0.00796	132.95	4.45	44.72	27.08	19.88	0.00	0.00	170.64	41.79	47.08	1.75	5.74	70.46	70.46	122.18	179.92
22 Road transport	0.00935	0.00092	0.00270	0.00512	0.00293	0.00729	136.23	2.72	80.50	61.15	30.17	0.00	0.00	395.97	88.12	99.73	5.49	15.79	121.72	121.72	294.83	475.58
23 Rail, pipeline	0.00131	0.00047	0.00086	0.00058	0.00046	0.00053	142.52	20.90	13.26	37.21	36.30	0.00	0.00	65.56	15.50	16.00	0.72	18.92	40.24	40.24	42.27	65.85
24 Water transport	0.00072	0.00005	0.00027	0.00089	0.00025	0.00037	17.58	1.11	166.45	4.46	2.91	0.00	0.00	17.17	4.61	4.20	0.11	1.70	247.52	247.52	249.84	253.35
25 Air and space tra	0.01226	0.00390	0.00568	0.01236	0.00251	0.00531	94.73	5.98	29.99	20.09	18.04	0.00	0.00	143.35	32.37	30.58	0.71	4.92	50.24	50.24	67.11	90.60
26 Services to trans	0.00767	0.00447	0.00771	0.00885	0.00209	0.00299	64.79	3.00	81.75	33.15	17.25	0.00	0.00	149.12	39.52	45.99	1.82	9.72	123.92	123.92	179.20	239.10
27 Communication	1.01431	0.01357	0.01227	0.02475	0.00989	0.01733	235.89	12.77	22.18	38.58	38.11	0.00	0.00	277.81	63.67	66.38	2.32	8.22	45.23	45.23	106.75	183.11
28 Finance and insu	0.01375	1.12682	0.03109	0.03041	0.01141	0.01906	969.97	42.19	38.64	130.35	125.97	0.00	0.00	881.44	192.89	214.91	6.11	28.84	97.90	97.90	251.59	452.95
29 Property and bus	0.04781	0.05244	1.12816	0.07232	0.03336	0.06994	1487.19	226.90	128.24	600.84	727.67	0.00	0.00	1762.81	386.46	1244.48	8.92	54.16	413.65	413.65	472.45	766.15
30 Govt. admin and	0.00279	0.00064	0.00148	1.03039	0.00108	0.00090	16.93	0.62	17.08	8.09	3.52	0.00	0.00	32.71	7.77	9.04	0.27	2.79	25.88	25.88	33.84	42.66
31 Education, healtl	0.00102	0.00241	0.00134	0.00234	1.00652	0.00226	36.78	1.70	5.75	23.87	4.36	0.00	0.00	25.11	5.70	6.90	0.42	12.96	10.15	10.15	22.04	36.01
32 Personal and oth	0.00224	0.00375	0.00848	0.00502	0.00461	1.03961	58.22	3.77	9.65	22.37	12.50	0.00	0.00	80.13	18.81	22.54	0.34	8.03	17.97	17.97	24.96	36.04
33 Electricity	2.0E-07	2.0E-07	2.1E-07	2.2E-07	1.9E-07	2.1E-07	1.0E+00	1.2E-04	1.4E-03	6.9E-03	9.0E-04	0.0E+00	0.0E+00	1.1E-02	2.8E-03	2.6E-03	9.6E-05	3.5E-03	8.3E-04	8.3E-04	3.8E-03	7.0E-03
34 Gas supply	2.4E-07	2.2E-07	2.5E-07	2.6E-07	2.2E-07	2.7E-07	8.1E-01	1.0E+00	6.2E-03	6.7E-03	1.5E+00	0.0E+00	0.0E+00	1.8E-02	4.9E-03	4.6E-03	1.5E-04	3.0E-03	1.0E+00	1.0E+00	7.6E-03	1.2E-02
35 Petroleum Produ	2.6E-07	9.8E-08	1.4E-07	2.4E-07	1.1E-07	1.9E-07	5.6E-03	2.6E-04	1.0E+00	8.0E-03	1.2E-03	0.0E+00	0.0E+00	1.1E-02	2.4E-03	3.6E-03	3.6E-04	4.2E-03	5.8E-03	5.8E-03	1.7E-02	2.9E-02
36 Coal pl.	4.4E-08	4.3E-08	4.5E-08	4.7E-08	4.0E-08	4.6E-08	2.1E-01	2.5E-05	2.9E-04	1.0E+00	1.9E-04	0.0E+00	0.0E+00	2.3E-03	6.0E-04	5.6E-04	2.1E-05	7.6E-04	1.8E-04	1.8E-04	8.1E-04	1.5E-03
37 GasPl	1.1E-07	1.1E-07	1.1E-07	1.2E-07	9.9E-08	1.1E-07	5.3E-01	6.1E-05	7.3E-04	3.6E-03	1.0E+00	0.0E+00	0.0E+00	5.7E-03	1.5E-03	1.4E-03	5.1E-05	1.9E-03	4.4E-04	4.4E-04	2.0E-03	3.7E-03
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	7.7E-09	7.6E-09	8.0E-09	8.3E-09	7.0E-09	8.1E-09	3.8E-02	4.4E-06	5.2E-05	2.6E-04	3.4E-05	0.0E+00	1.0E+00	4.1E-04	1.1E-04	9.8E-05	3.6E-06	1.3E-04	3.1E-05	3.1E-05	1.4E-04	2.6E-04
40 PV pl.	8.7E-09	8.6E-09	9.0E-09	9.5E-09	8.0E-09	9.2E-09	4.3E-02	4.9E-06	5.9E-05	2.9E-04	3.9E-05	0.0E+00	0.0E+00	1.0E+00	1.2E-04	1.1E-04	4.1E-06	1.5E-04	3.6E-05	3.6E-05	1.6E-04	3.0E-04
41 Wind	1.3E-08	1.3E-08	1.4E-08	1.5E-08	1.2E-08	1.4E-08	6.6E-02	7.6E-06	9.0E-05	4.5E-04	5.9E-05	0.0E+00	0.0E+00	7.1E-04	1.0E+00	1.7E-04	6.3E-06	2.3E-04	5.5E-05	5.5E-05	2.5E-04	4.6E-04
42 Biomass Plant	2.8E-08	2.7E-08	2.9E-08	3.0E-08	2.5E-08	2.9E-08	1.4E-01	1.6E-05	1.9E-04	9.3E-04	1.2E-04	0.0E+00	0.0E+00	1.5E-03	3.8E-04	1.0E+00	1.3E-05	4.8E-04	1.1E-04	1.1E-04	5.1E-04	9.4E-04
43 Biomass	1.0E-07	8.6E-08	9.4E-08	1.1E-07	8.3E-08	1.0E-07	4.1E-01	5.3E-05	6.6E-04	2.9E-03	4.3E-04	0.0E+00	0.0E+00	5.2E-03	1.3E-03	3.0E+00	1.0E+00	1.5E-03	4.9E-04	4.9E-04	1.0E+00	3.5E-03
44 Coal	8.9E-08	7.9E-08	9.2E-08	1.0E-07	7.6E-08	9.3E-08	3.6E-01	5.4E-05	5.1E-04	1.7E+00	8.9E-04	0.0E+00	0.0E+00	1.2E-02	3.2E-03	2.7E-03	3.6E-05	1.0E+00	3.4E-04	3.4E-04	1.4E-03	2.6E-03
45 CNG	9.9E-09	9.7E-10	2.9E-09	5.4E-09	3.1E-09	7.7E-09	1.4E-04	2.9E-06	8.5E-05	6.5E-05	3.2E-05	0.0E+00	0.0E+00	4.2E-04	9.3E-05	1.1E-04	5.8E-06	1.7E-05	1.0E+00	1.3E-04	3.1E-04	5.0E-04
46 Methanol	2.1E-09	2.0E-10	6.0E-10	1.1E-09	6.5E-10	1.6E-09	3.0E-05	6.1E-07	1.8E-05	1.4E-05	6.7E-06	0.0E+00	0.0E+00	8.8E-05	2.0E-05	2.2E-05	1.2E-06	3.5E-06	2.7E-05	1.0E+00	6.6E-05	1.1E-04
47 Ethanol	9.9E-09	9.7E-10	2.9E-09	5.4E-09	3.1E-09	7.7E-09	1.4E-04	2.9E-06	8.5E-05	6.5E-05	3.2E-05	0.0E+00	0.0E+00	4.2E-04	9.3E-05	1.1E-04	5.8E-06	1.7E-05	1.3E-04	1.3E-04	1.0E+00	5.0E-04
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00

Table D-24: Direct Requirement Coefficient Matrix 'A' for Advanced Scenario in 2040

	1	2	3	4	5	6	7	8	9	10	11	12	13
	Agri., hu	Forestry :	Mining	Services t	Meat and	Other foo	Beverage	Textile, c	Wood, pa	Basic che	Other che	Non-meta	Iron and :
1 Agri., hunting and trapping	0.05767	0.00287	0.00000	0.00000	0.23216	0.04077	0.03635	0.02383	0.00001	0.00063	0.00180	0.00000	0.00000
2 Forestry and fishing	0.00116	0.03771	0.00032	0.00000	0.00000	0.00018	0.00000	0.00000	0.00644	0.00024	0.00008	0.00000	0.00000
3 Mining	0.00021	0.00033	0.00733	0.00397	0.00004	0.00142	0.00001	0.00002	0.00004	0.00221	0.00013	0.01719	0.00260
4 Services to mining	0.00000	0.00000	0.03273	0.00653	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5 Meat and diary prod.	0.00245	0.00039	0.00001	0.00004	0.03539	0.01938	0.00014	0.00544	0.00000	0.00211	0.00092	0.00000	0.00000
6 Other food prod.	0.01809	0.01697	0.00013	0.00067	0.00648	0.07629	0.00392	0.00005	0.00001	0.00177	0.00208	0.00001	0.00001
7 Beverage and tobacco	0.00050	0.00094	0.00017	0.00018	0.00086	0.00166	0.02985	0.00037	0.00023	0.00033	0.00009	0.00008	0.00004
8 Textile, clothing, leather	0.00100	0.00429	0.00062	0.00018	0.00098	0.00259	0.00069	0.06351	0.00107	0.00092	0.00132	0.00074	0.00099
9 Wood, paper, printing	0.00304	0.00637	0.00195	0.00634	0.01003	0.00996	0.01300	0.00746	0.10383	0.00341	0.00769	0.00680	0.00202
10 Basic chemical	0.01752	0.00062	0.00583	0.00283	0.00020	0.00062	0.00028	0.00360	0.00410	0.07391	0.02290	0.00333	0.00113
11 Other chem., rubber, plastic	0.01753	0.01370	0.01175	0.00371	0.01873	0.01932	0.01144	0.00716	0.02290	0.02152	0.08225	0.00826	0.00751
12 Non-metalic mineral	0.00001	0.01223	0.00141	0.00231	0.00001	0.00235	0.00988	0.00016	0.00087	0.00015	0.00102	0.08597	0.00528
13 Iron and steel	0.00001	0.00034	0.00205	0.01797	0.00001	0.00002	0.00001	0.00040	0.00029	0.00014	0.00015	0.00437	0.10062
14 Basic non-ferrous	0.00000	0.00006	0.00052	0.00013	0.00019	0.00017	0.00003	0.00050	0.00110	0.00067	0.00144	0.00117	0.01299
15 Fabricated metal	0.00115	0.01752	0.00823	0.01343	0.00221	0.00367	0.01398	0.00212	0.00427	0.00196	0.00208	0.00954	0.00300
16 Transport equip.	0.00056	0.00481	0.00189	0.00222	0.00005	0.00015	0.00006	0.00005	0.00013	0.00013	0.00009	0.00062	0.00033
17 Other equip., manufacturing	0.00382	0.08122	0.04068	0.01758	0.00132	0.00325	0.00160	0.00436	0.00624	0.00177	0.00320	0.00342	0.00402
18 Water and sewerage	0.00234	0.00031	0.00067	0.00009	0.00295	0.00143	0.00157	0.00098	0.00079	0.00111	0.00100	0.00093	0.00144
19 Construction	0.00212	0.00031	0.00505	0.00085	0.00002	0.00004	0.00006	0.00006	0.00010	0.00008	0.00005	0.00014	0.00007
20 Trade and repair	0.03193	0.08817	0.02758	0.02391	0.03141	0.04781	0.02387	0.03672	0.02973	0.02351	0.02468	0.01671	0.00813
21 Accomodation, café	0.00521	0.00295	0.00243	0.02024	0.00050	0.00565	0.03482	0.00487	0.00666	0.00307	0.00587	0.00405	0.00187
22 Road transport	0.01774	0.00705	0.01484	0.00702	0.05126	0.02509	0.02037	0.00717	0.01133	0.00687	0.00576	0.06605	0.01017
23 Rail, pipeline	0.00235	0.00023	0.00104	0.00022	0.00206	0.00428	0.00213	0.00185	0.00066	0.00155	0.00155	0.01248	0.00719
24 Water transport	0.00009	0.00087	0.00009	0.01418	0.00003	0.00067	0.00014	0.00057	0.00037	0.00033	0.00018	0.00067	0.00100
25 Air and space travel	0.00160	0.00106	0.00267	0.00806	0.00023	0.00384	0.00139	0.00671	0.00601	0.00149	0.00247	0.00131	0.00091
26 Services to transport	0.00470	0.00177	0.00088	0.00187	0.00326	0.00918	0.00911	0.00365	0.00973	0.00691	0.00573	0.00373	0.00318
27 Communication	0.00612	0.00427	0.00821	0.00712	0.00415	0.00441	0.00283	0.00382	0.00669	0.00156	0.00295	0.00546	0.00158
28 Finance and insurance	0.01732	0.01809	0.01059	0.01346	0.00458	0.01465	0.00813	0.00443	0.00726	0.00262	0.00441	0.00519	0.00320
29 Property and business	0.01900	0.01016	0.01320	0.11866	0.02189	0.02370	0.02682	0.02428	0.04159	0.01708	0.04346	0.02058	0.03392
30 Govt. admin and defence	0.00056	0.00172	0.00308	0.00080	0.00072	0.00152	0.00077	0.00026	0.00262	0.00069	0.00030	0.00046	0.00083
31 Education, health, communi	0.00134	0.00040	0.00036	0.00082	0.00183	0.00060	0.00127	0.00256	0.00116	0.00037	0.00212	0.00051	0.00033
32 Personal and other services	0.00041	0.00158	0.00055	0.00155	0.00156	0.00228	0.00318	0.00255	0.00392	0.00072	0.00269	0.00145	0.00026
33 Electricity	2.7E-07	2.7E-07	9.8E-07	9.8E-07	2.2E-07	2.2E-07	2.2E-07	1.1E-07	2.4E-07	2.7E-06	3.7E-08	8.1E-07	4.5E-07
34 Gas supply	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.6E-07	2.6E-07	2.6E-07	6.8E-07	0.0E+00	1.0E-05	1.4E-07	2.1E-06	3.0E-06
35 Petroleum Product	9.3E-07	9.3E-07	1.1E-06	1.1E-06	4.4E-08	4.4E-08	4.4E-08	1.2E-07	6.0E-09	1.0E-05	1.4E-07	4.4E-08	0.0E+00
36 Coal pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
37 GasPl	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
40 PV pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
41 Wind	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
42 Biomass Plant	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
43 Biomass	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.3E-07	1.3E-07	1.3E-07	3.4E-07	3.5E-07	0.0E+00	0.0E+00	5.1E-08	0.0E+00
44 Coal	0.0E+00	0.0E+00	2.8E-09	2.8E-09	9.8E-08	9.8E-08	9.8E-08	2.6E-07	1.4E-07	0.0E+00	0.0E+00	1.4E-06	2.2E-06
45 CNG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
46 Methanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
47 Ethanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

	14	15	16	17	18	19	20	21	22	23	24	25	26
	Basic nor	Fabricate	Transpor	Other equ	Water an	Construct	Trade an	Accomod	Road trar	Rail, pipe	Water tra	Air and s	Services t
1 Agri., hunting and trapping	0.00000	0.00001	0.00000	0.00026	0.00004	0.00031	0.00020	0.00154	0.00000	0.00002	0.00000	0.00000	0.00009
2 Forestry and fishing	0.00013	0.00000	0.00000	0.00010	0.00001	0.00008	0.00041	0.00500	0.00002	0.00121	0.00000	0.00000	0.00002
3 Mining	0.04227	0.00075	0.00006	0.00062	0.00103	0.00343	0.00007	0.00026	0.00005	0.00013	0.00013	0.00003	0.00010
4 Services to mining	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5 Meat and diary prod.	0.00000	0.00003	0.00006	0.00003	0.00014	0.00007	0.00383	0.01647	0.00002	0.00024	0.00009	0.00004	0.00004
6 Other food prod.	0.00000	0.00004	0.00002	0.00003	0.00011	0.00002	0.00213	0.01164	0.00003	0.00011	0.00006	0.00008	0.00006
7 Beverage and tobacco	0.00002	0.00005	0.00010	0.00005	0.00027	0.00007	0.00027	0.03504	0.00008	0.00019	0.00008	0.00015	0.00018
8 Textile, clothing, leather	0.00064	0.00436	0.00091	0.00145	0.00020	0.00142	0.00118	0.00442	0.00047	0.00342	0.00106	0.00026	0.00068
9 Wood, paper, printing	0.00142	0.00872	0.00425	0.01126	0.00295	0.03440	0.02572	0.01210	0.00222	0.00754	0.00332	0.00202	0.00598
10 Basic chemical	0.00316	0.00560	0.00236	0.00150	0.00865	0.00049	0.00006	0.00021	0.00006	0.00104	0.00004	0.00001	0.00004
11 Other chem., rubber, plastic	0.00253	0.00919	0.01388	0.00871	0.01583	0.00970	0.00281	0.00624	0.00435	0.00229	0.00258	0.00233	0.00222
12 Non-metalic mineral	0.00364	0.00679	0.00222	0.00219	0.00645	0.05864	0.00160	0.00062	0.00020	0.00005	0.00000	0.00000	0.00008
13 Iron and steel	0.00223	0.09451	0.03480	0.02819	0.00150	0.01111	0.00039	0.00002	0.00003	0.00231	0.00007	0.00001	0.00004
14 Basic non-ferrous	0.13966	0.03143	0.00578	0.00734	0.00021	0.00038	0.00013	0.00017	0.00001	0.00019	0.00001	0.00001	0.00004
15 Fabricated metal	0.00077	0.05862	0.01056	0.00841	0.01098	0.03401	0.00198	0.00110	0.00237	0.03257	0.01450	0.00108	0.00279
16 Transport equip.	0.00003	0.00024	0.11765	0.00086	0.00010	0.00020	0.00331	0.00073	0.00446	0.04027	0.00975	0.02306	0.00425
17 Other equip., manufacturing	0.00780	0.01330	0.02624	0.05100	0.00745	0.03976	0.00509	0.01224	0.00386	0.01252	0.00179	0.00039	0.01408
18 Water and sewerage	0.00063	0.00086	0.00067	0.00051	0.04133	0.00048	0.00035	0.00243	0.00001	0.00002	0.00138	0.00001	0.00002
19 Construction	0.00003	0.00006	0.00010	0.00003	0.00021	0.00049	0.00045	0.00255	0.00017	0.00643	0.00036	0.00016	0.00118
20 Trade and repair	0.00712	0.02496	0.01652	0.02380	0.02455	0.03643	0.02452	0.02162	0.03705	0.02266	0.00689	0.01788	0.02595
21 Accomodation, café	0.00174	0.00647	0.00199	0.00201	0.00227	0.00297	0.00647	0.00168	0.00385	0.00155	0.00258	0.00404	0.00742
22 Road transport	0.00615	0.00823	0.00208	0.00416	0.00249	0.01106	0.01045	0.00336	0.04613	0.00290	0.00082	0.00551	0.01289
23 Rail, pipeline	0.00876	0.00113	0.00028	0.00065	0.00016	0.00091	0.00073	0.00084	0.00005	0.00053	0.00004	0.00089	0.00133
24 Water transport	0.00285	0.00066	0.00005	0.00017	0.00002	0.00003	0.00016	0.00004	0.00004	0.00005	0.13314	0.00012	0.00004
25 Air and space travel	0.00101	0.00248	0.00159	0.00244	0.00328	0.00048	0.00832	0.00125	0.00072	0.00024	0.00181	0.03451	0.00319
26 Services to transport	0.00161	0.00757	0.00233	0.00079	0.00066	0.00231	0.01770	0.00316	0.00635	0.00129	0.08122	0.03966	0.02988
27 Communication	0.00094	0.00572	0.00256	0.00405	0.00599	0.00204	0.02404	0.01273	0.01487	0.00472	0.00477	0.00519	0.02090
28 Finance and insurance	0.00537	0.00547	0.00409	0.00253	0.03735	0.01240	0.02073	0.01715	0.00707	0.01940	0.00824	0.00849	0.01045
29 Property and business	0.02064	0.02870	0.02354	0.01496	0.02682	0.06052	0.11503	0.06782	0.04087	0.06097	0.03875	0.04276	0.08242
30 Govt. admin and defence	0.00018	0.00092	0.00090	0.00022	0.00134	0.00085	0.00105	0.00028	0.00686	0.00160	0.00026	0.00007	0.00785
31 Education, health, communi	0.00028	0.00043	0.00060	0.00033	0.00053	0.00027	0.00049	0.00058	0.00037	0.00071	0.00058	0.00039	0.00224
32 Personal and other services	0.00020	0.00191	0.00228	0.00097	0.00093	0.00039	0.00551	0.00853	0.00108	0.00062	0.00060	0.00074	0.00153
33 Electricity	4.4E-06	3.2E-07	1.3E-07	1.3E-07	6.0E-07	4.7E-09	1.6E-07	1.6E-07	0.0E+00	1.3E-06	0.0E+00	0.0E+00	0.0E+00
34 Gas supply	1.4E-06	2.8E-07	2.8E-08	2.8E-08	2.4E-08	6.9E-09	3.7E-08	3.7E-08	0.0E+00	2.4E-07	0.0E+00	0.0E+00	4.4E-07
35 Petroleum Product	5.3E-07	8.0E-08	1.6E-08	1.6E-08	7.0E-08	4.0E-07	3.6E-08	3.6E-08	6.4E-06	3.6E-06	6.7E-06	1.0E-05	0.0E+00
36 Coal pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
37 GasPl	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
40 PV pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
41 Wind	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
42 Biomass Plant	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
43 Biomass	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
44 Coal	1.3E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.5E-09	3.5E-09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
45 CNG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.0E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
46 Methanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
47 Ethanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.1E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Source: Direct requirement coefficients are computed in this research as described in Section 5-2 and 5-4 (Chapter 5)

(contd ...)

Table D-24: Direct Requirement Coefficient Matrix 'A' for Advanced Scenario in 2040 (...contd)

	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
	Commun	Finance a	Property :	Govt. adr	Educatioı	Personal :	Electricit	Gas supp	Petroleun	Coal pl.	GasPl	Oil Pl.	Hydro	PV pl.	Wind	Biomass Pla	Biomass	Coal	CNG	Methanol	Ethanol	Biodiesel
1 Agri., hunting an	0.00000	0.00004	0.00020	0.00048	0.00013	0.00203	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	250.00	0.00	0.00	0.00	7758.62	16244.31
2 Forestry and fish	0.00002	0.00003	0.00001	0.00001	0.00002	0.00008	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00	0.00
3 Mining	0.00003	0.00002	0.00014	0.00026	0.00010	0.00078	2.41	0.21	4.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.08	6.37	6.37	6.37	6.37
4 Services to minir	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.76	0.00	0.00	0.00	0.00
5 Meat and diary p	0.00023	0.00013	0.00017	0.00006	0.00030	0.00036	0.59	0.05	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.22	0.22	0.22	0.22
6 Other food prod.	0.00015	0.00018	0.00013	0.00048	0.00025	0.00183	0.72	0.05	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.44	0.44	0.44	0.44
7 Beverage and tot	0.00033	0.00080	0.00012	0.00094	0.00018	0.00017	1.83	0.20	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	1.34	1.34	1.34	1.34
8 Textile, clothing.	0.00077	0.00011	0.00052	0.00167	0.00235	0.00281	4.41	0.26	1.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	2.88	2.88	2.88	2.88
9 Wood, paper, pri	0.01698	0.00502	0.00938	0.02259	0.00584	0.01160	34.29	3.20	21.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.12	32.42	32.42	32.42	32.42
10 Basic chemical	0.00012	0.00003	0.00045	0.00029	0.00068	0.00159	18.02	6.38	122.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.98	182.07	182.07	182.07	182.07
11 Other chem., rub	0.00611	0.00017	0.00332	0.00701	0.00541	0.00858	79.39	10.66	47.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.35	70.35	70.35	70.35	70.35
12 Non-metalic min	0.00005	0.00008	0.00105	0.00108	0.00037	0.00082	111.40	0.15	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.06	0.06	0.06	0.06
13 Iron and steel	0.00013	0.00001	0.00078	0.00045	0.00006	0.00024	14.81	0.66	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.62	0.04	0.04	0.04	0.04
14 Basic non-ferrou	0.00031	0.00000	0.00010	0.00115	0.00003	0.00019	0.34	0.08	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.13	0.13	0.13	0.13
15 Fabricated metal	0.00333	0.00013	0.00214	0.00266	0.00104	0.00264	39.26	4.22	5.29	531.84	396.07	0.00	0.00	2253.36	1478.77	1267.51	0.00	6.50	7.86	7.86	7.86	7.86
16 Transport equip.	0.00132	0.00003	0.00013	0.00818	0.00013	0.00028	5.15	0.12	1.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.41	1.78	1.78	1.78	1.78
17 Other equip., ma	0.02681	0.00174	0.00559	0.01094	0.01037	0.01814	367.93	3.09	5.94	1772.79	1320.24	0.00	0.00	33800.39	6802.33	4225.05	0.00	40.18	8.82	8.82	8.82	8.82
18 Water and sewer	0.00001	0.00020	0.00473	0.00154	0.00176	0.00135	123.74	7.46	16.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	25.24	25.24	25.24	25.24
19 Construction	0.00006	0.00016	0.00488	0.00529	0.00019	0.00014	13.18	1.27	0.34	886.40	660.12	0.00	0.00	8562.77	1478.77	2112.52	0.00	1.22	0.51	0.51	0.51	0.51
20 Trade and repair	0.04065	0.00365	0.00756	0.00972	0.01382	0.01690	425.61	20.65	86.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.72	128.43	128.43	128.43	128.43
21 Accomodation, c	0.00769	0.00653	0.00678	0.00876	0.00216	0.00638	80.15	1.94	39.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.45	58.20	58.20	58.20	58.20
22 Road transport	0.00740	0.00024	0.00140	0.00320	0.00204	0.00544	43.98	1.21	70.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.68	104.95	104.95	104.95	104.95
23 Rail, pipeline	0.00108	0.00031	0.00061	0.00028	0.00033	0.00028	105.07	20.58	12.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.08	17.92	17.92	17.92	17.92
24 Water transport	0.00053	0.00000	0.00016	0.00065	0.00017	0.00023	10.67	0.85	143.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	212.50	212.50	212.50	212.50
25 Air and space tra	0.01069	0.00284	0.00434	0.01043	0.00180	0.00395	51.30	4.09	25.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.17	37.43	37.43	37.43	37.43
26 Services to trans|	0.00520	0.00313	0.00580	0.00634	0.00110	0.00121	7.89	0.22	58.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.04	87.05	87.05	87.05	87.05
27 Communication	0.01146	0.01093	0.00951	0.02142	0.00844	0.01443	143.31	8.72	11.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.28	16.77	16.77	16.77	16.77
28 Finance and insu	0.00896	0.11070	0.02319	0.02283	0.00827	0.01323	663.74	30.23	20.98	35.46	26.40	0.00	0.00	450.67	98.58	84.50	0.00	18.98	31.17	31.17	31.17	31.17
29 Property and bus	0.03147	0.03852	0.10735	0.05341	0.02469	0.05272	483.42	192.91	65.51	319.10	237.64	0.00	0.00	0.00	0.00	760.51	0.00	30.07	97.32	97.32	97.32	97.32
30 Govt. admin and	0.00235	0.00040	0.00109	0.02911	0.00088	0.00055	6.08	0.14	14.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.18	21.66	21.66	21.66	21.66
31 Education, healtl	0.00079	0.00203	0.00103	0.00196	0.00634	0.00194	23.00	1.25	4.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.45	6.95	6.95	6.95	6.95
32 Personal and oth	0.00122	0.00271	0.00691	0.00368	0.00393	0.03721	24.85	1.60	6.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.56	9.32	9.32	9.32	9.32
33 Electricity	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07	0.0E+00	0.0E+00	1.1E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.5E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00
34 Gas supply	3.7E-08	3.7E-08	3.7E-08	3.7E-08	3.7E-08	3.7E-08	0.0E+00	0.0E+00	4.1E-03	0.0E+00	1.5E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00
35 Petroleum Produ	3.6E-08	3.6E-08	3.6E-08	3.6E-08	3.6E-08	3.6E-08	0.0E+00	0.0E+00	4.1E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.9E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00
36 Coal pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.7E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
37 GasPl	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.5E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.1E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
40 PV pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.6E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
41 Wind	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.1E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
42 Biomass Plant	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.5E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
43 Biomass	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	0.0E+00
44 Coal	3.5E-09	3.5E-09	3.5E-09	3.5E-09	3.5E-09	3.5E-09	0.0E+00	0.0E+00	0.0E+00	1.8E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00
45 CNG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
46 Methanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
47 Ethanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Table D-25: Total Requirement Coefficient Matrix '(I-A)-1' for Advanced Scenario in 2040

	1	2	3	4	5	6	7	8	9	10	11	12	13
	Agri., hui	Forestry a	Mining	Services t	Meat and	Other foo	Beverage	Textile, c	Wood, pa	Basic che	Other che	Non-meta	Iron and s
1 Agri., hunting and trapping	1.06339	0.00481	0.00050	0.00059	0.25708	0.05306	0.04082	0.02893	0.00061	0.00206	0.00278	0.00101	0.00032
2 Forestry and fishing	0.00139	1.03937	0.00043	0.00022	0.00047	0.00045	0.00039	0.00017	0.00756	0.00037	0.00024	0.00015	0.00007
3 Mining	0.00037	0.00084	1.00775	0.00431	0.00020	0.00170	0.00033	0.00012	0.00021	0.00260	0.00035	0.01914	0.00380
4 Services to mining	0.00001	0.00003	0.03320	1.00672	0.00001	0.00006	0.00001	0.00001	0.00001	0.00010	0.00001	0.00065	0.00015
5 Meat and diary prod.	0.00349	0.00139	0.00029	0.00063	1.03791	0.02236	0.00118	0.00644	0.00040	0.00268	0.00145	0.00026	0.00015
6 Other food prod.	0.02118	0.01957	0.00039	0.00118	0.01258	1.08414	0.00581	0.00091	0.00048	0.00237	0.00277	0.00023	0.00013
7 Beverage and tobacco	0.00090	0.00132	0.00039	0.00108	0.00125	0.00226	1.03221	0.00071	0.00065	0.00061	0.00043	0.00035	0.00019
8 Textile, clothing, leather	0.00145	0.00536	0.00099	0.00068	0.00167	0.00340	0.00128	1.06808	0.00161	0.00135	0.00178	0.00122	0.00138
9 Wood, paper, printing	0.00663	0.01335	0.00563	0.01136	0.01567	0.01602	0.01812	0.01152	1.11902	0.00703	0.01171	0.01087	0.00421
10 Basic chemical	0.02102	0.00192	0.00730	0.00385	0.00612	0.00268	0.00185	0.00516	0.00589	1.08237	0.02729	0.00477	0.00193
11 Other chem., rubber, plastic	0.02240	0.01867	0.01485	0.00654	0.02802	0.02588	0.01556	0.01019	0.02923	0.02752	1.09146	0.01191	0.01018
12 Non-metalic mineral	0.00056	0.01480	0.00261	0.00350	0.00049	0.00323	0.01163	0.00049	0.00157	0.00108	0.00151	1.09468	0.00685
13 Iron and steel	0.00068	0.00600	0.00600	0.02305	0.00078	0.00103	0.00210	0.00115	0.00152	0.00145	0.00083	0.00734	1.11293
14 Basic non-ferrous	0.00027	0.00188	0.00163	0.00142	0.00054	0.00060	0.00082	0.00088	0.00187	0.00129	0.00207	0.00226	0.01711
15 Fabricated metal	0.00251	0.02145	0.01134	0.01668	0.00399	0.00560	0.01648	0.00320	0.00620	0.00553	0.00317	0.01332	0.00494
16 Transport equip.	0.00125	0.00644	0.00279	0.00335	0.00101	0.00115	0.00069	0.00070	0.00084	0.00071	0.00055	0.00213	0.00107
17 Other equip., manufacturing	0.00755	0.09275	0.04985	0.02581	0.00579	0.00726	0.00530	0.00705	0.01112	0.01531	0.00572	0.01071	0.00874
18 Water and sewerage	0.00300	0.00083	0.00116	0.00121	0.00424	0.00223	0.00227	0.00150	0.00141	0.00223	0.00160	0.00154	0.00210
19 Construction	0.00301	0.00109	0.00674	0.00309	0.00134	0.00093	0.00092	0.00062	0.00095	0.00411	0.00063	0.00186	0.00125
20 Trade and repair	0.04035	0.10150	0.03454	0.03086	0.04828	0.06071	0.03208	0.04431	0.03899	0.03230	0.03115	0.02607	0.01261
21 Accomodation, café	0.00701	0.00527	0.00445	0.02263	0.00354	0.00816	0.03761	0.00646	0.00896	0.00512	0.00759	0.00594	0.00302
22 Road transport	0.02195	0.01193	0.01763	0.00966	0.06239	0.03267	0.02525	0.01015	0.01486	0.01028	0.00807	0.07743	0.01323
23 Rail, pipeline	0.00286	0.00091	0.00148	0.00085	0.00306	0.00513	0.00273	0.00227	0.00104	0.00263	0.00194	0.01412	0.00854
24 Water transport	0.00042	0.00136	0.00097	0.01683	0.00029	0.00099	0.00031	0.00082	0.00060	0.00240	0.00037	0.00109	0.00143
25 Air and space travel	0.00285	0.00307	0.00413	0.01001	0.00189	0.00572	0.00260	0.00837	0.00807	0.00300	0.00370	0.00249	0.00171
26 Services to transport	0.00727	0.00537	0.00281	0.00606	0.00714	0.01316	0.01184	0.00611	0.01331	0.01009	0.00816	0.00624	0.00481
27 Communication	0.00927	0.00907	0.01106	0.01109	0.00942	0.00888	0.00632	0.00665	0.01044	0.00448	0.00550	0.00936	0.00347
28 Finance and insurance	0.02445	0.02656	0.01624	0.02247	0.01474	0.02344	0.01445	0.00909	0.01339	0.00914	0.00890	0.01102	0.00730
29 Property and business	0.03565	0.03448	0.03147	0.14812	0.04624	0.04731	0.04611	0.04059	0.06453	0.03704	0.06213	0.03983	0.04991
30 Govt. admin and defence	0.00107	0.00233	0.00358	0.00134	0.00167	0.00234	0.00135	0.00062	0.00344	0.00128	0.00067	0.00139	0.00124
31 Education, health, communi	0.00170	0.00077	0.00063	0.00122	0.00254	0.00108	0.00164	0.00299	0.00159	0.00077	0.00252	0.00084	0.00057
32 Personal and other services	0.00134	0.00307	0.00140	0.00339	0.00281	0.00375	0.00460	0.00365	0.00559	0.00172	0.00393	0.00249	0.00096
33 Electricity	3.9E-07	3.8E-07	1.1E-06	1.1E-06	3.6E-07	3.2E-07	3.0E-07	1.7E-07	3.3E-07	2.9E-06	1.5E-07	9.8E-07	6.4E-07
34 Gas supply	5.3E-07	3.7E-07	8.8E-07	8.9E-07	6.5E-07	5.9E-07	5.7E-07	9.3E-07	3.3E-07	1.3E-05	5.7E-07	3.1E-06	3.8E-06
35 Petroleum Product	1.4E-06	1.1E-06	1.4E-06	1.4E-06	7.9E-07	4.3E-07	3.1E-07	3.8E-07	2.7E-07	1.1E-05	5.5E-07	7.1E-07	1.9E-07
36 Coal pl.	1.0E-07	1.0E-07	2.9E-07	2.9E-07	9.7E-08	8.6E-08	8.2E-08	4.7E-08	8.9E-08	7.9E-07	4.2E-08	2.7E-07	1.7E-07
37 GasPl	1.7E-07	1.7E-07	4.9E-07	4.8E-07	1.6E-07	1.4E-07	1.4E-07	7.9E-08	1.5E-07	1.3E-06	7.0E-08	4.4E-07	2.9E-07
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	1.6E-08	1.5E-08	4.4E-08	4.4E-08	1.5E-08	1.3E-08	1.2E-08	7.2E-09	1.3E-08	1.2E-07	6.3E-09	4.0E-08	2.6E-08
40 PV pl.	1.4E-08	1.3E-08	3.9E-08	3.9E-08	1.3E-08	1.1E-08	1.1E-08	6.3E-09	1.2E-08	1.1E-07	5.5E-09	3.5E-08	2.3E-08
41 Wind	2.8E-08	2.7E-08	7.7E-08	7.7E-08	2.6E-08	2.3E-08	2.1E-08	1.2E-08	2.4E-08	2.1E-07	1.1E-08	7.0E-08	4.5E-08
42 Biomass Plant	5.7E-08	5.5E-08	1.6E-07	1.6E-07	5.3E-08	4.7E-08	4.4E-08	2.6E-08	4.8E-08	4.3E-07	2.3E-08	1.4E-07	9.4E-08
43 Biomass	2.0E-07	1.9E-07	5.0E-07	4.9E-07	3.7E-07	3.3E-07	3.0E-07	4.6E-07	5.5E-07	1.3E-06	8.2E-08	5.8E-07	3.0E-07
44 Coal	2.0E-07	2.3E-07	5.6E-07	5.9E-07	2.9E-07	2.8E-07	2.8E-07	3.7E-07	3.2E-07	1.5E-06	8.6E-08	2.0E-06	2.8E-06
45 CNG	1.5E-08	8.4E-09	1.2E-08	6.8E-09	4.4E-08	2.3E-08	1.8E-08	7.1E-09	1.0E-08	7.2E-09	5.7E-09	5.4E-08	9.3E-09
46 Methanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
47 Ethanol	2.3E-08	1.3E-08	1.9E-08	1.0E-08	6.6E-08	3.5E-08	2.7E-08	1.1E-08	1.6E-08	1.1E-08	8.6E-09	8.2E-08	1.4E-08
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

	14	15	16	17	18	19	20	21	22	23	24	25	26
	Basic nor	Fabricate	Transport	Other equ	Water and	Construct	Trade and	Accomod	Road trar	Rail, pipe	Water tra	Air and s	Services t
1 Agri., hunting and trapping	0.00085	0.00054	0.00027	0.00054	0.00039	0.00078	0.00170	0.00829	0.00968	0.00055	0.00023	0.00024	0.00047
2 Forestry and fishing	0.00026	0.00017	0.00009	0.00025	0.00009	0.00043	0.00072	0.00537	0.00013	0.00138	0.00009	0.00008	0.00016
3 Mining	0.04975	0.00306	0.00070	0.00126	0.00134	0.00484	0.00020	0.00040	0.00016	0.00040	0.00029	0.00013	0.00019
4 Services to mining	0.00168	0.00011	0.00003	0.00004	0.00005	0.00016	0.00001	0.00001	0.00001	0.00002	0.00001	0.00000	0.00001
5 Meat and diary prod.	0.00018	0.00039	0.00027	0.00023	0.00041	0.00040	0.00436	0.01764	0.00037	0.00049	0.00030	0.00027	0.00037
6 Other food prod.	0.00016	0.00031	0.00020	0.00019	0.00034	0.00029	0.00263	0.01333	0.00045	0.00032	0.00022	0.00026	0.00032
7 Beverage and tobacco	0.00021	0.00041	0.00027	0.00020	0.00049	0.00034	0.00069	0.03639	0.00036	0.00040	0.00034	0.00043	0.00060
8 Textile, clothing, leather	0.00112	0.00535	0.00141	0.00186	0.00048	0.00208	0.00161	0.00509	0.00078	0.00411	0.00163	0.00052	0.00104
9 Wood, paper, printing	0.00447	0.01334	0.00771	0.01503	0.00601	0.04276	0.03271	0.01746	0.00581	0.01210	0.00709	0.00490	0.01038
10 Basic chemical	0.00493	0.00735	0.00372	0.00229	0.01049	0.00186	0.00060	0.00093	0.00181	0.00234	0.00149	0.00169	0.00039
11 Other chem., rubber, plastic	0.00575	0.01328	0.01878	0.01134	0.01932	0.01412	0.00550	0.00970	0.00673	0.00532	0.00511	0.00444	0.00409
12 Non-metalic mineral	0.00612	0.00912	0.00346	0.00304	0.00785	0.06504	0.00226	0.00171	0.00053	0.00150	0.00043	0.00030	0.00054
13 Iron and steel	0.00519	0.11274	0.04649	0.03432	0.00369	0.01829	0.00146	0.00108	0.00091	0.00922	0.00286	0.00149	0.00140
14 Basic non-ferrous	1.16304	0.04083	0.00918	0.00997	0.00099	0.00270	0.00050	0.00056	0.00030	0.00229	0.00092	0.00036	0.00047
15 Fabricated metal	0.00699	1.06410	0.01379	0.01016	0.01336	0.03821	0.00340	0.00299	0.00336	0.03732	0.01876	0.00216	0.00402
16 Transport equip.	0.00102	0.00090	1.13367	0.00137	0.00048	0.00085	0.00448	0.00125	0.00576	0.04601	0.01349	0.02758	0.00554
17 Other equip., manufacturing	0.03430	0.01994	0.03379	1.05600	0.01243	0.04530	0.00938	0.01645	0.00638	0.02248	0.00560	0.00316	0.01785
18 Water and sewerage	0.00184	0.00161	0.00119	0.00085	1.04354	0.00120	0.00123	0.00326	0.00059	0.00084	0.00222	0.00058	0.00066
19 Construction	0.00736	0.00125	0.00068	0.00051	0.00139	1.00120	0.00153	0.00335	0.00065	0.00871	0.00096	0.00063	0.00190
20 Trade and repair	0.01605	0.03282	0.02305	0.02857	0.02988	0.04505	1.03145	0.02914	0.04381	0.02945	0.01431	0.02357	0.03181
21 Accomodation, café	0.00357	0.00846	0.00337	0.00304	0.00375	0.00526	0.00879	1.00463	0.00571	0.00348	0.00508	0.00589	0.00931
22 Road transport	0.01000	0.01261	0.00432	0.00618	0.00446	0.01847	0.01327	0.00717	1.05046	0.00513	0.00377	0.00811	0.01521
23 Rail, pipeline	0.01123	0.00276	0.00096	0.00120	0.00056	0.00217	0.00108	0.00127	0.00037	1.00108	0.00043	0.00124	0.00159
24 Water transport	0.00413	0.00119	0.00023	0.00034	0.00014	0.00032	0.00033	0.00016	0.00167	0.00079	1.15493	0.00192	0.00015
25 Air and space travel	0.00236	0.00391	0.00269	0.00338	0.00452	0.00214	0.01039	0.00266	0.00217	0.00165	0.00347	1.03692	0.00479
26 Services to transport	0.00353	0.01051	0.00417	0.00230	0.00241	0.00532	0.02101	0.00559	0.00927	0.00361	0.09844	0.04435	1.03283
27 Communication	0.00404	0.00888	0.00477	0.00593	0.00867	0.00597	0.02819	0.01583	0.01840	0.00774	0.00937	0.00824	0.02469
28 Finance and insurance	0.01475	0.01103	0.00803	0.00542	0.04701	0.01929	0.02964	0.02447	0.01231	0.02723	0.01491	0.01349	0.01692
29 Property and business	0.04135	0.05061	0.03963	0.02668	0.04213	0.08443	0.14256	0.08810	0.05932	0.08156	0.06568	0.06119	0.10532
30 Govt. admin and defence	0.00068	0.00150	0.00130	0.00049	0.00169	0.00146	0.00176	0.00073	0.00785	0.00208	0.00143	0.00083	0.00874
31 Education, health, communi	0.00070	0.00075	0.00089	0.00050	0.00083	0.00063	0.00090	0.00097	0.00065	0.00105	0.00111	0.00072	0.00259
32 Personal and other services	0.00106	0.00304	0.00336	0.00164	0.00185	0.00188	0.00741	0.01016	0.00216	0.00191	0.00172	0.00174	0.00291
33 Electricity	5.3E-06	6.4E-07	2.6E-07	2.3E-07	7.0E-07	1.5E-07	2.2E-07	2.3E-07	4.7E-08	1.4E-06	4.9E-08	4.5E-08	4.7E-08
34 Gas supply	5.4E-06	1.3E-06	4.2E-07	3.5E-07	6.7E-07	3.6E-07	2.4E-07	2.5E-07	8.3E-07	1.3E-06	1.5E-07	1.3E-07	5.2E-07
35 Petroleum Product	9.1E-07	3.4E-07	1.3E-07	1.3E-07	2.7E-07	5.9E-07	2.5E-07	1.5E-07	6.8E-06	3.7E-06	7.8E-06	1.1E-05	1.7E-07
36 Coal pl.	1.4E-06	1.7E-07	6.9E-08	6.3E-08	1.9E-07	4.0E-08	6.0E-08	6.1E-08	1.3E-08	3.8E-07	1.3E-08	1.2E-08	1.3E-08
37 GasPl	2.4E-06	2.9E-07	1.2E-07	1.1E-07	3.2E-07	6.7E-08	1.0E-07	1.0E-07	2.1E-08	6.4E-07	2.2E-08	2.0E-08	2.1E-08
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	2.2E-07	2.6E-08	1.0E-08	9.6E-09	2.9E-08	6.1E-09	9.1E-09	9.2E-09	1.9E-09	5.8E-08	2.0E-09	1.9E-09	1.9E-09
40 PV pl.	1.9E-07	2.3E-08	9.2E-09	8.4E-09	2.5E-08	5.3E-09	8.0E-09	8.1E-09	1.7E-09	5.1E-08	1.8E-09	1.6E-09	1.7E-09
41 Wind	3.8E-07	4.6E-08	1.8E-08	1.7E-08	5.0E-08	1.1E-08	1.6E-08	1.6E-08	3.3E-09	1.0E-07	3.5E-09	3.2E-09	3.4E-09
42 Biomass Plant	7.8E-07	9.4E-08	3.8E-08	3.4E-08	1.0E-07	2.2E-08	3.3E-08	3.3E-08	6.9E-09	2.1E-07	7.3E-09	6.7E-09	6.9E-09
43 Biomass	2.3E-06	3.0E-07	1.2E-07	1.2E-07	3.2E-07	1.0E-07	1.3E-07	1.2E-07	1.1E-06	6.4E-07	2.9E-08	3.1E-08	4.1E-08
44 Coal	4.2E-06	6.3E-07	2.5E-07	2.1E-07	3.7E-07	2.1E-07	1.3E-07	1.3E-07	2.8E-08	7.3E-07	3.4E-08	2.8E-08	3.0E-08
45 CNG	7.0E-09	8.9E-09	3.0E-09	4.3E-09	3.1E-09	1.3E-08	9.3E-09	5.0E-09	7.4E-07	3.6E-09	2.6E-09	5.7E-09	1.1E-08
46 Methanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
47 Ethanol	1.1E-08	1.3E-08	4.6E-09	6.6E-09	4.7E-09	2.0E-08	1.4E-08	7.6E-09	1.1E-06	5.4E-09	4.0E-09	8.6E-09	1.6E-08
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Source: Total requirement coefficients are computed in this research as described in Section 5-2 and 5-4 (Chapter 5)

(contd ...)

Table D-25: Total Requirement Coefficient Matrix '(I-A)-1' for Advanced Scenario in 2040 (...contd)

	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
	Commun	Finance a	Property :	Govt. adr	Educatioı	Personal :	Electricity	Gas supp	Petroleun	Coal pl.	GasPl	Oil Pl.	Hydro	PV pl.	Wind	Biomass Pla	Biomass	Coal	CNG	Methanol	Ethanol	Biodiesel
1 Agri., hunting an	0.00041	0.00027	0.00050	0.00092	0.00044	0.00278	124.86	0.28	2.01	3.61	1.99	0.00	0.00	26.18	5.64	802.55	265.85	0.83	3.05	2.77	8519.00	17276.79
2 Forestry and fish	0.00025	0.00013	0.00016	0.00027	0.00010	0.00026	4.10	0.12	0.58	1.88	0.91	0.00	0.00	12.55	2.60	3.35	0.35	0.50	0.98	0.86	12.02	23.50
3 Mining	0.00013	0.00006	0.00027	0.00045	0.00015	0.00092	19.48	0.35	4.89	10.74	6.66	0.00	0.00	90.94	20.25	19.90	0.09	1.38	7.56	7.21	10.17	13.22
4 Services to minir	0.00001	0.00000	0.00001	0.00002	0.00001	0.00003	5.51	0.01	0.17	18.26	0.23	0.00	0.00	3.10	0.69	0.68	0.00	9.89	0.25	0.24	0.35	0.47
5 Meat and diary p	0.00062	0.00035	0.00043	0.00038	0.00047	0.00072	7.45	0.34	1.84	1.75	1.35	0.00	0.00	12.39	2.80	5.31	0.87	0.34	3.04	2.70	30.69	59.47
6 Other food prod.	0.00044	0.00038	0.00035	0.00080	0.00040	0.00232	8.20	0.29	1.70	1.74	1.10	0.00	0.00	9.91	2.25	18.00	5.29	0.47	2.79	2.50	172.09	346.48
7 Beverage and tot	0.00072	0.00124	0.00050	0.00145	0.00032	0.00053	8.91	0.46	2.78	1.89	1.51	0.00	0.00	11.08	2.58	3.23	0.22	0.45	4.56	4.09	11.30	18.70
8 Textile, clothing,	0.00112	0.00027	0.00081	0.00213	0.00266	0.00336	22.69	0.66	3.34	10.38	7.15	0.00	0.00	92.83	23.66	20.75	0.36	1.17	5.56	4.90	16.51	28.45
9 Wood, paper, pri	0.02206	0.00768	0.01340	0.02885	0.00812	0.01603	209.87	8.01	34.25	90.39	68.99	0.00	0.00	907.77	185.98	186.56	1.66	7.81	58.31	50.30	103.39	157.98
10 Basic chemical	0.00062	0.00018	0.00090	0.00094	0.00106	0.00237	51.34	7.60	135.61	16.58	19.01	0.00	0.00	109.98	29.22	39.39	5.26	3.67	208.13	200.53	368.90	542.04
11 Other chem., rub	0.00834	0.00097	0.00516	0.00992	0.00678	0.01128	194.85	13.58	59.98	76.63	51.58	0.00	0.00	534.49	117.74	115.37	5.60	19.40	101.94	88.36	267.78	452.29
12 Non-metalic min	0.00044	0.00031	0.00186	0.00195	0.00063	0.00130	229.16	0.85	1.37	72.53	52.31	0.00	0.00	680.33	130.36	163.65	0.14	2.22	2.52	1.67	6.14	10.74
13 Iron and steel	0.00177	0.00029	0.00174	0.00203	0.00072	0.00153	263.07	1.99	2.59	153.77	105.51	0.00	0.00	1570.90	427.26	328.42	0.17	8.90	5.40	3.41	8.86	14.47
14 Basic non-ferrou	0.00090	0.00010	0.00041	0.00185	0.00026	0.00065	74.38	0.51	1.15	44.19	31.99	0.00	0.00	452.06	132.19	100.09	0.07	1.25	2.10	1.59	3.75	5.97
15 Fabricated metal	0.00458	0.00069	0.00339	0.00421	0.00170	0.00385	893.36	6.37	12.46	640.59	470.66	0.00	0.00	3068.55	1699.21	1476.89	0.63	11.93	23.36	16.99	37.05	57.69
16 Transport equip.	0.00224	0.00026	0.00052	0.01012	0.00038	0.00072	26.09	1.47	6.15	11.48	5.10	0.00	0.00	55.74	11.94	10.08	0.31	4.20	10.51	9.05	19.07	29.37
17 Other equip., ma	0.03079	0.00401	0.00890	0.01538	0.01271	0.02239	4109.15	6.60	19.26	2033.75	1444.30	0.00	0.00	36127.82	7280.12	4595.38	1.89	59.37	28.61	22.01	82.44	144.59
18 Water and sewer	0.00039	0.00057	0.00569	0.00218	0.00210	0.00195	148.86	9.02	19.51	8.14	17.72	0.00	0.00	43.04	10.03	14.82	0.75	1.58	37.59	28.57	52.61	77.34
19 Construction	0.00065	0.00073	0.00584	0.00616	0.00062	0.00083	1292.02	2.71	3.54	902.34	667.63	0.00	0.00	8593.53	1485.95	2125.57	0.75	6.28	5.89	3.19	27.30	52.10
20 Trade and repair	0.04592	0.00634	0.01169	0.01553	0.01652	0.02218	711.86	26.25	108.89	182.45	123.57	0.00	0.00	1428.35	310.14	297.19	10.09	38.75	186.09	159.84	483.03	815.38
21 Accomodation, c	0.00908	0.00811	0.00846	0.01067	0.00294	0.00796	132.82	4.45	44.76	27.99	19.88	0.00	0.00	170.57	41.77	47.06	1.75	5.75	70.44	65.98	122.13	179.86
22 Road transport	0.00935	0.00091	0.00270	0.00512	0.00293	0.00729	137.02	2.71	80.55	63.65	30.16	0.00	0.00	395.84	88.09	99.70	5.49	15.80	121.67	118.95	294.72	475.48
23 Rail, pipeline	0.00131	0.00047	0.00086	0.00058	0.00046	0.00053	142.48	20.90	13.30	40.21	36.30	0.00	0.00	65.49	15.48	15.98	0.72	18.92	40.23	19.33	42.25	65.82
24 Water transport	0.00072	0.00005	0.00027	0.00088	0.00025	0.00037	17.59	1.11	166.50	4.72	2.89	0.00	0.00	17.01	4.57	4.16	0.10	1.71	247.42	246.32	249.68	253.14
25 Air and space tra	0.01226	0.00390	0.00568	0.01236	0.00251	0.00531	94.24	5.98	30.02	20.87	18.04	0.00	0.00	143.30	32.35	30.57	0.71	4.92	50.22	44.23	67.07	90.56
26 Services to trans|	0.00767	0.00447	0.00771	0.00885	0.00209	0.00299	65.50	3.00	81.78	34.69	17.24	0.00	0.00	149.02	39.50	45.97	1.82	9.73	123.87	120.88	179.11	239.00
27 Communication	1.01431	0.01357	0.01227	0.02475	0.00989	0.01733	234.73	12.77	22.23	39.89	38.10	0.00	0.00	277.74	63.65	66.36	2.32	8.23	45.22	32.45	106.71	183.07
28 Finance and insu	0.01375	1.12682	0.03109	0.03040	0.01141	0.01906	966.50	42.19	38.84	134.94	125.95	0.00	0.00	881.22	192.82	214.85	6.11	28.86	97.87	55.68	251.50	452.87
29 Property and bus	0.04780	0.05243	1.12816	0.07232	0.03336	0.06994	1472.38	226.89	128.65	609.38	727.62	0.00	0.00	1762.43	386.35	1244.37	8.91	54.16	413.54	186.65	472.18	765.82
30 Govt. admin and	0.00279	0.00064	0.00148	1.03039	0.00108	0.00090	17.16	0.62	17.09	8.54	3.52	0.00	0.00	32.69	7.76	9.03	0.27	2.80	25.87	25.25	33.82	42.63
31 Education, health	0.00102	0.00241	0.00134	0.00234	1.00652	0.00226	38.32	1.70	5.76	25.93	4.36	0.00	0.00	25.08	5.69	6.89	0.42	12.96	10.15	8.45	22.04	36.02
32 Personal and oth	0.00224	0.00375	0.00848	0.00502	0.00461	1.03961	58.70	3.77	9.67	23.64	12.50	0.00	0.00	80.09	18.81	22.53	0.34	8.03	17.96	14.19	24.95	36.03
33 Electricity	2.0E-07	2.0E-07	2.1E-07	2.2E-07	1.9E-07	2.1E-07	1.0E+00	1.2E-04	1.5E-03	7.5E-03	8.9E-04	0.0E+00	0.0E+00	1.1E-02	2.8E-03	2.6E-03	9.6E-05	3.6E-03	8.3E-04	7.2E-04	3.8E-03	7.0E-03
34 Gas supply	2.1E-07	1.9E-07	2.2E-07	2.3E-07	1.9E-07	2.4E-07	7.0E-01	1.0E+00	6.7E-03	6.4E-03	1.5E+00	0.0E+00	0.0E+00	1.8E-02	4.8E-03	4.4E-03	1.3E-04	2.6E-03	1.0E+00	2.8E-03	7.0E-03	1.1E-02
35 Petroleum Produ	2.4E-07	9.5E-08	1.4E-07	2.3E-07	1.0E-07	1.8E-07	5.9E-03	2.6E-04	1.0E+00	8.6E-03	1.1E-03	0.0E+00	0.0E+00	1.0E-02	2.3E-03	3.4E-03	3.5E-04	4.2E-03	5.3E-03	5.1E-03	1.6E-02	2.8E-02
36 Coal pl.	5.5E-08	5.4E-08	5.7E-08	6.0E-08	5.0E-08	5.8E-08	2.7E-01	3.1E-05	4.2E-04	1.0E+00	2.4E-04	0.0E+00	0.0E+00	2.9E-03	7.5E-04	7.0E-04	2.6E-05	9.7E-04	2.3E-04	1.9E-04	1.0E-03	1.9E-03
37 GasPl	9.2E-08	9.0E-08	9.5E-08	9.9E-08	8.4E-08	9.6E-08	4.5E-01	5.2E-05	7.0E-04	3.4E-03	1.0E+00	0.0E+00	0.0E+00	4.8E-03	1.3E-03	1.2E-03	4.3E-05	1.6E-03	3.7E-04	3.2E-04	1.7E-03	3.1E-03
38 Oil Pl.	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
39 Hydro	8.3E-09	8.2E-09	8.6E-09	9.0E-09	7.6E-09	8.7E-09	4.1E-02	4.7E-06	6.3E-05	3.1E-04	3.6E-05	0.0E+00	1.0E+00	4.4E-04	1.1E-04	1.1E-04	3.9E-06	1.5E-04	3.4E-05	2.9E-05	1.6E-04	2.9E-04
40 PV pl.	7.3E-09	7.2E-09	7.5E-09	7.9E-09	6.7E-09	7.7E-09	3.6E-02	4.1E-06	5.6E-05	2.7E-04	3.2E-05	0.0E+00	0.0E+00	1.0E+00	1.0E-04	9.3E-05	3.5E-06	1.3E-04	3.0E-05	2.6E-05	1.4E-04	2.5E-04
41 Wind	1.5E-08	1.4E-08	1.5E-08	1.6E-08	1.3E-08	1.5E-08	7.2E-02	8.2E-06	1.1E-04	5.3E-04	6.4E-05	0.0E+00	0.0E+00	7.6E-04	1.0E+00	1.8E-04	6.9E-06	2.6E-04	5.9E-05	5.1E-05	2.7E-04	5.0E-04
42 Biomass Plant	3.0E-08	2.9E-08	3.1E-08	3.2E-08	2.7E-08	3.1E-08	1.5E-01	1.7E-05	2.3E-04	1.1E-03	1.3E-04	0.0E+00	0.0E+00	1.6E-03	4.1E-04	1.0E+00	1.4E-05	5.3E-04	1.2E-04	1.1E-04	5.6E-04	1.0E-03
43 Biomass	1.1E-07	9.2E-08	1.0E-07	1.1E-07	8.9E-08	1.1E-07	4.4E-01	5.7E-05	7.8E-04	3.4E-03	4.6E-04	0.0E+00	0.0E+00	5.5E-03	1.4E-03	3.0E+00	1.0E+00	1.6E-03	5.2E-04	4.6E-04	1.0E+00	3.7E-03
44 Coal	1.1E-07	1.1E-07	1.2E-07	1.3E-07	1.0E-07	1.2E-07	5.0E-01	6.6E-05	7.8E-04	1.8E+00	8.0E-04	0.0E+00	0.0E+00	1.0E-02	2.7E-03	2.4E-03	4.9E-05	1.0E+00	4.4E-04	3.8E-04	2.0E-03	3.6E-03
45 CNG	6.6E-09	6.4E-10	1.9E-09	3.6E-09	2.1E-09	5.1E-09	9.6E-05	1.9E-06	5.7E-05	4.5E-05	2.1E-05	0.0E+00	0.0E+00	2.8E-04	6.2E-05	7.0E-05	3.9E-06	1.1E-05	1.0E+00	8.4E-05	2.1E-04	3.3E-04
46 Methanol	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00	0.0E+00	0.0E+00
47 Ethanol	9.9E-09	9.7E-10	2.9E-09	5.4E-09	3.1E-09	7.7E-09	1.5E-04	2.9E-06	8.5E-05	6.7E-05	3.2E-05	0.0E+00	0.0E+00	4.2E-04	9.3E-05	1.1E-04	5.8E-06	1.7E-05	1.3E-04	1.3E-04	1.0E+00	5.0E-04
48 Biodiesel	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+00

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