ANALYSIS OF FUTURE ENERGY PATHWAYS FOR VIETNAM

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Certificate of Authorship/Originality

I certify that the work in this thesis has not been 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 preparation of the thesis itself has been acknowledged. In addition, I certify that any information sources and literature used indicated in the thesis.

Signature of Candidate

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2. Tien Minh Do and Deepak Sharma, *Analysis of Long-term Energy Pathways for Vietnam, using Energy Scenarios*, Proceedings of the Fourth GMSARN International Conference, Halong, Vietnam 2009

3. Tien Minh Do and Deepak Sharma, *Exploration of Alternative Fuels pathways for Vietnam's Transportation, Using Scenarios Analysis*, Proceedings of the Fifteenth International Conference on Automotive Engineers, Hanoi, Vietnam, 2009.

4. Tien Minh Do and Deepak Sharma, *Analysis of Long-term Energy Pathways for Vietnam, using Energy Scenarios*, GMSARN International Journal (to be published)

List of Abbreviations

AAECP	ASEAN-Australia Economic Cooperation Program
ADB	Asian Development Bank
ADV	Advanced Scenario
AIT	Asian Institute of Technology
APAEC	ASEAN Plan of Action for Energy Cooperation
ASEAN	The Association of Southeast Asian Nations
BAS	Base Scenario
BETs	Biomass Energy Technologies
BF	Blast Furnace
BIGCC	Biomass Integrated Gasification Combined Cycle
bn.	Billion
BOF	Blast Oxygen Furnace
BOTs	Built-Operate-Transfer Projects
CC	Combined Cycle
CCS	Carbon Capture Sequestration
CDM	Clean Development Mechanism
CGE	Computable General Equilibrium
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
CRS	Constant Return to Scale
DRI	Direct Reduced Iron
DSM	Demand Side Management
EAF	Electric Arc Furnace
EFORM	Energy Flow Optimization Model
EU	European Union
EVN	Vietnam Electricity Group
FDI	Foreign Direct Investment
GAMS	General Algebraic Modelling System
GDP	Gross Domestic Product
GEM	General equilibrium Model
GHG	Greenhouse Gas
GSO	General Statistic Office of Vietnam
GW	Gigawatt
GWh	Gigawatt-hours
IE	Institute of Energy, Vietnam
IEA	International Energy Agency
IEEJ	Institute of Energy Economics, Japan
IGCC	Integrated Gasification Combined Cycle
IPCC	Intergovernmental Panel on Climate Change
IPPs	Independent Power producers
JICA	Japan International Cooperation Agency
kgOE	Kilogram of Oil Equivalence
KTOE	Kilo ton of Oil Equivalence
kW	Kilowatt
kWh	Kilowatt-hour
LEAP	The Long Range Energy Alternative Planning
LNG	Liquefied Natural Gas
LPG	Liquefied petroleum Gas

MARKAL	MARKet Allocation Model
MEDEE	Model for Evaluation of Energy Demand
MESSAGE	Model for Energy Supply Systems Analysis and their General Environmental Impact
MJ	Mega Joules
MOD	Moderate Scenario
mn.	Million
MOC	Ministry of Construction
MOIT	Ministry of Industry and Trade
MONRE	Ministry of Natural Resources and Environment
MOT	Ministry of Transport
MPI	Ministry of Planning and Investment
MTOE	Megaton of oil equivalent
MW	Megawatt
MWh	Megawatt-hour
NGCC	Natural Gas Combined Cycle
NO_x	Nitrogen Oxides
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
OVA	Other Value Added
QHR(Z)(Y)	Fraction of year for season, time-of-day
PJ	Petajoules
PM	Prime Minister
PV	Photovoltaic
PVN	Vietnam National Oil and Gas Group
RES	Reference Energy System
SO_2	Sulphur Dioxide
TJ	Terajoules
tn.	Trillion
TWh	Terawatt-hour
USA	United States of America
VINACOMIN	Vietnam National Coal and Mineral Industries Group
VNCA	Vietnam Cement Association
VND	Vietnam Currency Unit
VR	Vietnam Registration
WASP	The Wien Automatic System Planning
WB	The World Bank
$	United State Dollars

Abstract

This research conducts an in-depth analysis of the long-term impacts of alternative energy options for Vietnam up to 2050, with a view to identify an energy pathway that would meet the country's energy needs in a sustainable manner. Three scenarios (Base, MOD and ADV), developed in this research, represent a range of energy policy measures that Vietnam could adopt in order to achieve its economic, energy and environmental goals. The Base scenario reflects a continuation of the current policy trends while the MOD and ADV scenarios represent higher levels of commitment to economic growth, energy diversity and reduction of energy import dependency and CO2 emissions.

The impacts of these scenarios are analysed in this research using a comprehensive framework that consists of an energy optimization model (MARKAL model) and energy-oriented input–output model. The energy impacts are analysed in terms of how the country's primary and final energy requirements would evolve in response to alternative energy policies. And, the analysis of economic impacts focuses on how such evolution would affect sectoral outputs, income, employment, and energy and CO2 intensities.

The analysis suggests that if the current policy trends (as represented by the Base scenario) continue, by 2050, Vietnam would experience a fifteen-fold rise in primary energy requirements, and twenty-six-fold increase in CO2 emissions. The country's import dependency will increase to about 84% in the case of primary energy requirements and 100% in the case of oil. This would potentially invite insecurity of energy supply and cause serious environmental pollution due to the high share of fossil fuels (more than 90%) in total energy consumption. The severity of these impacts could, however, be reduced by adopting appropriate policy measures as demonstrated in the MOD and ADV scenarios. These measures include energy savings and renewable energy promotion and CO_2 restrictions. This would result in a reduction of primary energy requirements (by 6.6 and 9.3%), imported energy (by 14 and 18%), in the MOD and ADV scenarios, respectively, as compared with the Base levels, and CO2 emissions to the 1990 Kyoto level. Further, the analyses suggest that the economy-wide impacts of these policy measures are likely to be rather benign at the aggregate (national) level –

equivalent to a decrease in total output, wages and salaries, and employment in 2050 of merely 0.03%, 1% and 0.39%, respectively, in the ADV scenario as compared with the Base scenario. These impacts at disaggregated levels would, however, be more diverse and rather significant for some sectors. In 2050, for example, the main beneficiaries, which are cultivation, manufacturing, and construction sectors, would enjoy 1.4, 1.8 and 1.6% increase in total output, wages and salaries, and employment, while the main losers which are the conventional energy sectors (coal, oil and electricity) would suffer a decline in total output, income and employment of 14.6, 13.8 and 8.2%, as compared with the Base scenario.

Further, this research is a good example that demonstrates the importance of undertaking comprehensive analyses (both at macro- and micro-levels) in formulating energy policies. The disaggregated analyses could help avoid the pitfalls of basing policy decisions on aggregate analyses alone. Such disaggregate analyses also make transparent the sectoral linkages and provide more robust bases for developing trade-offs and compromises to achieve desirable policy outcomes. That is a novelty and one of the main contributions of this research to strengthening the energy policy settings in Vietnam.