Institute for Sustainable Futures

UNIVERSITY OF TECHNOLOGY SYDNEY

THINK SMALL

The Australian Decentralised Energy Roadmap

1st Issue:
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FEEDBACK INVITED

This Roadmap is released to inform and encourage community discussion on the potential role of Decentralised Energy in Australia. We invite feedback, suggestions, or other enquiries on the Roadmap and all other underpinning working papers, models and maps (available from the Intelligent Grid website: www.igrid.net.au). To submit comments please email: isf@uts.edu.au.

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Cover Images

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DISCLAIMER

THINK SMALL:
THE AUSTRALIAN DECENTRALISED ENERGY ROADMAP

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Institute for Sustainable Futures
University of Technology, Sydney

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ABBREVIATIONS

AEMC	Australian Energy Markets Commission
AER	Australian Energy Regulator
AEMO	Australian Electricity Market Operator
CCGT	Combined Cycle Gas Turbine
CCS	Carbon Capture and Storage
CHP	Combined Heat and Power
CO_2-e	Carbon Dioxide equivalent (the standard for GHG comparison)
CPRS	Carbon Pollution Reduction Scheme
DANCE	Dynamic Avoidable Network Cost Evaluation
D-CODE	Description and Cost Of Decentralised Energy
DE	Decentralised Energy (or Distributed Energy)
DG	Distributed Generation
DSR	Demand-Side Response
EE	Energy Efficiency
GHG	Greenhouse Gas
IEA	International Energy Agency
IMO	Independent Market Operator
IPCC	United Nations Intergovernmental Panel on Climate Change
MEPS	Minimum energy performance standards
NEM	National Electricity Market
NFEE	National Framework for Energy Efficiency
OCGT	Open Cycle Gas Turbine
POE	Probability of Exceedance
RAPS	Remote Area Power Supplies
[M]RET	[Mandatory] Renewable Energy Target
SOO	Statement of Opportunities
SWIS	South West Interconnected System
WADE	World Alliance for Decentralised Energy

EXECUTIVE SUMMARY

Introduction: Reconciling sustainability and affordability

One of the world's biggest challenges is how to address climate change, and in particular, how to do so while ensuring energy remains affordable for consumers and business. However, when it comes to finding solutions to major problems, bigger is not always better. From population to the size of government; from cities to school class size; from mobile phones to motorways; from families to fast food; there is an emerging consensus that if size matters, then not over-sizing matters just as much.

The concept of "right-sizing" also has significant implications for the electricity sector. Stemming from ideas of the 1960's and '70s, such as economist E.F. Schumacher's *Small is Beautiful* (1973), this paradigm shift has impacted the electricity sector via contributions such as Amory Lovins' *Small Is Profitable: The Hidden Economic Benefits of Making Electrical Resources the Right Size* (2002).

While the efficient use of local renewable resources was the principal approach to meeting energy needs for most of human history, a centralised supply approach based on fossil fuels became dominant during the 20th century. We sought to capitalise on economies of scale and move the adverse impacts of centralised energy supply further away from the communities that use that energy. For decades, this strategy was very successful, raising the living standards of billions and (usually) reducing urban pollution. However, in recent decades, as the economic cost and environmental impact of the centralised strategy has become less acceptable, there has been growing interest in a new paradigm – one which combines the local, low impact principles of the past with the advanced technologies of today. This new "Decentralised Energy" paradigm promises to reconcile environmental sustainability with energy affordability.

The electricity sector is Australia's largest source of greenhouse gas emissions, accounting for 36 percent of national emissions. For Australia to prosper in a carbon-constrained future, it is crucial to change dramatically the technologies and practices employed to meet our energy needs. The energy sources used to generate electricity must become less carbon intensive and electricity must be both produced and used more efficiently.

Australia currently faces steeply rising energy bills, and it often seems that whatever is proposed to reduce carbon emissions would increase energy costs even further. Conversely, many measures proposed to reduce energy costs pressures would raise emissions. Consequently, proposals to address either issue are contentious and are often blocked and community frustration at this deadlock grows. However, Decentralised Energy (DE) offers a potential solution to this dilemma. Decentralised Energy refers to energy technologies and practices that optimise the use of local resources and reduce the need for large-scale energy supply infrastructure. The three elements of DE are: efficient use of energy, peak load management and Distributed Generation. Each of these elements offers significant potential benefits in its own right, but when combined, **Decentralised Energy has the potential to offer major cost savings and carbon emission reductions while reliably meeting customer energy needs.**

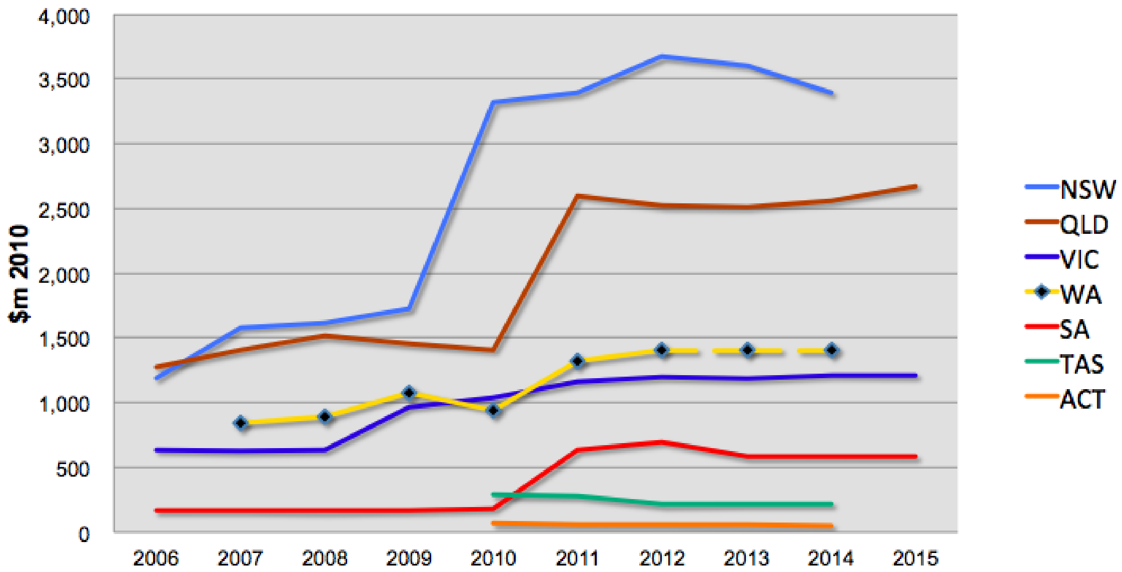
Although the potential benefits of DE are great, tapping these benefits requires a fundamental change in many areas of our energy policy, culture and institutions. The Roadmap aims to explain **where we are**, **where to go, and how to get there**. The Roadmap outlines the current status of DE, and the potential benefits of DE. It seeks to inform both the need for and the means to achieve a rapid acceleration of DE uptake.

This Roadmap aims to be both bold and pragmatic. While a roadmap can describe a possible future and outline a path towards it, a roadmap cannot by itself make this future a reality. The Roadmap's value and success depends on how well it serves the needs and aspirations of the energy sector's stakeholders.

Decentralised Energy in an Intelligent Grid

Over $45 billion is being spent on network infrastructure in the five years to 2015. Network spending is concentrated most strongly in NSW and Queensland but is affecting all jurisdictions. Figure 4 below shows the current and previous approved regulatory spend on network infrastructure, highlighting the massive growth in the 2010–2015 period. This investment is driving substantial electricity price increases around the country. Sydney metropolitan area customers face five-year nominal price increases as high as 83 percent.

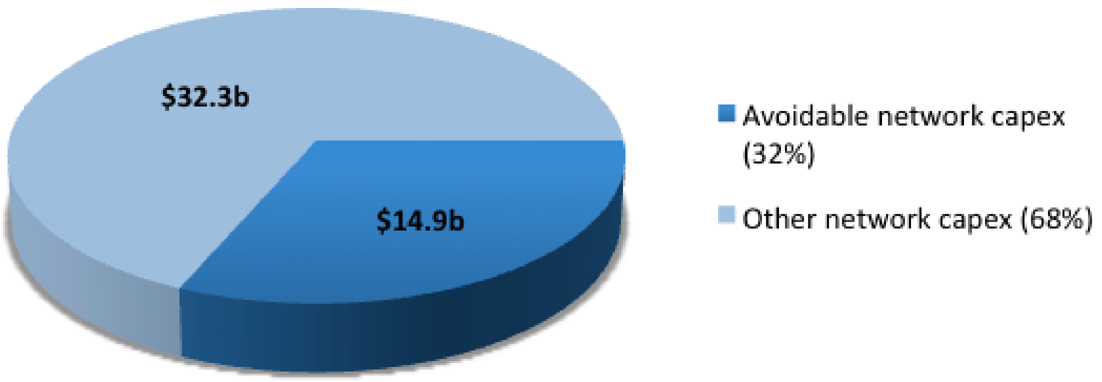
Figure 4: Electricity network capital expenditure by jurisdiction, 2006–2015



Rising peak demand is one of the three primary drivers of this network investment, and peak demand growth is projected to continue to outstrip growth in energy consumption over the next 10 years, placing continued upward pressure on electricity prices.

As shown in Figure 6, around one-third of total approved network investment, or almost $15 billion, is driven by peak demand growth and is thus considered potentially avoidable if demand growth were eliminated through measures such as Decentralised Energy. If deployed strategically, Decentralised Energy presents a means of achieving substantial reductions in this component of network spending.

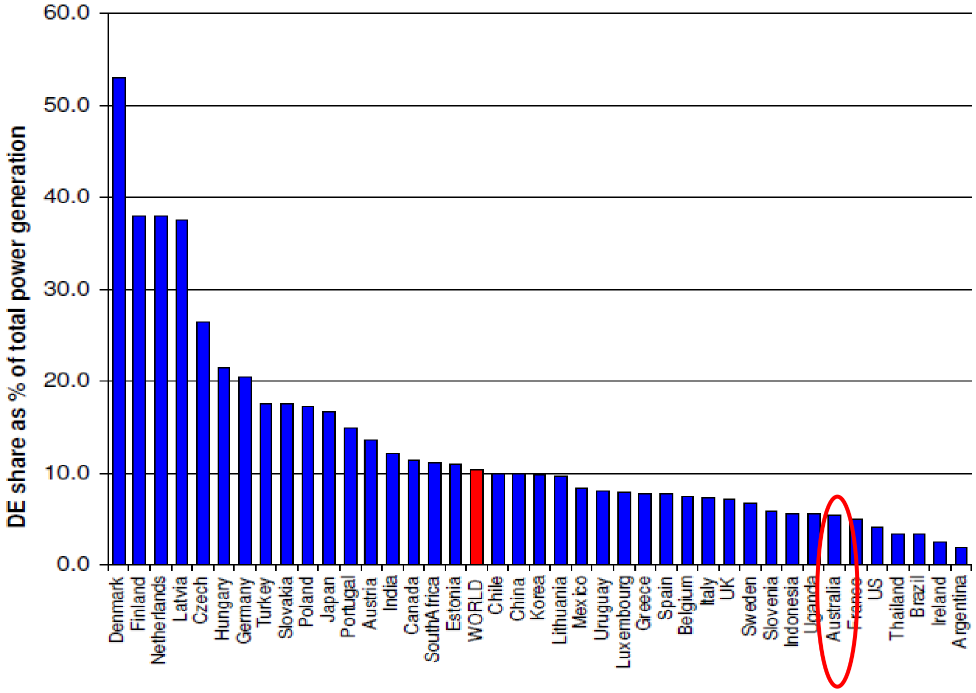
Figure 6: Avoidable network costs relative to total network capex ($m 2010)



Status of Decentralised Energy in Australia

Distributed generation is growing rapidly internationally, and in Australia grew by 20 percent in absolute terms between 2006 and 2010. However, this has not kept pace with the national average increase in installed capacity. At 5.4 percent of total electricity generation, Australia's use of Decentralised Energy lags the global average of 11 percent, as shown in Figure 13.

Figure 13: Proportion of total power generation from decentralised capacity



Source: WADE (2006, p.31)

Australia’s performance on *energy efficiency* also lags behind other developed economies. While Australia had a 1.5% improvement in energy intensity between 1990 and 2006, this was almost entirely due to structural changes in the economy, with energy efficiency accounting for just 0.2% of Australia’s improvement. This compares to the IEA average of a 1% improvement in energy intensity, and the highest performing countries which showed an efficiency improvement of 1.3 to 1.4%. Thus it appears that Australia’s active policy interventions on energy efficiency were largely neutralised by other factors. In particular, the gradual decline in energy prices in Australia over this period would have tended to offset improvement in energy efficiency. Other barriers have also impeded progress on energy efficiency. These barriers are described and addresses by the policy measures put forward in this Roadmap. Given that the trend of falling energy prices has been reversed in recent years, addressing these barriers could trigger a major improvement in energy efficiency.

Australia has a range of electricity network-driven and wholesale market-driven ***peak load management*** programs in operation. Electricity network-driven load management projects delivered peak demand reductions of 85 MW in 2009–10, rising to 310 MW in 2010–11. While this is a steep rate of improvement, it still amounts to just 0.9% of peak demand in the National Electricity Market (NEM). Furthermore, upon closer inspection, 91 percent of the reported 2010–11 peak load management occurred in Queensland where policy settings are more favourable. Wholesale market-driven projects contribute an additional 131-719 MW of peak load management. While it is not clear exactly how much load management has been employed in aggregate, it appears to be in the order of just 7 to 18% of the available potential load management 5,682 MW identified in this research.

Thus it is clear that while gains have been made in the DE arena, particularly in recent years, the overall DE penetration is low relative to the available potential, and therefore there are ample opportunities for the strategic application of DE within Australian electricity networks.

Benefits of Decentralised Energy

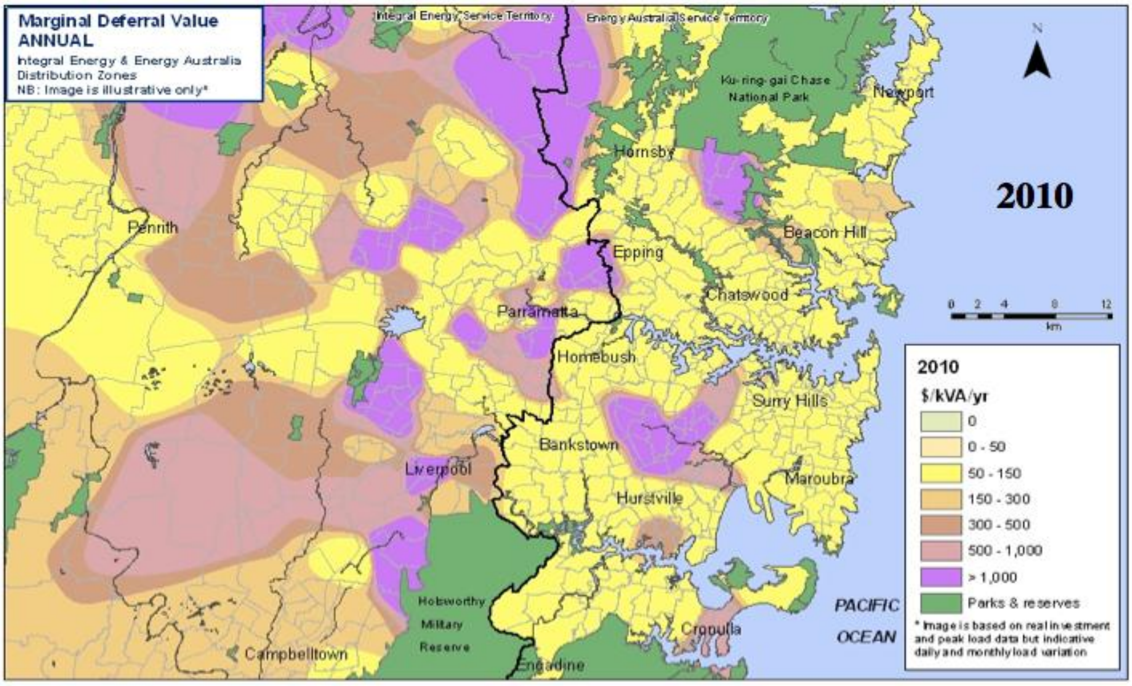
The main benefits of Decentralised Energy are:

- **Affordability** – delivering electricity services at lower cost to consumers than traditional centralised supply. Finding opportunities for the efficient application of DE in the electricity network is vital to this benefit stream.
- **Sustainability** – reduced greenhouse gas emissions from offsetting emissions intensive centralised fossil fuel electricity generation with energy efficiency and renewable or low carbon distributed generation, as well as through reduced transmission and distribution line losses.
- **Security and reliability** from having a diversified supply base and more dynamic demand-side participation leading to a larger range of options to meet network and generation constraints.

Under the current regulatory arrangements, the above benefits accrue – often unevenly – to energy consumers, energy supply companies and the environment (broader society) and thus care needs to be taken to ensure that the benefits are shared in a way that encourages broad participation in DE across the range of stakeholders.

It is also important to recognise that the cost of providing network services to meet growing demand varies markedly in time and space. Figure 25 below shows the striking variation in marginal network costs across Greater Sydney in 2010. Policy mechanisms to unlock the cost-saving potential of DE needs to acknowledge the value of prioritising areas of high avoidable network investment, such as those in shown in brown and purple in Figure 25. In these areas there are potential avoidable network costs of up to and beyond $1000 per kVA of peak demand reduction per year. If such a peak lasted, say, 10 hours per year, this represents a potential avoidable cost of $1000/10 hours or about $100 per kWh. When this cost is compared to a typical retail price of electricity supply of 20 cents per kWh, it highlights how poorly prices currently reflect costs and how much potential there is to reduce costs by intelligent use of peak load management.

Figure 25: Network investment deferral value, Sydney 2010



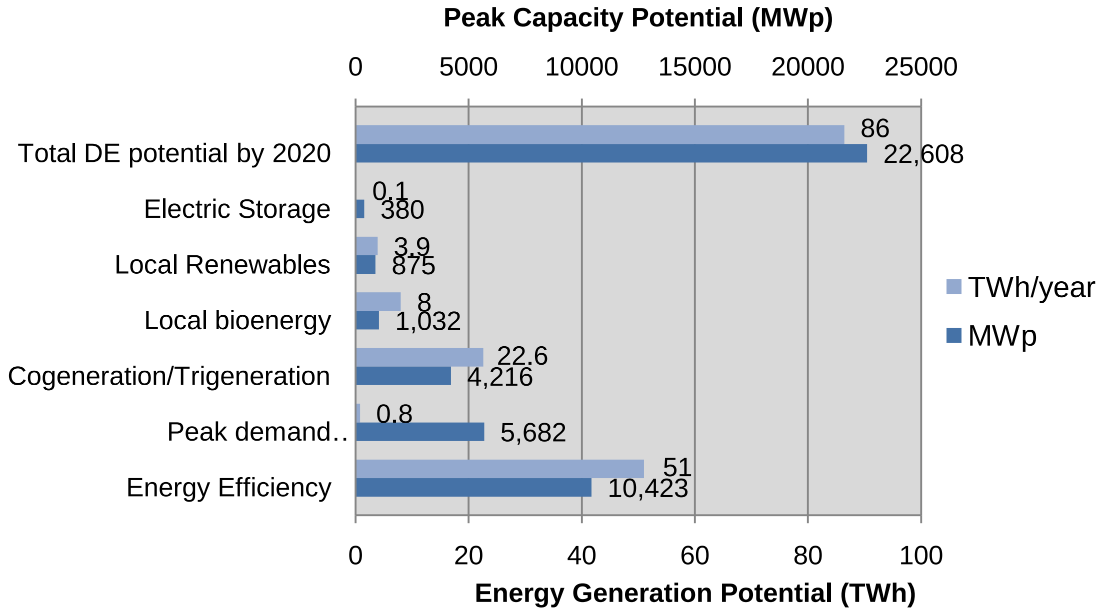
Source: Working Paper 4.4

Costs and potential of Decentralised Energy

Australia has very large untapped Decentralised Energy potential as shown in Figure 28 Decentralised Energy sources could deliver:

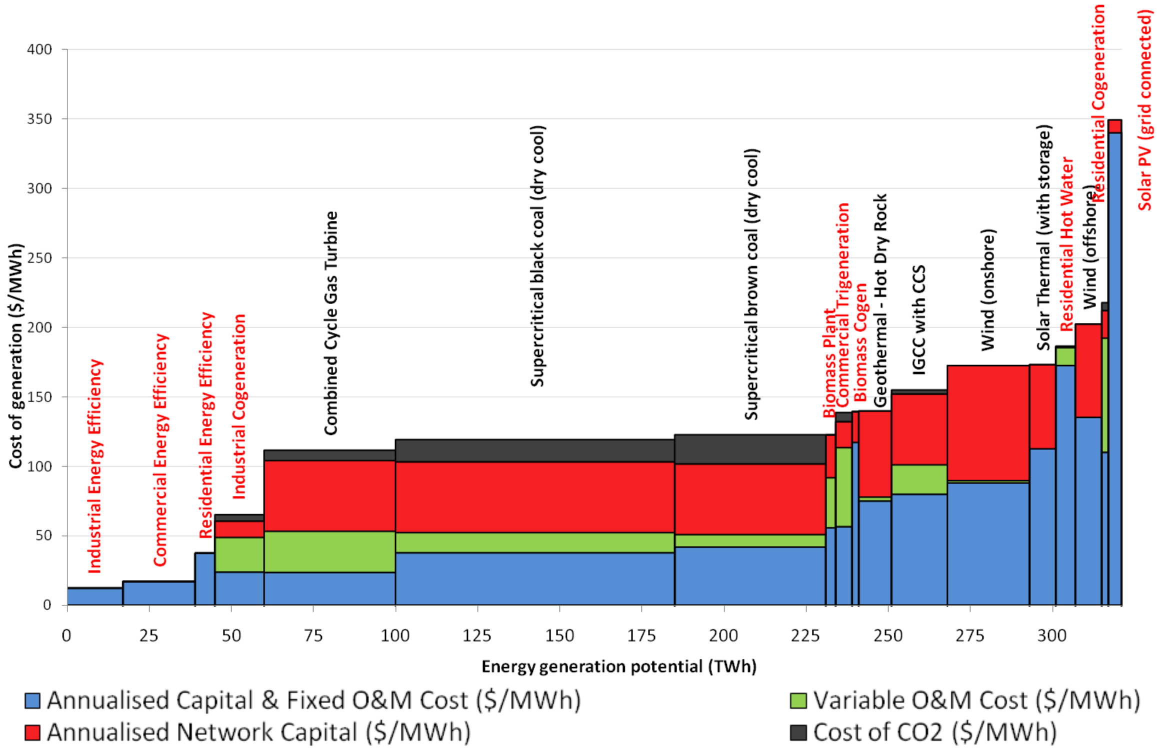
- 22,608 MW of peak capacity (> 50% of total peak demand); and
- 86 GWh per annum energy generation capacity (40% of energy demand).

Figure 28: Australia's Decentralised Energy potential



Traditionally, cost comparisons of electricity supply tend to exclude the cost of electricity network delivery. This is because such costs are often not borne by the generator, but by the network business, which in turn passes on costs on to electricity consumers in the form of network charges. For this reason many DE technologies are commonly considered to be more expensive than centralised generation technologies. However, when the network costs of delivering electricity from the point of generation to the point of consumption are included, the costs of many of today's DE options are favourable relative to centralised generation technologies, as shown in Figure 29 below. It can be seen that the addition of network costs – the red component of each column – has a large impact on the overall costs of centralised technologies. The most attractive options from a cost perspective are on the left side of the graph. In Figure 29 energy efficiency and industrial cogeneration have the potential to provide up to 60 TWh of additional supply at lower cost than expanding centralised supply.

Figure 29: Levelised cost and potential of supplying new energy demand

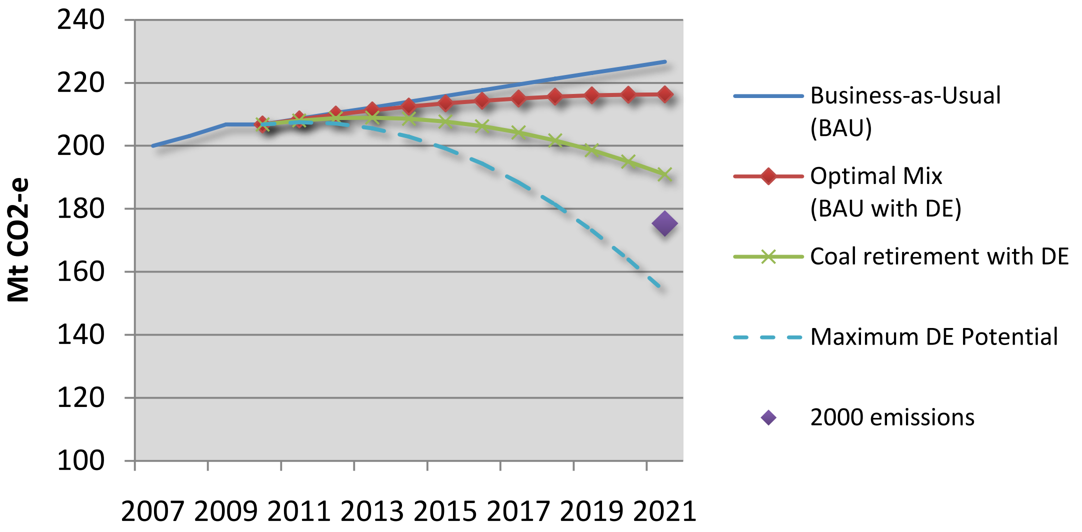


If all of the DE potential identified in this research was deployed, electricity sector emissions could be reduced by up to 73 megatonnes (Mt) per annum, which translates to a 35% reduction on 2009 levels. To investigate how cost-effectively DE could be applied at scale, a number of scenarios were modelled in the Description and Costs of Decentralised Energy (D-CODE) Model developed as part of this research. The results found that even in the absence of a carbon price:

- The lowest-cost deployment of DE could unlock $2.9 billion of savings per year for electricity consumers by 2020, while saving 4.5% of electricity sector emissions. An illustrative emissions pathway for this scenario is shown as the red line relative to the solid blue "Business as Usual" (BAU) line in Figure 32 below.

- For the same cost as the Business as Usual approach to centralised generation (i.e. no net cost), electricity sector emissions could be reduced by 17% through the large-scale application of DE and the retirement of 8,700MW of coal-fired capacity. This is shown as the green line in Figure 32. The emission reduction resulting from the maximum DE potential is shown as the dashed blue line below.

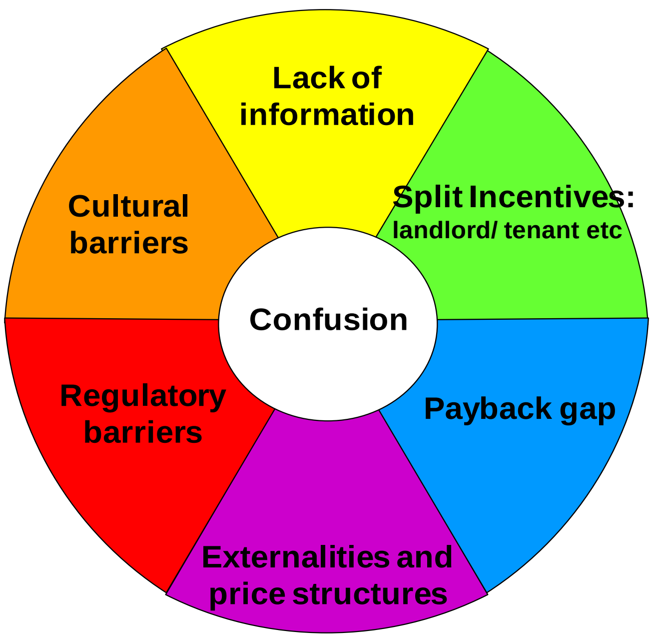
Figure 32: Australia's total electricity sector emissions under DE scenarios



Barriers to developing Decentralised Energy

Large volumes of cost-effective DE potential are not being delivered by the market is that there are numerous "market failures" or "institutional barriers" obstructing the uptake of DE. These are shown in Figure 34 below and include a lack of information on DE options (yellow), split incentives, where costs and benefits are do not accrue to the parties creating them (green), regulatory barriers (red), cultural barriers that favour business as usual approaches (orange), inefficient pricing structures (purple), the 'payback gap' (blue), and confusion resulting from a lack of coordination (white).

Figure 34: Institutional barriers to Decentralised Energy



According to a survey of energy industry stakeholders undertaken as part of this research, the top three barriers to DE are:

1. A lack of policy coordination and leadership on DE development (confusion)
2. The lack of an environmental objective in the National Electricity Market (cultural –and partly regulatory- barrier)
3. A lack of cost-reflective pricing (pricing barrier)

The top 10 rated barriers represent six of the seven barrier categories shown in Figure 8, indicating the need for a multifaceted and nuanced policy response.

Policy tools to develop Decentralised Energy

An effective policy package to unlock the potential of DE requires a balanced approach covering regulatory and pricing reform, information provision, incentives, facilitation, coordination and target setting. A list of 20 policy tools targeted at addressing the major barriers to DE is shown in Figure 37 below, 'mapped' against the relevant policy tool category. The policy tool categories broadly correspond to the barriers categories shown in Figure 34 above.

Figure 37: Policy Palette with 20 policy options mapped

1: DE Coordination Agency
2: Decouple electricity sales from network profits
3: Reform National Electricity Rules
4: Streamline DG Licensing
5: Extend retailer EE targets
6: DE targets & reporting
7: Resource assessments & case studies
8: DE handbook & advisory service
9: Network planning info
10: Annual DE Review
11: Energy audits & technical support
12: Training & skills development
13: Streamline network negotiation process
14: DE Ombudsman
15: Public recognition & awards
16: Distributed Energy Fund
17: Reform feed-in tariffs
18: Carbon Price
19: Cost reflective pricing
20: Network support payments

While a well-coordinated response is more efficient, it is also more complex. Moreover, building political support for a suite of measures can be more difficult and time consuming than for simpler less efficient approaches. Therefore, particularly where urgent policy action is required, it is sometimes more effective to prioritise a small number of measures even where a more comprehensive approach is called for. So with this in mind, the following is a highly simplified approach using the “top three” policy priorities for developing Decentralised Energy in Australia:

1. **Coordination Agency** (Policy tool #1 in Figure 37 above)**:** Nominate or establish an agency, with the appropriate skills and resources, to coordinate a coherent DE strategy. As a minimum this agency should be responsible for identifying DE opportunities and barriers, recommending policy and targets and monitoring and reporting on performance of DE policies and programs.

2. **DE Targets (#6):** Government to cooperate with electricity network businesses to establish “collaborative targets” for Decentralised Energy, which would deliver by 2017 (5 years from initiation) benefits in the order of:

    a. $1 billion p.a. in energy savings (comprising the value of both avoided network investment and customer energy savings)

    b. 3000 MW of peak demand reduction, below currently forecast “business as usual” growth

    c. 10 million tonnes of carbon dioxide avoided.

    While this scale of targets falls well short of the likely cost-effective potential for DE, they are deliberately modest to be more quickly adopted as policy, but still large enough to be have a significant positive impact on customer bills, carbon emissions and industry development.

3. **DE Incentive Fund (#16):** Between now and 2016, earmark significant funds to provide incentives for energy network businesses to take major actions to redirect network investment towards cost effective DE. Given that networks are currently spending over $9 billion per annum on capital expenditure, these incentives need to be large to have a meaningful impact. For example, the achievement of savings of $1 billion per annum (suggested above) would likely require incentives to be quickly ramped up to the order of $300–400 million per annum in funding. There may be scope to earmark such incentives from within the various policy initiatives committed as part of the federal government’s Clean Energy Futures Package (see Appendix 1 for further analysis). Whatever the fuding source, these direct incentives could be wound back after 2016 as barriers to cost-effective DE are removed and more balanced regulatory incentives are created for DE and network investment. This is particularly important in relation to the next round of electricity network economic regulatory decisions to be made by the Australian Energy Regulator for the 5-year periods commencing in each state (excluding WA) between 2014 and 2016.

The following pages demonstrate graphically the indicative timeframe over which policy reforms need to occur to begin to achieve the targets established in this Roadmap.

The road ahead: making it happen

This Roadmap represents the end of one journey and the beginning of another. The Intelligent Grid research program that supported the development of this Roadmap is now complete, but the Roadmap has just been released. While this Roadmap draws on of three years of research and stakeholder consultation, it is not intended as a final definitive statement of the potential, the challenges and the solutions for DE. Rather, it is intended to provide a detailed, considered and substantiated contribution to the ongoing conversation.

There are two other ways in which the Roadmap marks a new beginning. Firstly, it is hoped that this is just the first in a series of Australian Decentralised Energy Roadmaps over the coming years. For this reason, comments and feedback on the Roadmap are encouraged. Secondly, the Roadmap's researchers and authors are eager to continue to foster the network of hundreds of stakeholders who have contributed to Intelligent Grid Research and the development of the Roadmap. We hope to do this through various means including through the continuing research of the CSIRO and our partner universities and through public interest organisations such as the Australian Alliance to Save Energy.

As noted above, this Roadmap is both ambitious and modest. It is bold in that it envisions a fundamental shift towards Decentralised Energy in the Australian electricity sector over the next decade, resulting in both declining carbon emissions ***and*** lower pressure on energy bills. It encourages the community and governments to embrace this vision. But the Roadmap is also modest in that it recognises that ideas, data, analysis and policy proposals do not by themselves change the world. Ultimately, the value of this Roadmap will depend on how it is received and applied by the wide range of stakeholders who will influence and guide the evolution of the electricity sector in Australia over the next 10 years.

This Roadmap describes a set of policy steps that can be adopted by government (state and federal), in order to unlock the potential of DE. These policy steps will only be effective if they are embraced by government. And government will only adopt such steps if it is persuaded of their merit and if they are supported by key stakeholders.

This Roadmap is inspired by the idea that Decentralised Energy provides the missing link between sustainability and energy affordability. It is clear that no single party can make the Decentralised Energy revolution happen. But nor can any single party can stop it. It is hoped that this Roadmap will help to build the shared vision and collaborative spirit that is essential to allowing Decentralised Energy in Australia to fulfil its potential.

PROPOSED POLICY TIMELINE 2011-2020

Work Package	Policy Tool(s)	2012	2013	2014	2015	2016	2017	2018, 2019, 2020
Effective coordination of DE	#1: Establish central DE coordination agency	Nominate lead DE agency & role	Develop DE Strategy & Objectives	Annual Report on DE status		3 yearly review		3 yearly review
Adapt regulatory framework	#2: "Decouple" network revenue from sales volume	AER Consult & decide by June 2012 (NSW)	AER Consult & decide by 2013 (VIC & SA)	Implement NSW June 2014	Implement VIC & SA Dec 2015	Revenue cap operation	Review effectiveness and adjust	Next regulatory round starts 2019
	#3: Revise National Electricity Law to include environmental objective	Consult & consensus building		Legislative amendment			Review effectiveness and report	
	#4,#13: Streamline Dist Gen licensing, connection & negotiation processes	Consult	Draft legislative change	Enact legislative Change			Review effectiveness and report	
	#2,4: Evaluate/expand AEMC/AEMO reviews	AEMO review of Demand Side Participation	Consider matters outside current scope	Implement matters outside scope	Review effectiveness (See #10)			Review effectiveness
Targets and reporting	#5: Establish economy-wide target for Energy Efficiency	Consult & develop annual targets	Announce targets and strategy	Review progress and report	Review progress and report	Review targets and strategy		
	#5: Extend and harmonise retailer energy efficiency targets	Advisory Committee	Draft legislation	Enact legislation		Review progress and report		
	#6: Establish collaborative DE targets with networks	Consult on targets	Set targets and link to DE Fund	Review progress and report	Review progress and report	Review Targets	Review progress and report	Continue subject to outcomes
Address information gaps	#7 Produce DE Case Studies	Nominate agency & collect data	Publish pilot case studies	Evaluation and expand	Review effectiveness and scope	Operate and report		Continue subject to Review
	#8: Provide DE advisory service	Consult & nominate agency	Implement stand-alone service	Operate and report	Operate and report	Review		Continue subject to Review

PROPOSED POLICY TIMELINE 2011-2020

Work Package	Policy Tool(s)	2012	2013	2014	2015	2016	2017	2018, 2019, 2020
Address information gaps	#15: Improve network planning information	Enact AEMC rule change re Network Planning & DM	Improve info (mapping and outreach)	Disseminate complementary information	Review & Compare effectiveness		Review & compare effectiveness	
	#10 Annual DE Review	Consult	Nominate agency to coordinate & collect data	Publish DE Review			Review effectiveness	
Facilitate understanding and action	#11: Audits and technical support	Review extension of EEOA/ Green Start etc	Implement	Operate and report	Operate and report		Review effectiveness	
	#12: Training & skills development	Gap analysis & nominate delivery agencies	Pilot programs	Operate and report	Implement	Review curriculum relevance		
	#14 DE Ombudsman	Consult on role & structure of Ombudsman	Legislate new ombudsman functions	Capacity building of ombudsman office/s	Operate and report			Review and continue subject to outcomes
Streamline and rationalise incentives	#15: Public recognition and awards	Establish framework	Operate and award	Review effectiveness		Continue subject to outcomes		
	#16: DE Fund	Consult on fund level, source & reporting	Establish DE Fund and select projects	Fund projects based on performance	Operate and Report	Shift to funding via network regulation	Review: wind back and refocus Fund	Continue Fund subject to review
	#17: Reform Feed-in-Tariffs	MCE review nat'l streamlining of FiT for small DG	Enact legislation and/or rules	Implement	Operate	Review Effectiveness	Continue subject to net benefits	
Pricing Reforms	#18: Pursue carbon price	Implement	Operate and Report	Set 2020 Emissions target	Transition to Emissions Trading	Operate and Report		Set post 2020 Emissions targets
	#19: Incentivise cost-reflective pricing for networks and customers	Encourage voluntary ToU tariffs	Evaluate and educate re costs & benefits	Monitor and report, recognise best practice	Consider broad rollout with safety net	Review market and consumer impacts		Expand subject to benefit cost analysis
	#20: Establish default network support payments & negotiation framework	Review current practice	Consult on level and structure	Consider rule change if necessary	Operate and Report	Review		Continue subject to review

1 INTRODUCTION

Key Points:

- Decentralised Energy offers major cost savings and carbon emission reductions
- Decentralised Energy includes Distributed Generation, efficient use of energy, and the management of peak electricity demand
- This Roadmap aims to empower decision makers to deliver high levels of Decentralised Energy over the next 10 years
- This Roadmap represents three years of research and industry consultation and is launched as a consultation document upon which comments are welcomed.

1.1 Why Decentralised Energy?

The interlinked issues of rising energy bills and greenhouse gas emissions are two of the greatest challenges facing society today, particularly in Australia. It often seems that whatever we do to address one of these challenges exacerbates the other. As a consequence, effective action to address either area is often blocked and community frustration at this inaction grows.

Decentralised Energy offers a potential solution to this stalemate. Decentralised Energy (DE) refers to energy technologies and practices that optimise the use of local resources and reduce the need for large-scale energy supply infrastructure. The three elements of DE are: the efficient use of energy; peak load management and Distributed Generation. Each of these three elements has significant potential benefits in their own right, but when combined, **DE has the potential to offer major cost savings and carbon emission reductions while securely and reliably meeting customer energy needs.**

While making the most of local resources has been the dominant approach to meeting our energy needs for most of human history, it has become a less familiar approach over the past two centuries. Since the industrial revolution, we have sought to move the adverse impacts of centralised energy supply further away from communities that use that energy. The cost and global environmental impact of this strategy has become less acceptable and a new paradigm is called for.

Although the potential benefits of DE are great, tapping these benefits will require an extensive evolution in many areas of our energy policy, culture and institutions. This document seeks to inform both the need for such an evolution and the means to effect it.

"Decentralised" vs "Distributed" Energy – what's in a name?

This Roadmap uses the term **"Decentralised Energy"** (DE) to refer to the combination of Distributed Generation, Energy Efficiency and Peak Load Management deployed as a means of tackling the twin challenges of reducing costs and greenhouse gas emissions in the electricity sector. The term that has been used until now within the Intelligent Grid research program is **"Distributed Energy"**. However, in response to feedback from our consultation processes, we have chosen to adopt the term "Decentralised Energy" instead, as it communicates better and more intuitively the paradigm shift away from the current model of large-scale centralised energy generation and delivery.

This terminology is also likely to be less prone to the frequent confusion between *Distributed Energy* and its sub-component of *Distributed Generation*, which the iGrid research team has found throughout the course of this research. Combining these three different supply- and demand-side approaches has proven to be conceptually challenging for many stakeholders to grasp. It is important to communicate that DE is much more than a local supply-side approach as implied by Distributed Generation alone.

Another collective term that is sometimes used for these three components is "Local Energy". While this has the advantage of being a simpler term than Decentralised Energy, it also makes a less distinct contrast to "centralised energy". Whatever the name, the pieces of the puzzle are still the same, The authors of this Roadmap welcome any comments on how best to describe this new, flexible approach to delivering low carbon, low cost energy services.

1.2 Why a Roadmap?

Maps generally serve two key functions. Firstly, they tell us **where we are**, by informing us about what surrounds us: our context and environment. In so doing, maps can inform us of opportunities, threats and possible destinations. Secondly, maps help us decide **where to go, and how to get there**. The Roadmap aims to serve both these purposes.

A technology roadmap is defined by the International Energy Agency (IEA) as a specialised strategic plan that identifies and details the actions that must occur over a specified time frame to achieve a stated goal or desired outcome (IEA 2010). Roadmaps provide detailed information and tools to stakeholders to enable them to make better informed decisions and to develop priority actions. Roadmaps have in recent years become "tool(s) to help address complicated issues in a strategic manner at national, regional and global levels" (IEA 2010 p1). For examples of similar Roadmaps refer to Appendix 2.

The Australian Decentralised Energy Roadmap provides a concise and practical plan to accelerate the deployment of Decentralised Energy across Australia. It defines Decentralised Energy (DE) to include Distributed Generation, Energy Efficiency and Peak Load Management (see definitions in 'What is Decentralised Energy?' section below). It outlines a set of targets and timeframes in order to increase the penetration of DE resources in the electricity sector.

The **key objectives** of the roadmap are to:

- provide an overview of the current status of Decentralised Energy in Australia
- assess the potential of Decentralised Energy technologies to address rising greenhouse gas emissions and electricity prices
- present the 'business case' for Decentralised Energy as a basis for advocating the removal of impediments to the widespread uptake these technologies;
- outline a detailed set of policy actions and milestones to empower decision makers to deliver high levels of Decentralised Energy penetration.

The timeline for the DE policy actions outlined in this roadmap is five years, from 2012 to 2016. As the impacts of increased DE uptake flowing from these policy changes is expected to take place over a longer period, the timeframe for the DE targets outlined in this roadmap is a decade, spanning until 2021. It is anticipated that strongly increasing DE penetration in the electricity system over this period will reduce both consumption and capacity growth, and deliver a downwards trend in greenhouse gas emissions from Australia's power sector.

Australia's contribution to the global effort to rein in the growth of greenhouse gas emissions and initiate a steady decline is imperative over the next five years, the period which this Roadmap applies to. As noted by the Intergovernmental Panel on Climate Change (IPCC):

> *"... it is critically important that we bring about a commitment to reduce emissions effectively by 2020..."*

We must do this, the IPCC says,

> *"... to ensure stabilisation of temperatures at [2^{o}C above pre-industrial temperatures], then* ***global emissions must peak by 2015."***

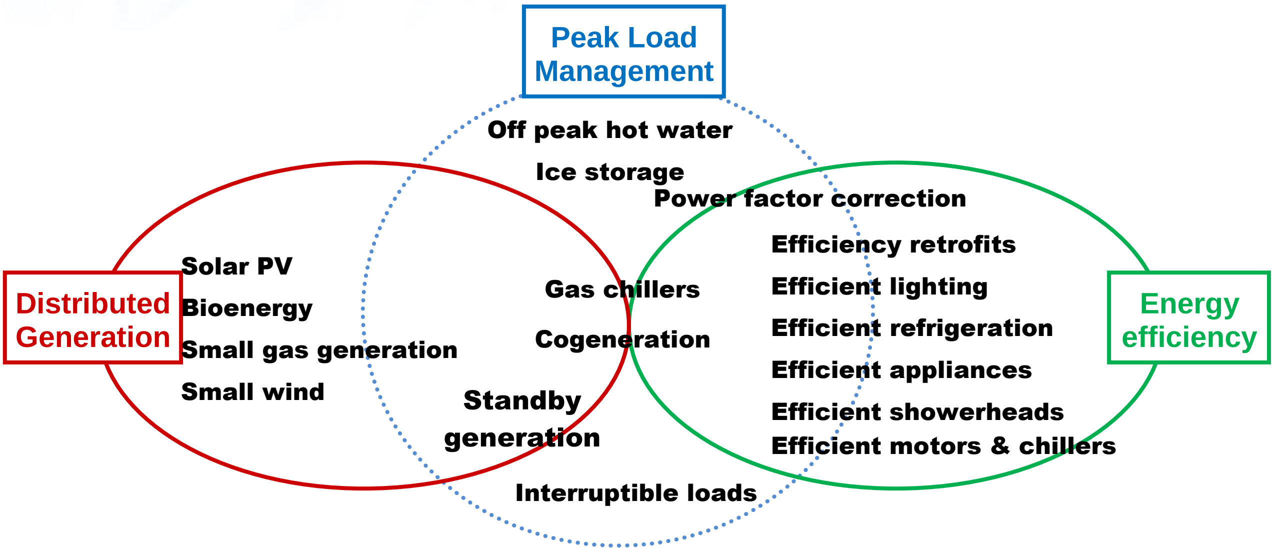
Rajendra Pachauri, Chairman, Intergovernmental Panel on Climate Change (IPCC)
15 Oct 2009 (Ingham 2009)

The intended audience for this Roadmap includes energy policy makers, regulators and government agencies, Decentralised Energy proponents, network businesses, energy investors as well as other key energy sector stakeholders, such as consumer advocates and environmental NGOs.

1.3 What is Decentralised Energy?

Decentralised Energy (DE) refers to energy supply and management options close to the point where the energy is used. Collectively, Distributed Generation, energy efficiency, load management (including demand-side response) describe the scope of Decentralised Energy options. This also includes a range of more specific enabling technologies such as smart meters that can help to unlock the potential of DE.

Figure 1: Decentralised Energy resources



Source: adapted from IPART (2002)

Distributed Generation (DG) refers to generation technologies that are 'embedded' within the electricity network, that supply electricity on-site or to the local area, and that may provide other services such as heating and cooling from the 'waste' heat associated with electricity generation, with a maximum size of 30MW. Technologies include solar PV panels, small wind turbines, gas or biomass micro turbines, fuel cells and cogeneration (combined heat and power), and solar or biomass heating.

Energy efficiency measures refer to both *technologies and behaviours* that deliver the required energy services to consumers using less energy input. Energy efficiency *behaviours* (sometimes called 'energy conservation') can be carried out by individuals or undertaken in an organisational context, and generally involve reducing unnecessary energy consumption. Examples include individuals turning lights off when not in a room, or organisations adjusting building management system settings to reduce total energy consumption while maintaining the desired level of occupant comfort. Energy efficiency *technologies* are appliances and equipment ('hardware') that reduce electricity or fuel consumption for the same service output.

Peak Load Management refers to actions that influence the *timing* of energy use. This occurs when customers are provided with information, technology and/or incentives to shed or interrupt their load at times of peak demand and shift it to times of lesser demand. The objective of peak load management is generally not to reduce emissions, but to limit unnecessary electricity price rises. This could enable greater implementation of other low emission DE options.

Smart meters are the hardware upon which a more cost-reflective electricity pricing and consumer interaction and information relies. To be of value in supporting DE, smart meters must be accompanied by time-of-use tariffs that reflect the cost of supply at a particular time and/or location. They also need to convey energy use and cost information to the users by, for example, interactive displays that enable consumers proactively to manage their electricity usage and spending, thereby becoming more active agents in the electricity market.

A day in the life of a Decentralised Energy user

Dena wakes early on a February morning in the year 2030. It has been another record breaking hot summer and she likes to swim before work. After a quick shower courtesy her gas-boosted solar water heater, she grabs an orange juice from her refrigerator, a fairly average model using about a third of the energy of a typical model of twenty years earlier. She does not notice as the fridge quietly hums to pre-cool its freezer, as it has received a signal from the electricity network business to power down later that day as a peak electricity demand day is forecast.

Dena's working day begins as she sits down in her home office. By working from home, she saves energy, commuting time and road charges. While the widespread shift to battery electric and fuel cell vehicles has virtually eliminated urban smog, peak hour traffic congestion is still frustrating. While video conferencing is now commonplace, she still likes to go into the city office about three days a week for the camaraderie with her colleagues.

She works for a management consulting firm. On the days she goes into the office, she finds the building is designed to provide a pleasant and productive environment. It maximises the use of daylight and natural ventilation. Unlike the most efficient new buildings, her office does need some supplementary heating and cooling, provided by a natural gas-powered fuel cell trigeneration unit in the basement. The trigen unit was installed with technical and financial assistance from the local electricity network business that was seeking cost-effective options to defer an expensive expansion in electricity network supply capacity. (This network upgrade, originally scheduled for 2018, has still not been built, as the network continues to find more cost effective and profitable energy efficiency and demand management options to offset peak demand growth.)

Today, Dena is developing a marketing strategy for a major food company. Her client has already invested in efficient refrigeration, lighting, cogeneration, variable speed drives and motors for cost reasons, but now they are seeking to capitalise on the marketing advantage of certified "zero pollution" products. They see great potential to enhance the clean, green image of the company.

Dena's brother Julian arrives for lunch. He has used just two litres of natural gas driving the 100 km from the city in his Australian-made fuel-cell electric car. The car is five years old, so is not as efficient as the newest models, but the ultra light vehicle has one fifth the emissions average car of the "noughties". Julian rolls into the parking bay, and says "engage vehicle to grid" before leaving his car. With this the car connects to Dena's home gas and electricity supply. This not only refuels the car, but also enables the car's fuel cell to generate power to feed back into the electricity grid.

Dena welcomes her brother at the door and he is eager to escape the heat outside. Although Dena's 40-year-old house still needs cooling on such a hot day, it achieves this without adding to peak electricity demand on the network due its thermal storage system and energy efficient retrofit. After lunch, when Julian returns to his car, his utilities account has been debited $2 for the use of the gas but credited $5 for the electricity fed back to the grid.

After work, Dena checks her monthly utilities statement. While her broadband bill makes her wince, the credit she earns on selling electricity back to the grid provides some relief. She is pleased that she recently had the solar panels with battery back-up and Home Area Network Demand Manager system installed. By setting the system to buy power in off peak periods and sell power back at times of high demand and prices, she earns almost enough to cover the network access charge.

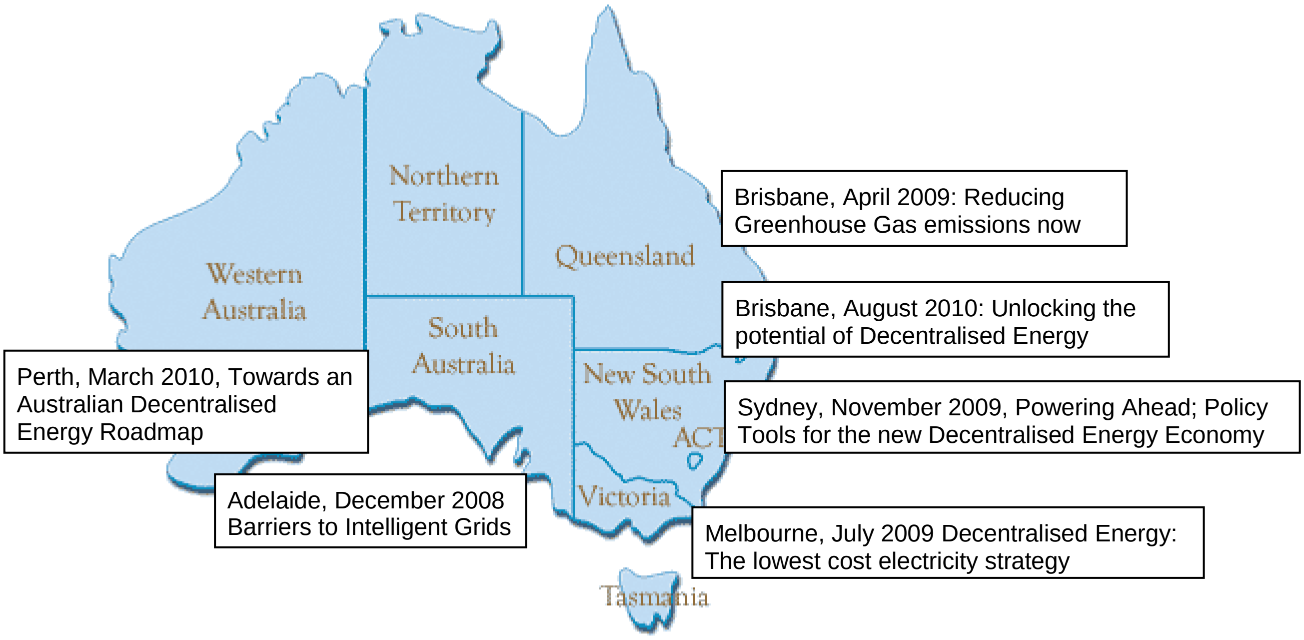
None of the above seems at all remarkable to Dena. Decentralised Energy is simply part of life and as far as Dena is aware; it has always been that way.

1.4 Developing the Roadmap

The consultation and engagement of stakeholders is a key element of the development of this Roadmap, and of the Intelligent Grid Research Program in general. The roadmap was developed through a series of consultations with stakeholders from the energy sector in Australia, which took place between 2008 and 2011. The final event was in December 2011 where the Roadmap was launched as a consultation document.

The map in Figure 2 shows the date, location and title of each consultation forum. At these forums feedback was sought through panel sessions with audience engagement and also via interactive workshops.

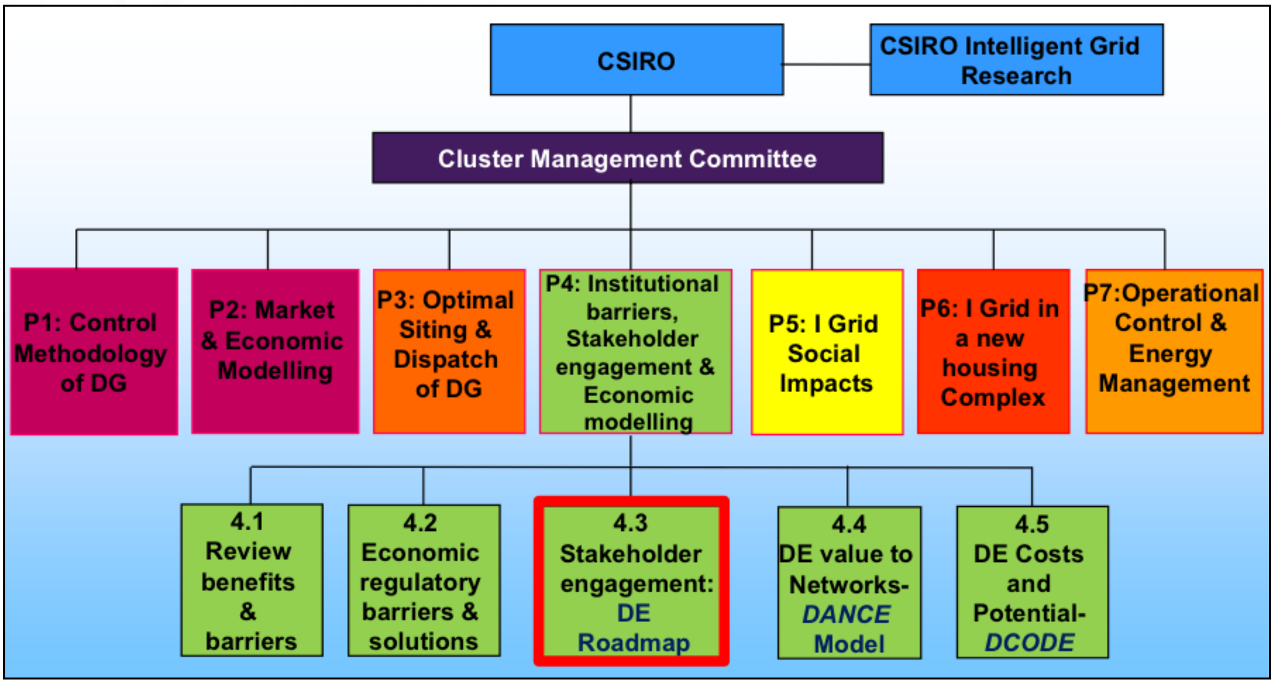
Figure 2: Location, timing and focus of Roadmap consultations



To encourage dialogue and collaborative learning, a series of working papers was released to coincide with each Intelligent Grid forum. Stakeholders were invited to comment on and contribute to the development of these working papers, which have been revised and reissued periodically during the research and consultation process. These working papers will be referred to throughout the roadmap document and provide more in-depth analysis on each of the key themes. They can be viewed on the Intelligent Grid Research Program website: www.igrid.net.au in the Resources and Publications section.

The Intelligent Grid (iGrid) Research Program was a three-year research collaboration involving CSIRO and five leading Australian universities, under the CSIRO Energy Transformed Flagship. Its aim was to establish the economic, environmental and social impacts and benefits of the large-scale deployment of intelligent grid technologies in Australian electricity networks. Figure 3 below illustrates the structure of the iGrid Research Program and shows how Project 4 – under which this DE Roadmap was developed – fits into the wider program context.

Figure 3: Intelligent Grid Research Program structure



2 DECENTRALISED ENERGY IN AN INTELLIGENT GRID

Key Points:

- Electricity networks are spending over $45 billion on network infrastructure in the five years to 2015, leading to strong electricity price increases around the country.
- Peak demand growth is one of the three major drivers of this investment, and is projected to continue to outstrip growth in energy consumption over the next 10 years, placing continued upward pressure on electricity prices.
- Up to one-third of network investment, ($14.9 billion in the current five year period), is potentially avoidable if peak demand growth could be eliminated through Decentralised Energy.

An unprecedented level of electricity sector capital expenditure is planned over the next five years, with over $45 billion in electricity network infrastructure alone planned between 2010 and 2015. This represents larger expenditure than the National Broadband Network in less than half the time period. This investment is driving substantial electricity price increases around the country. For Sydney metropolitan area customers, the five-year nominal price increase will be as high as 83 percent (Dunstan & Langham, 2010).

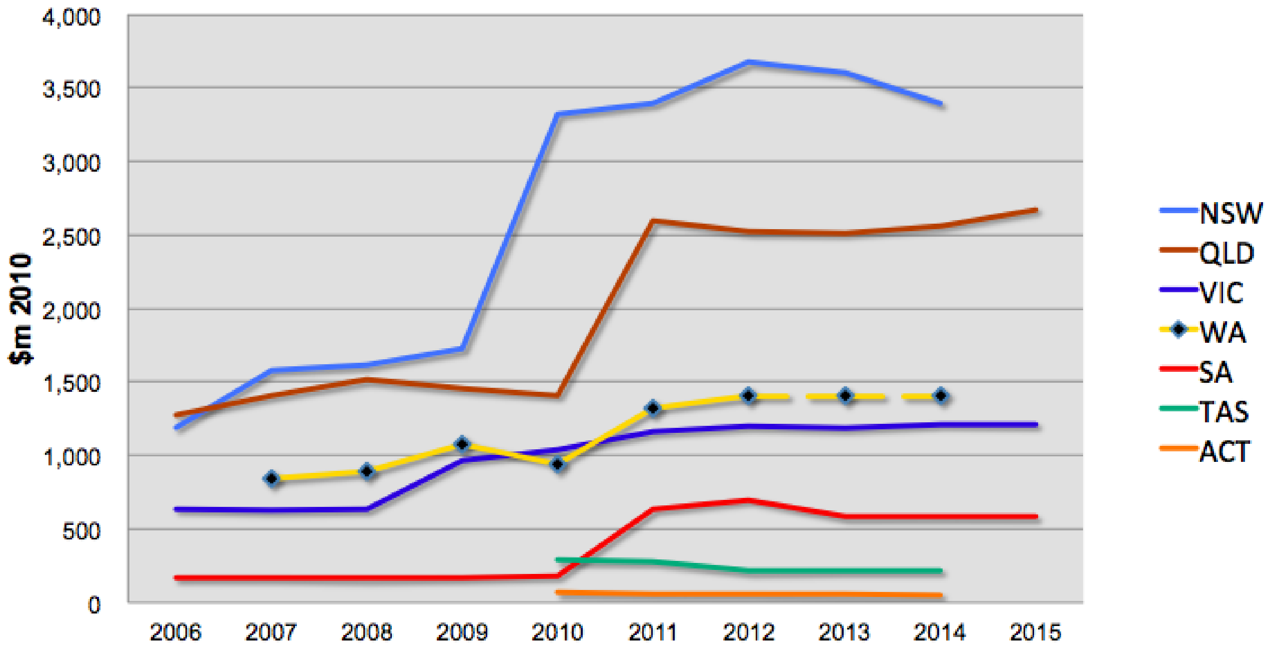
A large component of this investment is to meet growth in total and peak demand, with electricity consumption forecast to increase by almost 25 percent in the next 10 years, and peak electricity demand slated to rise by more than 30 percent over the same period (AEMO, 2010). These impending network constraints can be addressed through two possible approaches. The business-as-usual approach involves network businesses investing capital into building a bigger network, in line with traditional demand forecasting. This reinforces our existing model of large-scale centralised and greenhouse gas intensive power supply (Glassmire et al. 2010). The alternative approach is that the network provider addresses peak load growth in the network by using low carbon Decentralised Energy, including Distributed Generation sources embedded within the electricity network, adaptive management of critical peak loads and the implementation of energy efficiency measures.

If implemented strategically, DE options – also termed ‘Demand Management’ (DM) when used to avoid network constraints – have the ability to meet the parallel aims of reducing costs and reducing emissions by reversing the trend of continuing growth in demand and the dollars spent on delivering power from the producer to the end user.

2.1 Planned Network Investment

Figure 4 shows the regulator-approved network capital expenditure in each jurisdiction for the past two regulatory periods, 2006–2010 and 2011–2015. Note that spending in the second regulatory period – with investment totalling over $45 billion – is a dramatic increase on 2006–2010. This is particularly apparent in NSW and Queensland, which alone account for over 60% of the total capital expenditure over the five years to 2015. The proposed annual capital expenditure on distribution and transmission infrastructure is highest in NSW, at well over $3 billion annually for the next four years (Rutovitz and Dunstan, 2009).

Figure 4: Electricity network capital expenditure by jurisdiction, 2006-2015



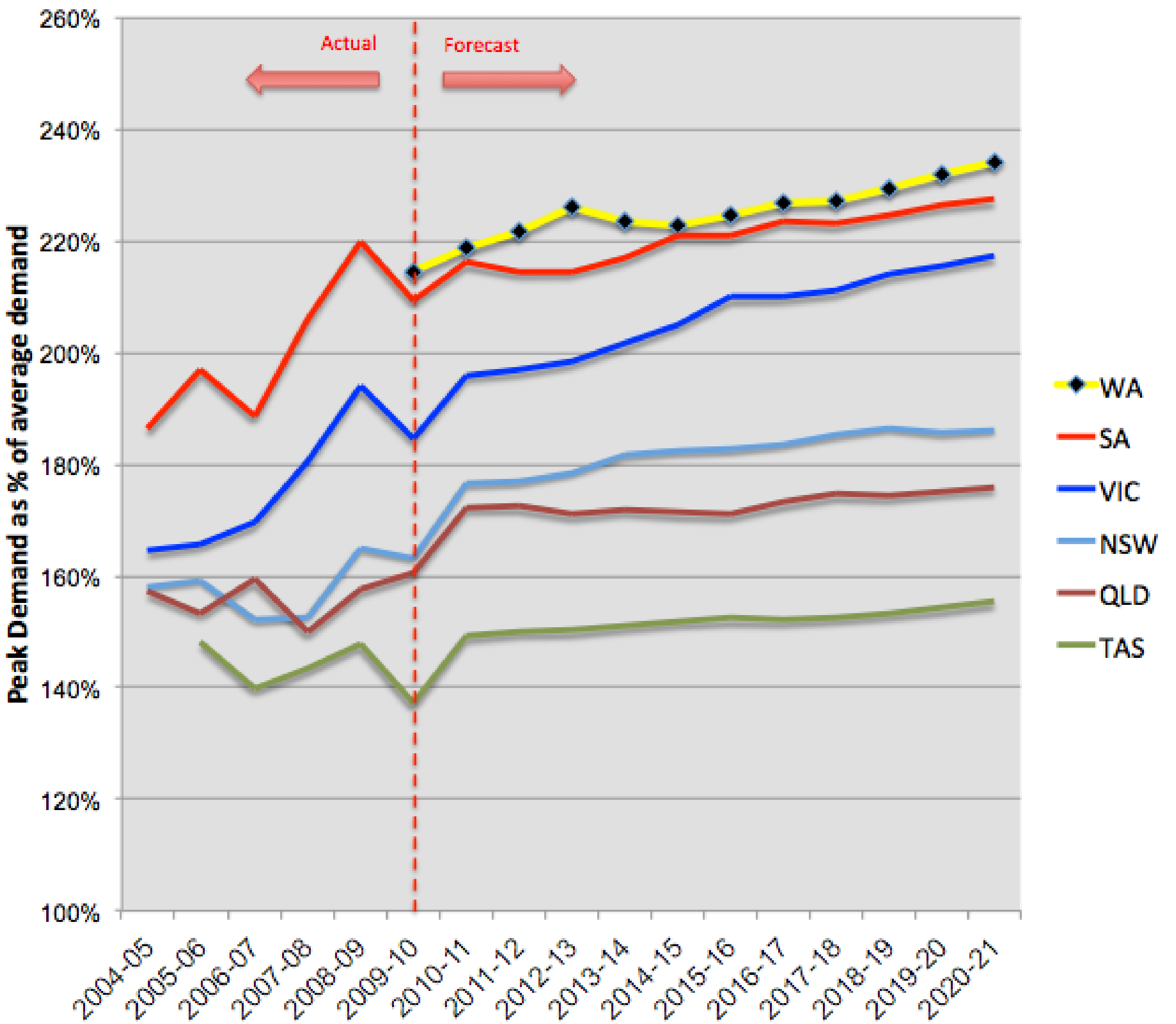
Sources: AER and WA Regulator decisions, see Working Paper 4.4 (Langham et al, 2011a) for full details.

2.2 Network Investment Drivers

There are three primary drivers for this capital expenditure on network infrastructure: replacement of ageing infrastructure; increased reliability standards imposed by governments on electricity utilities; and growth in peak electricity demand. The final driver of peak demand growth is the key area of interest in the context of potentially avoidable costs through the large-scale deployment of Decentralised Energy.

The forecast continuing trend of peak demand outstripping energy demand, as shown by the rising trend seen in Figure 5, is most concerning from the perspective of electricity prices. With the business-as-usual forecast demand becoming “peakier”, this results in greater infrastructure intensity and ensuing higher costs for every unit of electricity delivered from centralised power stations to end users. This indicates that growth-related infrastructure spending is expected to continue strongly for the foreseeable future, placing further upward pressure on electricity prices.

Figure 5: Peak demand as a proportion of average demand by state, 2004-2021



Source: iGrid Working Paper 4.4; based on data from AEMO and WA Independent Market Operator 2010 Statement of Opportunities documents. Based on summer peak demand at 10% Probability of Exceedance (POE).

2.3 What is 'avoidable' investment?

A significant benefit of DE is the ability to defer or avoid expensive transmission and distribution network investment by reducing peak loads. A central premise of much of Project 4 of the Intelligent Grid Research Program is that there are ample opportunities to apply efficient low carbon 'non-network' alternatives to overcome network constraints, thereby saving consumer dollars and reducing emissions in the process.

Implicit in the above proposition is that Decentralised Energy can *defer* or *avoid* the building of new infrastructure. The distinction between 'deferral' and 'avoidance' of infrastructure investment is relatively simple: the difference is merely in the amount of time for which an investment is delayed. If there is an impending growth-driven network constraint that would require a $10 million network augmentation to overcome, a moderate amount of DM may be available that can reduce the rate of underlying growth, and *defer* the need for that investment for say, two years. If a larger amount of DM was available relative to the underlying growth rate, it may be that no augmentation of the network would be required. This is what would be termed ‘avoidance’, but is in practice no different to prolonged deferral of network infrastructure beyond the current planning horizon. The vision of the Intelligent Grid is for DM to be implemented effectively and at scale into the future, slowing and eliminating growth in peak demand total and helping to reduce electricity consumption. In this case we would see short-term deferral initially, and long-term avoidance of network infrastructure.

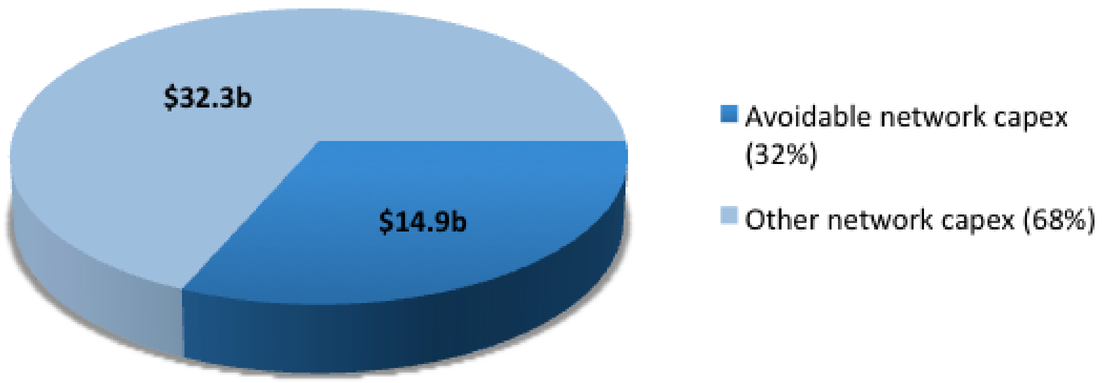
However, not all network capital expenditure (capex) is avoidable. In the context of the application of DE or ‘non-network’ options, avoidable capex costs are considered to be those costs that are ‘growth related’ – that is, investments undertaken in response to growing peak demand.

Extending network capacity, either to address demand growth or to meet new security of supply criteria imposed by governments, is considered avoidable if the demand growth driving the investment on the network could be sufficiently reduced. In practice, meeting new reliability criteria often implies very sudden and large changes in effective capacity, which if implemented quickly can be beyond the capacity of DM to address. If implemented gradually, these investments too may be avoidable through DM. Nonetheless, the only network infrastructure costs that are quantified and quantified as ‘avoidable’ in this research are ‘network augmentations’ specifically addressing peak demand growth.

2.4 Quantifying avoidable investment

The results of the Project 4 analysis, shown in Figure 6 below, indicate that over the next five years there is $14.9 billion of potentially avoidable capital expenditure if demand growth could be eliminated. NSW and Queensland together account for almost 70 percent of this value. Overall, around one-third of network capex is considered potentially avoidable over the current five-year regulatory period.

Figure 6: Total vs potentially avoidable network capex ($m 2010)[1]



Source: iGrid Working Paper 4.4 (Langham et al. 2011a) based on data from AER and WA Regulator decisions.

Working Paper 4.4 suggests that even if a portion of the $14.9 billion shown in Figure 6 above was redirected towards efficient DM measures, substantial economic and greenhouse gas emission savings could be achieved relative to the business-as-usual approach. This is covered in the benefits of Decentralised Energy in Section 4.

[1] In this research network operating costs that would be directly avoided by eliminating the need to maintain new additional network infrastructure are *not* included, but are in the order of a further 20 to 25 percent of the annual deferral value (Langham et al. 2010).

Case Study 1: Peak Load Management in Western Australia

The need to build sufficient electricity supply capacity to meet the very highest peak demand, even if this occurs for only a few hours per year adds significantly to electricity costs. It is often observed that in Australia, 10% of generation and network capacity is used less than 1% of the time. Peak load management can provide a significantly more cost-effective approach to meeting peak electrical demand during these short periods.

Peak load management refers to measures taken by or on behalf of electricity customers in order to **lower** peak demand and thus defer the need to build new network or generation capacity.

The most developed market for peak load management in Australia is in Western Australia (WA). Each year, the WA Independent Market Operator publishes a list of peak load management resources that are contracted to provide capacity to support the electricity market two years later. For example, the most recent statement indicates that for 2013-14, peak load management represents over 276 MW out of a total required contracted capacity of 6,087 MW (WAIMO, 2011). By comparison, the total peak load management in the National Electricity Market (ACT, NSW, Qld, S.A., Tas and Vic) was estimated at between 171 MW and 620 MW in 2010-11 out of a total peak demand of about 35,000 MW (see Table 2 in section 3.1).

One company participating in the Western Australian peak load management program is BGC (Australia) Pty Ltd. BGC is a large, diversified organisation with operations stretching from the quarry to building materials, to residential and commercial construction. BGC is also one of the top 200 energy users in Australia.

Figure 7: A BGC quarry that participates in the peak load management program

Eight BGC facilities, ranging from quarries to cement mills to manufacturing facilities representing around 90 percent of its overall electricity use participate in “demand response” by halting operations temporarily to reduce energy use and protect the grid in WA.

When called upon, these facilities can reduce their electrical load by shutting down equipment such as crushers, mills, a packing plant, and lighting - all within half an hour. These “Demand Response” events are coordinated through EnerNOC, Australia’s largest peak load management company.

BGC’s 5 MW peak load reduction earns the company payments of more than $400,000 annually fromfunds that go back to the participating facilities. According to Sam Buckeridge, Managing Director of BGC, “The payments from EnerNOC demand response are significant and stand out on the accounting ledger. We’re doing a lot of projects that eliminate waste, but the financial impacts of many of these are not as transparent.” (EnerNOC, 2011)

EnerNOC (formerly called Energy Response) estimates that there is 4,000 MW of potential peak savings as yet unrealised in Australia, equivalent to almost 10% of Australia’s peak demand (Energy Response, 2009) and many times more than the capacity currently being tapped as mentioned above .

3 STATUS OF DECENTRALISED ENERGY IN AUSTRALIA

Key Points:

- Distributed Generation is growing rapidly internationally, but Australia is lagging behind the word average, with 8.6% of total installed generation capacity, mostly in the form of industrial applications
- Australia's performance on energy efficiency is lagging behind other developed economies. Australia is in the bottom half of the International Energy Agency's list of countries ranked according to the reductions they have achieved in the energy intensities of their economies
- Significant barriers remain to the uptake of DE, many of which stem from the physical, commercial and regulatory structures associated with the current Australian electricity system.
- Information regarding the current size of the Australian DE sector is a key gap in knowledge and addressing this lack is important for the long-term development of a sustainable Decentralised Energy sector in Australia.

3.1 Status of Decentralised Energy deployment

Energy efficiency

A common comparative measure of energy efficiency performance is the 'energy intensity' of an economy, or the amount of energy consumed per unit of economic output. Figure 8 shows the whole-of-economy energy intensity of various countries for 1990 and 2007, showing that Australia sits in the bottom half of the global rankings for energy intensity, although it has demonstrated a reasonable level of improvement over that time period. While having a low energy intensity is positive from the perspective of an efficient and low-emissions economy, the measure strongly reflects the composition of the economy, and as such a manufacturing-orientated economy will generally have higher energy intensity than a service-based economy. Thus the *improvement* in energy efficiency is the factor that should be scrutinised when assessing the effectiveness or adequacy of energy efficiency measures undertaken.

Figure 8: Changes in energy intensity in IEA countries from 1990 to 2007

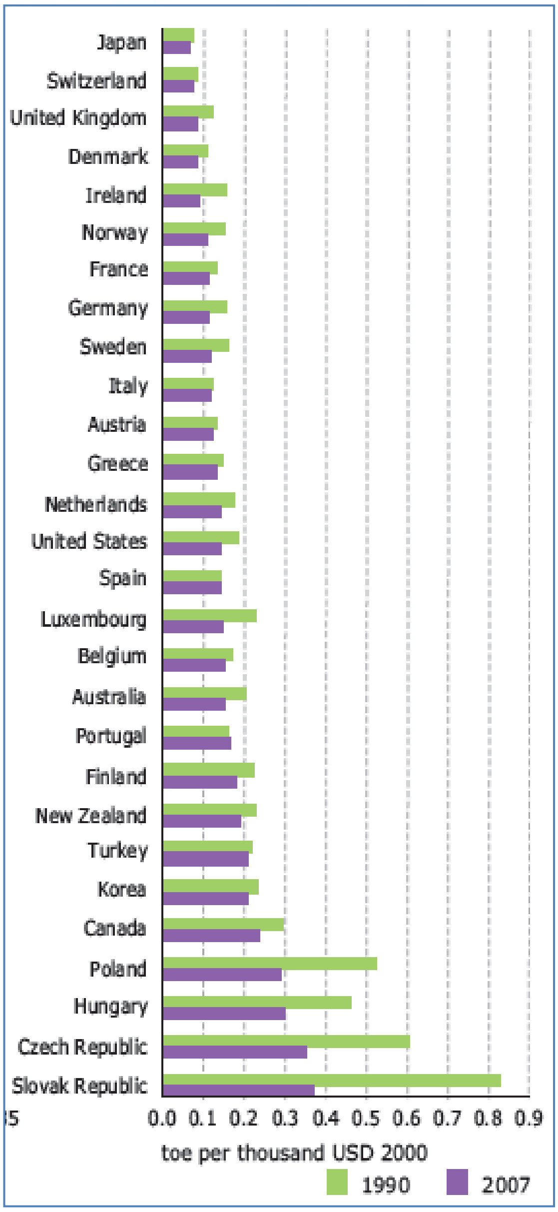
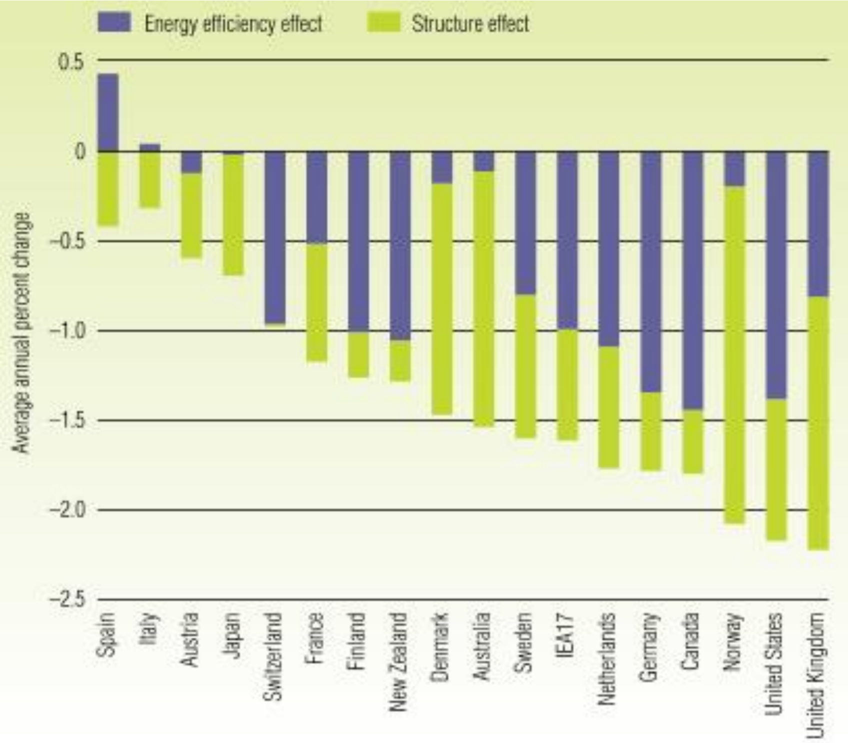


Figure 9 shows the composition of energy intensity changes of various countries from 1990 to 2006. The analysis is broken down into two components: the effects of structural change within the economy, such as shifts away from manufacturing towards service industries; and the effects of energy efficiency improvements. The figure shows that while Australia had a 1.5% improvement in energy intensity – just lower than the average of IEA countries of 1.7% – this was almost entirely due to structural changes in the economy, as energy efficiency only accounted for 0.2% of Australia's improvement. This compares to the IEA average of a 1% improvement in energy intensity and the highest performing countries such as Canada, the USA and Germany, which showed an efficiency improvement of 1.3 to 1.4%. While the comparison of energy intensity data has some limitations, the Australian government's own assessment of the available data concludes that the rate of improvement is less that of many other comparable developed countries (DCCEE, 2010c).

Improvements to efficiency in the stationary energy sector can come from increasing efficiency in the generation and delivery of electricity ('supply-side measures'), or from reducing consumption in the three main energy consuming sectors: residential, commercial and industrial ('demand-side measures'). Both residential and commercial energy efficiency include the replacement of old building stock with more energy efficient new buildings, as well as retrofitting of existing buildings with technologies that reduce energy inputs.

Source: IEA, 2009b

Figure 9: Energy efficiency vs structural changes in energy intensity, 1990-2006



Source: DCCEE (2010c). Note the following sectors are not included in this analysis: quarrying, fuel processing, electricity, gas and water supply.

Many of these demand-side measures are covered to some degree by policy mechanisms at the federal or state level. Australia initiated appliance energy labelling efforts in the mid 1980s, and after 1999 this was complemented by Minimum Energy Performance Standards (MEPS) for certain appliances. The aim of energy labelling is to influence buyers to select more efficient appliances at the point of sale, while MEPS require the removal of the least efficient products from the market. MEPS have been progressively strengthened and have increased in scope, now covering refrigeration, heating, cooling and lighting products as well as motors and some consumer electronics. A recent evaluation of the MEPS and labelling program found that the national refrigerator and freezer energy use in 2011 was 50% lower than it would have been if no measures had been implemented, while air conditioner use was 9% below the business-as-usual baseline. In total, the program claims to have reduced Australia's carbon emissions by 8.8 megatonnes in 2010 (DCCEE, 2011), which translates to around 4% of Australia's 2010 stationary energy emissions. Since 2004, the National Framework for Energy Efficiency (NFEE) has been at the core of Australia's policy efforts to improve energy efficiency. Under this program of works, in addition to appliance efficiency, the suite of policy packages included:

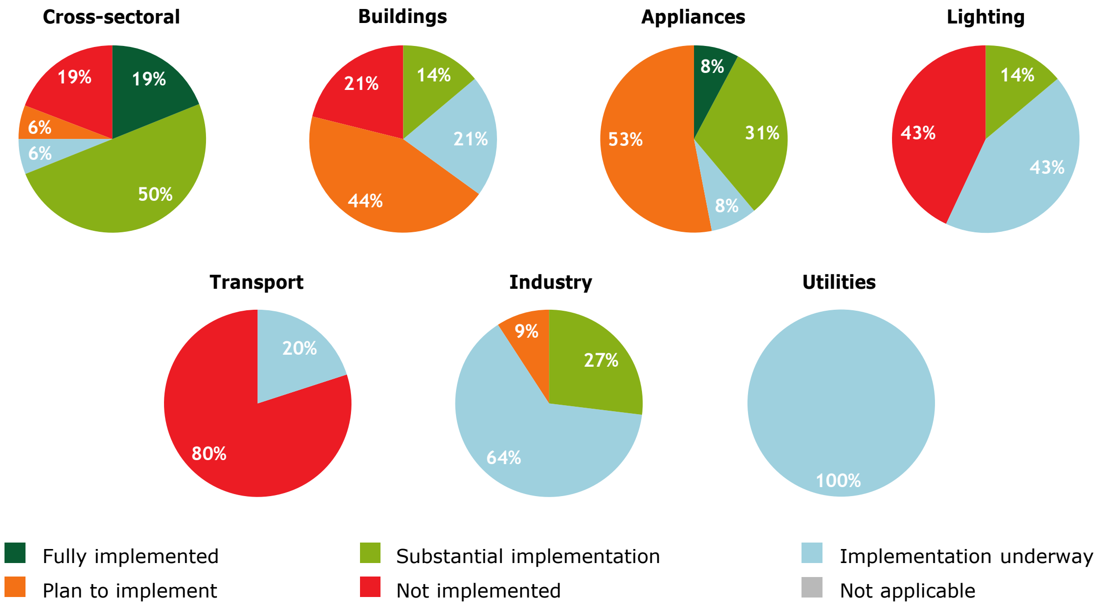
- Residential and commercial buildings energy efficiency measures, as part of changes to the Building Code of Australia
- Commercial/industrial energy efficiency through mandatory Energy Efficiency Opportunity Assessments, which to date have identified energy savings which would reduce emissions by around 6 Mt per annum *if* implemented (DRET, 2010).

- Awareness programs and industry training, skills development and certification.

Stage two of the NFEE, from 2009 onwards, has included measures such as phasing out inefficient incandescent lighting, and government leadership though green leases.[2] The other major developments in the energy efficiency policy arena that have occurred at the state level are modest end-use energy efficiency targets mandated by state governments upon electricity retailers. As of 2010, NSW, Victoria and South Australia all had such schemes in operation (DCCEE 2010c).

This extensive list of policy actions covers to some extent many of the stationary energy sector recommendations put forward by the IEA, as shown in the progress review in Figure 10; although only a relatively small proportion were found to be fully or substantially implemented as of 2009.

Figure 10: Australia's progress in implementing energy efficiency policy actions



Source: IEA 2009b

Thus, despite some significant energy efficiency policy efforts, Australia's energy efficiency performance appears to have been disappointing. To some extent this may be explained by the impacts of many of the more recent and cumulative impacts of the NFEE energy efficiency measures not being observable in 2006 energy intensity data. Additionally, however, many of the measures implemented target new building stock and appliances, which have positive *long-term* impacts, but more limited near-term results. The Australian Government concludes that the historically low, and until recently falling, cost of Australia's electricity supply has suppressed action on energy efficiency. There is also a range of other barriers, many of which are covered in Section 6 of this report (DCEE, 2010).

[2] For a full list of actions see: http://www.ret.gov.au/Documents/mce/energy-eff/nfee/default.html

Thus, while the success of energy efficiency policy measures to date is an important outstanding question and matter for review, the above discussion suggests that Australia still has a wealth of untapped energy efficiency opportunities. The projection that electricity consumption will increase by 25 percent in the next 10 years (AEMO, 2010) – the same period in which emissions need to start declining – underlines the need for strong action on energy efficiency. However, there are positive indications from the 2010 Prime Minister's Task Group on Energy Efficiency that a more comprehensive and ambitious strategy to improve energy efficiency is on the political agenda.

Peak load management

The main purpose of load management is to reduce the need for additional expensive investment in electricity network and power station capacity to service occasional extreme peaks in electricity demand. In Australia, load management programs have included direct load control, demand response, interruptible loads, load shifting, customer power factor correction, fuel substitution, time-of-use pricing and integrated demand management programs. It should be noted that while not the focus of this section, both energy efficiency and Distributed Generation can also help to reduce peak load, in addition to providing the benefits discussed above.

Network-Driven Load Management

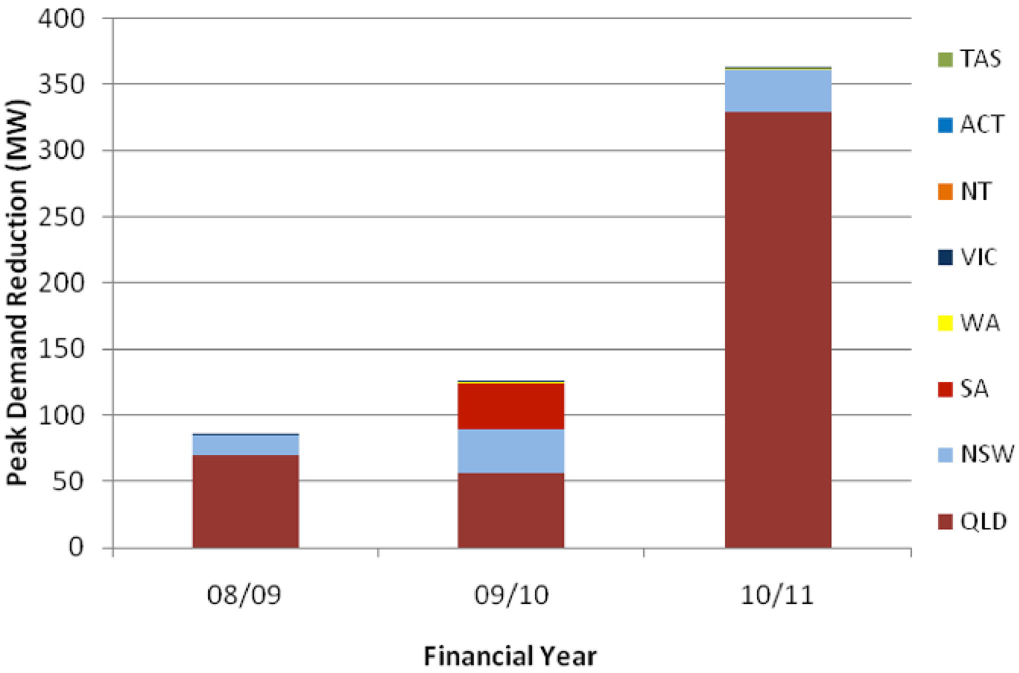
The Institute for Sustainable Futures recently conducted a survey of electricity network businesses' demand management programs in Australia. This survey found that across 19 of the 20 Australian network businesses there are 97 load management programs, spread over a range of initiatives as illustrated in Table 1 (Dunstan et al., 2011b).

Table 1: Number and types of peak load management projects in Australia

Load Management Project Type	No. of Projects
Power factor correction	23
Direct load control, including hot water, air conditioning and pool pumps	17
Stand-by generators for peak demand supply, including cogeneration and diesel	16
Tariff trials, including time of use	10
Load shifting	8
Commercial and residential energy efficiency projects	3
Fuel Switching	1
Mixed projects, where multiple elements are used in a particular location	8
Other	11
Total	**97**

The electricity network-driven load management projects in Table 1 above were reported to have delivered peak demand reductions of 85 MW in 2009–10, and 310 MW in 2010–11. While the 2010–11 load management contribution was a steep increase on the previous years, it amounted to just 0.86% of peak demand of the National Electricity Market (shown in Table 2 and discussed further below). In addition to load management, smaller contributions were also registered from energy efficiency measures (1 MW) and Distributed Generation projects (56 MW). When the total DM contributions (including load management, energy efficiency and Distributed Generation) are broken down by jurisdiction however, it becomes clear that there are significant disparities in where these projects are being implemented (Figure 11). In 2010–11, Queensland accounted for 91% of the reported peak demand reductions, while NSW accounted for 8% of the total.

Figure 11: Reported peak demand reduction by jurisdiction



Source: Dunstan et al, 2011b

Wholesale Electricity Market Driven Load Management

While network businesses are important instigators of load management programs for avoiding network congestion, participants in the wholesale and retail energy market also employ load management to manage peak period price spikes. This use of load management is *generally* distinct from (and additional to) network load management, except in cases where congestion occurs on the network and the wholesale market at the same time and one load management approach obtains credit through both mechanisms. Thus there is likely to be some overlap between these figures.

AEMO reports that the level of demand-side participation (which includes load management) in the NEM was 131 MW of committed resources in 2010, and 588 MW of uncommitted resources (AEMO 2010, p. 70), as shown in Table 2, which translates to between 0.4 and 2.1% of total peak demand, depending how many opportunities were actually contracted. The projection for 2010–11 was slightly down on this figure if all ‘very likely’ and ‘even chance’ demand-side opportunities are included.

Table 2: Electricity peak load management in Australia

Year	**Network** peak load reduction (MW)	**Energy market** peak load reduction (MW-AEMO reported)	NEM Peak Demand (MW)	**Networks** % reduction	**Energy market** % reduction
2010–11	310.1	177 (v. likely) 443 (even chance) 620 (total)	35,927*	0.86%	0.49% 1.23% 1.72%
2009–10	85.1	131 (committed) 588 (uncomm.) 719 (total)	34,451	0.25%	0.38% 1.71% 2.09%
2008–09	50.9	192 (committed) 559 (uncomm.) 751 (total)	35,322	0.14%	0.54% 1.58% 2.12%

** Projection based on medium-growth scenario, 50% POE, in AEMO (2010).*

Source: AEMO, 2010, p. 70; Dunstan et al., 2011b

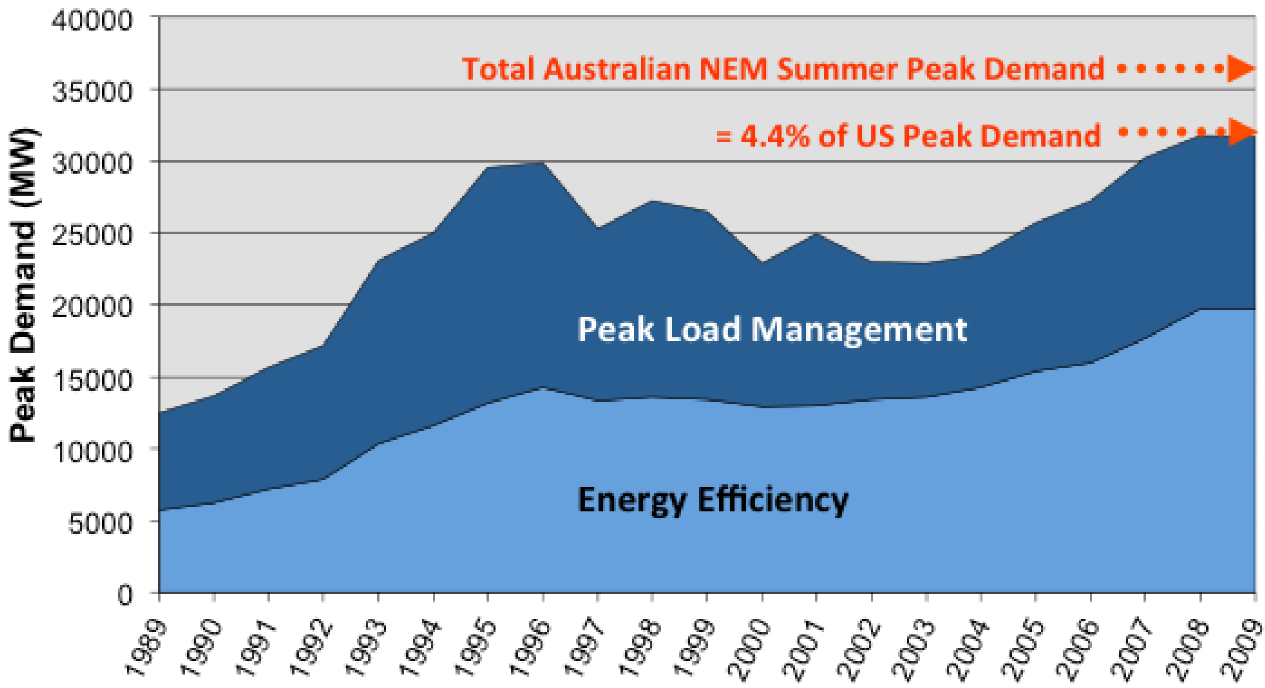
In the South-West Interconnected System (SWIS), Western Australia's main electricity grid, peak demand grew by 1.7% to 3,831 MW between 2009–10 and 2010–11, with load management programs contributing a higher proportion of peak demand than observed in the NEM, with 3.37% or 129 MW (IMO 2011).

International Comparison

Figure 12 below shows the utilisation of Demand Management in the USA, with 31,000 MW of Demand Management in 2009, resulting in peak demand reduction of 4.4% of total demand (US Energy Information Administration, 2011).[3] If the NEM were to have a similar penetration, demand management would contribute over 1,563 MW. In comparison with the figures in Table 2 above, Australia appears to be lagging behind the US in terms of uptake of Demand Management. This would still be a very small penetration relative to the 22,608 MW of peak reduction potential identified in the D-CODE Model (refer to Section 5).

[3] Reporting on DM programs is done in the US by the Energy Information Administration under the US Department of Energy in their Electric Power Annual Report.

Figure 12: Management – actual peak load reductions, 1989-2009



Sources: US Energy Information Administration (2011) and AEMO (2011)

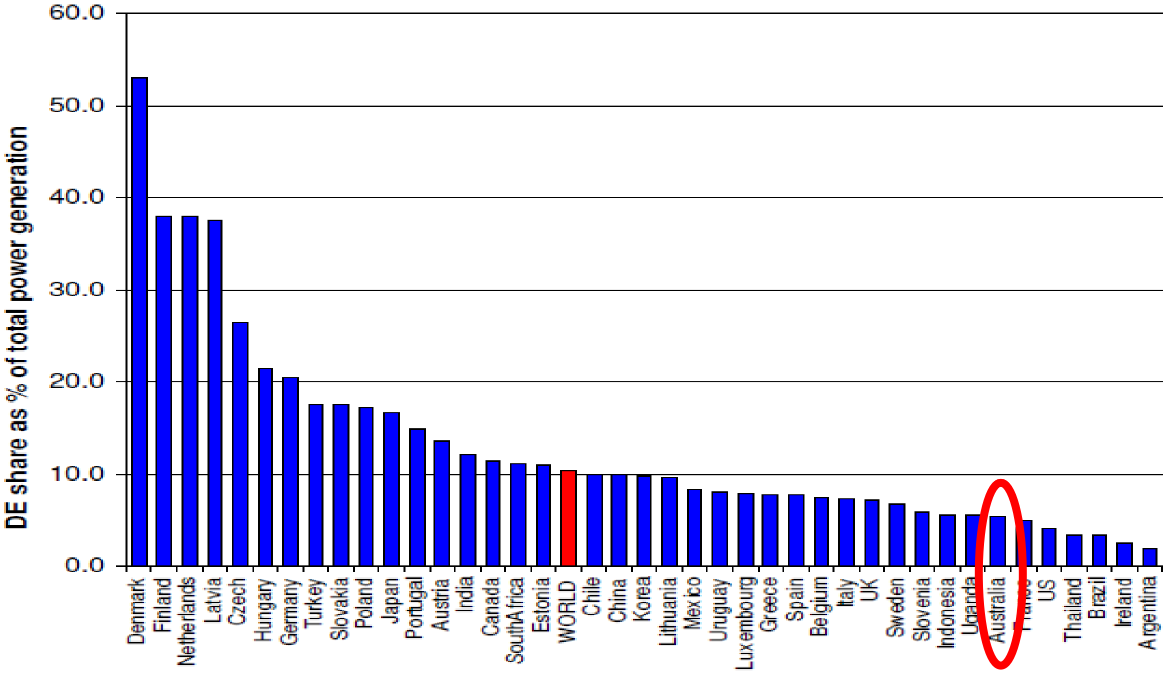
Despite an increased uptake in load management programs, summer peak demand is growing by 3.5% in the NEM or three times the rate of total energy consumption (AEMO, 2010) and by 4.4% in the SWIS (WAIMO, 2010). This increase is the major factor driving $14.9 billion of the more than $45 billion of network capital investment to 2015 (iGrid Working Paper 4.4). Thus there remains significant potential for load management and wider demand management strategies to minimise the need for network investment.

While not every network business surveyed reported the expenditure and cost savings of their load management programs, those that did reported an average expenditure of $34 million a year over three years, or just 0.4% of the annual $9 billion a year being spent on network capital over the five years to 2015 (Dunstan et al., 2011b).

Distributed Generation

Internationally, Distributed Generation (DG) is growing rapidly; between 2002 and 2006, DG accounted for 25% of global new installed electricity generation capacity (WADE, 2006). However, with a continued national focus on centralised fossil fuel energy options, Australia is lagging behind the world average. DG accounts for only 5.4% of Australia's total electricity generation, which is about half of the global average of 11% (Figure 13). Perversely, the lack of action in Australia on DG to date means there is still huge potential for growth in DG.

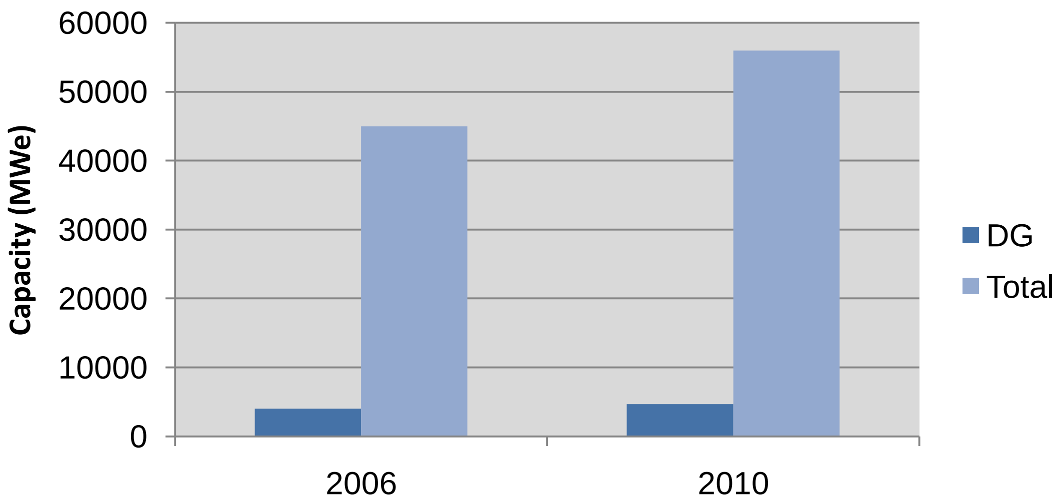
Figure 13: Proportion of total power generation from decentralised generation



Source: WADE, 2006. p. 31

In absolute terms, installed DG capacity has increased in Australia by about 20% between 2006 and 2010 (as shown in Figure 14), however this has not kept pace with the national average increase in installed capacity. Thus in 2006 DG accounted for 9% of Australia's installed capacity but by 2010 this figure had declined to 8.6%.

Figure 14: Australian installed generation capacity: Distributed Generation vs total



Source: IEA, 2010; CEC, 2010; ESAA, 2010, DEWHA, 2010

In this report, Distributed Generation (DG) is defined as including both renewable and non-renewable electricity and heat generating technologies smaller than 30MW. In 2010, renewable powered DG accounted for 1,654 MW, or 2.95% of total Australian installed electricity generation capacity (CEC, 2010; DEWHA, 2010; ESAA, 2010). Table 3 breaks this total down by different renewable fuel types, showing that solar hot water makes the greatest contribution, while the emerging technology of geothermal accounts for the smallest amount, at just 0.1 MW.

Table 3: Decentralised Renewable Energy Capacity 2010

Fuel Type	Installed Capacity (MW)	% of Total Installed Electricity Generation
Solar hot Water	1400.0	
Hydro	398.1	0.71%
Bagasse	420	0.75%
Biomass (mixed)	183.9	0.33%
Landfill gas	164.2	0.29%
Sewage Gas	58	0.1%
Geothermal	0.1	0.00%
Solar	311	0.56%
Marine	0.7	0.00%
Wind	1181.1	0.21%
TOTAL	1654	2.95%

Source: (CEC, 2010; DEWHA, 2010; & ESAA, 2010)[4]

Fossil fuel-based DG at 5.64% of total Australian installed electricity generation capacity, accounts for a larger percentage than renewable DG. In Table 4, fossil fuel-based DG is broken down by plant and fuel type, and by whether or not it is a cogeneration system (where waste heat is utilised for productive purposes). The largest contribution is from gas turbine cogeneration powered by natural gas at 1,106 MW, and the smallest contribution at 0.45 MW from natural gas powered cogeneration fuel cells. It should be noted that while Table 4 includes coal-based DG, these are not advocated by this Roadmap.

[4] Note the installed solar hot water capacity is not included in the total sum as electricity is not generated.

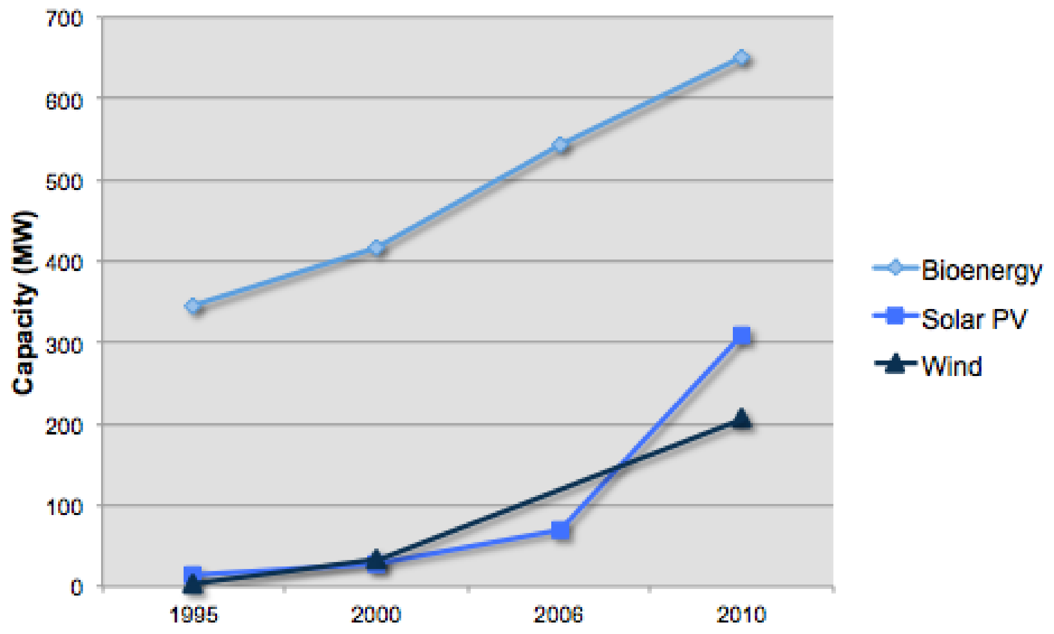
Table 4: Decentralised Non-Renewable Energy Capacity 2010

Plant type	Fuel type	Installed Capacity (MW)			% of Total Installed Electricity Generation
		Cogeneration	Not-cogeneration	TOTAL	
Steam	Black coal	91.7	-	91.7	0.16%
	Coal waste methane	-	6.00	6	0.01%
	Natural gas	191.2	54.50	245.7	0.44%
	Oil products	109	48.00	157	0.28%
	Waste gas	123.75	60.00	183.75	0.33%
Gas turbine	Natural gas	1106.23	249.85	1356.08	2.42%
	Oil products	-	163.30	163.3	0.29%
Combined cycle	Natural gas	76	26.50	102.5	0.18%
	Coal seam methane	33	-	33	0.06%
Reciprocating engine*	Natural gas		242.85	242.85	0.43%
	Oil products		308.86	308.86	0.55%
	Coal seam methane		45.00	45	0.08%
	Coal waste methane		218.80	218.8	0.39%
	LPG		1.49	1.49	0.00%
Fuel cell	Natural gas Co-gen	0.45	-	0.45	0.00%
TOTAL		**1731.33**	**1425.15**	**3156.48**	**5.64%**

Source: ESAA, 2010

One of the key impediments to understanding the status and contribution of DE is the lack of historical data. However, it is possible to map the growth of installed capacity of decentralised bioenergy, wind and solar PV over the past 15 years. Figure 15 shows that in absolute terms bioenergy has seen the greatest growth, increasing from 275 MWe in 1995 to 826 MWe in 2010. Solar PV has seen exponential growth rates in recent years, spurred by strong financial incentives at the federal and state government levels. Small-scale DG wind generation has seen only linear growth, as most growth between 2000 and 2010 has been wind farms that are considerably over the 30MW definition of for DG.

Figure 15: Renewable distributed generation in Australia (1995-2010)



Source: IEA, 2010; CEC, 2010; ESAA, 2010, DEWHA, 2010

3.2 The Australian Decentralised Energy industry

The Australian DE market covers a range of established and emerging actors. Energy retailers and network businesses are starting to develop internal DE teams and associated programs. One example is Ausgrid (formerly the network arm of Energy Australia), which is undertaking a Smart Grid pilot study, funded through the federal Department of Climate Change and Energy Efficiency's Smart Grid Smart City fund. However, the size and influence of these DE departments in existing energy utilities varies. Dunstan, Ghiotto and Ross (2011d) report that the number of full-time equivalent staff working on demand management within electricity network service providers currently ranges from zero to a team of 45. Demand management (DM) is defined as the application of DE for the purposes of managing specific capacity constraints on the electricity network and thus the terms are often used interchangeably in this Roadmap.

Within the DE sector there are also a number of dedicated DE businesses, social enterprises and community organisations. Examples include:

- Energy Response, an independent company dedicated to aggregating DM potential for participants in the Australian electricity markets
- Hepburn Wind, Australia's first community wind cooperative
- Cogent Energy, which builds, operates and owns cogeneration plants for large, typically commercial, energy users
- Energetics, a consultancy specialising in energy efficiency and climate change response for businesses

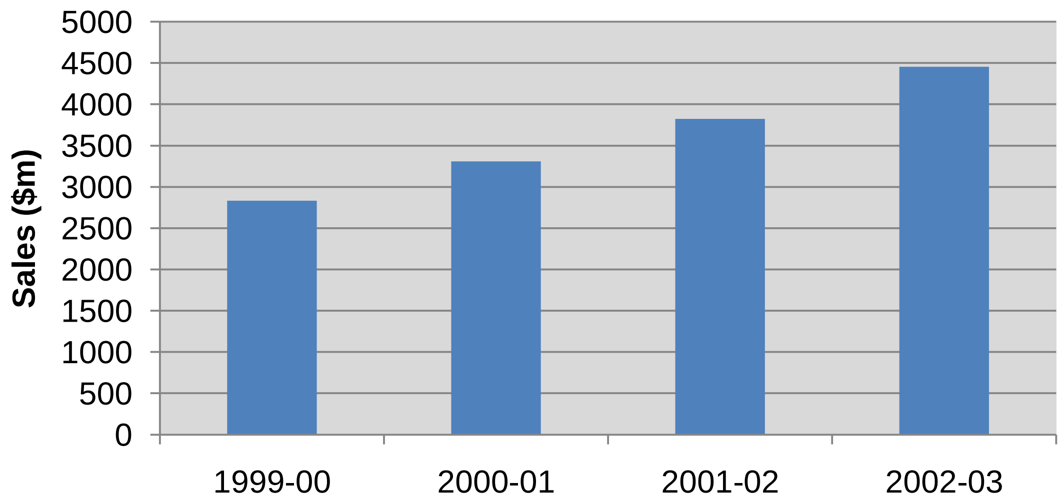
- Moreland Energy Foundation, a not-for-profit organisation that works with the local community to create practical demonstrations of local sustainable energy solutions
- Many hundreds of solar PV installation businesses.

Other organisations are emerging as key actors in the DE space, such as property developers Frasers Property Australia and commercial property trusts such as Investa Property Group. Investa has recently turned on Sydney's first commercial trigeneration precinct at Coca Cola Place in North Sydney, while Frasers are developing a trigeneration system to service their new Central Park commercial and residential mixed-use development. Local councils are also increasingly playing a role in the DE sector. For example, the City of Sydney aims to facilitate the development of 360MWe of trigeneration across the local government area as part of its Green Infrastructure Master Planning process (City of Sydney, 2011).

In the emerging DE sector there is a push towards an 'energy service' orientated business model. This model ties the success of an organisation to the quality of an energy service provided, such as heat or light, rather than to the amount of electricity or gas sold. Underlying this business model is that consumers do not want electricity or gas as such, but rather the services or outcomes that those products provide. Using a services approach, the same supply of a shortfall in energy production, for example, can be achieved through either the reduction of demand through improved energy efficiency, or an increase in supply through a range of means. The end result to the consumer remains unchanged – a reliable supply of energy services. There are, however, many institutional barriers to the widespread adoption of an energy service-based business model, which are discussed in Section 6.

Despite the existence of many examples of DE organisations, very little has been done in the past decade to map the DE market both in terms of actors and economic size. However, in 2002, a survey of 570 sustainable energy organisations found that the sustainable energy sector had annual sales in the order of $4.5 million in 2002–03, as shown in Figure 16, indicating a steady annual growth rate over four years of 16%. More recently, the Clean Energy Council (2010) reported that investment in renewable energy (large and small) for the 2009–10 financial year totalled US$1.8 billion.

Figure 16: Annual direct sales in sustainable energy



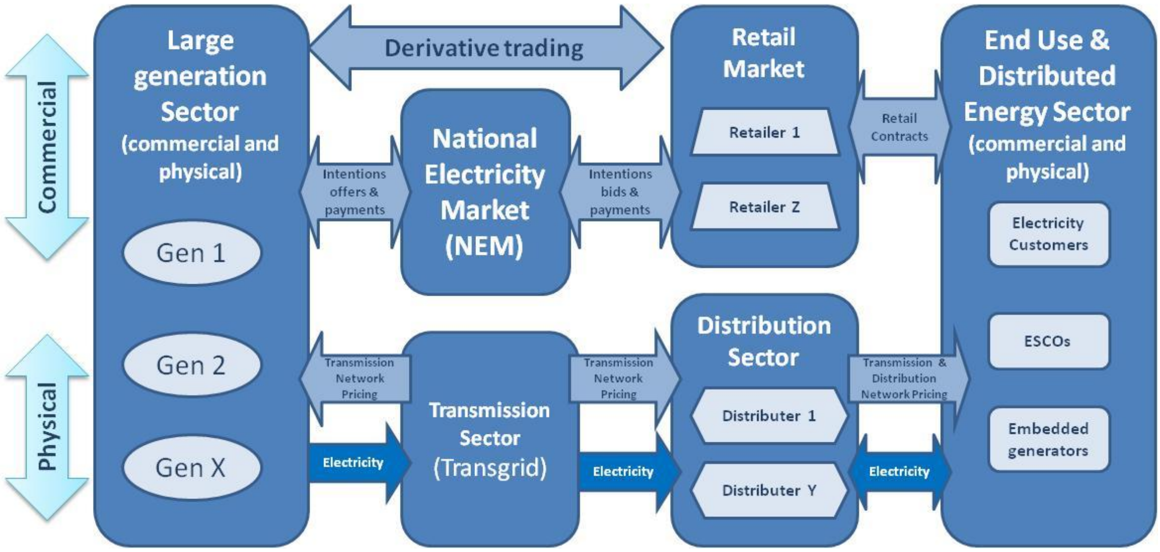
Source: Mark Ellis & Associates (2002, p. 15)

3.3 The Australian electricity system and regulatory context

The Australian electricity sector is made up of three main markets:

- The National Electricity Market (NEM), which covers most of Queensland, New South Wales, Victoria, South Australia and Tasmania;
- The Wholesale Electricity Market (WEM) in the South West Interconnected System (SWIS) of Western Australian; and
- The Darwin and Katherine Interconnected System (DKIS), which services part of the Northern Territory.

Figure 17: Electricity industry structure in the National Electricity Market



Source: modified from Outhred, 2006

These markets operate not only at the physical level, but also at the commercial and policy level. Figure 17 above provides a simplified representation of the key stakeholders, which include large centralised generators, transmission and distribution businesses, retailers and customers. They are connected physically and commercially within the NEM. While this diagram uses the example of the NEM, the SWIS and DKIS are structured similarly.

Figure 18 below outlines the key actors involved in regulating electricity markets. This is a complex regulatory and policy area involving contributions from different areas of regulatory responsibility:

- The Ministerial Council on Energy (MCE), which is a Council of Australian Government body and is made up of the Energy Ministers from the federal government and each state and territory. The MCE is responsible for all regulatory reform including drafting legislation and initial National Electricity Rules (NER) governing the sector.

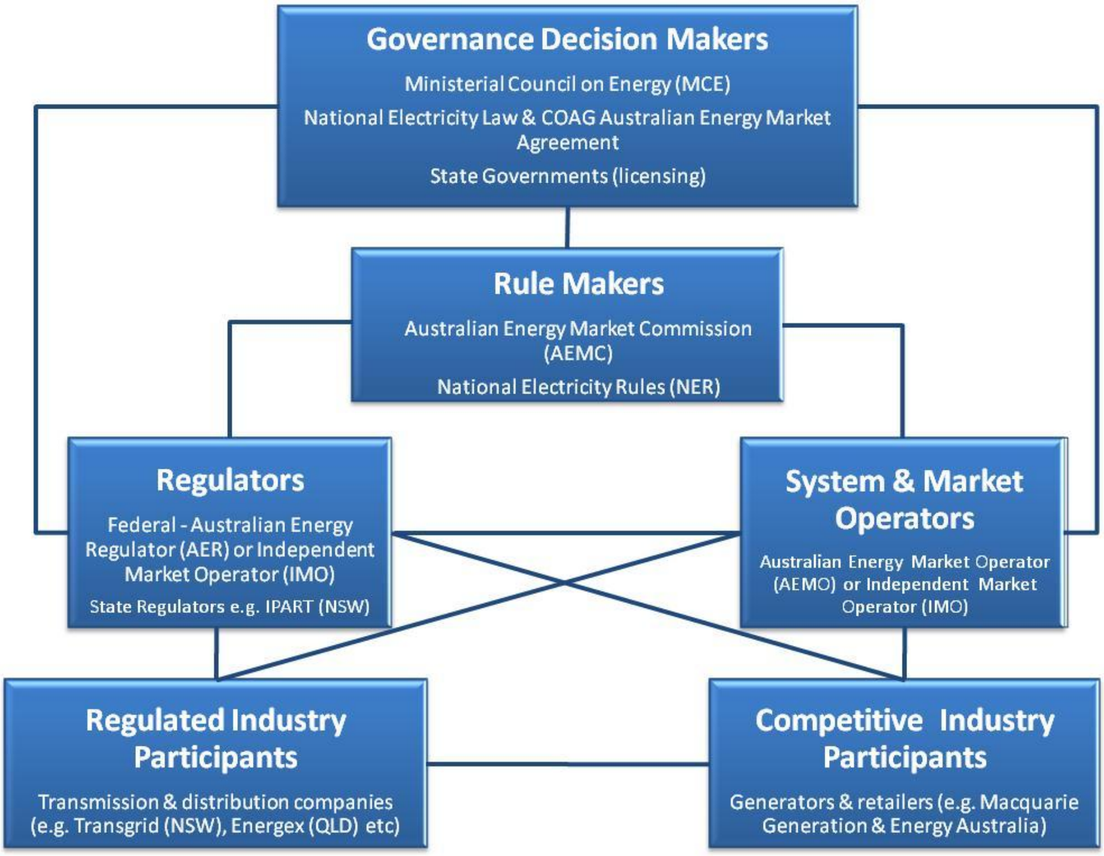
- The Australian Energy Market Commission (AEMC) oversees the NER and manages the progressive NER 'rule change' process, which can be proposed by any person or body.
- The Australian Energy Market Operator (AEMO) manages the operation of the NEM including development and amendment of *procedures* governing market participants, including generator registration. Again, procedural changes can be proposed by any person or body.
- The Australian Energy Regulator (AER) is the economic and market/rules compliance regulator. The AER determines what DNSPs and TNSPs can charge for their services, oversees market participant compliance with the NER, and can issue distribution licensing exemptions to embedded generators in certain cases.
- The Independent Market Operator (IMO) in Western Australia undertakes a similar role to both AEMO and the AER for the Western Australian energy market.
- Retail licensing is currently addressed at the state level, however retail licensing conditions are in the process of being standardised across the NEM under the auspices of the AER.

Detailed discussions of the interacting physical, commercial and regulatory processes of the Australian Electricity system can be found in CSIRO's *Intelligent Grid Report* (2009) the Australian Energy Market Operator website and Centre for Energy and Environmental Markets' website.

Decentralised Energy is located on the right-hand side of Figure 17, in the form of generation "embedded" within the electricity distribution network, energy service companies (ESCos), and energy efficiency and demand management programs that shift customers from passive to active participants in the electricity system. However, players may operate in more than one area, for example, electricity retailers may own and operate DE infrastructure directly or via intermediary operators, and are mandated to be involved in energy efficiency provision through schemes such as the Victorian VEET or the New South Wales EES.

The majority of physical, commercial and regulatory infrastructure has been established to facilitate and operate the three left-hand columns of Figure 17. That is, a physical structure based around centralised generation with a large and one-way electricity grid, connected to passive customers who interact only with energy retailers as power purchasers. As such, there are significant barriers at all levels to the integration and uptake of Decentralised Energy. These are outlined in Section 4 of this roadmap. The AEMC and AEMO have recognised that many of these barriers exist and have undertaken recent reviews and consultations including the Small Generator Design Framework Consultation (AEMO) and the Review of Demand Side Participation in the National Electricity Market (AEMC). However, the degree of change resulting from their reviews has been limited to date.

Figure 18: Decision-making framework of the Australian electricity industry



Source: Modified from Outhred (2006b)

Case Study 2: Electric Vehicles

Battery-powered electric vehicles use an electric motor to drive the vehicle. Power is drawn from electric batteries which can either be the sole power source for the vehicle (standard electric vehicles, or EVs), or may be used in combination with a petrol engine (‘hybrids’, or HEVs). The first large-scale production hybrids on the market, such as the Toyota Prius, do not connect to the electricity grid and recharge batteries only by recovering braking energy. However, some hybrid models are now being produced specifically for grid connection. These are referred to as plug-in hybrid electric vehicles (PHEVs) (IEA, 2011). PHEVs and EVs can either allow one-way (charging only) or two-way (charging and energy flow to grid), as in the prototype vehicle shown below).

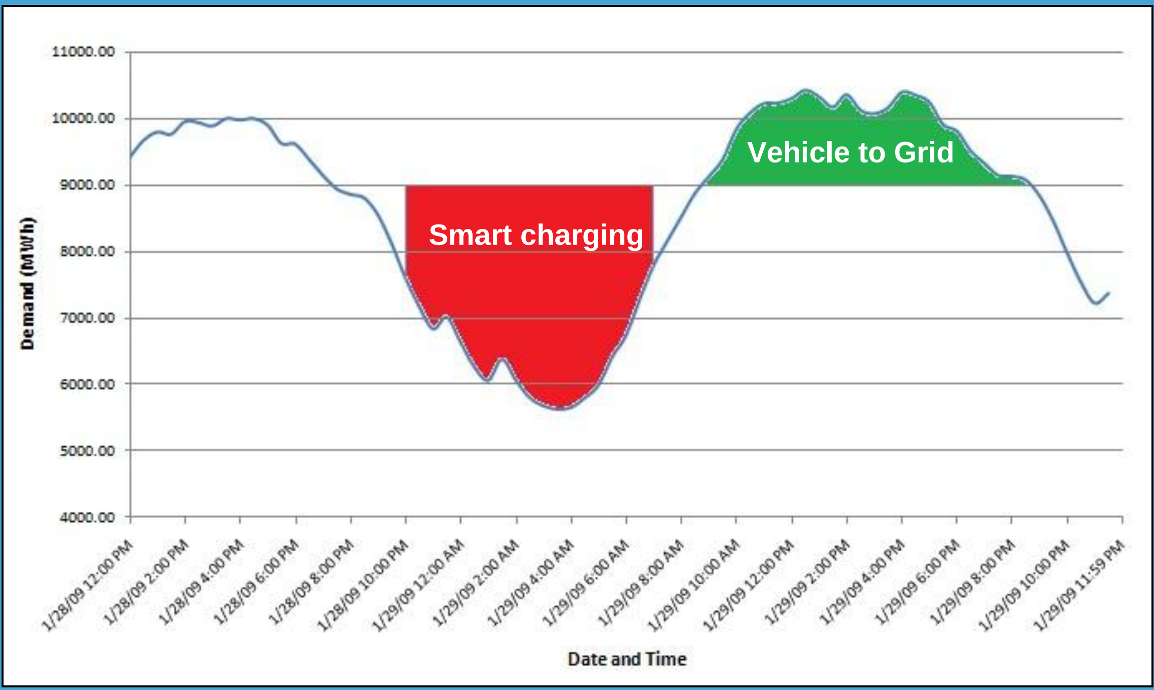
Figure 19: Vehicle-to-grid capable plug-in hybrid electric vehicle converted by UTS

EVs offer substantial environmental and other societal benefits – if charged with renewable energy from the electricity grid (for example using 100% GreenPower) they offer zero operational greenhouse emissions and air pollutants, in addition to low noise. Even when charged using grid electricity with the Australian average grid emissions intensity, the high efficiency of the electric motors means that the greenhouse gas emission are still reduced (Simpson, 2009). The main constraint of current EV technology is the reliance on batteries, which have very low energy and power densities relative to liquid fuels (IEA, 2011) – this makes them heavy for the necessary power output and places constraints on the possible driving range practically feasible in a passenger vehicle.

EVs as a Decentralised Energy Resource

EVs have the potential to provide as well as consume resources. Over 44 different electric vehicle models are currently, or will soon be, in production worldwide with some models already available in Australia (Usher et al., 2010). While EVs require electricity to run, owners can be incentivised to adjust the time at which they charge or even allow energy to be returned to the grid from the vehicle’s batteries. Using an EV as Decentralised Energy resource – by allowing discharge of power from EVs into the grid – would involve the creation of a tariff structure that would incentivise owners to charge their vehicles in non-peak periods, and discharge when connected during peak periods. Thus while electricity consumption will increase with EVs, with significant market penetration they could provide a major benefit in levelling demand on both the distribution and transmission systems. More advanced contractual arrangements could also encourage owners to allow the network to control their chargers during certain times of the day or year. This would allow a network to reduce the charging rate at peak times during a very hot day when the distribution system was under stress, as indicated by load shifting from green to red in the figure below. To maximise the use of EVs as a DE resource, an inverter could be coupled with the vehicle either on-board or in a home or office building to dynamically control the two-way flow of energy between the vehicle and the grid.

Figure 20: Load levelling via EV smart charging and Vehicle to Grid discharging



Source: *Usher et al. 2010, p. 60*

EVs are at the early stages of production and still relatively expensive compared to their petrol counterparts (Usher et al., 2010), but costs are expected to decline rapidly – a study undertaken for the NSW Government assumed that PHEVs would reach price parity with combustion engine vehicles by 2020, while PHEVs and EVs would reach price parity by 2030 (AECOM, 2009). While capital costs are higher than for combustion engine vehicles, the operational costs per kilometre are around 70% lower, at 2010 NSW electricity prices (AECOM, 2009, p. 48).

Curtin University estimates that a fleet of one million EVs in Australia (about 6% of Australia's current motor vehicle fleet) would reduce national greenhouse gas emissions by 0.9 MtCO2-e per annum when recharged from the national grid, or 3.8 MtCO2-e when recharged with 100% GreenPower (Simpson, 2009). They also suggest that the distributed batteries in the same one million EVs would facilitate an additional 45,000 GWh of intermittent renewable energy technology such as wind and solar power, resulting in eleven times the reduction in greenhouse gas emissions from the just the vehicles on their own.

4 THE BENEFITS OF DECENTRALISED ENERGY

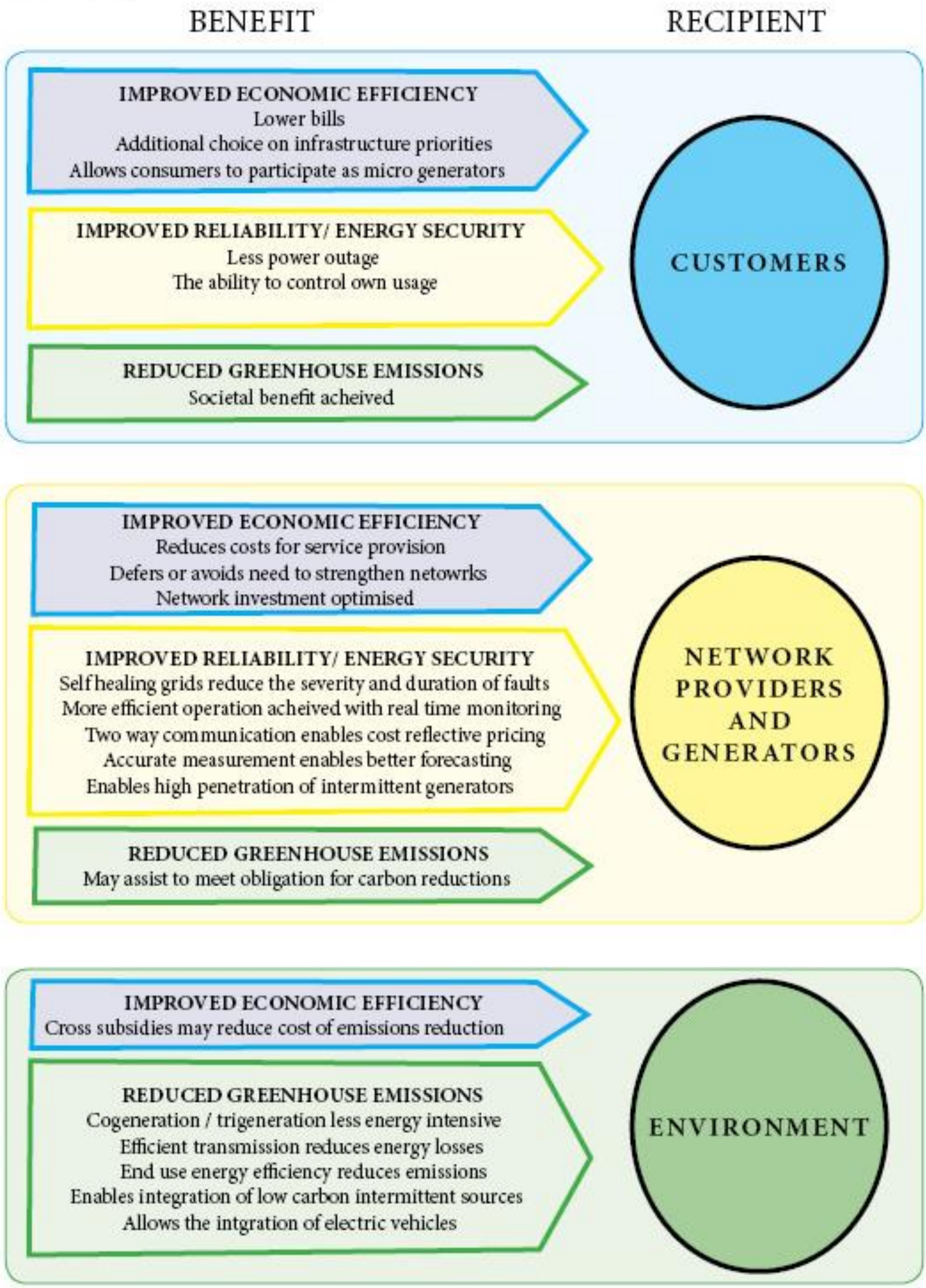
Key Points:

- Benefits of DE include:
    - Affordability – delivering electricity services at lower cost to consumers than traditional centralised supply. Avoidable network costs are key to this equation
    - Sustainability – reduced greenhouse gas emissions from electricity services
    - Security and reliability from diversified supply base and more dynamic demand-side participation
- These benefits accrue – often unevenly – to energy consumers, energy supply companies and the environment (broader society)
- The Dynamic Avoidable Network Cost Evaluation (DANCE) Model developed under this research program can be used as a communication tool to identify opportunities in space and time to alleviate network constraints using DE.

Decentralised Energy in the context of an Intelligent Grid has the potential to provide energy consumers, utilities and the environment with a range of benefits in terms of **affordability** (from improved economic efficiency), **sustainability** (lower greenhouse gas emissions), and **energy security and reliability**. These three major benefit categories accrue to key stakeholders in different ways, as shown in Figure 21 below. Each benefit is then explained in further detail.

- Lower greenhouse gas emissions, because of:
    - an overall increase in fuel efficiency
    - the potential for higher penetration of low carbon renewable energy sources
    - the potential for integration of electric vehicles.
- Improved reliability of electricity supply, with improved energy security, because of:
    - “self-healing grids” via improved monitoring and communications, and automation of fault detection resulting in faster restoration of power outages
    - network benefits such as voltage support and reduced reactive power losses
    - improved system ancillary services, such as black start capability and spinning reserves.

Figure 21: Benefits and beneficiaries of an Intelligent Grid



4.1 Improved economic efficiency

The strategic deployment of cost-effective Decentralised Energy options has the potential to result in better economic efficiency, and thus lower overall cost of energy services, due to:

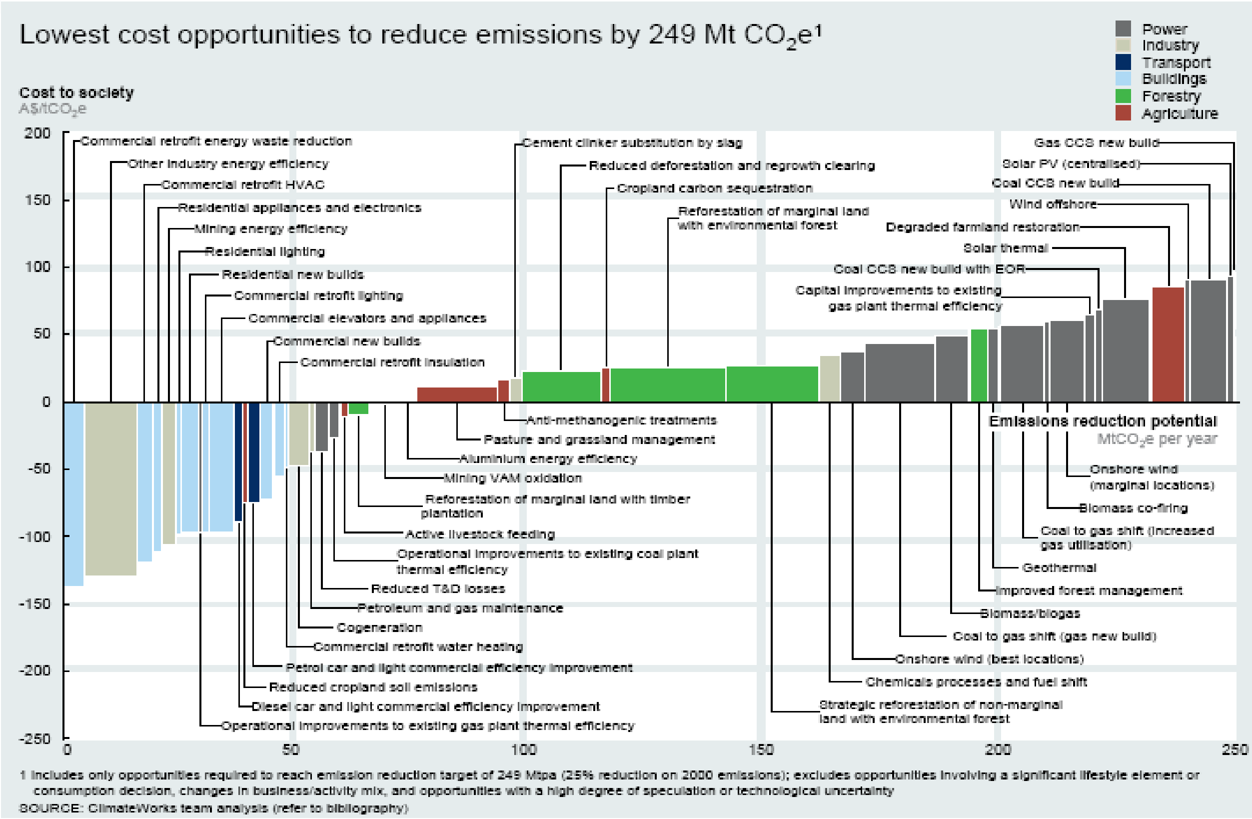
- **unlocking cost-effective alternatives** to business-as-usual modes of energy service delivery
- **reduced peak load** and peak load growth resulting in reduced and optimised network investment
- **two-way communication** with customers enabling cost sensitive pricing and active energy management, including remote switching of customer loads to manage peak demands.

Unlocking cost-effective opportunities

The integration of DE technologies in a smarter electricity grid provides a way to deliver a flexible energy supply cost effectively. A number of studies have explored the potential for cost-effective deployment of Decentralised Energy, however a number of barriers impede this deployment. One such study by McKinsey and Company (2007) found that 'almost 40 percent of emissions abatement could be achieved at "negative" marginal costs', meaning that investing in these options would generate positive economic returns over their lifecycle. A similar study undertaken by ClimateWorks Australia (2010) concluded that 71 million tonnes of abatement (almost a third of the abatement needed to achieve a 25% reduction in Australia's 2000 emissions by 2020) could be achieved with a positive economic benefit to society of $77 per tonne. More than 70% of these "negative cost" options – those options beneath zero on the y-axis in Figure 22 below – are Decentralised Energy resources. This could equate to a net societal benefit of at least $3.8 billion from implementing DE options (ClimateWorks Australia 2010, pp. 48, 63, 64).[5]

[5] Industrial efficiency contributes 17 Mt at a benefit of $100 per ton by 2020, cogeneration 5 Mt at a benefit of $63 per ton, and energy efficiency in buildings contributes 28 Mt, at a benefit of $99 per ton.

Figure 22: Greenhouse gas emission reduction potential

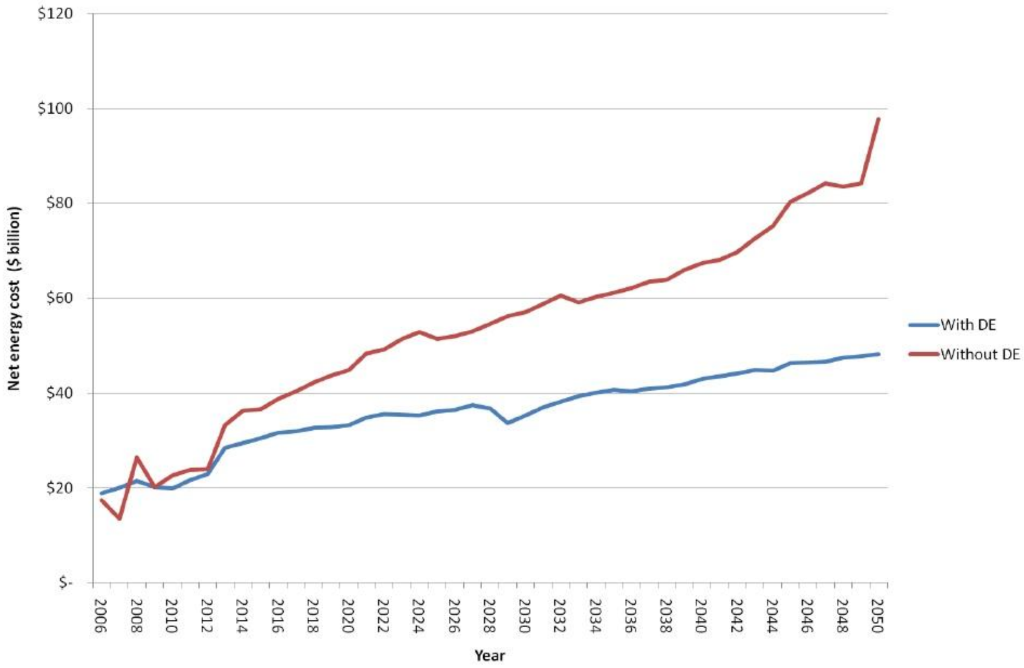


Source: ClimateWorks 2010, p.10

Modelling of the National Electricity Market (NEM) under the CSIRO Energy Transformed Flagship calculated the undiscounted value of DE over the period from 2006 to 2050 to be $800 billion, or approximately 85% of Australia's 2009 Gross Domestic Product. Figure 23 compares the energy costs over this period with and without DE (Lilley et al., 2009).

The cost effectiveness of DE options lies in a range of factors that are specific to each technology. Some technologies increase fuel efficiency, for example through the utilisation of waste heat (e.g. cogeneration), while others reduce material inputs, through increased energy efficiency and renewable Distributed Generation, while all DE technologies eliminate electrical transmission losses due to their location within the distribution grid close to the point of consumption. Currently, transmission and distribution losses equate to a loss of at least $4.5 billion nationally (Thomas, 2010, p. 24). All DE technologies also carry the potential to reduce capital-intensive investment in electricity transmission and distribution network upgrades, which is covered in the next sub-section.

Figure 23: Comparison of energy costs with and without DE



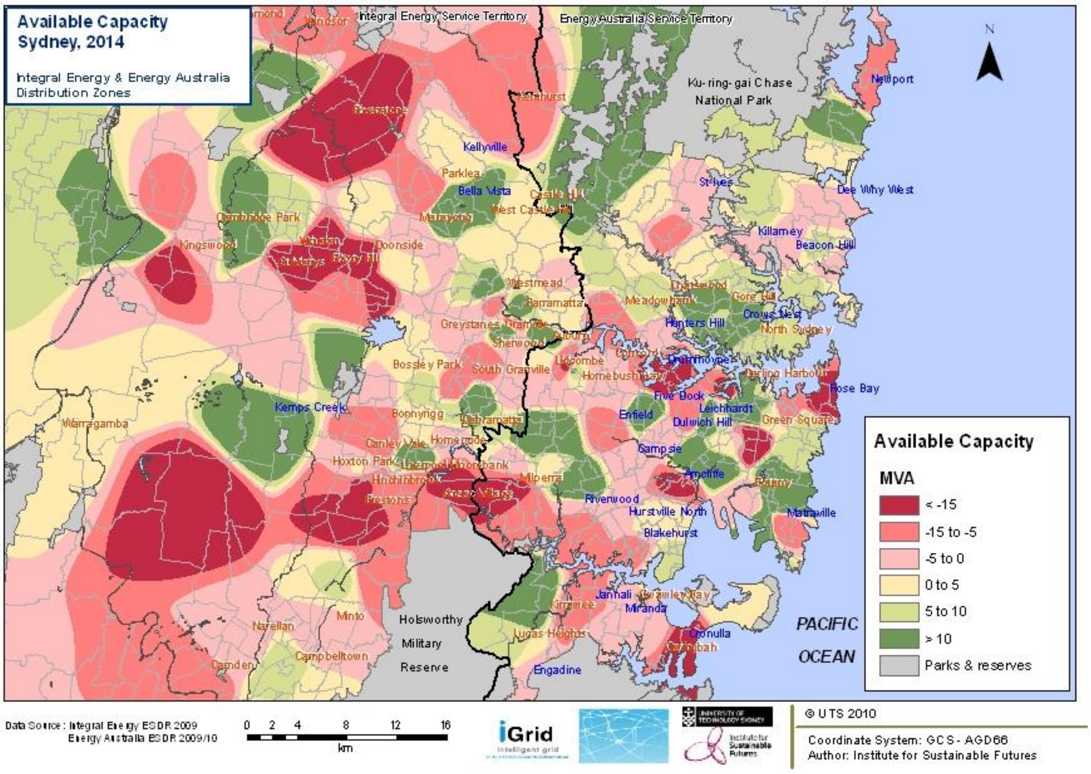
Source: Lilley et al. (2009)

Avoided network infrastructure costs

As outlined Section 1, DE reduces the requirement to augment capacity in the transmission and distribution system because the energy source is situated close to where it is needed. This is particularly important in the current environment of unprecedented projected electricity network expenditure, with almost $15 billion – or $3 billion per year – of growth-related investment to be spent around Australia to 2015. It has been estimated that energy efficiency measures in residential, commercial and industrial buildings alone could unlock savings in network infrastructure of between $1.6 and $2.2 billion per annum in 2020 (Langham et al., 2010).

While there are huge opportunities for economic efficiencies to be gained through the deferral of network infrastructure, these opportunities are “hidden” within a complex electrical network and vary greatly in value according to both time and location. This is illustrated in Figure 24 below, which shows the spare capacity available at different Sydney zone substations in 2014. The green and yellow colours indicate distribution zones that will have sufficient spare capacity in 2014, while the pink and red colours indicate distribution zones facing growth-related constraints where investment will be needed to ensure reliability is maintained. These constraints occur progressively between 2009 and 2014.

Figure 24: Available distribution network capacity in 2014 before augmentation

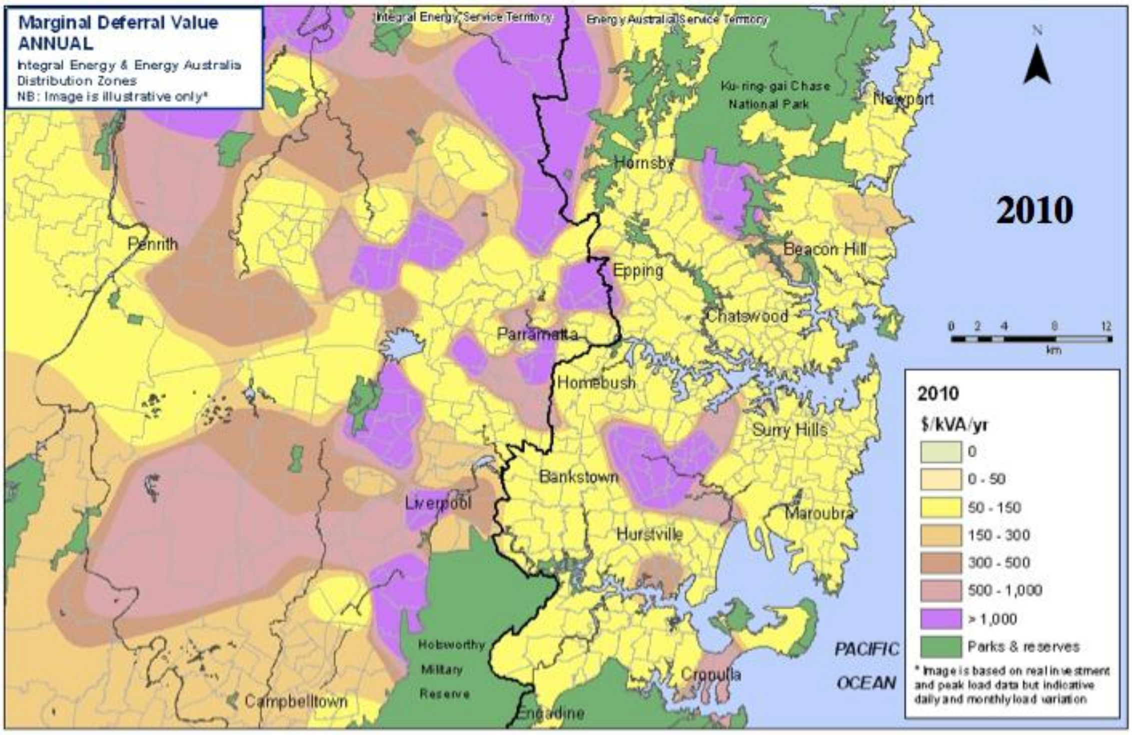


Source: Working Paper 4.4 (Langham et al, 2011a)

To determine the cost below which DM can be applied cost-effectively (or “efficiently” in regulatory terms), it is necessary to calculate the “annual deferral value”. This represents the amount of money that the network business would save on an annual basis if it did not need to implement the preferred business-as-usual network solution to a capacity constraint. This can be used as a proxy for the maximum value that society should be willing to pay for the implementation of DM if the same reliability and service criteria are met.

The calculation of ‘annual deferral value’ considers both the capital expenditure on network augmentation and the annual rate of growth being serviced by the proposed capacity addition. The annual deferral value is estimated at around 10% of the capital investment cost, after factoring in the Weighted Average Cost of Capital (WACC) and the avoided depreciation. Similarly to the network capacity constraints, investment cost and demand growth rates vary dramatically over time and space, which results in some geographical areas having zero or very low deferral values, while others are over $1000 per kVA per year, as shown in Figure 25.

Figure 25: Network investment deferral value, Sydney 2010



Source: Working Paper 4.4 (Langham et al 2011a)

4.2 Reduced emissions

Environmental benefits accrue from reduced greenhouse gas emissions from the utilisation of Decentralised Energy options in the context of an Intelligent Grid through three main mechanisms:

- direct emissions reductions
- making carbon reduction more cost effective
- enabling renewable technologies.

Direct emissions reductions

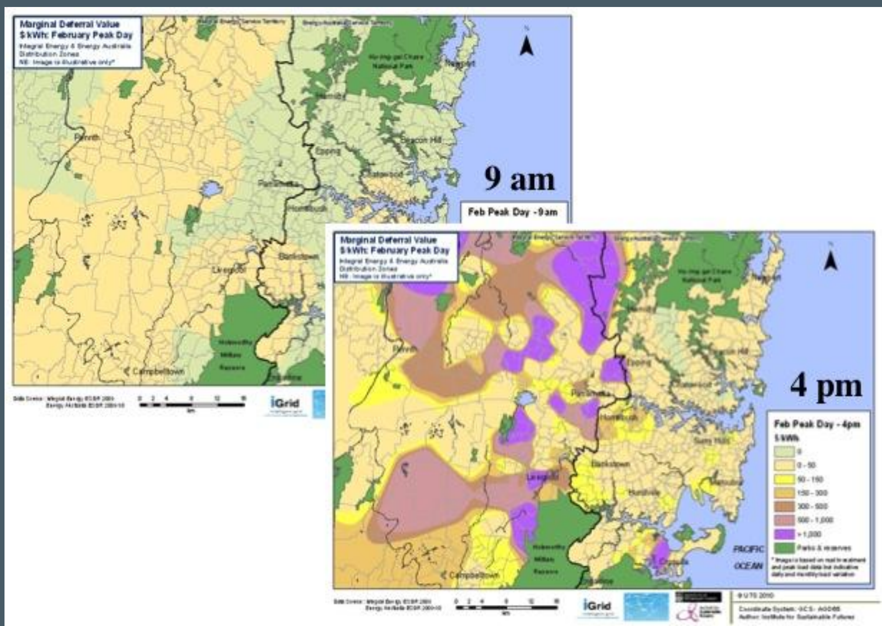
DE options reduce emissions directly through the displacement of more emissions intensive grid-based power with local low-emission decentralised renewable or low carbon energy generation, or through energy efficiency. As noted by the Electric Power Research Institute, reducing energy consumption by using energy more efficiently will reduce emissions through 'not only the load that it directly reduces, but also the new generation that it defers, buying time for incrementally cleaner and more efficient generation to come on-line' (EPRI, 2007, p. 3-2).

Technologies such as gas-fired cogeneration or trigeneration (also known as combined heat and power - CHP) deliver emissions reductions not only through the use of a less carbon intensive fuel than coal, but also greatly increase fuel use efficiency as the 'waste heat' from electricity generation is used for meeting heating and/or cooling loads (Engle, 2006). Depending on the size and efficiency of cogeneration units, generation may result in primary energy fuel efficiencies of

The Dynamic Avoidable Network Cost Evaluation (DANCE) Model

The DANCE Model was created as part of the Project 4 Intelligent Grid research program to assist in providing accessible information on the timing and location of electricity network constraints and to communicate better to a wide range of stakeholders information about where DE can be applied most efficiently. It is intended that DANCE will assist distribution network businesses by increasing the level of analysis currently undertaken with existing planning tools for the assessment of non-network options. Through powerful interactive visual outputs, DANCE aims to make this information accessible to policy makers needing to understand the dynamics of how DM can contribute to beneficial economic and environmental outcomes, and to DE service providers who need to know in advance the geographical areas in which they should be looking to develop projects in order to achieve the greatest benefit from their products.

Figure 26: Marginal deferral value at specific times on the summer peak day



The primary mapping outputs from DANCE include images showing the location and magnitude of network capacity constraints (Figure 24), and the marginal value that this could represent for Decentralised Energy across a given year, month or hour of the peak day (Figure 25). Areas in Figure 26 with in pale green or buff are those with limited to no deferral value, while marginal deferral value increases strongly towards the brown and purple categories. Figure 25 demonstrates that even in constrained zones with lower deferral value, we are seeing figures of $300 per kWh: 1500 times the $0.20/kWh value that a typical residential customer on a flat tariff is actually paying for power at that time. This demonstrates the inability of even current time-of-use tariffs (at $0.40) to pass on an adequate pricing signal to consumers to steeply reduce demand. As it is not practically and politically viable to implement fully cost-reflective pricing at the values shown in Figure 25, it is important that if efficient DM options are to be realised, non-network solutions that reduce peak demand be recompensed up to the extent that tariffs are not cost-reflective. This is the key to value of the DANCE model to efficient network planning and to the DE industry. See Working Paper 4.4 (Langham et al. 2011) for more information.

more than 70 percent (Lilley, Szatow et al., 2009, p. 95), compared to the 35–45 percent efficiency achieved in conventional centralised fossil fuel generation. Evaluating the efficiency of trigeneration is more complex, as this will depend on the cooling strategy used to turn waste heat into space cooling (Lilley, Szatow et al., 2009, p. 95), however, it is generally accepted that cogeneration and trigeneration units have fuel use efficiency of 60 percent or greater.

Furthermore, as DE is inherently decentralised or localised, it eliminates transmission losses and many distribution losses from electricity otherwise sourced from distant generation plants (Engle 2006; OFGEM 2007; US Department of Energy 2007). The current estimate for distribution losses in Australia is 5.1 percent of sent out energy (ESAA, 2009, p. 28) so there is potential for significant carbon savings.

Reducing total energy consumption through smart metering which empowers consumers to better manage demand will also lead to a reduction in emissions from fossil fuel power plants, thus benefiting the environment. EPRI (2007) suggests that reducing inefficiencies in the existing power grid alone and Smart Grid-enabled electrical distribution could reduce electrical energy consumption by 5 to 10 percent and carbon dioxide emissions by 13 to 25 percent.

Making carbon reduction cost effective

Not all forms of Decentralised Energy reduce emissions. For example, load shifting can achieve considerable economic savings through avoided network costs, but generally does not reduce electricity consumption, and can in some situations increase emissions by shifting demand into off-peak periods when more carbon intensive forms of generation are operating. However, Decentralised Energy deployment is most effectively undertaken as an integrated package, with the substantial economic savings achieved through the avoidance of network infrastructure, or energy purchases at peak times can be used to unlock more low carbon opportunities that are further along the cost curve. For example, low or negative cost options, below zero on the y-axis of a cost curve such as Figure 22 (see left-hand side of figure), can effectively pay for other low or moderate cost low emissions options further to the right of the cost curve. Note that if DE options were progressively deployed from left to right in Figure 22, the total cost is less than zero until the area of the rectangles beneath zero on the left-hand side equals the area of the rectangles above zero on the right hand side – this is known as the 'break even point'.

An investigation of the lowest-cost DE opportunities for Australia to meet energy and peak capacity shortfalls over the next ten years conducted as part of this research found that the lowest-cost optimisation would yield 10.4 Mt per annum of carbon savings, but at a cost of $2.9 billion per annum *less* than the business-as-usual centralised supply approach. If 7000 MW existing coal-fired generation was retired at the end of its planned lifetime to make room for more DE options, emissions reductions of 35.8Mt per annum could be achieved at an annual cost five percent lower than the business-as-usual approach (for more detail on these scenarios see Section 5.5). The end result is that addressing energy sector constraints more cheaply improves societal capacity to tap larger volumes of emissions reductions.

Enabling renewable technologies

In 2010 only 8.7 percent of Australia's total electrical power was generated from renewable sources with the remaining 91.3 percent generated from coal or gas (Clean Energy Council, 2010). Australia's federal Renewable Energy Target (RET), however, requires utilities to increase the amount of renewable energy sources on their system. The current renewable energy target set by the Federal Government is for 20 percent of electricity to be sourced from renewable energy by 2020. From the beginning of 2011 this is divided into a Large-scale Renewable Energy Target (41,000 GWh by 2020) and a Small-scale Renewable Scheme, which includes solar PV, small wind systems, and solar water heating and is expected to result in the equivalent of 11,000 GWh of small-scale renewable supply or generation avoided through the installation of solar water heaters (MMA, 2010).

The Large-scale Renewable Energy Target will generally result in generation that connects to the transmission network, and so does not fall within the definition of Decentralised Energy. Nonetheless, critical to the deep penetration of both small and large scales of variable renewable energy generation sources will be the ability to integrate and adaptively manage this output in a stable and reliable environment. Intelligent Grids have a vital role to play in this integration process, dynamically matching an increasingly diverse and less predictable supply with customer demand that also becomes more flexible as smart appliances and peak pricing come online (Horgan & Dunstan, 2010).

While nationally Australia is still well short of the variable renewable energy penetration levels that warrant grid integration concerns, there are some network areas this could in future become a limiting factor without rapid development of intelligent grids. One potential early candidate for such concerns is South Australia, which by 2009 had installed wind farms with capacity equal to 20 percent of total electricity generation capacity in the state (AGL, WWF et al., 2006, p. 56). As the European Wind Energy Association notes:

> *In the absence of sufficient intelligent and well managed power exchange between regions or countries, a combination of (non-manageable) system demands and production may result in situations where wind generation has to be constrained*
> European Wind Energy Association (2005, p. 35)

While there is not yet evidence of a firm technical upper limit of variable renewable power penetration (Electricity Supply Industry Planning Council, 2005, p. vi), the development of appropriate control systems, including the ability to control demand, will be required if Australia is to fully tap the emissions reduction benefits of variable renewable generators. In this way, establishing an electricity system that can respond to variations in network and generation capacity equally through the utilisation of supply- or demand-side opportunities will increase the potential penetration of carbon neutral renewable power. This is at the heart of the operation of a strong Decentralised Energy sector.

4.3 Reliability and security of supply

DG technologies enhance energy security by reducing the vulnerability of key energy infrastructure to a variety of natural and human threats as well as fuel supply disruptions and infrastructure failure. The current centralised electricity paradigm is particularly vulnerable to interruptions from extreme weather incidents which can cause major supply shortages or damage critical infrastructure (WADE, 2007, p. 5; US Department of Energy, 2007). A strongly decentralised model of electricity generation limits the impacts and reach of infrastructure failures. Diversifying fuel inputs also lowers the vulnerability to rising fuel prices or fuel supply shortages (Lovins, 2002). A dynamic DE market with supply-side and strong demand-side participation – enabled by two-way communication with the customer, with appropriate cost reflective pricing signals allowing distributed generators and demand-side participants to respond to price signals, and direct communication with appliances to automatically reduce or limit consumption during peak periods[6] – gives networks access to a greater number of options to assist in meeting constraints (Engle 2006). The aggregation of data surrounding consumer usage also facilitates more accurate energy and peak demand forecasting, allowing better-targeted investment in load management and network enhancement (van Gerwen et al. 2006, p.9).

DE can improve power quality and reliability by generating power from a diverse range of sources. Power quality can be improved as DE can assist with the provision of ancillary services, including reactive power (Saha et al., 2011). Distributed Generation sited close to demand can provide 'black start capability and spinning reserves' whilst 'micro-turbines, turbines, and internal combustion engine generators can provide voltage support and reduce reactive power losses'(NRECA 2007). Supporting Intelligent Grid architecture can coordinate available DE resources using a comprehensive monitoring, communications and control network. This would enable the grid to effectively become "self healing" by anticipating and instantly responding to system loads or faults, and by avoiding or mitigating power outages and system damage (Microplanet 2010). Advanced metering and control systems such as smart sensors enable rapid fault diagnosis and response, which assists in minimising the duration of blackouts.

However these benefits of DE also pose integration challenges to present day networks. The two-way energy flow of households with solar PV installations can cause problems for existing local distribution network infrastructure which was originally designed to only handle one-way energy flows. For example, the current practice of shutting down solar systems during an "upstream" supply interruption must be addressed, especially where sufficient PV generation capacity exists. Nonetheless, a well-designed Intelligent Grid can achieve integration through the use of new protection and control strategies such as those proposed by Project 3 of the Intelligent Grid Research Cluster (Queensland University of Technology and Curtin University of Technology, 2011), and can potentially improve distribution automation if micro-grid operation is allowed.[7]

4.4 Social benefits

The localised nature of DE lends itself to potential ownership by end-users in community energy projects. These projects have numerous socio-economic benefits such as providing development mechanisms, increased technology acceptability and providing more opportunities for investors. Community energy projects assist regional economic development and diversification of rural income streams by enabling the employment of local contractors, by providing economic returns to local investors and by ensuring that more wealth stays within the community. Community energy projects entail a high degree of participation, accountability, and/or ownership, which helps members grow their skills, confidence and social capital (Wise et al., 2011; Walker & Devine-Wright, 2008). This direct emotional and/or financial stake in the energy projects raises community acceptance of more controversial technologies such as wind power. They are typically scaled to meet a community's energy needs, which often results in projects producing between 10 kW and 5 MW. DE can help to provide cost-effective energy services to isolated communities where a centralised supply would be cost prohibitive. Across Europe and North America, community energy projects number in the thousands and have played a critical role in the development of the Danish,

[6] For example, domestic air conditioners can be remotely cycled by the network operator, achieving a peak load reduction of approximately 1 kW per household, with very little noticeable effect to the customer (Effeney, 2009).
[7] For more information on microgrids see: Ghosh & Dewadasa (2011).

German and Scottish renewable energy and DE sectors.

The use of smart meters and demand-side response provides opportunities for greater end-user engagement and assists consumers to better understand, monitor and control how energy is used in their homes. In a smart meter roll out in NSW, 72 percent of Energy Australia customers “were actively making changes to their electricity usage” (ENA CEO Message April 2010). Where dynamic time-of-use (TOU) energy pricing is used, consumers that are able to shift part of their energy demand to off-peak times can save money by reducing peak demand, thereby reducing overall system costs and consumer bills. According to the Energy Networks Association (ENA), around 200,000 NSW homes and businesses are using smart meters that have TOU pricing in the Energy Australia network. Around 76 percent of customers believed they were paying less for their electricity costs compared to traditional meter rates and 71 percent of customers thought that that TOU pricing is a fairer system (ENA CEO Message April 2010). There are, however, valid equity concerns for vulnerable consumer groups that are unable to shift peak demand, resulting in unavoidably higher costs, which need to be carefully considered. It is for this reason that Intelligent Grids must be developed with social considerations in mind. Methods of addressing such concerns could include a targeted program of energy efficiency, which could significantly ease the cost burden on disadvantaged consumers, as low-income households generally have less energy efficient housing and appliances and have limited access to capital to upgrade (Sachdeva & Wallis 2010).

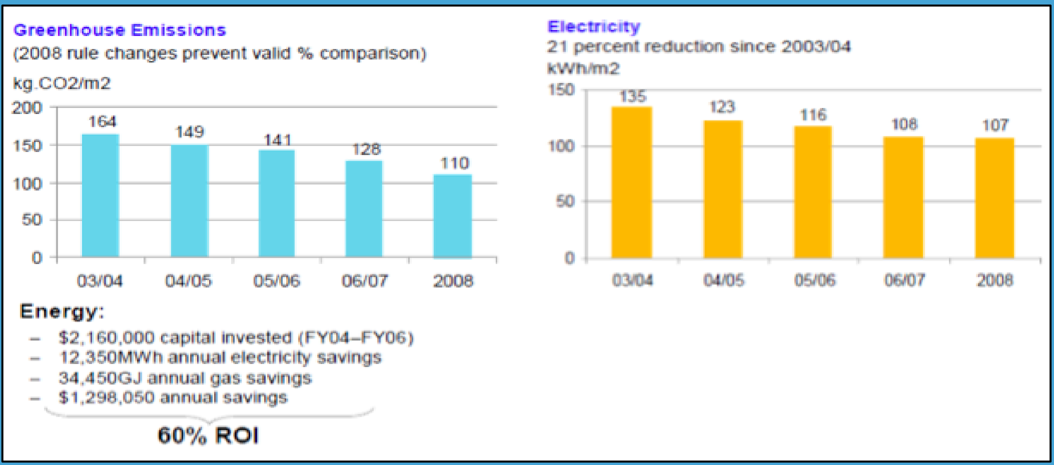
Case Study 3: Commercial Energy Efficiency

Energy efficiency represents a huge opportunity to reduce peak demand, energy costs and greenhouse gas emissions. Many programs and rating tools such as NABERS and Green Star guide the construction of buildings toward greater energy and water efficiencies. However, the majority of existing buildings require a retrofit of low energy equipment, control systems and initiatives to improve thermal performance to reduce their energy consumption. According to ClimateWorks (2010), a major retrofit of commercial buildings in Australia over the next decade could cut building emissions by 30 percent, save $1.4 billion and create 27,000 new jobs annually.

INVESTA PROPERTY GROUP

In 2005, Investa launched the 'Greenhouse Guarantee' which focuses on reducing energy consumption through energy efficiency measures, resulting in reduced operating expenses for tenants. Results from Investa modelling showed that moving from a 0-star to a 5-star rated building can reduce energy bills from $21/m2 to $8/m2 annually (Investa 2007). The new Property Council of Australia/IPD Green Property Investment Index also confirms that star-rated buildings outperform non-rated buildings, with the strongest returns for investors observed in 4-star rated assets (Property Council, 2011). As shown Figure 27, annual electricity use in Investa properties has been reduced by 12,350 MWh over the period 2004 to 2008. This represents a 21 percent reduction across Investa's portfolio of buildings (Investa, 2009b). As at 30 June 2007, Greenhouse Guarantees were reported to have provided combined annual savings of $215,000 to tenants and abated approximately 2,180 tonnes of CO_2 emissions per year (Investa 2007).

Figure 27: Investa commercial office portfolio energy and Greenhouse Gas reduction



According to Investa, lighting typically represents 60 percent of a tenant's electricity consumption (Investa, 2007). In some of their buildings high-efficiency, low-glare general office lighting and occupancy-based lighting controls were installed. Additionally, Investa undertook a 'Smart Thermostat Trial', which assessed the impact of varying the temperature throughout the year to improve tenant comfort and save energy. The trial was conducted on the HVAC (Heating, Ventilation and Air Conditioning) system in a commercial building in Melbourne. The trial demonstrated that energy use could be reduced by up to 15 percent on a hot summer's day through more intelligent controls of the building's thermostats (Investa, 2007).

5 COSTS AND POTENTIAL OF DECENTRALISED ENERGY

Key Points:

- Australia has huge untapped Decentralised Energy potential. It is estimated that DE sources could deliver:
  - 22,608 MW of peak capacity (> 50% of total peak demand)
  - 86 GWh per annum energy generation capacity (40% of energy demand).
- Many DE options are cheaper than traditional centralised energy supply when associated network costs are taken into consideration.
- Electricity sector emissions could be reduced by up to 73Mt per annum (35% reduction on 2009 levels) with full deployment of DE potential.
- The lowest-cost deployment of DE could unlock almost $3 billion of savings per year for electricity consumers by 2020.
- The D-CODE model is a freely available tool developed as part of this research for stakeholders to examine their own future energy scenarios.

5.1 Generation potential of DE

The generation and peak demand reduction potential for DE in Australia is significant. Figure 28 below presents the amount of DE that could be installed by 2020, using figures from the Description and Costs of Decentralised Energy (D-CODE) Model developed as part of this research. The figures are estimated based on the economic potential of each category, assuming favourable market and policy conditions, and come from a comprehensive review of the literature (see Working Paper 4.3: Dunstan et al. 2011a).

The total DE potential is substantial when viewed as a proportion of total national peak and energy demand. DE could supply:

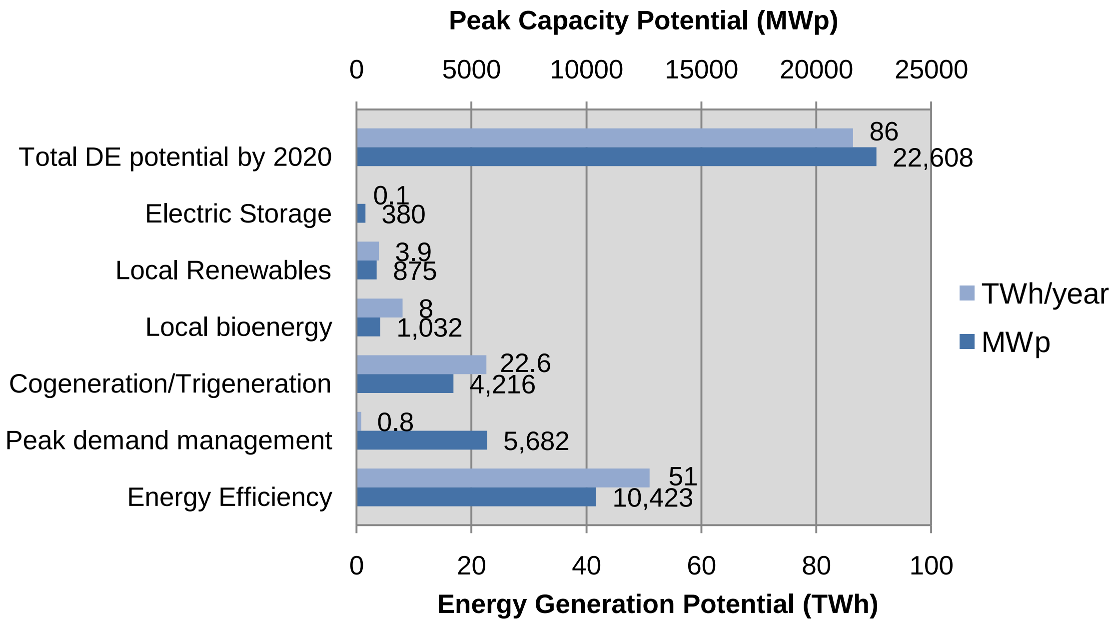
- over 50 percent of the national peak demand figure of around 42,500 MWp[8] and
- 40 percent of the total 215 TWh per annum energy demand (ESAA, 2010).

The largest contribution to these totals in energy terms is energy efficiency, followed by cogeneration/trigeneration, while the largest contributions to peak load reduction

[8] 2008-09 Figure for total summer system peak loads of each state and territory (ESAA 2010, Table 2.8)

comes from energy efficiency and peak demand management (Figure 28).

Figure 28: Australia's Decentralised Energy potential



Data Source: D-CODE Model (See Working Paper 4.3: Dunstan el al 2011a)

5.2 Current costs of DE technologies

Traditional cost comparisons of electricity generation tend to exclude the cost of electricity network delivery. This is because such costs are often not borne by the generator, but by the network business, which in turn passes on costs on to electricity consumers in the form of network charges. This is why many DE technologies are commonly considered to be more expensive than centralised generation technologies. This research, through the D-CODE Model, overcomes this oversight by including network costs in the generation equation, to present the true costs of energy supply options. For more detail on the way that network costs are calculated, see Working Papers 4.3 (Dunstan et al., 2011a) and 4.4 (Langham et al., 2011a).

When the costs associated with delivering electricity from the point of production to the point of consumption are factored into the generation cost equation, the costs of many DE options are favourable relative to centralised generation technologies. A key attribute of most DE options is that they reduce the need for future electricity transmission and distribution network expansion. This occurs because reducing demand or producing energy close to the consumer can 'flatten' the demand profile, thereby reducing the need for augmentation of network infrastructure in key areas of network constraints. Hence, DE options have lower costs associated with network service provision relative to centralised supply (Dunstan et al. 2011a). The concept of 'avoidable network costs' is discussed in more detail in Section 4.1. Depending on the type of DE, additional cost advantages may exist through lower upfront capital costs, lower variable costs and carbon costs.

Excerpts from D-CODE are shown in Figure 29 and Figure 30 below, which show installed 'levelised' costs. Levelised costs are a measure where all capital and operating costs are spread evenly across the lifespan of the technology, to allow an fair comparison of supply- and demand-side technologies with different lifespans and lifecycle cost profiles. In both graphs the vertical axis represents the costs, which are broken down into components (represented by different colours) to provide insight into the cost composition of each technology. The horizontal axis represents the potential output each type of technology that could be developed within the specific region and timeframe. These graphs highlight the cost advantages of decentralised options (shown with red labels) compared to centralised options (black labels) in achieving the dual aims of meeting future generation requirements and catering for the growth in peak demand. Note that neither graph includes a carbon cost, which would further improve the cost competitiveness of DE.

Each cost curve serves a unique purpose. If the electricity system in question requires additional energy supply, the energy cost curve (Figure 29) will provide an indication of the cost and quantity of installing additional energy available over the planning timeframe. If the electricity system in question is approaching a peak capacity constraint, the peak power generation curves (Figure 30) will provide an indication of the cost and quantity of installing addition capacity over the planning timeframe.

It can be seen that the addition of network costs – the red component of each column – has a large impact on the overall costs of centralised technologies. The lowest cost options are on the left-hand sides of the graphs. In Figure 29, energy efficiency and industrial cogeneration has the potential to provide up to 60 TWh of additional supply at lower cost than expanding centralised supply. Figure 30 shows that there is the potential for almost 19,000 MWp of peak power that can be supplied by DE at a lower cost than expanding centralised supply capacity. If the network cost component is omitted from the comparison, centralised gas and coal suddenly appear cheaper than many of the DE options.

This highlights the importance of overcoming the institutional and regulatory barriers outlined in Section 8, in order to align private investment decisions with outcomes that are optimal and lowest cost to society.

Figure 29: Levelised cost and potential of supplying new energy demand

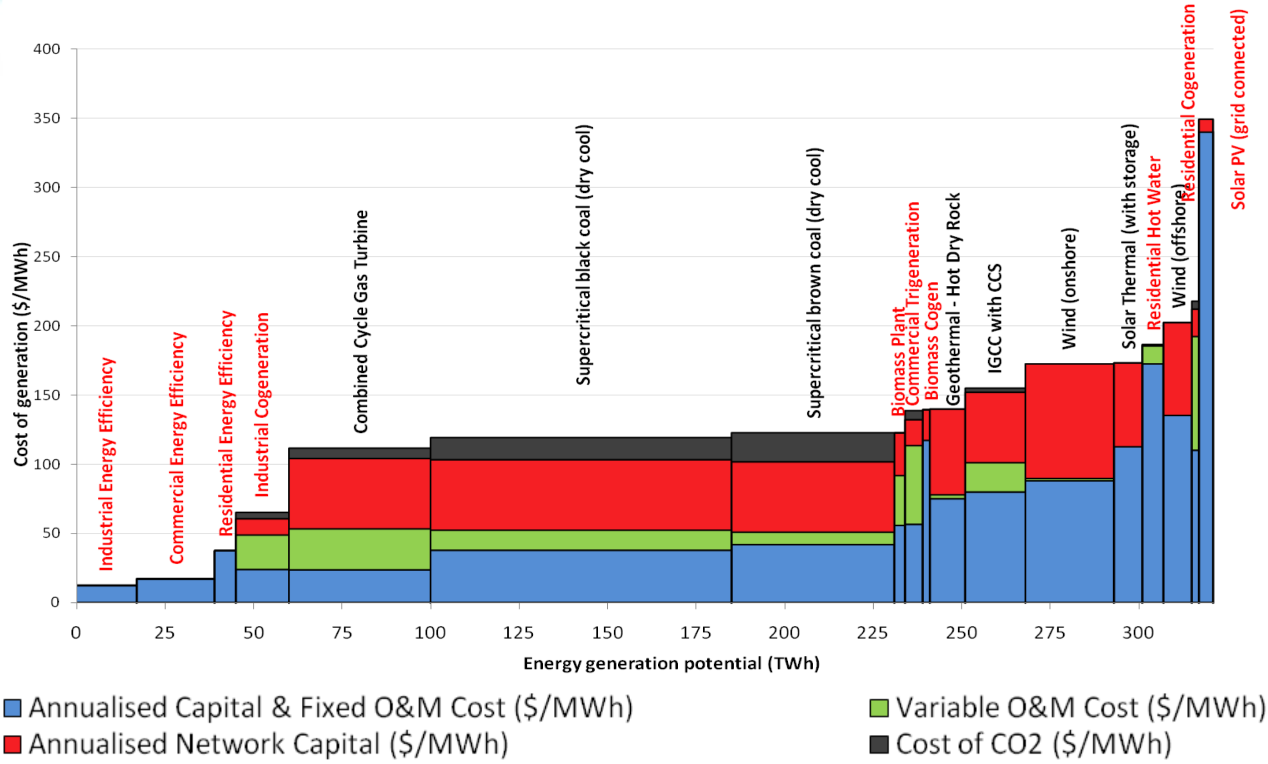
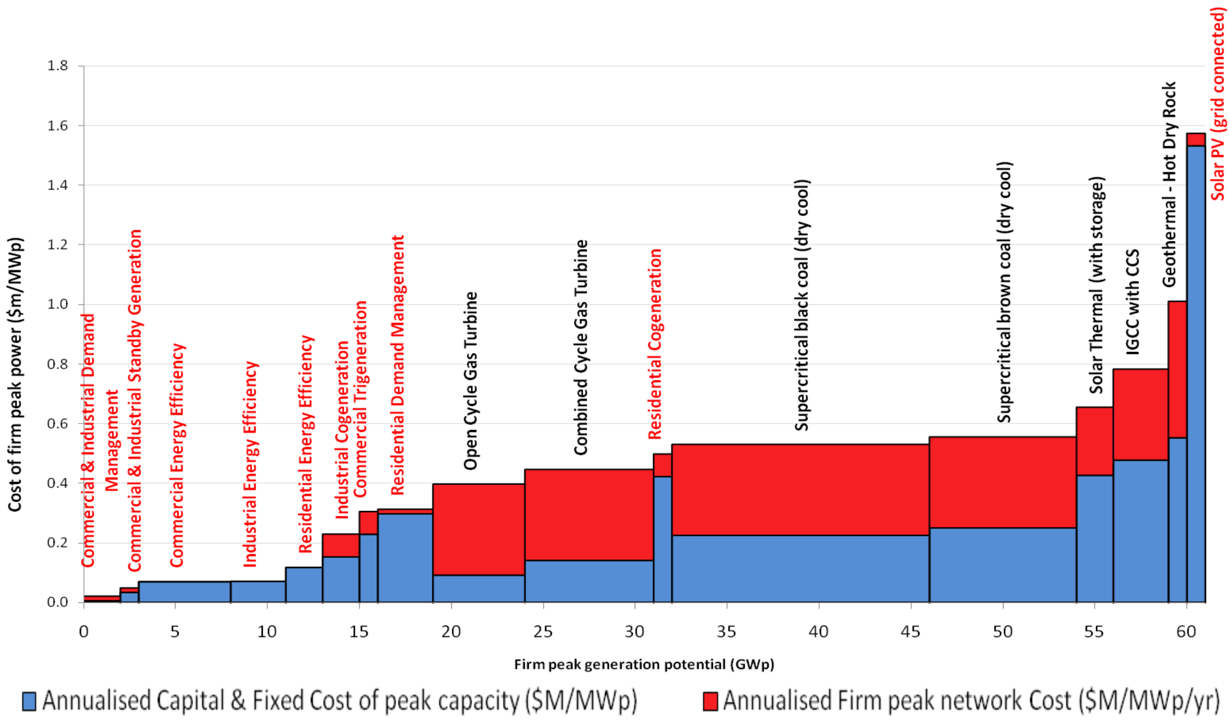


Figure 30: Cost and potential of options to meet additional peak demand



5.3 Future costs of DE technologies

The D-CODE data used to generate the cost curves in the figures above is based on technologies and costs available today. While several DE options such as energy efficiency measures are currently more cost effective than the alternatives according to the D-CODE analysis, other DE technologies are still in the development phase, and significant cost reductions are expected in future years.

These cost reductions can be explained by a learning-by-doing approach, which predicts that costs of deployment will fall by a fixed percentage (i.e. the learning rate) as deployment is doubled. Learning rates for DE technologies such as energy efficiency programs, cutting edge demand management systems, energy storage and solar PV are relatively high compared to long established centralised energy supply technologies and should lead to cost reductions over time as more capacity is installed. Solar PV, for example, has observed a decline in costs of about 19 percent for every doubling in installed capacity (see Case Study 4 on Solar PV below for further information).

5.4 Emission abatement potential

DE has the potential to significantly reduce GHG emissions in Australia. The Australian Bureau of Agricultural and Research Economics estimates that energy efficiency alone could make up over half of Australia's greenhouse gas reductions over the next 40 years (Gurney et al, 2007), while energy efficiency in buildings alone has been estimated to have the potential to deliver emissions savings of 29 to 39 megatonnes per annum (Langham et al., 2010). Energy efficiency is often found to offer the largest scope for cutting emissions (IEA 2009b; Energy Efficiency Council 2010). Payback periods for energy efficiency measures are often less than five years and therefore offer abatement potential in tandem with significant economic benefits. ClimateWorks Australia (2010) estimates that industrial energy efficiency and cogeneration could cut emissions by 22 megatonnes and save over $2 billion per year.

The combined (maximum) abatement potential of the DE technologies listed in Table 1 above is just over 73 $MtCO_2$-e per annum. If installed, this corresponds to a 35 percent reduction in Australia's annual electricity emissions compared to 2009 levels.[9] This is accomplished both by decreasing demand for electricity and reducing the emissions intensity of energy supply. Although not quantified here, reductions in total energy consumption and associated emissions are also expected to come through more active participation of consumers in the electricity market, catalysed by smart metering infrastructure and interactive interfaces.

In addition, by reducing the flow of power through transmission and distribution lines, DE reduces the electrical losses associated with the delivery of electricity (Ipakchi et al., 2009). With Australian distribution losses estimated to be approximately 5 percent of total electricity consumption (ESAA, 2010) and transmission losses accounting for a further 3–4 percent there is potential for further significant carbon savings.

[9] Based on National emissions data from DCCEE (2010b).

The Description and Costs of Decentralised Energy (D-CODE) Model

The D-CODE Model is a free, publicly available electricity cost comparison and electricity system planning model developed by the Institute for Sustainable Futures as part of Project 4 of the Intelligent Grid Research Program. D-CODE aims to both stimulate discussion on the costing of energy services, and to assist governments, utilities and other interested stakeholder groups in making informed energy planning decisions.

In seeking to determine the most cost-effective options to meet our future electricity needs, using supply technologies and demand management programs available today, D-CODE breaks new ground by incorporating network costs into the investment equation, thereby removing the inherent bias against DE options present in typical analyses that do not consider the delivered cost of electricity.

D-CODE is based on three key design principles:

- Accessibility – the model is freely available, and simple to use and understand relative to models of comparable purpose.
- Transparency – the operation of the model is fully described and all data inputs and calculations used to generate costs are fully observable to the user.
- Flexibility – the user can select the scale of analysis, technologies and policy settings to be included, and all embedded default data can be adjusted as desired.

The primary outputs of the model are levelised cost curves, presented earlier in Figure 25 and Figure 26. When creating cost comparison curves in D-CODE, users can include up to 33 inbuilt supply technologies and demand management options, with the option of including data for another nine technologies.

The model also has ability to model the optimal deployment of technologies and programs in order to meet predicted energy and peak supply shortfalls, at lowest cost as illustrated through the Australia case study in Section 5.5. The costs and emissions of the Optimal Mix can be easily compared to the Business-as-Usual scenario of expanding centralised fossil fuel generation and network capacity, through simple graphical outputs and data summaries.

With its innovative capturing of network costs, the D-CODE model clearly demonstrates the large benefits of DE options in a way not previously seen in levelised cost calculations. Through the optimal mix analysis, D-CODE highlights the role for DE in meeting the growth in electricity demand in real world setting. The model predicts that large societal cost savings are possible if the growth of our electricity system is planned with the mindset that network infrastructure costs can be avoided through DE measures. These results, coupled with its transparency, ease-of-use and flexibility, means the impact of D-CODE could be wide-ranging, both as a discussion and planning tool.

The D-CODE Model can be downloaded from the iGrid website complete with User Manual, and more information can be found in the on the model in Working Paper 4.3 (Dunstan et al. 2011a).

5.5 What can DE do for Australia in the next 10 years?

To determine how far Decentralised Energy can take us over the next 10 years if barriers to uptake were broken down through targeted policy measures, the D-CODE Model was run at the national scale, with a planning horizon out to 2020–21. Based on data from the National Electricity Market forecasts (AEMO 2010), over this time horizon Australia will face an annual energy shortfall of 39,594 GWh, and a peak capacity shortfall of 8,939 MW.

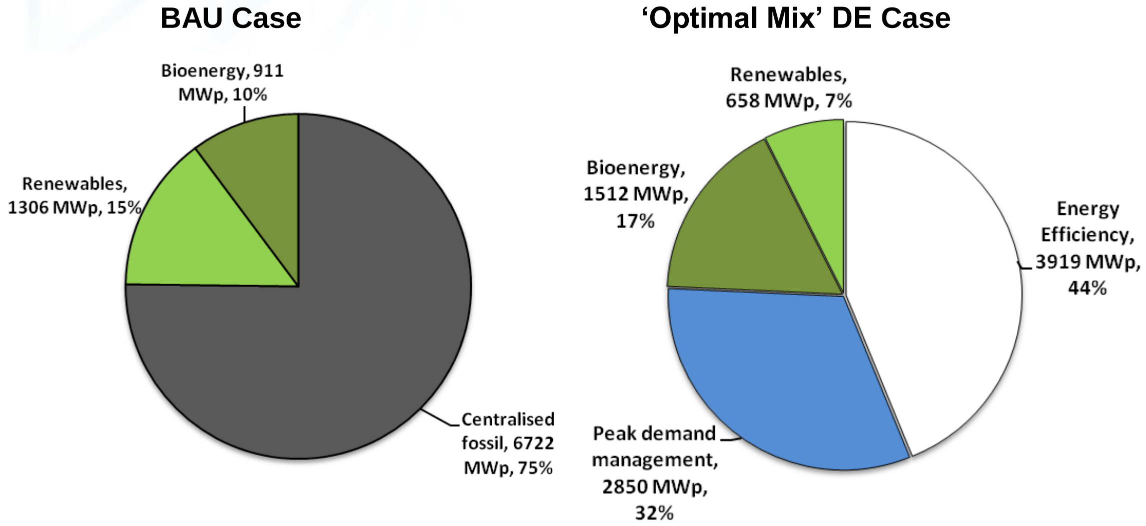
To determine the costs and emissions associated with different potential approaches to meet these shortfalls, two cases were run:

1. '**Optimal mix' of technologies (including DE):** this case allows the model to select the lowest-cost deployment from all inputted technologies, including both centralised and DE options.
2. **Business-as-usual (BAU)**: this case allows the model to select the lowest-cost deployment, but is excluded from using additional new DE capacity to meet the constraints.

The BAU case does not consider network costs when determining least-cost options, which mimics the current imperfections in the electricity market where network costs do not feature in the private generator investment equation. Network costs are then added afterwards to enable comparison with the optimal mix case, which deploys technologies taking into account network costs. Both cases assume that the 20 percent Renewable Energy Target (RET) will be met through additional renewable energy generation in 2020.

The technology categories deployed to meet the peak capacity constraint in each case are shown in Figure 31 below. Renewables and bioenergy feature in both cases, as this is 'forced' into the mix by the RET. The biggest difference between cases is that in the BAU case centralised fossil generation meets the remaining peak shortfall, while in the 'Optimal mix' case, energy efficiency and peak load management entirely replace centralised fossil fuel.

Figure 31: New peak capacity meet 2020-21 shortfall



Cost savings

The cost of deployed technologies is substantially lower in the Optimal Mix case relative to BAU. Overall, costs to meet energy and peak capacity shortfalls to 2020–21 are $2.9 billion (44 percent) lower in the Optimal Mix case where DE options feature strongly. Of particular note is the network cost component, which accounts for almost $2 billion of the $2.9 billion saving. The capital and variable fuel and operation costs of the Optimal Mix case are also lower. At $23 per tonne, the cost of carbon contributes a further $0.24 billion per annum saving.

Emissions savings

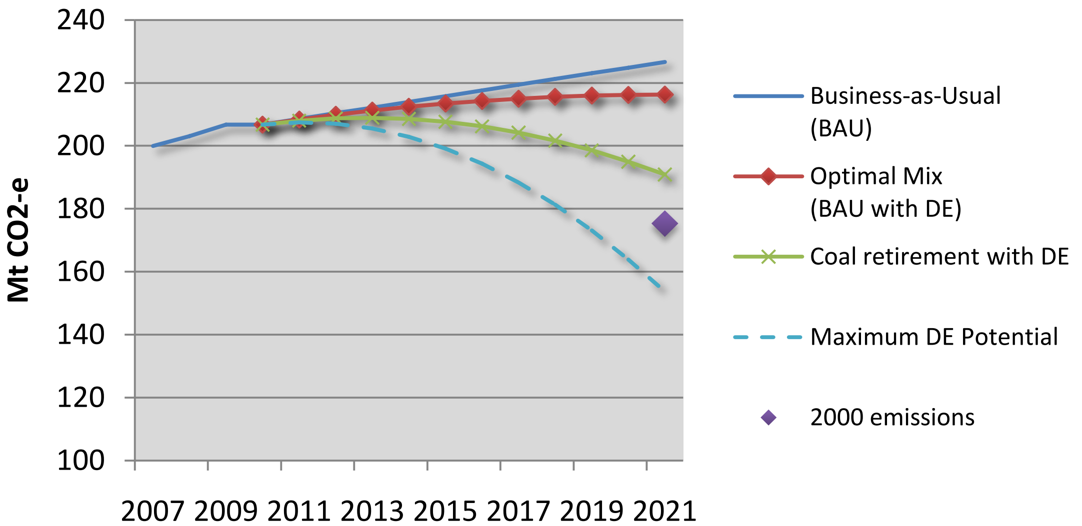
Emissions from the newly deployed technology options are 3.9 $MtCO_2$-e lower in the Optimal Mix case than in BAU, while an additional 6.5 $MtCO_2$-e of emissions savings derive from energy efficiency being lower cost and therefore displacing *existing* fossil fuel generation. This total 10.4 $MtCO_2$-e per annum saving equates to 4.6 percent lower total electricity sector emissions in the Optimal Mix case compared to BAU. The reason the disparity is not greater is because most of the energy generation shortfall was met through the Renewable Energy Target in both cases, and most of the remaining investment in the BAU case was in open cycle gas turbines, which – as peak generators – operate only for short periods and thus do not consume large amounts of gas.

In order for Australia to further reduce its electricity emissions over this period, it would need to retire existing coal-fired generators. This is not unrealistic, as many coal-fired generators have already reached or are approaching their planned economic life. By 2020, 8700 MW of existing coal-fired generation capacity will pass its normal "retirement age" of about 40 years.

To investigate the role that DE could play in a coal retirement scenario, another iteration of the model was run in which it was found that Australia could shut down approximately 7,000 MW of coal-fired generation capacity and replace it primarily with DE, renewables and some peaking gas plants at a total annual cost 5% *below* business as usual. This would reduce total 2020 electricity sector emissions by 35.8 $MtCO_2$-e per annum – **a 15.8% emissions reduction compared to BAU at a net saving to consumers.**

To graphically illustrate the relative impact of these emissions reductions, the above options are shown relative to BAU in Figure 32 below. Actual electricity sector emissions are shown from 2000 to 2010 (DCCEE, 2010b), and the BAU (centralised generation case) emissions are shown as a continuation of the navy blue line, which includes the 20 percent RET and the impact of a $23/tonne carbon price. Electricity sector emissions for 1990 are shown for reference as a purple diamond. The Optimal Mix case – that is, the lowest-cost option using both centralised and DE technologies – yields a moderate but meaningful reduction in emissions, as shown in red. If 7000 MW worth of coal-fired power stations are retired, creating a greater energy shortfall to be met through energy efficiency and renewable and low carbon Distributed Generation, the emissions reductions under this scenario are shown as the green line. This option is at no additional cost to the BAU emissions trajectory shown in blue. Finally, to illustrate how far DE could reduce emissions overall if all of the identified DE potential was realised, this is shown in the dotted blue line (the costs of this option have not been modelled). The difference between the unbroken blue and dotted blue lines in 2020 is the maximum amount of emissions reductions that could be delivered through DE according to the high level assessment undertaken for the D-CODE Model (Dunstan et al., 2011a).

Figure 32: Australia's total electricity sector emissions under DE scenarios



Note: Emission reduction trajectory from 2010-2020 is illustrative only, and is based on an arbitrary, progressively rapid rollout of Decentralised Energy, with 100% of savings being achieved in 2021.

This highlights the key role that DE can play in the cost-effective reduction of electricity sector emissions, but also shows that to pursue deeper electricity sector cuts as we move towards a zero emissions future, large-scale renewables will also play a vital role in displacing the large volumes of coal-fired electricity underpinning the vast majority of Australia's current power supply.

Case Study 4: Solar Photovoltaics (PV)

Solar Photovoltaic (PV) cells convert the energy in sunlight (photons) directly into electricity. PV systems can be installed on building rooftops, as standalone structures or integrated into building designs such as windows or awning structures, and connected to the electricity grid. The most common type of PV systems use crystalline silicon cells, however newer types are emerging. They include ‘thin film PV’ which requires less silicon, and ‘dye sensitised solar cells’ which have the potential for low cost application. PV is a modular technology, meaning that it can gradually be expanded in response to changing energy needs and costs.

In addition to providing renewable, carbon free electricity, the modular nature of solar PV means that it can be easily embedded within the electricity network close to the point of use. This reduces electrical network losses, and can contribute to the optimisation of the electricity network through peak load reduction, particularly if installed in areas where there is a non-residential load (Watt et al., 2006).

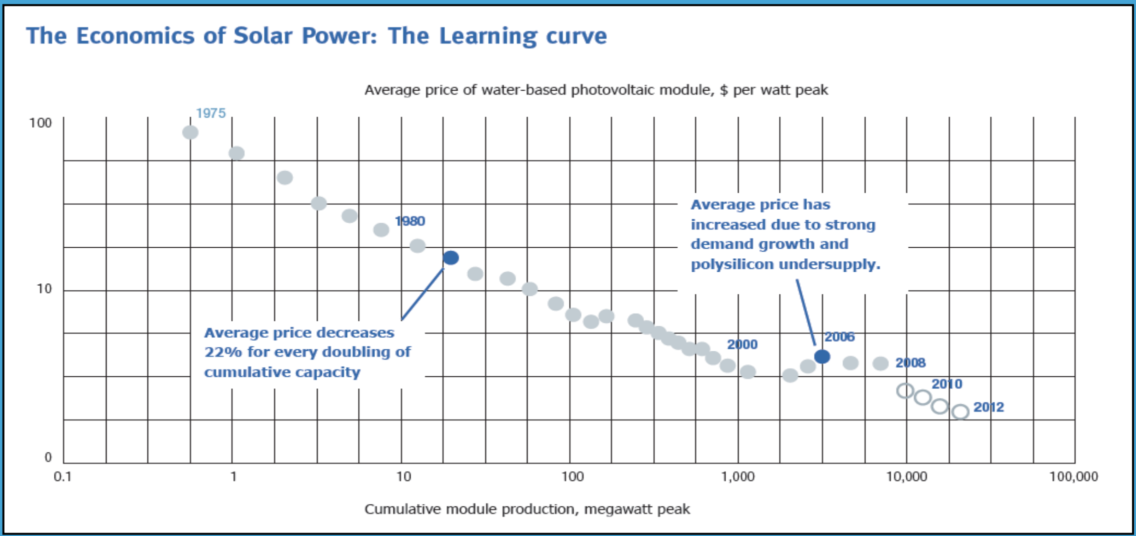
For example, PVs can be installed in situations where the distribution network peak demand corresponds closely with commercial air conditioning loads that occur during the middle of the day to early afternoon when solar is at peak production.

The supply from solar PV is less “firm” than many other sources because power output can vary with intermittent cloud coverage. However PV’s value in reducing summer peak demand should not be ignored. With greater penetration and geographical distribution of PV, such variations are lessened, and where network peaks are later in the day, solar PV may still contribute to peak reduction but at less than full capacity. While local battery storage is currently relatively expensive, the IEA advocates the use of PV combined with storage as one option to reduce peak demand and the need for high cost infrastructure investments (IEA, 2010b, p. 28). As battery storage becomes more pervasive with the uptake of electric vehicles, the value and flexibility of PVs will increase.

Solar PV is also already demonstrating substantial economic and social benefits, with PV-related employment in Australia in 2010 estimated at approximately 9,400 people (Watt et al, 2010). Between 2007 and 2008 the global PV market doubled and system prices fell by 40% (IEA, 2010b, p. 13). This trend of declining costs is expected to continue with the IEA projecting over 3 million MW of cumulative installed capacity out to 2050. Recent advances have brought manufacturing costs for PV modules to as low as US $740/kW for thin-film cadmium-telluride panels (First Solar, 2011), while the recent feed-in-tariff led boom in solar PV demand in Australia has reduced installed costs dramatically as the local industry has developed. Current installed costs for a residential system without Renewable Energy Certificates in NSW vary from $5,030/kW to $5,845/kW (Solar Online, 2011). In ‘levelised cost of energy’ terms, this is rapidly approaching standard coal-fired grid electricity tariffs.

In some areas of Australia ‘grid parity’ of solar PV –meaning that the unsubsidised levelised cost of supply is equal to that of regular grid electricity is currently being achieved or will be achieved in the coming years. Rapidly rising grid electricity prices due to network investment in some areas, are already starting to see PV grid parity (Parkinson, 2011). Figure 33 shows a technology ‘learning curve’ for solar PV, which illustrates that as solar PV has matured and increased in deployment, costs have dropped exponentially. The current learning rate for PV is estimated to be 81%, or a 19% reduction in cost for each doubling of cumulative production.

Figure 33: Solar PV Learning Curve of production cost



Source: Lorenz (2008)

GENERATION POTENTIAL

Solar PV is the fastest growing of all renewable energy technologies, achieving a 44% annual growth rate internationally between 1990 and 2009 (IEA 2010b, p. 41). In absolute terms, global electricity production from solar PV increased from 19 GWh in 1990 to 18 799 GWh in 2009. However, this still only accounts for 0.1% of total global energy production (IEA 2010a, p. 5). In Australia, the total annual number of solar PV system installations grew from just 52 in 2001, to over 105,520 in 2010 (CEC, 2010, p. 36). While cumulative installed capacity of PV in Australia reached 571 MW in 2010 (Watt et al, 2011 p. 1). The theoretical capacity to install solar PV is bounded only by the surfaces upon which modules can be installed and the ability to utilise power. This research estimates a potential of 2,500 MW could be deployed within 10 years (Cooper et al., 2011), based on 10-year installations in Germany, adjusted for Australia's population.

EMISSION ABATEMENT POTENTIAL

According to the IEA, solar PV, if rapidly deployed, could provide around 5% of global energy supply by 2030 growing to 11% by 2050, as shown in Figure 41 below. This could lead to a reduction of emissions by 2.3 gigatonnes (Gt) of CO_2 annually (IEA 2010b). In Australia, with an estimated 10-year national capacity potential of 2,500 MW, the emissions abatement potential is approximately 3.6 MtCO2-e, or 1.7% of national 2010 electricity sector emissions.

6 BARRIERS TO DEVELOPING DECENTRALISED ENERGY

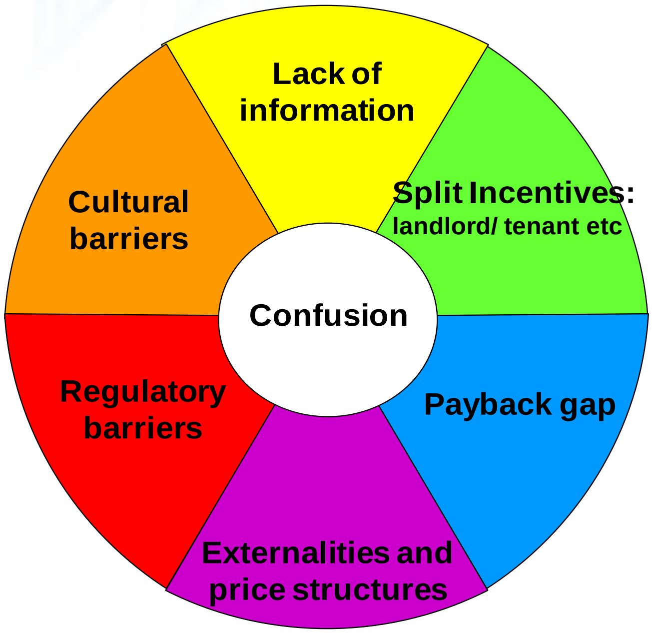
Key Points:

- The uptake of cost-effective DE options is being prevented by a host of institutional barriers, such as a lack of information, split incentives, regulatory barriers, cultural barriers, inefficient pricing, the 'payback gap', and a lack of coordination.
- The Top 3 barriers to DE as rated by a survey of energy industry stakeholders are:
  - confusion resulting from a lack of coordination and leadership on DE development.
  - the lack of an environmental objective in the National Electricity Market
  - a lack of cost-reflective pricing
- The Top 10 rated barriers include six of the seven barrier categories, indicating the need for a multifaceted and nuanced response.

The deployment of low-emission DE provides opportunities for a range of stakeholders. Rapid growth in DE is both technologically possible and economically attractive but is being impeded by a number of institutional, market and industry barriers. Addressing these barriers would allow more equitable treatment of DE and supply-side options. This section focuses on the institutional barriers that must be overcome in order to deliver low-cost, low-emission energy services in Australia.

Institutional barriers to DE can be classified into six broad areas, as shown in Figure 34. Categorising barriers establishes a logical structure to assist in considering the causal factors underlying institutional impediments to DE, although it should be noted that barriers do not always clearly fall into a single category and may have their roots in more than one barrier category or be strongly linked to other barriers. Each of the categories is explained below, starting with regulatory barriers and working clockwise, concluding in the centre with 'confusion', resulting from the interaction of numerous barriers. For more detail see Working Paper 4.1: Institutional Barriers to Intelligent Grid (Dunstan et al 2011e).

Figure 34: Institutional barriers to Decentralised Energy



6.1 Regulatory barriers

The regulatory environment surrounding Australia's electricity sector, particularly the National Electricity Market (NEM) servicing the bulk of Australia's population, was established around a model of large, centralised, primarily coal-fired electricity generation dispatched into a wholesale pool market and transported large distances to consumers. Given this model based on large, long-term infrastructure investment as a starting point, it is understandable that the regulatory frameworks established to govern the operation of such a system contain many embedded institutional barriers to smaller, more decentralised forms of delivering energy services. Many of the regulatory barriers have in fact been created as a by-product of trying to address other public policy objectives.

Some of the most significant regulatory barriers include:

- **Economic regulation of electricity networks** that rewards the sale of greater volumes of electricity with higher profits, which puts the financial interests of some of the most influential actors in the electricity market in direct conflict with measures that would reduce the volume of electricity sales passing through the network.

- **Distortionary fiscal and regulatory policies**, such as network charges on consumer bills that do not reflect the true costs associated with infrastructure; heavy solutions to constraints on the network; regulatory structures that result in electricity networks favouring capital investment in network infrastructure over the operational expenditure in Decentralised Energy services that could meet consumer needs more cost-effectively; network planning standards and requirements constructed with the centralised generation and supply model in mind; and cost structures which make connection to the network prohibitive for smaller players.

6.2 Cultural bias

In a sense, most institutional barriers can be viewed at least in part as having cultural roots. They reflect the way that people relate to technology and the operation of institutions created by society. Included in the category of cultural barriers as it is defined here are barriers that more directly relate to cultural norms and perceptions, and generally fall into one of two sub-categories: ‘cultural lag’ and ‘tragedy of the commons’.

- **‘Cultural lag’** is where prevailing attitudes and values that have evolved over time may no longer be appropriate in the present circumstances. For example, attitudes about the desirability of centralised energy supply, which evolved when this was the dominant technology, may become a significant barrier when times change and technological change and environmental concerns mean DE should play a bigger role. These values tend to be reflected in behaviours of individuals or organisations, such as in the natural tendency to base investment and other decisions on past experience and favour more familiar technologies and practices.

- **‘Tragedy of the commons’** (dilemmas) are where individual attitudes lead to behaviour of individuals which conflicts with the collective interests of society. For example, while the prevailing values in society may be that everyone should use energy efficiently, if this attitude is not also reflected in personal values that “I will use energy efficiently”, then it will not flow through to actual behaviour.

6.3 Imperfect information

The lack of appropriate, timely and relevant information is a major barrier to the establishment of intelligent grids and the wider deployment of DE. By necessity, the historical regulatory structures servicing energy markets have over time developed information and reporting structures to service the needs of existing technologies. As a consequence, new and innovative technologies and business models tend to suffer from a lack of information upon which the range of stakeholders – including consumers, networks, DE providers, and energy policy makers – can make reliable investment decisions. Critical areas of imperfect information relating to DE include:

- **Capital and operating costs:** Many DE options involve higher up-front costs but lower ongoing operating costs. If reliable information on operating costs is not easily and cheaply available at the time of purchase, this creates a bias in favour of choosing the lowest upfront cost option.

- **Lack of precedents for DE:** Reliable information about DE alternatives may be difficult or costly to access and/or the benefits that accrue from investment in DE can be much harder to anticipate with confidence, creating resistance towards these technologies.

- **Network planning information:** To exploit the opportunities that DE provides, information must be known about network infrastructure constraints such as the location, timing, and amount of generation or demand reduction required to meet the demand.

6.4 Split Incentives

"Split incentives" refers to situations where a course of action with a collectively efficient outcome is obstructed because it is not in the interests of a particular party. The United Nations Framework Convention on Climate Change recently highlighted this prominent barrier category was as being one of the top five impediments to energy efficiency (UNFCCC 2011). The most prominent case of split incentives is the **landlord–tenant problem**. In this example, the (commercial or residential) landlord is reluctant to invest in energy efficiency, because the benefit would accrue to the tenants over time through lower energy bills. Meanwhile the tenant is reluctant to pay for investment in energy efficiency if they may not remain a tenant for long enough to reap the benefits. A variant of this principle is the **principal–agent problem**, which occurs '…when an agent has the authority to act on behalf of a consumer, but does not fully reflect the consumer's best interests' (Brown, 2001). An example of this is where a design consultant is rewarded for minimising initial costs rather than life cycle costs for a client.

Split incentives can be as pervasive *within* groups or organisations as *between* them. In particular, this is the case when organisations do not have established processes for considering and deciding issues like investment in DE. For example, within an electricity supply business, the Demand Management department may develop plans for an efficient and cost-effective level of DM activity, but this may not proceed due other objectives in other parts of the business, such as asset renewal objectives of the asset management department.

6.5 Payback gap

The "payback gap" refers to the **discrepancy between payback periods** that consumers and businesses demand for DE investments compared to the payback periods for many other investments. Many households appear to be willing to invest in superannuation and other assets that offer a return on investment of say 7% per annum, but seem unprepared to invest in efficient lighting that may offer a return on investment of many times this rate. It appears that many consumers and businesses demand that DE investments to pay back their initial investment within about three years, which implies a discount rate of 30 percent (Stern 2006).

Similarly, network service providers also tend to require a much quicker return on investment for DE investments than for network augmentation investments. This is because unlike small DE providers and consumers, regulated monopolies have ready access to finance with long payback periods for centralised energy resources.

6.6 Inefficient pricing

There are two dimensions to inefficient pricing that represent institutional barriers to DE and the Intelligent Grid – unpriced external costs or "externalities", and inefficient pricing structures:

- **Externalities (environmental costs, e.g. carbon):** External costs are costs that are caused by the supply of a good but are not included in the price of that good. The most obvious external cost of electricity supply is the cost of climate change caused by burning of fossil fuels to generate electricity. This means that the average price of electricity is set below its true cost of supply, leading to excessive consumption of fossil fuel-based centralised electricity supply and reducing the uptake of low emission DE resources such as energy efficiency, renewable energy and cogeneration.

- **Inefficient Price Structures:** Most electricity consumers in Australia, particularly smaller consumers, still pay a **flat electricity tariff**. This does not account for the wide variations in the cost of providing electricity both in the wholesale (generation) price and reflecting the cost of providing peak capacity in networks. This flat price structure creates a bias against flexible DE resources, such as peak load management, that are much more able than centralised base load power stations to respond to these cost fluctuations. While flat tariffs are sometimes defended as protecting vulnerable consumers, the effect is often to impose unnecessary higher costs on *all* consumers to pay for large investment in centralised generation and centralised networks to meet occasional peak demand. The business deliberation component of the Intelligent Grid research program found that a lack of cost-reflective pricing was of particular relevance in both the NEM and in Western Australia. Other important pricing biases against DE include the inability of DE providers to reap rewards for the services and support they can offer to the electricity system, such as reducing network congestion which enables providers to **avoid infrastructure investment**.

6.7 Confusion

Many of the institutional barriers are interrelated, so the final category of “confusion” emerges from the observation that due to the *interaction* of these barriers, the total impact of institutional barriers is likely to be greater than the sum of the parts. It can be difficult if not impossible to effectively address all barriers simultaneously. Management complexity or policy paralysis can arise in which the difficulties associated with coordinating action frustrate any effective action, which could be further exacerbated by discord between levels of government or government agencies.

The barrier of confusion can also be expressed as a **lack of coordination** in addressing the suite of varied barriers facing DE in Australia’s electricity markets.

6.8 Ranking barrier importance

In order to assess which of the above barriers pose the most significant obstacles to the Intelligent Grid and the broader uptake of DE, a survey of 200 key industry figures was conducted (Dunstan et al., 2011b). These stakeholders represented electricity end users, regulators, electricity supply utilities, DE providers and environmental and other advocacy groups. The survey asked respondents to rate their level of agreement or disagreement with the prominence of the 25 proposed barriers in impeding the uptake of DE, categorised according to the seven types of barriers outlined above.

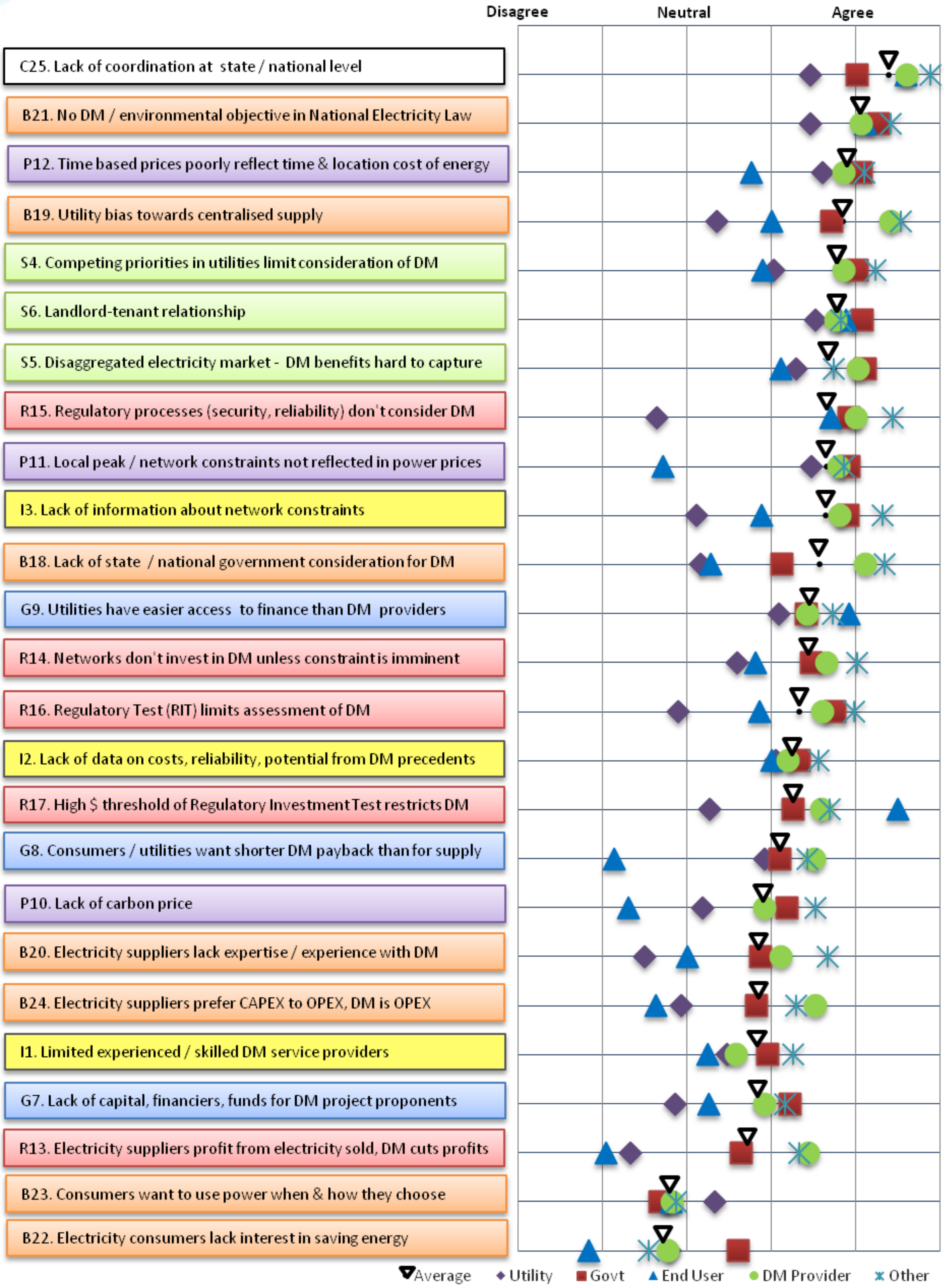
Figure 35 (Dunstan et al., 2011b) shows the diversity in the responses of each stakeholder category, arranged in order from the highest *average* ranking (across all stakeholder categories) at the top and the lowest average ranking at the bottom. It shows that the barrier with the greatest level of agreement by a large margin was Confusion (Barrier C25), demonstrating the dominant stakeholder perception that the lack of a coordinated approach to DE at a state or national level is one of the greatest barriers to DE.

It is important to note the large spread observed across the range of other barrier categories, with the top ten barriers including six of the seven barrier categories. Payback Gap is the only category that does not feature in the top ten. It ranks at number 12. While some barriers rank higher than others, it is important to note that 23 of the 25 barriers were on average agreed to be of concern. While almost all of the 25 barriers have been raised at the Intelligent Grid industry engagement forums over the past three years (and were in fact included in the survey partly due to comments logged at these events), the top three barriers in particular have come up repeatedly at several forums across the country.

Interestingly, the only two barriers to which respondents were ‘neutral’ were two perceived cultural barriers that are occasionally raised in stakeholder forums: consumers are indifferent in their desire to save energy; and that consumers’ desires to be able to use power when and how they choose overrides other considerations.

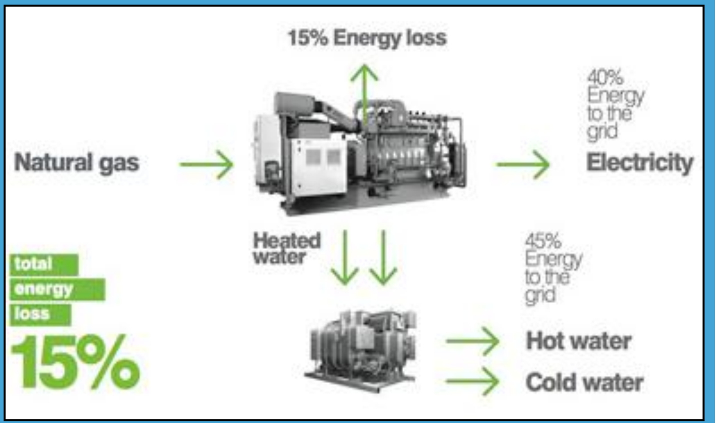
Figure 35 also shows that responses diverge strongly according to stakeholder group. Utilities and/or electricity end users were the two groups whose responses tended to diverge from the average by the greatest margin.

Figure 35: Stakeholder perception of barriers to DE



Case Study 5: Cogeneration and Trigeneration

Cogeneration, also known as combined heat and power (CHP), is a term used to describe a suite of energy options that produce both electricity and useful heat. Trigeneration facilities are effectively cogeneration plants that not only produce electricity and useful heat, but also convert some of the heat into cooling services for applications such as air conditioning.



Cogeneration and trigeneration plants range in scale from systems in the tens of kilowatts range for a small block of flats, to hundreds of megawatt plants that typically are associated with industrial applications with large process heat demands. This roadmap considers cogeneration and trigeneration systems of a scale up to around 30MW to be "Distributed Generation".

Australia employs much less cogeneration compared with countries in Europe and North America (see Section 1), due to its milder climate and lower demand for heating. Accordingly, the majority of cogeneration plants installed in Australia to date have been associated with industrial processes with high process heating demands. With the incorporation of cooling services through trigeneration, interest in urban applications is increased. Notable Australian urban trigeneration ate located at the Stockland Property Group building in Sydney, Curtin University, Royal Melbourne Hospital, Crown Casino, Macquarie University and Canberra Airport.

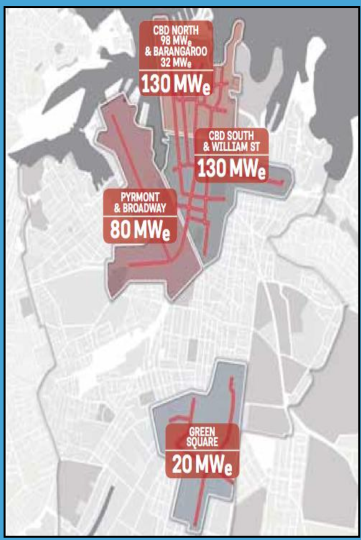
Cogeneration and trigeneration facilities are 65–85% energy efficient (Alanne & Saari, 2004) – around double the efficiency of conventional coal fired power stations. This increased efficiency is due to the productive use of waste heat, which is made possible by the generation unit being located where the heating or cooling is required. This increase in efficiency provides both economic and environmental benefits. Cogeneration and trigeneration are 23–37% less greenhouse intensive than a typical combined cycle gas-fired power station due to the displaced fuel required for steam heat or cooling production (Cooper et al., 2011).

In addition to resource efficiency, the embedded or decentralised nature of many cogeneration and trigeneration facilities can help to improve the efficiency of electricity distribution networks, and reduce investment in new network infrastructure through the provision of 'firm' peak power if they are located in areas of network constraint and are available at peak times.

The costs of cogeneration and trigeneration vary markedly according to the technology employed and the specific site where it is applied. Generally a significant thermal load is required to make these technologies cost competitive, For trigeneration in a commercial office environment, for example, it is rarely economic to produce power during off-peak periods when grid electricity is cheap, or to export into the grid if the trigeneration operator is only paid the wholesale rate for power, which is typically less than half of the retail rate (as it excludes network charges). The electricity price increases currently occurring around Australia are improving the business case for trigeneration substantially where retail electricity rates can be offset. Additionally, if these technologies can be applied in areas where they contribute to deferral of network augmentation, this could enable an additional revenue stream for proponents while still reducing costs for the electricity network. However, without regulatory change, few installations will benefit directly from such payments.

Despite the number of benefits provided by using cogeneration and trigeneration, a number of challenges inhibit their development in Australia. The low penetration of cogeneration in Australia to date means there is a lack of experience with these technologies. This can make it difficult to find adequately skilled labour and provides a barrier to entry for organisations without a background in energy generation to move into this sector.

CITY OF SYDNEY'S TRIGENERATION MASTER PLAN



The City of Sydney has set a target to reduce greenhouse gas emissions from its local government area by 70% from 2006 levels by 2030. Inspired by Woking and London in the UK, the City of Sydney has committed to delivering a network of 360 MWe of trigeneration plants clustered in 'low carbon zones', which aim to reduce the local area's greenhouse gas emissions by 18-26 percent by 2030 (Kinesis et al. 2010).

To map out this strategy, in December 2010 the City of Sydney launched a Trigeneration Master Plan for the CBD, outlining the prerequisites for the establishment of a trigeneration network. The City is also investigating the development of a public/private joint venture to create an energy services company to implement the Master Plan (Kinesis et al., 2010).

According to a 2009 study, a broader rollout of plans similar to Sydney's Sustainable Sydney 2030 in other Australian cities could achieve 50 percent cuts in greenhouse gas emissions over the next 20 years (Kinesis, 2009). This study suggested that a coordinated strategy of this nature could reduce emissions by a cumulative 540 million tonnes between 2010 and 2030, contributing to 41% of the national 5% reduction target.

7 POLICY TOOLS FOR DECENTRALISED ENERGY

Key Points:

- An effective policy package to unlock the potential of DE requires a balanced approach covering regulatory and pricing reform, information provision, incentives, facilitation, coordination and target setting.
- The following represents a simplified “top three” policy priorities for developing DE in Australia:

1. Establish “collaborative targets” in collaboration with electricity networks to achieve in the order of $1 billion p.a. in energy savings, 3000 MW of peak demand reduction and 10 million tonnes of carbon dioxide avoided.

2. Dedicate funds to provide incentives for energy network businesses to take major actions to develop DE.

3. Establish or nominate an appropriately skilled and resourced agency to coordinate a coherent DE strategy.

Barriers to DE were classified in the preceding section according to seven categories, visually displayed on a colour palette in Figure 34. To assist in forming logical, structured, comprehensive and non-overlapping policy responses to institutional barriers to DE, an equivalent classification scheme has been created for policy tools. The barrier categories to which each policy tool corresponds are shown in Figure 36. The types of policy options include the ‘primary’ drivers of regulation, incentives and information, which are complemented by the ‘secondary’ drivers of targets, facilitation and pricing. In addition, coordination is a further crucial tool for ensuring an efficient and coherent policy response. The division between primary and secondary does not imply that the secondary drivers are less important, but rather that they are less clearly delineated.

Figure 36: Barrier categories and corresponding policy tool categories

The result of the policy tool categorisation, shown in Figure 37, is entitled the "Policy Palette". The suite of specific policy tools that can be employed by governments and other stakeholders to overcome institutional barriers can then be 'mapped' on the policy palette, according to the type of approach and the underlying barrier(s) that each policy tool aims to address. Recognition that some policy tools share characteristics of different categories is reflected in the position of the numbered policy tool within each wedge. For example, reforming feed-in tariffs (#8 in Figure 37) is an incentive measure, but to some extent it is also a pricing reform, and thus it sits closer to pricing than facilitation on the palette.

Mapping the suite of planned policy tools on the palette enables us to see how 'balanced' the policy options selected are. Policy tools will be most effective when a full range of policy options from across the whole palette is deployed. For example, the use of regulation in isolation could elicit a backlash or have reduced effectiveness due to a lack of information. Equally, the use of incentives and information alone may result in weak uptake, or 'cream-skimming'. Above all, it is important to reduce the risk of fragmentation by the overall **coordination** of the implementation of the range of policy options.

A central premise of *Working Paper 4.2: 20 Policy Tools for Developing Decentralised Energy* is the need for a balanced policy response that not only covers types of policy approaches, but also adequately supports the three complementary forms of DE: energy efficiency, Distributed Generation and load management.

Figure 37: Policy Palette with 20 policy options mapped

1: DE Coordination Agency
2: Decouple electricity sales from network profits
3: Reform National Electricity Rules
4: Streamline DG Licensing
5: Extend retailer EE targets
6: DE targets & reporting
7: Resource assessments & case studies
8: DE handbook & advisory service
9: Network planning info
10: Annual DE Review
11: Energy audits & technical support
12: Training & skills development
13: Streamline network negotiation process
14: DE Ombudsman
15: Public recognition & awards
16: Distributed Energy Fund
17: Reform feed-in tariffs
18: Carbon Price
19: Cost reflective pricing
20: Network support payments

The different categories and examples of policy tools shown above in Figure 37 will now be discussed briefly, before a Policy Roadmap for the next 5–10 years is outlined. Broken down under each relevant heading, the suite of 20 policy options shown in Figure 37 representing a range of key reforms, is presented in no particular priority order.

7.1 Coordination

Given the scale and complexity of the task of rapid Decentralised energy development, coordination of stakeholder effort is essential. One straightforward mechanism to achieve this coordination is presented here:

1. ***Agency to coordinate Decentralised Energy development***: Establish a suitable government agency to coordinate a coherent DE strategy.

7.2 Regulatory reform

The Ministerial Council on Energy (MCE) is responsible for sound policy oversight of energy market reform and governance. This encompasses rule making, market development, network access regulation and market rule enforcement. Recent energy reform packages have broadly covered the governance of energy markets, economic regulation and rule making, electricity transmission, increasing the participation of energy users and suppliers, increasing natural gas penetration and addressing GHG from the energy sector on a national basis (MCE, 2003). According to the ENA “under the current regulatory environment in Australia, there is a clear disincentive for a distribution business to engage in activities of a developmental nature which may have the potential of reducing longer-term operating capital costs" (Brown, 2009).

While there have been attempts to encourage DE in the NEM (IPART 2002, AEMO 2009), the following reforms would encourage greater penetration of DE:

2. ***Decouple network business profits from electricity sales****:* Reform economic regulations, which financially penalise network businesses that reduce their electricity sales volume by supporting Decentralised Energy.
3. ***Fair treatment of DE in National Electricity Rules (NER)****:* Enforce current least cost requirements and edit the NER to better facilitate DNSPs in implementing DE options wherever they are cheaper than network augmentation.
4. ***Distributed Generation licensing requirements****:* Streamline the complex and costly licensing requirements and procedures required for distributed generators to produce and supply electricity to the grid.

7.3 Targets

Targets are often adopted by businesses, governments and individuals as a means of assigning a high priority to desired outcomes. Targets imply both measuring and reporting performance at regular intervals and can be an effective means of changing behaviour. Governments could set the following targets for DE development both in terms of energy efficiency and clear reporting:

5. ***Extend retailer energy efficiency targets:*** Extend mandatory energy efficiency targets to capture more of the available cost-effective energy efficiency potential.
6. ***Targets and reporting for DE development:*** Establish annual targets for DE and publicly report on progress. For more information on how this option would be incorporated into a Collaborative Targets' model, see "Case Study 6: Collaborative Targets for Decentralised Energy" below.

7.4 Information

Reliable information about the current practice and future potential of DE options is not widely available. Decentralised Energy developers require clear, accessible and relevant information and guidance to assist in streamlining the development process. Increased access to planning information that identifies current and future network constraints would provide for more economic opportunities for proponents to invest in DE. The information required includes:

7. ***Better information on network constraints and avoidable costs****:* Improve and standardise mandatory, easily accessible, up-to-date and relevant demand and network planning information.

8. ***Consolidate and disseminate information on Decentralised Energy****:* Develop a DE advisory service, website and/or handbook to provide information and guidance for DE proponents.

9. ***Resource assessments and case studies****:* Present a concise, consistent and accessible source of information on opportunities for developing DE options to overcome the lack of precedents within Australia.

7.5 Facilitation

Facilitation is intended to make it easier for consumers, businesses and service providers to access and deliver DE options. Facilitation is often aimed at reducing transaction costs, managing risk and building confidence. Facilitation measures could include:

10. ***Streamline network connection negotiation process***: Establish a clear and consistent framework governing the processes and timeframes surrounding the negotiation of generator connection agreements between decentralised generators and local network businesses.
11. ***Decentralised Energy Ombudsman***: Establish a DE Ombudsman with the knowledge, technical engineering skills and authority to assist in dispute resolution.
12. ***Decentralised Energy Review***: Publish a comprehensive annual Decentralised Energy review of the state of DE measures and opportunities for Australia.
13. ***Training and skills development***: Establish an industry training program for DE options, building on existing ‘green jobs’ training efforts.
14. ***Integrated energy audits and technical support***: Assist energy users to identify and implement energy saving opportunities.

7.6 Incentives

Incentive measures are intended to stimulate behaviour change. They are economically beneficial wherever the total benefits of this behaviour change exceed the total cost of providing the incentive. Incentives can be financial such as cash rebates to overcome the higher upfront cost of implementing DE, or they can be in the form of rewards such as prizes.

15. ***Decentralised Energy Fund***: Establish financial incentives to support Decentralised Energy options. For more information on how this option would be incorporated into a Collaborative Targets' model, “Policy Detail: Collaborative Targets for Decentralised Energy”.
16. ***Reform feed-in tariffs***: Implement an adequate and nationally consistent feed-in tariff program for Decentralised, renewable energy technologies.
17. ***Public recognition and awards***: Publicly recognise leadership in developing Decentralised Energy options.

7.7 Pricing reform

Pricing reform is required to internalise the external costs and ensure that pricing structures reflect the true costs incurred with energy generation and transmission and distribution networks. Pricing reform is needed in the following key areas:

18. ***Impose a price on carbon pollution***: Introduce an adequate market price on carbon as planned for July 2012 with the new fixed price on carbon.
19. ***More cost reflective network pricing***: Widely implement time-of-use pricing and deploy smart meters to residential and business customers.
20. ***Default network support payments***: Establish a standard or default network support payment to be paid by the network business to decentralised

generators exporting to the main grid, and ensure that network businesses are not disadvantaged in providing such payments.

7.8 From options to actions

The policy tools are outlined above as potential measures to address the identified institutional barriers to the timely and cost-effective development of DE. However, to transform these policy options into specific viable reforms requires significant policy development, including consideration of timing and budgets, human resources, consultation and balancing of stakeholder interests, distributional impact of costs and benefits, legal and legislative issues, risk assessment and communication strategy.

It is beyond the scope of this research to address all of these issues, particularly for such a wide range of policy options. However in order to provide a more concrete outline of the policy options and how they might be coordinated and phased in and, where appropriate phased out, they have been presented here in the form of a Proposed Policy Timeline from 2011 to 2020. This timeline is presented from a national perspective. While most of these policy tools are most effectively implemented or at least coordinated at the national level, many of the components could also be implemented at a sub-national level, either at the state and territory level or in some cases the local government level.

The Policy Timeline is focused on what governments can do to set and reform policy. This is essential in cases where proposed actions relate to legislation or spending government funds. However, in many other cases, there are opportunities for other stakeholders to facilitate the policy objectives, either with or without government support. In particular, electricity networks or retailers may see merit in progressing such options, either because they see direct business opportunities or advantages in building customer and community goodwill or they recognise the broader benefit or policy imperative and prefer to act voluntarily rather than not act and invite a more direct policy intervention by government.

In implementing government policy options, responsibility is shared across a range of agencies, regulators, rule makers, policy makers, legislators and program agencies. These actors need to play different but complementary roles in policy development and implementation from the national to the local level. The more the electricity industry is empowered to overcome the institutional barriers itself, the less will be the need for policy interventions. The roles of other stakeholders are also essential, as effective policy cannot occur without effective advocacy.

Case Study 6: Collaborative Targets for Decentralised Energy

Unlike the preceding five Case Studies which focus on existing real technologies, this one examines a potential policy option.

WHY COLLABORATIVE TARGETS?

Currently Australia's annual expenditure on Demand Management (DM) represents less than 1 percent of total annual expenditure on electricity supply, at a time when rising peak demand is driving unprecedented price increases, and electricity sector greenhouse gas emissions are at record levels. Wider application of DM has the potential not just to deliver benefits to consumers and the environment but also to enhance the operational and financial performance of the network businesses. This policy option could unlock significant consumer savings through avoided capital expenditure, and an approach that recognises that while DM may in many cases be in the interests of network businesses, active engagement and material support from government can be effective in addressing the barriers to DM and expediting its adoption.

WHAT IS A COLLABORATIVE TARGET?

Setting targets and direct funding are two of the most common mechanisms governments apply to pursue policy objectives. Collaborative DM targets supported by a DE Fund, proposed as part of this Roadmap, lie somewhere between the extremes of "voluntary" and "mandatory" targets, which have both have their policy benefits and drawbacks. A collaborative target entails government setting a national DM target; and working with each network to identify how much DM they could achieve to reach this target. It is important that network businesses are actively engaged in both setting and meeting DM targets as they have access to invaluable expertise and information about the current and future capacity of, and demand on, their networks and the potential for DM. To incentivise the achievement of targets, a DE Fund with money from both government and networks – in the form of redirected approved network expenditure – could be established to encourage investment in cost-effective DM. Network businesses would be invited to bid for funding, but funding would also be open to other DM providers to make a more competitive pool of service providers.

WHAT SHOULD THE TARGETS BE?

It is important that the Collaborative Targets and the funding model focus primarily on peak demand, but with monitoring and reporting of the energy savings (MWh) as well. Additionally, estimates of the value of both customer savings and avoided infrastructure costs associated with the targets should be made. It is suggested that the following targets could be delivered through DE by 2017 (five years from initiation):

- $1 billion p.a. in energy savings (comprising avoided network investment and customer energy savings)
- 3000 MW of peak demand reduction, below business as usual
- 10 million tonnes of carbon dioxide avoided.

While the above five-year targets fall well short of the likely cost-effective potential for DE, they are modest enough to be credible, but large enough to be meaningful and capture attention. Later, more ambitious but credible targets would be in the order of three times these amounts.

WHO WOULD IT APPLY TO?

While the focus of the Collaborative DM Target would be network businesses, other DM service providers including energy retailers could also benefit by bidding for funding to deliver targeted DM programs.

PRECEDENTS

There are national and international precedents for the collaborative DM target and fund approach. Key examples include:

- the $47 million Queensland “Energy Conservation and Demand Management Program” (Queensland Government 2009a)
- the Ontario “Energy Conservation and Demand Management Program” which sets targets of peak demand reduction of 1330 MW and energy savings of 6000 GWh per annum between 2011 and 2014 (Ontario Executive Council)
- “Public Benefit Funds” that support energy efficiency and/or Demand Management alone in over twenty US states (Pew Centre, 2010), which are often in addition to DM programs undertaken by utilities
- the UK Low Carbon Networks Fund.

REQUIRED FUNDING

If per capita funding levels similar to the US and Canada of between $22 and $72 (Nevius et al., 2010) were applied to the Australian population of 22 million, this would correspond to a DM Fund in the range of $480 million to $1.6 billion per annum. At a conservative incentive-to-benefit ratio of 1:3, the achievement of $1 billion per annum savings (see target above) would likely require incentives to be quickly ramped up to the order of $300–400 million per annum in funding. This funding could fit within a range of policy initiatives proposed as part of the Federal Government’s Clean Energy Futures Package, which has been analysed for funding relevance in Appendix 1. These direct incentives could be wound back after 2016 as barriers to cost-effective DE are removed and balanced incentives for DE and network investment are incorporated into the next round of network economic regulatory decisions to be made by the Australian Energy Regulator for the period commencing 2014 to 2016.

PROPOSED POLICY TIMELINE 2011-2020

Work Package	Policy Tool(s)	2012	2013	2014	2015	2016	2017	2018, 2019, 2020
Effective coordination of DE	#1: Establish central DE coordination agency	Nominate lead DE agency & role	Develop DE Strategy & Objectives	Annual Report on DE status		3 yearly review		3 yearly review
Adapt regulatory framework	#2: "Decouple" network revenue from sales volume	AER Consult & decide by June 2012 (NSW)	AER Consult & decide by 2013 (VIC & SA)	Implement NSW June 2014	Implement VIC & SA Dec 2015	Revenue cap operation	Review effectiveness and adjust	Next regulatory round starts 2019
	#3: Revise National Electricity Law to include environmental objective	Consult & consensus building		Legislative amendment			Review effectiveness and report	
	#4, #13: Streamline Dist Gen licensing, connection & negotiation processes	Consult	Draft legislative change	Enact legislative Change			Review effectiveness and report	
	#2, 4: Evaluate/expand AEMC/AEMO reviews	AEMO review of DemandSide Participation	Consider matters outside current scope	Implement matters outside scope	Review effectiveness (See #10)			Review effectiveness
Targets and reporting	#5: Establish economy-wide target for Energy Efficiency	Consult & develop annual targets	Announce targets and strategy	Review progress and report	Review progress and report	Review targets and strategy		
	#5: Extend and harmonise retailer energy efficiency targets	Advisory Committee	Draft legislation	Enact legislation		Review progress and report		
	#6: Establish collaborative DE targets with networks	Consult on targets	Set targets and link to DE Fund	Review progress and report	Review progress and report	Review Targets	Review progress and report	Continue subject to outcomes
Address information gaps	#7 Produce DE Case Studies	Nominate agency & collect data	Publish pilot case studies	Evaluation and expand	Review effectiveness and scope	Operate and report		Continue subject to Review
	#8: Provide DE advisory service	Consult & nominate agency	Implement stand-alone service	Operate and report	Operate and report	Review		Continue subject to Review

PROPOSED POLICY TIMELINE 2011-2020

Work Package	Policy Tool(s)	2012	2013	2014	2015	2016	2017	2018, 2019, 2020
Address information gaps	#15: Improve network planning information	Enact AEMC rule change re Network Planning & DM	Improve info (mapping and outreach)	Disseminate complementary information	Review & Compare effectiveness		Review & compare effectiveness	
	#10 Annual DE Review	Consult	Nominate agency to coordinate & collect data	Publish DE Review			Review effectiveness	
Facilitate understanding and action	#11: Audits and technical support	Review extension of EEOA/ Green Start etc	Implement	Operate and report	Operate and report		Review effectiveness	
	#12: Training & skills development	Gap analysis & nominate delivery agencies	Pilot programs	Operate and report	Implement	Review curriculum relevance		
	#14 DE Ombudsman	Consult on role & structure of Ombudsman	Legislate new ombudsman functions	Capacity building of ombudsman office/s	Operate and report			Review and continue subject to outcomes
Streamline and rationalise incentives	#15: Public recognition and awards	Establish framework	Operate and award	Review effectiveness		Continue subject to outcomes		
	#16: DE Fund	Consult on fund level, source & reporting	Establish DE Fund and select projects	Fund projects based on performance	Operate and Report	Shift to funding via network regulation	Review: wind back and refocus Fund	Continue Fund subject to review
	#17: Reform Feed-in-Tariffs	MCE review nat'l streamlining of FiT for small DG	Enact legislation and / or rules	Implement	Operate	Review Effectiveness	Continue subject to net benefits	
Pricing Reforms	#18: Pursue carbon price	Implement	Operate and Report	Set 2020 Emissions target	Transition to Emissions Trading	Operate and Report		Set post 2020 Emissions targets
	#19: Incentivise cost-reflective pricing for networks and customers	Encourage voluntary ToU tariffs	Evaluate and educate re costs & benefits	Monitor and report, recognise best practice	Consider broad rollout with safety net	Review market and consumer impacts		Expand subject to benefit cost analysis
	#20: Establish default network support payments & negotiation framework	Review current practice	Consult on level and structure	Consider rule change if necessary	Operate and Report	Review		Continue subject to review

8 THE ROAD AHEAD: MAKING IT HAPPEN

This Roadmap represents the end of one journey and the beginning of another. The Intelligent Grid research program that supported the development of this Roadmap is now complete, but the Roadmap has just been released. While this Roadmap draws on of three years of research and stakeholder consultation, it is not intended as a final definitive statement of the potential, the challenges and the solutions for DE. Rather, it is intended to provide a detailed, considered and substantiated contribution to the ongoing conversation.

There are two other ways in which the Roadmap marks a new beginning. Firstly, it is hoped that this is just the first in a series of Australian Decentralised Energy Roadmaps over the coming years. For this reason, comments and feedback on the Roadmap are encouraged. Secondly, the Roadmap's researchers and authors are eager to continue to foster the network of hundreds of stakeholders who have contributed to Intelligent Grid research and the development of the Roadmap. We hope to do this through various means including through the continuing research of the CSIRO and our partner universities and through public interest organisations such as the Australian Alliance to Save Energy.

As noted above, this Roadmap is both ambitious and modest. It is bold in that it envisions a fundamental shift towards Decentralised Energy in the Australian electricity sector over the next decade with both declining carbon emissions **and** lower energy bills. It encourages the community and governments to embrace this vision. But the Roadmap is also modest in that it recognises that ideas, data, analysis and policy proposals do not by themselves change the world. Ultimately, the value of this Roadmap will depend on how it is received and applied by the wide range of stakeholders who will influence and guide the evolution of the electricity sector in Australia over the next 10 years.

This Roadmap describes a set of policy steps that can be adopted by government (state and federal), in order to unlock the potential of DE. These policy steps will only be effective if they are embraced by government. And government will only adopt such steps if it is persuaded of their merit and if they are supported by key stakeholders.

No single party can make DE happen. And no single party can stop it. Making DE happen requires a common vision and collaborative spirit. This Roadmap is intended to contribute to shared vision and collaborative spirit.

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APPENDIX 1: DECENTRALISED ENERGY POLICIES AND THE CLEAN ENERGY FUTURES PACKAGE

This appendix provides a brief analysis of where the Decentralised Energy policy actions fit in relation to the currently released Australian Government's Clean Energy Futures Package and other ongoing energy market reform processes.

Policy Package	Policy Recommendation	Where this action fits in relation to Clean Energy Futures Package & other processes
Establish coordination agency	#1: Establish DE coordination agency	Within nominated existing Department
	#7, #10: Collate DE data and produce annual DE review; DE Case Studies	Part of and/or complementary to Energy Efficiency Information Grants.
	#9: Analyse and disseminate accessible information on: network planning	Annual review to be carried out by coordination agency once the reporting/review basis has been established in first issue. Enactment, review and refinement of AEMC Proposed Rule Change from *Review of National Framework for Electricity Distribution Network Planning and Expansion* (completed 2009). NEW: Improve accessibility through mapping (e.g. DANCE, through organisation such as ACCEDE)
	#2, #4: Respond to energy market developments on behalf of DE industry; propose rule changes	New

	#8: Provide national DE advisory service	As part of the Federal Government's Clean Energy Futures Package, a series of advisory services are proposed. This includes money to incorporate energy efficiency and Decentralised energy advice to businesses into existing advice services such as the Low Carbon Australia, Industry Capability Network, Supplier Advocates, Enterprise Connect etc. Additionally, Energy Efficiency information grants will be made available to target small business and community groups. While in the residential sector, the Low Carbon Communities programs will likely include an advisory service. For the large business sector the Energy Efficiency Opportunities Program exists. While these services are useful particularly in mainstreaming information about DE, an additional 'one stop shop' advice service for everyone interested in DE would also be instrumental in supporting the growth of DE in Australia.
Establish national framework for DE delivery	#5: Establish national target for EE #5: Extend retailer white cert schemes in line with national target	The Federal Government's proposed National Energy Savings Initiative (ESI) incorporates these two policies. However, since the ESI is still in proposal form, it will be important that these features remain in the final implemented ESI.
	#6: Establish collaborative targets & reporting for DM (peak demand, energy savings) with Networks	There are number of proposed or existing platforms which the collaborative targets, reporting and fund for DM could be incorporated into. These include: 1. Expanding Low Carbon Communities Programs - by engaging the networks, the total pool of funding could be increased; 2. Clean Energy Finance Corporation - networks could be attracted by the offer of concessional finance;

		3. Energy Security Fund - reducing energy consumption and in particular reducing peak demand is a probably the most cost effective way of ensuring energy security; 4. Energy Efficiency Opportunities Program - particularly with its new focus on electricity networks; and 5. The proposed National Energy Savings Initiative - the partnership could easily become part of the ESI
MCE to initiate regulatory reform processes	#3: Revise the National Electricity Market Objective (NEO) to include environmental objective	In the Federal Government's *Clean Energy Futures Plan* (2011), they identify that: *… the Australian Energy Market Commission will continue its review to identify market and regulatory arrangements that would achieve a more efficient balance between supply and demand for electricity. The Government will work with the Commission on these opportunities for reform.* This is currently very vague. We propose that any course of action to achieve "*a more efficient balance between supply and demand for electricity"* would need to include the specific regulatory reform processes outlined in this Roadmap, and are not sufficiently addressed in existing initiated reviews, such as the AEMC's *Power of Choice - Stage 3 DSP Review*.
	#2: National revenue cap model to decouple network business profits from electricity sales	
	#2: Review AER mandate to better enforce use of DM in planning process	
	#2, #4: Complete & evaluate success of recent AEMC/AEMO reviews (DG connection; network planning)	
Pricing Reforms	#20: Establish default network support payments &	New

	principles/framework for negotiated NS Payments.	
	#19: Cost reflective pricing	Refinement and extension of the process initiated under the MCE's Smart Meter Decision Paper (2008)
	#18: Pursue carbon price	Carbon price is being established through the Government's Clean Energy Futures Package
Streamline and rationalise incentives	#16: Decentralised Energy Fund	While both the Clean Energy Finance Corporation, Australian Renewable Energy Agency (ARENA), the expanded Low Carbon Communities programs, the Remote Indigenous Energy program and the Clean Technology Innovation and Investment programs announced as part of the Federal Government's *Clean Energy Futures* package, will provide funding for a variety of Decentralised energy projects. It will be important to insure that there is not a scale gap in the current incentives, specifically that funding is available for community and medium scale Distributed Generation projects.
	#17: Reform feed-in tariffs	Each state has a different solar PV Feed-in Tariff (FiT) arrangement, from no FiT in NSW to a 30.1c/kWh gross FiT in the ACT. We recommend rationalisation to a 1:1 credit at least for household scale PV systems nation-wide, whereby households get paid the same amount they pay for electricity. This is the approach currently taken in the Northern Territory. This 1:1 credit approach does not translate into a subsidy as excess electricity can be sold at adjacent properties for retail rates.
	#15: Public recognition and awards	New

Other facilitation	#14: Ombudsman	Currently there are Energy and Water Ombudsmen or Energy Ombudsmen in NSW, Victoria, Queensland, Western Australia and Tasmania. However, currently their remit is restricted to resolving disputes between energy customers and their providers. We thus recommend that their remit be expanded to include assist in dispute resolution between Decentralised energy proponents and utilities. Additionally, we suggest that Energy Ombudsmen services be established in the states and territories where they don't currently exist. Alternatively, a Federal Decentralised Energy Ombudsman could be established.
	#12: Training & skills development	As part of the Federal Government's Clean Energy Future Package, a clean energy skills will be developed by the Department of Education, Employment and Workplace Relations (DEEWR). The Decentralised energy training and skills development policy proposed as part of this Roadmap would fit well with this DEEWR program.
	#11: Audits and tech support	The announced extension of the Federal Energy Efficiency Opportunities program to include electricity networks and generators as well as voluntary participation for medium size businesses covers some of this policy option. There are sectors which are currently excluded from receiving audits and technical support. While these remaining sectors could be addressed through of the Low Carbon Communities, Remote Indigenous Energy and Clean Technology Innovation and Investment programs. Care must be taken in refining the detail of these programs to ensure all sectors are eligible for audits and technical support.

APPENDIX 2: OTHER ROADMAP EXAMPLES

Table 5 provides examples of roadmaps that focus on Decentralised Energy, energy efficiency and efficient fuels.

Table 5: Examples of clean energy technology roadmaps and national strategies

Author/organisation	Title of roadmap
IEA	Technology Roadmap - Wind energy (2009) - Solar photovoltaic energy (2010) - Concentrating Solar power (2010) - Smart Grids (2011)
Wyld Group and MMA, 2008	High temperature solar thermal technology Roadmap
Clean Energy Council, 2008	Australian Bioenergy Roadmap
Californian Energy Commission, 2007	Distributed Generation and Cogeneration Policy Roadmap for California
COAG, 2009	National Strategy on Energy Efficiency
Australian Academy of Science	Towards development of an Australian scientific roadmap for the hydrogen economy