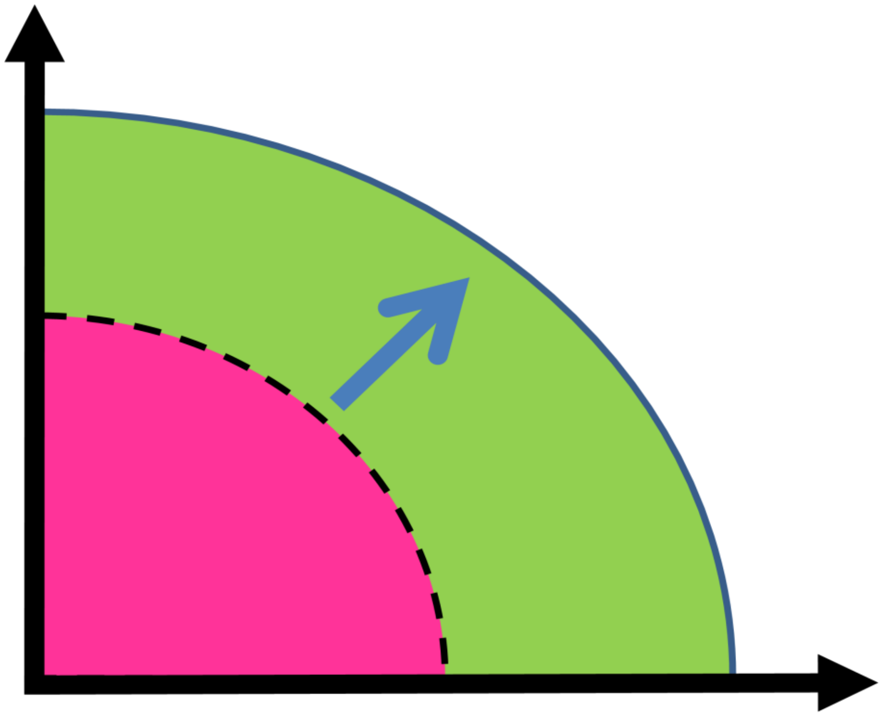
Intelligent Grid Research Cluster - Project 4

Institutional Barriers, Economic Modelling and Stakeholder Engagement

Institutional Barriers to Intelligent Grid



Working Paper 4.1

Version 3: June 2011

Institutional Barriers to Intelligent Grid:

Working Paper 4.1

Intelligent Grid Research Program
Project 4

Authors:

**Chris Dunstan, Jane Daly, Edward Langham,
Louise Boronyak, Jay Rutovitz**

Institute for Sustainable Futures

Intelligent Grid Working Paper Series

Consultation and engagement with stakeholder are key elements of the Intelligent Grid Research Program. In order to encourage dialogue and collaborative learning, this series of working papers is being published during the course of the three-year program. These working papers will be revised and reissued from time to time as the research and consultation proceeds. Stakeholders are invited to comment on and contribute to the development of these working papers. At the conclusion of the Research Program, the working papers will be formalised as final reports.

At the time of writing, the proposed working papers include:

4.1	Institutional Barriers to Intelligent Grid	(Version 1 published June 2009)
4.2	20 Policy Tools for Developing Distributed Energy	(Version 1 published November 2009)
4.3	Evaluating Costs of Distributed Energy	(Version 1 published November 2009)
4.4	Evaluating Avoidable Network Costs	(Version 1 published June 2011)
4.5	Stakeholder Consultation Report	(Version 1 published June 2011)
Final	Australian Distributed Energy Roadmap	(Version 1 to be published July 2011)

Submissions invited

This report is a working paper. We invite feedback and suggested improvements that we can consider in drafting subsequent versions of the document. In order to comment on this or other working papers, please email: 1 or refer to the Intelligent Grid website: www.igrid.net.au

Table of Contents

Executive Summary

The Intelligent Grid (iGrid) Research Program is a three-year collaborative research venture between the CSIRO and five leading Australian universities under the CSIRO Energy Transformed Flagship. Its aim is to elaborate the economic, environmental and social impacts and benefits of the large-scale deployment of intelligent grid technologies in Australian electricity networks. The research program is an interdisciplinary venture that complements other research being undertaken through the Energy Transformed Flagship. It brings together engineers, economists, social scientists, systems scientists and policy scientists to develop integrated insights that could not be achieved by working separately.

This working paper introduces the Intelligent Grid, a system of low-emission, distributed energy technologies and advanced electricity network control systems which aims to transform the sustainability of the electricity sector. At a time when the twin challenges of climate change and energy security demand a shift away from an electricity sector based on large-scale fossil fuel power stations and transmission networks, the Intelligent Grid is a desirable alternative. The working paper provides and overview of the significant benefits which could result from the implementation of the Intelligent Grid, namely:

1. Improved economic efficiency, with lower overall cost of energy services,
2. Lower greenhouse gas emissions, and
3. Improved reliability of electricity supply, with improved energy security.

Electricity consumers, network providers, and the environment may all benefit from the establishment of an Intelligent Grid. However, these benefits do not automatically result from Intelligent Grid implementation, unless policy development is specifically geared to ensure these outcomes. For example, the improved economic efficiency offered by Intelligent Grids can benefit the environment provided that implementation is linked to simultaneously reducing carbon emissions.

This working paper also provides an overview of typical barriers to the Intelligent Grid. A simplified classification of seven institutional barriers to distributed energy is proposed:

1. Imperfect information – lack of access to relevant information
2. Split incentives – the challenge of capturing benefits spread across numerous stakeholders
3. Payback gap – the gap in acceptable payback periods between energy consumers and suppliers
4. Inefficient pricing – failure to reflect costs (including environmental costs) properly in energy prices
5. Regulatory barriers – the biasing of regulation against distributed energy resources
6. Cultural values – insufficient attention given by individuals and organisations to energy use
7. Combined effects – the additional barriers created by the interplay of the other six types of barriers

The discussion of market transformation is informed by a view that markets are shaped as much by conscious and unconscious social factors as by technical factors, and are therefore amenable to a range of deliberate strategies for change. Some policy options for moving the market are introduced in the form of a “Policy Palette” in section 6. The categories of policy options include: regulation, incentives and information as the primary drivers, complemented by secondary drivers of targets, facilitation and pricing.

Abbreviations

AER	Australian Energy Regulator
CHP	Combined heat and Power
CSIRO	Australian Commonwealth Scientific and Industrial Research Organisation
DANCE	Dynamic Avoidable Network Cost Evaluation (Model)
D-CODE	Description and Costs of Distributed Energy (Model)
DE	Distributed Energy
DG	Distributed Generation
DM	Demand Management
ESAA	Energy Supply Association of Australia
EWEA	European Wind Energy Association
IEA	International Energy Agency
iGrid	Intelligent Grid
IPCC	Intergovernmental Panel on Climate Change
MMA	McLennan Magasanik Associates
R&D	Research and Development

1. Background

The interlinked challenges of climate change and energy security are prompting a shift away from an electricity sector based on large-scale, fossil fuel power stations and transmission networks. In its place, is the emerging potential of an "Intelligent Grid" that will use low-emission, distributed energy (DE) technologies and advanced electricity network control systems to transform the sustainability of the electricity sector.

The Intelligent Grid (iGrid) Research Program is a three-year collaborative research venture between the CSIRO and five leading Australian universities under the CSIRO Energy Transformed Flagship. Its aim is to elaborate the economic, environmental and social impacts and benefits of the large-scale deployment of intelligent grid technologies in Australian electricity networks. The research program is an interdisciplinary venture that complements other research being undertaken through the Energy Transformed Flagship. It brings together engineers, economists, social scientists, systems scientists and policy scientists to develop integrated insights that could not be achieved by working separately.

The Structure of the iGrid research program is illustrated below and how Project 4, which focuses on Institutional Barriers, Stakeholder Engagement and Economic Modelling fits into the wider program context. This Working Paper forms part of the Institutional Barriers work of Project 4. For more details about the iGrid Research Program please refer to the iGrid website www.igrid.net.au.

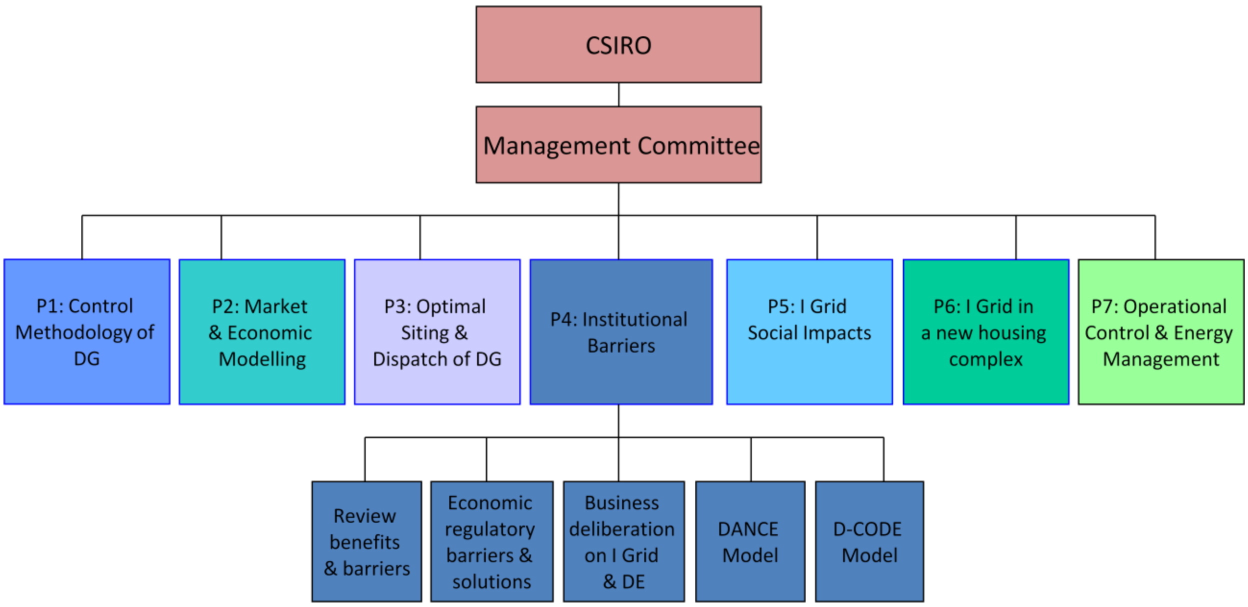


Figure 1: iGrid Research Program Structure

1.1 Introduction

The terms "Intelligent Grid" and "Smart Grid" have become such catchphrases over the past few years that care needs to be taken to clearly define their meaning. For the purposes of the research program, the "Intelligent Grid" is refers to an electricity network that uses "distributed energy" resources and advanced communication and control technologies to deliver electricity more cost-effectively, with lower greenhouse intensity than the current electricity supply mix, while being responsive to consumer needs. (Note that the term "iGrid" is used in this paper to refer to the Intelligent Grid *research program* itself.)

In this context, the term "distributed energy," means electricity generation and management of energy use applied at the consumer or distribution network level. It includes distributed generation, load management and energy efficiency options. Distributed generation refers to an array of technologies and can include solar panels, wind turbines (but not those connected to the high voltage transmission network), micro turbines, fuel cells and cogeneration (combined heat and power). These types of energy resources can generally be located closer to the users than large centralised sources. Some distributed energy resources rely on renewable energy with no greenhouse emissions and others make more efficient use of fossil fuels. For example, distributed energy resources could involve heating, cooling and powering a commercial building using a combination of solar panels, micro turbines, fuel cells, energy efficiency and load control.

Advanced types of control and management technologies can also make the electricity grid run more efficiently overall. The widespread deployment of distributed energy resources 'requires a smart, interactive infrastructure, including a range of solutions that can be integrated all along the distribution system'(EPRI, 2007, p. 3-1). Reductions in energy consumption and CO_2 emissions can be achieved through 'greater synergy…between energy consuming and producing devices and the electrical distribution system'(EPRI, 2007, p. 3-1). For example, this could be achieved with the use of advanced control systems and "smart" electricity meters that show real-time use and costs and can respond to remote communication and dynamic electricity pricing.

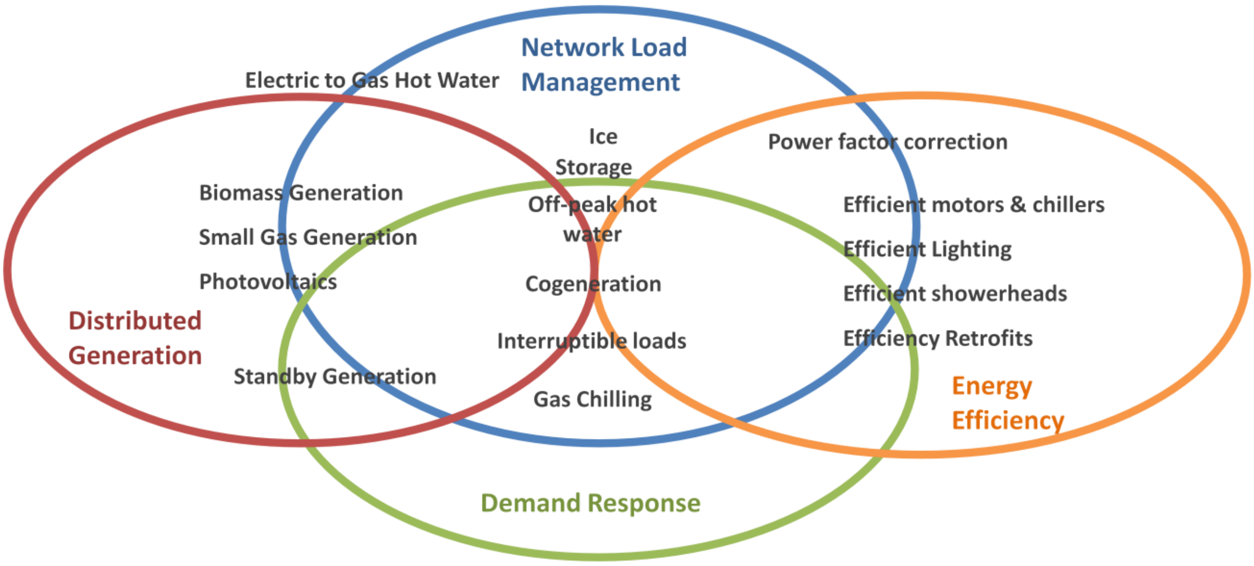


Figure 2: Some Distributed Energy Resources (adapted from IPART, 2002, p. 102)

1.2 Purpose of this Working Paper

One element of Project 4 is to improve understanding of the institutional barriers to establishment of the intelligent grid. This Working Paper is aimed at improving this understanding. A literature review of the barriers to distributed energy and intelligent grid has been undertaken and is summarised in Section 3 of this Working Paper.

The purpose of the Working Paper is:

1. to propose a simple, practical classification of institutional barriers to the use of distributed energy technologies in the context of an intelligent grid;
2. to briefly consider the alignment of policy responses to address these institutional barriers; and
3. to highlight the benefits of an intelligent grid and the role that Distributed Energy technologies will play in facilitating a transition to a low carbon economy;
4. to invite feedback from stakeholders on the issue of institutional barriers.

Feedback on this Working Paper will be used:

1. in drafting the final report on institutional barriers and benefits of the intelligent grid, which is one of the outputs of the iGrid research program; and
2. as an input to further research within the iGrid research program.

1.3 The structure of this Working Paper

The remainder of this Working Paper is structured as follows:

- Section 2 explores the benefits of an intelligent grid;
- Section 3 discusses some of the issues relating to barriers to intelligent grid and distributed energy;
- Section 4 reviews the literature of institutional barriers to distributed energy;
- Section 5 introduces a proposed systematic classification of institutional barriers; and
- Section 6 considers policy implications of this classification of institutional barriers and proposes a parallel classification of policy responses.

2. Benefits of an Intelligent Grid

Intelligent Grids have the potential to provide energy consumers, utilities and the environment with a number of benefits. Potential benefits of distributed energy resources that have been identified may be summarised as:

- Improved economic efficiency, with lower overall cost of energy services, because of:
    - An overall increased fuel efficiency, resulting from the use of 'waste' heat in cogeneration or trigeneration, reduced transmission losses, and Increased end use energy efficiency,
    - Reduced peak load and peak load growth resulting in reduced and optimised network investment, and
    - Two way communication with customers enabling cost sensitive pricing and active energy management, including remote switching of customer loads to mange peak demands.
- Lower greenhouse gas emissions, because of:
    - An overall increase in fuel efficiency,
    - The potential for higher penetration of low carbon intermittent energy sources, and
    - 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, and
    - Improved system ancillary services, such as black start capability and spinning reserves.

The major benefits are outlined in greater detail in the following sections.

Greater consumer choice is also a potential outcome of the Intelligent Grid as communities are provided with choice in the technologies that are generating their energy needs (NRECA, 2007). Customers may generate their own power wholly or partly, or choose from an increased number of types of power products purchased from the grid. Greater visibility of distributed energy resources within communities can increase awareness which might drive 'change in social attitudes and, in turn, more efficient use of…energy resources' (OFGEM, 2007, p. 3). In addition, increased competition within energy markets, and the associated consumer benefits that result, may be achieved through the greater uptake of distributed generation. As OGFEM note, 'If DG technologies are able to compete freely alongside centralised, larger scale methods of generation this increases the competitive pressure faced by the established businesses in the sector' (OFGEM, 2007, p. 25).

The major benefits are mapped to three major recipient groups, energy consumers, utilities, and the environment, in the figure below. However, all of these benefits will not automatically flow from Intelligent Grids, unless policy development is specifically geared to ensure these outcomes. For example, the improved economic efficiency offered by Intelligent Grids can benefit the environment provided that implementation is linked to simultaneously reducing carbon emissions. An overview of the policies available to ensure that intelligent grids are enabled and deliver the range of consumer and environmental benefits is given in section 6.

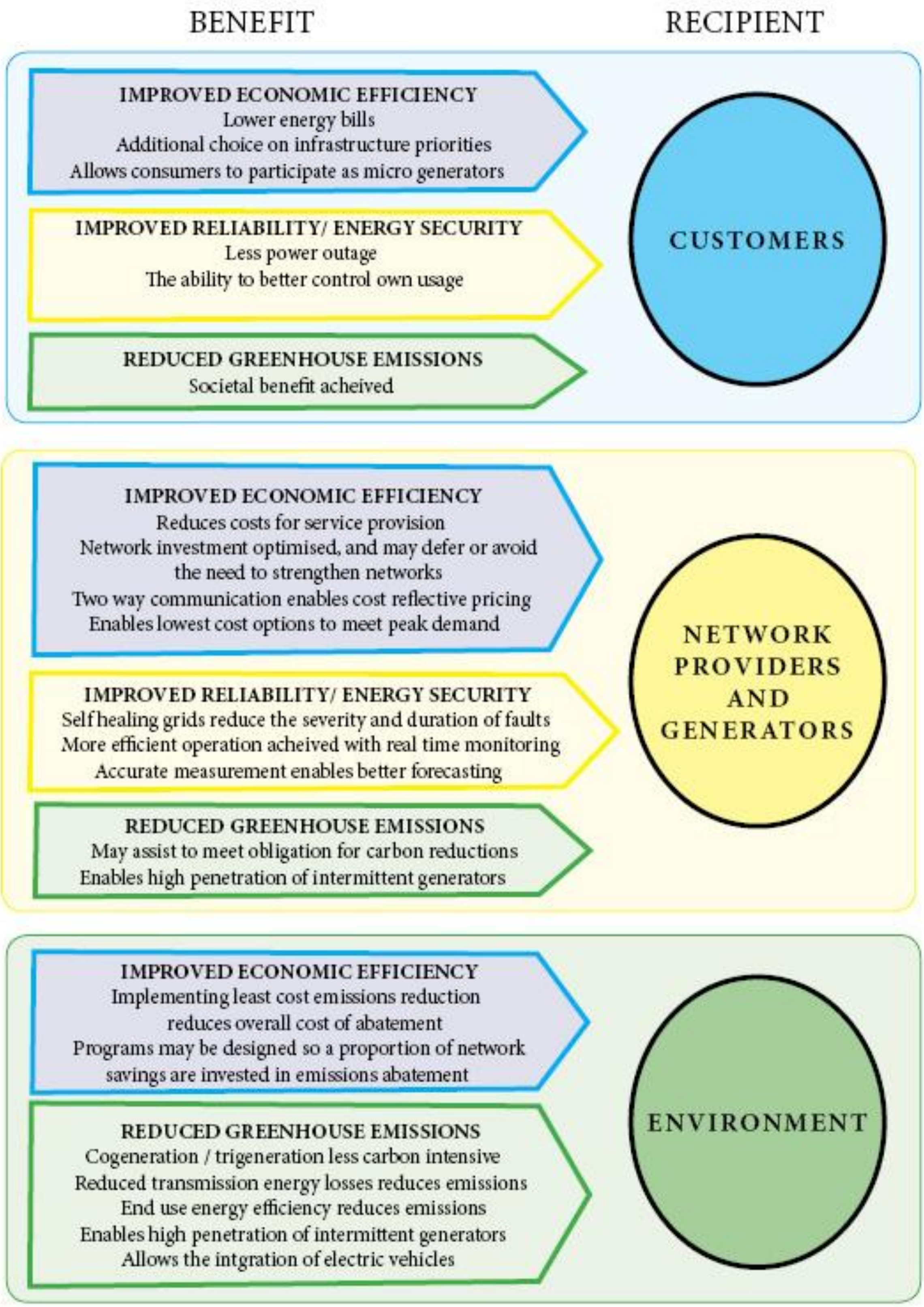


Figure 3: Benefits and beneficiaries of the Intelligent Grid

2.1 Improved economic efficiency

2.1.1 The potential to reduce overall societal energy costs

The integration of DE technologies in a smarter electricity grid provides a way to deliver a flexible energy supply in a more cost effective way. Numerous studies have concluded that there is a large potential for cost effective deployment of distributed energy, although there are significant barriers to uptake. One such study by McKinsey and Company (2007, p. xii) found that 'almost 40 percent of abatement could be achieved at "negative" marginal costs, meaning that investing in these options would generate positive economic returns over their lifecycle. While the McKinsey study was focused on emissions abatement, options with a negative cost must by definition also offer savings for energy service provision. A similar study undertaken by Climate Works Australia (2010, p. 13) concluded that 71 million tons abatement (30% 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.

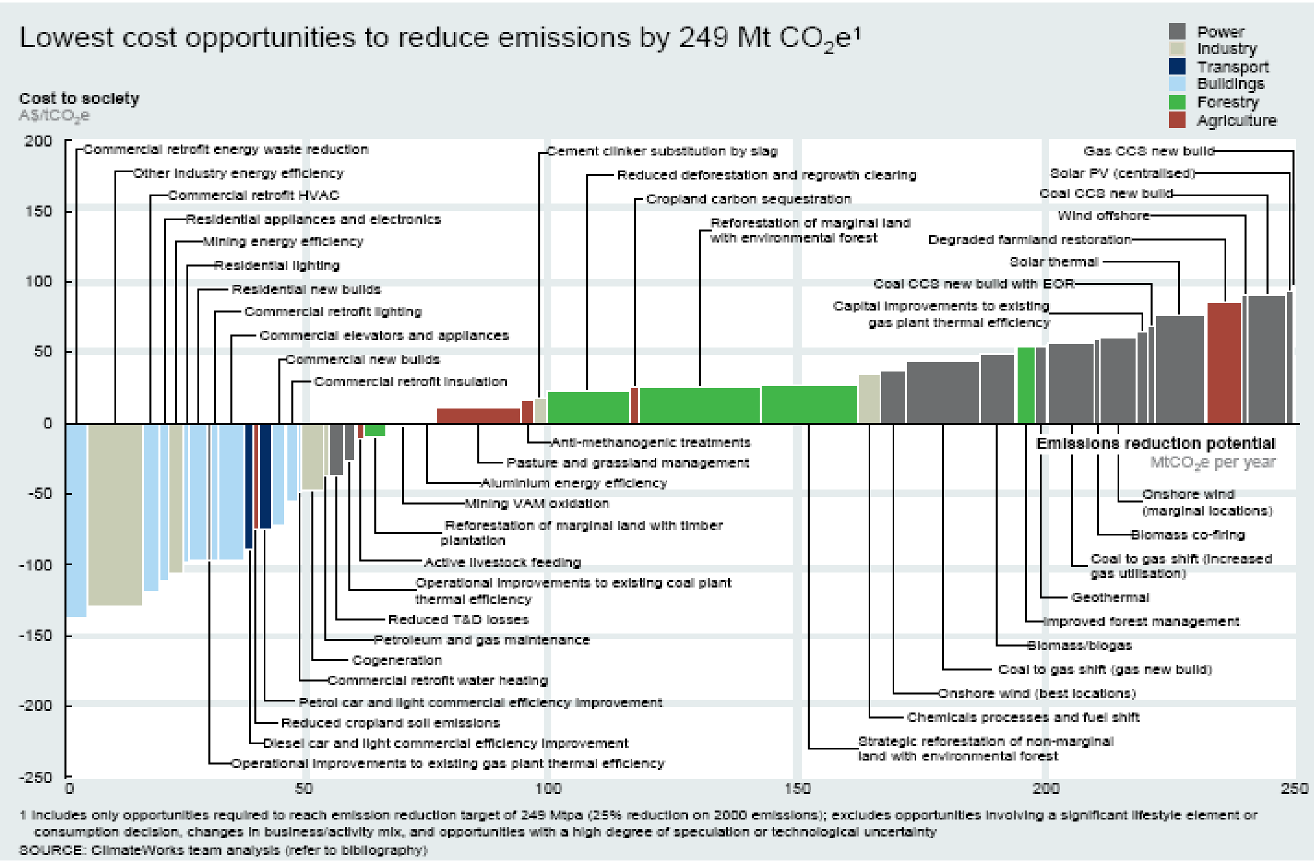


Figure 3: Greenhouse Gas Emission Reduction Potential (ClimateWorks 2010, p.10)

Figure 3 illustrates the potential for greenhouse emissions reduction in Australia by 2020, as assessed by Climate Works Australia. More than 70% of these "negative cost" options are distributed energy resources.

This equates to a net societal benefit of at least $3.8 billion from implementing distributed energy options, according to Climate Works Australia's calculations (Climate Works Australia, 2010 , p. 48, 63, & 64).[1]

Modelling of the National Electricity Market under the CSIRO Energy Transformed Flagships program has also shown distributed generation can significantly improve the economics of carbon abatement (Lilley, Szatow et al., 2009) . The study examined the cost of energy scenarios consistent with reaching 450 ppm atmospheric carbon, and found an estimated benefit for using DE technologies of $800 billion between now and 2050, with a net present value of $130bn (Lilley, Szatow et al., 2009, p. 10-11).

Pepermans et al. (2005, p. 788) discuss the flexibility that distributed generation offers in 'operation, size and expandability' and how distributed generation can serve as a hedge against electricity market price fluctuations. Facility managers can achieve fast payback of their DE investments through careful scheduling (Engle, 2006).

There are, of course, also costs associated with the use of distributed energy. The costs of DE are a focus of iGrid Project 4's Working Paper 4.3, released in November 2009. As studies such as that of Climate Works and iGrid research program suggest, the societal benefits outweigh the costs for many applications of DE, so there is a large amount of unrealised cost-effective DE potential. If the benefits of creating an intelligent grid with widespread use of distributed energy technologies are so substantial, what is preventing this from being achieved? What are the barriers? These questions are the focus of section 3.

2.1.2 Deferred or avoided infrastructure augmentation costs and optimised network investment

One of the key advantages of DE is the ability to defer or avoid the network infrastructure augmentation required to service rising peak demand. This is expected to cost $15 billion dollars across Australia between 2010 and 2015, or one third or the total projected spending on networks (Langham, Dunstan et al., in press).

Distributed energy supplies reduce the requirement to augment the transmission and distribution system because the energy source is situated locally relative to where it is needed. This is supported by the Office of Gas and Electricity Markets (OFGEM) in the UK who notes that distributed generation may be able to offer 'transmission and distribution cost savings for the UK by reducing or, in some situations, avoiding completely the costs incurred in reinforcing these networks' (OFGEM, 2007, p. 17). Transmission and distribution companies can use DE to substitute for investments in transmission and distribution capacity (Pepermans et al. 2005; Engle 2006; OFGEM 2007).

Energy efficiency reduces fuel use, but also reduces the requirement for network augmentation to the extent that it reduces peak loads. One study found that even moderate building energy efficiency could reduce network augmentation costs by $8 billion over five years (Langham, Dunstan et al., 2010, p. 83).

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

Demand side response (DSR) refers to a suite of measures specifically aimed at shifting loads from away from the peaks. It includes paying large customers, or aggregated small customers, to reduce their usage in critical times for a small number of hours per year for a contracted price, and smart appliances that can be controlled remotely by the consumer or the network operator, or operate in response to price signals. DSR can be extremely cost effective compared to network augmentation,

2.1.3 Two way communication with customers

One element of the Intelligent grid is advanced metering infrastructure (AMI). AMI has several key features, including the ability for real-time two-way communications via 'smart meters', and the capacity to remotely switch devices on and off, including generation units and energy using devices or circuits (van Gerwen, Jaarsma et al., 2006). 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).

Two way communications enable distributed generators to respond to energy price variations, acting as primary or secondary power suppliers during peak load events (Engle, 2006). Demand side response providers are also facilitated by AMI.

If smart meters are integrated into the system there are immediate benefits for utilities through meter reading cost savings, as well as gaining detailed information that enables better total and peak demand forecasting and enhanced detection of demand anomalies (van Gerwen, Jaarsma et al., 2006).

Smart or advanced metering in an Intelligent Grid can additionally help consumers better understand, monitor and control how energy is used in their home. In order to accelerate the penetration of smart meters and enable consumers to better manage their overall energy use, the Swedish government has required grid companies to provide monthly meter readings to all customers by 2009 (van Gerwen, Jaarsma et al., 2006).

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. Additionally, with the further development of smart appliances, consumers may allow utility providers to communicate remotely with their devices (e.g. electric car battery charger or high demand equipment such as a air conditioning units) to stop or reduce power consumption during expensive peak periods.

There have been concerns raised that TOU pricing could result in costs to consumers who are unable to shift peak demands, raising serious equity concerns for governments considering such pricing reforms (Johnston, 2010; Sachdeva and Wallis, 2010). In response to these concerns, the Victorian Government placed a moratorium on the extension of TOU pricing in March 2010, pending a review of these issues. On the other hand, there can also be serious equity consequences from not controlling peak demand and simply building expensive new supply capacity to meet growing demand. Moreover, targeted energy efficiency programs can play a significant role in easing the burden on disadvantaged consumers, as low-income households generally have less energy efficient housing and appliances, and have less access to capital to upgrade. (Sachdeva and Wallis, 2010, p. 11)

2.2 Reduced greenhouse gas emissions

The key environmental benefit the Intelligent Grid offers is a potential reduction in greenhouse gas emissions. This may be delivered via three main avenues:

- Emissions can be reduced directly by the utilisation of low-carbon distributed generation, energy efficiency, local renewable technologies, demand management and switching fuel sources toward cleaner options. Energy efficiency in particular directly reduces emissions associated with energy services, and as highlighted above, can deliver large amounts of negative cost abatement.
- Deployment of Intelligent Grids can significantly reduce the overall cost of emissions reduction, particularly if policies are for carbon reduction and iGrid development are linked.
- Intelligent Grids can enable high penetrations of large scale intermittent renewable energy sources, such as wind, and will be increasingly required as more challenging emission targets are set.

2.2.1 Direct emission reduction

The potential of energy efficiency is large: in the United States, the Electric Power Research Institute (EPRI), an independent, non-profit organisation for public interest energy and environmental research, projects that by reducing inefficiencies in the existing power grid alone, Smart Grid-enabled electrical distribution could reduce electrical energy consumption by 5 to 10 percent and carbon dioxide emissions by 13 to 25 percent (EPRI 2007). In Australia, Climate Works estimate that 71 million tons of greenhouse gas emission reduction can be achieved, with approximately 70% of this is energy efficiency initiatives (Climate Works Australia, 2010).

Reducing energy consumption by using energy more efficiency 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). As distributed energy is inherently decentralised or *localised*, it eliminates transmission losses from electricity otherwise sourced from distant generation plants (Pepermans et al. 2005; Engle 2006; OFGEM 2007; US Department of Energy 2007). The current conservative estimate for distribution losses in Australia is 5.1% of sent out energy (Energy Supply Association of Autralia, 2009, p. 28), so there is potential for significant carbon savings. Reducing total energy consumption through smart metering and demand response systems, will also lead to a reduction in emissions from fossil fuel power plants, thus benefiting the environment.

Technologies such as cogeneration (also called combined heat and power, or CHP) can greatly increase the efficiency of producing electricity and heat, as the 'waste heat' from generation can be used for meeting heating and cooling (Engle, 2006). Depending on the size and efficiency of cogeneration units, CHP generation may result in primary energy fuel efficiencies of more than 70% (Lilley, Szatow et al., 2009, p. 95), compared to 35% - 45% efficiency achieved in conventional centralised fossil fuel generation. Evaluating the impact of tri-generation is more complex, as the alternate cooling strategy may use reverse-cycle compression units, with coefficient of performance (COP) of 6 -7 common for large commercial units (a unit with a COP of 6 produces 6 units of cooling for 1 unit of energy) (Lilley, Szatow et al., 2009, p. 95). However, it is generally accepted that cogeneration / trigeneration units have fuel use efficiency of 60% or greater.

2.2.2 Making carbon reduction cost effective

Not all elements of Intelligent Grid development reduce emissions, for example load shifting may achieve considerable economic savings through avoided network costs, but can in some situations increase emissions by shifting demand away from more expensive but less carbon intensive generation. However, Intelligent Grid deployment is most effectively undertaken as a package. Provided policies for the development of Intelligent Grids are linked to carbon reduction policies, a proportion of the investment in network augmentation to meet peak load can be switched to the development of cleaner energy supplies (including energy efficiency), so that carbon reduction targets can be achieved with overall cost savings.

2.2.3 Enabling renewable technologies

In Australia, the federal Renewable Energy Target (RET) require 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 per cent 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 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). In 2010 only 8.7% of the total electrical power generated was from renewable sources with the remaining 91.3% generated from coal or gas (Clean Energy Council, 2010).

The Small-scale Renewable Scheme (SRES) includes solar PV, small wind systems, and solar water heating and provides significant incentives for distributed energy solutions. These technologies are installed close to where the energy is consumed, thereby reducing energy losses (Ipakchi & Albuyeh 2009). Solar water heating is one well-established means to reduce both emissions and peak loads. Solar PV can also play an important role in peak load reduction, provided it is installed in areas where there is a non-residential load (Watt et al, 2006). That is, where network peak demand corresponds more closely with, for example, commercial air conditioning loads that occur during the middle of the day to early afternoon.

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 distributed 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 and Dunstan, 2010).

While nationally Australia is still well short of the variable renewable energy penetration levels that warrant grid integration concerns, within some network areas such as South Australia – which in 2009 had installed wind power at 20% of total registered capacity (AGL, WWF et al., 2006, p.56) – could become a limiting factor without rapid development of intelligent grids. 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 no 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 benefits of variable renewable generators.

2.3 Improved reliability of electricity supply and energy security

Distributed generation technologies can achieve improved energy security because the impacts of distributed generation plant failures are lower and less widespread than the impacts of failure of large scale centralised systems. In addition, DE 'can also be used to decrease the vulnerability of the electric system to threats from terrorist attacks, and other forms of potentially catastrophic disruptions, and to increase the resiliency of other critical infrastructure sectors' (US Department of Energy, 2007, p. 4) as can diversifying generation fuels (Lovins, 2002).

An intelligent grid has the potential to facilitate large and flexible sources for distributed energy, and to coordinate available DE resources using a comprehensive monitoring, communications and control network. This would enable the grid to effectively become "self healing" through anticipating and instantly responding to system loads or faults, and avoid or mitigate power outages and system damage (Microplanet 2010).

An Intelligent grid with strong integration of distributed energy is inherently decentralised or *localised*, enabling greater end use efficiency and peak load management. Generation located near 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, p. 16).

Distributed energy poses challenges as well, as two way energy flow of households with solar installations can cause integration problems for existing local distribution network infrastructure which was intended to only handle one way energy flows. This can lead to inefficient use of infrastructure. For example, the current practice of shutting down solar PV systems when there is an "upstream" supply interruption needs to be addressed, especially where there is sufficient generation by the PV capacity to meet local demand. A well designed Intelligent Grid can achieve integration, perhaps using new protection and control strategies. It can potentially improve distribution automation to facilitate micro-grid functions, such as homes operating independently of the electricity grid, or voltage management of the local grid in general (Horgan & Dunstan, 2010).

3. Barriers to Intelligent Grid

3.1 Technical vs. Institutional Barriers

As will be discussed in Section 3, there are numerous ways to analyse and classify barriers to intelligent grid and distributed energy. As the iGrid Research program is particularly concerned with supporting distributed energy resources that are already technologically and economically viable, this Working Paper makes a fundamental distinction between technical barriers and institutional barriers.

Technical barriers relate to the characteristics of the distributed energy resources themselves – that is, their technological characteristics – what they do; and their economic characteristics – what they cost. Institutional barriers refer to the barriers that exist in how humans relate to the distributed energy resource, through laws and regulations, and through values and culture.

Consider the following example from the United States described by Koomey et al (cited in Brown, 2001, p. 1198):

> Efficient magnetic ballasts for fluorescent lighting were commercially available as early as 1976. They were a well-tested technology, with performance characteristics equal to or better than standard ballasts by the early 1980s. By 1987, five states – including California and New York – had prohibited the sale of standard ballasts. But the remaining three-quarters of the population chose standard ballasts over efficient ballasts by a ratio of 10-to-1, even though the efficient magnetic ballast paid back its investment in less than two years for virtually all commercial buildings (Koomey et al., 1996). The time required to establish retail distribution service networks and to gain consumer confidence are typical causes of slow innovation diffusions such as this. (Since 1990, federal standards have prohibited the sale of the standard ballast).

In this example, the distributed energy technology was technically proven and economically attractive but was not being adopted. Although it is possible that the free operation of the market would have eventually led to the elimination of the less efficient option, in this case the understanding of the institutional barriers led to the federal policy response of banning standard magnetic ballasts. This delivered an outcome that was both economically and environmentally superior.

Figure 4 below provides a conceptual framework for describing the relationship between technical and institutional barriers. As illustrated, there exists an optimum range of technologically possible and economically feasible outcomes that are limited by technical barriers. According to this framework, collective and individual judgements must be made relating to the balance between economic outcomes on the one hand and environmental and social outcomes on the other. However, it is crucial to recognise that we have the potential to achieve better outcomes in all three of these dimensions – economic, social and environmental – if we are able to reduce the institutional barriers that currently obstruct us from attaining "best practice".

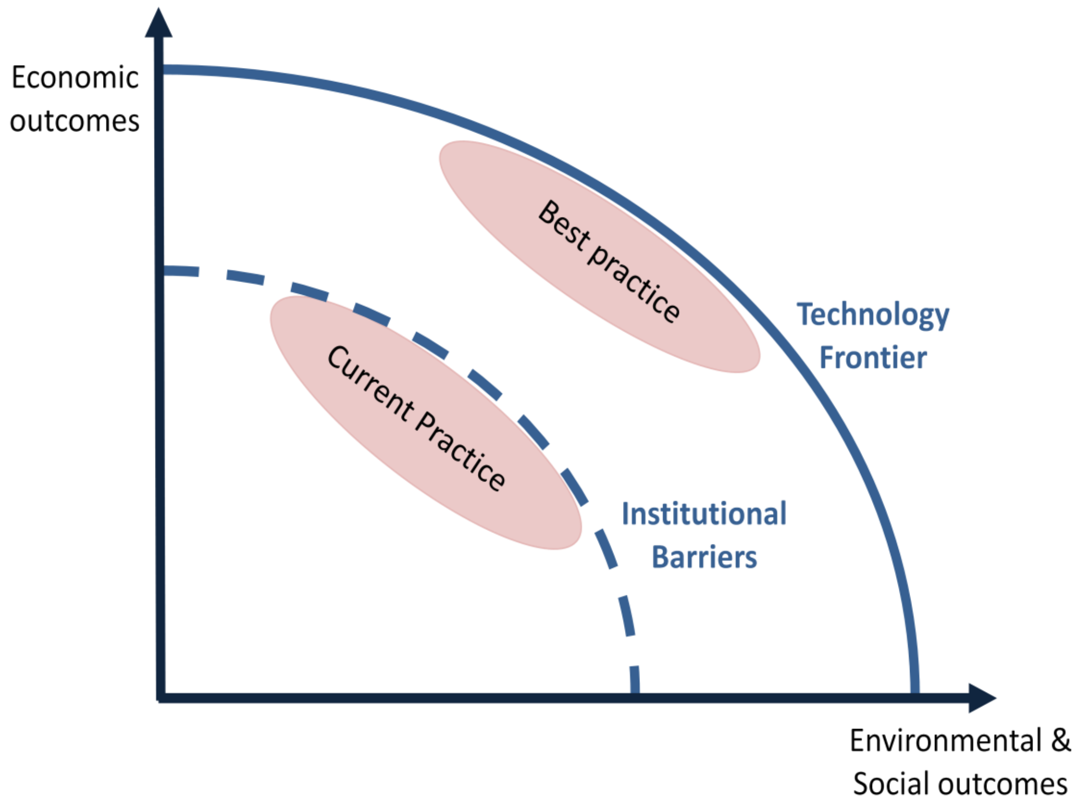


Figure 4: Conceptual Framework for Institutional Barriers to Distributed Energy

3.2 Energy policy decision making

3.2.1 Market Failures

A market failure occurs where there is a flaw in the way a market operates. The Australian Government Best Practice Regulation Handbook (2007, p.x) defines a market failure as 'a situation in which the free market fails to generate an efficient outcome or maximise net benefits'.

A market failure might occur where there are 'conditions of a market that violate one or more of the neoclassical economic assumptions that define an ideal market for products and services such as rational behaviour, costless transactions, and perfect information'(Brown, 2001, p. 1199). Brown explains that market failures arise due to: '(1) misplaced incentives; (2) distortionary fiscal and regulatory policies; (3) unpriced costs or externalities; (4) unpriced public goods or benefits; and (5) insufficient and incorrect information' (Jaffe & Stavins 1994; IPCC 1996; cited by Brown, 2001, p. 1199).

Fisher and Rothkopf (1989, p.405) explore how market failures distort the efficient allocation of resources in the energy sector and suggest activities for government on the basis of those market failures; the market failures being:

> (1) National security – inadequate incentive to individual importer to restrict oil imports;
> (2) Environmental quality – no incentive to protect environment;
> (3) Increasing returns – natural monopoly;
> (4) New technology – spillovers from research, downstream market failures;

(5) Residential conservation – inability of low-income consumers to finance;
(6) Landlord/tenant – inadequate incentives for either party to conserve;
(7) Non-renewable resources – private market discount rate too high; and
(8) Transaction costs – inadequate or hard-to-use information on energy efficiency.

Energy policy decision making has to date been largely aimed at addressing market failures. Government regulatory action can typically be justified provided a market failure can be demonstrated to policy makers. In the current Australian political culture, identifying a significant market failure is often seen as an essential condition for receiving a “licence” to intervene in the market.

3.2.2 Market barriers

While market failures usually justify government policy intervention, there are however additional circumstances where government intervention may be warranted. That is, where additional market barriers exist. As the International Energy Agency (IEA) (2005, p.24)) explains, market barriers ‘are not market failures, but limit the adoption of energy efficiency measures nonetheless’.

Brown discusses several market barriers, which may not be considered market failures, ‘but which nonetheless contribute to the slow diffusion and adoption of energy efficiency innovations…these include: (1) the low priority of energy issues, (2) capital market imperfections, and (3) incomplete markets for energy-efficient features and products’ (Jaffe & Stavins 1994; Hirst & Brown 1990; Levine et al 1995, and US Department of Energy, Office of Policy and International Affairs 1996b; cited in Brown, 2001, p. 1199).

It is important to note however, that throughout the barriers literature, there is some debate surrounding the market barriers concept. Some commentators question whether market barriers can provide a reasonable justification for government policy interventions. For example, some economists have viewed the market barriers concept as lacking a sound economic basis, believing that the concept ‘has not been developed in terms of well established economic concepts or using standard economic techniques’ (Sanstad and Howarth, 1994, p. 811). As a result, as Sanstad and Howarth (1994, p. 811-812) explain, the conclusions are generally that, ‘with a few narrow exceptions, the market barriers concept is inappropriate for energy policy and that there is little reason to believe that markets for energy services are economically inefficient’.

An example of this view can be found in Sutherland (1991, p. 15) who argues that ‘some market barriers are simply characteristics of the normal functioning of markets – even perfectly competitive markets’ and that ‘most of the market barriers are not “market failures”, if market failures are the appropriate analytical foundation for government policy’. According to Sutherland (1991, p. 15), reducing market barriers ‘will not appreciably encourage conservation investments nor will resources be allocated more efficiently’ and ‘conservation policies, such as appliance standards, that are based on the assumption of market barriers, may adversely affect economic efficiency’.

Despite this scepticism surrounding the market barriers concept, others present the view that the existence of *either* market failures or market barriers can warrant government policy interventions. As Brown (2001, p. 1203) concludes ‘the existence of market failures and barriers that inhibit socially optimal levels of investment in energy efficiency is the primary reason for considering public policy interventions’.

The opponent's of the market barriers concept appear to base their view on the assumption that markets are normally efficient. As Sanstad and Howarth (1994, p. 811) explain:

> The conventional distinction between 'economic' and 'engineering' approaches to energy analysis obscures key methodological issues concerning the measurement of the costs and benefits of policies to promote the adoption of energy-efficiency technologies. The engineering approach is in fact based upon firm economic foundations: the principle of lifecycle cost minimisation that arises directly from the theory of rational investment. Thus, evidence that so-called 'market barriers' impede the adoption of cost-effective energy-efficient technologies implies the existence of market failures as defined in the context of microeconomic theory. Problems of imperfect information and bounded rationality on the part of consumers, for example, may lead real world outcomes to deviate from the dictates of efficient resource allocation. A widely held contrary view, that the engineering view lacks economic justification, is based on the fallacy that markets are 'normally' efficient.

Sanstad and Howarth (1994, p.812) further argue that 'the equation of normal and efficient markets is a fallacy that can only serve to distort energy policy analysis'. They argue that 'in light of contemporary theory, the intuitions expressed by the market barriers concept may in fact be closer to the theoretical mainstream than the views of the skeptics' (Sanstad and Howarth, 1994, p. 812).

On this basis, Sanstad and Howarth (1994, p. 814-816) discuss key market imperfections such as (1) the existing regulatory environment, (2) imperfect information, (3) asymmetric information, (4) transaction costs, (5) imperfections in capital markets and (6) bounded rationality in energy decisions.

This working paper takes the view that market barriers do exist and that a range of regulatory and policy responses are available, appropriate, and necessary to achieve improved market conditions for distributed energy. Recognition of these market barriers and application of appropriate policy responses is necessary for achieving the vision of the Intelligent Grid.

4. Overview of Research on Institutional Barriers

Institutional barriers to distributed energy have been discussed for some time. The benefits of addressing the barriers have also been discussed in countless government reports, inquiries, independent studies and in the academic literature. What is clear from the literature is that classification models of institutional barriers appear diverse and relatively unstructured. Furthermore, disagreement remains among analysts over whether an institutional barrier warrants policy interventions if it cannot also be classed as a 'market failure'.

Shortly after the first oil price shocks of the early 1970s, Amory Lovins articulated a new alternative vision for energy policy in 1976 in the influential paper *Energy Strategy: The Road Not Taken* (Lovins, 1976). Lovins introduced the concept of energy efficiency: 'using less energy to produce more economic output' (Golove and Eto, 1996, p. 6). Soon after Lovins' publication, the ideas he presented on energy efficiency began to have a significant impact on energy policy (Golove and Eto, 1996).

The concept Lovins introduced, 'coupled with the review of the apparently highly inefficient use of energy by society at the time, led to a conclusion that the market alone was not working to provide the most desirable social outcome'(Golove and Eto, 1996, p.6).

The ideas that followed about energy efficiency 'were often expressed as questions about the existence and magnitude of an efficiency gap' which 'refers to the difference between levels of investment in energy efficiency that appears to be cost effective based on engineering-economic analysis and the (lower) levels actually occurring'(Golove & Eto 1996, p. 6; SERI 1981 cited in Golove and Eto, 1996, p. 6).

The significant gap between current and optimum levels of energy efficiency was thought to exist because 'for a variety of reasons, households, businesses, manufacturers, and government agencies all fail to take full advantage of cost-effective, energy-conserving opportunities' (Hirst and Brown, 1990, p. 267). In addition, following on from the energy crisis, 'some analysts insisted that efforts should also be made to moderate the demand for energy by adoption of conservation measures' (Blumstein et al., 1980, p. 355).

Blumstein et al. (1980, p. 355) presented the first analysis of this apparent divergence or "gap" proposing that 'although economically rational responses to the energy crisis, energy conservation actions may be hindered by social and institutional barriers' and that 'a "hands-off" strategy may not be sufficient'.

Analysts began to present a case for closing the energy-efficiency gap, pointing out many economic and societal gains to be had such as cost savings, improved industrial competitiveness and environmental benefits (Hirst and Brown, 1990). Additionally, analysts shifted attention to analysis of the possible obstacles inhibiting energy efficiency and increasingly paid attention to identifying and classifying the 'institutional barriers' to energy efficiency and energy conservation.

Despite all of the discussion that has taken place since, the barriers first identified by Blumstein et al (1980) almost thirty years ago, remain just as relevant today.

4.1 Overview of selected barrier classification models

Blumstein et al. (1980) were the first to assert that barriers inhibiting the market from achieving a satisfactory outcome were embedded in social norms and institutional arrangements. Blumstein et al (1980, p.356) offered a taxonomy of regularly occurring barriers:

1) misplaced incentives,
2) lack of access to financing,
3) flaws in market structure,
4) mis-pricing imposed by regulation,
5) decision influenced by custom, and
6) lack of information or misinformation.

Subsequently, a seventh barrier, referred to as 'gold plating' was added to the taxonomy (Golove and Eto, 1996).

Some have classified barriers as either structural or behavioural. For example, Hirst and Brown (1990, p. 267) explain structural barriers as including '…distortions in fuel prices, uncertainty about future fuel prices, limited access to capital, government fiscal and regulatory policies, codes and standards, and supply infrastructure limitations'. Additionally, they consider behavioural barriers to exist also, namely '…attitudes toward energy efficiency, perceived risk of energy-efficiency investments, information gaps, and misplaced incentives' (Hirst and Brown, 1990, p. 267). Hirst and Brown (1990, p. 269) make the distinction between the two types of barriers:

> Structural barriers result from the actions of many public and private sector organisations and are primarily beyond the control of the individual end-user. Behavioral barriers, on the other hand, are problems that characterise the end-user's decision-making, although they may also reflect structural constraints.

Other types of barrier classifications also appear in the literature. For example in addition to the six classes of barriers presented above, Blumstein et al. (1980), discuss how barriers can be classified as stable or transient. Transient barriers, being caused by inertia, '…may be tenacious, but when broken down, they stay down' and 'for the most part, one expects that transient barriers will eventually be overcome by the normal workings of the market' (Blumstein et al., 1980, p. 358, p. 358). On the other hand stable barriers are '…more deeply embedded in the social and institutional fabric' and '…when broken down, they tend to reappear in altered form'(Blumstein et al., 1980, p. 358).

Another form of typology is presented by Reddy (1991) in the form of barriers by actor, from the energy consumer to global financial agencies. Under Reddy's (1991) typology, for the case of energy consumers, there are the ignorant, the poor and/or first-cost sensitive, the indifferent, the helpless, the uncertain and the inheritors of inefficiency. For the end-use equipment manufacturers there are the efficiency-blind and for the end use equipment providers there are the operating-costs blind (Reddy, 1991). On the side of the energy carrier producers and distributors there are the supply obsessed, the centralization biased and the supply monopolists. In the case of the local and national financial institutions, there are the supply biased, the unfair and the anti-innovation attitude(Reddy, 1991).

For government/country actors, Reddy's (1991) typology presents the uninterested government, the skills-short government, the government without adequate training facilities, the government without access to hardware and software, the capital-short government of an infrastructure-poor country, the sales-promoting regulator, the powerless energy-efficiency agency, the cost-blind price fixer, the fragmented decision maker, the large-is-impressive syndrome and the large-is-lucrative sponsor. Lastly, for the international, multilateral and industrialised country funding and aid agencies, Reddy (1991) presents the inefficient technology exporter, the supply biased, the anti-innovation attitude, the large-is-convenient funder, the project-mode sponsor and the self-reliance underminer.

DeCanio (1993, p. 906, p. 906) explains certain barriers faced by firms can mean that 'many investments in energy efficiency fail to be made despite their apparent profitability' because 'internal hurdle rates are often set at levels higher than the cost of capital to the firm'. This situation is due to 'bounded rationality, principal-agent problems, and moral hazards' (DeCanio 1993, p.906). Were government to provide informational and organisational services beyond the traditional regulatory framework, the dual goals of improving overall energy efficiency and increasing private sector productivity could be achieved (DeCanio 1993).

Additionally, an analysis by Weber (1997, p. 834) suggests that the market barrier classifications are not typologies as such and 'in fact each real barrier has its institutional, economic and organisational and behavioural aspects'. According to Weber (1997, p. 834), as barriers are invisible and not observable, they cannot be empirically classified, thus barrier classifications are 'derived from theory and propelled by different concepts of action in order to remove obstacles, that is, theories of institutions, economic theories, organisational theories and theories of human behaviour'.

4.2 Recent discussion of Institutional Barriers

4.2.1 The Stern Report

The widely acclaimed report on the economics of climate change, the Stern Report (2006), makes the case for policies which price greenhouse gases and which support low-emission technology development in order to tackle climate change. However, Stern (2006, p. 427) cautions that '…even if these measures are taken, barriers and market imperfections may still inhibit action, particularly on energy efficiency'.

Stern (2006, p. 427) sees the considerable untapped energy efficiency opportunities in buildings, transport, industry, agriculture and power sectors as evidence of the impact of market failures and barriers which include: 'hidden and transaction costs such as the cost of the time needed to plan new investments; lack of information about available options; capital constraints; misaligned incentives; as well as behavioural and organisational factors affecting economic rationality in decision-making'.

Stern groups the barriers into three main categories: (1) financial and 'hidden' costs and benefits; (2) multiple objectives, conflicting signals, or, information and other market failures; and (3) behavioural and motivational factors (Adapted from the Carbon Trust, The UK Climate Change Programme: Potential Evolution for Business and the Public Sector cited in Stern 2006, p.429).

While an individual or firm would typically balance the financial costs and benefits of any investment in energy-using technologies, Stern (2006) notes that hidden or transaction costs are also required to assess the full range of costs and benefits. One study by Hein and Blok (cited in Stern, 2006, p. 430) found search and information costs of energy efficiency measures of between 3 and 8 per cent of total investment costs. As well, a lack of available capital will prevent actors from investing in more energy efficient processes which usually have a high upfront capital cost but a lower overall cost when the energy cost savings are taken into account. Likewise, incentive failures restrict the effectiveness of price instruments for example 'in the buildings sector is the 'landlord-tenant' problem in which landlords do not invest in the energy efficiency of their asset, because tenants benefit from lower energy bills, and more efficient capital typically does not command sufficiently higher rents' (Stern, 2006, p. 431).

4.2.2 The Garnaut Review

According to the most comprehensive Australian review on the economics of climate change, the Garnaut Review (2008b, p. 403), 'externalities in the provision of information and principal-agent issues inhibit the use of distributed generation and energy-saving opportunities in appliances, buildings and vehicles'. As Garnaut (2008b, p. 404) states:

> Two kinds of market failures are especially important in inhibiting the adoption of low-emissions technologies and practices. One relates to externalities in the supply of information and skills. The other involves a principal-agent problem – where the party that makes a decision is not driven by the same considerations as another party who is affected by it.

Some recent work by McKinsey and Company (cited in Garnaut, 2008a, p. 445) 'suggests that the majority of technically low-cost mitigation opportunities in Australia occur in sectors affected by information and principal-agent market failures'. Market failures are most likely to occur 'where mitigation opportunities are small relative to the transaction costs of securing them'(Garnaut, 2008a, p. 444).

The Garnaut review (2008b, p. 406) presents a market failure framework comprising:

- Public good information market failures (& 'bounded rationality');
- Information asymmetry market failures (& 'adverse selection');
- Information spillover market failures; and
- Principal-agent market failures.

The following table summarises each of the market failures highlighted within the Garnaut framework (2008b, p. 406-421).

Public good information market failures	▪ Includes the public good nature of some information and bounded rationality. ▪ As some information is a pure public good, one person's use of that information does not prevent others from using it. ▪ 'Where information has public good characteristics it is likely to be underprovided by the private sector'(Jaffee & Stavins 1994 cited in Garnaut, 2008b, p. 406) and 'as firms are not able to capture all of the benefits from public good information, there is insufficient incentive to make information as extensive and widely available as consumers may demand' (Garnaut, 2008b, p. 406).
Information asymmetry market failures	▪ 'Information asymmetry occurs when two parties to a transaction do not have equal access to relevant information' (Garnaut, 2008b, p. 407). ▪ E.g. 'There are potentially significant information asymmetries where appliances, vehicles and houses are not energy rated. It would be extremely difficult for non-experts to determine the ongoing energy use of an appliance, for example, without outside assistance. This allows opportunism, as a product manufacturer could mislead a buyer before they buy it. However, this can be costly and individuals may choose not to invest in further information gathering, avoid the transaction or place a risk premium on the transaction' (Garnaut, 2008b, p. 407). ▪ 'Information asymmetry can lead to adverse selection, which can occur where sellers are better informed than buyers, resulting in lower-quality goods dominating a market' (Akerlof 1970 cited in Garnaut, 2008b, p. 407).
Information spillover market failures	▪ 'Some actions by parties can result in benefits to other parties, without those other parties paying for them. Early adopters of some low-emissions options bear additional costs in gathering information, developing skills for adopting the option and testing the reliability of the option (Jaffee et al. 2004). In some cases, the boundary between early adoption and innovation can be blurred. However, early adopters are often unable to capture the knowledge and skill spillover benefits that accrue to other firms, other industries, and the community more broadly. This acts as a disincentive to early adoption of novel technologies and practices'(Garnaut, 2008b, p. 414).
Principal-agent market failures	▪ Occurs when one person (the principal) pays an agent for a service, but the parties face differing incentives and the principal cannot ensure that the agent will act in the principal's best interest. ▪ 'Principal-agent problems may entirely insulate some decisions from a carbon price, potentially reducing the adoption of low-emissions options. For example, as residential tenants pay energy bills, landlords may not install energy efficient appliances'(IEA 2007 cited in Garnaut, 2008b, p. 414).

Table 1: A Summary of Market Failures (Garnaut, 2008b, p. 406-421)

4.2.3 International Energy Agency

The International Energy Agency's (2005, p. 23) information paper on the experience with energy efficiency policy and programmes in IEA countries summarises the following:

> Energy efficiency proponents point to a wide range of market failures or barriers in order to justify energy efficiency policies and programmes. These market barriers and failures include:
>
> - the limited supply and availability of relatively new energy efficiency measures in the marketplace;
> - consumers lacking or having incomplete information about energy efficiency options;
> - some consumers lacking the capital to invest in energy efficiency measures;
> - fiscal or regulator policies that discourage energy efficiency;
> - misplaced incentives whereby the party designing, constructing or purchasing a building or price of equipment, or the landlord in rental property, generally seeks to minimize first cost rather than lifecycle cost;
> - consumers or businesses paying little attention to energy use and energy savings opportunities if energy costs are a small fraction or the total cost of owning or operating a home, business or factory; and
> - energy prices that do not reflect the full costs imposed on society by energy production and consumption.

4.3 Limitations of barrier classifications

In discussing barrier classification models, it is important to note also the limitations of such models. Weber (1997, p. 834) gives an explanation of how most barrier classifications fall down:

> First, barrier models assume that improved efficiency is the result of a particular action (eg buying more efficient equipment, retrofitting building shell or decree of an energy tax). Energy conservation which results from the omission of an action (eg not buying a certain machine) or doing something in a different way (eg integrated instead of isolated planning), cannot be described by a barrier model. Barrier models are limited insofar as they can only describe energy conservation in the sense of positive actions. Thus, they do not represent the whole range of energy conservation options.
>
> Second, barrier models do not question the purpose of an action. They focus on means to given ends. Preferences are exogenous and need not to be legitimised. Action is modelled technically in the sense that the challenge lies within the minimisation of means (ie energy consumption). The barrier model approach ignores the level of consumption and favours technical solutions.
>
> Third, barrier models are based on the assumption that there is an ideal level of efficiency. The existence of barriers as well as the level of inefficiency is derived by technical options (eg state of the art). Barrier models ignore social techniques and the social conditions of technology development (cf Shove, 1995).

Weber (1997, p. 834) adds however that 'practical measures can be realised for better institutional, organisational, behavioural and market conditions to make energy conservation more successful'.

5. Classification of Institutional Barriers

As with any classification system, the objective in classifying institutional barriers is not to devise "the correct system" but rather to develop "a useful system" given the context. To paraphrase the law or principle known as "Occam's Razor", such as system should be as simple as possible, but no simpler. Ideally, the classification should include categories that are "mutually exclusive and collectively exhaustive". In other words, each barrier should fit into one category but no others. Based on these criteria the following simplified classification of seven institutional barriers to distributed energy is proposed:

1. Imperfect information - lack of access to relevant information;
2. Split incentives - the challenge of capturing benefits spread across numerous stakeholders;
3. Payback gap - the difference in the acceptable periods for recovering investment between energy consumers (and Distributed Energy proponents) and large centralized energy supply utilities;
4. Inefficient pricing – the failure to reflect costs (including environmental costs) properly in energy prices;
5. Regulatory barriers - the biasing of regulation against distributed energy resources;
6. Cultural barriers - resistance to, and scepticism about, the use of Distributed Energy on the part of individuals and organisations (including utilities, regulators and policy makers); and
7. The interaction of barriers, resulting in widespread confusion.

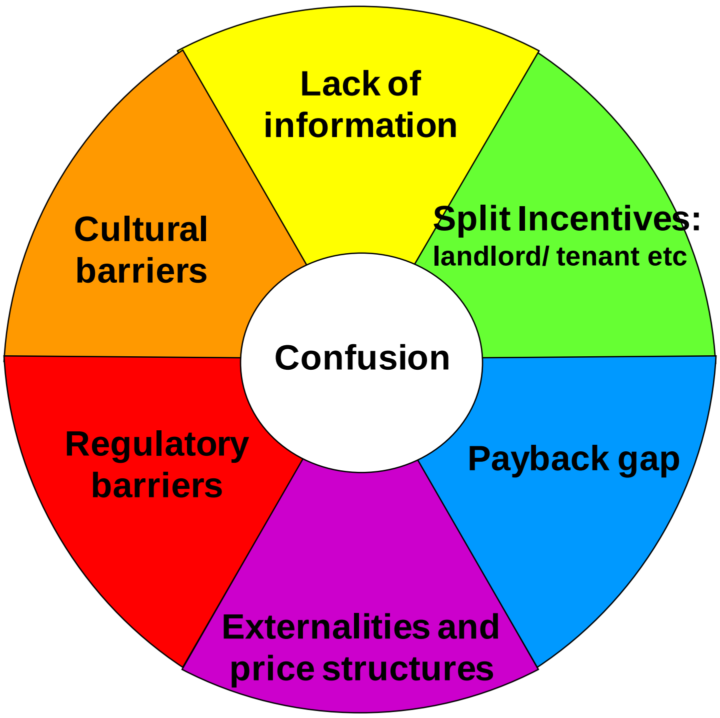


Figure 5: Institutional barriers to Distributed Energy

5.1 Imperfect Information

If the aphorism 'information plus analysis equals intelligence' is true of electricity networks, then information is crucial to the intelligent grid. Conversely, lack of appropriate information is a major barrier to the establishment of intelligent grids.

In orthodox economic theory, perfect information is one of the fundamental assumptions of perfect competition on which the fully efficient operation of the market depends. This essentially means that consumers and firms have free and immediate access to all relevant information in making decisions about how to make and choose goods and services. While economists understand that this is never strictly true, it is often used as a useful simplifying assumption. As the Garnaut Report (2008b, p. 406) noted:

> Individuals will rarely have perfect information relevant to a decision they are making. However, efficient adoption of established technologies and practices requires individuals to know:
>
> - the options available
> - the approximate costs and benefits of the different options
> - how to deploy the options (including hiring experts)
> - the cost of investigating the options.

Unfortunately, in the case of distributed energy, this simplifying assumption can disguise major inefficiencies in the operation of markets. As Brown notes, 'the time and cost of collecting information is part of the transaction costs faced by consumers' therefore, 'where the consumer is not knowledgeable about the energy features of products and their economics (for any of a large number of reasons, including technical difficulties and high costs of obtaining information), investments in energy efficiency are unlikely' (Office of Technology Assessment, US Congress 1993; Levine et al. 1995; cited in Brown, 2001, p. 1201).

> Governments should not be expected to fill the gap in every situation where individuals lack sufficient information to make good decisions. However, where information barriers are caused by market failures, governments may sometimes be able to improve the efficiency of the market (Garnaut, 2008b, p. 406).

This is the key rationale in Australia for mandatory energy performance labelling of many appliances and rating of buildings.

The following sections discuss where the lack of easy access to timely relevant information can present a significant barrier to DE options.

5.1.1 Energy operating costs (when purchasing): "First cost disease"

Many distributed energy options involve higher initial purchase or capital costs but lower ongoing operating costs. For example, this is true of solar and wind power, solar water heating, cogeneration and many energy efficiency options. 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. This phenomenon is sometimes called "the first cost disease".

5.1.2 Energy operating costs (when operating): "Who pays the bill?"

Even when energy using equipment is purchased and installed, useful information about operating costs may still be unavailable. Many consumers either do not personally receive billing information at all (for example, it may be directed to the accounts payable section of a company) or only receive an aggregated bill once every several months. It is difficult to respond appropriately to cost signals if no signals are received.

5.1.3 Benchmarks for energy performance: "What's normal?"

Even where energy use data is available, it may be difficult to interpret. If credible performance benchmarks are not available, judging between a good and poor energy performance may be difficult. For example, a factory may continue to use an expensive, inefficient and polluting coal-fired boiler, simply because its operators are not aware of the availability of better options.

5.1.4 Lack of DE precedents: "Will it work?"

Even where credible information about relative energy performance is available, reliable information about DE alternatives may be difficult or costly to access. Consequently while the costs of deploying advance metering infrastructure may be reasonably estimated, the benefits that flow from such an investment can be much harder to anticipate with confidence. It is also important to inform all stakeholders about the expected benefits about DE alternatives. For example, if the end use sector is unfamiliar with the technology and unclear about its performance, public resistance towards these technologies and policies can emerge.

5.1.5 DE technologies and opportunities: "What does DE really cost?"

Even where technical information is available and the performance of DE has been demonstrated, reliable information about the fixed and operating costs may be unavailable, particularly in relation to more innovative technologies.

5.1.6 Network planning information: "DM: when, where, how much?"

One of the key potential benefits of DE, compared to centralised generation, is its ability to locate close to centres of energy demand and therefore avoid or defer the need for network capacity. Smith (2007, p. 6) has noted that the opportunities for demand management within a network context are constrained by three factors; location, timing, and the amount of peak reduction, as follows:

1. **Location** - opportunities arise only in those specific parts of the network system that are facing constraints and require augmentation;
2. **Timing** - demand management is only required for short periods of system peaks and has its highest value in the period immediately before planned system augmentation investments are to be made; and
3. **Amount** - a specific quantum of peak load reduction is required to replace the need for a system augmentation in time to defer construction of supply side assets. Too little will not allow a deferral and any surplus has no value once a deferral can be achieved.

However, it is difficult for DE options to take advantage of these potential benefits, unless reliable timely information about such emerging network constraints is easily accessible. As Szatow (2008, p. 4) notes, 'planning information can help level the playing field for alternative energy supply options by providing accurate forecasts of network constraints and opportunities for investment'.

One specific example of the need for network planning information is in the implementation of Australia's Reliability and Emergency Reserve Trader (RERT). RERT is an avenue for the Australian Energy Market Operator to reserve contracts for when there is "compelling evidence of market failure" to provide the required level of capacity (AEMC 2009). The RERT offers the opportunity for demand side participation to provide reliability when it has the most value to the market. However, the lack of quality demand-side capability information available to AEMO hinders their ability to assess whether the RERT should be exercised or not. Improved information about demand-side capability would enhance AEMO's probabilistic assessments of demand-side participation at times of peak demand and subsequently increase their ability to forecast reserve shortfalls (AEMC 2009).

5.2 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. While in principle, all such split incentives could be resolved by the party that benefits from the action compensating the party that does not benefit. Indeed, such transactions make up a large share of normal economic activity. However, all such transactions have costs associated with them in terms of time, risks and resources, so in practice many split incentive situations are not resolved.

The greater the number of parties involved in decisions related to DE investment, the greater will be the transaction costs associated with devising and negotiating a mutually acceptable outcome. Similarly, the lower the level of trust and sense of common purpose between the relevant parties, the more difficult and costly it will be to overcome such barriers.

Facilitation through negotiation, awareness raising, education, confidence building, and access to reliable independent energy performance information can often assist in addressing these barriers.

5.2.1 Landlord-tenant problem

The classic example of split incentives is the landlord-tenant problem, which is often cited in relation to energy efficiency investments in rental accommodation. In this case the 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 long enough to reap the benefits. This situation could apply as much to insulating a low income residential flat as to installing intelligent lighting controls in a premium office space.

A variant of this principle is the principle-agent problem; a 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, p. 1199). An example of this is where a design consultant is either rewarded for minimising initial costs rather than life cycle costs for a client.

5.2.2 Complex decision making within groups

Split incentives can be as pervasive *within* groups or organisations as *between* them. In particular, where organisations do not have established processes for considering and deciding issues like investment in DE (such as through an energy manager or an energy management plan), then the costs associated with formulating, negotiating, deciding on and implementing a proposal relating to DE may seem prohibitive. 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 to unrelated objectives in other parts of the business, such as asset renewal objectives of the Asset Management department or operating expenditure targets of the Corporate Finance department.

5.2.3 Tragedy of the Commons

At the highest level of complexity, split incentives can be characterised as the "tragedy of the commons" where all parties are disadvantaged by the failure of each to act for the common good (Hardin, 1968). This is particularly relevant to the intelligent grid in relation to investment in research and development as described by Brown (2001, p. 1201):

> The risk of innovation leakage and exploitation by competing firms puts pressure on firms to invest for quick returns (Mansfield, 1994). Technology innovation is typically a longer-term investment fraught with risks to the investor. The result is an under-investment in R&D from the standpoint of overall benefits to society. The problem is particularly difficult in the newly restructured electric sector, where R&D funding has decreased dramatically. Companies will not fund the optimal societal level of basic R&D of new technologies, since many of the benefits of such research will flow to their competitors and to other parts of the economy.

5.3 The Payback Gap

Given that DE options often have higher initial or capital costs but lower ongoing or operating costs, it is not surprising that limited access to finance to manage the higher initial costs is often cited as a barrier to DE. However, some care needs to be taken in relation to this issue. Given the massive growth both in the finance industry and in the provision of personal and corporate debt over the past two decades, it is far from clear that limited access to finance has been a major barrier in retarding the development of DE and the intelligent grid. On the other hand, there appears to be ample evidence of a large neglected reservoir of cost effective investment opportunities in DE with relatively short payback periods of a few years or less. As the Stern Report (2006, p. 429) observed:

> Individuals and firms should invest until the expected savings are equal to the opportunity cost of borrowing or saving (assuming risk neutrality). Studies suggest that individuals and firms appear to place a low value on future energy savings. Their decisions expressed in terms of standard methods of appraisal would imply average discount rates of the order of 30% or more.

A 30 per cent discount rate implies that consumers and businesses require DE investments to pay back their initial investment within about three years. The so-called "payback gap" refers to this discrepancy between the payback period that consumers and business demand to be met by many DE investments and the payback period that is required of many other investments (including those made by utility companies in energy supply infrastructure).

It begs the question why it is that many households appear to be willing to invest in superannuation and other assets that offer a return on investment of say 7 per cent per annum, but seem unprepared to invest in efficient lighting that may offer a return on investment of many times this rate. Why are many households able to borrow thousands of dollars to spend on an energy intensive large screen television? There is clearly more at play here than simply access to finance. If the obvious answer is that a wide screen TV is more fun, then this should give us pause for thought about the limitations of relying solely on economic principles in explaining human behaviour.

The answer is likely to lie in part with the other institutional barriers described in this paper. However, there is another side to the question of financing and the notion of the “payback gap”. Much debate and analysis around this theme has focussed on why energy consumers often seem to require their DE investments to pay for themselves through operating costs savings within two or three years. Similarly, network service providers also tend to require a much quicker return on investment for DE investments than network augmentation investments. However, of equal significance to the DE payback gap is why the short payback periods do not apply to centralised energy resources. In other words, why regulated monopolies have ready access to finance with long payback periods relative to competitive providers or energy consumers. This reflects the historical development of the electricity industry, and is a key barrier to the development of DE resources.

5.4 Inefficient pricing

There are two dimensions to inefficient pricing that represent institutional barriers to DE and Intelligent Grid. These are:

- unpriced “external costs”, which relates to the average level of prices; and
- the structure of prices.

5.4.1 Externalities (Environmental costs/ Carbon price)

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, thus 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.

> Unpriced costs include a range of negative impacts from the discovery, extraction, production, distribution, and consumption of fuels and power. A strong case can be made that energy fuels are underpriced, because market prices do not take full account of the variety of social costs associated with fuel use. Fossil energy using today’s conversion technologies produces a variety of unpriced costs (or negative externalities) including greenhouse gas emissions; air, water and land pollution; and oil supply vulnerabilities associated with the need to import oil and the uneven geographic distribution of petroleum resources. As a result of these unpriced costs, more fossil energy is consumed than is socially optimal (Brown, 2001, p. 1200).

The simplest mechanism to redress this barrier is to put a price on carbon through either a carbon tax or a carbon emission trading scheme as proposed by the Garnaut Review (2008b) and as pursued by the Australian Federal Government originally in the form of the Carbon Pollution Reduction Scheme. For such a mechanism to overcome this barrier fully, the price of carbon must apply to all carbon emissions without exemption and be set at a level high enough to fully cover the cost of the environmental harm being caused.

5.4.2 Inefficient Price Structures

While more subtle than excluded external costs, pricing structures can be an even greater barrier than the exclusion of external costs. Some of the ways that inefficient price structures can create barriers to DE are described below.

Average rather than marginal cost pricing

Although interval meters and time of use tariffs are becoming more common, most electricity consumers in Australia, particularly smaller consumers, still pay a flat electricity tariff. That is, the same electricity price all day, everyday throughout the year[2]. This flat tariff is in contrast to 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 DE resources that are well suited to respond to these cost fluctuations including peak load management resources such as demand side response. While these flat tariffs are sometimes defended as protecting vulnerable consumers, the effect is often to impose avoidable costs on all consumers to pay for large investment in centralised generation and networks to meet occasional peak demand.

As Brown (2001, p. 1200) notes, 'because most customers buy electricity as they always have – under time-invariant prices that are set months or years ahead of actual use – consumers are not responsive to the price volatility of wholesale electricity', however 'time-of-use pricing would encourage customers to use energy more efficiently during high-price periods'.

Greater use of cost-reflective, time of use tariffs is a key condition for encouraging greater use of DE and delivering the benefits of the intelligent grid.

Undervaluing DE options

The converse of flat electricity tariffs for centralised electricity supply is that often the value that distributed energy resources can offer to support the centralised power system is not appropriately reflected in pricing arrangements for distributed energy. Historically, in Australia there have been relatively few offers to pay providers of distributed energy for the services and support they can offer to the electricity system. The current determination by the Australian Energy Regulator (AER) (Australian Energy Regulator, 2009) to endorse 17.6 billion dollars of network infrastructure investment in NSW with little regard to the potential role of distributed energy, suggests that there is still some way to go before distributed energy options are appropriately valued in the electricity supply system.

5.5 Regulatory barriers

To justify policy measures to address the institutional barriers to distributed energy, it is not enough to demonstrate that a significant barrier or market failure exists and that a viable policy initiative exists. It is also important to make the case that any anticipated or unforeseen costs and consequences of the policy initiative will be outweighed by the benefits of addressing the barrier. To understand the reason for this tougher test, one need look no further than the analysis of institutional barriers itself.

[2] The main exception to this rule is off peak electric water heating.

Some of the biggest institutional barriers have been created as a by-product of trying to address other public policy objectives. Regulatory barriers fall into this category. These are barriers created by the operation of laws and regulation. Some of these potential regulatory barriers are discussed below.

5.5.1 "Coupling" (monopoly) profits to sales volumes

One of the most prominent regulatory barriers results from the goal of limiting the abuse of market power by monopoly electricity suppliers. In the Australian context this now applies to the electricity network. Many electricity networks in Australia and overseas are subject to economic regulation in the form of a maximum average price they can charge. As network costs are mainly driven by capital costs, which in turn are linked to peak demand, a network business' cost structure is not strongly influenced by the volume of electricity flowing though their wires.

As a consequence, since revenue equals price multiplied by sales volume, a maximum price cap means that total revenue is directly related to the volume of electricity delivered. On the other hand, total cost is not related to sales volume except for sales at the time of peak demand. Since profit equals total revenue minus total cost, this means that the profitability of the network business is closely tied to the total sales volume. This puts the financial interests of the network business in direct conflict with any measures that would reduce the volume of electricity sales passing through the network. This means that DE measures that reduce network sales volume are a threat to the profitability of the network business.

Fortunately, this process of "coupling" network profitability to sales volume is not an inevitable consequence of effective economic regulation or price control. There are now well established techniques for protecting both consumers and the network business profitability, while simultaneously removing barriers to distributed energy. For further discussion of these issues see Dunstan et al. (2008).

5.5.2 Distortionary fiscal and regulatory policies

There are many distortionary fiscal and regulatory policies that act as barriers to distributed energy, and many of these policies have been identified, based on an analysis of 65 projects (Alderfer et al 2000; cited in Brown, 2001). Typical examples cited in this work include 'prohibitions against uses of distributed energy resources (other than emergency backup when disconnected from the grid) and state-to-state variations in environmental permitting requirements that result in significant burdens to project developers' (Brown, 2001, p. 1200).

In 2009, the Australian Energy Market Commission released their *Review of Demand-Side Participation in the National Electricity Market*, which summarised their investigation into policies that act as barriers to distributed energy and other forms of demand-side participation. The AEMC acknowledged that "at present there is a strong supply-side in the National Electricity Market and the demand-side is relatively under-represented" (AEMC, 2009). The major barriers to demand-side participation that were noted by the review include:

- Imprecise network charges: Network charges to customers are "too imprecise to signal costs at different locations and different times with sufficient accuracy to attain all the opportunities for efficient demand side participation", as described in Section 5.4 above. (The AEMC noted that the significant barrier to accurate real-time pricing is the absence of applicable metering technology.)

- Treatment of different types of costs between and over regulatory periods: Revenue regulation of transmission businesses provides businesses the ability to retain profits resulting from cost-savings (or losses resulting from overruns) for Capital expenditure. However, cost-savings (or losses) for Operational expenditure are only retained until the next revenue determination. Demand-side participation measures are typically paid for with Operational expenditure. Therefore, the AEMC found that the current method for re-setting revenue allowances for transmission businesses appears to penalise a business who in the previous regulatory period used expenditure on demand-side participation as a means of efficiently deferring capital expenditure. In other words, any cost overruns resulting from operating expenditure spent on demand-side participation results in the network business *over-spending* on its operating expenditure forecast in order to *under-spend* against its capital expenditure forecast. This has the effect of making demand-side participation "arbitrarily more expensive than a network infrastructure alternative."

- Incentives for innovation on demand side participation and for connecting generators: The AEMC also found that, "in the absence of additional incentives, the existing economic regulation of networks, does not encourage distribution businesses to appropriately innovate to demand-side participation or embedded generation connections" (AEMC, 2009).

- Planning standards: Network businesses are required to meet planning standards. These standards typically require that the network is still able to supply all load when one or more of the network elements is out of service (i.e. an 'n-k' planning standard). There are two types of planning standards that are predominantly used: deterministic standards and probabilistic standards. The question is how to best analyse the contribution of distributed energy when there is a requirement for redundancy ('n-k'). The AEMC found that probabilistic planning standards are likely to encourage more efficient use of demand-side participation, because probabilistic standards are more "amenable to handling demand-side participation with different degrees of 'firmness' ". However, the majority of jurisdictions apply deterministic planning standards.

- Jurisdictional planning arrangements: As noted above, there is inconsistency in the network planning arrangements that limits the ability for demand side participation proponents to effectively be involved in the planning process (AEMC 2009). The AEMC's Distribution Planning Review has recommended the establishment of nationally consistent annual planning requirements, however the bias against distributed energy tends to be in how the jurisdictional standards are applied, and not in the standards themselves.

- Complexity of the Regulatory Test: The purpose of the regulatory test in the National Electricity Rules is to identify new network investments *or non-network alternative options* that maximise the net economic benefit to all those who produce, consume and transport electricity in the market. While network businesses are required to consider distributed energy and "non-network alternatives" where it would be cost-effective in accordance with a "Regulatory Test", it is generally left to the network business to make this assessment. The application to the regulatory test is complex and often involves detailed economic modelling, which is beyond the resources of distributed energy proponents to engage with, particularly in an environment where there are few cases of distributed energy being supported by the outcome of the regulatory test. Cost effective measures will be excluded if extensive and expensive analysis is required by distributed energy proponents to prove this option has the same level of reliability to meet both the technical and cultural definition of reliability.

- Network access and connection: Minimum technical standards required of network businesses for embedded generators are flexible, which is causing delays and increasing costs for embedded generators.

5.6 Cultural Barriers

In one sense, all the preceding institutional barriers are cultural. They reflect the way that people relate to the technology and the operation of institutions created by society. However, there is also a specific set of barriers that are more fundamentally cultural in that they directly reflect cultural values, attitudes and habits of thought.

As Brown (2001, p. 1202) notes:

> Energy efficiency is not a major concern for most consumers because energy costs are not high relative to the cost of many other goods and services. In addition, the negative externalities associated with the US energy system are not well understood by the public. The result is that the public places a *low priority on energy issues* and energy efficiency opportunities. In turn, this reduces producer interest in providing energy-efficient products.

On the one hand, it can be argued that cultural values should not be considered a barrier at all, because people should be simply free to consider important whatever they consider important. On the other hand, the values we hold as individuals and as participants in the economy are shaped by our society and culture. Cultural values are constantly evolving. Values that evolved in the past 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 distributed energy and intelligent grid should play a bigger role.

This is not to argue simply that the development of distributed energy resources are being retarded because people do not give them enough priority. This would essentially be a circular argument. Rather, the argument is that society's collective desire to access the benefits of distributed energy may be frustrated by individual and organisational values and attitudes that are inconsistent with this social aspiration. In other words, if society as a whole considers energy abundant and energy use harmless then individuals and organisations wasting energy at their own expense is not a problem. On the other hand, if society considers the by-products of energy generation such as greenhouse gas emission a matter of serious concern, then the inefficient use of energy by individuals and organisations becomes a legitimate target of policy consideration.

There are therefore two dimensions to the institutional barrier of cultural values.

The first dimension of inappropriate cultural values is what might be called "cultural lag", in which the prevailing attitudes and values are no longer appropriate to the current circumstances. These values can be reflected in the behaviours of individuals or organisations. There is a natural tendency to base investment and other decisions on past experience and favour more familiar technologies and practices. This inherent conservatism represents a barrier to innovative concepts like intelligent grid and distributed energy. This cultural lag can also have a powerful impact through the accumulated skills base of organisations.

Potential examples of cultural lag include:

- A lack of state or national government attention (e.g. clear direction) for an Intelligent Grid
- Electricity supply businesses tend to prefer to spend / invest in Capital (CAPEX) over Operating Expenditure (OPEX) but distributed energy is usually viewed as an operating expense, causing a natural bias against DM.
- Electricity consumers might see the Intelligent Grid as a failure to invest in a reliable power supply and believe that they are being penalised by not being able to use power when and how they want.

The second dimension to inappropriate cultural values is "Social Dilemmas". Analogous to the concept of the "prisoner's dilemma", social dilemmas are where individual attitudes lead to behaviour of individuals that conflicts with the collective interests of the society. This is the cultural dimension of the Tragedy of the Commons described in section 5.2.3. 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.

5.7 Interaction of Barriers

It should be clear from the preceding discussion, that many of the institutional barriers are interrelated. The final category of institutional barriers 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 is much easier to overcome a single barrier than several barriers at once. Where any one of a number of barriers can obstruct a distributed energy option from proceeding, it can be impractical to effectively address all barriers simultaneously.

Potential examples of this effect include the following:

- Management complexity or policy paralysis, in which the difficulties associated with coordinating action frustrate any effective action.
- Interagency and intergovernmental discord, which is exacerbated in a federal system, with strong historical state government involvement in energy planning and investment.

Transaction costs

It is worth noting that high transaction costs have not been included as an institutional or a technical barrier. This is because higher transaction costs are a consequence or a symptom of barriers rather than a barrier in their own right. Indeed, all of the institutional barriers discussed below can be considered in terms of how they increase transaction costs for DE. For example, as Sanstad and Howarth (1994, p. 815) point out:

Problems of imperfect and asymmetric information may be viewed from the perspective of transaction cost analysis: the economic gains available from increased energy efficiency may be outweighed by costs in gathering, assessing and applying information on the characteristics and performance of energy using equipment, installing such measures as thermal shell improvements, making decisions about energy efficiency and energy utilization, or reaching and enforcing agreements among interested parties.

6. Policy Implications

The ultimate purpose of analysing institutional barriers to intelligent grid and distributed energy is of course, to develop effective strategies to overcome these barriers. While the focus of this working paper is primarily on understanding the barriers, it is appropriate here to consider some of the implications of this analysis. This section considers policy measures to overcome these barriers and thereby capture the opportunities for the efficient use of distributed energy resources.

Market Support vs. Market Transformation

While offering market support through subsidies can encourage the adoption of distributed energy options, if this is not strategically targeted at reducing barriers then it may have little long term effect and may even add additional barriers and inefficiencies of its own. Market transformation has been defined as 'The reduction in market barriers resulting from market intervention, as evidenced by a set of market effects, that lasts after the intervention has been withdrawn, reduced, or changed.' (International Energy Agency, 1999, p. 5). Moreover, the potential gains from distributed energy options will only be realised if the costs associated with adopting these policy measures is less than the value of the efficiency gains from applying the distributed energy options.

6.1 Reducing Institutional Barriers to Distributed Energy Options

Market transformation is informed by a view that markets are shaped as much by conscious and unconscious social factors as by technical factors and are therefore amenable to a range of deliberate strategies for change. Figure 6 illustrates this concept in terms of the standard supply and demand curves.

The quantity of a given commodity such as a distributed energy option, being used in the economy is initially at level q_0, reflecting the cost of supply. To increase the uptake of this commodity, there are essentially three options:

a) Lower the cost of supply (moving the supply curve to the right, from S_0 to S_1);
b) Increase the demand for the commodity (moving the demand curve to the right, from D_0 to D_1); or
c) Reduce the transaction costs so that the effective demand is lower than the true demand (this could be represented as either a lowering of the supply curve or as a lift of the demand curve).

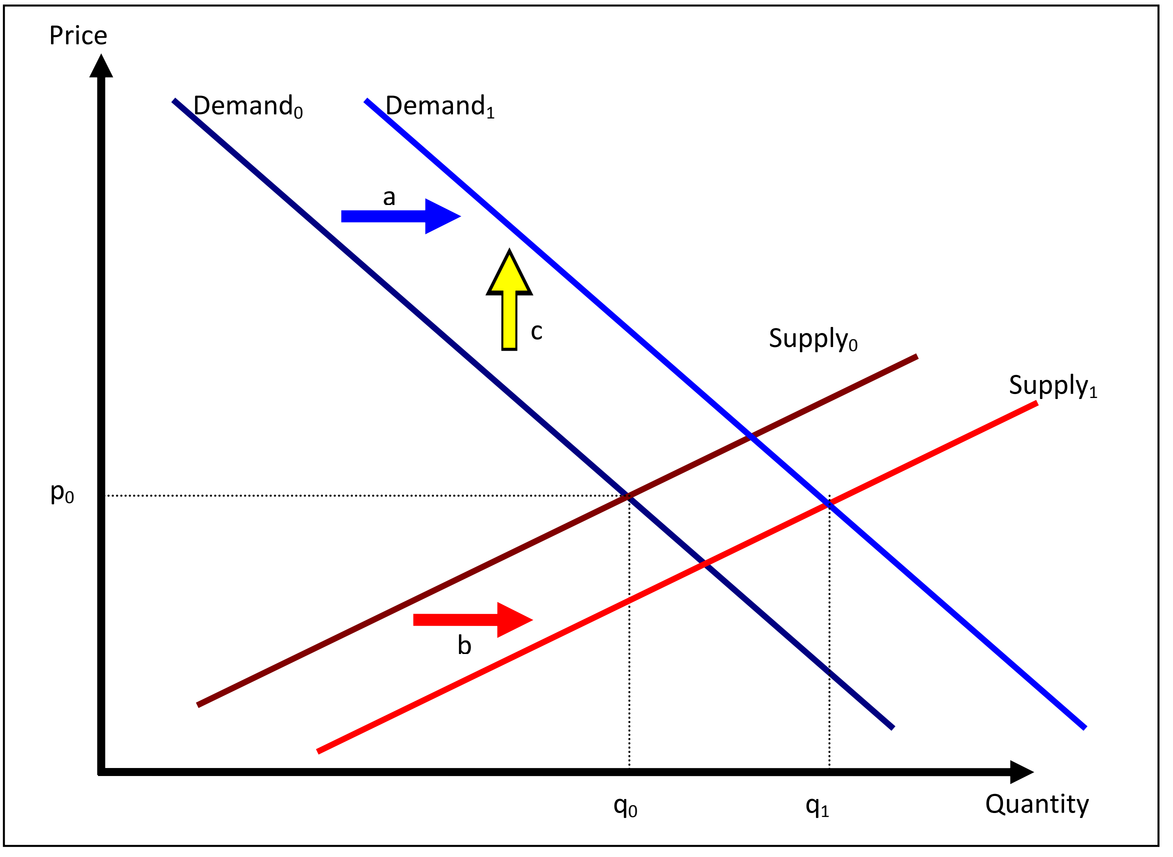


Figure 6: Moving the market (Demand & Supply)

The same principles are illustrated in a simpler form in Figure 7, in the form of "pushing" the market through mandatory measures such as regulation, "pulling" the market through incentives such as rebates or "lifting" the market by reducing transaction costs such as making better information available. The test of market transformation is whether these changes are effected as permanent and self sustaining or as temporary.

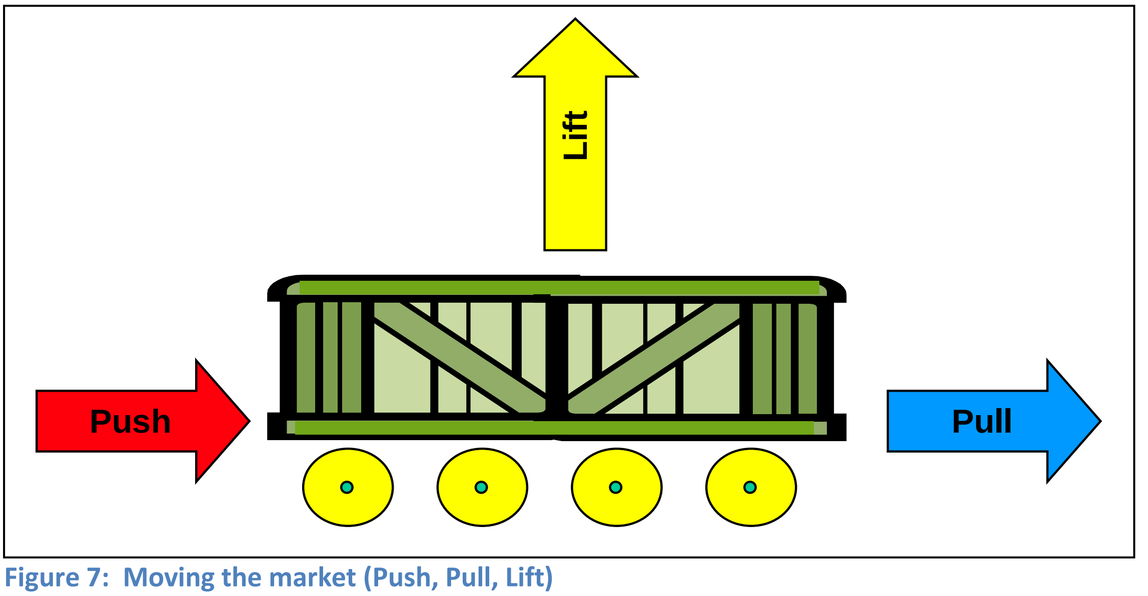


Figure 7: Moving the market (Push, Pull, Lift)

The nature of the available policy options for moving the market is illustrated in the “Policy Palette” presented in Figure 8. The categories of policy options include: regulation, incentives and information as the primary drivers, complemented by secondary drivers of targets, facilitation and pricing. This does not imply that these secondary drivers are less important, but rather that they are less simply defined.

This framework offers a structure that can be further developed for classifying and coordinating policy options to support distributed energy options.

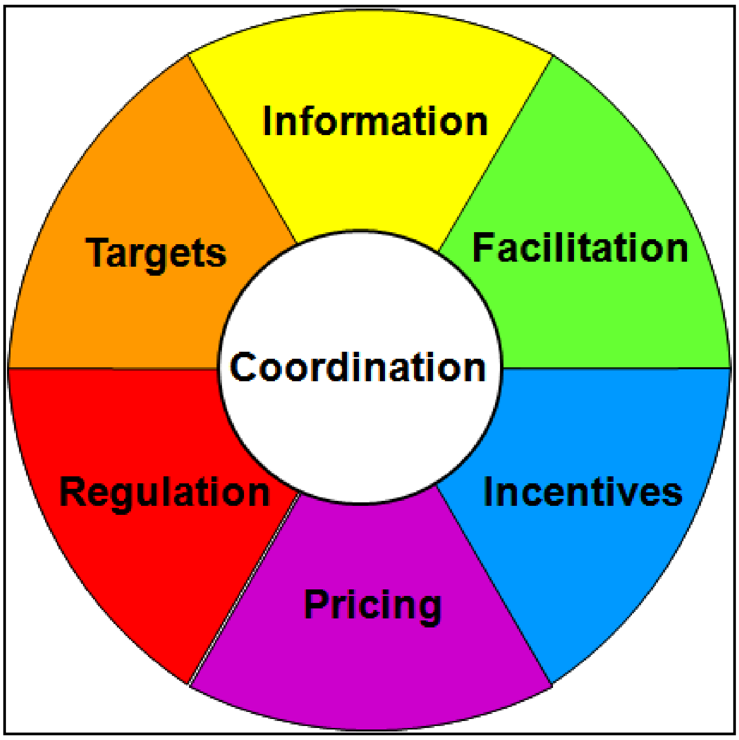


Figure 8: The “Policy Palette” of Drivers to Move the Market – “PIRFICT”

These seven categories of policy options provide, as indicated, a palette with which to address the institutional barriers described in Section 4. One of the key conclusions is that the use of these policy options is most effective when the full range of policy options is deployed, that is, including policy options from the whole palette. By itself, the use of regulation can promote backlash and reduced effectiveness due to lack of information. Equally, the use of incentives and information alone will often result in a weak uptake, or ‘cream-skimming’. Above all, the need for overall co-ordination of the implementation of the range of policy options is important, to reduce the risk of fragmentation.

These themes of the Policy Palette are the focus of iGrid Working Paper 4.2: ***20 Policy Options for Developing Distributed Energy***

References

AGL, WWF, et al. (2006). Options for Moving to a Lower Emission Future.

Australian Energy Market Commission (2009). Review of Demand-Side Participation in the National Electricity Market. Final Report.

Australian Energy Regulator (2009). Final decision, New South Wales distribution determination 2009–10 to 2013–14.

Australian Government (2007). Best Practice Regulation Handbook. Canberra.

Blumstein, C., B. Krieg, L. Schippera and C. York (1980). "Overcoming social and institutional barriers to energy conservation." Energy **5**(4): 355-371.

Brown, M. A. (2001). "Market failures and barriers as a basis for clean energy policies." Energy Policy **29**(14): 1197-1207.

Clean Energy Council (2010). Clean Energy Australia 2010.

Climate Works Australia (2010). Low Carbon Growth Plan for Australia. Melbourne, Climate Works Australia.

DeCanio, S. J. (1993). "Barriers within Firms to Energy-Efficient Investments." Energy Policy **21**(9): 906-914.

Dunstan, C., Abeysuriya, K.R. & Shirley, W. (2008). Win, Win, Win: Regulating Electricity Distribution Networks for Reliability, Consumers and the Environment: Review of the NSW D-Factor and Alternative Mechanisms to Encourage Demand Management, [prepared for Total Environment Centre], Institute for Sustainable Futures, UTS, Sydney.

Effeney, T. (2009). The role of smart electricity networks in a carbon constrained world. Intelligent Grid Forum. Brisbane.

Electricity Supply Industry Planning Council (2005). Planning Council Wind Report to ESCOSA.

Energy Supply Association of Autralia (2009). Electricity Gas 2009.

Engle, D. (2006). With the power at hand: it's simple logic: examining the merits of distributed energy. Planning**:** July 2006, 2034-2039. , American Planning Association.

EPRI (2007). The Power to Reduce CO2 Emissions: The Full Portfolio. Pala Alto, California, Electric Power Research Institute (EPRI) Energy Technology Assessment Center.

European Wind Energy Association (2005). Large scale integration of wind energy in the European power supply., European Wind Energy Association.

Fisher, A. C. and M. H. Rothkopf (1989). "Market failure and energy policy A rationale for selective conservation." Energy Policy **17**(4): 397-406.

Garnaut, R. (2008a). Garnaut Climate Change Review Final Report Canberra, Commonwealth of Australia.

Garnaut, R. (2008b). Garnaut Climate Change Review Final Report Canberra, Commonwealth of Australia.

Golove, W. H. and J. H. Eto (1996). "Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency." LBL-38059. Berkeley, CA: Lawrence Berkeley National Laboratory.

Hardin, G. (1968). "The Tragedy of the Commons." Science **162**(3859): 1243-1248.

Hirst, E. and M. Brown (1990). "Closing the efficiency gap: barriers to the efficient use of energy." Resources, Conservation and Recycling **3**(4): 267-281.

Horgan, C. and C. Dunstan (2010). Does Cleaner Energy need a Smarter Grid? A Discussion Paper., University of Technology Sydney.

International Energy Agency (2005). "The Experience with Energy Efficiency Policies and Programmes in IEA Countries: Learning from the Critics." IEA Information Paper.

International Energy Agency (1999). Public Policy Implications of Mechanisms for Promoting Energy Efficiency and Load Management in Changing Electricity Businesses. Task VI of the International Energy Agency Demand-Side Management Programme.

Ipakchi, A. and F. Albulyeh (2009). "Grid of the Future", Power and Energy Magazine, IEEE March-April 2009 Volume 7, Issue 2: Pages 52-62.

IPART (2002). Inquiry into the Role of Demand Management and Other Options in the Provision of Energy Services: Final Report. Sydney, Independent Pricing and Regulatory Tribunal of New South Wales.

Jaffe, A. B., Newell, R.G. and Stavins, R. N. (2004). A Tale of two Market Failures: Technology and Environmental Policy, Resources for the Future Discussion Paper 04-38, October 2004.

Langham, E., and C. Dunstan. (2011). iGrid Working Paper 4.4.

Langham, E., C. Dunstan, Walgenwitz, G., Denvir, P., Lederwasch, A., and Landler, J. (2010). Reduced Infrastructure Costs from Improving Building Energy Efficiency. Report prepared for the Department of Climate Change and Energy Efficiency by the Institute for Sustainable Futures, University of Technology Sydney and Energetics.

Lilley, B., A. Szatow, et al. (2009). Intelligent Grid Report: The value proposition for distributed energy., CSIRO.

Lovins, A. B. (1976). "Energy Strategy: The Road Not Taken." Foreign Affairs **55**(1): 65-96.

Lovins, A. B. (2002). Small is profitable : the hidden economic benefits of making electrical resources the right size. Snowmass, Colorado., Rocky Mountain Institute.

McKinsey & Company (2007). Reducing US Greenhouse Gas Emissions: How Much at What Cost? Executive Report; US Greenhouse Gas Abatement Mapping Initiative, McKinsey & Company Analysis, Washington, DC.

NRECA (2007). White Paper on Distributed Generation, National Rural Electric Cooperative Association (USA).

OFGEM (2007). Review of Distributed Generation, A joint Government/OFGEM report.

Pepermans, G., J. Driesen, Haeseldonckxc, D., Belmansc, R. and W. D'haeseleerc, W. (2005). "Distributed generation: definition, benefits and issues." Energy Policy **33**(6): 787-798.

Reddy, A. K. N. (1991). "Barriers to improvements in energy efficiency." Energy Policy **19**(10): 953-961.

Sachdeva, A. and P. Wallis (2010). Our demand: reducing electricity use in Victoria through demand management, Monash University.

Sanstad, A. H. and R. B. Howarth (1994). ""Normal" markets, market imperfections and energy efficiency." Energy Policy **22**(10): 811-818.

Smith, R. (2007). Shifting the Spare Tire: Values and Incentives for Electricity Demand Management Following Market Reform - The Australian Experience. 30th International IAEE conference, Wellington, NZ, Energy Australia.

Stern, N. (2006). The Economics of Climate Change. The Stern Review. Cabinet Office–HM Treasury, Cambridge University Press.

Sutherland, R. J. (1991). "Market Barriers to Energy-Efficiency Investments." The Energy Journal **12**(3): 15-34.

Szatow, T. (2008). Beyond Free Market Assumptions: Addressing Barriers to Distributed Generation. Melbourne, Consumer Utilities Advocacy Centre**:** 1-57.

US Department of Energy (2007). The Potential Benefits of Distributed Generation and Rate-Related Issues that may Impede their Expansion.

van Gerwen, R., S. Jaarsma, et al. (2006). Smart Metering. Leonardo-energy. org**:** 9.

Weber, L. (1997). "Some reflections on barriers to the efficient use of energy." Energy Policy **25**(10): 833-835.