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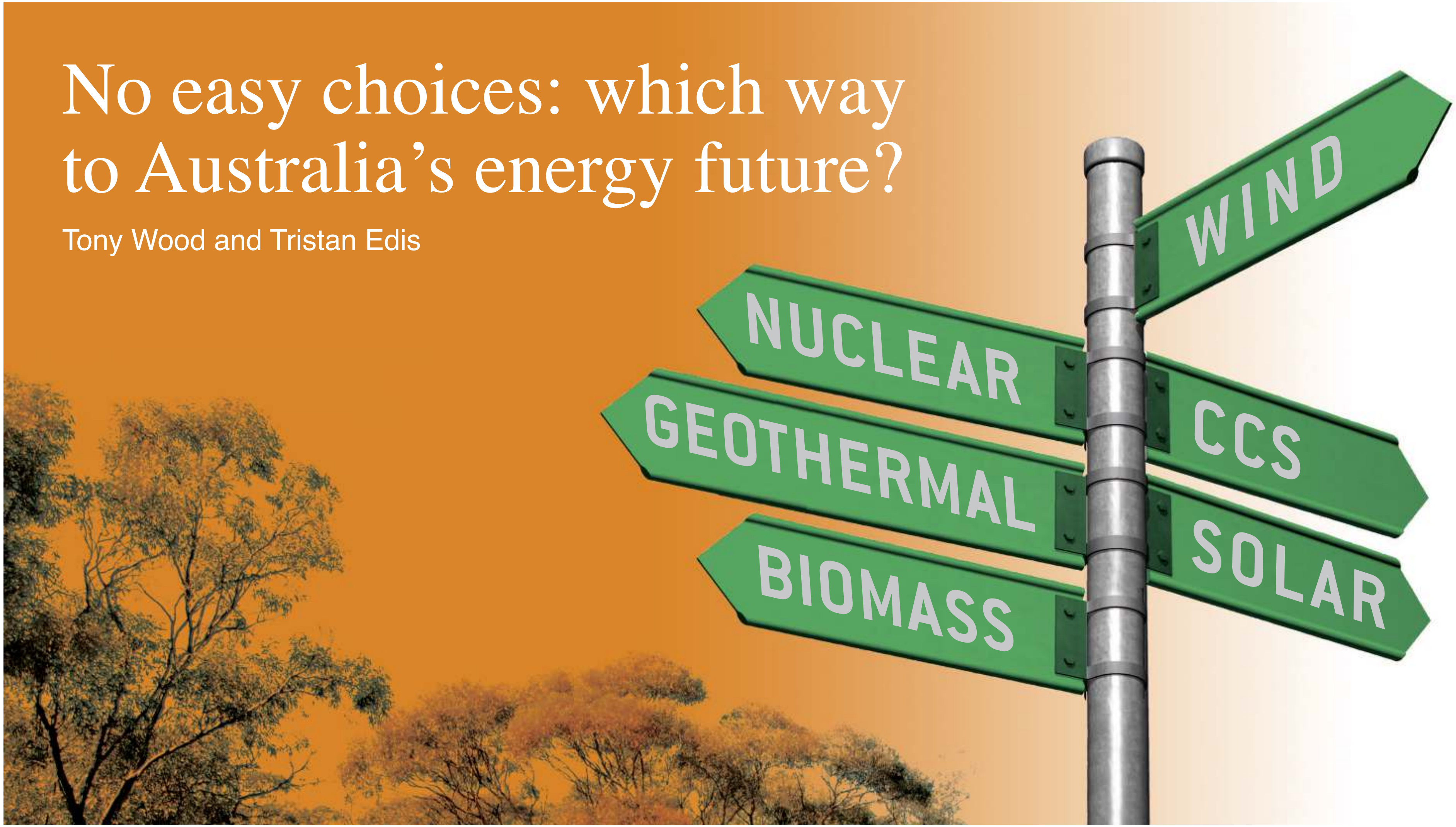
# No easy choices: which way to Australia's energy future?

Tony Wood and Tristan Edis



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This report is accompanied by a publication: *No easy choices: which way to Australia's energy future – Technology Analysis.* The accompanying publication can be downloaded from the Grattan Institute website.

This report was written by Tony Wood, Program Director, Tristan Edis, Research Fellow, Helen Morrow, Associate and Daniel Mullerworth, Associate, Grattan Institute. John Daley, CEO made a substantial contribution and James Button assisted in its preparation.

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The opinions in this report are those of the authors and do not necessarily represent the views of Grattan Institute's founding members, affiliates, individual board members or reference group members. Any remaining errors or omissions are the responsibility of the authors.

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## Overview

Australia must substantially and relatively quickly change the nature of its electricity supply. The Commonwealth's goal is to reduce Australia's greenhouse gas emissions to 80% below 2000 levels by 2050. Much of this reduction will need to come from changes in electricity production, while keeping energy secure and affordable for Australians.

How might this happen? This report and its companion detailed report assess the prospects for seven technologies that generate electricity with near-zero emissions, and which are already developed enough that large-scale deployment by 2050 is plausible. They are wind, solar PV, geothermal, nuclear, concentrating solar power, carbon capture and storage and bio-energy. We assess the current performance and future potential of each, and what would need to change for it to be deployed at large scale and at sufficiently low cost. Each of these technologies might materially contribute to Australia's future energy mix. All face obstacles to achieving their full potential.

Considering the seven technologies together, Australia has no quick fix or easy choices. Despite current projections, it is possible that none of the technologies can produce power at a scale and at costs similar to today's electricity. In other words, existing policies will not on their own produce the transformation we need. The carbon pricing scheme, while a good start, is not enough. So what is to be done?

First, to minimise uncertainty about future returns due to regulatory changes the government must implement the scheme without compromising its core design and governance. This includes the processes for setting emissions caps and scheme reviews. Markets must be the primary mechanism by which Australia reduces its emissions.

To ensure markets work properly, government must also remove barriers to deployment of several technologies, such as transmission connection hurdles and subsidies to incumbent technologies. Yet even then, it remains unlikely that enough funds will be invested in the short term to give any of the low-carbon technologies a chance to deliver. The reasons are many. Early movers face higher costs than followers. Finance costs are higher for technologies that are not well understood. New infrastructure and regulatory frameworks must be developed, imposing delays and costs on early movers. Resource mapping is inadequate and some technologies lack long-term public support.

Early movers get little reward for paying these higher costs. Because electricity is an undifferentiated product, innovations do not earn more, and intellectual property may not be defensible. Early movers cannot bank the full value of projected higher long-term revenues for low-emissions electricity because government policy on climate change and energy is inherently unreliable.

As a result, private sector investment will deliver less than the best outcome for Australia. Governments should therefore support research and development in areas of national interest, and demonstration and early-stage deployment of a suite of technology options. It is not easy for governments to steer a course between, on the one hand, inadequate support for low-carbon technologies, and on the other, picking winners or favouring one technology over another. How they should do so will be the subject of a forthcoming Grattan report.

## Table of Contents

# 1 How we wrote this report

In this report, we have assessed the challenge of transforming Australia's electricity sector by looking at the scale and speed of what is required. We have done so by analysing seven low-emission electricity technologies with the potential to make a big difference in a relatively short time. These technologies also have the potential to be commercially feasible when projections of their future cost are tested against economic forecasts of future prices in Australia to the order of $100 to $150 per megawatt-hour.

This report sets out the findings of the technology assessments and reviews the implications for government policy in terms of developing and deploying low emissions electricity technology. An accompanying publication: *No easy choices: which way to Australia's energy future – Technology Analysis,* available on the Grattan Institute, website, assesses each of the seven low-emissions technologies in detail. It also includes a review of the barriers that the transmission network can pose to large-scale deployment of low-emissions energy technologies. The grid is a special case, being monopoly infrastructure and essential to electricity supply.

This report focuses on the electricity supply mix and does not address the role of energy efficiency in climate change policy. Improvements in energy efficiency could slow projected energy demand and relax the timeframes in which technology scale-up is required.

The report assesses the role of government in developing low emission technologies. A second report will examine in detail the range of policy instruments through which this role could be exercised.

Our analysis has drawn on the expertise of many individuals with specific expertise in the various fields, for which we are grateful. Grattan Institute also acknowledges the input of its Reference Group. We take full ownership of the report, its conclusions and any errors or emissions it might contain.

# 2 Australia's future energy supply

## 2.1 Australia's electricity sector must change substantially and quickly

The Commonwealth Government has committed to reduce Australia's greenhouse gas emissions by 80 per cent of 2000 levels by 2050. This is in line with a global objective to limit the risk of an increase in average global temperature of more than two degrees.

Historically, stationary energy policy in Australia has focussed on supplying electricity that is both secure and affordable. Australia has now effectively added a third objective: achieving low-carbon electricity generation within the coming four decades.

The goal could be achieved in a number of ways, but a large part is likely to come from reductions in Australia's physical emissions, and from changes in the mix of Australia's electricity technology supply, since it is the major contributor to these emissions.[1] Other ways to meet Australia's emissions targets are either more risky or less plausible.

For example, it would be unwise to rely entirely on international emissions permits, in which Australia achieves its carbon targets by buying emissions reduction achieved overseas. Buying such permits could play an important role in reaching targets, as other countries may be able to cut their emissions more cheaply than in Australia. But there is considerable uncertainty as to how international agreements and linkages will develop. The risk is that Australia's emissions trading partners will not recognise high levels of Australian abatement originating in other countries (for instance in Asia or Africa), especially if there is no international agreement to enforce common standards for accounting and verification of abatement projects.

In this scenario, countries that have invested in abatement at home may seek to protect their markets from 'dodgy carbon' goods. Australia could be disadvantaged by border taxes designed to level the playing field.

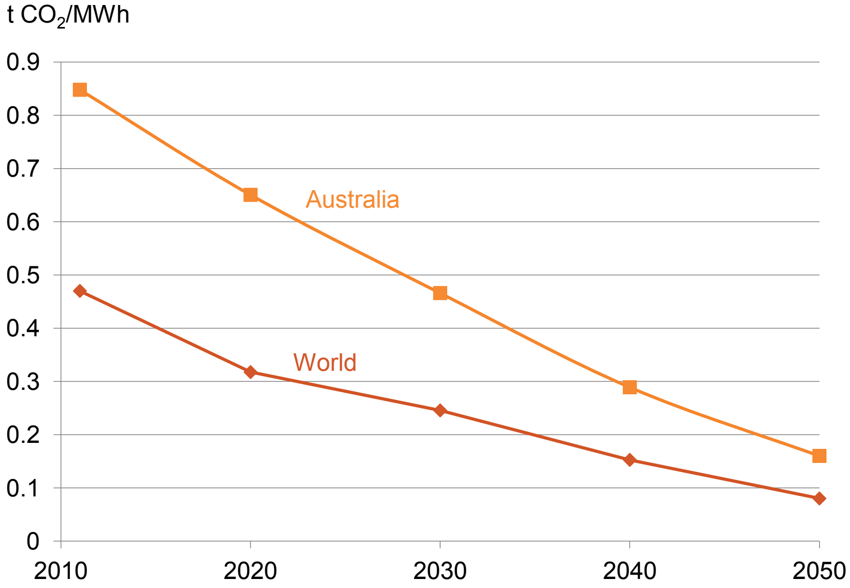
Figure 2.1, based on projections modelled for the Australian Treasury for global and Australian electricity sector emissions indicates the scale of the changes that this challenge demands.

It is clear that we cannot rely simply on fuel switching to gas-fired electricity to achieve all our emissions reductions. Conventional gas-fired power plants can achieve a carbon intensity of about 0.4 tonnes of $CO_2$ emitted per megawatt-hour of electricity produced. While this is a substantial cut on most current power generation – the carbon intensity of coal-fired power stations is between 0.8 and 1.2 tonnes of $CO_2$ for every megawatt-hour -- it is too high to be a sole long-term solution. It is estimated that Australia must achieve a carbon intensity of 0.2 tonnes of $CO_2$ per megawatt-hour or lower if it is to meet its targets.[2]

[1] DCCEE (2011), Garnaut (2008)

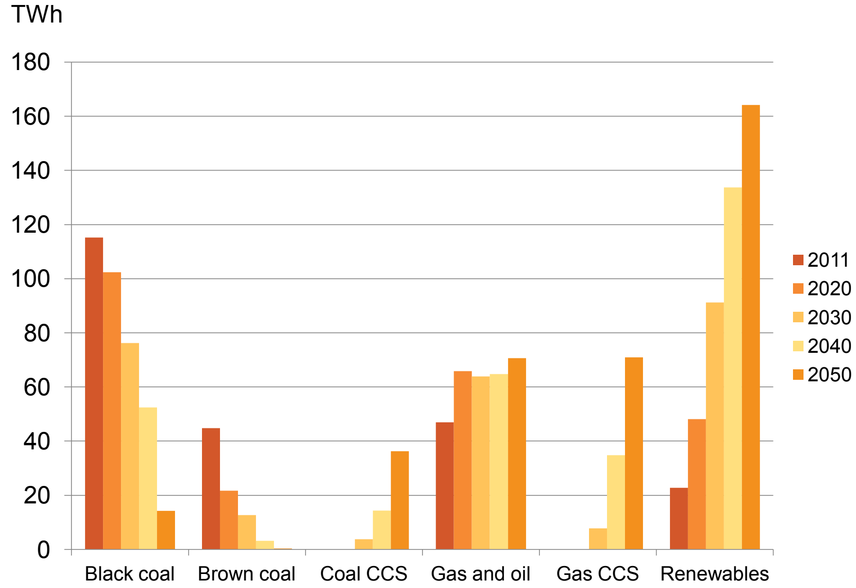
[2] Australian Treasury (2011)

**Figure 2.1 Projected electricity emissions intensity under average of 450ppm and 550ppm scenarios**




*Source: The Australian Treasury, (2011)*

**Figure 2.2 Projected sources of Australian electricity generation under average of 450ppm and 550ppm scenarios**




*Source: The Australian Treasury,( 2011)*

This will require large-scale change in Australia's stationary energy sector. Gas can play a important bridging role, but in the longer-term Australia will need to either retrofit existing coal and gas plants with Carbon Capture and Storage technology (CCS) or replace them with low- or zero-carbon technologies. Economic modelling for the Australian Treasury (Figure 2.2) indicates the degree and speed of required change.

This modelling foresees a major ramp-up of renewable energy from under 10% market share to become the largest source of electricity. All of this growth comes from non-hydro renewable sources that currently represent only 4% of current electricity supply. CCS is also modelled to rapidly ramp-up, from zero to 30% share, largely from 2030 to 2050.

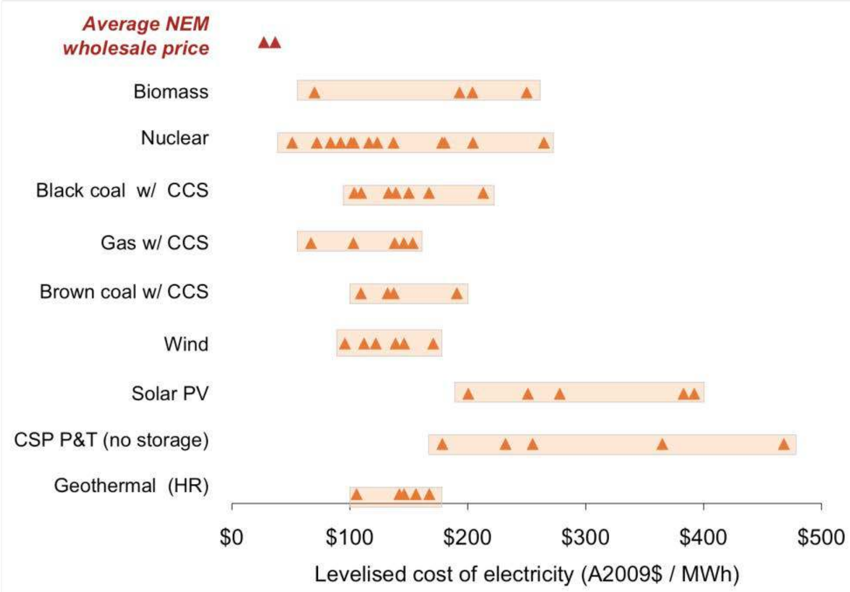
Modelling projections depend on assumptions of future technology costs and should not be taken as forecasts. The projections can disguise the high level of uncertainty about the assumptions across all of the technologies, and the future energy mix could be completely different. However, the scale and timing of the shift to low-emission technologies will be the same regardless of the costs of the individual technologies. Such a rapid shift both globally and in Australia poses serious questions. For such a large change to occur, what must happen and by when?

## 2.2 Current technology cannot meet all of Australia's electricity supply objectives

A range of technologies available today can generate electricity at or below 0.2 tonnes of $CO_2$ per megawatt-hour and have significant scale-up potential (excepting hydro, for which little expansion is feasible in Australia). Yet none currently represents more than 2% of Australia's electricity supply and their future technical and economic potential is shrouded in uncertainty.  To achieve the transition smoothly and affordably, the most important task will be to further refine the underlying power technologies such as wind turbine blades, photovoltaic cells and fuel combustion. But various resources, capabilities and infrastructure are also needed to deploy new technologies in Australia at competitive cost. These include new transmission, pipelines, resource maps, market frameworks, regulations and specific engineering skills.

At present low emissions electricity costs significantly more than current electricity market wholesale prices. The estimates shown in Figure 2.3 range from three to five times the current wholesale price for electricity in Australia of between about $30 and $40 per megawatt-hour.

**Figure 2.3 Estimated electricity generation costs prior to 2015**




*Note: The range of estimates reflects major differences in these sources' assumptions about the cost of fuel, labour, capital (including finance), capacity factor and exchange rates. Some assumptions may not be realistic for current Australian circumstances and the range and relativities are primarily illustrative.*

*Sources: Estimates for all technologies, except nuclear and biomass, are taken (where available) from ACIL Tasman (2010), EPRI (2010), Hayward, et al. (2010), IEA (2010), ROAM Consulting (2011) and SKM-MMA (2011), the EPRI, Hayward et al and IEA sources as reported in CSIRO (2011). Estimates for LCOE of nuclear power are taken from the following sources:Keystone Centre (2007), UK BERR (2007), MIT (2009), EPRI (2010), Citigroup Global Markets (2009), Moody's Investor Services (2008), Severance (2009) and CSIRO (2011).  Biomass figures are from IEA Bioenergy (2009) and SKM-MMA (2011). Prices are in 2009 dollars. Data for all technologies includes a carbon price of $28/t except one CCS estimate, which assumes a price of $25/t, and all nuclear power, which do not account for a carbon price.*

As Figure 2.3 shows, even the near-term costs for low-emissions electricity are highly uncertain. Expert estimates vary widely, even for current costs, because most of our technology options are still immature – they have not been deployed at significant scale in Australia.  Two exceptions to this are wind power and some forms of bioenergy.

# 3 Australia’s portfolio of near-zero emissions technology

This report assesses the prospects for seven near-zero emissions technologies, all of which could materially contribute to Australia’s future energy mix, as summarised in Table 3.1. The shading in this table indicates the depth of the obstacles to commercial deployment of the technology as a material part of Australia’s electricity generation.

This assessment has implications for Australia’s strategy for low emissions electricity.

**It is possible that none of the technologies can produce power at a scale and at costs similar to today’s electricity**. Australia has no quick fixes or easy choices. Wind and solar PV may well become commercial if carbon prices rise to forseeable levels over the next 20 to 30 years. However, these technologies can inherently not provide more than about 50% of Australia’s electricity needs without storage technologies whose commercial viability remains uncertain.

**Given the lack of any “sure bets”, Australia should maintain all the options.** This does not imply that *Australian* governments need to support research and development of every technology. However, it does suggest that government should support demonstration plants of any technology sufficiently developed that commercial application is within sight.

**There are significant barriers for each technology for which governments are responsible**. In particular, better network regulation, and government assessments of solar and geological resources, are required, as discussed below.

**Without government support beyond a carbon price, none of the technologies is likely to be developed** to be commercially competitive, demonstrated, or deployed in Australia. The current deployment of wind and solar PV in Australia has depended on government support for financial viability. Whether *Australian* governments should support the development of any of these technologies is discussed further below.

**CCS and nuclear are unlikely to be demonstrated in Australia in the near future unless government takes on most of the material risks of the project**. The demonstration of these technologies in Australia involves risks that only government is in a position to bear.

**Table 3.1 Summary of technology assessments**

| | Scaleability | Current costs and rate of decline | Extent of commercial deployment | Prospects for near term private sector involvement | Government barriers |
|---|---|---|---|---|---|
| **Wind** | Could supply at least 20% of Australia's electricity needs.<br>Given wind variability, other sources also required | Can scale up rapidly at less than key benchmark of $150/MWh, although cost decline has flattened | Significant deployment underway in Australia | Significant investment underway given effective subsidy through 20% renewable energy target<br>Private sector readily involved, provided that some government support is maintained | Grid infrastructure and system integration needs to be improved for remote sites to support multiple, expensive and timely network upgrades.<br>Community resistance to wind farm noise can achieve a high profile: the regulatory framework needs to provide certainty for all stakeholders |
| **Solar PV** | Could generate more than 30% with grid integration management; significantly more with viable storage | Costs are fair, not yet competitive with wind, but falling rapidly<br>Value depends on local network and timing of peak demand | Already widespread in Australia, but not yet at scale to impact grid | Growing strongly from existing base, but dependent on existent government subsidies | Large-scale deployment constrained by integration with electricity distribution grid, in which Australia lacks skills and knowledge. |
| **Concentrating solar power** | Resource sufficient to meet all of Australia's electricity needs<br>Thermal storage and gas cogeneration needed to overcome intermittency | Currently uncommercial; costs (particularly mass production of components, better solar field engineering, and more efficient temperature fluids) may decline with development and broad deployment.<br>Towers likely to be cheaper than other CSP technologies in medium term | Some deployment overseas, but limited scale as high cost relative to wind and solar PV | Some involvement already in Australia, but dependent on government subsidies | Grid infrastructure and system integration need to be improved for remote sites (as per Wind).<br>Government needs to collect and disseminate solar radiation data, given knowledge spillovers. |
| **Geothermal** | Abundant resource in Australia could underpin a major contribution | Reliability and costs highly uncertain as still at exploration and development stage, with fundamental engineering challenges in reservoir management | Minimal deployment in Australia, although private companies involved in exploration | May be involved in more accessible shallower Hot Sedimentary Aquifer, which will also develop experience and investor confidence to exploit the more difficult Hot Rocks resource. | Government needs to map, model and disseminate geological resource data, given knowledge spillovers<br>Grid infrastructure and system integration needs to be improved for remote sites (as per Wind).<br>A clear regulatory framework is required to provide certainty for stakeholders. |

| | Scaleability | Current costs and rate of decline | Extent of commercial deployment | Prospects for near term private sector involvement | Government barriers |
|---|---|---|---|---|---|
| **CCS** | Could contribute very significantly and extend life of existing and coal and gas plants | Projected costs competitive, but not proven at scale.<br>Early costs will be high as models are developed to integrate different stages and interests | Only deployed for gas production fields, which are much less complex than CCS for power generation | Absolute size of investment a major barrier for early mover projects<br>Difficult to set up given complexity of many different stages and industries working together | Government needs to map, model and disseminate geological storage resource data, given knowledge spillovers.<br>Clear legal and regulatory frameworks are required to provide certainty for stakeholders. |
| **Nuclear** | Could meet a large proportion of Australia's electricity needs | New-build costs uncertain as limited experience in the last 25 years. Developing designs may be cheaper, safer and more efficient, but at R&D stage and commercially unproven | No deployment in Australia<br>Widespread deployment overseas in the past, but limited recent deployment in Western Europe and North American countries.<br>Deployment continuing in several other countries | Absolute size of investment a major barrier<br>Financial and regulatory risks make private sector involvement unlikely in Australia without strong public sector support | Including legal and regulatory frameworks the lead time in Australia would be 15-20 years. Government could reduce this by about 5 years without committing to build a nuclear power plant<br>Sustained public engagement is essential for developing a nuclear power option |
| **Bioenergy** | Significant energy available, although unlikely to be more than 20% of energy demands given competing needs for food.<br>Easy to control short-run output to meet peak daily demand, but some seasonal variation | Not competitive unless supply chain from production to transport improved; likely to take over 10 years. Local customisation required, particularly for nature of demand for electricity and heat and feedstock<br>Commercial viability also may be enhanced through improvements to reduce minimum economic scale to <5MW plants | Employed at significant scale in a number of countries and the combustion technology well-understood.<br>Feedstocks with greatest potential in Australia only deployed in a handful of projects | Several private sector developers already involved in Australia.<br>At current costs, some form of additional government support will be necessary for meaningful levels of project development. | Grid infrastructure and system integration needs to be improved to cater for connection of large number of relatively small power stations in regional areas |

# 4 Why government should intervene

Government intervention beyond a carbon price is required for the development, demonstration and early deployment of low emissions technologies, for a number of reasons.

Markets cannot work properly unless government removes barriers to deployment of several technologies, such as transmission connection hurdles and the enduring subsidies we outline below. Government regulation of transmission distorts electricity generation markets against low emissions technologies and in favour of conventional coal and gas generation.

Even if government removes these obstacles, it remains unlikely that enough will be invested in the short term to give any of the technologies a chance to deliver. That is because early movers face higher costs than followers. Finance costs are higher for technologies that are not well understood. New infrastructure and regulatory frameworks must be developed, imposing delays and costs on early movers. Resource mapping is inadequate and some technologies lack long-term community support.

Early movers get little reward for paying these higher costs. Because electricity is an undifferentiated product, innovations do not earn more, and intellectual property may not be defensible. Early movers cannot bank the full value of projected higher long-term revenues for low emissions electricity because government policy on climate change and energy is inherently not reliable. This section analyses these difficulties in detail.

## 4.1 Government regulatory barriers

New technologies do not compete on a level playing field with existing generation technologies, because they face higher barriers to transmission, may not share the subsidies provided to existing energy sources and a "public licence to operate" is not assured.

### 4.1.1 Transmission

Several potential low emissions electricity technologies would be located in a different geographic pattern to existing generation. Some substantial generators, such as wind, CSP and geothermal, would be far from existing generation centres. Others, such as solar PV and biomass, would involve small generators distributed within existing population centres. Existing transmission networks and network regulation are designed around the assumption that almost all electricity generators will be large plants close to existing centres of generation. Decisions on transmission networks are largely determined by the regulatory framework rather than market forces because transmission is a regulated monopoly business in Australia. The Ministerial Council on Energy, in 2010, noted[3] that transmission network providers "currently have no commercial incentive to build network connections to an efficient scale in anticipation of future connection". The result is that new wind farms or large-scale solar farms may be located to avoid incurring transmission connection charges when alternatives requiring an improved transmission system might have delivered an overall lower cost outcome. New

[3] MCE (2010)

regulatory frameworks are required that ensure long-run cost-efficient trade-offs.

These problems are not unique to Australia. The UK Committee on Climate Change noted[4] that "the market power of incumbent technologies makes it harder for new technologies to enter the market. Supporting infrastructure – primarily grid and pipelines – are built around centralised 'baseload' power supply and are not well suited to remote or distributed generation."

Chapter 9 of the Detailed Report describes the particular barriers to securing transmission connection, including first mover disadvantage, for key low-emissions technologies such as wind, solar thermal, geothermal and large-scale solar PV. Chapter 3 of the Detailed Report sets out the particular barriers that exist in connecting and integrating solar PV within distribution networks, including misalignment of incentives for distributed generation. Removal of these barriers should be a government priority.

### 4.1.2 Subsidies for existing technologies

Government subsidies to incumbent technologies and structures continue to discourage innovation in new technologies. A 2011 OECD study estimated the level of subsidies for fossil fuels within 24 OECD countries (including Australia) to be in the range of US$45 billion to US$75 billion per year over the period 2005-2010.[5] Australian State and Federal Government budgetary support for fossil fuels was estimated to be US$7.2 billion per annum, whilst the Australian Taxation Office[6] estimated the subsidies at $8 billion per annum and the Australia Institute[7], $9.3billion. Proposals to reserve a proportion of gas production for domestic use and the New South Wales Government's recent action to subsidise local coal prices for power generation are a further example of such intervention. Based on the reported coal price[8], and using current prices for coal exports[9], the effective subsidy would be around $300 million per year.

### 4.1.3 Lack of public support

The deployment of new technologies in the community inevitably raises real and perceived concerns about threats to public health, water quality, asset values and visual amenity, among others. Governments influence and/or address such concerns through the way they communicate support or otherwise for new technologies.

Most low-emissions technologies in this report raise some sub-set of such concerns. For nuclear power, there is considerable public concern about the safety of the technology. Public concerns with storage integrity have caused CCS projects in Europe to be delayed or cancelled. Health concerns have been raised from residents close to proposed wind farms. Geothermal plants raise issues about their impact on groundwater, and the interaction of their activities with gas extraction. Inevitably there will be concern about their impact on local geological stability.

Until governments settle the regulations defining how these concerns will or won't be met, people will be more reluctant to invest in new technologies rather than in incumbent technologies

[4] Committee on Climate Change (2010)
[5] OECD (2011b)
[6] ATO (2010)
[7] Dennis and Macintosh (2011)
[8] IES (2011)
[9] ACIL Tasman (2011)

where the rules of the game are established and future costs more certain.

## 4.2 Market failure – in theory

Government intervention in markets is justified where actions that would benefit society do not also result in a commensurate private benefit.[10] For example, the creators of new knowledge and skills through R&D often find it practically impossible to exclude others from sharing the benefits of their work. Private firms in this situation are reluctant to invest in R&D if they will not earn additional revenue for their R&D expenditure. Without government intervention, market-driven investment in R&D will be less than would provide the optimal public benefit. This is one reason why governments fund university research.

Thus there is “market failure” whenever a private actor does not take on socially desirable costs because they won’t result in commercial returns. This may be because an early mover incurs costs that also benefit subsequent entrants, with the result that followers have lower costs but earn the same revenues. Or it may be because private actors individually perceive uncertainty (which they treat as a cost) whereas society sees the collective outcome as certain.

## 4.3 Market structure – high costs

Early movers on new low emissions electricity technologies face higher costs than followers. This is true for the research and development of these technologies, and is also an issue for demonstration plants and the first few plants constructed in a jurisdiction.

[10] Stern (2007)

### 4.3.1 Finance

Finance costs are higher for first movers who use technologies that are not well understood by their financiers. Financiers faced with a new technology will either incur higher costs in managing risks unfamiliar from conventional generation, or will see the project as higher risk than conventional generation. This perceived higher risk may spur the financier to demand a higher interest rate or internal rate of return. Or debt funders may demand that a higher percentage of the project be equity financed than would be the case for conventional generation. The perception of higher risk may also be reflected in more onerous terms and conditions. These will inevitably impose higher effective costs of finance, so that the total costs of an early project are higher.

Subsequent projects will have relatively lower finance costs because their financiers will understand the technologies. They will have an advantage in competing with early movers whose cost base reflects the initial uncertainty of lenders.

In their report for the IPCC on the financing challenges for renewable energy projects, Mitchell et al[11] noted: "Developers of RE projects are often under-financed. Additional development costs imposed by financiers on under-capitalized developers during due diligence can significantly jeopardize a project". The UK Energy Research Centre (2007)[12] also highlighted these financing challenges in relation to high capital cost investments common to low-emission technologies.

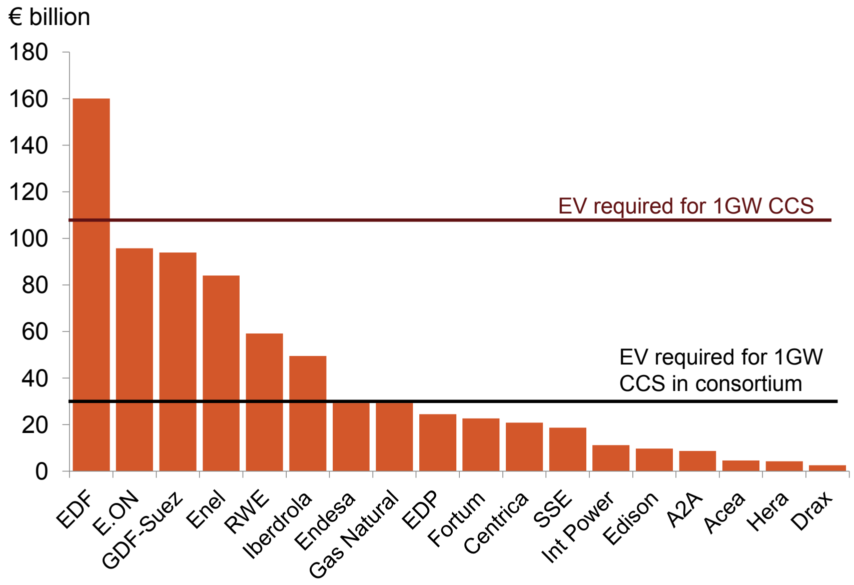
[11] Mitchell et al (2011)
[12] Gross et al (2007)

### 4.3.2 Minimum scale

The minimum scale of investment is particularly high for many new electricity generation technologies, at the same time as they are inherently complex and high risk.[13] Very few substantial companies will "bet the company" on a project that is also high risk. Some low-emissions technologies, particularly nuclear and CCS, require an investment in the order of $1 billion even for a demonstration plant. There are few energy companies globally, and none in Australia, that can afford to invest this amount without a very high probability of success.

In a 2009 report on the economics of nuclear power[14], Citigroup analysts concluded that the development risks were "so large and variable that individually they could bring even the largest utility company to its knees financially". The Climate Group and Ecofin estimated that given the relatively high risks of CCS, and a corporate desire to avoid investing more than a small percentage of enterprise value in high-risk ventures, a company would need an enterprise value of over EURO100 billion to take on the risk of financing a 1,000 MW commercial CCS plant. This is larger than the enterprise value of all but one of the largest utilities in Europe, as shown in Figure 4.1. By way of comparison, Origin Energy and AGL Energy, the largest listed integrated energy companies in Australia, have market capitalisations of around $16 billion and $7 billion respectively.

**Figure 4.1 Enterprise value of European utilities required to finance a 1,000 megawatt CCS plant**




*Source: The Climate Group et al., (2010)*

### 4.3.3 Resource mapping

For several low-emission technologies, understanding the potential of the underlying resource is vital to achieving the confidence necessary to embark on major commercial-scale projects. However, private firms undertaking such early-stage data acquisition incur costs in that that the information will almost inevitably leak out to benefit future competitors. The nature of the information is such that it is very difficult to protect using existing intellectual property regimes.

[13] Committee on Climate Change (2010), Stern (2007)
[14] Citigroup Global Markets (2009)

For example, although government geosciences agencies have already undertaken considerable assessment of CO2 storage potential and made the data available to industry, five to 10 years of further greenfield storage assessment will be required to underpin commercial projects.[15] Similar challenges apply to early movers in geothermal and concentrating solar energy, as explored further in the Detailed Report.

#### 4.3.4 Regulatory costs

The builder of a demonstration plant or the first substantial plant using a new technology may also incur substantially higher regulatory costs than will be incurred for subsequent plants. Governments may well only work through some of these issues once there is a live project. The constructor of the first project in a jurisdiction may often be left waiting when a novel problem arises and government takes time to indicate how it will be resolved.

In some cases, community concerns such as those identified in 4.1.3, may already be reflected in legislation or regulation. These include the exclusion of nuclear power or the application of buffer zones for wind farms.

Even after a regulatory framework has been set up, the constructor of a demonstration plant in Australia can expect significant delays as policy issues arise through practice.

All of the low-emissions generation technologies have very substantial capital costs – for most of the technologies this is the dominant cost. Once an investor has started to incur these costs, anything that delays commissioning substantially adds to the cost of the project.

[15] Global CCS Institute (2011)

Of course, this regulatory uncertainty itself adds to costs for early constructors of new electricity technologies. Even if government succeeds in articulating a regulatory framework well in advance, and avoids delaying the project through any policy decisions that arise in practice, the *possibility* that this might happen is an additional risk that adds to financing costs, as discussed above.

Governments can reduce the obstacles for early movers by providing public information and setting up robust planning and approval processes. In the case of nuclear energy, the public engagement, political process, and policy implementation is likely to take many years. Governments are unlikely to entirely eliminate the additional regulatory costs faced by early movers.

### 4.4 Market structure – low rewards

Early movers facing the higher financing, resource mapping, regulatory and technology development costs as detailed in the last section get little reward for incurring these higher costs.

#### 4.4.1 No premium for early movers

Because electricity is an undifferentiated product, innovations do not earn more, and intellectual property may not be defensible. In most industries there is a substantial premium for bringing an innovation to market. Early adopters are often prepared to pay a premium for a new technology. Even if the developer cannot protect its intellectual property, there is usually a space for the developer to reap higher rewards while subsequent entrants identify the opportunity, reverse-engineer the innovation, and bring their offering to market.

By contrast, developers of new electricity generation technologies usually do not earn such a premium. Electricity is an unusually pure commodity: from a consumer's perspective electricity is all the same, however it is generated.

The only exception might be consumers who are prepared to pay a premium knowing that their power is green. In Australia this is a small proportion of the total generation market (less than 1% of Australia's electricity demand), and it may well become smaller once a carbon price is in place and there is a public perception that greenhouse concerns are already built into prices..

### 4.4.2 Discounted value of carbon pricing

Early movers cannot bank the full value of projected higher long-term revenues for low emissions electricity because government policy on climate change and energy is inherently not reliable and continues to shift.

Demand for low-emissions technology is created by government policy in order to price the environmental impact of carbon emissions. But there is significant uncertainty about the long-term credibility of the policy commitment, when energy infrastructure investment needs a high level of predictability.

Electricity sector investments are subject to many risks and uncertainties, including over climate change policy. This uncertainty encourages firms to delay investment to keep options open in the short term in the expectation that they can make better informed decisions later. As a result there is less investment in the technologies needed than is socially desirable.

In an ideal world government would legislate emissions constraints over several decades. The private sector could confidently rely on this to form a view about the likely path of the carbon price over time and the relative merits of investing now or later and in which emission reduction technologies. Speculators would also emerge to arbitrage – or carry the investment risk – between carbon prices today and those likely in the future. Investors could then understand the potential future pay-offs of investments made today in developing improved abatement technologies for the future.

Unfortunately, people cannot confidently rely on carbon prices more than a few years ahead, because:

1. Current parliaments are unable to securely bind future parliaments to their decisions. Even if a parliament were to set an emissions constraint several decades into the future, future parliaments could rescind or alter it. This perennial challenge is particularly acute in today's political environment that lacks consensus on carbon pricing.

2. The international nature of the climate change problem means that Australian government commitments depend on what other governments do. Consequently future Australian carbon prices are uncertain because of considerable uncertainty over likely future levels of international action to reduce emissions.

3. The market in carbon emissions permits is new and establishing a reputation for credibility and commitment simply takes time. Over time, as increasing levels of investment are made on the basis of a particular market design, it becomes less vulnerable to arbitrary government policy change.

4. The energy system vital to our modern economy has evolved over 200 years.[16] This creates a degree of inertia and incrementalism that simply means it is hard to make the

[16] Shell International (2007)

changes that would lead to long-term credibility of emission reduction targets. Investors fear that any tension between maintaining the stability of the energy system and emissions reduction will be resolved in favour of stability.

5. Credibility is particularly hard to establish because the scope of the emissions market is wider, and is being implemented more quickly, than any previous environmental market. The emissions price will apply to several sectors of the economy, with emissions reductions to be achieved through potentially hundreds of technological or behavioural changes. By contrast, the Renewable Energy Target (RET) scheme, for example, affects only the electricity generation sector and a small number of technologies. Even then the market for certificates under the RET faced uncertainty and limited forward trading, particularly after the 2003 review,[17] but its smaller and narrower focus meant that the broader economic impact of this was modest.

This does not undermine the rationale for a long-term carbon pricing regime. Without one, investment uncertainty would be even greater. Government intervention by regulation is an alternative, but one that is ill-suited to efficiently delivering the breadth and scale of change that is required. Regulation is more likely to be effective when the scope of required change is narrow and the alternatives to the status quo well understood, such as with appliance standards.

The above characteristics mean that the private sector is likely to discount future revenues reliant on a carbon price for many years, and therefore hesitate to make large investments in low carbon technologies.

There is evidence that uncertainty about future carbon pricing policy is affecting investor decisions both in Australia and overseas.

The Investor Reference Group on Investment Activity in the Electricity Generation Sector (Investor Reference Group) reports that uncertainty is manifesting itself in shorter trading horizons and reduced activity in over-the-counter contract markets. The Group concluded that '*investors will need confidence in the stability of the carbon policy over a long period before committing to...assets*'.[18]

The Group also points out that only one merchant or independent base load power generator has been built in the NEM since 2002, and development of a further 22,000 megawatts of 'announced' generation projects has stalled.[19] However, this is not solely a consequence of carbon price uncertainty. The lack of base load investment is due to relatively low wholesale electricity prices and alternate investments in peaking plant to address a range of uncertainties in the electricity system.[20]

Sub-optimal investment and underperformance of utilities is also occurring overseas, due in part to policy "inconsistency" and

[17] MMA (2002)

[18] Investor Reference Group on Investment Activity in the Electricity Generation Sector (2011)
[19] Investor Reference Group on Investment Activity in the Electricity Generation Sector (2011)
[20] Garnaut (2011b)

uncertainty being priced into equity markets by European utilities.[21]

A major survey of 65 European power utilities and 136 power technology providers indicates that the price of EU emission permits does influence their investment decisions. However, the survey also showed that shifting public opinion, government policies such as feed-in tariffs for renewable energy and unclear government statements about long-term climate change policy all create damaging uncertainty for investments with longer-term pay-offs. It also found wide variance in $CO_2$ price expectations. Most respondents expressed substantial uncertainty about the likely carbon price in 2020.

Similarly, surveys of European carbon market participants show a fall in confidence that there will be a global reference price for carbon in 2020. In 2011 60% expected one, down from 72% in 2009 and 66% in 2010.[22]

This uncertainty is apparent in existing international emissions markets. For example, there is relatively little futures trading of certified emissions reductions (CERs) generated under the Clean Development Mechanism (CDM) of the Kyoto Protocol. For post-2015 CER contracts there is "zero liquidity".[23]

After consulting stakeholders and modelling the impact of different carbon prices, and uncertainty, on low-emissions investment, the UK Government concluded that uncertainty justified changes to its climate change policy. It stated that the carbon price – which has been in place for several years – '*has not been stable, certain or high enough to encourage sufficient investment in low-carbon electricity generation in the UK*'.[24]

### 4.4.3 Systemic under-pricing of carbon

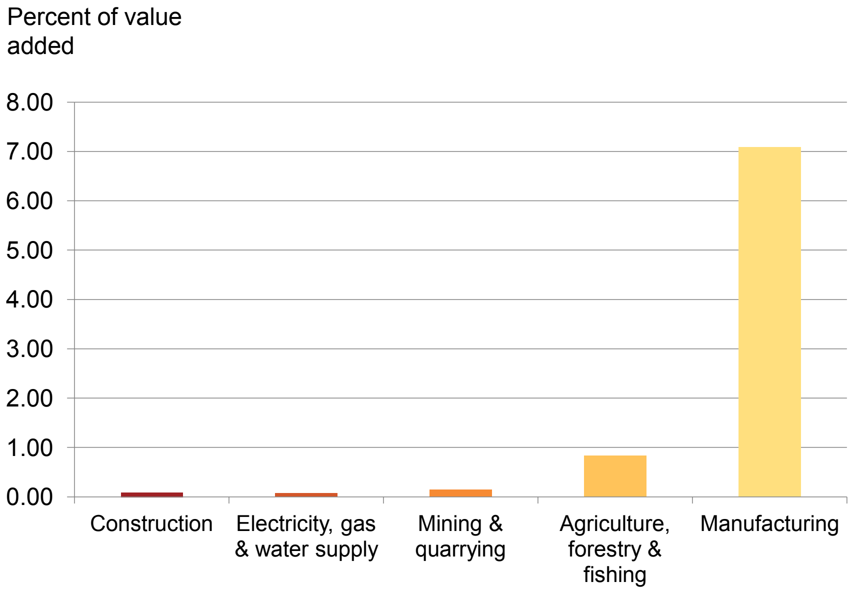
Governments will tend to underprice the externality of greenhouse gas emissions due to political realities, providing a further incentive towards disinvestment in long-term technology development. For example, the Australian Government was a party to the Copenhagen Accord in 2009 that identified an ultimate objective of stabilising greenhouse gas concentrations in the atmosphere at a level consistent with a global temperature increase below 2 degrees Celsius. Australia's 5% reduction target embodied in the current Clean Energy Future legislation falls well short of consistency with this objective[25].

## 4.5 Past experience

Given the high costs and limited rewards, investment in R&D relative to revenue has always been lower in electricity generating technology relative to other industries such as car manufacturing electronics, as shown in Figure 4.2. Given the uncertainties of carbon pricing discussed in 4.4.2, without government intervention, private investment in the development of low emission electricity is likely to be even lower.

[21] Peetermans (2011)
[22] Point Carbon (2011)
[23] Peetermans (2011)
[24] UK DECC (2011b): 34
[25] Garnaut (2008)

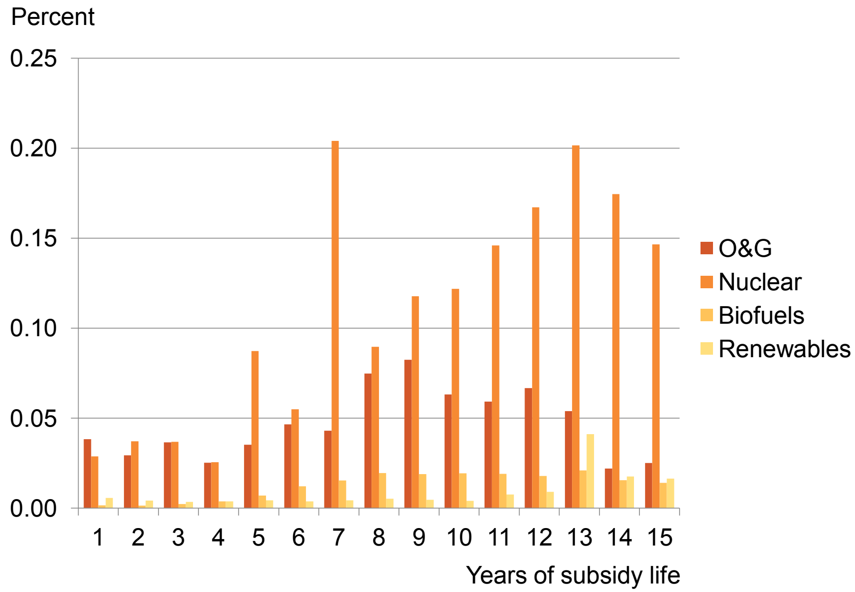
**Figure 4.2 Business R&D intensity in the UK by sector, 2006 (R&D as percent of value added)**




*Source: Committee on Climate Change (2010)*

These issues partly explain why governments have frequently intervened in the energy sector in the past. Since the 19th century subsidies, often justified by the need to ensure energy security and affordability, have been used to drive innovation and change, as shown in Figure 4.3.[26] Also, because the sector is so capital-intensive, governments have often intervened when the projects are so large the private sector cannot borrow the necessary funds.

**Figure 4.3 Energy subsidies as a proportion of the US Federal Budget**




*Note: Year 1 equivalent to inflation-adjusted 1918 Federal Budget*

*Source: Pfund and Healy, (2011)*

[26] Pfund and Healy (2011)

# 5 How government should intervene

## 5.1 Government interventions to promote an efficient market

Australian governments can act to reduce the distorting regulations that disadvantage new emissions technologies unfairly. In addition governments must remove a number of barriers to create a "level playing field" between electricity generation technologies. Generally these actions are relatively low cost, and there would be few regrets even if the technology ultimately proved to be unsuccessful or uncompetitive.

### 5.1.1 Structure emissions cap and associated trading scheme to minimise uncertainty

As described in 4.4.2, investors will discount future emissions prices to reflect uncertainty about whether they will be implemented. Government can reduce (although not eliminate) this uncertainty by using "gateway mechanisms" that set upper and lower bounds on longer-term emissions caps. These would enable investors to plan with greater certainty. The 2008 Garnaut Review, the Prime Minister's Task Group on Emissions Trading report to the Howard Government (2007) and the State and Territory governments (2007) all advocated such gateway mechanisms. The Prime Minister's Task Group on Emissions Trading noted that the "medium-term gateways should...ensure sufficient pressure is applied to accelerate the expected technology development".[27]

### 5.1.2 Map resources

Governments should maintain and expand funding of exploration and mapping of solar and geological resources to acquire information on resource quality and quantity for solar thermal and geothermal energy and for $CO_2$ Storage. This would redress the inability of individual firms to capture the value of capturing knowledge that is available to all players, as discussed in 4.3.3.

There is already a history of governments playing a valid role in oil and gas exploration. Geoscience agencies fund early-stage data acquisition and then make the data available to companies bidding for acreage to be released under exploration and production programs.

### 5.1.3 Reduce existing subsidies

In Australia precise quantification of subsidies is subject to a degree of dispute (for example, does concessional tax treatment constitute a subsidy). A genuinely comprehensive assessment that included a range of non-fiscal regulatory distortions is yet to be undertaken. As well as the areas identified in 1.4.2, governments provide a range of other more subtle subsidies. They include price controls over residential electricity prices; cross subsidies that provide electricity to regional areas below costs; the continuing resistance to roll-out of time-of-use pricing for residential consumers; and contracts to provide electricity below market prices to large industrial facilities such as aluminium smelters.

[27] Prime Minister's Task Group on Emissions Trading (2007)

A number of these should be immediately phased out, and at the very least, the Productivity Commission should be tasked with tracking and reviewing these assorted subsidies and tax exemptions and their potential effect in undermining the effectiveness of the carbon pricing mechanism.

### 5.1.4 Reform network regulation

Barriers to the coordination and planning of transmission investment decisions and integration with distribution grids need to be addressed. In the case of transmission, the 2002 Parer Review, the 2008 and 2011 Garnaut Climate Change Reviews and the 2009 AEMC review of energy markets in light of climate change policies[28] all identified the need for changes in governance structures and processes.[29] Recommended areas for change include planning and approving new connections, charging for extensions into regions involving clusters of generators, and inter-regional charging for capacity that delivers benefits across regional boundaries.

Optimising the value of energy generation capacity such as small-scale solar PV that connects to distribution networks requires the removal of barriers that prevent time-of day pricing, integration with grid management and locational pricing.

## 5.2 Government support for low emissions technologies

As shown in the last section, the private sector will invest less than is ideal from a social perspective when those who develop, demonstrate, and deploy early examples of new electricity technologies face higher costs than those who follow them, and when it must discount the expected revenue given the inherent uncertainties of carbon pricing markets.

This justifies at least some government involvement to promote research and development, demonstration and early-stage deployment not only through but beyond the central platform of the emissions trading scheme. However, government intervention needs to be designed without compromising the central policy or leading to unintended consequences, based on a full assessment of the market, the technologies and nature of the market failures.

A carbon price and an efficiently structured electricity market are unlikely to trigger the investment in the electricity sector necessary to meet Australia's multiple objectives of secure, affordable and low-emissions power. Similar conclusions have been reached elsewhere. In 2011, the UK Government announced that, from 2013, a carbon price floor would be introduced to "reduce uncertainty" and provide "a stronger incentive to invest in low-carbon generation". It also announced new contracts to "provide stable financial incentives to invest in all forms of low-carbon electricity generation", saying that "long-term contracts will be the key mechanism for encouraging investment in low-carbon generation by providing greater long-term revenue certainty to investors."[30]

Similarly, Australia's Investor Reference Group concluded in 2011 that carbon pricing would not be "sufficient in itself for investors to make commercial decisions to invest in long lived electricity generation and other energy assets". The Group suggested that effective policy would require "an appropriate framework of complementary measures...additional to a carbon price", including

[28] Parer (2002), Garnaut (2008), Garnaut (2011), AEMC (2009)
[29] Parer (2002), Garnaut (2008), Garnaut (2011), AEMC (2009)
[30] UK DECC (2011b), UK DECC (2011c), UK DECC (2011a)

policies to develop and deploy low emission technologies.[31] The recent Global Investor Statement on Climate Change, from a group of 285 investors representing $20 trillion of assets, also called for an “integrated climate change and clean energy policy framework” that included, as well as meaningful and enforceable emissions reduction targets, policies to accelerate the investment in, and deployment of, cleaner energy generation.[32]

Further policy interventions beyond the emissions trading scheme are justified only if the expected benefits exceed the expected costs.[33] Such government interventions must be designed to avoid undermining investor confidence in the emissions market. For example, sudden and substantial short-run price fluctuations, can undermine confidence, as happened when Australian solar rebates and subsidies introduced in 2008-2009 overwhelmed the renewable energy credit market a year later.

### 5.2.1 Research and development

The R&D and innovation market failure has been described[34] as a key factor motivating the need for policy intervention beyond carbon pricing. Markets produce less R&D investment than is socially ideal, as discussed in 4.2. Electricity technologies are particularly prone to under-investment, as discussed in 4.5. When other firms can benefit from much of the knowledge or information produced by electricity technology R&D without paying for the activity, the private sector will tend to underinvest in R&D. [35]

[31] Investor Reference Group on Investment Activity in the Electricity Generation Sector (2011)
[32] Global Investor Statement on Climate Change (2011)
[33] OECD (2011a)
[34] Mitchell et al (2011)
[35] Garnaut (2011a), OECD (2011a), Fischer and Preonas (2010)

Further R&D would probably lead to significant advances in geothermal, biomass, solar PV, solar thermal and CCS technology. Yet it is less clear that *Australian* governments should support R&D in all of these areas. R&D in many of these technologies will progress elsewhere. Ideally Australian decisions would be informed by international agreements aimed at knowledge sharing and coordination of R&D,[36] although these often struggle to survive international politics.

Beyond international cooperation, certain technologies may become a source of international competitiveness. For example, countries with significant, favourable geological structures may invest in CCS[37], and Australia has had some success in the export of its solar PV R&D.

In his 2008 and 2011 Reports[38], Garnaut recommended the support of research and development targeted at "areas of national interest where Australia has a comparative advantage". Technologies assessed in this report that might meet such criteria include CCS and geothermal energy. This report does not canvass the design of such support mechanisms.

### 5.2.2 Demonstration and early deployment

The high costs and limited rewards for early movers that result in less than the socially optimal level of investment (often described as “market spillovers”)[39] also justify government support for demonstration and early deployment of low-emission technologies. Our technology assessments in this Report have

[36] De Conninck et al (2008), in Fischer (2009)
[37] Fischer (2009)
[38] Garnaut (2008), Garnaut (2011c)
[39] Garnaut (2011c), Fischer and Preonas (2010 ), OECD (2011)

identified a range of spillovers, including skills, knowledge and development of regulations. The financial market issues discussed in section 4.3 are particularly acute at this stage of technology development.

Technology development at the demonstration and early deployment stages involves more locally-specific issues and requires more overall funds than at the R&D stage, although risks associated with the technology per se will be lower. Intervention by *Australian* governments should therefore be aimed at projects and technologies likely to resolve these issues and reduce the costs to future players of locally-specific technology development, financing uncertainty, project risk and regulatory definition.[40]

### 5.2.3 Rollout

Once emissions are capped through an emissions trading scheme, there is no case to support technologies beyond addressing the market and system failures identified in this report. It may be argued that setting an insufficiently stringent cap on emissions through the ETS justifies an additional mechanism such as renewable energy or low-emission energy quotas. Whilst an understandable next-best policy and attractive politically, it would be a poor response. The best solution is to set emission caps with environmental integrity, supported by measures that address market failures and barriers.

It follows that existing policy mechanisms such as the Renewable Energy Target and various feed-in-tariffs should then be assessed in this context. The elimination of these existing schemes would require careful management, including grandfathering of existing commitments.

### 5.2.4 Form of government intervention

Substantial questions remain about the ideal form of Australian government intervention to support demonstration plants and early deployment.

Governments cannot support low-emissions technology without, to some extent, implicitly making choices about which technologies are likely to be lower cost in the medium term. Given the level of uncertainty about the future costs of all the technologies, no-one can foresee accurately which low emissions technology is most likely to be low cost in the medium term. There is no reason to believe that government has any special ability to foresee these developments, and yet all government decisions about which technologies are eligible for support, and to support particular projects implicitly make choices about technologies.

In the face of such uncertainty, the best strategy is usually to support a variety of options.[41] Although creating options is not the cheapest way to deploy *any one* technology, over time it is the cheapest way to deploy the best technologies and the best results.

In pursuing these options, it is desirable to maximise the incentives to deliver each of them efficiently. The precise form of government assistance will vary depending on the nature of the technology and the obstacles it faces. However, as our report, *Learning the hard way: Australia's policies to reduce emissions*, showed, direct government grants to companies to promote

[40] Garnaut (2011c)

[41] Courtney (2001)

individual technologies has a poor track record both in Australia and overseas. Little of the announced money is ever spent.[42]

A subsequent Grattan Institute report will discuss the optimal design of government intervention. Options range from government essentially sponsoring the project itself, taking on all of the material risks, through to schemes such as renewable energy certificates that provide a financial reward to the operator of any low-emissions electricity generator. These trade-offs need to be made in the light of the justifications for intervention discussed in this report, and the nature of the technologies.

[42] Daley*, et al.* (2011)

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