A Quantifying the costs and benefits of low-emissions energy targets

Economic modelling has generally projected that low-emissions energy targets are a more costly abatement measure than an emissions trading scheme (ETS). Two recent reports, however, project that low-emissions energy targets operating in conjunction with an ETS could lead to a small decrease in abatement costs. This conclusion rests on optimistic assumptions about the potential benefits from 'learning-by-doing'. Relaxing these assumptions is sufficient to bring the conclusions into line with other economic modelling.

A.1 Introduction

Low-emissions energy targets have been mooted as a supplementary measure to operate alongside an emissions trading scheme (ETS) (Australian Government 2007). The term 'low-emissions energy target' is a broad one, referring collectively to:

- clean energy targets — which specify that a certain amount of energy must come from a broad range of energy sources associated with minimal greenhouse gas (GHG) emissions
- renewable energy targets — which are more restrictive on the technologies that can be used to meet the target by excluding low-emissions technologies that are non-renewable, such as carbon capture and storage and nuclear power.

As discussed in chapter 2, adding a low-emissions energy target to an ETS is unlikely to lead to any additional GHG abatement and so would have to be justified on other grounds. This requires two criteria to be satisfied:

- the benefits from the target must outweigh its cost
- the low-emissions energy target needs to be the best way to access the benefits (rather than, for example, funding for research and development).

This appendix focuses on the first hurdle: are the benefits from a low-emissions energy target likely to exceed its cost?

The nature of costs and benefits from low-emissions energy targets are discussed in chapter 2. To summarise, there are immediate costs involved in meeting a low-emissions target because of reduced flexibility in how emissions reductions can be achieved. Relatively more expensive abatement activities are likely to be favoured. The benefits are more uncertain and, to the extent that they do occur, are likely to come in the longer term, mostly through technological development.

Quantitative evidence on low-emissions energy targets can be broken into two streams: data on the historical experience of low-emissions energy targets; and projections of the likely future impacts of targets. Historical data on the effects of low-emissions energy targets in Australia are presented in section A.1. Given data limitations, particularly regarding technological development, no attempt is made to place a numerical estimate on the costs and benefits from existing low-emissions energy targets. Instead, this section gives a broad overview of the impacts of existing targets. Section A.2 reviews modelling work that projects likely future costs and benefits. Recent work by McLennan Magasanik Associates has yielded results that are at odds with other studies, and is thus considered in some detail.

A.2 Experience with low-emissions energy targets in Australia

This section focuses on the most significant low-emissions energy target introduced in Australia to date: the Australian Government’s Mandatory Renewable Energy Target (MRET). State-based schemes have also been introduced, but the MRET is the sole renewable energy target to have been legislated on a national basis. Moreover, the National Emissions Trading Taskforce has reported that, subsequent to the introduction of various state schemes (including the Victorian Renewable Energy Target), the MRET remained the major policy mechanism to encourage renewable energy generation in Australia (NETT 2006).

Mandatory Renewable Energy Target

The MRET scheme was introduced in 2001 to encourage additional generation of electricity from renewable sources to reduce emissions of GHGs (AGO 2003b).

The MRET requires wholesale purchasers of electricity to contribute proportionately towards a target of 9500 GWh of newly installed renewable energy by 2010, which must be maintained until 2020. There is a series of interim targets leading up to 2010.[1] Liable parties meet their requirements by purchasing ‘renewable energy certificates’, which are

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[1] In 2007, the Australian Government announced that the MRET would be expanded to meet a 45 000 GWh target by 2020, it is estimated that this would result in 20 per cent of electricity being sourced from renewable energy in 2020.

issued to renewable generators that use a variety of technologies including hydro-electricity, wind, biomass,[2] biogas, geothermal and solar power (NETT 2006).

Impact on the renewable share of generation

Low-emissions energy, in the form of various renewable energy sources, historically has been an important part of the energy supply in Australia. At various times in the past 40 years, more than one-fifth of the electricity generated in Australia has come from renewable energy sources (figure A.1). The main contributor has been hydro-electricity, but wind, biomass, biogas and solar power have all made some contribution. Prior to the introduction of the MRET, the development of renewable capacity was based on cost, reliability and other factors, rather than reducing GHG emissions. Non-renewable low-emissions energy sources, such as nuclear power and fossil fuel with carbon capture and storage, have not been a part of Australia's energy supply.

The share of electricity generated in Australia from renewable sources has declined over the past four decades. The renewable share of electricity generation peaked at over one-fifth in the mid-1960s, and rose to similar levels during the 1970s, before declining to less than 10 per cent by the start of this century (figure A.1). This decline was mainly because there has been little increase in the major source of renewable generation — hydro-electricity — since the Snowy Mountain Scheme was completed in the mid-1970s. With total electricity generation more than tripling between 1975-76 and 2005-06, the hydro-electric share (and the renewable share more broadly) decreased (ABARE 2007).

The current MRET is projected to stem the decline in the renewable share of generation. When originally conceived, the MRET was promoted as a measure that would increase the renewable share of generation by 2 percentage points between 1997 and 2010 (AGO 2003b). However, increases in the renewable share from 2005-06 levels are only likely to be sufficient to reach a level approximately equal to the 1997 share by 2010 (AGO 2003b; REGA 2004; Syed et al. 2007[3]).

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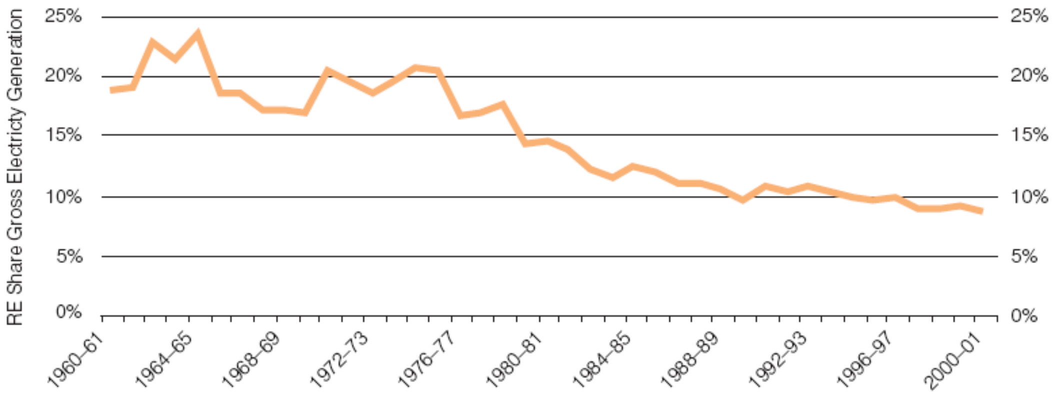
[2] Energy derived from plant and animal material, including bagasse (a waste product from sugar refining), wood and woodwaste.

[3] Syed et al. (2007) project that by 2010, taking into account existing policies including the MRET, the renewable share of electricity generation is likely to increase by about 1.3 percentage points from 2005-06 levels. Data reported in ESAA (2007) show that the renewable share declined by a similar amount between 1997-98 and 2005-06.

Figure A.1 **Renewable energy share of electricity generation in Australia**[a]



[a] ESAA and ABARE (Syed et al. 2007) data indicate that the renewable share of electricity generation was 7.5 per cent and 7.7 per cent respectively in 2005-06. However, the lack of historical data in these sources precluded the construction of a consistent time series through to 2005-06.

Source: AGO (2003b).

Impact by renewable generation source

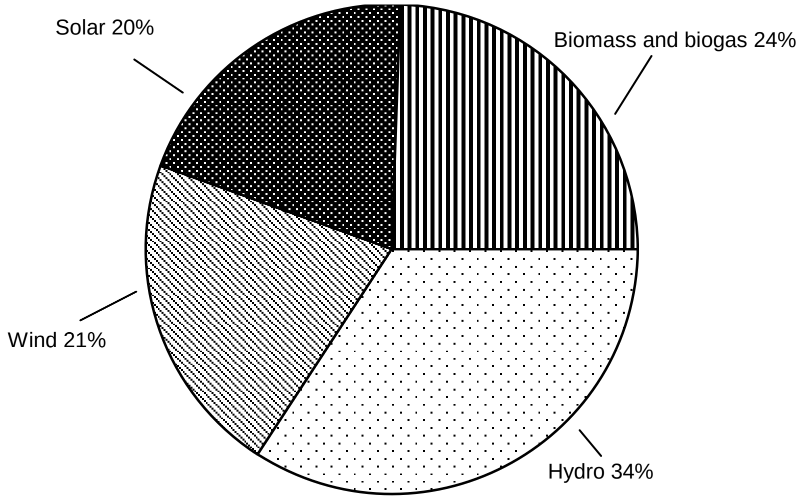
Renewable capacity installed under the MRET has been shared fairly evenly across different renewable sources (figure A.2). Hydro has been the most significant source of new renewable capacity, but wind and solar have grown rapidly from a low base. Most new solar energy has come from solar hot water heaters, which do not generate electricity, but rather are a substitute for electricity use. By 2010, biomass and wind are forecast to be the most important contributors to the MRET scheme, with shares of around 40 per cent and 30 per cent respectively (Short and Dickson 2003).

The importance of hydro-electricity in meeting the MRET is not surprising, given its dominance as a renewable electricity source (figure A.3). However, the potential for further hydro generation is limited, as most hydro resources in Australia are already developed (AGO 2003b).

Compared with their share of electricity generation (7.8 per cent), renewable energy sources account for a somewhat smaller (4.6 per cent) share of total energy use (figure A.3). The distinction between electricity and energy more broadly is important when comparing the contribution of different renewable sources. Total energy use includes the use of energy for purposes other than electricity generation. For example, oil is the largest single source of energy used in Australia, but is used for transport rather than to generate electricity (ABARE 2006).

Figure A.2 **Share of new generation under MRET**

Renewable energy certificates created by 31 December 2006, by source[a]



[a] Shares do not sum to 100 per cent due to rounding.

Data source: ORER (2007).

Biomass is the most important renewable energy source by some margin, but contributes much less to electricity generation. This is largely because most biomass is used directly by industry for process heat or as firewood in homes (Saddler, Diesendorf and Denniss 2004). Also, there are inefficiencies in converting energy from biomass to electricity, so that 36 PJ of biomass energy is used to produce 4 PJ of electricity (ABARE 2007). In contrast, all wind and hydro energy is used to produce electricity. As a consequence, hydro is the most important renewable source of electricity, in spite of being overshadowed by biomass as an energy source.

Existing and proposed low-emissions energy targets in Australia apply to electricity generation only. Therefore, a large part of the total renewable energy supply is not eligible to meet renewable energy targets as currently specified.

Costs

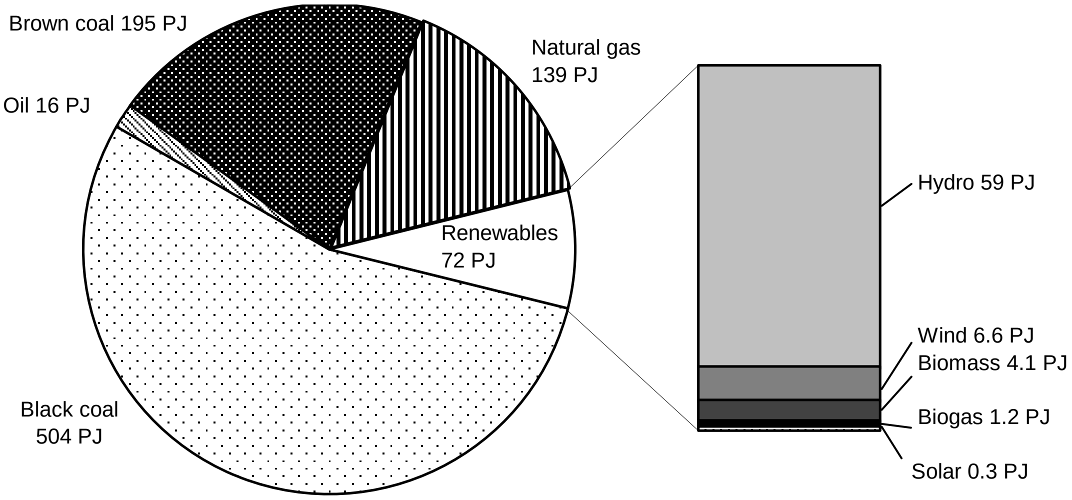
Indicative estimates show that renewable energy sources are generally more expensive than coal generation, but involve far lower GHG emissions (table A.1). Natural gas generation lies somewhere between coal and renewables, both in terms of costs and emissions.

The higher cost of generation from renewable energy sources means that the MRET imposes costs to the economy. These have been forecast to reach several hundred million dollars annually by 2010. AGO (2003b) cited research suggesting costs would amount to a

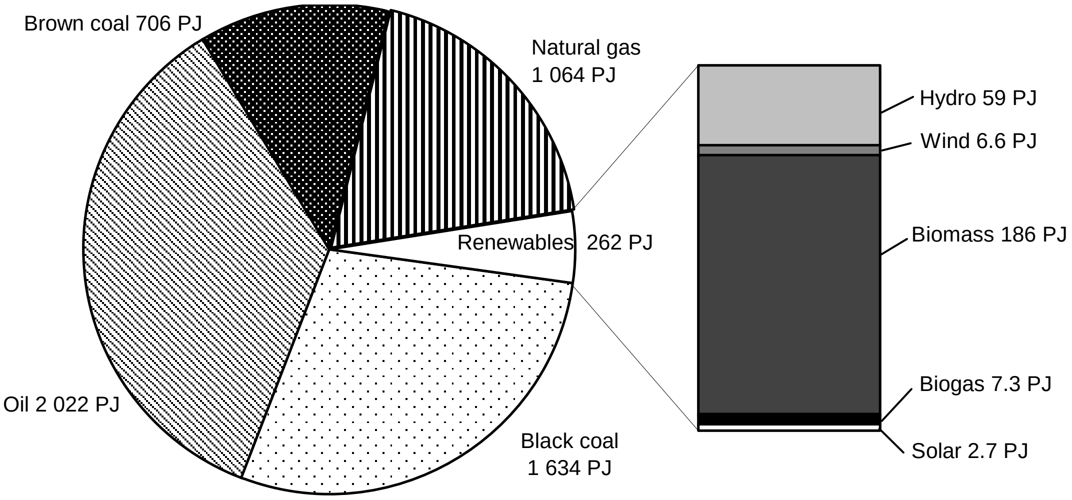
$260 million reduction in GDP in 2010, while COAG (2002) estimated the annual electricity cost of the current MRET scheme in 2010 at $323–543 million.

Figure A.3 Fuel shares of energy in Australia, 2005–06

panel (a) electricity generation (renewable share = 7.8 per cent[a])



panel (b) total energy use (renewable share = 4.6 per cent)



[a] Estimate not strictly comparable with figure A.1 because different data sources were used.

Data source: Syed et al. (2007).

These costs mean that the MRET is a relatively expensive GHG abatement measure, costing more than $30 per tonne of carbon dioxide (AGO 2003b; COAG 2002). This is significantly more expensive than the average cost of abatement for Australian Government programs — $4 per tonne of carbon dioxide based on Australian Government expenditure to the end of 2003 and abatement projections (DEH 2005) — even allowing for some costs incurred by the private sector from these programs.

This average cost relates to a range of different types of abatement programs, including partnership programs with industry such as Greenhouse Challenge Plus. It is likely that this low unit cost could not be maintained if much larger quantities of abatement were required. This, however, does not invalidate the comparison with the MRET costs, as these would also be expected to increase substantially (per unit) if the target were to be increased (as is planned) (COAG 2002).

Table A.1 **Indicative costs and emissions for electricity generation**

Projections for 2010

Technology	*Cost per unit of electricity generated*	*Greenhouse gas emissions*
	\$/MWh in 2010	kg CO_2 per MWh
Supercritical black coal	30–35	780–820
Supercritical brown coal	36–40	1000–1100
Natural gas combined cycle	35–45	430
Wind	55–80	–
Bagasse[a,b]	30–100	–
Small hydro[a]	50–70	–
Solar hot water[c]	80–100	–
Photovoltaic	250–400	–

[a] Limited resources available. [b] One component of broader biomass energy. Short and Dickson (2003) estimate that other forms of biomass are likely to cost between \$20 and \$130 per MWh in 2010. [c] As solar hot water does not create electricity, costs are based on electricity savings. – Nil or rounded to zero.

Source: Department of the Prime Minister and Cabinet (2004).

A.3 Projections of future costs and benefits

Several studies undertaken in Australia have found that ETSs are a substantially cheaper abatement measure than low-emissions energy targets (box A.1). Whereas an ETS creates an incentive for the lowest cost abatement options to be taken up wherever they are found, low-emissions energy targets specify that abatement must come from certain sources, which are often relatively high cost. This modelling has been used to suggest that renewable energy targets should be replaced by an ETS (COAG 2002).

Three modelling studies differ from earlier work by modelling the effects of low-emissions energy targets in addition to — rather than as a substitute for — an ETS:

- CRA International analysis for the Australian Petroleum Production and Exploration Association finds that such an approach would be significantly less efficient than using an ETS alone to achieve a given level of abatement (the level of abatement modelled was 67 Mt carbon dioxide equivalent (CO_2-e) in 2020). It shows that, relative to an ETS only policy, an ETS combined with a 20 per cent renewable energy target would:
  - cost Australia \$1.8 billion more in economic welfare losses (gross national product) in 2020

  - result in the loss of an additional 3600 full-time job equivalents in 2020
  - cause substantial switching away from gas fired generation
  - result in electricity prices rising at least 6 percentage points (that is, rising by 24 per cent, compared to 18 per cent under an ETS only policy) (CRA International 2007)
  - leave total GHG emissions unchanged.
- Two reports by McLennan Magasanik Associates (MMA) find that introducing a low-emissions energy target in addition to an ETS would result in a small net benefit for some scenarios, depending on the ETS permit price and the size and nature of the low-emissions energy target (MMA 2007a, 2007b).

This section considers the reasons why the conclusions reached by MMA are different from those of other studies.

Box A.1 **Modelling shows that low-emissions energy targets are a costly abatement measure**

Australian macroeconomic modelling has generally found that low-emissions energy targets are a more costly abatement measure than emissions pricing through an ETS or an emissions tax. As noted in the Productivity Commission submission to the Task Group on Emissions Trading:

> Access Economics (2006) and COAG (2002) report results suggesting that replacing some existing measures (such as the MRET scheme, GGAS and Queensland’s 13% Gas Scheme) with an economywide emissions price signal would reduce costs by 50 to 75 per cent. Evidence from CRA International (2006) modelling supports this level of cost savings from emissions pricing compared with an extended version of the MRET scheme. (PC 2007a, p. 39)

Modelling work by ABARE commissioned by the Task Group on Emissions Trading is also broadly consistent with these findings. The ABARE modelling showed an 11 per cent mandatory renewable target for electricity generation combined with a 27 per cent fuel efficiency improvement in transport by 2030 resulted in a *doubling* of the GDP cost in 2030 compared to using a comprehensive ETS to achieve the same abatement outcome (PMTGET 2007b).

The second of the two MMA reports — commissioned by the Renewable Energy Generators of Australia — offers more sophisticated analysis of low-emissions energy targets than the first report. For the first report, MMA modelled a range of different abatement policies, including energy efficiency measures, and the modelling of low-emissions energy targets was less detailed. Technological benefits from low-emissions energy targets were assumed at an aggregate level and these assumptions were more optimistic than the disaggregated assumptions made for the second MMA report.[4]

The assumptions and methodology underpinning MMA's work for the Renewable Energy Generators of Australia are considered in more detail below.

MMA work for the Renewable Energy Generators of Australia

MMA was commissioned by the Renewable Energy Generators of Australia to model the benefits and costs of low-emissions energy targets in conjunction with an ETS. Various low-emissions energy targets were modelled, including a renewable energy target and several clean energy targets. The clean energy target could be met either by renewables or by coal with carbon capture and storage (according to an emissions intensity limit of 0.2 tCO_2-e/MWh). Nuclear energy generation was not considered.

The study finds that the benefits from a low-emissions energy target marginally outweigh its costs, provided the target is not too stringent (box A.2). The most stringent clean energy target found to deliver a net economic benefit requires 20 per cent of electricity demand in 2020 to be sourced from low-emissions generation.

Costs from a low-emissions energy target arise from reduced flexibility in how abatement is undertaken. This represents an unavoidable immediate and ongoing cost, as some low-cost abatement options are replaced with higher cost abatement mandated as part of the low-emissions energy target. MMA's modelling is consistent with modelling work by COAG (2002) and CRA International (2006) in finding that there are short-term costs to the economy associated with the shift to

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[4] In the first report, commissioned by The Climate Institute, a clean energy target equal to 70 per cent of electricity demand growth 'is assumed to lead to an effectively faster rate of cost reduction for all adopted low-emission technologies, with the rate of cost reduction reaching 5 per cent per annum' (MMA 2007a, p. 17). For the more mature low-emissions technologies at least (such as wind energy), this assumption is more optimistic than the assumptions made in the second MMA report.

Box A.2 MMA modelling indicates that low-emissions energy targets could yield net economic benefits to Australia

In its study for the Renewable Energy Generators of Australia, MMA modelled various scenarios for adding a low-emissions energy target to an ETS. The scenarios covered a range of carbon prices and different low-emissions energy targets.

In some scenarios, low-emissions energy targets were shown to bring about small net benefits, while others showed small net costs. MMA note the potential for net benefits from 'modest' low-emissions energy targets and draw a policy implication that benefits to the economy would be maximised by a low to modest target for low-emissions generation, in addition to an ETS.

The potential for low-emissions energy targets to produce a net benefit was based on comparing costs and benefits likely to accrue within Australia. This was achieved through detailed modelling using MMA's electricity market model, supported by computable general equilibrium modelling to capture economywide effects. The report indicates that costs accrue in the early years of the scheme (as investment in low-emissions generation occurs) but that these costs are compensated for by benefits later in the modelling period.

Benefits arise from cost reductions for low-emissions technologies, as early deployment is assumed to pull technologies down the cost curve sooner. Both private and external (spillover) technological benefits are included. Other benefits modelled are savings in fuel and other costs of displaced fossil fuel generation and increased GHG abatement.

Source: MMA (2007b).

low-emissions generation. Further, MMA's estimates of these costs appear to be reasonably consistent with these previous estimates.[5]

The benefits foreseen from a low-emissions energy target relate mainly to longer-term technological benefits, but there are also some benefits claimed from additional GHG abatement. Several billion dollars of technological benefits are estimated (in net present value terms), compared with a few hundred million dollars of benefits from additional abatement. Assumed technological benefits alone are sufficient to explain the difference

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[5] COAG (2002) estimates the annual cost of the existing MRET target at $190 million in 2020, compared with MMA's estimate of additional costs of just over $500 million (in 2020, with a low carbon price) to meet a renewable-only target that is more than three times as stringent. CRA International (2006) estimate that a low-emissions energy target of about double the 'high' target modelled by MMA will carry a net present cost of $12.4 billion, close to double MMA's estimate of $5.0–5.5 billion with no accelerated learning-by-doing. Methodological differences and the non-linearity of costs as the stringency of the target increases complicate these comparisons, but they suggest that MMA's estimates of additional costs from a clean energy target are approximately consistent with other studies.

between MMA’s conclusions and those from previous studies that a low-emissions energy target would be costly. Previous studies do not assume the same technological benefits.

Technological benefits from low-emissions energy targets come from assumptions about ‘learning-by-doing’. That is, the use of low-emissions energy technologies increase due to the target and this is assumed to lead to reductions in the cost of generating electricity using these technologies. As MMA (2007b, p. 21) explain, in assessing the potential for learning-by-doing in Australia, ‘[a] key issue is the degree to which deployment of low or zero emission technologies in Australia can lead to cost reductions’. They note that a large proportion of the equipment for renewable generation is sourced internationally and that Australia is a small part of the international market for renewable energy. This means that learning from additional Australian low-emissions energy deployment requires Australia-specific learning in other components of generation costs. Several examples of Australia-specific learning in wind generation are noted, such as responding to local wind regimes and dealing with high summer temperatures. MMA (2007b) claim that the assumptions made about technological benefits are conservative.

Rates of learning-by-doing were assumed to vary across low-emissions technologies. For a doubling of generation capacity, capital costs were assumed to decline by:

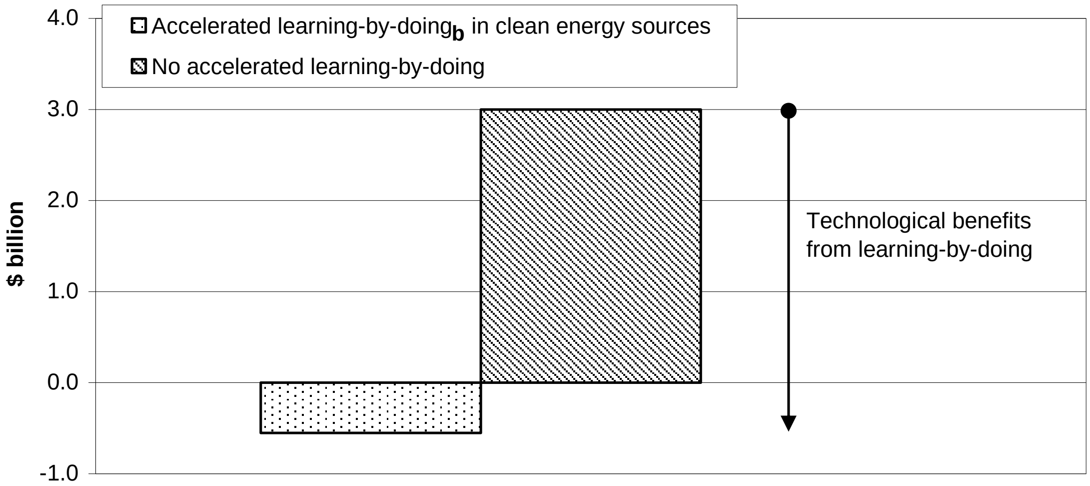
- 3 per cent for wind generation
- 6 per cent for new biomass options (such as gasification and pyrolysis)
- 10 per cent for geothermal and solar thermal/photovoltaic concentrator options
- 10 per cent for carbon capture and storage options (MMA 2007b).

No learning-by-doing was assumed for fossil fuel technologies. There is also some discussion of the possibility of cost reductions from factors beyond learning-by-doing — such as improved economies of scale — but these were not cited as justification for the assumed reduction in capital costs.

Under the learning-by-doing rates assumed by MMA, several billion dollars in technological benefits from modest clean energy targets are projected to marginally outweigh the costs of the target. Costs are reflected in a $2.5–3 billion increase in generation costs with no accelerated learning-by-doing (figure A.4). Where learning-by-doing in clean energy sources is assumed, the low-emissions energy target yields longer-term benefits, as investment in low-emissions energy in previous years leads to cheaper renewable energy. These benefits just offset the additional short-run costs, leading to a small net benefit from having a clean energy target together with an ETS.

Figure A.4 **Change in generation costs from a low clean energy target**[a]

Estimates from MMA's work for the Renewable Energy Generators of Australia



[a] Estimates are the average of ranges given for the net present value of the change in generation costs with the introduction of a 'low' clean energy target, under 'low' and 'moderate' carbon prices. The 'low' clean energy target modelled is equal to around 16 per cent of total generation in 2020 (the sum of the targets under all existing state-based renewable energy targets plus a 10 per cent margin).[b] 'Accelerated' learning-by-doing refers to extra learning-by-doing that is caused by the clean energy target.

Data source: MMA (2007b).

The other source of benefits foreseen from a low-emissions energy target — additional GHG abatement — arises because the modelling in the report pertains to a low-emissions energy target in the presence of an *emissions tax*, rather than an *ETS*. Under a 'cap-and-trade' ETS, emissions prices can adjust while total emissions are fixed by the cap. In contrast, under an emissions tax, prices are fixed while total emissions are set by the market. The modelling in MMA (2007b) is based on emissions prices that are not allowed to adjust in response to the introduction of low-emissions energy targets, and thus describes an emissions tax.[6] This point, which is not explicitly made in the report, means that abatement increases as a consequence of the introduction of low-emissions energy targets.

MMA reports that '[t]he benefit of additional abatement is a key contributor to the net benefits of the low-emission generation target (MMA 2007b, p. 49). Over two-thirds of the net benefits can be attributed to this factor alone'. Based on the assumed emissions price, additional abatement is valued at around $200–$400 million (depending on the scenario modelled).

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[6] The modelling could perhaps apply to an ETS with a 'safety valve' (as suggested in McKibbin and Wilcoxen 2002) which involves a penalty for non-compliance set at a low level, analogous to an emissions tax for any emissions that exceed the cap in the trading scheme. However, for emissions prices not to adjust there must be some emissions beyond the cap in every year, whereas a safety valve is generally proposed as a device that is only required occasionally.

In summary, MMA conclude that the benefits of moderate low-emissions energy targets — under an ETS — just outweigh their costs. This conclusion rests on the assumptions made about learning-by-doing in low-emissions energy sources. In its model, learning-by-doing delivers benefits of several billion dollars, which is sufficient to explain the difference between the conclusions of MMA and those of other studies. Thus, to evaluate the validity of MMA's conclusions, the assumptions made about learning-by-doing need to be assessed. This is undertaken below, drawing on estimated rates of learning-by-doing for renewable energy technologies from international sources, including the International Energy Agency (IEA).

Assessing the validity of assumptions about technological benefits

There is a scarcity of Australia-specific estimates of the technological benefits from increased deployment of low-emissions energy technologies. Consequently, international estimates need to be used for comparison with the MMA studies. Technological benefits from learning-by-doing can be quantified using 'learning rates', which estimate the reduction in the cost of a technology from a doubling of capacity. Projected, rather than historical, learning rates are appropriate for comparison with MMA's assumptions for future learning rates, as learning rates are liable to vary over time (Winskel 2007).

At first glance, projected learning rates from the IEA and the European Renewable Energy Council (EREC) suggest that the assumptions made by MMA are, as claimed, quite conservative (table A.2). These organisations project learning rates in the range of 5–20 per cent, depending on the technology and (in the case of the EREC estimates) the timeframe. The IEA is an international authority on energy technologies, while the EREC represents the European renewable energy industry. The EREC projections — referred to as supporting evidence in MMA (2007b) — are broadly consistent with those of the IEA.

The IEA and EREC projections, however, were not intended for individual country analyses and are likely to overstate learning-by-doing as a consequence of policy choices in Australia. There are two main reasons for this:

- *They pertain to global learning rates*: The benefits of technology learning are typically shared on a global level (IEA 2006a), so that it will take a doubling of *global* capacity to deliver the cost reductions foreseen. Australia's small share of global renewable capacity means that a doubling of capacity in Australia will only represent a small increase in global capacity, and thus deliver correspondingly small cost reductions. For example, the manufacture of wind turbines involves learning on a global scale, as more than 85 per cent of turbines are produced by just seven firms (Juninger 2007). Australia's share of worldwide wind energy capacity in 2007 was less than 1 per cent (GWEC 2008), meaning that, all else equal, a doubling of capacity in Australia could only be expected to generate a 0.05 per cent reduction in manufacturing costs, based on the IEA projections.

- *The learning rates ascribe all cost reductions to learning-by-doing*: Cost reductions can come from a number of sources apart from increases in capacity, most notably from learning through research and development. Jamasb (2007) shows that accounting for research and development significantly reduces estimated learning rates, with reductions ranging from 15 per cent for wind energy to as much as 90 per cent for solar thermal power. Studies referred to by EREC (2007) and IEA (2006a) to support their projections do not generally adjust for the impacts of research and development.

Table A.2 **Projected future learning rates**

Reduction in cost per doubling of capacity

Technology	*Global learning (EREC 2007)*		*Global learning (IEA 2006a)*	*Australian learning (MMA 2007b)*
	2010	*2050*	*2006–2050*	*2007–2050*
	Per cent	*Per cent*	*Per cent*	*Per cent*
Wind	6	6	5	3
Biomass	15	8	5	6
Geothermal	20	10	5	10
Solar photovoltaic	20	8	18	10[a]
Solar thermal	12	5	5	10
Carbon capture and storage	na	na	na	10

a Does not include small scale photovoltaic generation, which was not considered in the analysis. **na** Not available.

Sources: EREC (2007); IEA (2006a); MMA (2007b).

Thus, it is surprising that MMA assumed learning rates for Australia that are so close to the global rates projected by the IEA and the EREC. Australia’s small share in worldwide renewable generation means that an increased reliance on renewables in Australia will have little effect on global learning-by-doing. While Australia may benefit from global learning as renewable capacity expands worldwide, the *marginal* effect on global learning from increased capacity in Australia (to meet a low-emissions energy target) is likely to be very small, if not negligible. For increased capacity in Australia to generate significant technological benefits, there must be considerable scope for Australia-specific learning. The extent to which there is potential for Australia-specific learning in renewable technologies varies by technology, but is typically small.

For wind energy, the limited scope for local learning suggests that MMA’s assumed learning rate is optimistic. Wind energy has been described as ‘a truly international learning system’ (Junginger 2007) and, as mentioned above, learning in the manufacture of wind turbines is likely to be global. MMA (2007b) point to the potential for Australia-specific learning in other components of generation costs. However, on average, turbines represent around 75–80 per cent of the capital costs of wind energy projects (EWEA 2004; IEA 2006b).

Even of the remaining one-quarter to one-fifth of capital costs, there is much scope for learning to be global. There is potential to learn from international experiences in wind forecasting and incorporating wind energy into the electricity network (Porter, Yen-Nakafuji and Morgenstern 2007). In some of the examples noted for Australia-specific learning by MMA — dealing with local wind regimes and high summer temperatures — there is almost certainly some scope to learn from overseas experience.

Given the limited scope for local learning it seems very optimistic to assume a learning rate for Australia that is at least half that of the global learning rates estimated by IEA and EREC.[7]

The MMA assumptions for biomass and geothermal energy assume an Australian learning rate that is *higher* than the global learning rate projected by the IEA. Assessing the basis for these assumptions is difficult, as the MMA report contains no discussion of the potential for Australia-specific learning in these technologies. The mix of technologies used for geothermal power in Australia is likely to differ from the international mix. Geothermal power in Australia is likely to come predominantly from emerging ‘hot dry rocks’ technologies, whereas internationally, developments in hot dry rocks will augment existing ‘hot springs’ technologies (Peacock 2007). This will affect the relationship between global and Australian learning rates. However, it is unlikely that a doubling of global capacity will have a smaller impact on innovation than a doubling of capacity in Australia alone.

The assumptions about learning-by-doing in solar energy — for solar thermal at least, MMA assumes a higher local learning rate than the IEA’s global rate — are also not supported by any evidence of Australia-specific learning. While some technology breakthroughs (such as thin-film photovoltaic technology (AGO 2003a)) might emerge in Australia, a low-emissions energy target in Australia is unlikely to drive significant global learning and it is unclear that there is potential for significant Australia-specific learning. Thus, Australia-specific learning rates would be expected to be significantly lower than for the world as a whole.

For carbon capture and storage, the assumptions about learning-by-doing are also more optimistic than appear to be justified by the literature, which recommends more circumspect use of learning curves. As the IEA has pointed out, as carbon capture and storage ‘has yet to enter the demonstration stage, using learning curves for unproven

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[7] An argument could be made that the global learning rates for wind energy projected by EREC and the IEA might be biased downwards. The studies referenced to support these projections typically exclude learning that increases the actual quantity of electricity generated without increasing the installed capacity — i.e. improving wind capture from a particular site. This biases estimates downward (Neij et al. 2003). However, this must be offset against the bias upwards that comes from assuming all cost reduction come from learning-by-doing, so the net bias is ambiguous.

technologies can lead to uncertain results' (IEA 2007a, p. 6). An Australian learning rate of double the global projection of 5 per cent suggested by the IEA (Tam 2007) would seem very optimistic.

On the other hand, MMA (2007b) projects *no* learning-by-doing in fossil fuel technologies, which is inconsistent with evidence in the literature — particularly in relation to gas generation technologies (for example Jamasb 2007; Nakicenovic and Riahi 2002). Consequently, the estimated net benefits from low-emissions energy targets in the MMA analysis are inflated because the switch to renewables is assumed not to crowd out any technology development in fossil fuel technologies, and associated learning-by-doing.

In the MMA modelling approach there is also no consideration of the potential to miss out on learning-by-doing in abatement activities other than clean electricity generation. As mentioned previously, a low-emissions energy target will likely deliver no additional abatement when brought in within the umbrella of an ETS, because some other abatement actions will not occur. If these forgone abatement measures also exhibited learning-by-doing, then an additional opportunity cost of the low-emissions energy target will be a reduction in this learning. For example, a low-emissions energy target might mean that some improvements in the energy efficiency of the transport network are no longer necessary to meet the emissions cap, and potential learning in this area would thus be lost. The MMA modelling does not consider this issue because a tax, rather than an ETS, is modelled, so there is no crowding out of abatement. This would not be the case for an ETS that covered the sector affected by the low-emissions energy target.

It should be noted that the interactions between an ETS and a low-emissions energy target are complex. If the ETS allows flexibility as to when emissions permits can be used, then there is potential for a low-emissions energy target to affect not only the composition of abatement, but also its timing.

For example, a low-emissions energy target that was phased out over time could cause an increase in abatement initially matched exactly by a decrease in abatement once the phase out was complete (relative to an ETS operating alone). As GHGs are stock pollutants there would be virtually no environmental consequence of this. It would, however, be expected to add to abatement costs, assuming that the market determined emissions trajectory under an ETS was efficient. This would be an additional cost of adding an MRET to an ETS (and one that is not factored into MMA's analysis). There could also be consequences for learning-by-doing with various abatement technologies from the change in timing.

The implications of these complexities could only be understood through modelling of specific proposals for an ETS and a low-emissions energy target.

Further assumptions implicit in MMA's analysis need to be understood in interpreting their results. First, there is no consideration given to the possibility that 'breakthrough' technologies for low-cost clean electricity might render learning-by-doing in existing renewable technologies redundant. Some analysts have suggested that this is highly likely to occur (Montgomery and Smith 2005).

Second, the results are specific to a particular mix of low-emissions energy technologies being brought forward by the target. If a greater proportion of the target was met by relatively mature technologies, such as wind power, the estimated learning-by-doing benefits could be substantially reduced. Sensitivity analysis would be useful to understand this better.

Third, MMA estimate that there are cost reductions available that would quite quickly make a range of renewable technologies competitive without the support provided by a low-emissions energy target. Despite this, these technologies are for the most part assumed not to be deployed unless this support is provided. This seems questionable, given the financial rewards that would accrue to firms prepared to incur losses initially (provided, of course, that the assumed cost reductions could be achieved).

Conclusions

MMA's modelling suggests that a moderate low-emissions energy target is likely to generate long-term benefits from learning-by-doing that are just large enough to offset additional short-term costs (figure A.4). This means that making even slightly less optimistic assumptions about learning rates would tip the balance, so that a low-emissions energy target (acting in parallel with an ETS) would carry net costs.

MMA (2007b) uses learning-by-doing rates for low-emissions energy technologies that appear to be very optimistic compared to international estimates, while simultaneously assuming no learning-by-doing in fossil fuel generation. The modelling results also require specific conditions to hold about the make-up of technological advances — breakthrough technologies or a dominance of mature renewable technologies could reduce the importance of learning-by-doing. Finally, the modelling applies to a tax, so part of the estimated benefit of a low-emissions energy target from additional abatement would not occur under a pure ETS.

Just one of these factors — the optimistic assumptions about learning-by-doing — is sufficient to explain why MMA concludes that there are cost savings available from low-emissions energy targets, in contrast with other modelling work that has shown that they increase costs compared to an ETS only policy. In addition, the conclusions of MMA's work should be considered in the light of the IEA's warning that: '[t]he sole use of learning curves to estimate future technology costs can lead to over optimistic results on cost reductions and deployment needs' (IEA 2007a, p. 4).