excluding technologies from the

MANDATORY RENEWABLE ENERGY TARGET

ABARE report prepared for the
Department of Industry, Tourism and Resources

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introduction

The ‘mandatory renewable energy target’ (MRET) establishes a set of yearly targets between 2001 and 2020 for the consumption of electricity produced from certain eligible technologies. The MRET scheme is implemented through the issuing of certificates for the electricity generated from eligible technologies and requires liable entities (the purchasers of electricity at certain points in the market — usually at the wholesale level) to surrender a specified number of certificates for the electricity that they acquire during the year. By 2010, certificates equivalent to 9500 GWh of electricity sourced from renewable technologies are required to be surrendered.

These certificates are traded in the ‘renewable energy certificate’ (REC) market (also known as the ‘green electricity market’). If a liable entity does not have enough certificates to surrender, the liable entity will have to pay a penalty known as the ‘renewable energy shortfall charge’, currently set at $40/MWh.

The objectives of MRET program [as set out in the Renewable Energy (Electricity) Act 2000)] are to:

• encourage the additional generation of electricity from renewable sources;
• reduce emissions of greenhouse gases; and
• ensure that renewable energy sources are ecologically sustainable.

Another objective of the MRET program is to encourage and support the development of the renewable energy industry in Australia.

By December 2002, approximately 1759 GWh of certificates had been registered (table 1) with another 329 GWh pending registration. The 2089 GWh of electricity generated from eligible sources exceeds the combined target for 2001 and 2002 (300 GWh and 1100 GWh respectively) and the excess can be ‘banked’ and used to offset liabilities in future years.

Although the mix of technologies that will occur by 2010 cannot be inferred from the current mix of registered certificates, electricity sourced from hydroelectric generators (which includes both existing large and new small hydroelectric sources) accounted for almost 40 per cent of the certificates generated to December 2002, with a further 26 per cent accounted for by reduced electricity consumption through the use of solar hot water systems. Municipal sites (landfill and sewage gas), bagasse, wind and wood waste account for the majority of the remaining certificates.
ABARE has been asked to assess the costs of possible changes to the MRET scheme, including:

- the exclusion of wood waste as an eligible fuel source;
- the exclusion of existing large hydroelectric projects from generating Renewable Energy Certificates;
- an increase in the target up to and beyond 2010; and
- an increase in the level of the renewable energy shortfall charge.

An assumption that the target of 9500 GWh a year will remain in place, unchanged, between 2010 and 2020 is to be assumed for the reference case.

In this report, the cost impacts of excluding certain technologies or increasing the target are presented, together with a discussion of changing the level of the penalty. The study has been conducted using ABARE’s Australian MARKAL database and model.
the mix of technologies under M RETs

Under the MRET scheme, an additional 9500 GWh of electricity is required to be generated by eligible technologies in 2010, relative to output from renewable sources in 1997. With the ability to bank certificates, the target is effectively a cumulative target over the life of the scheme and the actual generation in 2010 may be less than 9500 GWh; production from eligible technologies may exceed interim targets in the years preceding 2010. The impact of banking is not examined in this report.

The increase in generation from renewable technologies is defined after transmission losses have been accounted for (for all generators) and the relevant relative measure is consumption. The reference case for energy projections has electricity consumption increasing by 49 per cent between 1997 and 2010 to 232 TWh (Dickson, Akmal and Thorpe 2003). The target applies only to consumption on grids with a capacity in excess of 100 MW, which accounts for approximately 98 per cent of total consumption, or 227 TWh in 2010.

Under the current target, the share of consumption attributable to renewables increases from approximately 10.5 per cent in 1997 to 11.2 per cent in 2010 (table 2). For comparison, table 2 includes calculations for an increase in the target to 5 per cent by 2010 (assuming the same growth in the interim targets that exist for the current target).

## 2 Renewable energy target

<table>
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<tbody>
<tr>
<td>Consumption (TWh)</td>
<td>152.2</td>
<td>189.2</td>
<td>199.0</td>
<td>210.3</td>
<td>218.9</td>
<td>227.0</td>
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<tr>
<td>1997 renewable generation a (TWh)</td>
<td>16.0</td>
<td>16.0</td>
<td>16.0</td>
<td>16.0</td>
<td>16.0</td>
<td>16.0</td>
</tr>
<tr>
<td>MRET target (TWh)</td>
<td>–</td>
<td>1.1</td>
<td>2.6</td>
<td>4.5</td>
<td>6.8</td>
<td>9.5</td>
</tr>
<tr>
<td>Renewable share %</td>
<td>10.5</td>
<td>9.0</td>
<td>9.3</td>
<td>9.7</td>
<td>10.4</td>
<td>11.2</td>
</tr>
<tr>
<td>MRET share b %</td>
<td>–</td>
<td>0.6</td>
<td>1.3</td>
<td>2.1</td>
<td>3.1</td>
<td>4.2</td>
</tr>
<tr>
<td>5% target by 2010 (TWh)</td>
<td>–</td>
<td>2.2</td>
<td>5.3</td>
<td>9.1</td>
<td>13.7</td>
<td>19.2</td>
</tr>
<tr>
<td>Renewable share %</td>
<td>10.5</td>
<td>9.6</td>
<td>10.7</td>
<td>11.9</td>
<td>13.6</td>
<td>15.5</td>
</tr>
<tr>
<td>MRET share b %</td>
<td>–</td>
<td>1.2</td>
<td>2.6</td>
<td>4.3</td>
<td>6.3</td>
<td>8.5</td>
</tr>
</tbody>
</table>

a The amount of electricity generated from renewable technologies in 1996-97 (Renewables Target Working Group 1999).
b MRET share is share of total consumption contributed to by the target each year.
Reference case

In order to examine the costs associated with either excluding technologies or increasing the target, a reference case for the likely mix of technologies to occur under the existing MRET program was established using ABARE’s MARKAL model of the Australian energy system.

MARKAL is a flexible analytical tool that can be readily adapted to model different energy systems at the national, state and even local level. In generic terms, the MARKAL model is described as an engineering based or ‘bottom up’ model and a particular feature of Australian MARKAL is its regional structure. ABARE’s current model has been developed in an ongoing manner at ABARE since the early 1990s.

MARKAL involves an intertemporal, linear programming approach whereby technologies effectively compete (on a relative cost basis) to meet the levels of consumption of energy services required. The forecasts of energy services are exogenously given to MARKAL and hence the model is sometimes described as ‘demand driven’.

In modeling the MRET scheme, the annual renewable energy target is specified as an explicit constraint (or requirement) that the model must allow for. Ultimately, the mix of technologies that the model chooses to use to meet the target will depend on the relative costs of each technology (judged across all time periods) as well as the requirements of any other constraints imposed, such as limits to the penetration of particular technologies.

The level of investment in new technologies is dependent on the investment cost for the plant, the life time over which that investment can be recovered, the expected availability factor of each plant as well as the annual operating and maintenance costs together with any fuel costs. This information can be summarised in the annual average cost of output for each technology under expected conditions. An example of the average annual cost of each eligible technology that is considered in this report is presented in appendix A. As evident in appendix A, average costs may vary over time — the important implications of this are discussed in more detail below.

Redding Energy Management (2000) provided most of the specifications of the relevant parameters for the eligible renewable generation technologies included in the modeling analysis undertaken here and outlined in appendix A. The statistics provided by Redding included information on the investment costs for an average plant in each state, upper bounds of the potential availability of particular technologies, unit delivery costs of biofuel inputs (such as wood waste and energy crops) together with operating and maintenance costs and how the various parameters might evolve over time. These cost parameters are summarised in an estimate of the long run average cost per megawatt hour, in appendix A.

In some cases, however, there is a range of estimates other than those from Redding for the cost of new and/or prospective technologies. Of particular relevance in the context of this study is the range of estimates for the cost of wind generation.
Redding provided estimates for the cost of wind generation that varied (in 2010) from $38.39/MWh in Tasmania to $61.43/MWh in New South Wales and Queensland (see table 3 and appendix A). This included estimated investment costs (again in 2010) of approximately $1400/kW and an estimate of availability of 0.4 (or 40 per cent) for Tasmania, 0.32 for Victoria, South Australia and Western Australia and 0.25 for New South Wales and Queensland.

More recent cost estimates based on Passey (2003) are for investment costs to decline to $1200/kW by 2010. Passey’s estimates do not differentiate between regions, although it is recognised that costs may be critically dependent on regional factors. Assuming availability of 0.4 for Tasmania (as with Redding) and 0.32 for all other states, Passey’s estimate of the cost of wind energy (in 2010) would vary from $33.40/MWh to $41.75/MWh. In this analysis the most recent estimates of the cost of wind generation (based on Passey 2003) have been used and replace the existing Redding estimates.

### Changing cost estimates and rankings

As discussed above and as illustrated in the case of wind energy in table 3, the long run average cost of various options can change over time. In the case of wind energy, average costs are expected to decline sharply in the period to 2010 as fixed investment costs are estimated to decline by almost 40 per cent from $1900/kW in 2000 to $1530/kW in 2005 and $1200/kW in 2010.

One important point that follows from this is that the ranking of technologies or options, simply on a relative cost basis, may change over time. This is illustrated clearly in table 4 where all the eligible renewable energy options included in the MARKAL analysis are listed in order of their ranking from the least expensive to the most expensive, for each of the years 2000, 2010 and 2020. For convenience both of the wind options (in Tasmania and elsewhere) have been shaded in the table.

In 2000 wind energy (at between $51.88/MWh and $64.85/MWh) ranks in the lower half of the list and, on the basis of the cost estimates included here, is not cost competitive with a range of alternative options. However, casting forward it can be seen that, as the capital investment costs of wind energy decline so wind energy’s relative ranking improves. In 2010 wind power in Tasmania is estimated to be one of the most cost competitive renewable energy options available.

It is important to note, however, that in assessing the optimal mix of technologies that might be used to meet the renewables target over the full period of the scheme, it is potentially...
misleading to focus exclusively on the ranking of options in any particular year. The reason for this is that it is a requirement that the target at least be met on an annual basis (as mentioned earlier, the target can be exceeded in earlier years); waiting until 2010 and then specialising in the least cost option is not allowable (even if it were feasible). Having chosen to invest in a particular technology, say in 2005, the model is effectively committed to this investment subsequently and only in extreme circumstances would it be cost effective to disinvest in one technology and reinvest in another. In terms of assessing the relative competitiveness of technologies, this amounts to something akin to first mover advantage. Consequently, when the mix of technologies being used are examined for any particular year it is not uncommon to find technologies that are more expensive (in that year) being used alongside less expensive options.

Another issue to note is that the use of solar hot water heaters is often represented as a reduction in the consumption for electricity delivered as part of a grid system. This is the approach taken in this report. To account for this in the modeling, the assumed level of penetration of solar hot water systems reduces the level of the target. It is assumed that, by 2010, approximately 400 GWh will be accounted for by additional hot water systems annually (and the target is reduced accordingly to 9100 GWh). This level of penetration of solar hot water systems was discussed explicitly with David Rossiter (the Renewable Energy Regulator) in late 2002 and is consistent with ABARE’s most recent long term projections of Australian energy consumption and production. In 2020 the penetration of solar hot water systems is assumed to have increased, albeit modestly, to approximately 450 GWh.

### Ranking of different technologies in 2000, 2010 and 2020 based on long run average costs

<table>
<thead>
<tr>
<th>2000</th>
<th>2010</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro – large, existing</td>
<td>Hydro – large, existing</td>
<td>Hydro – large, existing</td>
</tr>
<tr>
<td>Biomass into coal capacity</td>
<td>Biomass into coal capacity</td>
<td>Biomass into coal capacity</td>
</tr>
<tr>
<td>Bagasse, new (with wood waste)</td>
<td>Bagasse, new (with wood waste)</td>
<td>Wind (Tas)</td>
</tr>
<tr>
<td>Landfill gas</td>
<td>Landfill gas</td>
<td>Bagasse, new (with wood waste)</td>
</tr>
<tr>
<td>Municipal waste water</td>
<td>Municipal waste water</td>
<td>Municipal waste water</td>
</tr>
<tr>
<td>Wet waste</td>
<td>Wet waste</td>
<td>Wind (other states)</td>
</tr>
<tr>
<td>Hydro – large (Qld)</td>
<td>Hydro – large (Qld)</td>
<td>Hydro – large (Qld)</td>
</tr>
<tr>
<td>Hydro – small, various states</td>
<td>Hydro – small, various states</td>
<td>Hydro – large (Qld)</td>
</tr>
<tr>
<td>Bagasse, new</td>
<td>Wind (other states)</td>
<td>Bagasse, new</td>
</tr>
<tr>
<td>Municipal solid waste</td>
<td>Bagasse, new</td>
<td>Municipal solid waste</td>
</tr>
<tr>
<td>Hydro – large (Tas)</td>
<td>Municipal solid waste</td>
<td>Bagasse, new (with wood waste)</td>
</tr>
<tr>
<td>Wind (Tas)</td>
<td>Hydro – large (Tas)</td>
<td>Hydro – large (Tas)</td>
</tr>
<tr>
<td>Wind (other states)</td>
<td>Hydro – small, various states</td>
<td>Hydro – small, various states</td>
</tr>
<tr>
<td>Forest residue and wood waste</td>
<td>Forest residue and wood waste</td>
<td>Forest residue and wood waste</td>
</tr>
<tr>
<td>Hydro – large (NSW)</td>
<td>Hydro – large (NSW)</td>
<td>Hydro – large (NSW)</td>
</tr>
<tr>
<td>Hydro – large (Vic)</td>
<td>Hydro – large (Vic)</td>
<td>Hydro – large (Vic)</td>
</tr>
<tr>
<td>Energy crops</td>
<td>Energy crops</td>
<td>Energy crops</td>
</tr>
<tr>
<td>Bagasse, existing</td>
<td>Solar thermal</td>
<td>Solar thermal</td>
</tr>
<tr>
<td>Black liquor</td>
<td>Bagasse, existing</td>
<td>Bagasse, existing</td>
</tr>
<tr>
<td>Crop waste</td>
<td>Crop waste</td>
<td>Crop waste</td>
</tr>
<tr>
<td>Solar thermal</td>
<td>Black liquor</td>
<td>Black liquor</td>
</tr>
<tr>
<td>Photovoltaics, remote areas</td>
<td>Photovoltaics, remote areas</td>
<td>Photovoltaics, grid connected</td>
</tr>
<tr>
<td>Photovoltaics, grid connected</td>
<td>Photovoltaics, grid connected</td>
<td>Photovoltaics, remote areas</td>
</tr>
</tbody>
</table>
Given the cost assumptions and known committed investment plans for a variety of technologies such as wind, the reference case is presented in table 5.

Just a note on the estimated trends beyond 2010: as is well known, the MRET scheme is currently set to continue beyond 2010 to 2020, although the target level itself is set to remain at 9,500 GWh in the period beyond 2010. Generally speaking, there would be expected to be little change beyond 2010 in the mix of technologies used to meet the target given that the infrastructure developed prior to 2010 will be sunk, and without any growth in the target, new options would need to compete on marginal costs (rather than long run average costs) to gain entry to the market. Where opportunities will arise will be where capital is retired, where resource constraints begin to bind and, in some cases, where cost reductions to new technological options are simply compelling. In the estimates provided below some contraction in the bagasse and forest residue sectors has been assumed beyond 2010, which is largely replaced by new wind but also to a lesser extent by municipal waste options.

Prior to the introduction of the MRET scheme, large hydroelectric schemes were the largest supplier of renewable energy in the Australian green electricity market. In the period to 2010 the largest contributors to the renewables target among eligible technologies are estimated to be cogeneration in the sugar industry (either bagasse alone or bagasse cofired with wood waste), forest residue (including cofiring with existing coal fired thermal facilities), wind energy and municipal waste (table 5).

It should be noted, however, that there is considerable uncertainty about the technologies that might emerge under the MRET program, and that much of this uncertainty is not well captured in the modeling approach used here.

**Bagasse**

Technologies associated with the use of bagasse, for example, are estimated to account for 29 per cent of the target output by 2010. However, for sugar mill located cogeneration to be a viable technology in meeting a significant share of the renewables target, a high capacity factor is required to ensure sufficient generation time to recover costs associated with the investment. With current knowledge of costs for different technologies for this fuel source (ranging from stored bagasse, to supplementing the bagasse with wood waste of various sorts) only cofiring with wood waste appears to give a sufficiently high capacity factor for the technology to be economically viable.
There is concern within the industry, however, about the viability of high capacity factor sugar mill based cogeneration (with or without cofiring with wood). There is also some concern about the sustainability of the sugar industry given its current regulatory structure. Both of these factors increase the perceived risk associated with investing in bagasse based cogeneration options and is believed to be affecting the credit risk for financing such plants. This may reflect the current low uptake of bagasse based technologies suggested by table 1.

There are also technical uncertainties associated with the long term storage of bagasse. For example, Stanwell Corporation, previously the company with the largest publicly declared support for biomass generation, has recently indicated a de-emphasising of renewable energy in their portfolio of technologies to produce electricity, citing problems of scale associated with small plants and difficulties of managing stockpiled heaps of sugar cane waste (Courier Mail 2002).

The nature of the modeling does not allow for detailed consideration of differential risks associated with different types of renewable technologies. This is an important consideration, as identified above, as there is significant uncertainty about the future investment costs of some of the technologies, particularly bagasse.

**Wood waste**

In the reference case, technologies that use forest residue or wood waste are estimated to contribute around 10 per cent of the required renewable output by 2010. Of this, approximately 65 per cent is associated with cofiring of wood waste with coal, while the remaining 35 per cent is associated with investment in plants designed for using wood in boilers.

As indicated in appendix A, cofiring existing coal fired thermal generation facilities with forest waste products is estimated to cost only $23.14/MWh, and is the second least expensive of all eligible renewable technologies included in this analysis. The low long run average cost reflects the very low capital cost associated with this option in comparison with other renewable energy options.

As with bagasse, there is a large amount of uncertainty associated with the use of forest residue, and despite the apparent cost advantages, other factors such as consumer sentiment or political pressure are not able to be considered in the modeling framework. The reference case results summarised in table 5 reflect an assessment of the physical limits to the availability of suitable combustible material. Without such a constraint the model would specialise in this technology to the exclusion of all others, resulting in an unrealistic outcome. It should be noted, however, that to the extent that this constraint underestimates the availability of suitable materials for cofiring, the penetration of this option in the green electricity market will similarly be under estimated, as will the penetration of other options be overestimated.

**Municipal wastes**

Municipal related technologies include landfill gas, waste water (sewage gas), wet waste and municipal solid waste. As shown in table 4 and appendix A, the estimated long run average cost of landfill gas and municipal waste water, at $35.60/MWh and $36.30/MWh respec-
tively, are relatively cost competitive and both of these technologies feature in the solution. By 2010, these municipal waste related technologies are estimated to account for 16 per cent of the increase in renewable electricity output since the commencement of the scheme (table 5).

Upper bounds or constraints on the penetration of municipal waste based electricity generation have been included in the analysis to reflect the availability of suitable landfill and waste water materials and are sourced from Redding Energy Management (2000). In this case, however, these constraints are not binding as the significant improvement in the relative competitiveness of wind energy (discussed below) is the main limiting factor to the further growth in municipal waste energy.

**Hydroelectricity**

New eligible hydroelectricity generation is constrained to grow only modestly over the forecast period, reflecting the limited availability of suitable locations for the expansion of large grid based generation and the relatively limited availability of suitable small hydroelectricity sites (despite the cost of small hydroelectricity being relatively competitive). Most expansion in large hydroelectricity capacity is forecast to result from upgrading existing equipment and facilities, operational changes such as minimising downtimes etc, and above base year growth in hydroelectricity generation (particularly in Tasmania). In the reference case, large hydroelectric schemes are expected to account for approximately 936 GWh of the target by 2010, or approximately 10 per cent of eligible renewable generation. Some modest growth in small hydro is also expected, and is estimated to account for around 450 GWh by 2010 or 5 per cent of the total.

It should also be noted that the costs included in this analysis for existing large hydro schemes do not include new capital investment costs. That is, there is a charge associated with refurbishment costs but it is not assumed that new large scale hydroelectricity capacity will be developed in the foreseeable future. This means that the long run average cost of hydroelectricity is particularly low, as reflected in the rankings shown in table 4. This is also an important point to note in the next section. Excluding hydroelectricity as an eligible renewable energy option would have significant cost implications.

**Wind**

Despite the ranking of technologies in table 4, which implies that currently wind energy is not relatively competitive against a range of alternative options, significant investment in wind energy in Australia has already occurred and is planned over the short to medium term. The Australian Wind Energy Association (2003) reports a total of around 230 5MW of wind energy investments are currently committed or planned in Australia. Based on this information a set of lower bounds were included in the analysis to reflect currently completed and committed investments across each of the states. Collectively these investments are conservatively assumed to amount to 105 MW in 2000, 270 MW in 2005 and 840 MW in 2010. These assumptions do not limit the model to such a level of investment (and the 2005 assumption may be considered particularly conservative), but simply disqualifies lower rates of penetration, and in some sense underpins future development of the industry. Having said
that, estimated wind energy capacity in 2010 is not expected to be significantly higher than
this lower limit, at around 900 MW. This is certainly significantly lower than the 2305 MW
reported by the Australian Wind Energy Association and points both to the prospective nature
of this estimate and the advantage (to other renewable options) inherent in capturing market
share earlier.

As discussed earlier, new estimates of the cost of wind power were used in this analysis that
suggest that wind power may effectively be the backstop technology in the green electricity
market by 2010. This means that wind energy is the option that is available to meet most
of the increase in the renewable target in 2010 and beyond. It is not technically correct to
say that wind is the ‘marginal’ technology as wind does not determine the (marginal) price
of a certificate in 2010 as a range of more expensive options also feature in the solution.
However, as illustrated in table 4 and appendix A, the cost of wind energy declines signifi-
cantly over the period to 2010 and beyond.

It is clear that the prospects for wind and its relative competitiveness to other large scale
options (such as municipal wastes) are critical issues to the analysis of the green electricity
market and the mix of technologies that make up the MRET. Certainly other options such
as biomass cofired with coal or bagasse with wood waste contribute to the target, but these
are both assumed to meet physical constraints to their expansion (as discussed earlier).
Similarly a range of (seemingly) more expensive options feature in the solution (in 2010)
which benefit from investments having already been made earlier in the target period. In
2010 wind energy is estimated to contribute 2658 GWh of electricity to the green electric-
ity market, accounting for approximately 29 per cent of the total.

Photovoltaics
As indicated in table 1, as at December 2002, approximately 1.2 GWh worth of renewable
credits were created from photovoltaics, making up less than 1 per cent of the total at that
time. These are likely to have been generated from experimental operations. Given the small
contribution made by photovoltaics, and the limited prospects for this technological option
in the immediate future (see the cost rankings in table 4), photovoltaics are not included in
the results reports in tables 5–7.

System costs of intermittent generation
There are other costs associated with increasing the use of renewable technologies that are
not examined in detail in this study. The use of intermittent generation technologies such as
wind increases the cost of ancillary services. Ancillary services are those services that provide
security to the power network such as standby generation reserves, frequency control services
and voltage control services.

Increasing the use of wind generation for supplying electricity and the inherent uncertainty
associated with such supply will primarily involve the increased use of frequency control
services (ensuring sufficient spinning reserve is available for supply and demand to be
matched at each point in time while maintaining the appropriate frequency of 50 Hz).
The increased system costs associated with wind generation are uncertain at this stage. They depend in part on the level of interconnection in any given grid system, which increases the flexibility to share ancillary service costs. NEMMCO recently completed a study on the impacts of large scale increases in wind generation on system performance and Western Power has recently released a technical paper examining the issues.

Under specific assumptions associated with the South West Interconnected System (SWIS) in Western Australia, Western Power estimated that for between 150 and 200 MW of wind power, the additional ancillary service costs would be in the range $4–10 million (Western Power 2002). These costs do not include capital or labor costs for operation and maintenance, network access costs or additional costs associated with mitigating local network constraints through out of merit order dispatch.

Another consideration is that it may be economically more suitable to curtail wind generation rather than thermal plants to avoid overnight rescheduling of base load plants. Such an approach may require a mechanism to compensate wind generators. While not insignificant, these costs will likely represent an increase in total costs of less than 0.5 per cent at the wholesale level. For this study, no further consideration is given to increases in ancillary service costs.
excluding technologies and increasing the target

Four separate scenarios were examined in part of the analysis, and included restricting the technologies that qualify to generate certificates under the MRET program and increasing the target. These included:

- the exclusion of wood waste;
- the exclusion of large hydroelectric projects;
- the exclusion of both wood waste and large hydroelectric projects; and
- increasing the target to 19 000 GWh between 2010 and 2020.

Excluding wood waste

The first policy experiment examined is the exclusion of wood waste. Wood waste is used in its own right (in boilers etc) and in coal based electricity generation facilities, as well as being cofired with bagasse. In the reference case, it is associated with technologies that account for 30 per cent of the target (10 per cent forest residue and 20 per cent cofired with bagasse).

In the reference case a number of constraints were included that reflected estimates of physical limits to the expansion of some sectors. The maximum estimated size of the sugar industry, for example, is unlikely to change simply as a result of the exclusion of wood waste from MRETs, and in fact it is ABARE’s assessment that the long term outlook for bagasse is for a steady decline beyond 2010. However, to reflect some upward potential (albeit limited) to use bagasse in an environment where the value of renewable energy credits are higher (than in the reference case), electricity generation from bagasse (that is, bagasse only and not bagasse cofired with wood waste) is estimated to increase slightly to 890 GWh in 2010 (up from 808 GWh in the reference case) before slipping thereafter to 750 GWh by 2020 (table 6).

In the case of the municipal waste sector, excluding wood waste from the MRET scheme means additional attention would be directed to maximising the use of these resources, particularly in the early part of the target period where they are relatively cost competitive. In particular, additional generation from landfill gas and municipal waste water would be expected as the equilibrium point (between the supply of renewables and the 9500 GWh quantity target) is driven up the renewables cost curve. Redding Energy Management (2000) assessed the upper limits to the penetration of municipal waste options by 2010 at around
3200 MWh, comprising around 2300 MWh of landfill gas and municipal waste water with the remainder potentially being made up from wet waste and municipal solid waste. As is evident from appendix A, however, these latter two options are unlikely to feature significantly in the green electricity market without further substantial reductions in costs.

Overall, in the case where wood waste is excluded, renewable energy generation from municipal waste options is estimated to increase by around 60 per cent, or nearly 875 GWh (table 6), increasing their contribution to the target to 2329 GWh by 2010 or 25 per cent of the total.

Under this alternative case, wind energy is also estimated to contribute some 4281 MWh or 45 per cent of the target in 2010, increasing modestly thereafter to 4425 MWh by 2020. Given the physical limits to capacity expansion assumed to exist for a number of renewable options (such as bagasse, landfill, waste water etc), and with the cost of wind energy expected to decline relatively sharply in the period to 2010, it is not surprising that the contribution made by wind energy is estimated to increase so significantly. Interestingly, this contribution is well below the upper limit indicated by Redding Energy Management (2000) of around 9700 MWh. Similarly, the total required investment of 1500 MW by 2020 is also significantly less than the 2305 MW which, according to the Australian Wind Energy Association, is already planned for this sector.

Excluding a technology that is associated with a third of the output in the reference case would be expected to lead to a substantial increase in the economic cost of the program. That excluding wood waste increases costs is clear when you consider the stylised diagram in figure A and the ranking of technologies presented earlier in table 4.

To estimate the cost of meeting MRETs, the analysis undertaken here is simply a more sophisticated way of estimating a supply curve for renewable energy, as presented in figure A. Here the cost and capacity of various renewable options are stacked from least expensive to most expensive, the vertical portions of the curve illustrate the cost differences from option to option, the horizontal portions the capacity (or potential contribution) of each option. In the event that low cost options

<table>
<thead>
<tr>
<th>Renewable output under current MRET scheme, excluding wood waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
</tr>
<tr>
<td>GWh</td>
</tr>
<tr>
<td>Black liquor</td>
</tr>
<tr>
<td>Forest residue / wood waste</td>
</tr>
<tr>
<td>Hydro – large (exc. pumped storage)</td>
</tr>
<tr>
<td>Hydro – small</td>
</tr>
<tr>
<td>Municipal</td>
</tr>
<tr>
<td>Sugar industry (bagasse only)</td>
</tr>
<tr>
<td>Wind</td>
</tr>
<tr>
<td>Solar hot water</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>
are removed such as (ii) or (iii), the new supply curve is simply a mirror of the remaining portions but moved to the left and hence is steeper. The total cost of meeting the target is calculated as the area under the curve and to the left of the supply/demand equilibrium point, or in this case, where the supply curve intersects with the MRETs quantity constraint at points A and B. Clearly the area under the original curve is less than the adjusted curve, indicating that, unambiguously, removing options that are cost effective (that is, they are positioned somewhere along the supply curve below point A) will increase the cost of meeting the target.

Relative to the reference case, the cost (in net present value terms over the full period from 2000 to 2020) of meeting the target for renewable energy excluding the use of wood waste is increased by $25 million, or around 1.3 per cent. This calculation is based on the long run average cost of each renewable option included in the analysis and an assessment of their relative contribution with and without using wood waste.

Excluding large hydroelectric projects

Generators commissioned prior to 1997 are eligible to create credits to the extent that their renewable power production exceeds an established baseline. For large hydroelectric schemes, the baseline is the average output between 1987 and 2000. Credits can also be created through any increased output associated with refurbishment of the facilities.

Under the reference case, large hydro projects are estimated to account for 10 per cent of the target by 2010. Excluding this technology induces an increase in output from most of the other technologies but principally wind (up by 16 per cent) and municipal waste (up by 27 per cent) (table 7). The growth in output from both of these option is lower than in the case where wood waste was excluded, commensurate with the smaller contribution made by large hydroelectricity to the reference case. That the increase in renewable energy is spread across a number of technologies reflects both physical constraints in different states for specific technologies, as well as changes in the relative cost competitiveness of the different renewable energy options over the period of the analysis.

Again, it is ABARE’s assessment that excluding hydroelectricity (as with wood waste) would not lead to a dramatic expansion in output from the options based on the sugar industry (bagasse or bagasse cofired with wood waste).

The effect of excluding large hydroelectric projects from the MRETs program results in the costs of the scheme increasing relatively significantly. Relative to the reference case, the cost of meeting the renewables target (in net present value terms) is increased by $117 million, or

<table>
<thead>
<tr>
<th>Renewable output under current MRET scheme, excluding large hydroelectricity</th>
<th>2010</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black liquor</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>Forest residue / wood waste</td>
<td>1050</td>
<td>800</td>
</tr>
<tr>
<td>Hydro – large (exc. pumped storage)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hydro – small</td>
<td>450</td>
<td>450</td>
</tr>
<tr>
<td>Municipal</td>
<td>1850</td>
<td>1950</td>
</tr>
<tr>
<td>Sugar industry (bagasse and wood waste)</td>
<td>2636</td>
<td>2450</td>
</tr>
<tr>
<td>Wind</td>
<td>3083</td>
<td>3369</td>
</tr>
<tr>
<td>Solar hot water</td>
<td>400</td>
<td>450</td>
</tr>
<tr>
<td>Total</td>
<td>9500</td>
<td>9500</td>
</tr>
</tbody>
</table>
around 6.3 per cent. This amounts to an almost fivefold increase in the cost of meeting the target relative to the case where only wood waste is excluded.

As mentioned previously, this result reflects the fact that existing large hydroelectricity capacity does not include new capital investment costs, which reflects the eligibility criteria for existing hydroelectricity generators under the MRET scheme. In the calculation of long term average costs for large hydroelectricity there is a charge associated with refurbishment etc (not dissimilar to the cost of cofiring wood waste in coal fired electricity technologies) but this does not include costs associated with new large scale investment in hydroelectricity capacity. As a result, in the reference case the long run average cost of hydroelectricity is particularly low (see table 4 and appendix A) and is approximately $20–30 MWh lower than the long run average cost of wind and municipal waste based energy. It is this difference that accounts for the significant overall increase in the relative cost of meeting the target without large hydroelectricity.

**Excluding both wood waste and large hydroelectric projects**

As illustrated in table 8, excluding both large scale hydroelectric projects and technologies associated with forest residue results in wind powered generation increasing to account for over 50 per cent of the target. Again the contribution made by the municipal waste options increases, reflecting their relative competitiveness toward the beginning of the target period. However, at 2910 MWh the contribution from municipal wastes is beginning to approach the (collective) limit indicated by Redding Energy Management (2000) of around 3200 MWh. In this scenario the contribution to be made from solar hot water is also increased from 450 MWh to 600 MWh. However, wind energy is still considered to have considerable potential to meet additional needs and is one of the least cost renewable energy sources in 2010 and beyond. The contribution made by wind is estimated to increase to around 4730 MWh. Relative to the reference case, the cost of meeting the renewable energy target with both wood waste and large hydroelectricity excluded (over the full period, 2000–20) is estimated to increase by around $179 million (in net present value terms), or almost 10 per cent.

**Increasing the target**

The target under the reference case (and in each of the alternative cases examined above) is 9500 GWh or approximately 1.3 percentage points more than the level of electricity generated from all renewable technologies in 1996-97 (table 2).

An alternative policy to excluding certain technologies (such as forest residues) in order to encourage other technologies (such as wind) is to increase the target. To analyse
this, a case where the target is assumed to double between 2010 and 2020 (rather than remaining fixed) and then remain fixed between 2020 and 2030 is considered.

An increase in the target from 2010 onwards would be expected to change investment opportunities prior to 2010, because returns to investments would continue to increase after 2010 compared with the reference case. Similarly investors would be able to bank renewable credits generated prior to 2010. Nevertheless, it is ABARE’s assessment that there are likely to be only minor changes in the output associated with eligible technologies before 2010 compared with the reference case presented earlier (table 5).

In the period 2000–10, a range of technologies compete across a relatively small price band. Early in the target period bagasse (cofired with wood waste), landfill gas and municipal waste water are all relatively competitive with long run average costs of approximately $32.90–36.30/ MWh. Allowing for some regionalisation in the renewable electricity market it is understandable that the market would include a mix of each of these options. Toward the end of the period wind energy (in Tasmania) comes into this equation, with long run average costs estimated to be approximately $33.40/ MWh, although the cost of new bagasse (cofired with wood waste) is also estimated to decline to around $29.70/ MWh.

After 2010 the ranking order continues to shift towards wind. The long run average cost of wind energy (in Tasmania) is estimated to decline further to $28.12/ MWh and this option is ranked third only behind large existing hydroelectricity and biomass cofired with existing coal fired capacity, where in both these cases capital investment costs are minimal. The ranking of wind energy in all other states also improves to sixth (at $35.15/ MWh) and is estimated to have a lower cost than either wet waste ($37.28/ MWh) or municipal solid waste ($41.03/ MWh).

Based on these cost rankings, it can be seen that any increase in the target after 2010 would, in the first instance, be met by increased wind energy generation, particularly if it is assumed that large hydroelectricity and biomass (cofired with existing coal fired assets) are capacity constrained. While there may not be a strict resource constraint in the case of biomass used in coal fired facilities, in this analysis an upper constraint has been imposed to limit the longer term penetration of this option.

Similarly, in material provided to ABARE by Redding, the upper limit to capacity in 2020 for options based on using municipal waste were not significantly larger than those for 2010, and largely reflects modest population growth. The upper capacity constraint for landfill was assessed to be 2040 MWh, while that for municipal waste water was 700 MWh. As already mentioned, it should also be noted that wind power (in all states) is expected to be more cost competitive than the other municipal waste options (wet waste and municipal solid waste) and hence their capacity constraints are not relevant.

As a consequence of these factors, most of the additional renewable energy required to meet a 19000 GWh target in 2020 would be sourced from wind energy resources. Redding assessed the upper limit on the expansion of the Tasmanian wind energy sector (up to 2020) at around 4400 GWh. Given this, an additional 6500 MWh (approximately) of wind energy would be
required from the other states. With a total upper capacity of around 8500 MWh, this outcome would appear to be feasible.

In terms of costs, in nominal terms a doubling of the target would be expected to add an additional 50 per cent to the cost of the MRET scheme (approximately). That this figure is not higher largely reflects the fact that the additional 9500 GWh of renewable electricity is being sourced from relatively low cost sources, particularly from an historical perspective. In net present value terms, doubling the target is estimated to add an additional 37 per cent or $670 million to the cost of the scheme over the full period to 2020.

Of course, looking out beyond 2010 and speculating about the possible mix of renewable technologies and their relative cost is simply that, speculation. As evidenced in this analysis, changes in the costs of options over time will be critical to market outcomes. It is also the case that a raft of regional issues will have an impact on local decisions on what renewable energy options will be adopted, and when. While the MRET scheme is a national program, there are a range of factors that influence a ‘regionalisation’ of actual market outcomes. In the event that the upper limits to the expansion of Australia’s wind energy industry indicated here are optimistic, the cost of meeting a larger target will escalate quickly. With the possibility that upper constraints to the penetration of municipal waste technologies may bind relatively quickly, the next tranche of options are in the $95–130/MWh range (solar thermal, energy crops and crop wastes). Beyond that, photovoltaics are estimated to cost in the range $240–250/MWh which, if required, would significantly affect the overall cost of the scheme and renewable credit prices.
impact on consumers

The requirement for liable parties (retailers and large users contracting directly with generators) to purchase Renewable Energy Certificates (RECs) to offset their liability (or pay the non tax deductible penalty, currently set at $40/MWh) is the mechanism through which electricity consumers will face increased costs. RECs can be purchased through the spot market or directly from the creators (or other owners) of certificates. In the latter case, they may or may not be associated with a financial contract for the purchase of electricity from the creator of the REC.

The cost to consumers of the MRET program can be considered by spreading the costs of REC market purchases across all consumption. This is the only way that retailers will be able to recover their costs as liable parties. For large customers who incur liabilities through direct purchase of electricity, spreading the cost across all electricity consumption reflects the increase in total costs to them. As such, the size of the impact across all consumers depends on both the total consumption in any given year together with the size of the target.

Although it appears that almost all REC purchasing occurs outside the REC spot market in this early stage of the scheme (Chapman 2003), the spot market does provide a convenient reference point for considering the change in costs to consumers. Any prices negotiated in bilateral exchanges between liable parties and REC suppliers as part of forward financial contracts should reflect the expected cost of purchasing electricity in wholesale markets (such as the spot market in the ‘national electricity market’) and the expected cost of purchasing RECs in the REC spot market over time. Conversely, the revenue earned by generators who supply RECs can be viewed as revenue from the sale of the generated electricity and the sale of their RECs.

The extent to which a spot market reflects the true economic value of the good being traded depends on the liquidity of the market. At the moment, trading in the REC spot market (also known as the ‘green electricity market’) is irregular and may provide only limited information of the true underlying value of RECs.

In a competitive market, the price in the REC spot market reflects the cost of the marginal technology required to meet the target (which is combined with expectations about future electricity prices to provide anticipated revenue for the owners of facilities induced to produce electricity under the MRET program). Changing allowable technologies can change the expected price in the REC market if those technologies were, or were anticipated to be, in use.
In May 2003, the price in the REC market was approximately $37.65/REC (a slight increase from the price in December 2002 when it was around $36.50/REC). As the banking of RECs is permitted, this price reflects the discounted value of a certificate over the life of MRETs. This is the value used in the following calculations for the impact on consumers.

It should be noted that it is expected that there will be no change in the average price that occurs in the wholesale markets for electricity (such as the ‘national electricity market’) brought about by the current MRET policy. Many renewable technologies have zero or very low marginal costs. As such if they are bid into the electricity market, they will displace higher cost thermal technologies and, hence, the wholesale electricity price will not increase. Where renewable technologies may have a positive marginal cost in generation (such as wood waste plants), such operations would still bid under the spot price of other thermal generators to ensure they are dispatched. If they are not dispatched they cannot generate the renewable certificates. Similarly, even if the electricity from renewable technologies is not bid into the market (which is not compulsory for plants with less than 30 MW capacity), the electricity generated from these renewable plants that is supplied into the grid will displace electricity that is bid into the NEM spot market as less electricity from other sources will be required to ensure energy balance in the system. As such, all the increase in costs to consumers flow from the trade in RECs and not from changes in wholesale electricity prices.

As noted earlier, no consideration is given to any additional costs that may arise from increases in the use of ancillary services that may be required to maintain system stability by NEMMCO (or other system operators) incurred through the increased use of intermittent generation technologies such as wind.

Calculating the cost to consumers

MRET only applies to grids with a capacity of at least 100 MW, which accounts for approximately 98 per cent of total electricity consumption in Australia (Renewables Target Working Group 1999). Given ABARE’s current long term energy projections, consumption by liable parties is projected to grow from 189 GWh in 2002 to 227 GWh in 2010.

The cost of purchasing RECs in 2010 is presented in table 9. The analysis assumes that the price of RECs in 2010 will reflect the REC spot market price today. That is, whether purchased directly from the creator, or purchased through the REC market where the number of transactions are expected to increase as the scheme matures with a greater use of the spot market for clearing surpluses or deficit positions, the cost of each REC will be approximately $38.

The increase in electricity consumption costs for a target of 9500 MWh will be approximately $361 million. This equates to an average increase of $1.60/MWh. Final electricity prices to industrial and residential customers averaged $64/MWh and

<table>
<thead>
<tr>
<th>Additional cost in 2010 to customers of the renewable certificate scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity consumption TWh</td>
</tr>
<tr>
<td>MRET target TWh</td>
</tr>
<tr>
<td>Total renewables output TWh</td>
</tr>
<tr>
<td>REC price $/MWh</td>
</tr>
<tr>
<td>REC market revenue $ million</td>
</tr>
<tr>
<td>Average additional price increase $/MWh</td>
</tr>
</tbody>
</table>
$124/MWh in 2001 (ESAA 2002). A $1.60/MWh increase in costs to consumers relates to an increase of between 1 and 3 per cent.

Table 9 also includes the impact on average wholesale costs for a target of 5 per cent for comparison with recent studies on increasing the target. A 5 per cent target is equivalent to approximately 19.2 TWh, or doubling the current target. At an average REC cost of $38/MWh, the total cost to consumers would be approximately $730 million, or an increase of $3.20/MWh. This translates to an increase of between 2.5 and 5 per cent across residential and industrial customers respectively.

However, as discussed earlier in chapter 4, reaching a 5 per cent target would require using a range of options to their maximum capacity, including forest residue, wood waste, landfill, municipal solid waste, and wind energy to a significant extent. If this is not feasible, significantly more costly alternatives, such as energy crops and solar technologies, would be required to meet the target. This could only be done at a substantially higher REC price in order to induce the production of renewable energy required from these more expensive technologies. Due to the non tax deductibility of the penalty, the REC price could increase to approximately $57/REC before it would be necessary to increase the penalty.

If energy crops or solar technologies were required, it is likely that the REC price would need to increase to an order of magnitude of around $60. With a 5 per cent target, this equates to an increase of approximately $5/MWh across all electricity consumed or 4–8 per cent for residential and industrial consumers respectively.

Who bears the cost?
The cost estimates discussed above are averaged across all consumers. However, where full competition across all consumers is not operating, or where retailers are able to price discriminate across different customer classes, the burden of sharing the costs associated with the MRET policy may fall disproportionately on some customers.

For example, where full retail contestibility has not been introduced and some retailers still have franchise customers, then given that some of the retailer’s customer market is contestable (say for large consumers), that retailer will have strong incentives to pass as much of the costs associated with the MRET program to the franchise customers as possible in order to be as competitive as possible in the contestable sector of the market.

Similarly, where one class of customer is not as sensitive to a change in the price of electricity as another, then if different prices can be charged to separate classes of customers, the less price responsive customer class will bear a larger share of costs imposed by those like the MRET scheme.

In electricity, commercial and industrial customers are nearly a third more price sensitive than residential consumers (Ho Trieu and Rolph 1996). That is, for a 1 per cent increase in electricity prices, the fall in consumption by commercial and industrial customers will be a third greater than for residential consumers. As a result, retailers have an incentive to shift
a larger share of the MRET cost onto residential consumers relative to other consumers in order to reduce the impact on their revenue.

The extent to which price discrimination can occur between customer classes depends not only on the sensitivity of customers to price changes but also the extent to which there is sufficient competition between suppliers. In a fully competitive market, the discipline imposed by retail offers from other suppliers prevents price discrimination between customer classes. With the small number of firms supplying retail services in the Australian industry, it is not clear to what extent retailers have the ability to shift the costs of the scheme across different customer classes.
increasing the penalty

As certificates can be ‘banked’ for use in the future, they can be considered to have the same properties as holding money. A holder of certificates could sell them now, invest the proceeds and purchase the required certificates in the future.

As certificates can be traded across time, they should be able to earn the same rate of return as investments elsewhere in the economy. Currently, the government bond rate (taken to be the risk free rate) is approximately 5 per cent. Using this as the discount rate, the current spot price of $37.65 today suggests that participants in the market expect that prices for certificates will just exceed $50 by 2010.

The non tax deductible penalty to liable parties of $40/MWh for failing to have sufficient certificates places a cap on the price of certificates in the REC market of approximately $57. Given a discount rate of 5 per cent, the market price for certificates is not anticipated to exceed that cap by 2010.

However, using a discount rate more reflective of business risks (say 8.5 per cent) the price of certificates would reach the cap of $57 around 2008. Hence there is a risk that participants will pay the penalty in the latter years of the scheme rather than purchase RECS. That is, there may be an insufficient increase in the REC price to induce the level of investment in renewable energy required to meet the target.

Several caveats to this analysis are required. First, as discussed in chapter 4, the green electricity market appears to be only thinly traded. As such, the starting price in 2003 of nearly $38 may not be representative of the current economic value of a REC. Second, changes in investment costs over time would alter the above result. For example, the investment costs for wind are projected to continue to decline at approximately 5 per cent a year (Passey 2003). This is likely to result in the average cost for wind technology falling to near the $30/MWh level by 2010 (from the current $50–65/MWh range). With a relatively large resource base for wind technologies, such a reduction in costs would be likely to also reduce REC prices (because part of the revenue for wind generators will come from the sale of electricity, which has a long run average cost of around $35–40/MWh). Thus, even though RECs are bankable and there is an economic cost associated with holding certificates in forgone revenue, it is ABARE’s current assessment that the value of RECs will not increase with the rate of interest over time because of falls in the cost of eligible technologies and the associated cost of producing RECs. That is, given expected falls in technology costs, the market price for certificates is not anticipated to exceed the tax inclusive penalty rate.
But to complicate things, and as mentioned in chapters 2 and 3, although wind technologies
are being implemented now (which might be consistent with a view that their costs are declin-
ing) so too are technologies associated with municipal waste treatment, which appear at the
moment to be more cost competitive. Further, investments are highly regionalised and there
does not appear to be a clear (or deep) national market for renewable energy as yet. As a
consequence, it is simply not possible to say clearly at the moment what the exact time path
of REC prices will be over coming years without further detailed analysis.

Currently, how the interaction of the non tax deductible penalty and REC prices will play
out over the next couple of years is unclear, particularly as the target is set to increase sharply
in 2006. Nonetheless, it would appear that given the anticipated falls in the cost of wind
technology, the current non tax deductible penalty of $40 may be sufficient to ensure that
the target is met in 2010. However, if the costs of wind energy do not fall as anticipated,
there is a possibility that a penalty of $40 will not be sufficient. Close attention will need to
be paid to changes in technology costs over the life of the scheme.
average technology costs

The average cost of energy for a given technology can be calculated with information about investment costs, the discount rate, the life of the plant, the availability (or capacity) factor for the plants using that technology together with information on fuel, operating and maintenance costs.

The assumed average costs for investing in a variety of technologies in 2000, 2010 and 2020 are presented in table 10.

10 Projected average cost of energy from different technologies

<table>
<thead>
<tr>
<th>Technology</th>
<th>2000 $/MWh</th>
<th>Rank</th>
<th>2010 $/MWh</th>
<th>Rank</th>
<th>2020 $/MWh</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro – large, existing</td>
<td>10.95</td>
<td>1</td>
<td>10.95</td>
<td>1</td>
<td>10.95</td>
<td>1</td>
</tr>
<tr>
<td>Biomass into coal capacity</td>
<td>23.14</td>
<td>2</td>
<td>23.14</td>
<td>2</td>
<td>23.14</td>
<td>2</td>
</tr>
<tr>
<td>Bagasse, new (with wood waste)</td>
<td>32.93</td>
<td>3</td>
<td>29.71</td>
<td>4</td>
<td>29.71</td>
<td>4</td>
</tr>
<tr>
<td>Landfill gas</td>
<td>35.59</td>
<td>5</td>
<td>35.59</td>
<td>7</td>
<td>35.59</td>
<td>7</td>
</tr>
<tr>
<td>Municipal waste water</td>
<td>36.31</td>
<td>6</td>
<td>36.31</td>
<td>5</td>
<td>34.17</td>
<td>5</td>
</tr>
<tr>
<td>Wet waste</td>
<td>37.28</td>
<td>7</td>
<td>37.28</td>
<td>8</td>
<td>37.28</td>
<td>8</td>
</tr>
<tr>
<td>Hydro – large (Qld)</td>
<td>39.87</td>
<td>8</td>
<td>39.87</td>
<td>9</td>
<td>39.87</td>
<td>9</td>
</tr>
<tr>
<td>Hydro – small, various states</td>
<td>40.11</td>
<td>13</td>
<td>48.25</td>
<td>13</td>
<td>48.25</td>
<td>13</td>
</tr>
<tr>
<td>Bagasse, new</td>
<td>42.17</td>
<td>10</td>
<td>42.17</td>
<td>11</td>
<td>42.17</td>
<td>11</td>
</tr>
<tr>
<td>Municipal solid waste</td>
<td>43.60</td>
<td>11</td>
<td>43.60</td>
<td>10</td>
<td>41.03</td>
<td>10</td>
</tr>
<tr>
<td>Hydro – large (Tas)</td>
<td>48.23</td>
<td>12</td>
<td>48.23</td>
<td>12</td>
<td>48.23</td>
<td>12</td>
</tr>
<tr>
<td>Wind (Tasmania)</td>
<td>51.88</td>
<td>13</td>
<td>41.75</td>
<td>20</td>
<td>35.15</td>
<td>20</td>
</tr>
<tr>
<td>Wind (other states)</td>
<td>64.85</td>
<td>14</td>
<td>63.62</td>
<td>14</td>
<td>58.51</td>
<td>14</td>
</tr>
<tr>
<td>Forest residue and wood waste</td>
<td>74.49</td>
<td>15</td>
<td>63.62</td>
<td>14</td>
<td>58.51</td>
<td>14</td>
</tr>
<tr>
<td>Hydo – large (NSW)</td>
<td>77.79</td>
<td>15</td>
<td>77.79</td>
<td>15</td>
<td>77.79</td>
<td>15</td>
</tr>
<tr>
<td>Hydo – large (Vic)</td>
<td>81.52</td>
<td>16</td>
<td>81.52</td>
<td>16</td>
<td>81.52</td>
<td>16</td>
</tr>
<tr>
<td>Energy crops</td>
<td>98.91</td>
<td>17</td>
<td>95.02</td>
<td>17</td>
<td>92.30</td>
<td>17</td>
</tr>
<tr>
<td>Bagasse, existing</td>
<td>112.46</td>
<td>18</td>
<td>112.46</td>
<td>19</td>
<td>112.46</td>
<td>19</td>
</tr>
<tr>
<td>Black liquor</td>
<td>138.67</td>
<td>19</td>
<td>138.67</td>
<td>21</td>
<td>138.67</td>
<td>21</td>
</tr>
<tr>
<td>Crop waste</td>
<td>141.08</td>
<td>20</td>
<td>133.30</td>
<td>20</td>
<td>130.58</td>
<td>20</td>
</tr>
<tr>
<td>Solar thermal</td>
<td>169.54</td>
<td>21</td>
<td>101.06</td>
<td>18</td>
<td>97.41</td>
<td>18</td>
</tr>
<tr>
<td>Photovoltaics, remote areas</td>
<td>641.73</td>
<td>22</td>
<td>244.55</td>
<td>23</td>
<td>219.90</td>
<td>23</td>
</tr>
<tr>
<td>Photovoltaics, grid connected</td>
<td>784.34</td>
<td>23</td>
<td>254.26</td>
<td>22</td>
<td>206.27</td>
<td>22</td>
</tr>
</tbody>
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references


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