2% RENEWABLES TARGET IN POWER SUPPLIES

POTENTIAL FOR AUSTRALIAN CAPACITY TO EXPAND TO MEET THE TARGET

REDING ENERGY MANAGEMENT

in association with

RMIT Energy and Environmental Management Group

Submitted to

Australian Greenhouse Office

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EXECUTIVE SUMMARY

The purpose of this study was to provide the Australian Greenhouse Office with the best possible analysis of the potential for the **Australian** renewable energy industry to expand capacity to meet the +2% target specified in the Prime Minister's statement of November 1997. The overall approach for the project was designed to deliver a substantiated analysis of different implementation options for the +2% Renewables Measure that will support the development of Australian industry capacity.

CHARACTERISTICS OF THE AUSTRALIAN RENEWABLE ENERGY INDUSTRY

Rather than being a single industry sector with a single set of common characteristics, the renewable energy industry is comprised of a number of separate sub-sectors each of which has a distinctly different set of characteristics of its own. Identifiable renewable energy industry sub-sectors and their key characteristics are:

* **Large Hydro Industry**
  A major sub-sector in Australia of both the largely publicly owned power generation industry and the private heavy engineering industry, with significant export capability in engineering services and project development. Largely Australian owned.

* **Mini Hydro Industry**
  Part of the independent power producer (IPP) industry with both specialist and non-resource-specific IPPs involved in developing, owning, and operating projects. Companies in the local market have both local and foreign ownership and some Australian-based operations are also involved in developing projects in other countries.

* **Biomass Cogeneration Industry**
  The industry is primarily based in the sugar industry, utilising the bagasse resource. It has many elements in common with the gas cogeneration industry which in turn has some elements in common with the thermal power generation industry. There are also common elements with the agriculture and food industries. Until now most biomass cogeneration projects have been developed, owned, and operated by the host manufacturing company, but IPPs are beginning to participate.

* **Solar Hot Water Heater Industry**
  Part of the household appliance manufacturing and retailing industries with the major Australian companies in those industries now having significant equity and ownership in the solar water heater industry. However, in contrast to the case with appliance manufacturing generally, Australia is a world leader in the manufacture of solar water heaters and a major exporter.
**Solar Photovoltaic Industry**
An established high technology manufacturing industry in Australia for both the domestic and export markets. It is one of the few areas where Australia is a significant high technology exporter. The two Australian manufacturers are subsidiaries of a US firm, and a UK firm, respectively which are in turn both owned, in whole or in part, by the world's largest oil companies. The product has applications in many markets including industrial, and household applications. Australia is also a world leader in the dramatic rate of development and commercialisation of this new technology and also the associated componentry for complete power supply systems.

**Wind**
Wind farm development is a fledgling industry in Australia but several of the major European wind turbine manufacturers now have sales representation here. Some publicly owned utilities are involved in development and operation of near commercial demonstration projects. IPPs are also pursuing project development.

**Landfill Gas Industry**
Part of the IPP and cogeneration industries. Dominated in Australia by a single publicly listed company for which this represents a significant component of the total business. This company is also involved in the UK market that is driven by the Non-Fossil Fuel Obligation (NFFO).

**Tidal Energy**
If any projects proceed they would have major civil engineering involvement as for major hydro projects.

**Renewable RAPS Industry**
The industry is made up of a large number of mostly regionally based very small retailers, distributors, and installers supplying the local rural market. Some of the slightly larger companies also export systems. Companies may be solar photovoltaic (PV) system specialists or may also supply wind, micro-hydro, and diesel systems. The PV manufacturing companies are also involved in supply of complete systems both locally and for export.

For other technologies that are at a pre-commercial stage, characteristics generally include strong linkage to, and involvement with, the R&D community, public sector agencies, and specialist new technology development companies and investors.

This is not to say that some of the above sub-sectors do not have common interests. For example landfill gas and mini hydro are both essentially part of the Independent Power Producer (IPP) industry and some companies own and operate generation capacity from both resources.

The single characteristic which all the renewable energy industry sub-sectors have in common is the utilisation of renewable energy resources. This results in the renewable energy industry having a relationship with the community that is influenced by the sustainability and environmental benefits of renewable energy resources; in particular the greenhouse gas abatement benefits. This relationship in
turn leads to complexities in the market for the industry’s products, as environmental benefits start to be factored into the assessment of these products by the market. It also leads to the renewable energy industry having a particular relationship with governments, and it is impacted in particular ways by government environmental and industry policies; the +2% renewables measure being the case in point.

There are signs that industry worldwide is beginning to see renewable energy development as a more integrated area of opportunity. For example:

• Shell has recently combined its formerly separate areas of business associated with biomass and with PV into a single business unit, and has announced that it will pursue and invest in related business opportunities worldwide.
• In the UK, 40 of the companies that won contracts under the NFFO, have formed the Renewable Generator’s Consortium (RGC) as a vehicle for contractual negotiations with electricity supply companies.
• In Australia, the company GreenECO has been formed to pursue a wide range of renewable energy generation projects.

There are a number of directions for implementation of the measure which flow from this characterisation of the renewable energy industry. It is necessary to consider the development path separately for each of the industry sectors identified above. Developing a single strategy for the renewable industry as a whole is unlikely to be effective. Strategies need to be based on detailed information about the industry and market characteristics for each sub-sector, such as that which is provided in the technology-resource assessment chapters of this report.

INDUSTRY AND MARKET ASSESSMENTS OF AUSTRALIAN RENEWABLE ENERGY TECHNOLOGIES AND RESOURCES

To provide a basis for the analysis of implementation options, a rigorous assessment of the full range of renewable energy technologies and resources available to respond to the target was completed. These technology assessments:

• Use the latest available Australian and international information, including extensive consultations with the renewable energy industry in its broadest sense to provide detailed information on Australian industry and technology development capability and local and international markets.
• Provide quantitative data not only for the ranges of capital and operating costs but also estimates of the Australian content of generation investment projects, capacity factor, and a quantitatative measure of other constraints on the extent to which each resource-technology can contribute to achieving the +2% target. This last measure (MWmax) factors in, for technologies and resources where they are applicable, constraints such as:
  - time to complete R&D and commercially prove the technology
  - time to scale up manufacturing capacity, locally and/or internationally
  - generation project development and construction lead times
  - limits on the amount of the resource
  - siting and environmental constraints on the use of the resource

The technologies and resources for electricity generation that have been assessed are:
• New small and medium hydro generators, and upgrades to existing hydro generators to increase long term average output
• Wind
• Solar photovoltaic
• Solar thermal electricity generation
• Biomass
• Municipal solid waste (landfill gas and combustion) and municipal wastewater:
• Marine energy resources: wave energy, tidal energy, and ocean thermal energy conversion
• Geothermal: aquifer and hot dry rock
• Remote area power supply: solar photovoltaic, wind, and micro hydro
• Solar water heaters

Biomass technologies assessed are direct combustion, gasification, anaerobic digestion (biogas production), and co-firing at coal-fired power stations. The resources assessed are bagasse, black liquor from paper pulp production, forestry residues and wood waste, energy crops, and wet wastes from agriculture and food processing.

Points emerging from the technology assessments include:
• A wide range of capital and operating costs, with the lowest generation costs being competitive or near to competitive with Combined Cycle Gas Turbines (CCGTs).
• For most renewable energy technologies, based on the level of analysis undertaken to date regarding the supply chain for renewable energy generation projects, the levels of Australian content were found to be significant, varying between 50% and 100%. However, a high level of Australian content does not necessarily equate to a high level of ‘internationally competitive industries which could participate effectively in the burgeoning Asian energy market’; the phrasing used in the stated third objective of the measure. There are issues of interpretation related to this statement which are referred to in the following recommendations.
• There are considerable constraints on the rate at which all technologies could be deployed but to greatly varying degrees. For example, no combination of technologies can achieve the target on the basis of linear growth in the first years of implementation. Those technologies that are currently at a pre-commercial stage are the most constrained as it will necessarily take time for them to proceed through the various stages of the commercialisation process before they can make significant contributions to achieving the +2% target.

SCENARIO ANALYSIS

Following completion of the detailed industry and market assessments for the range of technologies and resources, the data obtained was used to quantitatively test various scenarios. A spreadsheet tool developed specifically for this purpose was used. The tool is automated so that a virtually unlimited number of options for achieving (or not achieving) the target can be quantitatively assessed. Input data for
the scenario analysis was developed for a total of 22 technology-resource combinations. The input data required is:

- the current and projected unit investment cost
- the current and projected cost of generated electrical energy
- the current and projected Australian content of generation projects
- non-cost limits on the maximum amount of new capacity that could be installed and changes in these limits over time
- capacity factors expressing the expected annual capacity utilisation

Unit investment costs and energy costs were derived from information in reports of very recent local and international studies, from commercial industry analysis services, and from direct survey of Australian industry sources. The assumptions used by these information sources in deriving unit energy costs are reported in the respective technology/resources assessments where they are available. This includes figures for parameters such as operation and maintenance (O&M) costs, fuel costs, project lifetimes and assumed discount rates or real rates of return. In cases where these parameters were not documented, the reported energy cost figures were generally tested by comparison of data from several sources.

Various scenarios were then set by allocating the contribution that each technology-resource would make to achieving the target (or not achieving it in the case where the measure is not introduced) at two year intervals over the period to 2010.

For each scenario the factors determined are:

- progressive increases in generation capacity over the period to 2010
- progressive increases in generated energy
- cost and distribution of investment in new generation
- cost and distribution of investment in Australian content
- cost of electricity generated

The scenario approach used in this study is intended to explore the boundaries of possible outcomes arising from implementation of the +2% Renewables measure and the impact of various options for how the measure is implemented. Hence, none of the particular scenarios selected for analysis is intended to be a definitive forecast of actual expected outcomes. Once the approach to implementation and other uncertainties are resolved, the scenario analysis tool can be readily used to forecast more definitive outcomes. To facilitate this the report is presented with as much transparency as possible to allow review of the assumptions and data used. In utilising the scenario tool for forecasting, it should be noted that it does not attempt to account for, or forecast, the effect of changes in general economic conditions on the expected outcomes of implementation of the +2% Renewables measure.

The following table summarises the scenario results. Descriptions of each of the scenarios selected for analysis are then presented.
<table>
<thead>
<tr>
<th>Code No.</th>
<th>Input total</th>
<th>Totals over 1998 to 2010 period</th>
<th>$m/yr Energy 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MW installed</td>
<td>$m invested</td>
<td>$m AC invested</td>
</tr>
<tr>
<td>Absolute Least Cost</td>
<td>1M</td>
<td>1651</td>
<td>2923</td>
</tr>
<tr>
<td>Least Cost Linear</td>
<td>2M</td>
<td>1783</td>
<td>3739</td>
</tr>
<tr>
<td>Dual Slope Linear</td>
<td>3M</td>
<td>1656</td>
<td>2934</td>
</tr>
<tr>
<td>10% Portfolio: PV &amp; Solar Thermal</td>
<td>3M</td>
<td>2099</td>
<td>5410</td>
</tr>
<tr>
<td>10% PV Portfolio</td>
<td>4M</td>
<td>2178</td>
<td>6608</td>
</tr>
<tr>
<td>Diversified Resource &amp; Technologies</td>
<td>6M</td>
<td>2603</td>
<td>7395</td>
</tr>
<tr>
<td>Measure Not Introduced</td>
<td>7M</td>
<td>585</td>
<td>1145</td>
</tr>
</tbody>
</table>

Notes:
1. Annual energy generated in 2010 is 9700 GWh/yr for all scenarios except for the case where the measure is not introduced where it is 3211 GWhr/yr.
2. As differing sets of assumptions have been used in developing the various scenarios selected for assessment, not all the results shown in the above table are directly comparable. This point is addressed further in the following paragraphs describing each of the scenarios.
3. The $m/yr energy margin is an indicator of the cost that is directly attributable to implementation of the measure. See Appendix 4 for details.

**Scenario 1: Absolute Least Cost**
This scenario is intended to demonstrate how the +2% target would be achieved where the absolute least cost options are pursued. The absolute least cost scenario provides a base case against which to compare the other scenarios for achieving the target.

It should be noted that the "cost" of this least-cost scenario, or the other scenarios for achieving the target that are derivatives of it (2, 3 & 4), cannot be directly compared with the business-as-usual scenario (7). This is because the least-cost scenario does not assume that the "non-least cost" resources in the business-as-
usual scenario will contribute to achieving the target. The reasons for not assuming
this include that it is uncertain how much of these non-least-cost resources will be
captured by the liable parties and what fraction of the full cost the liable parties
would pay. The primary purpose of Scenario 1 is to establish a minimum boundary
for the cost of achieving the +2% Renewables target. In light of the uncertainties
outlined above, for this scenario, the simplifying assumption is made that the lowest
cost technologies and resources make the maximum possible contribution. The
outcome of this approach is exponential because this is pre-determined by the non-
cost contraints for the contributing technology-resources. Estimation of costs directly
attributable to the +2% measure is addressed in Appendix 4.

The technology/resource inputs and outputs for this scenario are shown in the
following table. The main contributors are bagasse and solar hot water heating. The
two technologies combined contribute more than 82% of the generated electricity (in
the case of solar hot water, displaced electricity generation). They also account for
more than 85% of Australian content investment and 84% of installed capacity, from
77% of total investment cost. Under a least cost scenario, a major percentage of the
required output is provided by a very small range of technologies and resources.

### Scenario 1: Absolute Least Cost: Technology/Resource Summary

<table>
<thead>
<tr>
<th>Resource-technology combination:</th>
<th>Totals 1998 to 2010</th>
<th>2010 Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MW Installed</td>
<td>$m invested</td>
</tr>
<tr>
<td>Wind</td>
<td>13</td>
<td>.79</td>
</tr>
<tr>
<td>Bagasse Cgn</td>
<td>940</td>
<td>56.94</td>
</tr>
<tr>
<td>Wood Waste</td>
<td>107</td>
<td>6.48</td>
</tr>
<tr>
<td>Landfill gas</td>
<td>77</td>
<td>4.66</td>
</tr>
<tr>
<td>Sewage gas</td>
<td>54</td>
<td>3.27</td>
</tr>
<tr>
<td>Solar Hot Water</td>
<td>460</td>
<td>27.86</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td><strong>1651</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

The absolute least cost scenario has a relatively high Australian content share of
investment. This is due in part to the relative low cost of solar hot water as a
displacement technology and its rating as 100% Australian content. Bagasse
cogeneration, the major contributor to the least-cost scenario, is also expected to
have an Australian content of well over 50%.

**Scenario 2: Least Cost Linear**

If it was decided to require an equal increment of growth in electricity generation in
each 2 year period, this would result in linear growth. To achieve this, available, but
non-least cost, resources will have to be included in the mix in the earlier periods.
This scenario explores the least cost way of achieving linear growth for comparison
with Scenario 1. The technology/resource inputs and outputs for Scenario 2 are shown in the following table.

### Scenario 2: Least Cost Linear: Technology/ Resource Summary

<table>
<thead>
<tr>
<th>Resource-technology combination:</th>
<th>Totals 1998 to 2010</th>
<th>2010 Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MW Installed</td>
<td>$m invested</td>
</tr>
<tr>
<td>Hydro (large)</td>
<td>40</td>
<td>2.24</td>
</tr>
<tr>
<td>Hydro (small)</td>
<td>116</td>
<td>6.51</td>
</tr>
<tr>
<td>Wind</td>
<td>153</td>
<td>8.58</td>
</tr>
<tr>
<td>Solar PV (Grid connected)</td>
<td>11</td>
<td>.62</td>
</tr>
<tr>
<td>Bagasse Cgn</td>
<td>663</td>
<td>37.18</td>
</tr>
<tr>
<td>Wood Waste</td>
<td>158</td>
<td>8.86</td>
</tr>
<tr>
<td>Energy crops</td>
<td>20</td>
<td>1.12</td>
</tr>
<tr>
<td>Crop Waste</td>
<td>5</td>
<td>.28</td>
</tr>
<tr>
<td>Food &amp; Ag Wet Waste</td>
<td>10</td>
<td>.56</td>
</tr>
<tr>
<td>Landfill gas</td>
<td>106</td>
<td>5.95</td>
</tr>
<tr>
<td>MSW Combustion</td>
<td>4</td>
<td>.22</td>
</tr>
<tr>
<td>Sewage gas</td>
<td>27</td>
<td>1.51</td>
</tr>
<tr>
<td>PV &amp; PV-hybrid RAPS</td>
<td>9</td>
<td>.50</td>
</tr>
<tr>
<td>Wind &amp; wind-hybrid RAPS</td>
<td>1</td>
<td>.06</td>
</tr>
<tr>
<td>Solar Hot Water</td>
<td>460</td>
<td>25.80</td>
</tr>
<tr>
<td>TOTALS</td>
<td>1783</td>
<td>100</td>
</tr>
</tbody>
</table>

It was found that linear growth could not be achieved before 2002 due to non-cost constraints. In addition, the linear growth requirement forces early deployment of a certain amount of virtually all the commercially available technologies. However, bagasse continues to contribute more than 50% of the electricity generated in 2010.

The least-cost linear scenario demonstrates clearly that if linear growth were mandated this would be a more stringent requirement than the exponential option. The total investment cost increases by $816m compared to the exponential case due to the more expensive technology-resources that must be added in the period up to 2004. In this scenario the annual cost of generated electricity is also higher than in scenario 1 not only because more expensive options must be included to meet the linear requirement but also because the total amount of energy required to meet the linear target is greater in all years except 2010. As the more expensive options continue to contribute once they are installed, the annual cost of energy in 2010 is significantly greater than in scenario 1. Another penalty of a mandated linear
approach is that the Australian content of investments is reduced by 8% as more imported technology and equipment must be introduced.

**Dual-Slope Linear Scenario**

Subsequent to completion of the main analysis for the study, the AGO asked that an additional scenario be tested based on linear growth in eligible generation over the period from 2001 to 2005 and linear growth, but at a steeper slope, from 2005 to 2010. It was thought that this would reflect the preference for setting intermediate targets on the basis of linear growth while at the same time minimising the cost of implementation by approximating the intermediate targets from the least-cost scenario (1M). The intermediate targets for the dual-slope linear scenario compared with the least cost scenario were as follows (GWh/yr):

<table>
<thead>
<tr>
<th></th>
<th>Least-Cost</th>
<th>Dual Slope</th>
<th>Increase</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>1092</td>
<td>1187</td>
<td>95</td>
<td>9</td>
</tr>
<tr>
<td>2004</td>
<td>2278</td>
<td>2728</td>
<td>450</td>
<td>20</td>
</tr>
<tr>
<td>2006</td>
<td>3944</td>
<td>4688</td>
<td>744</td>
<td>19</td>
</tr>
<tr>
<td>2008</td>
<td>6878</td>
<td>7103</td>
<td>135</td>
<td>2</td>
</tr>
</tbody>
</table>

The technology/resource summary for the dual-slope linear scenario is shown in the following table.

**Dual Slope Linear Scenario: Technology/Resource Summary**

<table>
<thead>
<tr>
<th>Resource-technology combination:</th>
<th>Totals 1998 to 2010</th>
<th>2010 Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MW Installed</td>
<td>$m invested</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Hydro (small)</td>
<td>40</td>
<td>2.42</td>
</tr>
<tr>
<td>Wind</td>
<td>13</td>
<td>.79</td>
</tr>
<tr>
<td>Bagasse Cgn</td>
<td>898</td>
<td>54.23</td>
</tr>
<tr>
<td>Wood Waste</td>
<td>81</td>
<td>4.89</td>
</tr>
<tr>
<td>Landfill gas</td>
<td>120</td>
<td>7.25</td>
</tr>
<tr>
<td>Sewage gas</td>
<td>44</td>
<td>2.66</td>
</tr>
<tr>
<td>Solar Hot Water</td>
<td>460</td>
<td>27.78</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td>1656</td>
<td>100</td>
</tr>
</tbody>
</table>

It was found that the difference in the total investment cost between the dual slope scenario and the least cost scenario is minimal. The total increase in the cost of energy over the period 2001 to 2010 for the dual slope linear scenario compared to the least-cost scenario was $239m with the highest annual increase being $56m in 2006. See Appendix 5 for details.
Scenario 3: 10% Portfolio, Solar Photovoltaic and Solar Thermal Electric

This scenario is designed to demonstrate the effect of a portfolio approach, where specific shares of the measure's implementation are set for specific technologies. In this case, 10% of the new renewables are to be implemented using the PV and solar thermal electric technologies. For solar thermal there is a non-cost constraint of 416 GWh/yr, slightly less than 5% of the target requirement which is taken to be 9700 Gwh/yr. Therefore 554 GWh/yr is required from PV (including PV RAPS) to meet the portfolio target of 10% in 2010. The major contributing technologies remain the same as in scenario 1. The technology/resource inputs and outputs for this scenario are shown in the following table:

<table>
<thead>
<tr>
<th>Resource-technology combination:</th>
<th>Totals 1998 to 2010</th>
<th>2010 Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MW Installed</td>
<td>$m invested</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Wind</td>
<td>13</td>
<td>.62</td>
</tr>
<tr>
<td>Solar PV (Grid connected)</td>
<td>289</td>
<td>13.77</td>
</tr>
<tr>
<td>Solar Thermal</td>
<td>210</td>
<td>10.00</td>
</tr>
<tr>
<td>Bagasse Cgn</td>
<td>940</td>
<td>44.78</td>
</tr>
<tr>
<td>Landfill gas</td>
<td>81</td>
<td>3.86</td>
</tr>
<tr>
<td>Sewage gas</td>
<td>17</td>
<td>.81</td>
</tr>
<tr>
<td>PV &amp; PV-hybrid RAPS</td>
<td>89</td>
<td>4.24</td>
</tr>
<tr>
<td>Solar Hot Water</td>
<td>460</td>
<td>21.92</td>
</tr>
<tr>
<td>TOTALS</td>
<td>2099</td>
<td>100</td>
</tr>
</tbody>
</table>

Compared with the absolute least cost scenario, this portfolio case increases total investment cost from $2.9bn to $5.4bn. The additional cost of $2.5bn is the cost of providing a specific stimulus to the development of solar electricity generation technologies. The two solar generation technologies combined require 53% of the total investment needed to meet the target in this scenario. The Australian content is 7% higher, and in this case the increased Australian content is clearly achieved by investment in Australian high technology manufacturing.

Although the investment cost in renewable generation capacity for this scenario is far higher than for the least cost case, the annual cost of energy in 2010 is only about 15% higher. This reflects the relatively small contribution of the solar technologies to total energy supply to meet the target and also the capital intensive and low operating cost nature of the technologies, their expected long lifetimes, and their relatively low capacity factors.
**Scenario 4: 10% Portfolio, Solar Photovoltaic**

This scenario is based on another possible portfolio approach, this time specifying that 10% of the total new renewables must be implemented using the solar PV technology only. Bagasse and solar hot water remain as the major contributors to the required GWh/yr in 2010. The technology/resource inputs and outputs for this scenario are shown in the following table:

<table>
<thead>
<tr>
<th>Resource-technology combination:</th>
<th>Totals 1998 to 2010</th>
<th>2010 Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MW Installed</td>
<td>$m invested</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-------------</td>
<td>-------------</td>
</tr>
<tr>
<td><strong>Wind</strong></td>
<td>13</td>
<td>.60</td>
</tr>
<tr>
<td><strong>Solar PV (Grid connected)</strong></td>
<td>578</td>
<td>26.54</td>
</tr>
<tr>
<td><strong>Bagasse Cgn</strong></td>
<td>940</td>
<td>43.16</td>
</tr>
<tr>
<td><strong>Landfill gas</strong></td>
<td>81</td>
<td>3.72</td>
</tr>
<tr>
<td><strong>Sewage gas</strong></td>
<td>17</td>
<td>.78</td>
</tr>
<tr>
<td><strong>PV &amp; PV-hybrid RAPS</strong></td>
<td>89</td>
<td>4.09</td>
</tr>
<tr>
<td><strong>Solar Hot Water</strong></td>
<td>460</td>
<td>21.12</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td>2178</td>
<td>100</td>
</tr>
</tbody>
</table>

The two PV applications (grid-connected and RAPS) together require approximately 62% of total investment to achieve the 10% contribution to new renewable energy generation in 2010. The investment cost is $2.8bn more than the least-cost case but only $300m more than the previous combined portfolio case.

Both portfolio scenarios more than double the cost of implementing the measure compared with the absolute least cost scenario due to the relatively high cost of the solar photovoltaic and solar thermal electric technologies. The highest Australian Content share of all scenarios developed is achieved in the two portfolio scenarios. This is expected as the portfolios are designed to give a weighted advantage to two technologies that have high Australian content and which have the potential to promote Australian industry development.

**Scenario 6: Diversified Technology/ Resource Mix**

This scenario is designed to assess the effect of assuming that a broad range of technologies and resources will contribute to the measure. It assumes that some technologies that are not yet commercial reach the pilot stage or the commercial stage. Technologies and resources that are not yet utilised in Australia, either at all, or on a fully commercial basis, become more widely used.

Best judgements are made about the technologies that could make a contribution and the amount of their respective contributions, but this is done without fully considering cost implications. To allow for a broader range of technologies and
resources to make a contribution, it is assumed that only a moderate development of new bagasse-based generation occurs. A 'delayed linear' investment pattern is assumed with 'catch-ups' for some resources that have constraints in early years. The effect of this is linear growth in GWhr/yr from 2002 onwards. It is also assumed that non-least cost resources that have drivers other than the +2% target are captured by the liable parties. This includes for example remote area power supply. The technology/resource inputs and outputs for this scenario are shown in the following table:

### Scenario 6: Diversified Technology/Resource Mix: Summary

<table>
<thead>
<tr>
<th>Resource-technology combination:</th>
<th>Totals 1998 to 2010</th>
<th>2010 Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MW Installed</td>
<td>$m invested</td>
</tr>
<tr>
<td>Hydro (large)</td>
<td>114</td>
<td>4.37</td>
</tr>
<tr>
<td>Hydro (small)</td>
<td>102</td>
<td>3.91</td>
</tr>
<tr>
<td>Wind</td>
<td>433</td>
<td>16.60</td>
</tr>
<tr>
<td>Solar PV (Grid connected)</td>
<td>73</td>
<td>2.80</td>
</tr>
<tr>
<td>Solar Thermal</td>
<td>192</td>
<td>7.36</td>
</tr>
<tr>
<td>Bagasse Cgn</td>
<td>227</td>
<td>8.70</td>
</tr>
<tr>
<td>Wood Waste</td>
<td>202</td>
<td>7.75</td>
</tr>
<tr>
<td>Energy crops</td>
<td>42</td>
<td>1.61</td>
</tr>
<tr>
<td>Crop Waste</td>
<td>408</td>
<td>15.64</td>
</tr>
<tr>
<td>Food &amp; Ag Wet Waste</td>
<td>12</td>
<td>.46</td>
</tr>
<tr>
<td>Landfill gas</td>
<td>77</td>
<td>2.95</td>
</tr>
<tr>
<td>MSW Combustion</td>
<td>54</td>
<td>2.07</td>
</tr>
<tr>
<td>Sewage gas</td>
<td>54</td>
<td>2.07</td>
</tr>
<tr>
<td>Geothermal - Aquifer</td>
<td>18</td>
<td>.69</td>
</tr>
<tr>
<td>Geothermal - Hot Dry Rock</td>
<td>25</td>
<td>.96</td>
</tr>
<tr>
<td>Wave</td>
<td>21</td>
<td>.81</td>
</tr>
<tr>
<td>Tidal</td>
<td>48</td>
<td>1.84</td>
</tr>
<tr>
<td>PV &amp; PV-hybrid RAPS</td>
<td>87</td>
<td>3.34</td>
</tr>
<tr>
<td>Wind &amp; wind-hybrid RAPS</td>
<td>4</td>
<td>.16</td>
</tr>
<tr>
<td>Micro hydro RAPS</td>
<td>2</td>
<td>.07</td>
</tr>
<tr>
<td>Solar Hot Water</td>
<td>413</td>
<td>15.84</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td><strong>2603</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
In this scenario, the cost is approximately 2.5 times the absolute least cost scenario and also results in the lowest Australian content of all scenarios at 65%. This can be attributed to some extent to the fact that many of the new emerging technologies are not Australian.

Sensitivity analysis showed that this scenario has the greatest range of uncertainty in projected costs. This is expected as it utilises many technologies that are only now emerging as technically viable. Until a significant installed base is built up the possible cost range of an emerging technology will by nature be broader than those of established technologies.

**Scenario 7: Measure not Implemented**

This scenario is based on judgements about the investment in renewable energy generation that may occur if the measure is not introduced. In this case there is no requirement that the target be met. This scenario considers developments that should occur as a result of drivers other than the +2% Renewables measure. These drivers include for example GreenPower schemes, Commonwealth government renewable energy industry development initiatives, the negative cost of landfill gas and sewage gas fuels, the existing base level annual market for solar water heating, continuing piloting of wind farm development and grid-connected PV, and the cost-effectiveness of small-scale PV RAPS. Linear growth in MW-installed for each contributing technology is assumed. The technology/resource inputs and outputs for this scenario are shown in the following table:

<table>
<thead>
<tr>
<th>Resource-technology combination:</th>
<th>Totals 1998 to 2010</th>
<th>2010 Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MW Installed</td>
<td>$m invested</td>
</tr>
<tr>
<td>Hydro (small)</td>
<td>100</td>
<td>17.08</td>
</tr>
<tr>
<td>Wind</td>
<td>13</td>
<td>2.22</td>
</tr>
<tr>
<td>Solar PV (Grid connected)</td>
<td>2</td>
<td>.36</td>
</tr>
<tr>
<td>Bagasse Cgn</td>
<td>200</td>
<td>34.16</td>
</tr>
<tr>
<td>Landfill gas</td>
<td>66</td>
<td>11.27</td>
</tr>
<tr>
<td>Sewage gas</td>
<td>15</td>
<td>2.48</td>
</tr>
<tr>
<td>PV &amp; PV-hybrid RAPS</td>
<td>10</td>
<td>1.67</td>
</tr>
<tr>
<td>Solar Hot Water</td>
<td>180</td>
<td>30.75</td>
</tr>
<tr>
<td>TOTALS</td>
<td>585.4</td>
<td>100</td>
</tr>
</tbody>
</table>

The major contributors are bagasse and solar hot water as for the least-cost case. However, there are other resources and technologies that contribute even though they are not least cost. Some percentage of landfill gas, small hydro, grid connected-PV and wind proceed to meet the market demand under greenpower.
schemes etc. PV RAPS proceeds where it is cost-effective to the consumer. When the measure is not introduced approximately 33% of the target new generation is achieved in 2010.

**MAIN FINDINGS AND RECOMMENDATIONS**

The main findings and recommendations outlined in this section address the following five issues:

1. **The Australian Renewable Energy Industries to be Developed**: The potential for focusing the implementation of the +2% Renewables measure on the sub-sectors of the Australian renewable energy industry that will contribute to the development of "internationally competitive industries which could participate effectively in the burgeoning Asian energy market".

2. Integration of implementation of the +2% Renewables measure with other related government policies and programs.

3. The positive effect of the guaranteed market provided by the +2% Renewables measure in reducing renewable generation project finance costs.

4. The variation between the different sub-sectors of the Australian renewable energy industry in the potential of the measure to lead to increased exports.

5. The unnecessary increase in the cost of implementation of the measure that would result if intermediate targets were set on the basis of linear growth in renewable electricity generation over the period to 2010 rather than progressively increasing increments.

1. **The Australian Renewable Energy Industries to be Developed**

As noted previously the renewable energy industry is comprised of a number of sub-sectors with differing characteristics. This leads to the question of whether it is possible to implement the measure in certain ways that will stimulate development of the Australian renewable energy industry in its entirety or whether attempts to do this will lead to the development of some sub-sectors at the expense of others.

The scenario analysis shows clearly that Australian industry will have a major involvement in, and benefit from, the implementation of the +2% measure regardless of how it is implemented. The least-cost option is near to being the highest Australian content option. This is because solar hot water has the highest Australian Content of any option and bagasse is as high as most. Generally for biomass and other combustible fuels Australian content should be at least 50%. This is also the case for most other technologies. Wind energy is a different case as there will be a high dependence on imported equipment at least until demand reaches a level high enough to justify local assembly.
The portfolio scenarios for the solar generation technologies, and specifically for solar photovoltaic, do achieve marginally higher Australian content outcomes but at a greatly increased cost of investment in generation capacity. However, the Australian content investment fraction by itself does not completely define the relative benefit of favouring these technologies. This is because in the case of these technologies the Australian content is clearly comprised of investment in Australian high technology manufacturing. In this case there is no doubt that the Australian content reflects the third stated objective of the +2% renewables measure: to contribute to the development of internationally competitive industries which could participate effectively in the burgeoning Asian energy market. However this wording does not specifically say high technology manufacturing industries. Stimulating demand for say Australian-made biomass boilers could equally be regarded as development of the Australian renewable industry and have associated employment and export enhancement benefits.

This raises a question of interpretation of the intention of the stated industry development objective of the measure. Once this policy issue is resolved, the study shows that if the focus is on high technology exports then a specific stimulus must be provided at least to the solar photovoltaic sub-sector. This could be extended to include solar thermal electricity generation once the technology becomes commercially available. However, if the focus is on more general industry development, then the marginal benefit of the portfolio approach does not justify the substantial increase in the cost of implementation. In considering this question it is important to consider the potential of solar photovoltaics as a technology in the long term as well as the related shorter term benefits for the Australian industry. PV is different and unique as it could provide the basis for a total shift over the long term in the way electricity is generated and utilised, but this potential cannot be realised to a significant degree in terms of the world's total energy consumption until well into the next century. If this potential is to be realised, the current exponential growth in the PV industry, which is now driven largely by government initiatives to stimulate demand, will need to be maintained.

While the portfolio approach appears to be the only option to provide a market stimulus to a particular renewable energy industry sub-sector, it is worth noting that other market stimulus mechanisms are available specifically for grid-connected solar photovoltaics such as those in operation in Japan, Europe, and the USA.

2. **Policy and Program Integration**

The scenario inputs for technologies where Australian manufacturers must compete against imports involve assumptions about the market share that Australian manufacturers can achieve. The +2% measure represents a stimulus to the renewable energy industry but not specifically to the Australian renewable energy industry. To ensure that Australian industry captures the benefit, for many of the renewable energy industry sub-sectors complementary direct industry development and export enhancement programs will be needed.
For reasons already outlined a generic approach to direct support of the Australian renewable energy industry will not be effective. A strategy for each industry sub-sector could be developed based on a development path that takes into account that sub-sector's particular characteristics and status. For example for tidal energy the strategy may simply be to facilitate the first generation project while for solar thermal the strategy may be based on supporting the demonstration and commercialisation of the Australian technologies. There are already significant government renewable energy industry support programs underway and the more integrated these programs are with the implementation of the +2% measure, the more effective they will be in ensuring that the Australian industry captures the greatest possible benefit from the market stimulus provided by the measure.

It is also recognised that not all programs have the same objectives or seek the same benefits. For example while the current level of market response to greenpower schemes is not significant in terms of the amount of new generation required to meet the +2% target, it is stimulating exponential growth in the installed capacity of technologies such as wind and grid-connected PV at this early stage of development of these applications in Australia. This is reflected in the range of technologies contributing to the scenario where the measure is not introduced.

3. Guaranteed Markets and Project Financing

The +2% renewables target provides a guaranteed market for renewables – although for particular renewable technologies only to the extent that there is a portfolio approach. It is also important to note that the market is only guaranteed to the extent that the penalties and incentives are sufficient to promote investment. Nevertheless, it is clear from experience worldwide, particularly in the UK, that regulatory frameworks such as the +2% measure do make renewable energy generation projects more attractive to investors. The introduction of the measure should in itself have the effect of reducing the cost of new renewable energy generation projects as it will be taken into account by the investment community when setting the required rate and period of return.

4. Export Industry Development

Included in the process of development of the +2% renewables measure during 1998 has been the idea that the cost to the Australian economy of implementation of the measure can be off-set by its effect in generating increased export income for the Australian renewable energy industry. This effect would be realised if the measure was successful in stimulating the local market for the outputs of industries which could take advantage of this local growth by building on it to achieve increased growth in exports.

The potential for the measure to lead to increased exports varies for the different sub-sectors of the Australian renewable energy industry and has been addressed in detail in the individual technology-resource assessment chapters in the report. Particularly detailed assessments have been undertaken for solar photovoltaic and
wind, with the former showing a high potential while that for the latter is low. This is an area where still more detailed studies could be undertaken to quantify the effect more closely.

5. Intermediate Targets

A clear finding from the scenario analysis is that setting intermediate targets on the basis of linear growth increases the cost of implementing the measure without providing any added benefits over a more exponential growth pattern. In particular, setting of linear growth targets was shown to disadvantage the Australian renewable industry to some extent as well as significantly increasing the cost of implementation.

The absolute least cost scenario (Scenario 1) which has an exponential growth pattern provides a basis for setting intermediate targets. (The term exponential here is simply used to mean that the increase in electricity generation in any two year period is greater than the increase in the previous period). It is recommended that the intermediate GWhr/yr figures from Scenario 1 be used to actually set intermediate targets in the first instance. These intermediate points can then be progressively adjusted as information becomes available on the actual amounts of new generation achieved. Similarly, if a centralised approach to implementation is decided on, the growth curve from Scenario 1 could be used to set the amount for the first tranche, and could also be used to give an initial indication of the amounts for all subsequent tranches.

The scenario analysis was based on intermediate targets set for generation as at December 31 2000, 2002, 2004, 2006, 2008, and 2010. It is recommended that this approach be used in the setting of intermediate targets. Setting annual targets requires excessive reporting while a five year intermediate target does not monitor progress closely enough.