4th Meeting of the REDGTF: Strategic Action 3 - RE & DG deployment cost initiative

The Task Force has identified that the higher costs of deploying renewable energy and distributed generation technology when compared to higher emissions energy options is resulting in sub-optimal deployment of RE & DG solutions in target communities.

The TF agreed to identify and review already available literature on this matter and bring a summary of this information to the next TF meeting.

PAPER FOR DISCUSSION

A brief literature review (see attached document) has been undertaken to source published data for comparative costs of renewable energy, distributed generation and conventional generation technologies together with cost barriers and cost-levelising actions. This review was not comprehensive and additional suggestions for review are welcome.

The literature indicates that renewable energy is comparatively cheaper than fossil fuel technologies for off-grid and mini-grid applications, and more expensive in grid-connected scenarios. Barriers for renewable technologies include the high cost of materials, labour and fuel, grid connection issues, intermittency of resources, legal frameworks and the perception of high risk by financiers. Actions to reduce the cost barriers include implementation of stable, long term measures to increase investor security, support for research and development, and fair treatment of renewables in terms of access to the grid, tariffs and policy frameworks.

Information in the literature on the cost barriers to renewable energy is generally broad and high-level. Scope exists for more comprehensive analyses for all of the cost issues presented, particularly for the diversity of costs between countries, and the breakdown of costs for a particular technology.

Comparative costs of electricity generation technologies

The approximate levelised cost range for different energy technologies, summarised from the literature review data, is provided in the table below. Values for 2004 and projected to 2015 are provided in 2004 US $/MWh (converted using CPI method). The large range in values reflects the diversity of assumptions used in the reports reviewed.

Generation Type	2004	2015
Solar PV	420 - 750	250 - 650
Wind	40 - 390	30 - 340
Fuel cells	110 - 290	90 - 260
Concentrating Solar	110 - 210	90 - 200
Geothermal	40 -160	40 -160
Small hydro	50 -150	50 -150
Large hydro	40 – 70	40 - 60
Biomass	60 – 150	60 – 90
Natural Gas	30 – 140	30 -140
Coal with CCS	-	80
Nuclear	70	70
Coal	30-60	60

A 2005 World Bank technical and economic assessment (not including any cost for greenhouse gas emissions) of off-grid, mini-grid and grid electrification technologies concluded that:

- Renewable energy technologies are the least-cost option (on a levelised basis) for off-grid electrification applications, assuming availability of the renewable resource. Small-hydro, small wind, and PV-wind hybrid technologies in particular are projected to be in the range 15-25 cents/kWh, less than half the 30-40 cents/kWh for gasoline and diesel engine generators.
- The assessment for mini-grid applications (village- and district-level networks with loads between 5 kW and 500 kW not connected to a national grid) indicates that numerous renewable energy technologies (biomass, biogas, geothermal, wind, and micro-hydro) are the potential least-cost generation option, assuming a sufficient renewable energy resource is available.
- In grid-connected configurations, conventional power generation technologies (open cycle and combined cycle gas turbines, coal- and oil-fired steam turbines) remain the least-cost option. However, when sufficient resources are available, four major renewable power generation technologies - geothermal, bioenergy, hydro, and wind power – are potentially as economical as conventional power plants of similar size (e.g., less than 50 MW) but not competitive with larger (50-300 MW) conventional generating units.
- Choices among generation and network arrangements are broader than what is typically considered by power system planners. New technologies are becoming more economical and technologically mature, uncertainty in fuel and other inputs is creating increasing risk regarding future electricity costs, and old assumptions about economies of scale in generation may be breaking down.

This brief review did not find any easily accessible data that distinguished costs in different countries. The IEA regularly undertakes country reviews, as do internal agencies within countries. However, these often (usually) are focused on tariffs and other publicly-available data rather than cost-of-production data, which would allow contextual analysis for different countries.

There has been a rapid and significant escalation during the last few years in capital cost of new plants (materials and labour) and in fuel costs (coal, natural gas and oil), significantly increasing financing and operational cost risks for conventional energy and REDG project developers. The full extent of these risks often cannot be mitigated by commensurate increase in prices for the energy products and/or services.

Cost barriers faced by renewable energy and distributed generation technologies

The following barriers were identified in the literature:

- Many traditional financial institutions still consider clean energy applications as “niche” sectors with prohibitive market development and initial transaction costs. They also lack the information, experience and tools needed to quantify, mitigate and hedge project and product risks, which results in higher interest rates and more restrictive lending conditions.
- Grid connection and extension costs are significant factors for integrating RES-E generation technologies into an existing electricity network. If developers have to pay these costs this increases their long-run marginal generation costs.
- Intermittency of resources hinders the ability to be competitive in an open market.
- Government subsidies – whether direct or indirect – for use of fossil fuels keep their costs artificially low.
- Time delays in implementation – in negotiating financing for what are perceived generally as “higher

risk" projects, negotiating with grid connecting entities, governments, etc – add to the costs of deployment for RE & DG projects.

- Current global imbalance in the supply-demand curves has resulted in a 20% increase in wind turbine generator pricing over the past 12 months.
- The major concerns for doing business internationally include protection of intellectual property when exporting renewables technology or site facilities abroad, and the frustration of dealing with myriad local requirements (or their selective non-enforcement) when doing business in some countries – noting that these problems of intellectual property protection and enforcement are not unique to the renewables sector.

Cost-reducing actions to support renewable energy and distributed generation technologies

The literature contains the following established criteria for policies to reduce the cost barriers faced by renewable energy and distributed generation technologies. These criteria can be used as a benchmark for specific activities and projects designed to reduce costs. Costs will be reduced for RE & DG through policies that:

- *Create stability and investor security*: Include long-term targets, are stable and have adequate lifetimes for market development.
- *Are fair:* Ensure transparent and fair access to the electricity grid, consider all market players in designing of renewable energy policies, and identify ways to guarantee longer debt terms and lower interest rates.
- *Are proactive:* Support reduction in technology costs through interim measures to bring forward the next generations of technologies, through research and development, demonstration and commercialisation initiatives.
- *Are 'smart'*: Use a portfolio of schemes – carrots, sticks & guidance - that are optimised with regard to effectiveness & efficiency. The design of the policy instrument is more important than the type of instrument (various aspects in the policy detail - such as where liability falls - can alter the net economic benefits, technology costs and abatement). The financial support level, or penalty, should be higher than the marginal costs of generation.

Relevant cost-reducing developments:

Conventional generators are beginning to feel the impact of investor concern on greenhouse gas emissions from fossil fuels, for example.

- Citigroup, JPMorganChase, Morgan Stanley have issued strict new guidelines for coal investments noting that "investing in CO_2 emitting fossil fuel generation entails uncertain financial, regulatory and environmental liability risks"
- Kohlberg Kravis Roberts and other investors made their $45 billion buyout of TXU contingent on the utility scrapping plans for 8 of its 11 planned coal plants

Gaps in the Literature and Options for Further Work

1) There is a lack of publicly available information on the locational and stochastic variability of renewable resource costs, including capital and fuel costs, grid connection costs, land costs, labour and transport costs. The method of accounting for the incremental cost of delivering electricity should also be reviewed, and the need to accommodate environmental externalities in the economic assessment needs more attention.

On this issue, the Cleaner Fossil Energy Task Force has a recently-commenced project entitled *Costs and Diffusion Barriers to Deployment of Low Emission Technologies for APP*. This project will evaluate the levelised cost of electricity and barriers to deployment of emerging low emission technologies (LETs) in Australia. It has received $200,000 in Australian Government funding. The project will deliver a final report in September 2008. A potential second phase would involve an in-depth analysis of the cost effectiveness of the different technologies in the context of comparative environmental attributes, and identify and explore the enabling infrastructure or systems required to deploy these technologies within the APP region.

To deliver the objectives of this project, publicly available information on the capital cost and performance of electricity generation technologies will be used to estimate the cost of electricity for hypothetical Australian-based power plants. The United States Electric Power Research Institute (EPRI) will use their Technical Assessment Guide (TAG) methodology, which is enhanced by the International Energy Agency Greenhouse Gas R&D Programme's (IEAGHG) set of standard technical and economic criteria. An advisory committee of stakeholders from the Australian electric power industry and public policy makers will assist EPRI in identifying relevant design and economic parameters to include in their assessment methodology.

For discussion: Should the Task Force commission a detailed analysis of renewable energy and distributed generation cost barriers? To what extent should the REDGTF link with the Cleaner Fossil Energy Task Force project? Should the Task Force consider other options to fill this gap in information?

2) There is a need for accurate environmental and life-cycle analyses of all emerging RE&DG technologies to understand the true impact of investment and development decisions. Analysis should show that these technologies meet the following criteria: positive net energy; fossil fuels displaced > 0; and GHG displacement > 0.

For discussion: Should the REDGTF commission a study to address this issue?

3) It is acknowledged that:

- The 'high risk' perception of renewable technologies by financial institutions will be addressed at the finance session. In general, projects which educate financiers and RE project developers about the needs of the other will help to alleviate this issue.
- Concerns about protection of IP in exporting RE technologies and innovation to developing countries will be addressed in the session on Technology Transfer.
- The Policy Inventory session will address the efficacy of different cost-reducing policies.

REVIEW OF LITERATURE

A number of different key words were used to identify recent literature that would be of relevance to this strategic action. Some of the literature sourced provides (at least at a high level) differentials in costs between fossil fuel and renewable generation. Brief summaries of the literature surveyed are listed below, grouped under the following headings: comparative costs of electricity generation technologies, cost barriers faced by renewable energy and distributed generation technologies, and cost-reducing actions.

Comparative costs of electricity generation technologies

- *Discussion Paper – Technical and Economic Assessment: Off Grid, Mini-Grid and Grid Electrification Technologies, Summary Report, November 2005 (prepared for Energy Unit, Energy and Water Department, The World Bank)*

  This report – conducted for the World Bank by a study team comprising Toyo Engineering Corporation, Chubu Electric Power Co. Inc., Princeton Energy Resources International and The Energy and Resources Institute – provides an assessment of the current and future economic readiness of electric power generation alternatives for developing countries.

  Notwithstanding that the numbers are likely to have changed since publication of this report, the objective of the research was to characterise the current and future commercial prospects of renewable and fossil fuel-fired electricity generation technologies configured to suit off grid, mini-grid and grid applications. The study results make it possible to compare the levelised economic costs of electricity technologies over a broad range of deployment modes and demand levels, as shown in the table below (units are in 2004 US cents/kWh).

Generating Types	Outputs	2004			2010			2015		
		Mini	**Probable**	Max	Mini	**Probable**	Max	Mini	**Probable**	Max
Solar PV	50W	55.0	**65.0**	75.3	51.7	**60.6**	69.6	47.8	**56.3**	64.8
	300W	42.2	**51.6**	60.6	39.2	**47.2**	55.8	35.6	**42.8**	49.9
	25kW	43.6	**50.8**	58.0	40.2	**46.4**	52.2	36.7	**41.9**	47.3
	5MW	36.5	**43.1**	49.4	33.1	**38.9**	44.8	29.4	**34.7**	39.8
Wind	300W	22.4	**29.7**	38.7	20.7	**28.1**	36.5	19.9	**26.5**	34.1
	100kW	13.8	**17.1**	22.5	12.5	**16.3**	20.8	12.2	**15.5**	19.4
	10MW	4.8	**6.6**	9.2	4.4	**6.0**	8.4	3.9	**5.5**	7.4
	100MW	3.9	**5.6**	7.8	3.5	**5.1**	7.0	3.3	**4.7**	6.3
PV-Wind Hybrids	300W	24.1	**30.9**	36.6	21.8	**28.6**	33.7	20.6	**26.4**	30.6
	100kW	16.2	**19.8**	23.5	15.1	**18.7**	21.7	14.2	**17.6**	20.3
Solar thermal (without thermal storag	30MW	15.0	**17.2**	21.1	14.0	**15.9**	19.2	12.8	**14.5**	17.7
Solar thermal (with thermal storage)	30MW	11.4	**12.0**	14.8	10.5	**11.0**	13.5	9.6	**10.1**	12.3
Geothermal	200kW (Binary)	13.3	**14.8**	16.2	13.1	**14.5**	15.9	12.8	**14.2**	15.5
	20 MW (Binary)	6.2	**7.0**	7.8	6.1	**6.9**	7.6	6.0	**6.7**	7.5
	50MW (Flash)	4.0	**4.4**	5.0	3.9	**4.4**	4.9	3.9	**4.3**	4.8
Biomass Gasifier	100kW	7.7	**8.7**	9.7	7.6	**8.5**	9.5	7.4	**8.3**	9.2
	20MW	6.6	**7.4**	8.3	6.4	**7.3**	8.1	6.2	**7.1**	7.9
Biomass Steam	50MW	5.6	**6.3**	7.1	5.5	**6.2**	7.0	5.5	**6.2**	6.9
MSW/Landfill Gas	5MW	5.4	**6.0**	6.6	5.2	**5.8**	6.4	5.0	**5.6**	6.1
Biogas	60kW	5.6	**6.2**	6.8	5.6	**6.1**	6.7	5.4	**6.0**	6.5
Pico/Micro Hydro	300W	10.7	**14.6**	18.6	10.9	**14.5**	18.5	10.4	**14.3**	18.3
	1kW	9.8	**12.4**	15.6	9.7	**12.3**	15.5	9.5	**12.1**	15.2
	100kW	8.6	**10.6**	12.6	8.6	**10.5**	12.5	8.6	**10.5**	12.5
Mini Hydro	5MW	5.3	**6.8**	8.4	5.3	**6.7**	8.3	5.2	**6.6**	8.2
Large Hydro	100MW	4.1	**5.3**	6.6	4.3	**5.2**	6.6	4.0	**5.2**	6.5
Pumped storage Hydro	150MW	28.8	**34.1**	39.1	28.6	**33.8**	39.2	28.1	**33.4**	38.8
Diesel/Gasoline Generator	300W	49.2	**57.4**	79.1	44.9	**55.5**	75.8	46.6	**56.4**	76.9
	1kW	39.3	**45.3**	63.2	35.1	**43.8**	60.6	36.2	**44.6**	62.1
	100kW	15.4	**18.1**	24.9	14.6	**17.7**	24.2	15.4	**18.0**	24.9
	5MW(Base-Load)	6.9	**8.3**	11.6	6.7	**8.1**	11.2	6.8	**8.3**	11.5
	5MW(Peak-Load)	14.2	**16.3**	19.9	14.0	**16.1**	19.5	14.1	**16.1**	19.7
Micro Turbines	150kW	27.1	**29.1**	33.2	26.2	**28.1**	32.2	26.8	**28.7**	32.9
Fuel Cells	200kW	22.8	**24.7**	28.7	21.4	**23.2**	27.0	20.8	**22.5**	26.3
	5MW	11.2	**13.1**	16.2	10.3	**12.0**	14.9	9.3	**11.0**	13.7
Oil/Gas Comb. Turbines	150MW(1,100C class	9.2	**11.1**	14.8	8.7	**10.8**	14.4	9.0	**10.8**	14.4
Oil/Gas Combined Cycle	300MW(1,300C class	3.5	**4.5**	7.0	3.4	**4.4**	6.8	3.4	**4.4**	6.9
Coal Steam	300MW	3.4	**3.9**	4.8	3.3	**3.7**	4.5	3.4	**3.8**	4.6
Coal IGCC	300MW	4.2	**4.6**	5.5	3.9	**4.3**	5.1	3.7	**4.2**	4.9
Coal AFB	300MW	3.4	**3.8**	4.4	3.4	**3.7**	4.4	3.3	**3.7**	4.4
Oil Steam	300MW	5.0	**6.2**	9.6	4.9	**6.1**	9.5	5.1	**6.2**	9.8

- *http://www.whitehouse.gov/cea/2008_erp_ch7.pdf, "Chapter 7, Searching for Alternative Energy Solutions, Economic Report of the President", USA 2008*

  Chapter 7 of this report is focused on looking at alternative energy solutions to underpin energy security and to offset the environmental effects of current fossil fuel-based sources of energy. In the area of alternative production this Chapter discusses the difficulty in comparing plants that differ in both cost and generation capacity and suggest that one way is to assess economic return by comparing the levelised cost of electricity.

  The report goes on to provide an estimated average levelised cost of production for various plants (fossil fuel and alternative energy based) entering service in 2015 (see table below). This Chapter also acknowledges that other factors, for example support schemes such as Renewable Portfolio Standards, tax incentives, etc, will also be important contributors in determining what type of plants are likely to be built.

Estimated Average Levelized Costs (2006 US $/megawatthour) for Plants Entering Service in 2015

Plant Type	Capacity Factor (%)	Levelized Capital Cost	Fixed Operations & Maintenance (O&M) Cost	Variable Operations & Maintenance Cost (including fuel)	Transmission Investment	Total System Levelized Cost
Fossil Fuel Based Electricity Generation............						
Coal-fired............						
Conventional Coal............	85	$31.4	$3.6	$22.3	$3.6	$60.9
Advanced Coal............	85	36.9	5.1	18.4	3.5	63.9
Advanced Coal with CCS............	85	52.0	6.0	22.3	3.5	83.8
Natural Gas-fired............						
Conventional Combined Cycle............	87	14.1	1.6	48.7	3.7	68.1
Advanced Combined Cycle............	87	13.8	1.5	45.8	3.7	64.8
Conventional Combustion Turbine............	30	25.7	4.5	72.5	10.8	113.4
Advanced Combustion Turbine............	30	24.0	3.9	61.9	10.8	100.6
Alternative Energy Based Electricity Generation..						
Advanced Nuclear............	90	50.7	8.4	8.2	2.5	69.7
Geothermal............	90	47.9	20.1	0.0	4.9	72.9
Biomass............	83	48.3	8.6	18.9	4.0	79.8
Wind............	35	64.6	9.6	0.0	8.2	82.5
Solar Thermal............	31.2	122.8	20.7	0.0	10.5	154.0
Solar PV............	21.7	268.8	6.1	0.0	13.0	287.9
Conventional Hydropower............	....	....	....	....	....	....

Source: Department of Energy (Energy Information Administration).

- *McLennan Magasanik Associates, Increasing Australia's Low Emission Electricity Generation – An Analysis of Emissions Trading and a Complementary Measure, A Report to Renewable Energy Generators of Australia, 24 October 2007.*

  This report provides an estimate of the benefits and costs of a low emission generation target that would accelerate deployment of zero and low emission electricity generation technology in conjunction with an emissions trading scheme. The table below provides the estimates from this analysis for long-run average cost of the renewable energy technologies considered.

Long-run average costs of renewable generation options in 2007, AUD/MWh

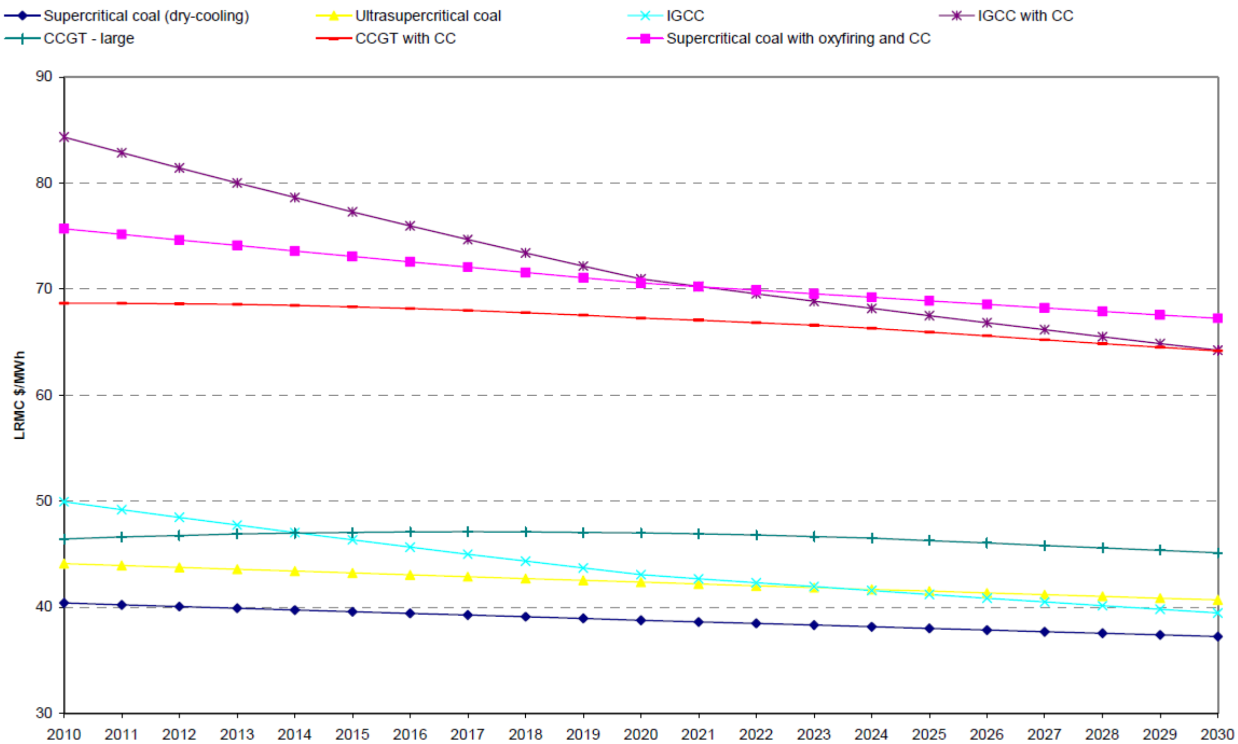
Renewable generation type	Minimum	Maximum
Hydro-electric	60	150
Wind	80	120
Biomass	85	158
Geothermal	65	95
Concentrating PV	130	200

Note: Long-run average costs represent average cost (including capital, transmission, operating and fuel costs) calculated using 9% pre tax cost of capital. Costs are in mid 2007 dollar terms.

These estimates were obtained from an earlier report by McLennan Magasanik Associates (MMA), which was released in June 2006, updated for this study by applying a CPI escalation factor and a

35% one off increase to reflect the current capital cost trends for all new generating equipment. It was noted in this report that capital cost for new plant, both renewable energy and fossil fuel, has increased markedly in recent years due to high material prices, high labour costs, shortages of qualified engineers and constraints in equipment production capacity.

MMA also analysed the trend in long run marginal cost (or levelised energy cost) for conventional and next-generation fossil fuel technologies, including some with carbon capture, as shown in the figure below.



In discussing implications from its analysis for policy, MMA commented that:

- The key objective of an emissions trading scheme is to reduce emissions across the economy at the lowest cost. However, in the early years of an emissions trading scheme, this alone may not produce the structural changes in the electricity generation industry, particularly assuming an initially low to moderate emissions permit price.
- First of a kind demonstration projects often involve significant technical risks and are most effectively supported through competitive direct government funding sources. Continued direct funding from such policy programs is needed to support emerging technologies – essential to deliver the next generation of low-cost energy options.
- Various aspects in the policy detail (such as were liability falls) can alter the net economic benefits, technology costs and abatement.
- The report demonstrates the benefits of a complementary measure to pull various levels of zero and low emissions projects into the electricity market, in order to accelerate their progression down the cost curve.

- *Australian Government Energy White Paper – Securing Australia's Energy Future, 2004.*

This paper includes an estimate of the relative costs in 2010 of different generation technologies, based on data from the IEA, IPCC, US DOE, Australian Bureau of Agricultural and Resource Economics, and the Australian Business Council for Sustainable Energy. Values are provided in 2004 A $/MWh.

Table 2: Indicative costs and emissions for selected electricity generation technologies

(Low-emission technologies in bold)

Technology	$/MWh cost in 2010[1]	kg CO2/ MWh
Natural gas combined cycle (NGCC)	35–45	430
NGCC with geosequestration	**n/a**	**80–150**
Integrated gasification combined cycle (IGCC)—black coal	n/a	720–750
IGCC—black coal—with geosequestration	**n/a**	**150–200**
Supercritical/(Ultra-supercritical (SC/USC)—black coal	30–35	780–820
SC/USC—black coal—with geosequestration	**n/a**	**150–200**
Integrated dewatered gasification combined cycle (IDGCC)—brown coal	n/a	780–820
IDGCC—brown coal—with geosequestration	**n/a**	**150–200**
Supercritical (SC)—brown coal	36–40	1000–1100
SC—brown coal with geosequestration[3]	**n/a**	**250–300**
Wind	**55–80[2]**	**0**
Bagasse[3]	**30–100**	**0–?[4]**
Small hydro[3]	**50–70**	**0**
Delivered electricity[5]		**950–1000**
Residential (including off-peak)	**50–210**	
Maximum pool price[6]	**10 000**	
Solar hot water	**80–100[7]**	**0**
Photovoltaic	**250–400**	**0**

Sources: Australian Government estimates based on IEA (b 2001), IPCC (2002), US DOE (2004), ABARE (2003 b), BCSE et al (2002) and unpublished data

1. Listed as n/a when stage of development indicates technology will not be available by 2010.
2. Costs based on meeting less than 20 per cent of electricity supply.
3. Limited resources are available.
4. Depends on fuel source.
5. Solar hot water and photovoltaics (PV) are distributed energy sources, and so compete with delivered prices for electricity rather than against other sources of generation. Solar hot water does not produce electricity so the comparison is conceptual. PV output available at peak demand times in some states and territories, when wholesale prices are at their highest.
6. This represents the maximum wholesale price. While retail prices would not go this high, it represents the value of reduced demand at the highest peak times, so is an upper value bound.
7. As solar hot water does not create electricity, prices are notional.

- *Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) Energy Transformed Flagship paper – The Heat is On: The Future of Energy in Australia, Part 2, 2006*

  In this assessment of the status and potential of Australian energy generation options, the following comparison of electricity generation costs was provided. Values are in 2006 A $/MWh.

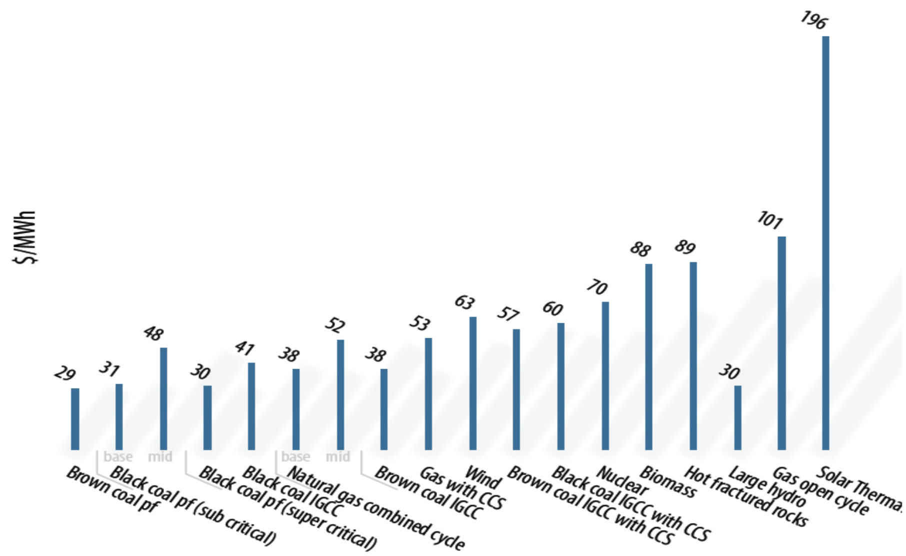


Figure 15: Estimated electricity generation costs of selected centralised electricity generation technologies (source: CSIRO estimates.)

<u>Cost barriers faced by renewable energy and distributed generation technologies</u>

- http://www.solarbuzz.com./DistributedGeneration.htm

  The SolarbuzzTM website notes that distributed generation has these advantages:
  - It can reduce or avoid the necessity to build new transmission/distribution lines or upgrade existing ones.
  - It can be configured to meet peak power needs.
  - It can diversify the range of energy sources in use and increase the reliability of the grid network.
  - It can be configured to provide premium power, when coupled with uninterruptible power supply (UPS).
  - It is well-suited to the use of some renewable energy technologies, because they can be located close to the user and can be installed in small increments to match the load requirement of the customer.

  However, when comparing the costs of different energy sources, an "apples to apples" comparison is not straightforward for the following reasons:
  - Power stations are major increments of power, which does not easily make for comparison with distributed energy, which is installed in relatively small increments.
  - The cost of finance is critical to renewable energy sources – a low cost of finance amortised over the life of the equipment/capital investment can vastly enhance the economics of renewable energy.

- Dispatchability has value – and renewable energy sources alone are generally not dispatchable.
- Fit with load curve – an energy source that produces at the time of high demand (over a 24 hour period) has greater value to both utilities and customers.
- The economics of many renewables are dependent upon location and therefore can vary dramatically.

- http://www.acore.org/renewableenergyinfo/

The American Council on Renewable Energy (ACORE) runs a monthly Renewable energy Seminar and Teleconference series in collaboration with the Renewable Energy Resources Committee of the American Bar Association SEER Section & Renewable Energy Committee of the Energy Bar Association.

The March 2008 seminar was focused on what it considers the single greatest challenge to growth of Cleantech and renewable energy – specifically its inability to compete with traditional energy sources without subsidies or market preferences. The seminar overview suggested that "clean technologies can only compete effectively with traditional energy sources if they achieve similar economies of scale. Whether they can meet this challenge depends both on these technologies' physical attributes and on the legal environment which can smooth – or bar – their way to the marketplace. Three key challenges will affect this attempted transition: (1) financial feasibility of bundling projects or enlarging their size, (2) surmounting environmental siting and operation challenges for broad-scale use of these technologies, and (3) recognizing the value of these technologies' environmental benefits through laws and regulations that capture environmental externalities. On all fronts, lawyers have an important influence on the economic scale-up of renewables through legal and regulatory processes affecting development and financing transactions."

Presentations given for this seminar covered – levelised energy costing (fossil fuel and renewable), financing challenges (including models for financing) and a methodology for regulation. The presentations are available on the website listed above.

- *Makower J, Pernick R and Wilder C, "Clean Energy Trends 2008", Clean Edge, 2008*

This report provides an overview of clean energy trends – with a particular focus on the growth of clean energy markets, global installations and production growth, a high level comparison of the capital costs of new plants (coal, geothermal, wind, nuclear and solar). The report notes the significant increase in capital available for investment in clean energy and that legislative and investor concerns on the impacts of greenhouse gas emissions are creating financing issues for deployment of new conventional fossil fuel-based plants. It also notes a number of challenges that could impact the future for clean energy markets including:

- the need for accurate environmental and life-cycle analyses for a range of renewables and conventional sources to understand the true impact of investment and development decisions
- impact of biofuel production on food supplies
- uncertain policies and the finiteness of term of these policies
- global economic recession

Finally the report notes the increase of up to 60% in investment level in clean energy sectors from 2006 to 2007.

- *UNEP, "Investing in a climate for change", 2008*

  This paper is focused on the core objective of UNEP which is to facilitate the removal of investment barriers and develop markets for renewable energy and energy efficiency.

  It notes that most financial institutions still consider sustainable energy applications as "niche" or "boutique" sectors with prohibitive market development and initial transaction costs, and are unwilling to create the new financial products the sector needs to develop. It suggests this "wait-and-see" attitude is compounded by an overall lack of information, experience and tools needed to quantify, mitigate and hedge project and product risks. To compensate for these perceived risks banks implement higher interest rates and more restrictive lending conditions that hinder development.

- *UNEP SEFI, "Global trends in sustainable energy investment in 2007", 2007*

  This report provides an overview of different types of capital flows and an analysis of the trends in sustainable energy investment activity in OECD and developing countries. The report is offered as a tool for weighing future public and private commitments to the sector. It notes that the biggest growth has been in public markets and venture capital/private equity investment activity.

- *Swider DJ et al, "Conditions and costs for renewables electricity grid connection: Examples in Europe", Renew Energy (2007), doi:10.10.1016/j.renene.2007.11.005*

  This paper compares conditions and costs for RES-E (renewable energy source of electricity) grid connection in selected European countries (Germany, Netherlands, UK, Sweden, Austria, Lithuania and Slovenia). Country specific case studies are presented for wind onshore and offshore, biomass and photovoltaic power systems. The paper shows that for wind offshore, the allocation of grid connection costs can form a significant barrier for the installation of new RES-E generation if the developer has to bear all such costs.

  The paper concludes that the main factors affecting RES-E deployment (apart from site conditions) are (i) the costs for grid connection, (ii) the unit generation costs, (iii) respective feed-in tariff or other supporting schemes and (iv) the allocation of the costs.

- *Australian Case Study, Renewable Energy International Law Project.*

  This report is an examination of relevant international law which Australia has ratified and its relationship to Australia's renewable energy sector. The objective of the report is to identify the barriers that this international law may present to the uptake of renewables, and how these barriers may be mitigated or removed. The report examines six key areas: three general issues (trade, investment and the Clean Development Mechanism) and three technology-specific areas (wind/hydro, biomass and offshore facilities), the barriers created by international law in these areas, and opportunities for mitigation of those barriers.

  Focusing particularly on trade, to date the Australian renewable energy industry has encountered few trade barriers. Instead, the industry's primary concern is for domestic policies that will foster development of a robust Australian industry, which could then expand its export potential. Major concerns for doing business internationally include protection of intellectual property when exporting renewables technology or site facilities abroad, and the frustration of dealing with myriad local requirements (or their selective non-enforcement) when doing business in certain countries – noting that these problems of intellectual property protection and enforcement are not unique to the renewables sector.

- *Barriers, Challenges and Opportunities: A synthesis of various studies on barriers, challenges and opportunities for renewable energy deployment, International Energy Agency Renewable Energy Technology Deployment Implementing Agreement, May 2006.*

  The objective of this report was to synthesize relevant studies on barriers, challenges and opportunities for the deployment of renewable energy published in recent years. The table over provides a list of the most important barriers to renewable energy deployment divided into some generic categories. In addition, there are a number of examples of possible opportunities for overcoming the barriers, and relevant stakeholders are outlined.

Barriers	Opportunities	Important stakeholders
There is no level playing field for renewable energy technologies	International cooperation on: - Phasing out subsidies for conventional technologies - Good practice for subsidies - Internalisation of externalities	National governments and international forums for cooperation (UN, EU, IEA, G8)
The incentives for governments and private companies to support renewable energy development are insufficient	- International agreements committing governments to demonstrate and deploy renewable energy technologies - Multilateral funds for RE deployment and demonstration – partnerships with the private sector	National, regional and local authorities, international forums for cooperation (IEA, G8), the RE industry, international financing institutions
Financing is unreasonably costly for renewable energy technologies	- Favourable loans for renewable energy projects through national or international institutions. Promote long-term power purchase agreements between consumers and RE generators - Initiatives to stimulate carbon financing of renewable energy projects; - Training and education of financiers	International/national financing institutions, national governments, CDM executive board, JI advisory committee, Asia-Pacific Partnership on Clean Development and Climate, energy producers, private financing institutions
Technology standards are lacking for (some) renewable energy technologies and fuels	- Develop standards for renewable energy technologies, components and fuels - Develop test facilities for renewable energy technologies	National and international standardisation organisations, the RE industry, industry associations, international trade organisations (WTO, NAFTA etc.)
Import tariffs and technical barriers impede trade in renewables	- International cooperation on removing duties and technical barriers to trade in renewable energy products	International and regional trade organisations (WTO, NAFTA etc.), international forums for cooperation (IEA, G8), the RE industry
Permits for new renewable energy plants are difficult to obtain	- Cooperation on best practice between national and local authorities from different countries - Developing internationally harmonized standard forms and requirements (to help RE project developers working internationally)	National and local authorities, the RE industry needs to adapt its products to meet requirements of authorities
Energy markets are not prepared for renewable energy	International cooperation on: - best practice for grid connection/access - removing market imperfections in relation to RE - new interconnectors - integration of intermittent RE sources - promoting demand response in energy markets	National authorities, transmission system operators, distributions system operators, energy regulators, energy traders
Renewable energy skills and awareness are insufficient	- Information and education on all educational levels at national level or through international programmes - Twinning between authorities and TSOs from countries with different experience and between operational personnel from different countries - International in-service training programmes - National and international awareness campaigns.	National and local authorities, NGOs, consumers, international forums for cooperation (IEA, G8), universities and technical colleges, operational personnel

- *Ministerial Council on Energy – Renewable Energy and Distributed Generation Working Group, Impediments to the uptake of renewable energy and distributed generation, Feb 2006, Australia*

  The Ministerial Council on Energy (MCE) commissioned a paper to identify the issues affecting the uptake of R&DG. The paper identified a range of policy and technical issues, which fall into the following categories:

  - emerging technology issues (cost of R&DG generation, resource and business opportunity identification, project approvals, access rights to resources, consumer confidence); network pricing and price regulation (improved locational and cost reflective pricing);
  - network connection arrangements (connection costs, reward for network services, use of

system charges, regulatory complexity, immature non-wholesale generation market); and
  - network management and development (management of intermittent supply, information disclosure

The paper noted that because emerging industry issues were outside its terms of reference the main focus of the paper was on issues concerning Australia's National Electricity Market (NEM) where the MCE has the authority to progress future work. For these issues the paper identifies responses currently in place to overcome the challenges while also seeking input on a number of other areas (a number of industry responses were provided in response).

Issues raised included:

<u>Non NEM issues</u>:

- Emerging Technology issues
  - RE&DG generally remain higher cost to implement than conventional sources.
  - Lack of comprehensive pre-competitive information on national RE resources.
  - Limited ability of proponents to identify business opportunities.
  - Licensing regimes for a number of newer RE resources such as geothermal energy are currently underdeveloped and inconsistent across jurisdictions.
  - Government approvals processes can be complex and inconsistent across jurisdictions.
  - Building consumer and market confidence in RE&DG products and services.
- Network pricing and price regulation
  - Distribution network price regulation may not appropriately reward and facilitate the use of DG as an alternative to network augmentation and a means of reducing network losses.
  - Network pricing structures can distort locational incentives at transmission and distribution levels.
  - Lack of transparent cost-effective pricing and appropriate metering inhibits more accurate reflection of the value of DG in terms of managing network losses and constraints.

<u>NEM issues</u>:

- Incremental connection costs can be potentially prohibitive for new RE&DG projects particularly where they require network augmentation or provision of a major new line.
- Distributed generators can have difficulty in capturing the value of their network services in connection agreements with network service providers
- Some forms of network use of system charges can be relatively prohibitive for smaller on-site generators that occasionally import or export to the grid.
- Network connection regulations, including technical standards can be complex, unnecessarily onerous or non-existent for small and medium scale R&DG.
- Relatively high transaction costs for individual small generators and lack of generalised business procedures may inhibit opportunities for small and medium RE&DG.

It is noted that these issues are likely to be of equal applicability to other nations.

Cost-reducing actions to support renewable energy and distributed generation technologies

- *German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety "What electricity from renewable energies costs" (abridged version), 2007*

This paper looks at the development and implementation of the Renewable Energy Source Act and its effect on the cost of electricity prices – see table below that shows the composition of monthly electricity costs for an average private household in Germany with an electricity consumption of 3,500 kWh per year.

	1998	1999	2000	2001	2002	2003	2004	2005*
Electricity bill (EUR/month)	**49,95**	**48,2**	**40,66**	**41,76**	**46,99**	**50,14**	**52,38**	**54,36**
Renewable Energy Sources Act	0,23	0,28	0,58	0,7	1,02	1,23	1,58	1,84
Heat-Power Cogeneration Act	0	0	0,38	0,58	0,76	0,90	0,85	0,93
Electricity tax (eco-tax)	0	2,25	3,73	4,46	5,22	5,97	5,97	5,97
Concession charge	5,22	5,22	5,22	5,22	5,22	5,22	5,22	5,22
Generation, transmission, marketing	37,6	33,8	25,15	25,05	28,29	29,9	31,52	32,90
Value-added tax	6,90	6,65	5,60	5,75	6,48	6,92	7,24	7,50
Cent per kWh	17,1	16,5	13,9	14,3	16,1	17,2	18,0	18,6
Electricity bill in prices from 2000	50,97	48,88	40,66	40,94	45,44	47,98	49,32	50,19

The report shows that in comparison with quotas and bonus models, fixed, long-term feed-in tariffs are significantly more efficient and cost effective for the promotion of renewable energies. The report also states that the additional costs for a household with an average electricity consumption in Germany are around the price of bread and that while conventional electricity generation is on the increase, most of the feed-in tariffs laid down under the Act are decreasing each year due to the increasing competitiveness of renewables.

- *International Energy Agency, Energy Policies of IEA Countries: Germany 2007 Review, Paris, 2007, pp 65–77.*

In 2007 the International Energy Agency review of the German energy market was critical of the German government's feed in tariff policy and the costs it was imposing on the German economy. In particular, the IEA report noted that:

- The German association of network operators estimated that between 2000 and 2012, the feed-in tariff will lead to payments for grid operators of EUR 68 billion;
- Solar will account for 20% of these payments, even though it produces less than 5% of the electricity;
- Between 2000 and 2012, the excess cost of promoting renewable electricity in Germany will be EUR 30 to 36 billion or around EUR 2 to 2.5 billion per year;
- The benefit of the policy in terms of avoided CO2 emissions corresponds to a carbon abatement cost of EUR 1,000 per tonne of CO2 abated – assuming solar PV replaces gas fired generation – or EUR 350-400 per tonne if solar PV replaces coal-fired generation;
- Even more expensive energy efficiency measures like building retrofitting would be 30-50 times less expensive than the feed-in tariff for solar PV in terms of abated CO2; and,
- The feed-in tariff policy risks creating a class of energy that requires fixed subsidies to survive – such subsidies can easily become entrenched and be very difficult to remove.

The IEA recommended to the German Government that it consider moving towards a more market-based means of promoting renewables.

- *International Finance Corporation, GEF, "Selling Solar – Lessons from more than a decade of IFCs experience", 2007*

  This report documents IFCs solar PV experience through five GEF funded solar PV initiatives (four are discussed in the report). The summary indicates that while IFC programs have resulted in over 84,000 solar home systems the programs have been less successful from a financial standpoint. IFC has been unable to significantly transform markets and create sustainable businesses as originally anticipated. The report suggests it is not the technology but in accurately judging market reality and trends that has been the primary issue. Reality did not live up to the expectation of these trends including a reduction in the price of solar PV panels, a decrease in the supply of smaller modules and a number of economic shocks.

  The IFC notes that it has learned a great deal about the solar PV market in general and also the types of financing required to support solar PV market growth and what it takes to develop a successful solar PV company. It suggests that a most important lesson is that supporting the growth of the solar PV market is far more complex than envisioned particularly due to the level of market segmentation.

  Moving forward the IFC suggests it will move from a narrow focus as a way of addressing rural electrification to a broader approach which supports a variety of technologies, the commercialisation of low-power lighting devices and distributed power generation. The report includes some costs associated with deployment.

- *Huber C et al, "Economic modelling of price support mechanisms for renewable energy: Case study on Ireland", Renew Energy (2006), doi:10.1016/j.enpol.2006.01.025*

  This paper expands on earlier reviews with an economic analysis of RE price support mechanisms in the Irish electricity generation sector. The focus is on three primary price support mechanisms: quota obligations, feed-in tariffs and competitive tender schemes. Computer modelling is utilised to characterise the RES-E potential and costs in Ireland to 2020. The results indicate that in achieving a 20% RES-E proportion of gross electricity consumption by 2020 a tender scheme provides the least costs to society over the period but only in the case where there is limited or no strategic bidding. If strategic bidding is taken into consideration then it is suggested that a feed-in tariff can be more efficient. Looking at quota systems and feed-in tariffs, the total costs are highest for feed-in tariffs until 2013 at which point the costs for a quota system begin to rise rapidly to overtake FIT.

- *Annette Schou, International Energy Agency Renewable Energy Technology Deployment Implementing Agreement, presentation at Brazil NEET Workshop 19-20 November 2007.*

  This presentation gave an overview of the IEA Renewable Energy Technology Development (RETD) Implementing Agreement (http://www.iea-retd.org/default.aspx) and the status and key findings of current projects. In particular, key findings and recommendations from the Policy Design for the Financing of Renewable Energy Technology Project were reported to be:

  - Create stability and investor security through policies that:
    - Include long-term targets
    - Are stable and have adequate lifetimes for market development

- Reduce costs of capital by:
  - Creating stability and confidence
  - Ensuring transparent and fair access to the electricity grid
  - Considering all market players in designing of renewable energy policies
  - Identifying ways to guarantee longer debt terms and lower interest rates
- Design smart policy schemes:
  - Use a portfolio of schemes – carrots, sticks & guidance
  - Optimize each instrument with regard to effectiveness & efficiency
  - Design of instrument is more important than type of instrument
  - Financial support level, or penalty, should be higher than the marginal costs of generation
  - Supports should be restricted to a certain time frame

- *Daigee Shaw, Challenges for Designing Renewable Energy Development Policies, OECD Forum 2007 – Innovation, Growth and Equity, 14-15 May 2007, Paris.*

  Although renewable energy comes from natural flows of sunlight, wind, or water, in order to capture some of this energy, many inputs, including human resources, man-made capital, water, land, the environment, and fossil fuels, are needed. In addition, the quality of most kinds of renewable energy is low because these natural flows of sunlight, wind, or water are mostly unstable and have low energy content. Daigee draws three policy implications from these facts:

  - First, more investment in research and development and policy analysis in regard to renewable energy is warranted before the technology can be implemented on a very large scale.
  - Second, it is imperative to ensure that the new renewable energy technologies can meet the tests of energy analysis and benefit-cost analysis.
    - Specifically, the criteria for the adoption of a development policy should include the following: (1) a positive net energy; (2) fossil fuel displaced >0; and (3) GHG displacement >0.
  - Third, the policy instruments used to promote renewable energy production, for example, price support, should base themselves on net energy output (i.e. energy surplus after deducting the energy invested for its production) instead of on gross energy output.

  Daigee concludes that since the production cost of renewable energy is generally higher than the corresponding costs of fossil fuels, we cannot depend on the free market to promote the development of renewables. Policy instruments are therefore necessary to facilitate the introduction of renewable energy.