SUBMISSION TO THE SENATE JOINT SELECT COMMITTEE ON FUEL AND ENERGY

The public portion of a submission by Carnegie Corporation Ltd to the Senate Joint Select Committee on Fuel and Energy

Dr Laurence Mann – Research and Intellectual Property Manager, Carnegie Corporation Ltd

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TABLE OF CONTENTS

Executive Summary

Submission Overview

This document is a submission on behalf of Carnegie Corporation Ltd ("**Carnegie Corporation**") to the Joint Senate Select Committee on Fuel and Energy.

Carnegie Corporation is a developer of renewable energy and clean energy technologies. Led by its Chairman and CETO inventor, Alan Burns, Carnegie employs around 40 scientists, engineers and commercial staff at 5 locations across Perth, Western Australia.

CETO is Carnegie's flagship product, and leads a pipeline of new clean technologies under development including a clean coal, solar thermal and wind turbine blade technologies. The CETO technology allows the renewable energy from the ocean's waves to be converted into zero-emission base-load power and zero-emission desalination freshwater.

Carnegie is supporting the development of wave energy technology through CETO and is seeking Federal Government funding to deploy a 50 MW commercial wave power demonstrator at a favourable location along the Australian coastline. Through means such as these Carnegie will demonstrate the potential contribution that wave energy could make to Australia's power and water needs. In this regard the proposed project and Carnegie can be considered to be an early-mover in wave energy, at least in Australia.

This submission is therefore directed towards the terms of reference covering the impact of an emissions trading scheme (ETS) on (iii) domestic energy supply, and (iv) future investment in fuel and energy infrastructure.

In summary, we assert in this submission that

1. There is a clear market failure for commercializing new clean energy technologies that an ETS alone doesn't address;

2. A significant portion of ETS revenue should be invested in assisting the development of clean technologies (not just clean coal) so that we are ultimately able to generate clean power at fossil fuel competitive prices and therefore remove the need to compensate consumers as well as generating technologies that will create green collar jobs locally, export revenue and assist developing countries;

3. That the deferral of the Renewable Energy Fund to July 2009 (despite the coal fund starting in July 08) risks driving investment in clean technologies offshore at the very time that we need it here; and

4. That we should be encouraging investment in those resources where we have natural comparative advantage such as solar and wave.

1 Introduction

The imperative for action on climate change mandates a ratcheting up of effort to fund new renewable energy sources and Carnegie believes there are several courses of action open to the Australian Government, all of which should be pursued. Firstly the emission targets need to be binding in order to send a clear signal to industry and markets to act quickly.

Equally importantly an emissions trading scheme should be implemented as soon as it is practical to do so; without it there can be no level playing field for renewables in a carbon-constrained future. Furthermore, the July 2008 Draft Garnaut Report identified the need to address market failures in relation to research and development and commercial demonstration of new technologies.

Carnegie agrees with the view that beyond a price on emissions, government support is required to allow new, emerging renewable technologies to gain a foothold in the power generation industry. It believes that support of this nature should be seen as finite and targeted at R&D and commercial demonstration activities, after which, an emissions trading scheme and mandatory clean energy target should be sufficient incentive for such technologies to be competitively viable.

Carnegie would welcome the opportunity to present its views in person to the Committee if invited to do so.

2 An ETS doesn't address the clear market failure for commercializing new technologies

Garnaut Draft Report (July 2008) at page 406:

> *16.1.2 What are the barriers to an efficient market response?*
> *"While an emissions trading scheme will drive both the development and uptake of new low-emissions technologies, market failures that impinge on the efficient and competitive function of markets for new ideas and technologies may result in suboptimal levels of investment in innovation. These market failures stem from the special characteristics of ideas and knowledge, as well as the unique processes of knowledge creation.*
> *If, as a result of market failures, there are suboptimal levels of investment in low-emissions technologies, then inferior, more expensive substitutes will need to be deployed to reduce emissions. This inefficient response will lead to a carbon price that is higher than it would otherwise be.*
> *These market failures are most important in the early research and demonstration and commercialisation phases of the innovation chain (see Figure 16.2). The emissions trading scheme will create sufficient demand-pull for new low-emissions technologies, and thus there is generally no need for any additional support for innovation at the market uptake stage."*

The Garnaut Report identifies research and development in renewable energy as elements that will not benefit from an ETS without additional funding support. The reason for this lies in the unique nature of research where the high level of associated risk is not easily catered for in market funding. That is, investors will naturally shy away from commitments to perceived speculative investments and, therefore, a public source of funding is required to move renewable energy projects from the R&D phase to the commercial uptake phase.

Carnegie Corporation has been successful in obtaining public funding for wave energy development but only to the extent of approximately $750,000 in total (AusIndustry R&D Start Grant 2002). The balance of some $20 million total project development costs to date has been raised through equity funding, both public and private. While Carnegie Corp's success in moving the wave energy project to pre-commercialisation has been impressive, it still requires government funding to establish a commercial scale demonstration project where commercial risks will be mitigated, and thereafter commercial uptake should follow upon successful project completion.

Carnegie Corporation's CETO wave energy project is an example- and we believe a good example- of getting research projects closer to market but it also highlights the obstacles to getting new technology, renewable energy projects over the line and on to market take up.

Carnegie would welcome the opportunity at a committee hearing process to elaborate on the process of commercialisation of renewable energy projects and the associated difficulties in the absence of clear funding options.

3 A significant portion of ETS revenue should be invested in assisting the development of clean technologies (not just clean coal)

This will ultimately enable Australia to generate clean power at fossil fuel competitive prices and therefore remove the need to compensate consumers as well as generating technologies that will create green collar jobs locally, export revenue and assist developing countries.

The draft Garnaut Report (July 2008) at page 402 states:

> *"Basic research and development of low-emissions technologies is an international public good, requiring high levels of expenditure by developed countries.*
> *Australia should make a proportionate contribution alongside other developed countries, in its areas of national interest and comparative research advantage. This would require a large increase in Australian commitments to research, development and commercialisation of low-emissions technologies, to over $3 billion per annum.*
> *There are externalities associated with private investment in commercialising new, low-emissions technologies.*
> *To achieve an effective commercialisation effort on a sufficiently early time scale, an Australian system of matching grants should be available where private investors demonstrate externalities, low emissions and innovation.*
> *A new research council should be charged with elevating, coordinating and targeting Australia's effort in low-emissions research."*

Carnegie supports these views and calls on the government to provide a direct ETS revenue input to various existing and new government programs for commercialising clean energy technologies.

4 Encourage investment in those resources where we have clear national advantage

Carnegie has formed the view that Australia has a natural resource advantage for base load renewables in wave and solar energy. The rationale for this assessment is derived from the following information about Australia's renewable energy resources.

Wave Energy Overview

Wave energy is a reliable and sustainable renewable energy resource that is plentiful in supply.

Wave energy is constantly renewed by the sun according to the following sequence:

- Radiation from the sun warms the earth;
- The effects of cloud cover, the earth's rotation and differential heat absorption by land and water surface conditions result in the earth's atmosphere warming to different degrees;
- The uneven warming patterns create pressure variations and general rotation of the atmosphere;
- The rotation of the atmosphere in combination with gravity and the rotation of the globe cause winds;
- As the winds drag across the surface of the ocean ripples, wavelets and ultimately waves are formed;
- Ocean waves can travel great distances with minimal loss of energy until they break at a shore.

Wave energy flows in the direction of wave propagation and is measured as the amount of power (in kW) contained in each linear metre of wave front.

Wave Energy as a Base-Load Power Resource

Wave energy is generally considered to be the most concentrated and least variable form of renewable energy. It is the high power density of wave energy that suggests it has the capacity to become the lowest cost renewable energy source.

Unlike solar, hydro and wind energy which are primarily suited to peak power supply, a number of factors contribute to making wave energy suitable for base-load power supply. These include:

- the inherent reliability and predictability of wave activity;
- the fact that any variability in wave activity happens gradually and with significant warning, making issues of grid interfacing manageable; and
- the proximity of favourable wave energy sites to ultimate end users, thereby minimising transmission issues. Notably, approximately 60 per cent of the world's population lives within 60 kilometres of a coast.

Wave Energy as a Global Energy Resource

The World Energy Council estimates that the energy that could be harvested from the world's oceans is equal to twice the amount of electricity that the world currently consumes. Once wave technology is established as being commercially viable, there is potential for the majority of world base-load power requirements to be sourced from the ocean.

The potential use of wave power is, unsurprisingly, limited to areas of the world where there are waves and is best suited to sites benefiting from strong and consistent swell. On a global scale, this is dictated by global wind patterns, with the result that waves are more prevalent in the mid-latitudes (40-60(N/S), than nearer the equator where there is a lack of ocean wind. This potential for wave power contrasts with that of solar power, which is more effective in lower latitudes.

Within the mid-latitudes, wave energy is greatest in areas where waves have travelled a long distance, in practice across large oceans. Western Europe, the Americas, South Africa and the coasts of Australia, New Zealand and Japan are particularly suitable. Sheltered coastlines are less suitable.

Figure 1 shows the wave energy flux that exists at various locations around the world.

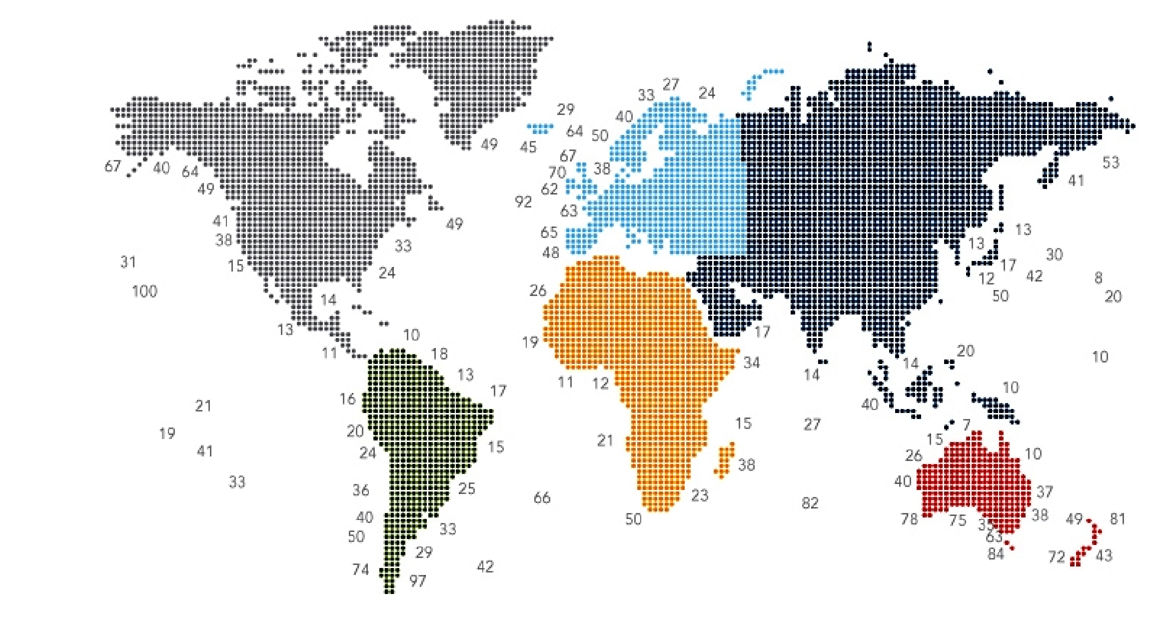

Figure 1 – Annual average wave energy flux in kW per metre of wave front

Australia's Wave Energy Resource

Australia has the world's longest coastline exposed to the world's most reliable wave energy regime due to its proximity to the circumpolar Southern Ocean and the West Wind drift. Geological evidence shows both these phenomenon have operated continuously for over 20 million years. Figure 2 shows the wave energy engine that is created around the Antarctic land mass.

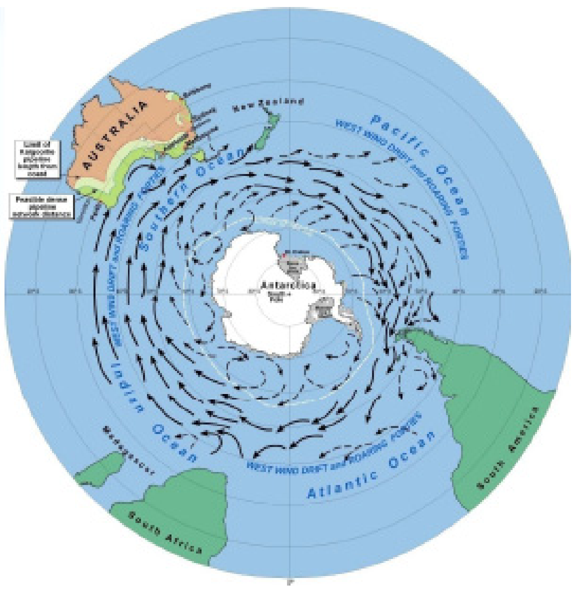

Figure 2 – Circumpolar energy flow in the Southern Ocean

Australia has access to the world's greatest opportunity to convert, in time, its base-load power to a total renewable energy resource that abuts most of our capital cities. It is estimated that the wave energy that hits Australian shores annually is around four times that of Australia's current annual electricity consumption. Harnessing just a fraction of that amount of wave energy in favourable sites around the coast and linking to nearby electricity transmission lines and water infrastructure could allow Australia to meet significant green energy targets for our electricity grids and contribute measurably to drought-proofing our cities' water supplies.

Broadly speaking, the whole southern half of the Australian coast line, from Brisbane through to Exmouth, is suitable for harnessing wave energy. This area is highlighted in Figure 3 which shows the average wave heights in the waters surrounding Australia.

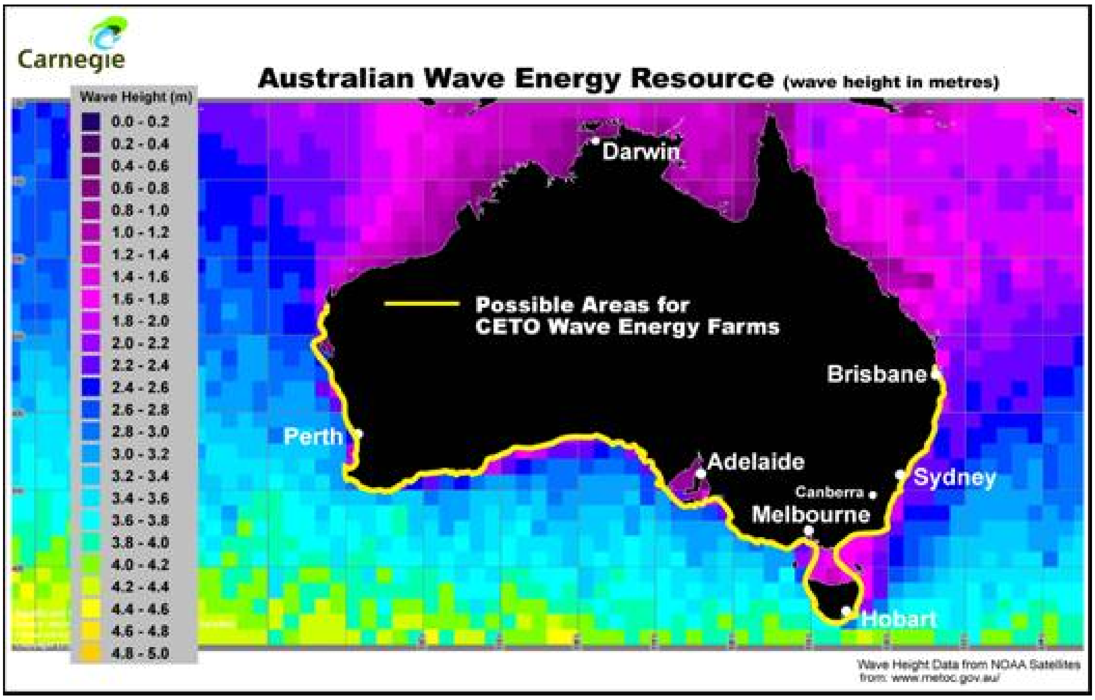

Figure 3 – Wave heights and the location of Australian wave sites suitable for wave power

The favourable sites for harnessing Australian wave energy are those representing the most consistent and powerful wave patterns and are importantly located in close proximity to large cities and the end users of both electricity and desalinated water. Figure 4 shows that the south-western, southern and south-eastern shores of the mainland as well as the western shores of Tasmania are exposed to excellent wave regimes, both in terms of quantity and reliability, and are suitable for the provision of base-load electricity.

Other areas of the southern Australian coastline, within the areas from Brisbane around to Exmouth, are more suited to the provision of non base-load power, or freshwater-only, because these sites are not likely to have as consistent enough waves to provide base-load power. Nevertheless these wave regions can support viable desalinated water plants and non base-load electricity production generally of higher availability than the best wind farms. Further work is required to quantify the exact potential of Australia's wave energy resource and Carnegie is leading this through its ownership of three wave rider buoys specifically purchased by the company to quantify the wave regime at specific sites around Australia. Additionally, Carnegie is in discussions with a number of international

Governments and potential industry partners as part of its investigations into international locations for development of commercial CETO wave farm projects.

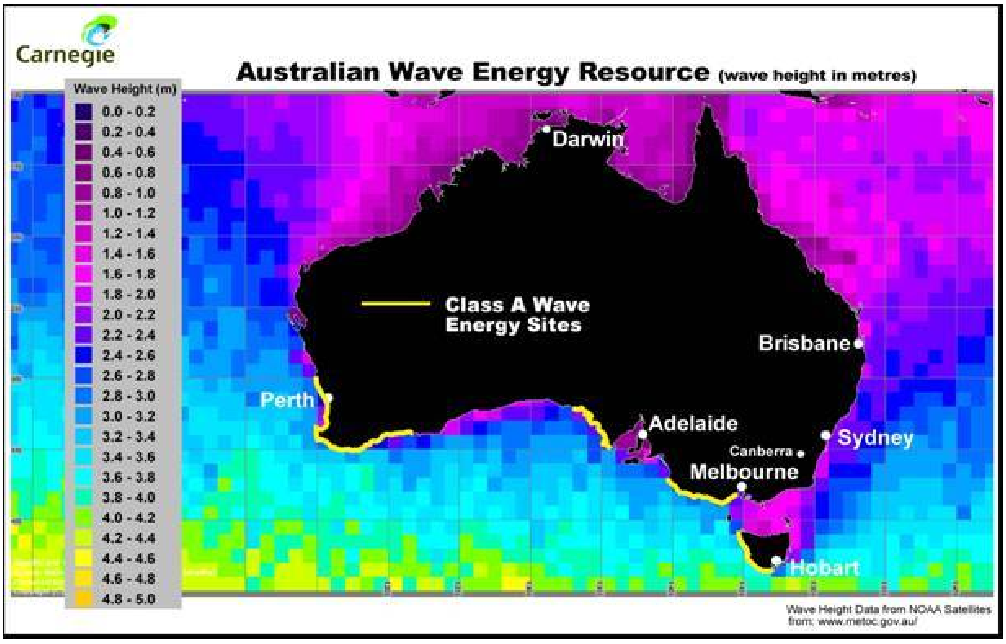

Figure 4 – Wave heights and the location of Australian wave sites suitable for base-load power generation (Class A wave regimes)

Carnegie Corporation has analysed the available Australian deep water wave energy resource along the coast from Perth all the way around to the NSW-QLD border which encompasses all of the sites in Figure 4 where base-load power could be generated. The results of the analysis are presented in Table 1.

The estimates have a maximum and minimum range which is dictated by the way wave height data such as that shown in Figure 4, is binned into ranges; minimum values of wave power correspond to the summation of all data at the lower ranges and maximum values to the summation of upper range data.

Table 1 - Estimated Deep Water Wave Resource by State and conversion to electricity by CETO

Coastal Area	Available Wave Power (GW)		Power Captured by CETO @40per cent		Annual power production GWh*		Cap City Annual Power Usage (GWh)
	Min	Max	Min	Max	Min	Max	
WA (Perth -SA)	163	193	65	77	462,633	547,780	26,000
SA	134	158	54	63	380,324	448,442	13,000
VIC	101	121	40	48	286,662	343,427	55,000
NSW	83	100	33	40	235,574	283,824	76,000
Totals:	**481**	**572**	192	229	1,365,193	1,623,473	
	(GW)	(GW)	(GW)	(GW)	(GWh)	(GWh)	

*Assumes 90 per cent conversion to electricity and 90 per cent availability

There is an abundance of wave power available along this coastline. This survey estimates the size of the deep water wave power resource from Perth right around to the NSW-QLD border as being between 481 and 572 GW, **approximately 10 times the current total installed power capacity of Australia.**

The capture of wave power by CETO is conservatively rated as 40 per cent of the available wave power, in line with the calculated estimates. Clearly there is sufficient energy availability from wave power to provide large-scale input to the national grid and to the South West Interconnected System in Western Australia.

Wave Energy Technology Activity around the World

Wave energy technology is at an early stage of development and is therefore still relatively expensive when compared to other sources of electricity. The development of wave energy technology commenced in the 1970s, which makes it relatively young when compared with the technology associated with other renewable energy resources such as solar, hydro and wind.

The market for wave energy technology is currently moving from research, development and testing into pre-commercial trials, with full-scale commercial production in sight.

A number of different technologies have been developed to harness energy from waves – however, the challenge lies in making such technologies commercial. To date, no wave energy technology has been developed that is able to generate electricity at a cost that is competitive or acceptable to the market.

The barriers to success with wave energy technology to date have included:

- High capital and maintenance costs;
- Risk of total failure in floating systems, due to destruction by breaking adrift;
- Problems associated with mass reticulation of electrical energy on the seabed; and
- Environmental problems with coastal scars caused by land-based systems or large floating systems deployed at sea.

Table 2 below provides examples of competitors to the CETO Technology within the wave energy industry. Apart from being fully-submerged beneath the ocean surface, CETO is unique in that it delivers high pressure seawater ashore as opposed to other technologies that deliver electricity ashore via subsea power cables. This gives CETO the added advantage of being able to directly produce zero-emission desalinated water in addition to zero-emission power.

Table 2 - CETO Technology Competitors

Company	Location	Technology	Status
Wavegen	Scotland	▪ Oscillating Water Column (OWC) ▪ Land Installed Marine Powered Energy Transformer (LIMPET)	In July 2007, announced the commencement of the first commercial breakwater energy plant in Spain. The plant will utilise OWC technology and will supply 300kW by 2009.
Wave Dragon Ltd	Wales	Large floating barge that contains turbines.	In April 2007, submitted their Environmental Impact Statement as an important milestone in the commercialisation of the technology. First step in establishing a 70MW wave power plant in the Celtic Sea by 2010.
Ocean Power Technologies Inc	USA	PowerBuoy wave generation system.	In August 2007, announced funding from a co-operative to support phase 1 of ocean testing for 2MW-grid wave park (expandable to 50MW).
Oceanlinx Ltd	Australia/UK	Offshore OWC, with an improved design of the Wells turbine.	In April 2007, announced it has secured a berth at the Cornwall Wave Hub and that it has applied for a wave farm permit near Oregon, USA. Currently listing on the AIM market of the London Stock Exchange.
ORECon Ltd	England	MRC1000 wave energy converter – a 1MW water column device	Technical development. Sea trials and tank testing performed over past 5 years.
Pelamis Ltd	Scotland	Pelamis offshore wave energy converter. Ultimately, multiple units expected to connect to shore via single sub-sea cable.	In February 2007, received grant funding for development of UK's first wave farm project.

Photographs of a sample of the competing technologies are provided in Figure 5, demonstrating both their scale and their environmental and aesthetic impact.

Figure 5 – CETO's Wave Energy Technology Competitors

Other Renewables

The following summary information is derived from a survey undertaken by Carnegie Corporation Ltd. of the latest developments in renewables.

Wind

Available Resource

The available wind resource has been studied extensively by the Australian Greenhouse Office (1), by the CSIRO (2, 3) and by the Renewable Energy Generators Australia (4).

Generally speaking, Australia's wind resource is spread predominantly across the southern half of the continent with the best wind availability being on the southern coastal areas including the south coast of WA, the coastlines of South Australia and Victoria (3). Not surprisingly from the connection between the two, this mimics the areas of best wave resource. There are also many inland areas in southern South Australia, New South Wales and Victoria that are favourable sites for wind farms owing to local topographic effects.

Overall the wind resource availability in the six Australian states is estimated to be 8,900 MW (1) of which the total installed capacity in 2006 was 817 MW (5). The available area for wind farming is estimated to be 200,000 square km (1) which gives a distributed density of 0.04 MW/sq. km if all of the capacity were taken up. This is just greater than the actual installed density for Germany (0.033 MW/sq. km) but still less than the actual installed density for Denmark (0.067 MW/sq. km). Hence, based on the successful experience of Denmark and Germany, two of the world's most highly wind integrated countries, Australia could absorb between 7,000 MW and 14,000 MW of wind power at similar average densities to the present levels in Germany and Denmark respectively. At such levels the distribution of wind farms in Australia would tend to be more uniform owing to the much larger land mass available in Australia compared to these two countries. Still, the resource cannot, no matter how diverse, provide base-load power.

Solar

Available Resource

Australia has the highest average solar radiation of any continent (6). Solar energy is also pervasive. Maps of Australia give Isorads (contours) showing the annual average daily solar energy available (in Mega Joules per square metre per day, $MJ/m^2/day$) for a fixed solar collector facing north and tilted to the latitude angle for near optimum year round performance (7,8).

Numbers range between 16-24 $MJ/m^2/day$ over Australia- the best areas are central inland and northern inland, grading to best in the Pilbara region of Western Australia. If we take a value of 16 $MJ/m^2/day$ as lower estimate we see that 4.44 $kWh/m^2/day$ or 1.6 $TWh/km^2/year$ is available in much of Australia.

Australia consumed 255 Billion kWh (255 TWh) of electricity in 2006 (9). Based on the above, the equivalent amount of solar energy is deposited on just ~ 160 sq. km of land.

If we assumed conservatively that the combination of land use efficiency and solar PV conversion efficiency amounted to only 5 per cent then the actual area of land required to provide the equivalent amount of electricity in a year would be about 20 times larger, or 3,200 sq km of land. Of course this does not imply that such an area could supply base-load capacity; it can't, but it gives an indication that the resource availability and the land availability is not the issue with solar power; rather it is the economics of solar PV conversion or solar thermal energy conversion that will drive the uptake of the resource.

Solar photovoltaic output tends to follow the daily electricity demand curve in summer: the maximum output in hottest part of the day when summertime air-conditioning is peaking load. Solar photovoltaic is not as useful in winter where demand peaks are due to heating and are often outside periods of maximum solar output (mornings and evenings).

The abundance of solar energy means that uptake is limited by cost factors rather than availability. A large portion of Australia's peak domestic electricity needs could be met in large part by rooftop mounted solar photovoltaic panels on every household-at very high cost- but there is no way that solar photovoltaic, with its inherent diurnal flux and high cost of battery storage, can offset the need for centralised base-load generation capacity. Advances in solar thermal technology, with energy storage capability to smooth load, are developing rapidly worldwide and locally within Carnegie itself, but a sustained effort and investment will be needed to turn these technological innovations in the solar thermal space into viable commercial base load electricity generators.

Geothermal

Available Resource

Geothermal resources are classified into two distinct categories: Hot Dry Rock, which to date have been identified mostly in South Australia, and Hydrothermal mostly located in the Great Artesian Basin and the Mt Gambier-Otway Basin.

Australia's hot rock energy based on a minimum temperature difference 150°C and extending to 5 km depth is approximately 1.2 billion Peta-joules PJ (10). This is approximately 20,000 times the annual primary energy use in Australia (2004/2005).

Despite the inferred overall abundance of energy, Australia's geothermal resource, when judged by world standards that also factor in the difficulty of extraction of the resource, is seen to be modest. This is because the Australian distribution of temperature gradients indicates that large scale harvesting will need very deep drilling (over 5 km) to achieve usable temperature deltas.

Deep hot dry rock energy harvesting is still novel and no-one has yet succeeded in making the entire system work. The barriers to success include the cost and complexity of drilling to these depths, hydrating the rocks and the paucity of appropriate geothermal data upon which to base site selections. Remoteness of HDR resources also increases costs of transmission. Australia is also known for its lack of near surface geothermal resources.

Nevertheless the Federal Government has recognised the potential of Geothermal and is supporting the mapping of the resource as well as earmarking $50m of the $500m renewable fund entirely for development of a geothermal industry.

(1) National Wind Power Study *An estimate of readily accepted wind energy in the National Electricity Market* A report prepared on behalf of Unisearch Ltd for the Australian Greenhouse Office by Assoc Prof Hugh Outhred November 2003
(2) Davy, R and Coppin P, SOUTH EAST AUSTRALIA WIND POWER STUDY, Wind Energy Research Unit CSIRO Atmospheric Research 2003
(3) Coppin, PA, Ayotte, KA and Steggel, N. Wind Resource Assessment in Australia- A Planners Guide. CSIRO Wind Energy research Unit 2003)
(4) Final Report to Renewable Energy Generators Australia Renewable Energy – A Contribution to Australia's Environmental and Economic Sustainability June 2006 M M A McLennan Magasanik Associates Pty Ltd Ref: J1281 Final Report Website: www.rega.com.au
(5) Australian Wind Energy Association, 2006
(6) Report CSIRO's National Solar Energy Centre in 2001

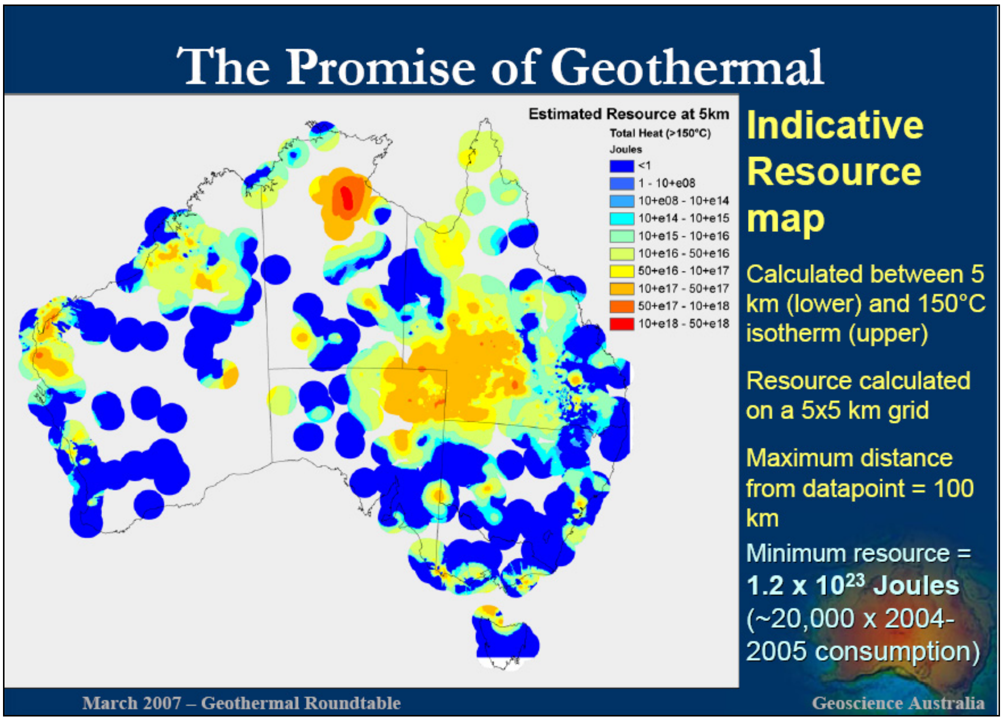

Figure 6 – Estimated geothermal resources (from 10)

Accessible Resource

There are indications that the accessible as well as the available resource will be large. Here are examples of the largest explorations:

1. Hot Dry Rock is defined as insulated hot rocks at depths of greater than 3.5 km and at temperatures above 200°C
   - Geodynamics estimates there is more than 280 MW at Innaminka SA,
   - PetraTherm estimates there is greater than 520 MW at Paralana SA etc.

2. Hydrothermal resource utilises trapped water. The largest known hydrothermal resource in Australia is the Great Artesian Basin resource
   - Pacific Hydro has assayed a 400 MW resource in the basin at Birdsville Track SA

Geothermal exploration licenses (GEL's) have been or are being issued in all states and territories. The following is a listing current at 2/2007 (from 11).

South Australia
110 applied-for (87 Granted)
Amendments to legislation posed to allow larger GELs with lower fees

Victoria
Regulations came into effect in '06.
GELs necessary at > 1km or > 70° C
31 GELs offered for bids; 20 applications lodged. Expect grants from April 07

Queensland
Grant of 5 GELs pending Native Title Land Access
Agreements. Legislation for production in progress
10 GELs offered. Bids close in April 07

New South Wales
4 GELs granted

Tasmania
1 large GEL granted

Western Australia
Legislation introduced in 2008. GEL bids to close in April 2008
The land has been divided into 495 lots, each with an area of 320sq km and will cost potential power prospectors $3900 to buy (12)

Northern Territory
Legislation expected in '07. Call for GEL bids to follow

Tidal

There are no commercial tidal power stations operating in Australia at this time. Proposal for a 50 MW tidal project in Derby, WA was the last such project to be mooted. This project did not proceed to completion because of environmental and other objections.

The available tidal resource in Australia is diffuse and quite limited. The most promising ocean tidal variations are to be found in the Kimberly region of Western Australia; other resources are smaller and located around coastal estuarine or island channels making them both remote from grid connection points and often environmentally sensitive.

Hydro

Available Resource

Current installed capacity in Australia is 7083 MW; over 80 per cent of this is in Snowy Mountains Hydro and Hydro Tasmania Installations (13).

Hydro capacity is not expected to grow through the acquisition of new sites for new projects as there are few if any of these available. It is generally regarded that environmental objections would forestall any new planned projects.

Increases in capacity may come about mostly from technology upgrades of existing installations. Generation from mini-hydro schemes (less than 10 MW) where environmental impacts are less, could also be a significant source of new renewable generation. A decade old study identified around 200 MW of potential new mini-hydro capacity (14).

ABARE predicts only a modest growth for hydro in Australia out to 2030 (15).

(7) 'Australian Solar Radiation Data Handbook', by T Lee, D Oppenheim and T Williamson, 1995, published by ERDC
(8) CONDENSED SOLAR RADIATION DATA BASE FOR AUSTRALIA By Graham L. Morrison and Alex Litvak Report No 1/1999 Solar Thermal Energy Laboratory University of New South Wales Sydney Australia)
(9) ABARE 2006)
(10) Johnson, J Geothermal Energy Industry Roundtable GEOTHERMAL RESOURCES IN AUSTRALIA – Status and Research Needs Australian Government Geoscience Australia March 2007 – Geothermal Roundtable http://www.ga.gov.au/image_cache/GA10036.pdf
(11) From: Goldstein, B IEA Geothermal Task: Australia's 2006 Report, REGA Forum 3-4 April 2007, Accessed 25/2/2008 From http://www.pir.sa.gov.au/geothermal
(12) Australian 22 Jan 2008
(13) From http://www.rise.org.au/info/Tech/hydro/table4small.html accessed 27/2/2008)
(14) Green, T.R, Ewbank, and Preece, Sinclair Knight 1991, Advanced Generation Options for the Australian Electricity Industry, report to the Energy Research and Development Corporation and the Electricity Supply Association of Australia
(15) ABARE 2005, Australian Energy, National and State Projections to 2029-30, Canberra.

Summary

Of the renewables discussed here, at present, only unproven geothermal with possibly solar and solar storage have a capacity factor that would allow it, along with wave, to provide a substantial portion of Australia's base-load electricity needs into the future. Hot Dry Rock Geothermal has resource potential but will require mastery of new techniques and carries significant risk at this stage. Costs of transmission lines are a major issue for HDR Geothermal due to the remoteness of many of the currently favoured sites.

Wind capacity will continue to expand beyond its current installed base of some 817 MW as it acquires more of the available resource. The natural variability of the resource will dictate limits to the grid penetration of wind and will likely keep it as an adjunct energy resource complementing other base-load renewables. Similarly solar, both photovoltaic and thermal are set to expand as new technologies come on line and market pull is created through, for example, feed-in tariffs as is happening now in South Australia. However, in the absence of any new viable energy storage technology, solar energy and solar PV in particular will remain in the same role as wind for supplying grid connected electricity as they are all non base-load energy sources.

Hydro is a mature technology and there isn't any new untapped resource, save for low power stream based hydro, to promote significant growth. Nevertheless with technology improvements at the major established installations and the addition of some low power hydro there is scope for modest growth in capacity.

Based on these findings, Carnegie argues that funding for development of base load electricity generation renewable capacity should be favour the sources most appropriate for its provision, namely wave and solar thermal.

5 Implications for deferment of the Renewable Energy Fund to July 2009

Notwithstanding that the coal fund is starting in July 08, the delay in implementing the Renewable Energy Fund risks driving investment in cleantech offshore at the very time that we need it here.

Quote from the Draft Garnaut Report (Feb 2008) at page 55 is relevant:

"These circumstances generate tendencies for each potential user of new infrastructure to delay investment in the hope that another may take the first step. In addition, they may lead to potential investors in low-emissions power generation who would need to use new infrastructure assuming that they would have to meet the full cost of pioneering investment, even if there were some prospect of investment costs being shared by others. These considerations raise the commercial hurdles over which the investment must jump before an investor decides to proceed. The higher hurdle is likely to lead to unnecessary caution and underinvestment. The correction of the resulting tendency to underinvestment would require public contributions to infrastructure investment (as favoured in Britain in the encouragement of renewable energy generation in new locations), or regulatory action to bring together decisions on power generation requiring new technologies (as under current discussion in California). These issues will be even more important in Australia than in other countries, because of the great distances separating new sources of energy and centres of demand, and between sequestration sites and established locations of industrial activity generating significant emissions."

Carnegie recognises that Australia lags the rest of the world in renewables funding in general, and that this deficit is particularly acute in wave energy funding.

Support for Wave Energy Worldwide

Support for wave energy is growing rapidly throughout the world as individual countries with coastal wave resources invest in and encourage the development of this new technology as a hedge against peak oil and to help meet ambitious carbon emission targets. At latest survey there is *A$496 million* committed or already spent by governments around the world on developing wave energy projects. Notably, the US Government has recently committed US$250 million in funding to advance wave energy technologies. In addition to direct grant funding, the Irish government has recently introduced preferential power feed-in tariffs for wave generation of €220/MWh ($350/MWh).

Table 3 provides examples of significant grant funding associated with wave energy.

Table 3 – Grant Funding Associated with Wave Energy Development

Country	Details	Funding (AU $million)
USA	▪ Federal legislation approved for US$200 million in federal funds to advance R&D of wave energy technologies over the next 4 years. ▪ Grant funding of US$1 million from three US states (Massachusetts, Rhode Island and Connecticut) for a wave plant in the New England region.	300
Ireland	▪ Funding over three years to boost ocean energy production including grants to developers of ocean energy devices to help with commercialisation. ▪ Preferential feed-on tariffs for wave energy power of 220Euro per MWh ($350/MWh) ▪ Funding for state of the art "national ocean energy facility" in University Collage Cork to develop & test ocean energy devices, development of a wave energy test site	44
UK	▪ South West of England Regional Development Agency grant of GBP21.5m announced to support the Wave Hub project off the Cornish coast.	84
New Zealand	▪ Federal Government issued draft energy strategy that proposes funding for the early deployment of marine-based electricity generation such as wave or tidal, worth NZ$8 million over four years.	7
Portugal	▪ European Commission, under the Framework Protocol 6 (FP6) program, committed EUR1.37 million toward the deployment of a wave energy power plant. ▪ The Portuguese Government agrees to a feed-in tariff for wave energy of EUR 0.23/kWh.	30
Denmark	▪ EU's FP6 R&D program committed EUR2.4 million of funding to commercial development over the period Apr-06 to Mar-09. ▪ Danish Energy Agency launched the Danish Wave Energy Program for 1998-2004. The Programme had a maximum 80 million Danish Krone at its disposal for supporting development projects.	23
Norway	▪ European Commission provided part-funding for a pilot project for full-scale demonstration of the SSG wave energy converter under FP-6-2004-Energy-3. ▪ Norwegian state foundation Enova has granted around US $5 million as a subsidy towards financing a sea-wave power plant in Rogaland county.	10

Note: Exchange rate assumptions: AUD:GBP=2.4; AUD:USD=1.25, AUD:NZD=0.84

World Wave Energy Research, Promotion and Technology Centres

The main centre of activity has historically been located in Europe in countries with Atlantic or North Sea coasts. The more prominent of these are listed below:-

- European Marine Energy Centre (EMEC) Ltd Orkney Islands, Scotland, UK
- The Wave Energy Centre (WavEC) Portugal

- Noregs teknisk-naturvitskaplege universitet (NTNU), Trondheim, Norway
- BWEA-The British Wind Energy Association is the trade and professional body for the UK wind and marine renewables industries
- European Thematic Network on Wave Energy
- South West England Wave Hub Project- 17 September 2007: The UK Government has given planning approval for the world's first large scale wave farm off the coast of Cornwall in South West England.
- European Ocean Energy Association. Formed to promote development toward implementation and commercial exploitation
- Hydraulic and Maritime Research Centre – UCC- University County Cork, Ireland. The Hydraulics and Maritime Research Centre (HMRC) is a centre for research in support of the Maritime Engineering sector in Ireland.
- Wave Energy Research Team - University of Limerick: Turbine testing and modelling.

The European Union has played a large part in supporting wave energy development through the European Thematic Network on Wave Energy. The Network was launched in 2000 with participation of 14 wave energy representatives from various European countries in the frame of the Fifth Framework Programme for Research, technological Development and Demonstration of the European Commission. Its main targets are the co-ordination and the improvement of the interactions between major players in wave energy and the establishment of industrial confidence in emerging wave energy conversion technologies.

In the UK the Carbon Trust has played a role by helping to found and then fund the European Marine Energy Centre in Scotland.

In the USA there are far fewer dedicated centres focusing on wave energy but this is now changing. Some notable examples are:-

- The Electric Power Research Institute EPRI (California) EPRI continually monitors and analyses wave energy technology and produces numerous comprehensive reports, for example, *Primer: Power from Ocean Waves and Tides* released June 2007
- The Electric Power Research Institute (EPRI) and the Electricity Innovation Institute (E2I) are collaborating with energy agencies and utilities in Oregon, Washington, Hawaii and Maine, as well as the Department of Energy's National Renewable Energy Laboratory, to produce a conceptual system design for a demonstration and a commercial facility at one site in each state. The study would estimate construction costs and generating potential for each facility using technology-ready devices, and would determine whether wave energy is economically practicable off the shores of the U.S. by 2010.
- Oregon Department of Energy and Oregon State University are working to create the POWER group, made up of electricity stakeholders. The POWER group is currently gauging utility support and developing an action plan and permitting roadmap for a project to be sited on the Oregon coast in 2008.

By comparison, Australia lags far behind the rest of the world in the provision of a supportive research development and commercialisation environment for wave energy technologies.

For example, in the clean energy sector the Business Council for Sustainable Energy estimates there were 6,100 people employed in the renewable energy sector in Australia in 2006-07. If the comparison is made with California where there are currently 22,000 people currently employed in the renewables sector then Australia, with a GDP roughly 56per cent of California’s, should have something like 12,000 people employed in the renewables sector instead of half that number as currently the case.