Sustainable Energy Now

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24th September 2008

Committee Secretary
Senate Economics Committee
Department of the Senate
PO Box 6100
Parliament House
Canberra ACT 2600
Australia

By email: economics.sen@aph.gov.au

Submission to Inquiry into matters relating to the gas explosion at Varanus Island, Western Australia

Executive Summary

Sustainable Energy Now Inc. (SEN) is pleased to have the opportunity to make a submission to the Senate Committee on matters relating to the gas explosion at Varanus Island, Western Australia.

The intent of SEN's submission is to state the options that WA has to diversify its energy supplies by displacing and eventually replacing our present fossil fuel generation, using our abundant renewable energies, with the added benefits of:

- Reduced environmental damage, including greenhouse gas emissions.
- Safe, benign and largely proven technology.
- Security and robustness of energy supply by use of multiple and dispersed renewable energies.
- Plentiful energy supply.
- An energy cost which is steadily reducing. (The crossover point at which renewables are cost-competitive relative to our conventional fossil fuels, is now, and will continue to reduce as fossil fuel prices rise from increasing demand and the inclusion of carbon emissions costs).
- Provision of fresh and/or desalinated water.
- Other by-products with environmental and agricultural improvements.
- Increased employment, particularly in rural areas.
- Increased income for rural land owners/farmers.
- Reduced use of water for mining of coal, such as mine dewatering (currently an issue in the Collie area with the Yarragadee aquifer).

In simplistic terms, WA's South West Interconnected grid System (SWIS) annual and 'peak' electrical energy demand could be met by any one of the following renewable energies:

- Solar thermal plant area: 15 km x 15 km
- Solar PV collector area: 21 km x 21 km
- Wind area: 50 km x 50 km
- Wave farm along coastline: 300 km[1]
- Geothermal: 20 km x 20 km (x 1 km thick granite underground)

Alternatively, and more likely, a mixture of the above could also meet the energy demand. Some of these, namely Geothermal, Solar Thermal, Wave energies, are fully capable of providing baseload power.

With emissions trading and an increasing charge for CO2 emissions, renewable energy sources become increasingly cost competitive. These technologies are largely proven and ready for utility scale implementation, as is occurring internationally.

[1] The wave resource, though demonstrably large along the aforementioned coastline from Geraldton to Bremer Bay, has regions along the lower west and south coast where wave conditions are most suitable for base load power extraction. These wave areas are of prime commercial importance and can conceivably support large aggregations of CETO wave units within a few well chosen sites that combine high wave resource availability with access to onshore power and/or water grid connection.

Contents

1 Introduction

1.1 SEN'S BACKGROUND & AIMS

- Sustainable Energy Now (SEN) is a volunteer organisation formed in 2007. The backgrounds of SEN's members include fields of engineering, physics, geology, geophysics, renewable energy and communications.
- Our aim: to promote practical, affordable strategies for the adoption of renewable energy and a sustainable future.
- Through promotion, research and the creation of a computer simulation we are demonstrating that renewable energy can sustain and diversify Western Australia's electrical energy supply, while reducing greenhouse emissions.

1.2 DISCLAIMERS AND DEFINITIONS

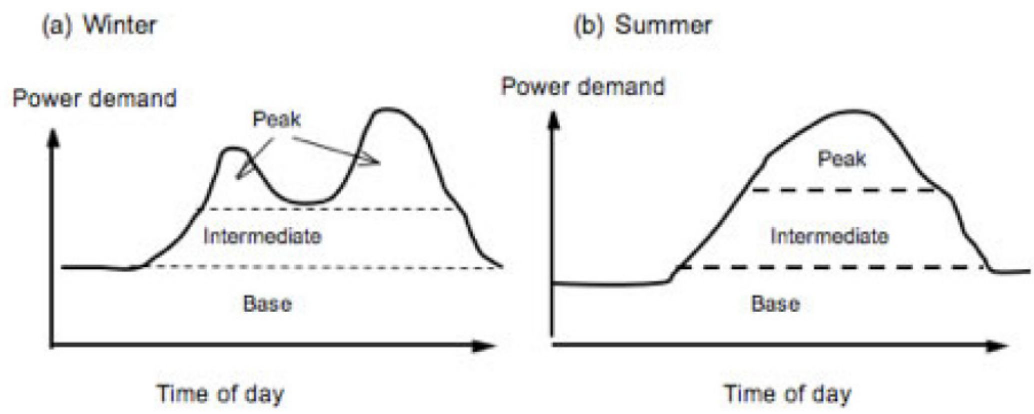
- This submission claims only to make comment on a portion of the issues relating to the provision of energy supplies, in particular section (b) *The Government response to the Western Australian gas crisis*. It does not address regulatory or transmission network/stability issues.
- SEN's focus is presently on the stationary electrical energy generation for the Southwest Interconnected System (SWIS). This represents approximately 55% of the total electrical energy use of WA. (Office of Energy, Govt of WA, Energy WA: Electricity Generation from Renewable Energy, 2008 [1]).
- SEN does not claim to be experts in the field of renewable energy, however we apply our technical and other skills to research and collate our findings on the renewable energy resources and applicable energy conversion technologies which are commercially available or very close.
- References for information in this submission are contained in the References section (page 15). Supporting calculations are available on request.

2 Adequacy of reliance on one source supplies of gas for domestic markets ((b) (ii))

The explosion at Varanus Island and the following gas shortage for Western Australia, has highlighted that relying on few centralised sources for critical energy supply provides poor energy security.
By building infrastructure to supplement Western Australia's energy supply from multiple sources, such as wind, solar thermal with storage, geothermal, wave and solar photovoltaic, the impact of the loss of a single energy source would be alleviated by the other diversified sources.

3 Provision of reliable and affordable supplies of alternative energy ((b) (iii))

The conventional expectation of electrical energy supplies is that they must be centralised and use fossil fuels which are available on-demand, night and day. This requires management of a number of sources; coal, gas and distillate to follow the varying energy demand.



Ref: "The Baseload Fallacy" by Dr. M. Diesendorf

Figure 1

The term 'baseload supply' is related to the minimum power demand required. Coal and nuclear fuelled plants are not able to vary their power output quickly enough to meet the changing power demand. Therefore, they are only able to be used to provide the minimum 'base' power needed throughout a 24-hour day. (Refer to Figure 1 above). The conventional method of dealing with the changing power demand (above baseload) is to "top-up" the shortfall by using faster-acting energy sources such as oil, distillate and gas. This requires management of the generation to follow the varying demand.

An ideal generator is one which is available on-demand and able to follow the changing load demand rapidly, ie. "load-following".

While some types of renewable energy, such as wind, are not always available "on-demand", they can be combined with other energy such as solar thermal (storage), wave, geothermal and gas, to provide load-following power on-demand. (Ref: "The Baseload Fallacy" by Dr. M. Diesendorf [2])

To utilise renewable energy, management of various supplies is also required. However, different challenges and methods are applicable. With some renewables such as geothermal and solar thermal with storage, management may be simpler because the stored energy can be used not only for baseload supply but can also be varied rapidly to follow demand. Wave energy generation can also load-follow.

3.1 RENEWABLE ENERGY CHALLENGES AND SOLUTIONS

This section discusses the applicable challenges and technologies of renewable energy.

3.1.1 The sun only shines in the day

While this is true, there are energy storage methods such as molten salt and hot water which are able to supply energy for 16-20 hours continuously during cloudy times and at night. (Ref: AUSRA Solar Thermal electricity [3])

Solar energy is conveniently available when we need most of our energy, and particularly matches our summertime peak energy needs, ie. it is hottest when we most need our air-conditioning.

3.1.2 Winds don't blow all the time

Installing wind turbines at windy sites and at locations over a wide area, helps to provide a more constant energy output. Winds are predictable hours ahead, which helps in combining them with other energy sources. Offshore winds are generally more steady and intense, with less disruption from obstacles. Gas turbines (as we presently use to supplement coal-generated electricity) can be used to supplement wind as needed to provide baseload or load-following power.

3.1.3 Waves vary over time

Wave energy may vary, but with the design of generators such as the CETO system in WA, more than 90% of the time there is sufficient energy to provide their rated electrical power (or desalinated water). (Ref: Carnegie Corporation [4])

3.2 RENEWABLE ENERGY TECHNOLOGIES

WA is has numerous types of renewable energy resources, with an abundance of energy exceeding our present demand many times over. SEN's research and calculations indicate that the types of resources described in this submission would meet our demand with only a miniscule 'footprint', relative to our land area.

The power generation of energy resources such as solar PV, wave and geothermal energy can be located in presently unused areas such as rooftops, subsurface along the coastline and underground, respectively.

Wind generation, while needing large areas, has a small physical footprint and can be installed in rural/desert areas with little or no impact. The land can still support multiple uses such as farming, tourism or recreational purposes, providing valuable supplementary incomes to rural communities. This cannot be said of open-cut coal or uranium mining.

Renewable energy is largely inherently safe and environmentally benign due to the fact that it simply uses what occurs naturally around us.

3.2.1 Electricity Generation

The following sections provide further detail on each of the renewable energy types suited to WA. (In the interests of keeping this submission relatively concise, only a few examples of each of the renewable technology applications are included).

3.2.1.1 Solar Thermal

Solar Thermal energy (STE) conversion works by concentrating the solar radiant energy by using reflectors, which then heats water and this is used to power steam turbines and generators. Alternatively the energy is focused on a "Heat Engine" directly, which turns a generator.

The concentration can be achieved by several reflector configurations:

- Parabolic reflectors – dish (circular) and trough type focusing energy onto a single point or line collector, respectively.
- Linear Fresnel Reflectors (LFR) – a number of rows of 'flat' reflectors focusing energy onto a line collector
- Centre tower (Power Tower) – a number of reflectors surrounding a central tower with collector at the top


Parabolic Trough reflector


Compact Linear Fresnel reflector


Power Tower – Heliostat reflectors


Acciona Solar Power – Solar 1 Nevada

Figure 2

By its nature, STE is only available in clear sunny conditions, so the collection of energy is only during cloud-free daylight hours. However, by storing excess heat energy in water or molten salt, solar thermal power plants are able to operate for 16-20 hours without sunlight, (Ref: AUSRA [5]) so that their output can be considered constant, and better yet, they are able to match the varying load of the electricity grid without needing intermediate or peak generation normally supplied by gas generated electricity.

STE is a well-proven technology. Following are a few of the numerous examples (others are referenced in the appendix):

- Parabolic Trough – Luz Industries built a total of 354 MW of Solar Electric Generating System, or SEGS, power plants in California's Mojave Desert in the 1980s.
- Worley Parsons has just announced plans to pursue installation of this technology in Australia of over 8GW by 2020, based on many years of successful operations in California.
- Power tower - Southern California (Pacific Gas & Electric) since the 1980's.
- Linear Fresnel Reflector - Solar Heat & Power in Australia demonstrated a solar co-generation at the Liddel coal power station in NSW in 2006. This technology was transferred to California several years ago with the key proponent, David Mills becoming involved with AUSRA. This technology is being further developed to include hot water energy storage for continuous operation up to 16 – 20 hours without sunlight.

3.2.1.2 Solar PV

Solar energy conversion directly to electricity using photo-voltaic (PV) cells is a very simple and reliable technology generally suited to smaller applications, and although it is able to have energy storage, this is expensive.

However, solar PV-generated electricity is still useful for meeting high demand periods, especially during summer afternoon peak periods when expensive standby 'peak' generation is required. Furthermore, the fact that this supply can be embedded into the area where it is needed reduces transmission infrastructure costs.

San Francisco Solar Power: "*A 50MW solar power facility will come from 140-250 acres of photovoltaic panels on the rooftops of businesses, residential homes and government buildings*."

Figure 3

Synergy provides electricity to approximately 870,000 separate residences. If only 25% were assumed to have access to suitable roof top orientation and were installed with 1.5 kW solar PV systems, that would equate to approximately 325 MW of available peak power. According to the WA Independent Market Operator (IMO), if temperatures in 2008/09 summer reach a level that might be expected to occur once in every 10 years, the maximum demand is forecast to be around 280MW higher that a normal summers day. According to Market Rules, the IMO must have available this additional peak generation for this one in 10 year occurrence [6]. This peak load could be met by solar mounted PV on only 25% of available rooftops, offsetting the need for costly standby fossil fuelled generation.

3.2.1.3 Wind

Wind-generated electricity is a well-known and proven technology and large amounts are being installed in China, Europe and the UK. The UK is presently planning to install 30 GW of offshore wind farms by 2020, or approximately 7 times WA's SWIS peak demand.

Numerous Low-Load Diesel and Wind systems in WA have been installed and operated by Verve Energy at fringe-of-grid sites. By development of distillate engine powered generators which are able to idle down to 5% of rated full load (low-load), the amount of wind energy which can be integrated is up to 90% [7].

3.2.1.4 Wave

There are numerous methods of converting wave energy to electrical energy, but for the purposes of this report, the West Australian developed technology, CETO, will be used to demonstrate the potential for wave generated electricity as well as desalinated water.

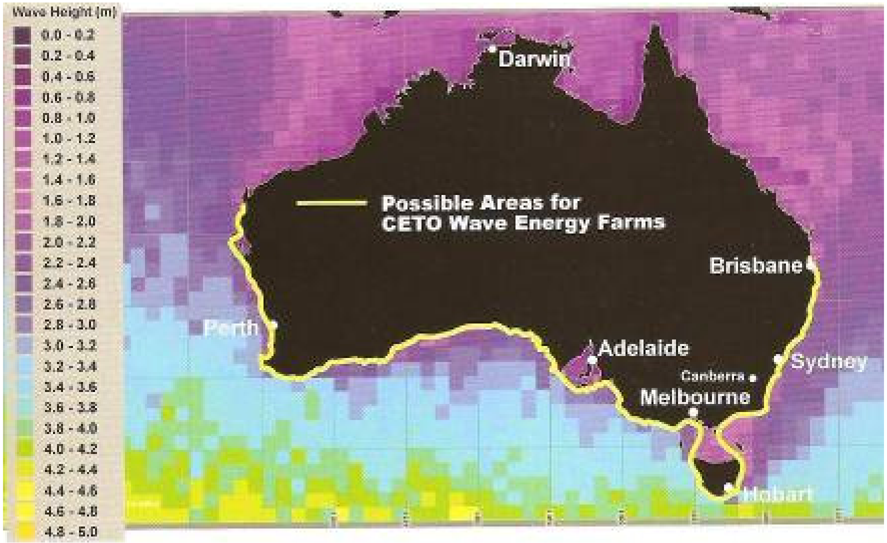


Figure 4

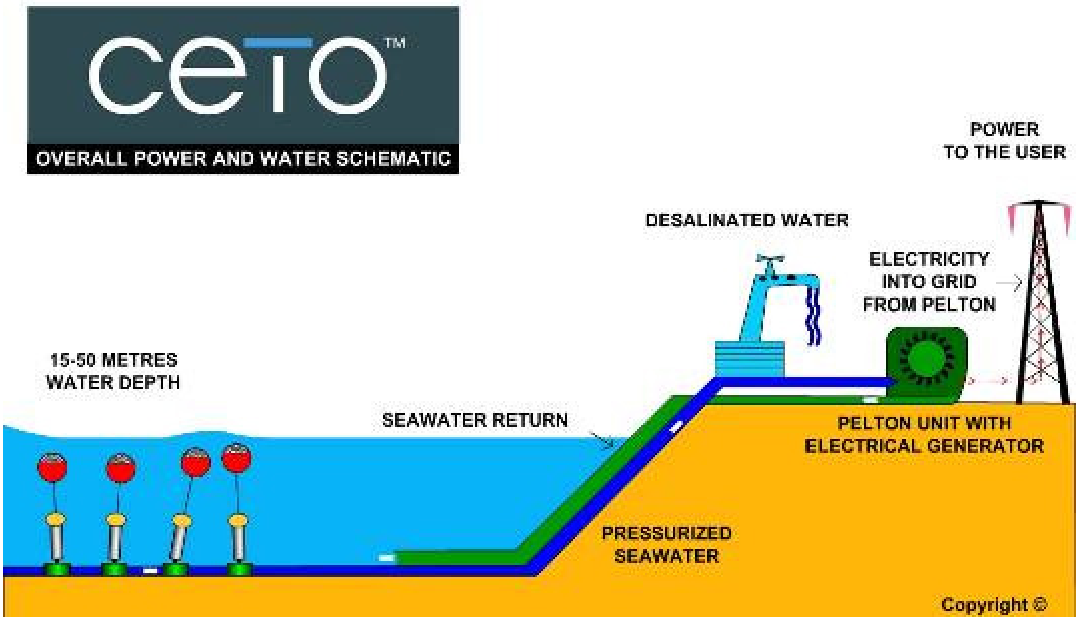


Figure 5

CETO utilises sub-surface buoys arranged in an array, located along the coastline, in water depths of 25-100m. The buoys are tethered to the seabed by a simple clump-anchor and held below the nominal sea surface. The elliptical water motion of the waves causes the buoy to also move in a similar motion, and mimics that of seaweed. The buoy tether causes a piston at the clump anchor to pump seawater at high pressure, into a pipeline on the seabed and back to the generator onshore.

Once onshore, the high pressure water flow can be used to turn a generator, or applied to a desalination membrane to produce fresh water. An elegant feature of this is that any combination of electrical power and freshwater production can be created, to suit the demand.

As the system has a small physical footprint on the seabed, is streamlined, and spaced at 20m between each, the environmental effects are minimal and in fact serve as a habitat for sealife.

The proximity of buoys to the surface of about 3-5m does mean that it is a shipping/boating exclusion zone, however, this is not uncommon in nautical navigation, and breaks can be designed into the array spacing for access.

3.2.1.5 Geothermal

Australia has extensive hot granites (150 degrees C and upwards) which can be used to heat water and drive turbines to generate electricity. These granites are typically at depths of 3 – 5 km and are usually overlain by insulating sediments which act as a thermal blanket. The concept is shown in figure 6 below.

The granites are engineered to create more fractures to enhance the ability to transfer heat to water which is pumped down to the granite and then returned to the surface up separate boreholes. A heat exchanger system transfers the heat to turbines to generate electricity. The water is then re-injected into the original injection boreholes to continue the process.

Over many years the temperature of the heat reservoir decreases but once heat extraction is stopped the temperature builds back up again due to the radiogenic decay of Potassium, Thorium and Uranium in the granite. The hottest granites that we currently know in Australia are in NE South Australia in the Cooper Basin and here Geodynamics are busy developing proof of concept and expect to be generating electricity by 2010 and then scale up progressively thereafter. They have estimated that the Habanero field in the Cooper Basin is capable of producing 10 GW of electricity ie about 3 times WA's current production in the SWIS.

About 30 companies are currently exploring for geothermal resources and most recently, following new legislation in WA, some of these are starting to explore in WA. The first acreage has been released in the Perth Basin and will be followed with acreage in the Carnarvon Basin. Ghori, 2007 [8] (figure 7) shows the most prospective areas based on currently known temperature data – mainly from hydrocarbon exploration. It should be noted that many parts of WA have not been evaluated for geothermal resources because of lack of data.

Work by Geoscience Australia (Budd et al, 2008 [9]) has estimated that even extracting 1 % of the available hot granite heat could power Australia for about 26,000 years.

In addition to geothermal production of electricity, lower temperature water is available for industrial and domestic purposes and is already in use heating swimming pools in Perth. The Yarragadee acquifer underlies large parts of the Perth Basin and this resource will be further evaluated.

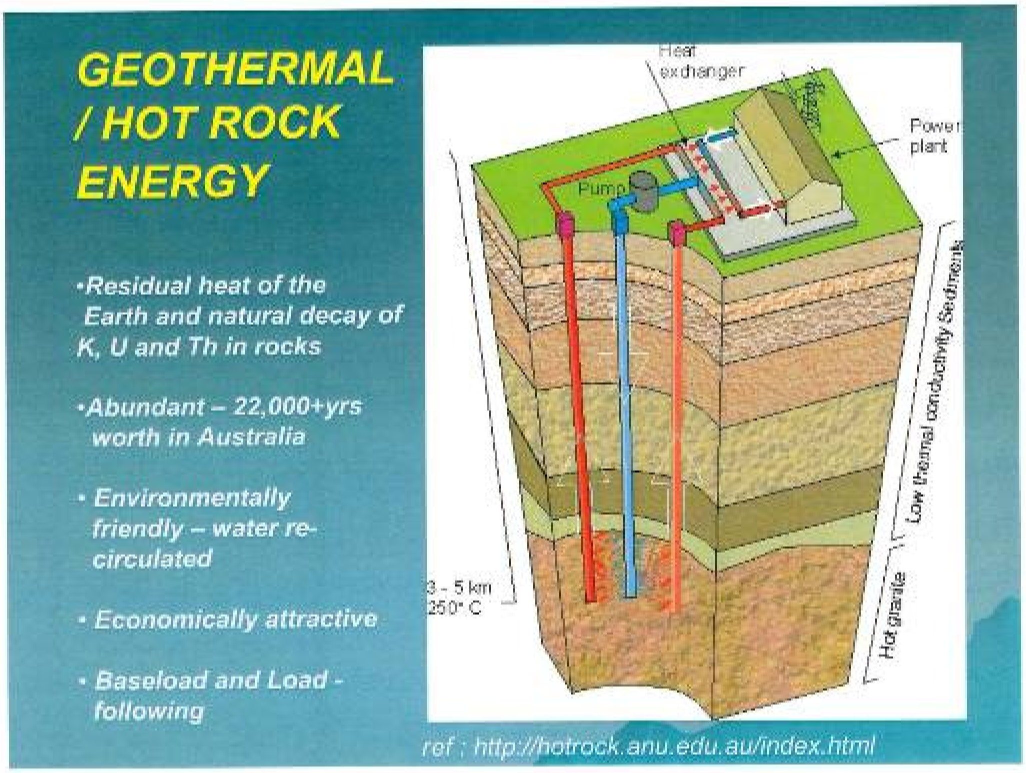


Figure 6 Schematic of Hot Rock Energy

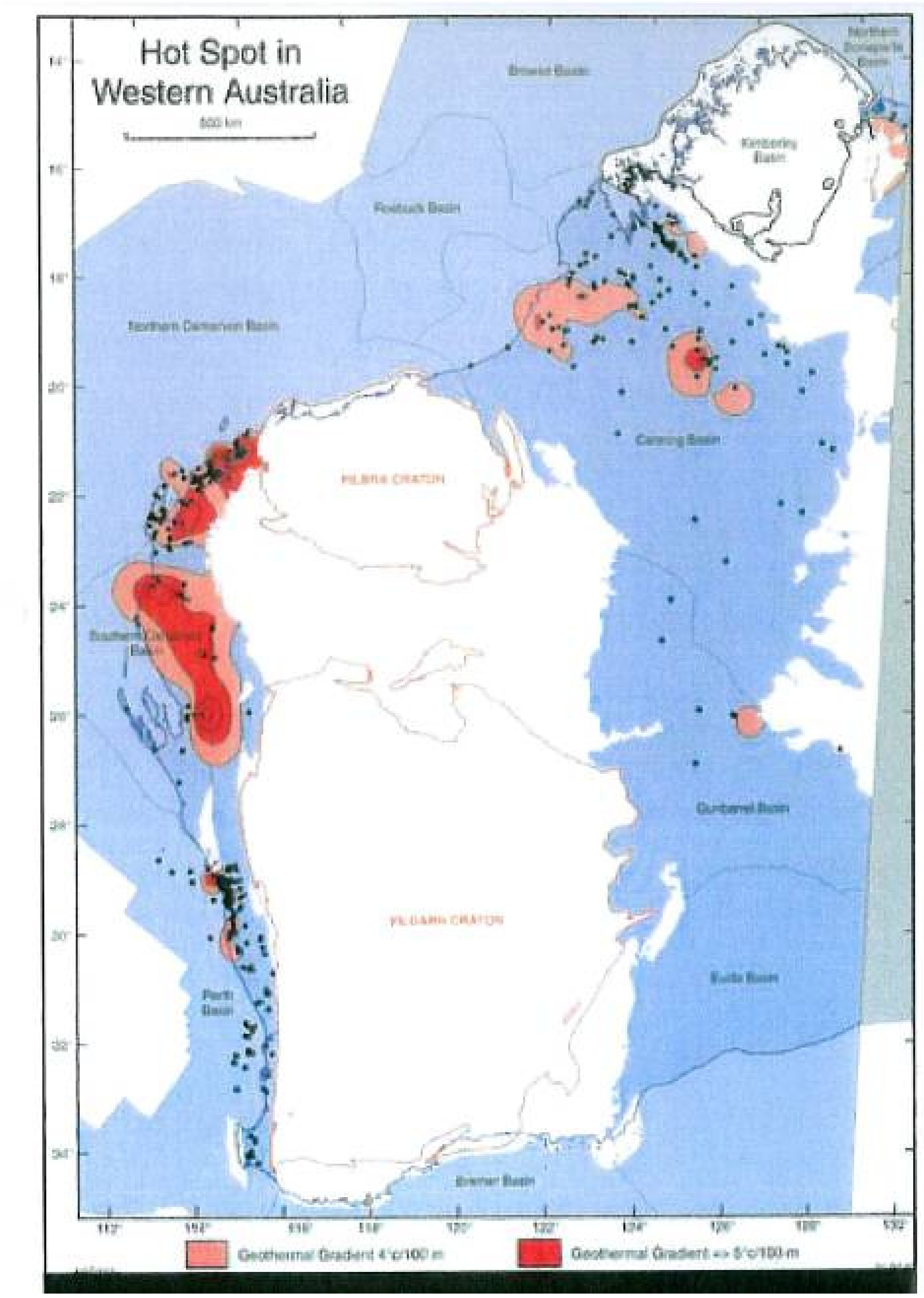


Figure 7 WA hot spots for geothermal energy

3.2.1.6 <u>Biomass</u>

The use of biomass for production of energy must be carefully considered to ensure that it is conducted sustainably, as there are examples of major environmental damage occurring in the process of growing energy crops, as well as competition for food crops.

However, West Australia has a unique opportunity to use the native Oil Mallee for a number of benefits:

- Energy supply to generate electricity.
- The extracted oil can be used in pharmaceuticals and industrial solvents.
- The roots and charcoal byproduct are a carbon store, and the charcoal can be activated for water purification and other process uses.
- The ability for it to grow in degraded soils helps combat salinity in the wheatbelt of WA.

Furthermore, growth of the oil Mallee is rapid and it can be coppiced every 2-3 years, re-growing naturally and sustainably from the remaining root base.

Mallees are typically proposed to be grown on crop land in rows spaced between the crop, using up to 15% of the area. These are known as "Mallee Alleys".

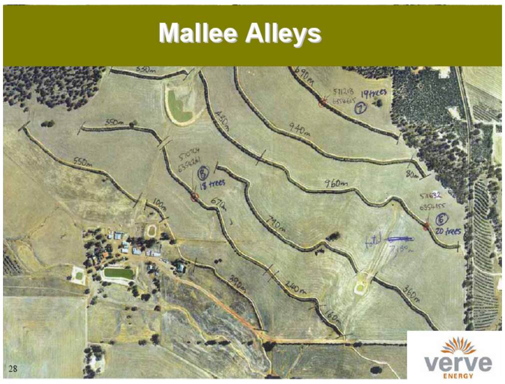


Figure 8

Once harvested, the Mallees are processed to extract the eucalyptus oil, gasified to burn for electricity generation, and the charcoal byproduct is 'activated' to produce activated charcoal. Alternatively, the charcoal is useful as a soil conditioner, helping to hold nutrients and acting as a carbon store.

An excerpt from Western Power describes the trials done recently:
"Western Australia's wheatbelt town of Narrogin is home to an innovative project, the Integrated Wood Processing (IWP) demonstration plant that addresses global warming and farmland salinity, two of Australia's most pressing environmental concerns. The electricity produced will displace fossil-fuelled generation and is carbon dioxide neutral. Because trees are planted specifically for the project, carbon dioxide is first fixed from the atmosphere as carbon, before being later released in the generation of electricity as carbon dioxide again. The carbon dioxide is essentially borrowed, not generated. Mallees are now the farmers' ally in combating salinity that threatens 30 per cent of the wheatbelt in Western Australia."

Western Power projected that there is potential for 10 biomass plants of 5 MW capacity each, giving a total of 50 MW. As this is a relatively small amount of energy, its capacity appears limited and is likely to be most useful in fringe-of-grid locations.

3.2.2 Thermal Processes / Heating

Our present use of 'high-grade' energy such as gas and electricity, which is used for low-temperature heating applications is a poor and inefficient practice. The burning of gas is a poor practice because the high heat is far in excess of that needed, and could be better used in processes which require that higher temperature. Similarly, the use of electricity for creating low-temperature heat is inefficient because of the conversion losses from the original energy generating source to electricity, then back to mechanical and then to heat.

Instead, simple, low-cost solar heat collection can be used directly to provide numerous useful functions which only require these relatively low temperatures, up to about 150 degrees C.

3.2.2.1 <u>Solar Thermal</u>

A few examples of commercial systems available for low-temperature solar heating applications include:

- Solar hotwater – Solahart, Solar Edwards
- Swimming pool heating – Heliocol, Freeheat Industries
- Solar space heating systems – Sun Lizard Solar Climate control, Solar Lord Australia
- Solar drying/kilns (timber, fruit, other) – Solar Dryers Australia, Rosegum's Solar Kilns
- Process steam/heat – AUSRA

3.2.2.2 <u>Geothermal</u>

In addition to geothermal production of electricity, lower temperature water is available for industrial and domestic purposes and is already in use heating swimming pools in Perth. The Yarragadee aquifer underlies large parts of the Perth Basin and this resource will be further evaluated.

3.2.3 Freshwater Supply

Renewable energy can be used in a number of ways to produce desalinated or fresh water, and variability of renewable energy is not so critical as the water can be stored relatively simply. Following are some of the potential applicable methods and technologies:

3.2.3.1 Solar Thermal

Production of freshwater by solar distillation is a well-known and proven method. The simplest of these is the simple evaporation pond under a clear roof which condenses the evaporated moisture and captures it as fresh water. It has the capacity to provide approximately 2.3 ML/day (0.8GL/yr) from a 1km x 1 km area [10].

3.2.3.2 Wave

The previously mentioned CETO wave energy conversion technology is capable of efficient direct conversion of seawater to desalinated water. The efficiency is high because the wave mechanical energy is converted directly to water pressure against the reverse-osmosis membrane, at approximately 1,000psi.

"An array *of 100 CETO buoys would cover less than the area of the MCG and generate around 45GL/yr of freshwater."* [11]

Other wave technologies can also provide desalinated water, but may rely on an intermediate energy conversion to electricity, and then back to water pressure or distillation. This intermediate step would result in a lower efficiency, but as the energy input cost is zero, it would only be other factors such as increased equipment size and cost, and maintenance which would be deciding factors in their feasibility.

3.2.3.3 Wind

Wind energy converted to electricity can be used to power pumps for desalination of water, for example the Rottnest Island desalination system, powered directly by a single 600 kW wind turbine installed by Verve Energy. This supplies 70% of the island's use, and the electricity generated also supplies 40% of the island's electricity needs [12].

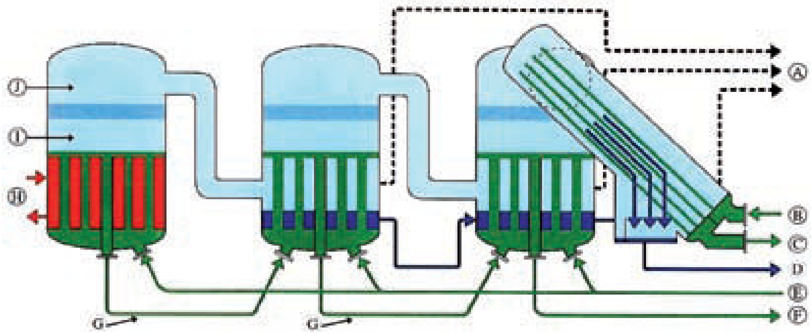
A more efficient method would be to use wind turbines to directly pump seawater or other against an RO membrane to produce desalinated/clean water. This would increase the efficiency by eliminating the intermediate step of producing electricity.

In either of the above methods, variability of wind is of little or no consequence provided sufficient water storage is available.

3.2.3.4 Geothermal

The heat from geothermal energy can be used to distil seawater to clean water, and it could be used either from the primary geothermal heat, or the waste heat (cogeneration) from the electricity generation process. There are areas of geothermal energy close to the coastline which would be possible sites for this, and matches the large population centres.

One example of this technology is that of the multi-effect distillation process successfully demonstrated by the Kimolos pilot plant in Greece [13]. This process uses not only the heat to evaporate the seawater, but also a low (vacuum) pressure to increase the evaporation rate.



A. *Suction ejectors*
B. *Sea cooling water inlet condenser*
C. *Sea cooling water outlet condenser*

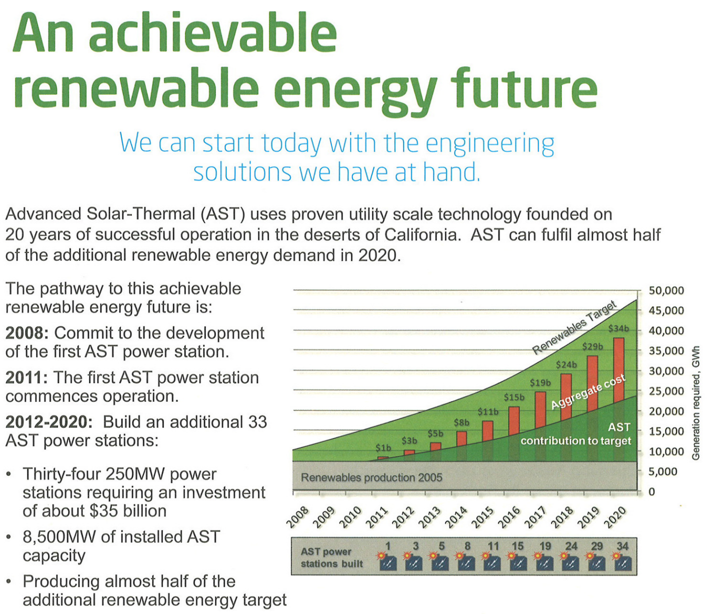
D. *Freshwater outlet*
E. *Feed-water inlet*
F. *Brine outlet*
G. *Brine heat recovery*
H. *Heat supply*
I. *Wet generated vapour*
J. *Dry vapour*

Figure 9

3.3 TIMEFRAME FOR ROLLOUT OF RENEWABLE ENERGY TECHNOLOGIES

3.3.1 Solar Thermal Energy

Worley-Parsons Proposed Timeline for Australia:
Worley Parsons is proposing a massive development of solar thermal electricity generation, equalling 40% of Australia's 2020 renewable energy target. Their proposed timeline is as shown in Fig 10.



An achievable renewable energy future

We can start today with the engineering solutions we have at hand.

Advanced Solar-Thermal (AST) uses proven utility scale technology founded on 20 years of successful operation in the deserts of California. AST can fulfil almost half of the additional renewable energy demand in 2020.

The pathway to this achievable renewable energy future is:

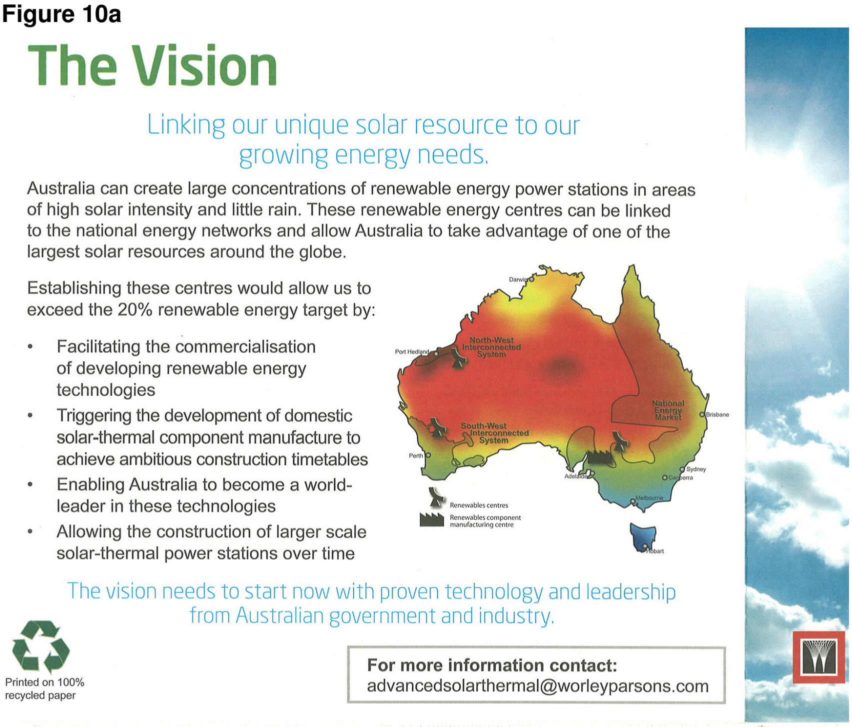
2008: Commit to the development of the first AST power station.

2011: The first AST power station commences operation.

2012-2020: Build an additional 33 AST power stations:

- Thirty-four 250MW power stations requiring an investment of about $35 billion
- 8,500MW of installed AST capacity
- Producing almost half of the additional renewable energy target

Figure 10a



The Vision

Linking our unique solar resource to our growing energy needs.

Australia can create large concentrations of renewable energy power stations in areas of high solar intensity and little rain. These renewable energy centres can be linked to the national energy networks and allow Australia to take advantage of one of the largest solar resources around the globe.

Establishing these centres would allow us to exceed the 20% renewable energy target by:

- Facilitating the commercialisation of developing renewable energy technologies
- Triggering the development of domestic solar-thermal component manufacture to achieve ambitious construction timetables
- Enabling Australia to become a world-leader in these technologies
- Allowing the construction of larger scale solar-thermal power stations over time

The vision needs to start now with proven technology and leadership from Australian government and industry.

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For more information contact:
advancedsolarthermal@worleyparsons.com

Figure 10b

AUSRA timeline:
AUSRA are in negotiations with a number of potential clients, have committed with FPL Group, Inc. and Southern California's PG&E Corp. to installing 1,000MW of capacity and have also announced the site for 177MW solar thermal plant in San Luis Obispo, Ca for Pacific Gas & Electric.

AUSRA's new manufacturing facility has just opened in Nevada with production for solar thermal power capacity rollout rate of 700MW/year from the one facility.

3.3.2 Solar PV

Solar PV is a market ready solution, but not cost effective at this point in time. With the introduction of an Emission Trading Scheme and taking into account the massive amount of production capacity being built around the world, Solar PV will readily become more cost effective and rollout of the technology will only depend on the will to do so.

3.3.3 Wave Energy

The CETO wave energy technology of Carnegie Corporation is scheduled as follows:

2008	CETO 2 design testing (Fremantle)
2009	CETO 3 design testing (Fremantle & Garden Is)
2008 - 2010	Demonstration site selection, assessment & approvals
2010	Site construction & manufacturing begins
2011	5 MW peak installed capacity
2013	50 MW peak installed capacity
2020	2,000 to 3,000 MW potential (2 –3 GW)

Note that the rate of implementation of the CETO technology after 2011 is limited only because Carnegie would require funding to install more than this amount, due to the fact that it is a relatively small company. SEN understands from Carnegie that given more commercial backing, the installation could be significantly more rapid.

3.3.4 Wind Energy

The generation of energy from wind is a relatively mature technology. At the end of 2007, the installed capacity of wind energy was 93.8 GW globally. Of this, 19.7 GW was added during 2007, representing a growth rate of 26.6% [14]. In Western Australia, the installed capacity of wind energy is 202 MW, which is 2.9% of the total installed power generating capacity of 6,951 MW [15].

The time taken to build and commission a wind farm is variable and dependent on many factors. As an example, the Cedar Creek wind farm in Colorado was installed in 13 months. Construction of this 300 MW wind farm, with 274 turbines commenced in December 2006. 280 MW was on line by November 2007. The remaining 20 MW was brought on line on January 3, 2008 [16]

3.3.5 Biomass Energy

SEN is not aware of a timeframe for the proposed 10 x 5 MW Mallee generation facilities.

3.3.6 Geothermal Energy

Geodynamics plans to be producing electricity from 2010 onwards at the Habanero Project in South Australia. There are about 33 companies currently with geothermal projects and it is expected that some of these will be producing electricity from about 2012 onwards.

3.4 RELIABILITY & SECURITY

As commented in section 2 above, multiple dispersed energy sources provide a more resilient energy supply network. Development of demand-side management provides the potential for energy demand to be matched to availability of some of the variable renewable energy sources.
Developing infrastructure and policy to incorporate demand-side management would create greater reliability for Western Australia's electricity system.

3.5 INDICATIVE COSTS

McLellan Megasanik Associates, 2007, has reported on economic analysis commissioned by the Renewable Energy Generators of Australia (REGA). Figures 11 and 12 are reproduced from this source.

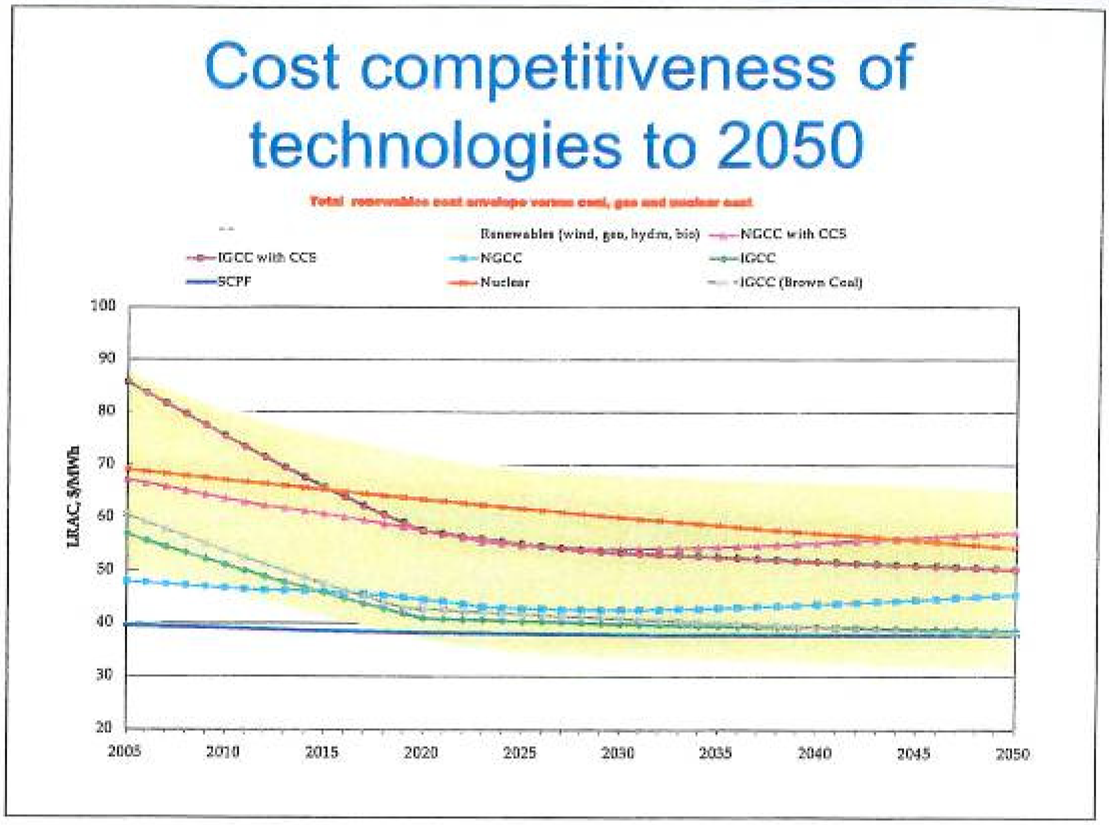

Figure 11

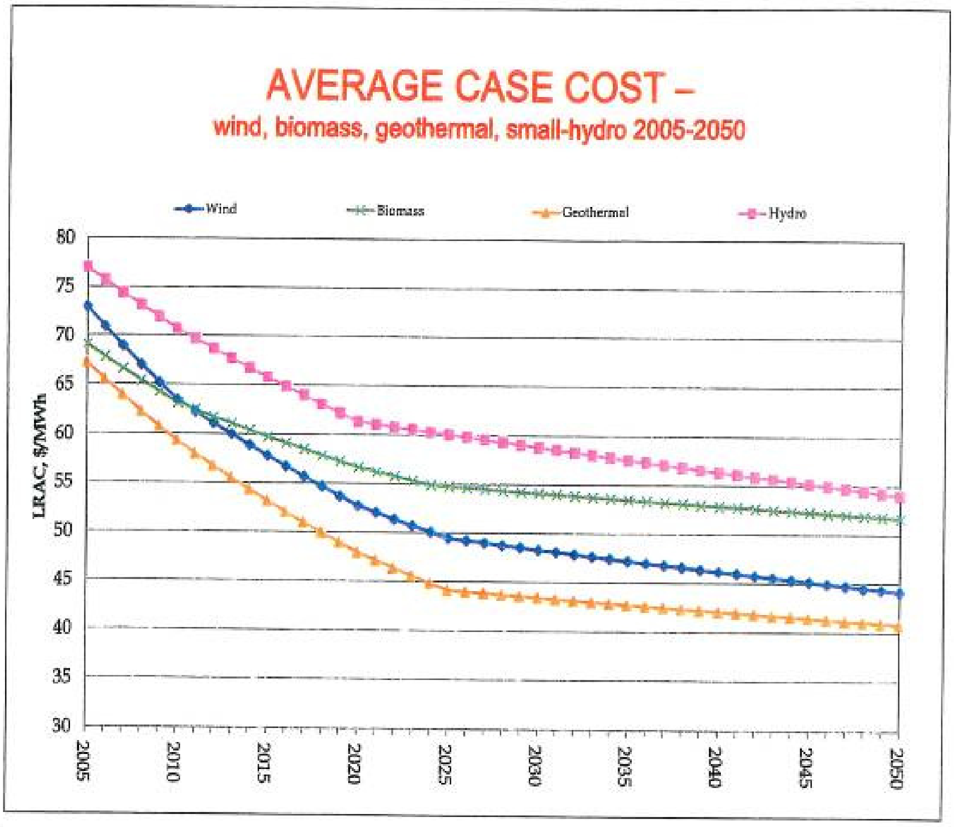

Figure 12

Definitions :

- LRAC : long range average costs. This includes capital costs as of 2005, fuel costs, operating and maintenance costs and transmission costs.
- IGGC with CCS : Integrated gasification combined cycle with Carbon Capture and Storage.

- SCPF : Supercritical Pulverised Fuel.
- NGCC with CCS: Natural Gas Combined Cycle.

The analysis shows that the costs of renewable energy sources overlap with fossil fuels. With the introduction of an Emissions Trading Scheme and a price on CO2 emissions, the renewable energy sources become more competitive. Geothermal energy from hot granites is shown to be the cheapest of the renewable energy sources. Wave power costs are likely to be similar to Wind Power.

Figure 13 below shows Geodynamics comparative costs of geothermal HDR relative to others.

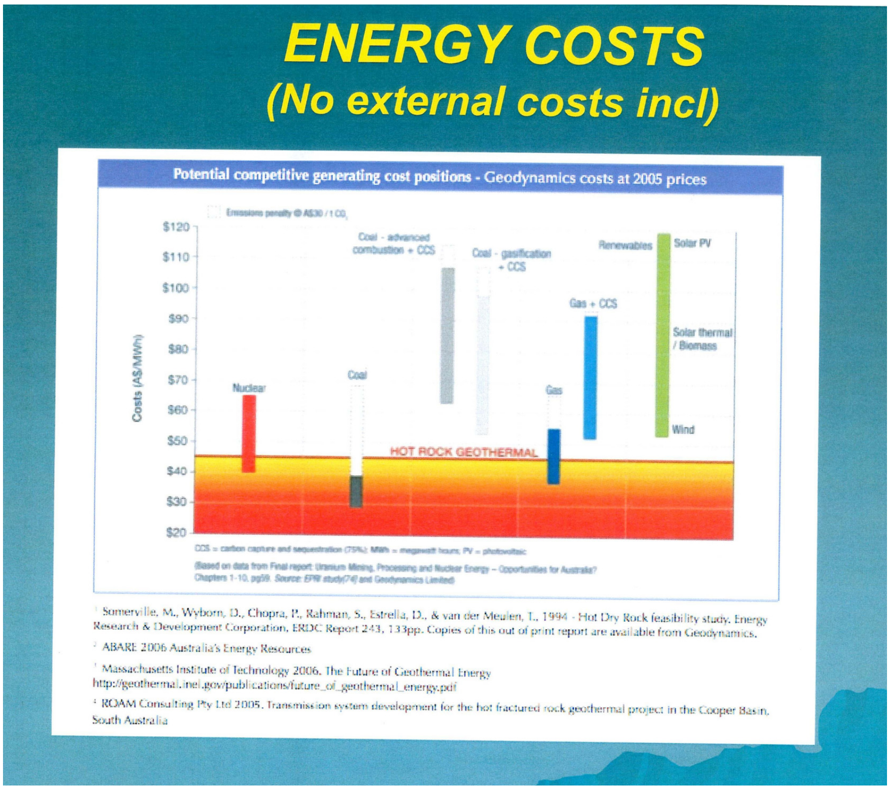

Figure 13

Wind:

Carnegie Corporation estimates that the initial CETO III plants at 50 MW scale will have cost / MWh comparable to wind (6 to 7 c / KWh) in the first instance then progress downwards as the technology and the take up matures. These estimates are based on modelling, and have yet to be substantiated by building a 50 MW demonstration energy plant.

References

For each of the renewable energy types, SEN has researched the relevant energy conversion technologies and references, and using that information, performed calculations to determine how much area would be required to supply both:

- the total 2007/08 forecast energy demand of the SWIS of 35 TWh/y or 96 GWh (National Institute of Economic and Industry Research, 2005 *Verification of Western Power Corporation Forecasts of Demand and Energy*)

- the peak power requirement in 2007/08 is approximately 3,800 MW (Perth Energy, 2008)

[1] (Office of Energy, Govt of WA, Energy WA: Electricity Generation from Renewable Energy, 2008, Available: http://www.sedo.energy.wa.gov.au/pdf/No_5_-_Renewable_Energy.pdf)

[2] "The Baseload Fallacy" Dr. M. Diesendorf, Available: www.energyscience.org.au

[3] [5] AUSRA Solar Thermal electricity, Available: http://www.ausra.com/pdfs/SolarThermal101_final.pdf

[4] Ref: Carnegie Corporation, Available: http://www.ceto.com.au/ceto-technology/pdf/pb-report-full.pdf

Solar Thermal:

Solar Thermal (Electricity)

AUSRA Inc. (http://www.ausra.com/)
Report on the design of a 240MW solar power plant Design of a 240 MWe Solar Thermal Power Plant, by *D. Mills, G.L. Morrison, and P. Le Lièvre*

AUSRA Press release;
"CLINTON GLOBAL INITIATIVE 2007 ANNUAL MEETING, NEW YORK—Sept. 27, 2007—Today, in association with leading utilities FPL Group, Inc. and PG&E Corp., Ausra, Inc., a solar thermal power technology company, presented a formal commitment at the Clinton Global Initiative Annual Meeting for a clean energy future through the development of 1,000 megawatts of solar thermal power plants that will generate 50 million megawatt-hours of clean power over a 20-year period. As part of this announcement, PG&E Corp. committed to purchasing an additional 1,000 megawatts of solar thermal power over the next five years. Separately at the Clinton Global Initiative Annual Meeting, FPL Group committed to develop 500 megawatts of solar thermal power plants."

Worley-Parsons
Peter Meurs, Managing Director EcoNomics ™

Examples of the "The World's Largest Solar Energy Projects" (http://www.foreignpolicy.com/story/cms.php?story_id=4239):

Stirling Energy Systems (with Southern California Edison):
Size: 500MW (possibly expand to 850 MW) 4,500-acre thermal solar generating station in southern California's Mojave Desert
Expected cost: Undisclosed
Projected completion date: 2011
"The station will initially encompass 20,000 40-foot-tall, dish-shaped mirrors and produce 500 MW of electricity… Stirling dish technology uses mirrors to focus the sun's rays on the receiver a Stirling engine,… which drives a generator without need for water. Stirling is also planning to construct a 300 MW site in California's Imperial Valley. Construction of the Mojave Desert facility is due to begin in the middle of this year."

Tres Cantos, Spain:
Size: 300MW, an expansion from its current 55
Expected cost: $390 million - $470 million
Projected completion date: 2010

"BP Solar, a division of energy company BP, announced a year ago that it has begun construction of a mega solar plant at its European headquarters in Tres Cantos, at a site it acquired in 2002. The project will employ innovative photovoltaic technology that utilizes high-quality antireflective materials coated on solar cells and silver paste screen-printed on the back and front of the cells to improve the efficiency of its panels. It helps that BP Solar will reportedly be able to sell its energy to the national grid at 575 percent of the cost of production—and the company has entered a 25-year contract with the Spanish government that obliges utilities to purchase the plant's electricity. Tata BP Solar (a joint venture between India's Tata Power Company and BP Solar) is also undertaking the construction of a similar facility in Bangalore, India, which is also set to produce 300 MW."

Gila Bend, Arizona
Size: 280 MW
Expected cost: $1 billion
Projected completion date: 2011
"… Specialty solar technology firm Abengoa Solar, supported by Arizona Public Service Company (APS), is developing a solar farm spanning 1,900 acres. Abengoa Solar will make use of … "solar power trough technology." …The heated fluid can be stored, which enables electricity to be produced even after the sun sets. The farm is expected to have 2,700 parabolic trough collectors and power about 70,000 homes. APS has already contracted to buy Solana's power for 30 years, which will move APS a third of the way by 2011 toward achieving the state's mandate of having 15 percent of the company's electricity derived from renewable sources by 2025."*

Ashalim, Israel
Size: 250 MW
Expected Cost: $600 - $700 million
Projected completion date: Not set
"The Israeli government is currently seeking bids from companies around the globe to build and operate two solar thermal plants at a 1,000-acre site in the central Negev Desert. … a final deal is expected to be reached by the end of the year. The government envisages that the plants will produce 3 percent of Israel's electricity, and the project is part of the government's drive to ensure that 5 percent of Israel's electricity comes from the sun by 2016."

[10] Solar Thermal (Freshwater)

Practical Action http://itdg.org/docs/technical_information_service/solar_distillation.pdf

An example of a commercial solar thermal powered clean water supply system is the TiNox-Mage Water Management technology: http://www.tinox-watermanagement.de/ie1024/start1024.htm

Solar Thermal (Timeframe)
http://www.ausra.com/news/releases/070927.html
http://www.ausra.com/news/releases/071105.html
http://news.cnet.com/8301-11128_3-9980815-54.html *"Solar thermal company AUSRA on Monday opened a Las Vegas factory meant to produce enough equipment each year to provide 700 megawatts of power."*

Solar PV:

[6] IMO**,** Statement of Opportunities Report, The SWIS, July 2006

NREL, Fuel from the Sky: Solar Powers Potential for Western Energy Supply, 2002, page 50.

Deming, New Mexico
Size: 300 MW
Expected cost: $1.6 billion
Projected completion date: 2011
"With help from a 30 percent federal tax credit for renewable energy, Governor Bill Richardson has vowed to make sun-drenched New Mexico the "Saudi Arabia of renewable energy." That would make New Solar Ventures' Deming plant, which began construction in 2006, the equivalent of the famous Ghawar oil field. Located 230 miles southwest of *Albuquerque, the plant will incorporate a*

$650 million solar-panel-producing factory as well as a massive $950 million solar farm. The potential 3,200-acre site will take advantage of its 350 days of sunshine a year to power 240,000 homes using special patented photovoltaic technology."

Mildura, Australia
Size: 154 MW
Expected cost: $270 million
Projected completion date: Power generation to begin in 2010, plant completion by 2013
"In the largest solar project in Australia to date, Hong Kong-owned TRUenergy is set to construct a major solar plant in southeastern Australia, near Mildura. Using technology developed by Melbourne firm Solar Systems, the project will utilize mirror arrays that concentrate light onto advanced high-efficiency photovoltaic cells, lowering the required size of cells—and therefore the cost. The plant is expected to generate emission-free power for 45,000 homes (avoiding the 437,000 tons of annual greenhouse-gas emissions that a coal-fired plant with a similar power output would produce). The project has secured about $120 million in funding from the federal and state governments, along with private investment through TRUenergy's parent company. Construction on the plant will begin next year and continue to 2013, but don't be fooled by the size of the project: It would account for just 0.1 percent of Australia's electricity generation in 2006."

Wind:

[7] Wind (Electricity)
Verve Energy presentation by Dr D. Harrison to Institute of Engineers Australia, Perth, May 2007
Dr M. Diesendorf – Greenhouse Solutions with Sustainable Energy; Towards WA's Clean Energy Future

[12] Wind (Freshwater)
ABC Catalyst 07/04/2005 – Desalination

Wind (Timeframe)
[14] World Wind Energy Association, 2008
[15] Office of Energy, 2008
[16] New Energy News, January 2008

Wave:

[11] Dr. L. Mann of Carnegie Corp, Renewable Energy Holdings (Ex-Seapower Pacific) CETO wave energy technology: http://www.ceto.com.au/home.php

Geothermal:

[8] Ghori, K.A.R., 2007 Search for energy from geothermal resources in Western Australia In Petroleum in Western Australia, Department of Industry and Resources,WA.

[9] Budd, A.R., Holgate, F.L., Gerner, E., Ayling, B.F., and Barnicoat, A. 2008, Pre-competitive Geoscience for Geothermal Exploration and Development in Australia : Geoscience Australia's Onshore Energy Security Program and the Geothermal Energy Project. in Geoscience Australia Record 2008/18

Greenrock Energy Pty
"Hot-rock geothermal energy in Australia could provide Australia's electricity needs for 22,000 yrs."

Geoscience Australia estimate + similar from Prof Ian Lowe of Australian Conservation Foundation
"Australia is known to have several thousand cubic kilometres of identified high heat producing granites and these have the potential to meet the total electricity demand of the country for hundreds of years".

Geodynamics
There is enough geothermal energy in Western Australia to provide our energy for thousands of years.

Geothermal (load-following):
ABC Stateline 14 May 2007.
The geothermal analog of pumped storage for electrical demand load following
Brown, D.W.
Energy Conversion Engineering Conference, 1996. IECEC 96. Proceedings of the 31st Intersociety

Volume 3, Issue , 11-16 Aug 1996 Page(s):1653 - 1656 vol.3
Digital Object Identifier 10.1109/IECEC.1996.553349
Summary: A six-day cyclic load-following experiment, conducted in July 1995 at the Los Alamos National Laboratory's Fenton Hill hot dry rock (HDR) test site in north-central New Mexico, has verified that an HDR geothermal reservoir has the capability for a significant, and very rapid, increase in thermal power output upon demand. The objective of the load-following experiment was to study the behaviour of the Fenton Hill HDR reservoir in a high-production-backpressure (2200 psi) baseload operating condition when there was superimposed a demand for significantly increased power production for a four-hour period each day. In initial tests of this concept, an enhanced thermal power output of 65% for a period of 4 hours each day was obtained. This enhanced power output was obtained from a level of baseload operation that was within only a few percent of the previously determined optimum steady-state reservoir operating conditions. The principal objection to cycling the production from any geothermal reservoir has been the temperature cycling induced in the production wellbore. However, in this present method of surging the production flow, the temperature excursions were limited to only about 19°F. The demonstration of this load-following capability could greatly increase interest in HDR geothermal systems by electric utilities because providing for surges in electric power demand is one of their major concerns at present.

[13] Geothermal (desalination):
European Geothermal Energy Council (www.egec.org)
Low enthalpy (t>60°C) geothermal energy can effectively drive a sea or brackish water desalination unit in order to produce fresh water for drinking and/or irrigation. As a geothermal plant, whether used for power generation or for space heating or other applications, has large quantities of available heat at low cost, the most cost effective method for seawater desalination is to provide directly geothermal heat to a MED (multi effect distillation) plant.
Why should geothermal energy be preferred in a desalination process?
1. Geothermal energy provides a stable and reliable heat supply 24 hours a day, 365 days a year, ensuring the stability of the thermal processes of desalination.
2. Geothermal production technology, i.e. to extract hot water from underground aquifers, is mature.
3. Low temperature MED desalination technology is also mature.
4. Geothermal desalination yields fresh water of high quality.
5. MED desalination method has low energy requirements maximizing the fresh water output from a given low enthalpy geothermal potential and minimizing the corresponding costs.
6. Geothermal desalination is cost effective, as fresh water costs of less than 1 Euro/m3 are possible.
7. Geothermal desalination is friendly to the environment, as only renewable energy is used with no emissions of air pollutants and greenhouse gasses.
8. Geothermal desalination aids local development and improves employment perspectives.
9. Geothermal desalination saves foreign
currency as no imported fossil fuels are used.
10. Geothermal desalination has been successfully demonstrated on the island of Kimolos, Greece through a project supported by the European Commission (THERMIE GE.438.94.HE).

Geothermal (Thermal Processes / Heating)
Energy Core geothermal heating: http://www.energycore.com.au/index.php

Biomass:
Verve Energy Integrated Wood Processing (IWP) Power Plant in Narrogin, WA:
http://www.verveenergy.com.au/mainContent/sustainableEnergy/Projects%20in%20progress/media/index.html

A power plant was built and operated to demonstrate the feasibility to commercialise the use of locally planted mallee trees to generate renewable electricity.

"Verve Energy has successfully demonstrated the IWP technology through the demonstration plant at Narrogin. Now Verve Energy wants to take the next logical step and build the first commercial scale IWP plant, with a view to further development in the future."

Western Power:
A prior Western Power datasheet "Renewable Energy Commercialization in Australia" stated:

“Full-scale, fully economic IWP plants will be five times the size of the demonstration plant, each requiring the planting of 20 million trees. There is potential for at least ten plants throughout the wheatbelt of Western Australia, with many more possible in other states and overseas.”

As the demonstration plant was intended to be 1MW, the potential mentioned is for 10 each of 5MW power plants.

General Magnitudes of Renewable Resources:

"If the irradiance on only 1% of the Earth's surface could be converted into electric energy with a 10% efficiency, it would provide a resource base of 105 TW, whereas the total global energy needs for 2050 are projected to be about 25-30 TW". (Note: Solar cells are now commonly 15-20% efficient).

"The total theoretical potential for onshore wind power for the world is around 55 TW with a practical potential of at least 2 TW (2004), which is about 2/3 of the entire present (2007) worldwide generating capacity. The offshore wind energy capacity is even greater".

2007 technical publication "Handbook of Energy Efficiency and Renewable Energy" CRC Press, Ed. F. Kreith & D. Goswami.

Australia’s current primary energy consumption could be met by an area of 4000 sq km of solar collectors with an average 20% conversion efficiency. This equates to an area of 138km x 138km, similar to the area of domestic house roofs available nationally

Int. Journal of Environmental studies, Dec 2006, Lovegrove & Dennis