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Mr Aden Barker

Western Australia Office of Energy
Level 9, 197 St. Georges Terrace,
Perth, WA 6000
By email: Aden.Barker@energy.wa.gov.au

Date 5 March 2010

Subject: **Comments on the West Australian Strategic Energy Initiative Issues Paper**

Dear Mr Barker,

Sustainable Energy Now (SEN) commends the Minister and the Office of Energy for this progressive initiative and is pleased to have opportunity to comment.

SEN is particularly interested in urgent and effective reduction in greenhouse emissions and other environmental impacts, by the integrated implementation of increased efficiency, reduced waste, demand-side management and renewable energy systems, complemented with the use of electrified transport.

This holistic approach is necessary to ensure an effective and secure sustainable energy future.

Yours sincerely,

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1 Executive Summary

WA's renewable energy resource is many times our energy demand but present utilisation is very low, despite the availability of existing technologies and others on the cusp of commercialisation.

To meet the Mandatory Renewable Energy Target (MRET) of 20% by 2020 and CO2 reduction targets beyond (80-90% reduction by 2050), will require an integrated plan of generation, transmission and holistic management of energy use.

The present electrical energy system lacks coordination or planning between generation, transmission and energy demand management, resulting in ad hoc development. This is a major barrier to the implementation of renewable energy supplies.

In this submission, SEN addresses the topics of the SEI 2030 and proposes a methodology for displacing fossil generated electricity with high penetration of renewable energy, in both electrical form and by 'direct' use. Additionally, reduced waste, increased efficiency and demand-side management, complemented with increased use of electrified transport, are discussed.

Some renewables combined with energy storage 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. Options to provide sufficient 'baseload' supply to ensure grid stability against step-load changes and 'intermittency' of some renewable energy sources, are also proposed.

SEN introduces our recently developed SWIS renewable energy computer simulation which is a tool to assist in developing scenarios of various integrated 'mixes' of renewable energy conversion technologies to produce high-levels of low-emission electrical energy.

This submission builds on SEN's prior submission to the Senate Economics Committee Inquiry into the Varanus Island Gas Explosion (VIGE) - see Appendix. That document covered a similar scope, and provides further detail on the various renewable energy technologies.

Beyond the scope of the SEI 2030, the displacement and eventual replacement of our fossil fuel generation with renewable energies, provides additional benefits including:

- Reduced environmental damage, including reduced greenhouse gas emissions.
- Demonstrating safe, reliable and adequate energy alternatives for other countries considering nuclear, such as Indonesia (on fault lines), with associated weapons proliferation issues.
- Provision of fresh and/or desalinated water.
- Other by-products with environmental and agricultural improvements.
- Reduced use of water for mining of coal, such as mine de-watering (currently an issue in the Collie area with the Yarragadee aquifer).

2 SEN Introduction

2.1 SEN'S BACKGROUND & AIMS

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

2.2 DISCLAIMERS AND DEFINITIONS

- SEN's current focus is primarily on the stationary electrical energy generation for the Southwest Interconnected System (SWIS). This represents approximately 55% of the total electrical energy use of WA. (Ref: Office of Energy, Govt of WA, Energy WA: Electricity Generation from Renewable Energy, 2008).
- SEN's members with technical and engineering backgrounds apply their skills to research and collate findings on renewable energy resources and technologies.

3 Comments on the Issues and Trends

3.1 Economic Development

SEN acknowledges the projections for energy demand growth due to foreign economic demand but this can be offset to some extent by increases in energy efficiency and reductions in waste.

Common estimates for our potential to reduce energy consumption are up to 25%. ("How can we create a sustainable future for Australia?" Professor Ian Lowe, Emeritus Professor, Griffith University, Qld, 2006 http://mpegmedia.abc.net.au/rn/podcast/2007/02/bia_20070211.mp3)

For applications which do not need "high-grade" (high-temperature or electrical) energy, there can be further significant displacement of coal, gas, petroleum and electricity by using "low-grade" (low-temperature) energy from solar thermal and geothermal sources and/or waste heat from cogeneration.

There are numerous economic advantages to the increased use of renewables:

- Climate change, causing a reduction in rainfall in some areas, is making prior farming practices in marginal areas unviable. Renewable energy such as wind and solar can provide major income and employment for these stressed regions.
- Developments in renewable energy technology will result in greater intellectual property and commercial opportunities worldwide.
- Manufacturing of renewable technologies will result in a major industrial sector with resulting benefits of increased and more diverse employment, training and manufacturing, all with export income. A review of "RechargeNews" weekly newsletter paints a vibrant and booming industry in renewables internationally, utilising much of the existing oil and gas technology. (A free trial subscription is available from www.rechargenews.com)
- Minerals needed for renewable technologies are available locally within WA, so associated mining will benefit.
- Much of the technologies needed for renewables is similar to those used in the oil and gas industry, ie. Geothermal drilling, offshore wave and wind, so the diversity of opportunities for WA's existing expertise will be expanded.

The implementation of renewable technology has begun to receive incentives through the State Government's grants to wave energy development, and the Federal Government's Solar Flagships plan to build 1000MW of solar thermal energy and encourage State partnership/take up of this economic funding. This is an opportunity for WA to lead in a new technological area.

3.2 Changing Human Settlement Patterns

SEN is aware of the projections for increase in population however, the sustainable limit of population in WA needs to be addressed as a separate issue.

With a diverse location of population it makes sense to use the renewable energy resources available locally rather than import from large distances, with the inefficiencies and costs associated with the required transmission infrastructure.

An example of the advantages of locally-sourced renewable energy is their application in remote areas, such as fringe-of-grid locations (Denham, Albany, etc.) and existing Aboriginal communities.

Mining areas in the Pilbara are (in conjunction with Horizon Power) investing in solar energy to take advantage of the enormous and reliable local solar resource to significantly reduce energy costs otherwise provided by costly imported fossil fuels.

(www.watoday.com.au/environment/energy-smart/solar-power-station-a-step-closer-to-reality-20100216-o6in.html)

Dispersed renewable energy generation generally provides a more reliable/constant supply which means that improving infrastructure to allow for efficient electrical transmission has advantages which also include the ability to distribute the power to a wide area to accommodate demographic changes.

Peak electricity demand on hot days largely matches the availability of solar energy, so there is a natural synergy to make use of it.

3.3 Technological Change

SEN agrees that improvements in technology hold much potential and many of these are already being demonstrated internationally.

There are also many simple changes which can be initiated immediately, to reduce energy use with little or no new technology required. These include:

- Design residential and commercial developments with district heating infrastructure to enable the use of combined heat and power (cogeneration) from small scale local energy generation.
- Better design of homes (solar passive, etc), including retro-fitting the existing housing stock
- Urban planning to include cluster and multistorey housing to enable medium and high density developments to have room for trees/vegetation to reduce peak summer demand and overall demand.
- Urban growth limits and planning to reduce commuting and other transport energy/costs.
- Urban planning to allow for locally grown produce to continue to exist in, or near population centres. (Ref: Dan Rather report on locally grown food in Hardwick, Vermont, USA http://vimeo.com/7729181)
- Capturing and storing water on site (ie from roof and other runoff) reduces pumping energy and hedges against reduced rainfall due to climate change.

Adapting the current grid infrastructure will require planning to ensure it is optimised to accept technological change in energy generation. The capacity and geography of new supply will require planning to enable infrastructure and project design and implementation. The SEN computer model will enable development of various WA renewable energy scenarios to be simulated, providing the basis for detailed analysis and estimates.

3.4 Climate Change Mitigation and Impacts

SEN agrees that as a result of climate change, there will be changing patterns and amounts of water use.

SEN suggests that desalination could be achieved more efficiently by direct means rather than generating electricity to run pumps to create water pressure. Examples of this are:

- Wave energy directly pressurising seawater against desalination membranes, or
- Geothermal energy providing heat for distillation (ref: Appendix, SEN's VIGE submission).

This not only reduces the demand on the electrical system but also reduces the amount of primary energy required.

With decreasing rainfall, and considering that water pumping uses typically about 4% of metro energy (The Water Corporation report shows annual energy consumption as 2,205 TJ), the installation of more water tanks/reservoirs to capture run-off from urban roofs/impervious surfaces, and strong encouragement of grey-water use could not only provide more water, but also reduce energy demand.

4 Meeting the Goals

4.1 Secure Energy

The explosion at Varanus Island and the following gas shortage for Western Australia, has highlighted that relying on a 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. 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.

4.1.1 Renewable Energy (RE) Availability and Sufficiency

In simple 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 and corresponding surface area:

- 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 x 40 metres (or equivalent smaller wave farms)
- Geothermal: 20 km x 20 km (x 1 km thick granite underground)

To ensure energy reliability and security through diversity, a combination of the above would be used meet the energy demand. Some renewables such as Geothermal, Solar Thermal (with storage) and Wave energy, are capable of providing baseload power.

Furthermore, there are numerous methods to reduce the need for electrical energy, by "directly" using certain types of renewables. This can significantly reduce the amount of electricity required, and is discussed further in Section 4.5 – "Direct Energy Use".

4.1.2 Renewable Energy Diversity

The following sections summarise the various renewable energy resources well suited to South-western WA.

For further details and supporting references, please refer to the SEN submission to the Senate Economics Committee Inquiry into the Varanus Island Gas Explosion (VIGE).

4.1.2.1 Solar Thermal Energy (STE)

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 onto a “Heat Engine” directly, which turns a generator.

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 up to 16-20 hours without sunlight. Their output can therefore be considered constant, and better yet, could be used 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 on scales up to 100MW, (as illustrated in the VIGE) but are economically suited to sizes up to about 400MW.

4.1.2.2 Solar Photovoltaic (PV) Energy

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, commonly batteries, 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 may reduce transmission losses and infrastructure costs.

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.

4.1.2.3 Wind Energy

Wind-generated electricity is a well-known and proven technology and large amounts are being installed in China, Europe, USA and the UK. Refer to the Appendix for examples.

WA’s wind resource availability varies by location. North of Perth along the coast there tends to be most energy at night, whereas on the SW coast it is highest during the day, but also good at night. By using dispersed wind farms, it is possible to achieve a more constant supply of energy.

4.1.2.4 Wave Energy

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. (Refer to the Appendix for description and examples).

The ability for the CETO system to provide a constant supply of energy (more than 90% of the time, based on WA’s Carnegie Wave Energy CETO system) wave resource between Geraldton and Bremer Bay qualifies it as a ‘baseload’ source, but better still, it can respond rapidly to changing energy demand. This enables it to complement other ‘intermittent’ renewable sources such as wind.

When wave energy exceeds the system demand, it can be used to desalinate seawater.

4.1.2.5 Geothermal Energy

Australia has extensive geothermal resources which include:
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 further described in the VIGE.

Hot aquifers of up to 150 degrees C, which can be used for direct heating applications, air-conditioning and generation of electricity.

Geoscience Australia (Budd et al, 2008) has estimated that extracting just 1% of the available hot granite heat could power Australia for about 26,000 years, at the current rate of electricity comsumption. Geodynamics Ltd 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.

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 is being further evaluated. (Ref: WA Geothermal Centre of Excellence)

About 48 companies are currently exploring for geothermal resources in Australia and most recently, following recent 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 and other parts of WA.

It should be noted that many parts of WA have not been evaluated for geothermal resources because of lack of data.

4.1.2.6 Biomass Energy

The potential for biomass to generate baseload electrical energy in Western Australia is significant. Generating electrical energy in combination with use of waste heat for other purposes, (ie. Cogeneration), can achieve overall efficiencies in excess of 80% ("Australia's Clean Energy Future" report, Saddler, Diesendorf, Denniss, Mar 2004). This utilisation of biomass energy also favours WA's rural and remote communities and would reduce transmission losses and reduce loads on the existing transmission network.

WA has a leading example of biomass fuel production with the Plantation Energy pelletising plant in Albany. This facility utilises crop residues from Bluegum plantations to produce high density biomass pellets. Unfortunately due to the poor economic structure for renewable energy in WA the pellets are currently exported, mainly to Europe.

WA also has a unique opportunity to use the native Oil Mallee for a number of benefits besides energy generation, including:

- extracted oil can be used in pharmaceuticals and industrial solvents.
- roots and charcoal by-product are a carbon store, and the charcoal can be activated for water purification and other process uses.
- 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.

Looking to the future, the gasification of biomass also produces hydrogen. A number of biomass generation companies are already researching the use of hydrogen cells for power generation.

Present practical limitations of biomass crops for energy supply are not initially the biomass catchment/collection area and economics of transport of feedstock, etc. but more the grid capacity at those outlying areas, such as at Northam. One would want to put in the largest plant possible to make a good economic case in terms of grid infrastructure.

However, 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.

4.1.2.7 Waste to Energy

Western Australian's each produce nearly 2.5 tonnes of waste each year, and currently only 33% of this waste is recycled or recovered, leaving 3.5 million tonnes to be desposed of as landfill each year in WA (2006-07 values). Large quantities of timber and other organic matter are disposed of each year, generating methane as it breaks down. Methane has a GHG potential 21 times greater than CO_2.

This 'fuel' should be separated and processed to produce a refuse derived fuel to an acceptable standard and then harnessed to produce renewable energy. The technologies to process the material and harness the power are scalable and together with biomass crops could be used for both renewable energy generation and the reduction of waste disposal, in line with the Governments 2009 draft Waste Strategy.

4.1.3 R.E. Price Movements Manageability

The cost of conventional fossil generated electricity, over the life of a typical power station, is primarily from the cost of the fuel, roughly 80% (D. Aberle, Western Power). This makes electricity pricing sensitive to increasing fossil fuel prices, as well as the associated labour and materials increases.

In contrast, the cost of renewable energy resources is zero, thereby providing certainty of this portion of the pricing. (Capital cost amortisation and operation-and-maintenance expenditure are the only ongoing costs). Furthermore, if Australia builds and maintains the value-chain industries supporting the production of renewable energy technologies, then sourcing of labour and materials within Australia will be achievable, and provide more control and therefore manageability of costs.

4.1.4 R.E. Affordability

It is generally acknowledged that renewable energy is more costly than that of coal generated, however, costs are ever decreasing with improving technology, manufacturing scale and economies of scale for larger systems. Furthermore, our present pricing is not cost-reflective of the externalised costs of using fossil fuels.

The projected reduction in costs of various types of renewables is illustrated in the graphics below, taken from the McLellan Megasanik Associates, 2007 economic analysis commissioned by the Renewable Energy Generators of Australia (REGA).

The analysis indicates that the costs of renewable energy sources overlap with the range of fossil fuels. With the introduction of an Emissions Trading Scheme and a price on CO2 emissions, the renewable energy sources become more competitive.

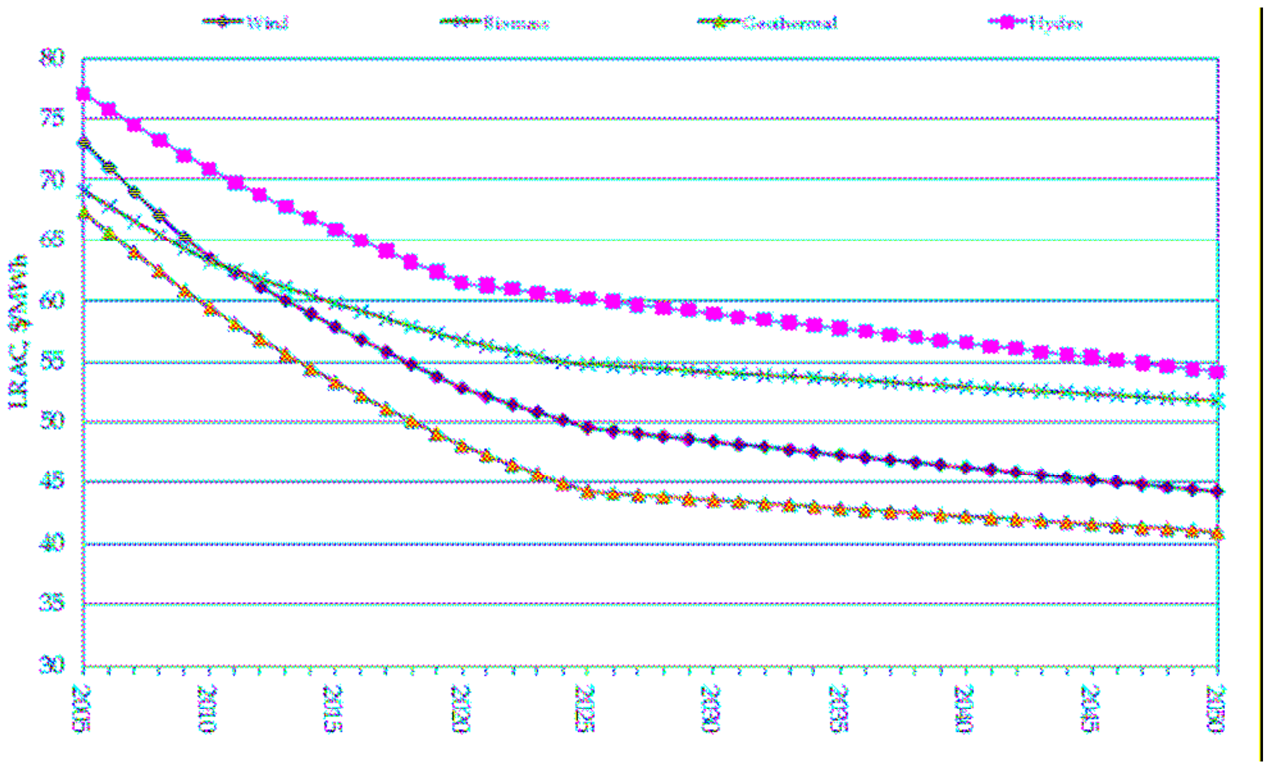


Figure 1: Average cost – wind, biomass, geothermal, small hydro (Ref: MMA report to REGA, June 2006)

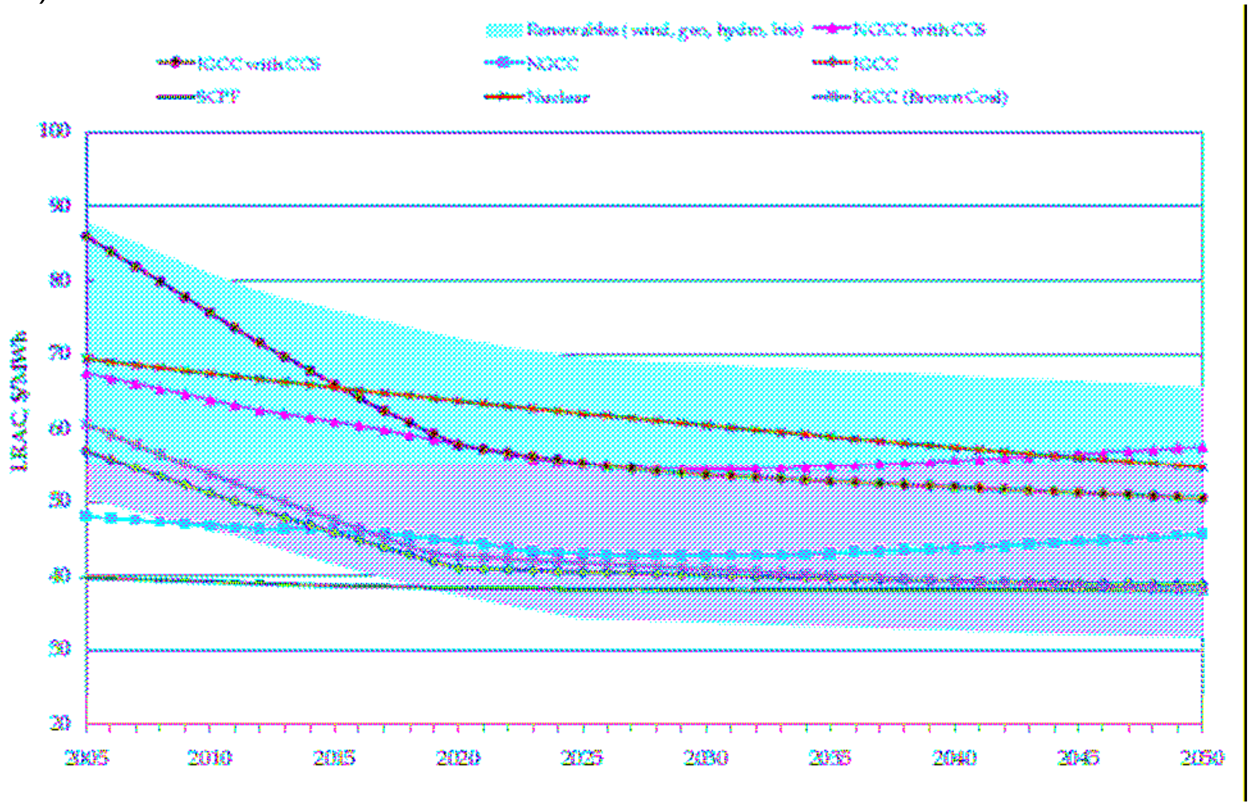
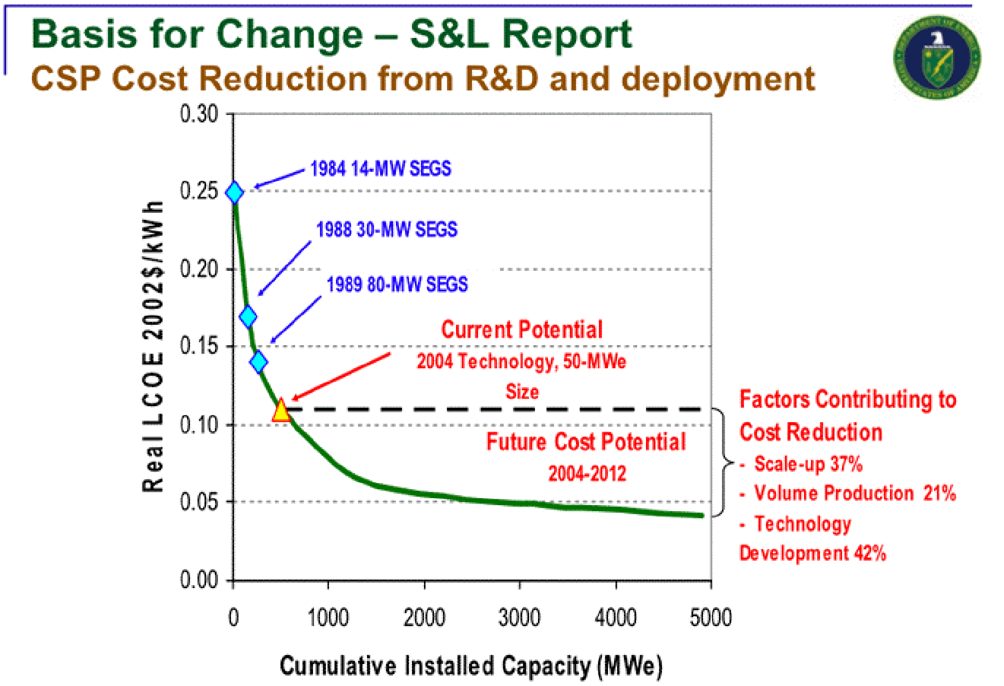


Figure 2: Total Renewables cost envelope versus coal, gas and nuclear costs (Ref: MMA report to REGA, June 2006)

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.

Figure 3 below illustrates how prices for solar thermal in California's SEGS (Solar Energy Generating System) plants have fallen with scale, production volume and technology improvements, and the potential for future reductions.



*Sargent and Lundy (2003). Assessment of Parabolic Trough and Power Tower Solar Technology Cost and Performance Impacts. http://www.nrel.gov/docs/fy04osti/34440.pdf

Figure 3: below shows Geodynamics costing of geothermal energy (from hot granites) relative to other sources.

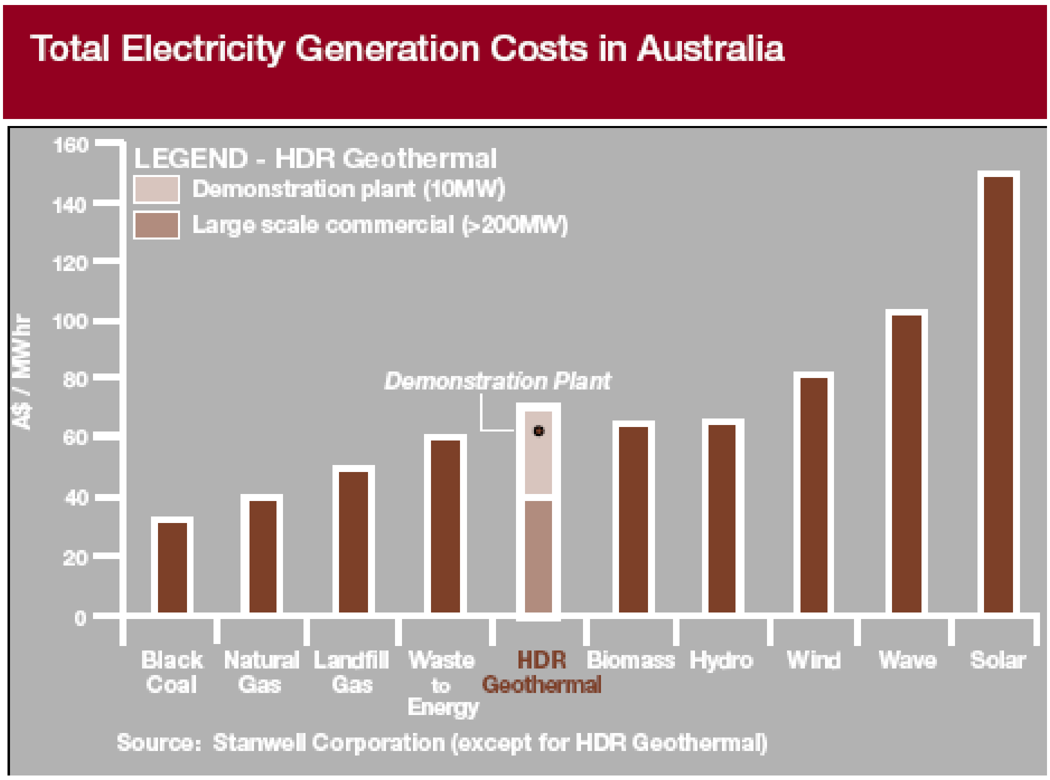


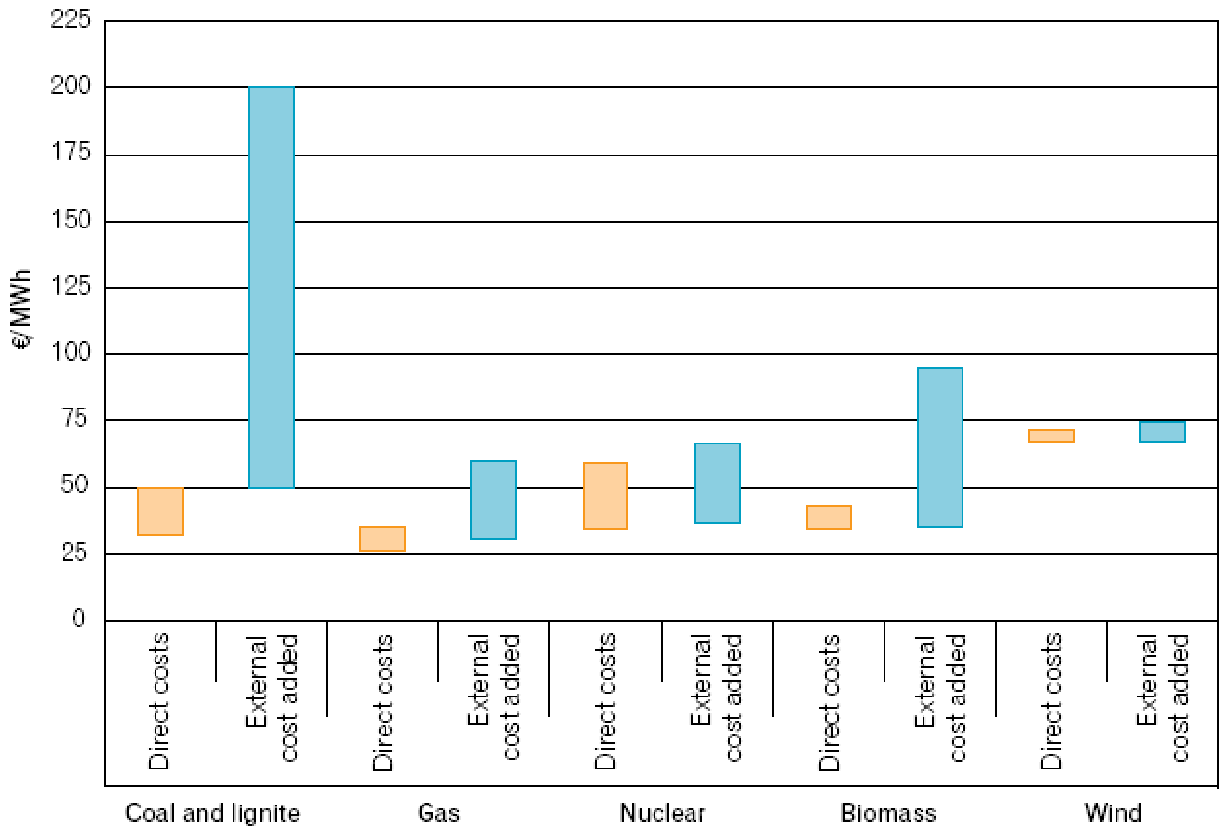
Figure 4: HDR Geothermal Costs in Australia (Ref: Geodynamics Annual Report 2006)

Carnegie Wave Energy Ltd estimates that the initial CETO wave power costs are likely to be similar to present costs of wind power, and project that they will compete with fossil energy, excluding any benefits from carbon pricing.

The externalised costs of various energy sources are shown in the graph below, illustrating the competitiveness of biomass and wind relative to conventional fossil generation, when these are taken into account.

It should be noted that recent estimates of the cost or decommissioning nuclear power plants in the UK have been increased dramatically, indicating that the costs in this graph for nuclear are understated.

Figure 4.8 External and direct costs of electricity generation in the European Union (€/MWh)[31]



[31] €1 = A$1.66, approximately

Source: ExternE[71]

Fig: 5: External and Direct Costs of Electricity generation in the European Union (Ref: UMPNE Report 2006, Switkowski)

4.1.5 R.E. Physical Security

The keys to security against man-made, accidental or natural disruptions are to create an energy system with the following characteristics:

- ***Diversity of energy sources***: This feature means that failure or damage of any one or more sources has less impact and some or all of the energy shortfall can be provided by others.
- ***Dispersed energy sources***: This reduces the likelihood of damage to one area affecting others due to physical proximity.
- ***Interconnected, smart grid network with sufficient redundant-path capacity***: Like the internet, these qualities increase resiliency against critical path failures due to the ability of other transmission infrastructure network to share the distribution of power.

It is clear that the dispersed and diverse nature of renewables, and their need for a robust distribution network is in line with the qualities required for physical security.

4.2 Reliable Energy and 'Baseload' Requirements

4.2.1 Conventional System Management:

The conventional expectation of electrical energy supplies is that they must be centralised and use 'cheap' fossil fuels to meet the 24-hour daily variations of electricity demand, (illustrated in Fig. 6 below), which requires careful coordination of a number of sources; coal, gas and distillate. Peak power demand is around 8am and 5pm in Winter and around 4pm in Summer.

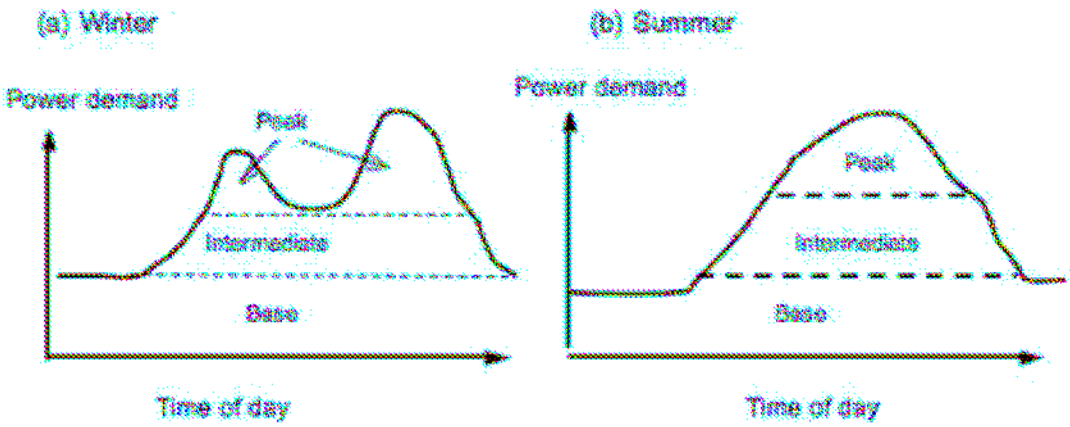


Figure 6: Typical Daily 24-hour energy demand profiles (Ref: "The Baseload Fallacy" by Dr. M. Diesendorf)

A certain minimum portion of the energy generated is required to be 'baseload' to provide sufficient AC frequency stability and synchronisation for the 'conventional' grid.

The requirements for baseload are that it:

- provides a continuous and predictable energy supply
- has 'spinning inertia' which refers to the stored energy in the generators' rotating parts

These qualities ensure that when step-changes in energy demand occur, the spinning speed (related to AC frequency) will stay within allowable limits during the brief period needed for generators to ramp their power up or down to match the new demand.

For conventional power where coal is the cheapest supply, the term 'baseload' also relates to the limitation that coal power output cannot be changed rapidly. This limits its use to the daily minimum or 'base' power demand required, illustrated in Fig 6 above. The conventional method of matching the changing power demand (called 'intermediate' or 'peaking') is to use faster-acting expensive energy sources such as gas, oil and distillate, requiring careful coordination.

4.2.2 Alternative System Management:

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.

To meet frequency stability requirements, a number of options can be used:

- ***Spinning Inertia***: Add spinning inertia to the generators to give a range of 'response' times to meet both baseload and 'peaking' loads.

- ***Load Shedding/Adding***: Ensure a portion of load can be very rapidly shed or increased, to balance other load changes.

- ***Energy Storage***: Add a portion of supply from sources (such as storage) which can very rapidly increase or decease their output power output, such as pumped hydro, flywheels, pumped air. As the size of the electric vehicle fleet increases, their batteries can store a significant amount of energy as described in Section 5.4.4.

To utilise renewable energies, a combination of these options can be used to match supply and demand. Different challenges and methods are applicable to each type of renewable energy source. With some renewables, such as geothermal, biomass, wave and solar thermal with storage, management may be simpler because of continuity of supply and the output can also be varied to follow demand. These capabilities, combined with adjustment of spinning inertia and load-shedding/adding can increase the penetration of variable sources of wind and solar PV. Consequently, given the enormous renewable resources and the technologies available, it is conceivable that 100 percent of our energy could be met with renewables. Scenarios for this are discussed later.

The generation and use of significant amounts of renewable energy cannot occur without a distribution system with the following capabilities:

- ***Bi-directional energy flow***: Energy must be able to flow around the network from where power is generated to where it is needed, and with the dispersed nature of renewables, this flow can change significantly.

- ***Bi-directional load control and Demand-Side Management (DSM)***: The load-shedding/adding and power generation must be coordinated rapidly (from millisecond to half-hrly) to match the two. This may be achieved with smart-meters/appliances able to load-shed/add very rapidly and controlled by system management. (Curtin University Sustainability Policy Institute is performing development of electric vehicle charging systems which can provide this capability)

- ***Sufficient power capacity***: To allow large changes in direction of energy flow requires transmission infrastructure capacity to be sufficient throughout the system, rather than just at the 'core', Collie/Muja in the case of the SWIS, as with conventional generation. Building in this capacity however, can also benefit physical security and reliability of the network by the fact that there is greater redundancy.

Other options to reduce the issues of intermittency from wind or solar follow from the way and locations that the renewable generators are installed:

- ***Wind locations***: Installing wind turbines at locations over a wide area helps to provide a more constant energy output. Winds are predictable hours ahead, which help in combining them with other energy sources. WA's southern areas tend to be strong during the day and less strong but still good at night. Areas north of Perth, to Geraldton, have strong evening winds. Inland locations may give further time-shift diversity. Offshore winds are generally more consistent, but costs are higher. To improve economics of offshore wind, the trend is to larger turbines, such as the new 10MW units planned by Norwegian company Sway, for installation in 2011.

- ***Solar locations***: Solar energy received on-ground varies according to solar irradiance contours and moisture/cloud cover, so WA's northerly and interior dry areas tend to be optimal particularly for concentrating solar technologies which require direct (specular) light. Also affecting solar generation is the time shift due to east-west (longitudinal) solar time differences. WA's major energy demand in Summer comes from the west coast at around 4pm +/- a few hours, and local solar supply falls off rapidly after 4pm. However, this can be mitigated by stored solar heat to extend generation time over this peak period.

The SEN simulation is being refined to allow actual meteorological conditions at various locations to be modelled to determine the effectiveness of these strategies on the continuity of energy output. This is discussed further in section 5.

4.3 Competitive Energy

Renewable energy entering the grid benefits commercial competition as numerous and dispersed generators create a healthy market with increased employment in rural areas, and increased income for rural land owners/farmers.

A regulatory framework is needed to ensure fair and competitive access to transmission infrastructure, supply of generation, capacity credits and carbon pricing benefits to kick-start this industry. Furthermore, service agreements for capacity will need to be packaged according to the integrated strategy to meet the goals of this initiative.

5 Integrated Plan to Achieve the Goals, and the SEN Simulation

The goal of achieving 20% renewable generation by 2020 is not going to occur without an integrated plan, which presently does not exist. Both Western Power and Verve Energy state that as a result, their businesses are reactive to demand rather than being proactive. Western Power does not know where the next renewable generators will be located, in order to provide adequate grid capacity. Likewise, Verve is limited in locations available to install additional renewables due largely to limits of grid capacity access.

SEN welcomes the SEI 2030 and trusts that it is a starting point for a detailed integrated plan which includes the regulatory, geographic, schedule and cost details needed to implement the latest renewable energy technologies and management techniques. This is an opportunity to take advantage of the existing need for system upgrades to be used to invest in and transform to a modern renewable energy system that will be relevant for the long-term future.

SEN recommends that the first step to planning renewable generation is to determine where and when the energy is available and design a system to work with that. Meetings with Verve and Western Power indicate that they support and require integrated modelling of various energy scenarios, such as SEN's computer simulation, as a tool to help with this planning.

The SEN simulation uses engineering and economic calculations to model the effects of numerous parameters, including:

- renewable energy conversion technologies
- renewable resource availability and intensity
- energy generation, storage and efficiency measures
- transmission systems
- costs
- jobs
- space occupied
- greenhouse gas abatement

The graphical interface provides the ability to clearly and quickly model various integrated energy scenarios as a means to explore and optimise energy systems for detailed analysis and planning. At this time, the simulation is adequate for demonstration and is under further development which will incorporate half-hourly Bureau of Meterology (BoM) data and corresponding load data from the (SWIS).

SEN recommends that this type of computer modelling is required to optimise future energy scenarios to determine a strategy. An example of the SEN simulation 'cover' page is illustrated by the screen-shot in Fig 7 below.

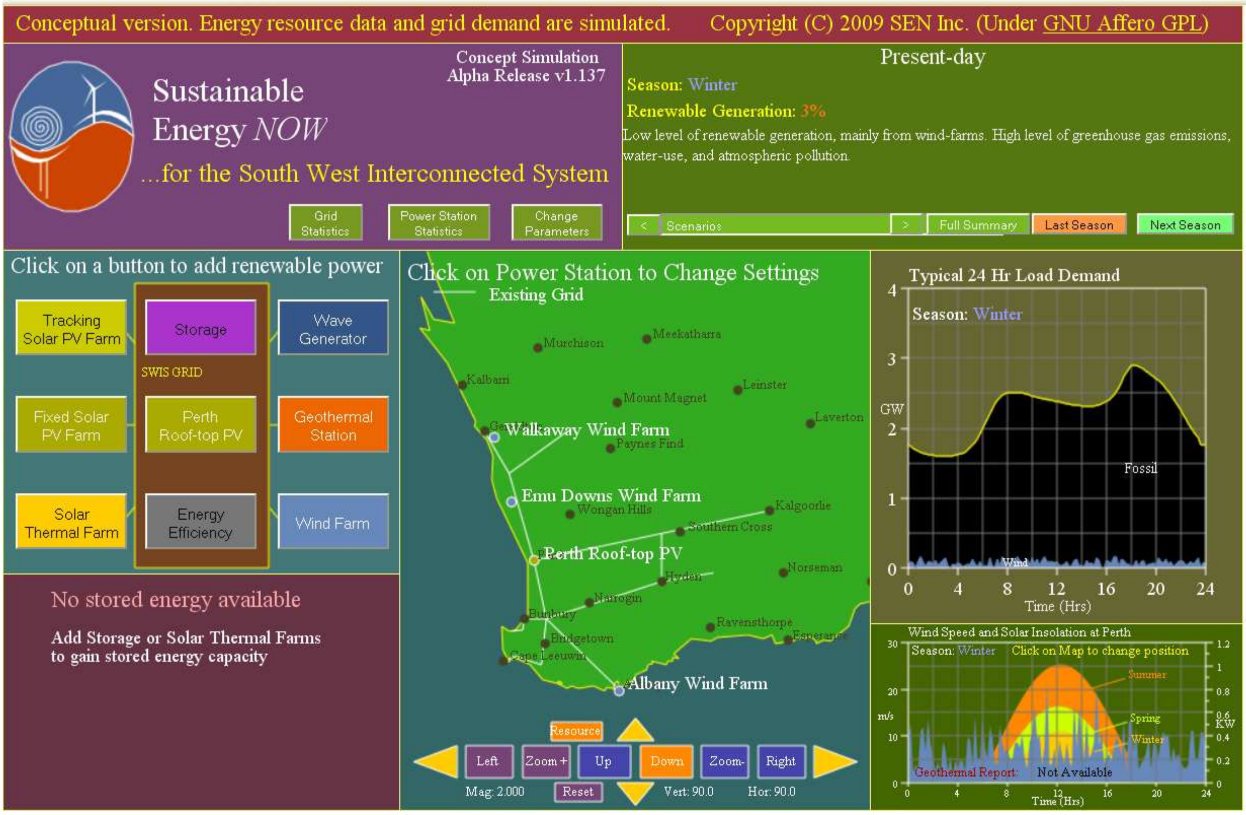


Fig: 7: Screenshot from the SEN renewable energy simulation 'cover page'

We explore possible renewable penetration scenarios in later sections.

5.1 Required Rate of Implementation of Renewable Energy & Reduction in GHG Emissions

To meet the 2020 MRET of 20% and beyond, requires a plan to take advantage of the rollout of a range of renewable technologies. Starting from 2010, with just under 5% of the SWIS energy coming from renewables and assuming a growth in rate of electrical energy use of 2% per year, it will be necessary to grow renewable energy by just over 15% per year. (See Figure 8 below).

While 15% per year seems fairly ambitious, it is interesting to note that the global growth rate of wind energy has been around 25% per year for the last few years. Likewise the uptake of solar has been very high. With the right regulatory and pricing structures in place, the required growth should be achievable.

Projecting further to 2030, that rate of growth could reach approximately 50% generation by renewables.

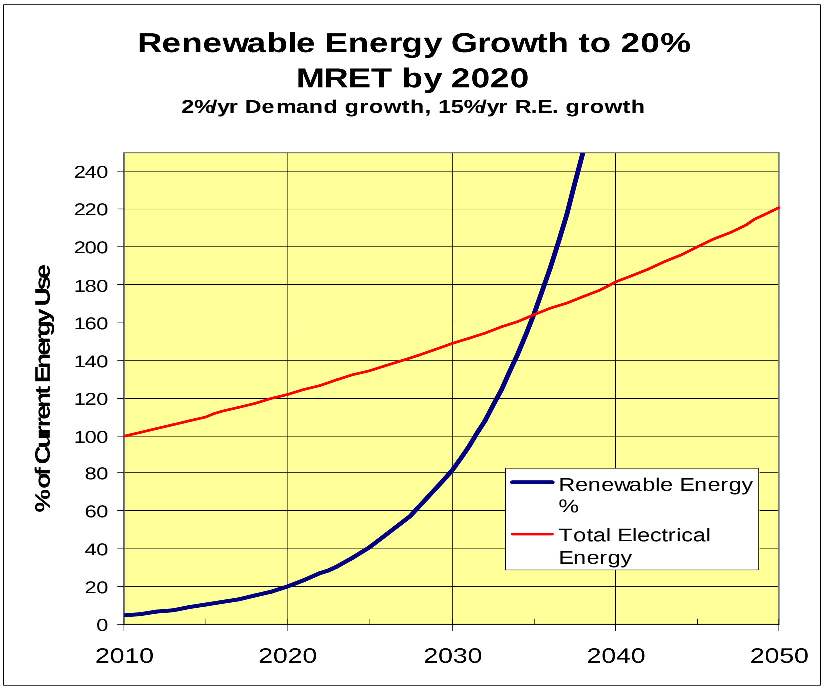


Figure 8: Required implementation rate of renewable energy in WA to meet 2020 MRET

5.2 Establish RE Generator Locations & Required Infrastructure

It will be necessary to establish appropriate areas for installation of the various renewable energy technologies. This requires consideration of sufficient renewable energy resources, proximity to existing and future transmission infrastructure, projections for future energy growth locations, appropriate land use and acceptability to local residents and business.

Using the SEN simulation, it is interesting to explore a simple scenario for 20% renewable energy generation, as shown in Figures 9, 10 and 11 below.

The basic parameters are:

- Wind farms: Existing at Albany, Walkaway, Emu Downs, plus 240MW at Eneabba and 240MW at Geraldton
- Solar Thermal: 7 ea x 35 MW solar thermal w/2.5 hours storage, between Geraldton and Carnarvon
- Solar PV: 100MW in Perth
- CETO wave farms: 100MW each at Albany, Garden Island and Lancelin
- Infrastructure: 3,700 km of new transmission lines

Resulting estimated costs are:

- Average cost of renewable electricity: 20 c/kWh
- Renewable generation capital cost: $4.8 billion
- Grid connection cost: $2.5 billion
- Transmission infrastructure capital cost: $2.5 billion

Note that the above numbers are subject to numerous other input parameters, which can be altered by the user of the simulation, so that any disputed values can be simply updated and the simulation immediately re-run.

Fig 9: SEN Conceptual simulation example screenshot - 20% Renewable energy generation on the SWIS – overall scenario.

Conceptual version. Energy resource data and grid demand are simulated. Copyright (C) 2009 SEN Inc. (Under GNU Affero GPL)

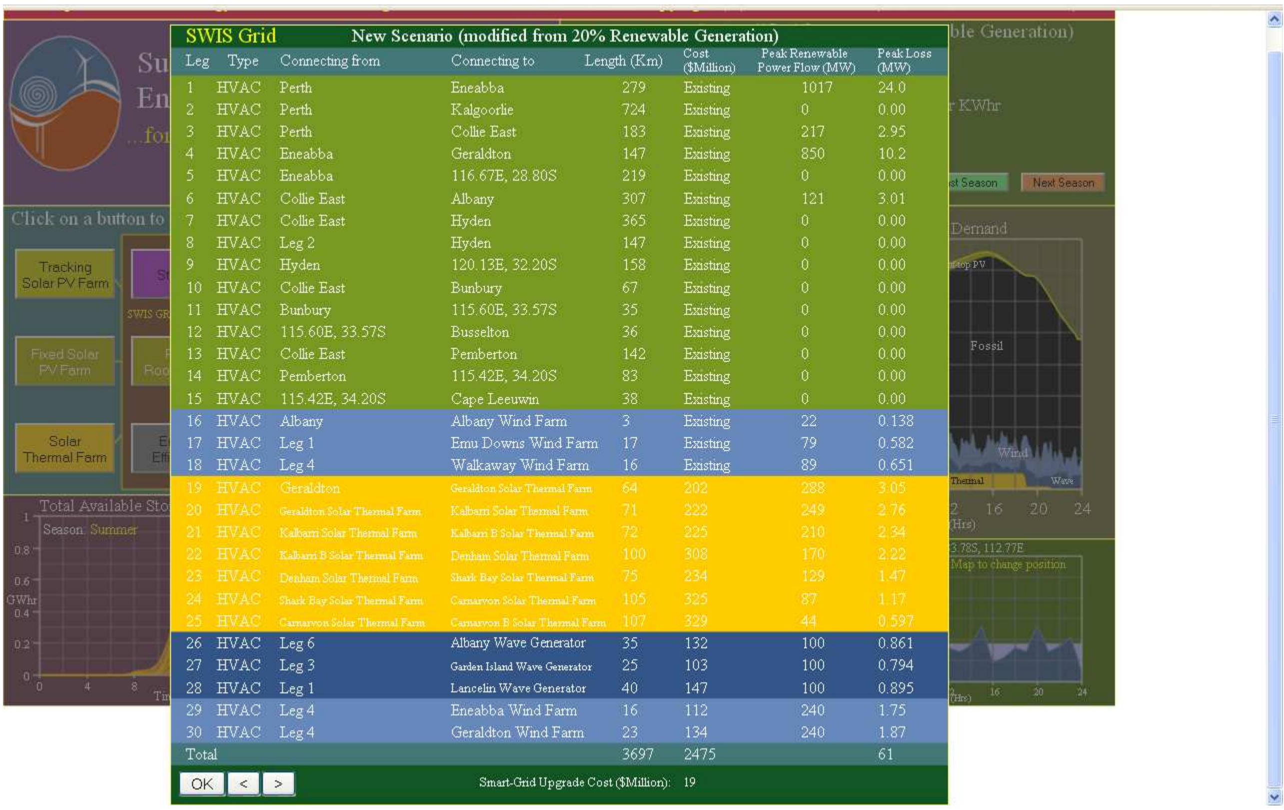
Renewable Power Station Statistics

Scenario 1: 20% Renewable Generation
Season: Winter Typical generation: 13883 MWhr/day (25.9%)

Name	Type	Size (MW)	Daily Output or Load Reduction (MWhr)	Capacity Factor	New Capital Cost ($Million)	Grid Connection ($Million)	Levelised Price (cents/kWhr)	Carbon Saved (tonnes CO2e/day)	Levelised Abatement Cost ($/tonne CO2e saved)	Estimated Jobs	Surface Area Used (Km2)
Albany	Wind Farm	21.6	179 (0.33%)	0.35	Existing	-	-	126	-	-	3.35
Emu Downs	Wind Farm	79.2	677 (1.3%)	0.36	Existing	-	-	474	-	-	20.7
Walkaway	Wind Farm	89.1	869 (1.6%)	0.41	Existing	-	-	608	-	-	23.2
Perth	Roof-top PV	5	20 (0.038%)	0.17	Existing	-	-	14	-	-	-
Perth B	Roof-top PV	95	387 (0.72%)	0.17	486	19	27.9	271	398	268	-
Geraldton	Solar Thermal Farm	35	278 (0.52%)	0.33	205	202	42.0	194	601	83	2.07
Kalbarri	Solar Thermal Farm	35	279 (0.52%)	0.33	204	222	43.3	195	619	83	2.06
Kalbarri B	Solar Thermal Farm	35	280 (0.52%)	0.33	206	225	43.5	196	621	84	2.08
Denham	Solar Thermal Farm	35	281 (0.52%)	0.34	211	308	50.3	197	718	86	2.13
Shark Bay	Solar Thermal Farm	35	283 (0.53%)	0.34	214	234	44.9	198	641	87	2.16
Carnarvon	Solar Thermal Farm	35	284 (0.53%)	0.34	212	325	51.2	199	732	87	2.15
Carnarvon B	Solar Thermal Farm	35	286 (0.53%)	0.34	202	329	49.9	200	714	82	2.04
Albany	Wave Generator	100	1568 (2.9%)	0.65	578	132	15.5	1098	221	97	0.444
Garden Island	Wave Generator	100	1698 (3.2%)	0.71	578	103	13.9	1189	198	97	0.444
Lancelin	Wave Generator	100	1857 (3.5%)	0.77	578	147	13.3	1300	190	97	0.444
Eneabba	Wind Farm	240	2348 (4.4%)	0.41	533	112	11.4	1644	163	83	41.5
Geraldton	Wind Farm	240	2308 (4.3%)	0.40	533	134	11.8	1616	169	83	41.5
Total		1315	13883	0.44	4739	2494	18.9	9719	270	1316	146

OK Last Season Next Season < > Net New Jobs: 988 (0.65x Collie Coalfield)

Fig 10: SEN Conceptual simulation example screenshot - 20% Renewable energy generation on the SWIS – Renewable energy generators' details.


SWIS Grid — New Scenario (modified from 20% Renewable Generation)

Leg	Type	Connecting from	Connecting to	Length (Km)	Cost ($Million)	Peak Renewable Power Flow (MW)	Peak Loss (MW)
1	HVAC	Perth	Eneabba	279	Existing	1017	24.0
2	HVAC	Perth	Kalgoorlie	724	Existing	0	0.00
3	HVAC	Perth	Collie East	183	Existing	217	2.95
4	HVAC	Eneabba	Geraldton	147	Existing	850	10.2
5	HVAC	Eneabba	116.67E, 28.80S	219	Existing	0	0.00
6	HVAC	Collie East	Albany	307	Existing	121	3.01
7	HVAC	Collie East	Hyden	365	Existing	0	0.00
8	HVAC	Leg 2	Hyden	147	Existing	0	0.00
9	HVAC	Hyden	120.13E, 32.20S	158	Existing	0	0.00
10	HVAC	Collie East	Bunbury	67	Existing	0	0.00
11	HVAC	Bunbury	115.60E, 33.57S	35	Existing	0	0.00
12	HVAC	115.60E, 33.57S	Busselton	36	Existing	0	0.00
13	HVAC	Collie East	Pemberton	142	Existing	0	0.00
14	HVAC	Pemberton	115.42E, 34.20S	83	Existing	0	0.00
15	HVAC	115.42E, 34.20S	Cape Leeuwin	38	Existing	0	0.00
16	HVAC	Albany	Albany Wind Farm	3	Existing	22	0.138
17	HVAC	Leg 1	Emu Downs Wind Farm	17	Existing	79	0.582
18	HVAC	Leg 4	Walkaway Wind Farm	16	Existing	89	0.651
19	HVAC	Geraldton	Geraldton Solar Thermal Farm	64	202	288	3.05
20	HVAC	Geraldton Solar Thermal Farm	Kalbarri Solar Thermal Farm	71	222	249	2.76
21	HVAC	Kalbarri Solar Thermal Farm	Kalbarri B Solar Thermal Farm	72	225	210	2.34
22	HVAC	Kalbarri B Solar Thermal Farm	Denham Solar Thermal Farm	100	308	170	2.22
23	HVAC	Denham Solar Thermal Farm	Shark Bay Solar Thermal Farm	75	234	129	1.47
24	HVAC	Shark Bay Solar Thermal Farm	Carnarvon Solar Thermal Farm	105	325	87	1.17
25	HVAC	Carnarvon Solar Thermal Farm	Carnarvon B Solar Thermal Farm	107	329	44	0.597
26	HVAC	Leg 6	Albany Wave Generator	35	132	100	0.861
27	HVAC	Leg 3	Garden Island Wave Generator	25	103	100	0.794
28	HVAC	Leg 1	Lancelin Wave Generator	40	147	100	0.895
29	HVAC	Leg 4	Eneabba Wind Farm	16	112	240	1.75
30	HVAC	Leg 4	Geraldton Wind Farm	23	134	240	1.87
Total				3697	2475		61

Fig 11: SEN Conceptual simulation example screenshot - 20% Renewable energy generation on the SWIS – Renewable energy additional transmission infrastructure details.

5.3 Establish RE Resources Database/Atlas

In order to determine suitable locations for installation of renewable generators, a database and atlas of the available renewable resources, will allow for planning and engineering suitable sites, which not only take into account the energy but other constraints such as land use.

Examples of this are;

- The Australian government's "Renewable Energy Atlas of Australia" at: http://www.environment.gov.au/settlements/renewable/atlas/index.html
- The US National Renewable Energy Laboratory (NREL) "Dynamic maps" at: http://www.nrel.gov/gis/solar.html

While the Australian Atlas is an excellent source, it appears to lack some critical information in certain areas. One of these is that of solar 'direct' radiance, needed for concentrating solar technologies. Note that the US NREL site does provide this.

It is necessary to ensure that the information on the atlas/database has sufficient data locations and periodic frequency (i.e. grid resolution and half-hourly intervals, respectively) to be of most use for calculating potential renewable energy output. Furthermore, the data needs to be in a format easily and freely accessed and over a historical period of say a decade, through to the present. Projections of effects on these resources, due to climate change, are further considerations.

5.4 Revise Regulatory Framework to Specifically Promote and Subsidise Implementation of RE

5.4.1 Short Term Regulatory issues to be resolved:

Regulatory change is required to ensure a dedicated queue for grid and generation access for renewables, as under present pricing, renewables cannot compete with the relatively low cost of fossil fuel generation.

The major constraint of network access for generation is a constant issue with intermittent renewables, and a coordinated effort is needed between Western Power and Verve Energy (and other large-scale generators) to determine where capacity exists to add more generation.

It is accepted that much wind and other energy is available north of Perth to Geraldton, and an upgrade of the Eneabba- Geraldton line is critical to providing access for this new generation. Market constraints to penetration of wind and other intermittent generation are partly a result of independent generators supplying third-party loads who quarantine their energy 24/7. This forces Verve to take up all variability of intermittent generators. Market rules changes are needed to make independent generators modulate (turn down or up) output as well. A system of signals is required to allow increase in intermittent generation.

Capacity payments need to be reviewed to encourage installation of storage (thermal, pumped hydro, or otherwise) to provide more predictable and constant output.

5.4.2 Other Regulatory Options

The introduction of feed-in tariffs for renewable energy is required to stimulate the market by creating an attractive economic environment. For example, the UK provides Renewable Obligation Certificates (ROC) for each MWh generated, however, unlike the Australian renewable energy credit (REC) each ROC is valued at the same as the wholesale value of a MWh and some technologies can attract double or triple ROCs. This means that a renewable energy generator can receive 2-4 times the revenue from the generation of renewable electricity when compared to non-renewable generators.

The MRET needs to be adhered to so that the 20% renewable energy generation is indeed achieved in WA, and not instead by purchasing RECs from other states.

Regulations are required to ensure that sufficient grid capacity and intelligence, as well as sufficient complementary renewables and measures discussed in section 4, are in place to allow an increase in penetration of renewables.

5.5 Grid Upgrade, Stability & Interactive Smarts

Information gleaned from various sources, including Verve Energy, Western Power, Curtin University Sustainability Policy Institute (CUSP) is incorporated into the following discussion and proposals. These items are all important components in an system to allow maximum use of renewable energy.

5.5.1 Current SWIS Grid Design and Capacity Constraints:

Most of the existing infrastructure was set up for large generation in the Muja (Collie) area. Any change in the generation pattern, even if baseload/frequency controlled (such as biomass, solar thermal with storage, wave, geothermal), will incur added cost. Therefore a short term method to increase renewable generation would be to first add baseload renewables in the Muja area. This could be complemented with other intermittent renewables limited by an acceptable ratio of intermittent-to-baseload/load following, to continue to provide a stable system.

To allow access for significant renewable energy generation, the requisite transmission infrastructure must be developed for a combination of sources concurrently, such as; 50 MW of geothermal, 100 MW of wind, 50 MW of solar thermal (with storage) and 100 MW of any renewable/s with baseload/load following ability. Such a plan improves the economic case for installing transmission lines to handle the energy upgrade. At the moment small wind farms, biomass and solar plants are being added to lines already at capacity, which limits the available areas for sustainable energy expansion.

5.5.2 ***Ratio of Baseload-to-Intermittent Generation and System Stability:***

To ensure the grid AC frequency is sufficiently stable, it is necessary to maintain a minimum ratio of spinning inertial energy in the generators, relative to the variable load demand on the grid. For example, if a 330MW generator drops out, there must be 60% of this maximum trippable load in spinning reserve, i.e.200MW idling. If a trip does occur, gas will come on within a few seconds to take up the load. The inertia prevents the frequency from dropping in those few seconds. If there is not enough gas to take up the load, the system will go into staged load shedding.

Likewise with intermittent renewables such as wind, a certain minimum ratio of baseload-to-intermittent generation is needed for system stability. However, other renewables such as solar thermal with storage, geothermal, pumped hydro and wave energy can perform the function of baseload supply in order to complement wind.

5.5.3 ***Demand-Side Management (DSM) & Smart grid:***

In addition to varying generation output to match load demand, it is also advantageous to be able to adjust the load demand to match the available generation supply of wind or solar. As such, it essentially could reduce the need for baseload power.

Demand-side management (DSM) refers to the active control of loads by a central system management coordinator. It must be capable of load shedding/adding to respond to both slow and very rapid load changes, in order to be useful in reducing the need for baseload power.

A slow response example would be to an increasing demand for air-conditioning.

A rapid response would be to an unanticipated step load such as a sudden generator failure, without warning. CUSP and other institutions' work on DSM by modulation of electric vehicles' (EVs) charging (referred to as “Negawatts”), can help meet this need.

Western Power and Synergy are presently implementing a second, larger trial of DSM in Perth based on the success of the first trial in the western suburbs.

5.5.4 ***Grid Energy Storage:***

The use of energy storage is of high value to complement the use of intermittent renewables such as solar and wind. The release of stored energy must have some or all of the following characteristics:

- Rapid response rate
- Adequate amount to meet demand for a period of time
- Able to be cycled frequently over the output range without being damaged

The following examples illustrate the potential which exists to provide storage:

Pumped hydro-electric: Verve is investigating the potential for use of pumped hydro storage at a local reservoir and two others with 200 MW and 100MW power output, respectively, for 8-10 hours duration. Hydroelectric power has a rapid response, is predictable, stable and is able to withstand cycling.

Pumped air storage: Duke Energy Generation Services who are installing 5GW of wind systems in the USA, are developing pumped utility-scale underground air storage to complement wind energy systems and are projecting an overall storage efficiency of 70%. (Ref: http://www.bizjournals.com/charlotte/blog/power_city/2010/02/duke_energy_puts_venture_money_in_storage_project.html) Characteristics are similar to pumped hydro.

Electric Vehicle Fleet batteries: CUSP's work in the area of Vehicle-to-grid (V2G) includes the use of EVs' energy storage in their batteries. Given that EVs typically have 20kW-hr or more of energy each, a fleet of 250,000 vehicles would have a total capacity of 5 GW-hrs. If only 15% of this were available to draw on it would be 750 MW-hrs. Batteries and electronic management systems used in this manner have a long cycle life (relative to their normal EV use) and respond extremely rapidly.

Other options include flywheel energy storage systems, (such Beacon Energy's) essentially to provide spinning inertia for relatively short periods to smooth rapidly changing loads and generation supply.

5.6 'Direct' Energy Use

While much of this discussion is on electrical energy, which is a "high-grade" form of energy, it is not necessarily needed for many applications, and is more expensive due to conversion inefficiencies derived from the original energy form (i.e. Heat).

There are numerous applications which can make direct use of renewable energy such as heat from geothermal, solar, or biomass. Their use is well proven in applications such as heating water, desalinating water, residential and commercial heating and process heating.

Examples of direct uses of energy include:

Comfort and process heating: by wood/biomass combustion or low-temperature geothermal heat. The city of Reykjavik, Finland heats 95% of the houses with geothermal heat, and likewise, Unterhachen, Germany obtains 40MW worth of heating, as well as producing 3.3MW of electricity. Solar-passive building design uses the direct heating and cooling of solar and wind to reduce energy consumption dramatically. Perth's climate is such that it is possible to maintain comfortable temperatures year-round with only very small amounts of energy required at certain times/extremes.

De-salination: Thermal multi-effect distillation by IDE Technologies (http://www.ide-tech.com/products-and-services/thermal-distillation). The CETO wave energy system is able to directly use the water pressure from it's generators against a reverse-osmosis membrane for desalination.

Cooling and air conditioning: The University of Western Australia's air-conditioning system is being implemented using geothermal heat energy in the absorption-method chilling process.

Water and Pool Heating: Solar hot water systems are extremely effective in most of WA, typically providing between 70-80% of the annual water heating energy for a residence. Perth's Claremont Aquatic Centre uses low-temperature geothermally heated water (43℃) from 864 m depth below ground. About ten other pools in Perth are similarly heated for year-round operation.

5.7 Cogeneration or Combined Heat and Power (CHP)

The 'waste heat' from high-grade thermal energy such as that from fossil or biomass combustion, concentrated solar or other high-temperature sources can be used for applications that only require lower temperatures. This is a common, proven and very effective way to extract the maximum amount of energy from the primary supply.

Like 'direct' use of low temperature thermal energy, CHP can and is used for the same applications.

5.8 Renewable Energy 'Co-firing' with Fossil Generation

As a 'transition' strategy from fossil generation to renewables, it may be possible to retrofit existing coal and gas plants with the ability to use concentrated-solar, biomass and/or geothermal resources to provide some of the thermal energy for steam production for power generation. Solar co-firing has been demonstrated at the Liddell coal power station in NSW, using the Solar Heat and Power 'Compact Linear Fresnel Reflector' (CLFR) technology developed by Dr David Mills of UNSW, and now being carried forward by AUSRA in the USA and Australia.

SEN cautions that while this is a possible transition strategy, there is a risk that it may further entrench our dependency on fossil fuels, unless there is a regulated phase-out to renewables. SEN does not recommend co-firing for any new generation facilities as the capital investment will discourage any effort to shut down fossil generation ahead of its design life, and therefore delay transition to renewables.

5.9 Waste Reduction, Efficiency Gains and Education/Awareness

It is commonly estimated that society could reduce energy waste by up to 25%, and this would be largely a result of simply reducing unnecessary energy use and losses, plus behavioural changes.

Examples of unnecessary use or waste of energy include:

- Building windows and doors left open with heating and cooling in operation.
- Excessive street and other lighting need only used when and where needed. (Safety issues are an immediate consideration, however an study by a member of the Institute of Engineers Australia in conjunction with the Geraldton Police, on the effect of lighting vs. crime rate, found no long-term correlation in a particular suburb). Possible options to reduce energy use and light pollution include street lighting which uses sensors to detect motion and switch lights on/off as needed. This can work well with new low-energy LED street lights which the City of Joondalup is considering. Philips LUXEON LED lights are being used in Japan with an energy savings of 88%. (http://www.gizmag.com/philips-lumiled-luxeon-led-street-lighting/11195/) Costs for retrofitting would be offset by energy cost savings.
- Excessive building lighting at night in the city. The response by commercial building managers during the VIGE loss of gas provided a significant drop in energy use.

Much of the above can be addressed by education of the public, businesses and providing a feedback to them via an energy use indicator similar to the Water Corporation's daily newspaper graph, or more innovatively, an internet or other publicly accessible method.

While numerous efficiency gains are being realised, it should be noted that this can be quickly lost by incorrect or wasteful behaviour.

Other education in schools and publicly can include awareness of the cost and comfort benefits of sustainable principles and continued subsidies for:

- energy and water audits
- solar HW and PV/wind systems
- self-sustaining solar passive buildings with water capture and recycling
- water tanks of reasonable size
- low energy appliances

One of the major users of energy for residences are swimming pool pumps. It would seem that alternative options to the 4-8 hour per day pump operation should be explored.

The opportunities for waste/efficiency and behavioural gains are many and beyond the scope of this submission at this point.

5.10 Transport Options

By building infrastructure to supplement WA's energy supply for electrified public transport from multiple renewable energy sources, benefits will flow beyond the usual public transport advantages of reduced congestion and highway infrastructure, and air pollution.

The added benefits include:

- Reduced environmental damage, including greenhouse gas emissions.
- Reduced risk of health issues from emissions of mercury, sulphur-dioxide and nitrogen oxides from conventional fossil-generated electricity.
- Security and robustness of energy supply for transport networks by use of multiple and dispersed renewable energies.
- Plentiful energy supply, independent and insulated from future fossil fuel cost rises and, in fact an energy cost which is steadily reducing relative to our conventional fossil fuels, particularly as fossil fuel prices rise from increasing demand, the effects of peak oil and the inclusion of carbon emissions costs.
- Increased employment, in a clean energy industry for the future, particularly in rural areas.
- Increased income for rural land owners/farmers.

Designing public transport networks to connect residential areas with business and industry areas will aid in the transition from car and oil dependency to a sustainable energy future and reduced asphalt 'footprint'.

6 Conclusion

SEN trusts that the discussion, examples and proposals made in this submission provide useful input to the development of the energy systems to carry us forward into a low-carbon and more sustainable future relying upon renewable energy.

This submission has addressed the issues normally associated with the use of renewable energy with examples of methods to estimate how much and where renewable resources would be used, reliability, costing and other outcomes such as permanent job creation.

SEN strongly urges that the implementation of this strategy be based on the usual engineering project and business modelling such as SEN's computer simulation (in greater detail) in order to help optimise technical and cost outcomes. In conjunction with this, regulatory changes must be developed to drive the necessary investment and implementation within the strategic plan.

We look forward to further interaction on this ambitious and very necessary strategy.

7 Appendix:

Attachments:

- SEN submission to the Senate Inquiry into matters relating to the gas explosion at Varanus Island, Western Australia (Main document with “supplemental calculations” attached)