Repowering Port Augusta

A blueprint to replace Northern and Playford B coal power stations with renewable energy

- 1800 jobs
- Protect the health of the Port Augusta community
- 5 million tonnes of CO2 saved each year
- Lower and stable electricity prices
- Energy security for South Australia

beyond ZERO emissions

Repowering Port Augusta

Above: Abengoa PS20 power plant Spain. Courtesy Markel Rodondo

Above: Professor Ross Garnaut, Jayne Garnaut and Tony Windsor visiting the Torresol Gemasolar power plant in Spain, 2011

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1. Executive Summary

Repowering Port Augusta is a blueprint for replacing the emissions intensive Northern and Playford B brown coal power plants at Port Augusta with renewable energy. This proposal would help Australia to take advantage of our natural competitive advantage of abundant solar energy. It would enable South Australia to become a world leader in renewable energy, and Port Augusta would become an iconic global hub for baseload solar power generation.

This scenario does not include solar photovoltaic power (solar PV), as the focus is on providing baseload/ dispatchable power that solar thermal power plants are able to deliver. However either utility scale photovoltaic power plants, or solar panels on households and factories could certainly be incorporated into the mix, and there would be be cost advantages in doing so. Solar PV is a crucial renewable power source and should be encouraged at all levels of government additional to this plan.

Six solar thermal power towers and ninety five wind turbines would replace these power plants and provide secure, affordable electricity to South Australia and the Eastern Australian grid. The development would more than secure the existing 250 jobs at local power stations[1], as well creating 1,300 construction jobs and 225 manufacturing jobs for South Australia[2].

The health problems faced by the people of Port Augusta are well documented, with the region having double the number of cases of lung cancer than the expected state average according to the Health Minister[3]. Patients with lung cancer, (with no history of smoking) as well as patients with bronchitis, asthma and sinus problems are regularly treated in Port Augusta, with many blaming the power stations, and the high levels of ash in the air[3]. These health issues could be significantly reduced by transitioning to a clean renewable energy power source. The significant greenhouse gas emissions produced by coal power plants (almost 5 million tonnes per annum) would be completely eliminated.

The proposed alternative, replacing the plants with gas-fired power stations, would tie South Australia to highly volatile and increasing international gas prices. As Australian LNG export volumes increase over the next few years, the cost of gas for domestic electricity generation will move closer to international prices, and is expected to rise sharply[4]. Australian gas prices are also expected to become linked to the global oil price[5], further increasing price volatility. South Australia will begin to experience the same price volatility at the light switch that they now experience at the petrol pump.

A gas powered future would increase South Australia's dependence on unconventional gas from interstate or high cost and emissions intensive shale gas from the Cooper Basin. It would also compromise the state's energy security with the risk of exposure to catastrophic accidents like the Western Australian Varanus Island or Victorian Longford explosions of recent years, which cost lives and have caused billions of dollars damage to the respective state economies[6].

A gas powered future would also lead to a significant reduction in power generation jobs in Port Augusta. The recently completed 500MW Mortlake gas fired powered station in Victoria provides employment for only 10 full time staff[7]. Even if twice as many were employed at a larger 760 MW gas plant (enough to replace the entire capacity of Northern and Playford B), this is only a small fraction of the currently employed workforce of 250[8]. Replacement with gas would, in the best case scenario, also lock in almost 2 million tonnes of emissions[9] per annum for the next 30-50 years, and exposes Port Augusta to the environmentally controversial Coal Seam Gas. If fugitive emissions of the level being found in unconventional gas fields in the US are included[10], the emissions rate may be only marginally better than coal, and perhaps even worse.

The cost of completely replacing both power plants at Port Augusta with renewable energy as detailed in this scenario is best approached using a two-phase installation. Initially replacing Playford B with two solar thermal plants would be equivalent to a 0.7c per kWh price rise across the South Australia electricity market. Replacing Northern with solar thermal and wind in phase two would be a further 0.15c per kWh if spread across the national market. This is one 30th of the price rises predicted to occur by the AEMO out to 2013.

This proposal outlines a pathway to energy security, power price stability, increased jobs, emissions reductions and beneficial economic and health outcomes. Its stipulated outcomes prove achievable and affordable. It is a once in a generation opportunity that all South Australians, and all Australians should support. It presents an opportunity that our state and federal governments cannot afford to miss.

1 MP Dan van Holst Pellekaan, Member for Stuart, 2011, Port Augusta Power Stations, available at: http://www.danvhp.com.au/announcements/port-augusta-power-stations

2 See Appendix A

3 Sarah Mennie, 2010, Port Augusta is SA's cancer hotspot, Sunday Mail: Available at: http://www.adelaidenow.com.au/news/south-australia/port-augusta-is-sas-cancer-hotspot/story-e6frea83-1225846333836

4 SKM MMA, 2011, Gas Market Modelling for QLD Gas Market Review, Available at: http://www.deedi.qld.gov.au/energy/gas-market-rev.htm

5 Santos 2011, Investor Presentation 2011, Available at: http://www.santos.com/library/220911_Investor_Presentation_CLSA_Conference.pdf

6 Parliament of Australia (Senate), Report: Matters relating to the gas explosion at Varanus Island WA Available at: http://www.aph.gov.au/senate/committee/economics_ctte/wa_gas_08/report/c02.pdf

7 Origin Energy, Mortlake Power Station Project – Key Facts, Available at: http://www.originenergy.com.au/1376/Mortlake-Power-Station-Project

8 MP Dan van Holst Pellekaan, Member for Stuart, 2011, Port Augusta Power Stations, available at: http://www.danvhp.com.au/announcements/port-augusta-power-stations

9 See Appendix B

10 http://researchmatters.noaa.gov/news/Pages/COoilgas.aspx

2. Introduction

The Northern and Playford B power stations in Port Augusta have provided a large portion of South Australia's electricity for decades, and have made an enormous contribution to the state's prosperity. They currently provide around 40 percent of South Australia's power[11].

Increasing understanding of the health and environmental impacts of coal fired electricity generation has highlighted the need to shift away from coal[12,13]. At the same time, the global boom in renewable energy has dramatically driven down the costs of these technologies and is providing a clear alternative for baseload power generation.

The closure of Port Augusta's Playford B coal plant is on the horizon. Alinta Energy, the owner of the Northern and Playford B coal generators, has confirmed it will seek Federal funds to retire Playford B. Industry experts also believe that Northern Power Station could also be forced to close by 2015[14]

To maintain Port Augusta's status as an electricity generator and associated jobs and economic benefits, replacement infrastructure must be built. With an excellent available wind and solar resource, as well as existing transmission infrastructure, Port Augusta is ideally positioned to invest and establish itself as a renewable energy centre.

Repowering Port Augusta presents a plan to maintain Port Augusta's central role in power generation for South Australia, and the jobs and economic benefits that go with it, while eliminating the negative health and environmental impacts[15].

The plan outlines a preliminary costed scenario for replacing the Northern and Playford B coal plants with renewable energy.

11 Australian Energy Market Operator (2010), South Australian Supply and Demand Outlook, available at: http://www.aemo.com.au/planning/SASDO2011/chapters.html

12 Epstein et al, 2011, Full cost accounting for the life cycle of coal, Annals of the New York Academy of Sciences, available at: http://onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.2010.05890.x/full

13 American Lung Association, 2011, Toxic Air The Case for Cleaning Up Coal-fired Power Plants, Available at: http://www.lungusa.org/assets/documents/healthy-air/toxic-air-report.pdf

14 Kelton, G 2011, Threatened power supply paints dim future for state, The Advertiser, April 13. Available at: http://www.adelaidenow.com.au/threatened-power-supply-paints-dim-future-for-state/story-e6frea6u-1226038168485

15 Sarah Mennie, 2010, Port Augusta is SA's cancer hotspot, Sunday Mail: Available at: http://www.adelaidenow.com.au/news/south-australia/port-augusta-is-sas-cancer-hotspot/story-e6frea83-1225846333836

3. Context

3.1. Port Augusta: South Australia's Power Centre

Port Augusta has historically supplied a large proportion of South Australia's electricity demand, with the Northern and Playford B power plants. Both Northern and Playford B are fuelled by lignite (brown coal) brought to the power stations by rail from the Leigh Creek coal mine around 250kms away. The plants collectively consume around 3 million tonnes of coal each year and employ approximately 250 people, with a further 200 employed at the Leigh Creek coal mine[16].

Playford B power station was commissioned in the early 60's and is the older and smaller of the two power plants, with a nameplate capacity of 240 MW. The Northern power station was commissioned in 1989 and has a generating capacity of 520 MW. Over the past 10 years, the individual and total generation levels from the Northern and Playford B power stations have fluctuated. The Playford B power station in particular has varied significantly, running at a capacity factor as low as 0.6% in 2002-03 (effectively shut down) to as high as 50% in 2009-2010[17]. The Northern power station capacity factor has fluctuated between 80% and 95% over the same time period, and is operated as a baseload plant .

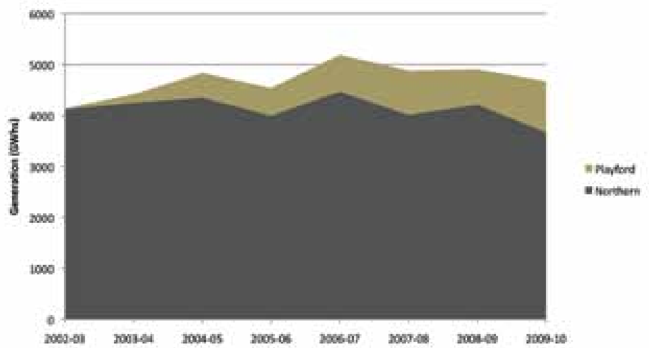


Figure 1: Output of Northern and Playford B power stations

The total output from both brown coal plants has increased from approximately 4,100 GWhrs in 2002-03 to as high as 5,200 GWhrs in 2006-7, and has fluctuated considerably[19], as can be seen in figure 1. The 2008-09 generation level (4,650 GWhrs) was selected as a basis for determining the renewable energy replacement capacity. This represents approximately 31% of the South Australian electrical energy supply requirements (and the average output), and was used in the replacement scenario proposed.

Above: Port Augusta Northern power station

16 MP Dan van Holst Pellekaan, Member for Stuart, 2011, Port Augusta Power Stations, available at: http://www.danvhp.com.au/announcements/port-augusta-power-stations

17 Australian Energy Market Operator (2010), South Australian Supply and Demand Outlook, available at: http://www.aemo.com.au/planning/SASDO2011/chapters.html

3.2. Port Augusta's Renewable Resource

There are abundant renewable energy resources in the Port Augusta region. The Direct Normal Incidence (DNI, a measure of the solar resource) is approximately kWhr/m^2/year [18] at Port Augusta. This is more than suitable for Concentrating Solar Thermal (CST), with developers typically setting a much lower minimum resource threshold (a DNI of 1900 kWh/m2/year to 2100 kWhr/m^2/year [19]). The wind resource in the area has an annual average speed of approximately 10m/sec[20], which correlates to high capacity factors (higher than 40%[21]). With wind farms in South Australia typically having capacity factors in the range of 20-40%[22], the Port Augusta wind resource is again more than appropriate for wind developments.

A two phase replacement scenario is proposed, which would reliably replace the existing baseload electricity. The first phase would replace Playford B entirely with CST, and the second phase would replace the remaining Northern plant with a combination of wind and CST.

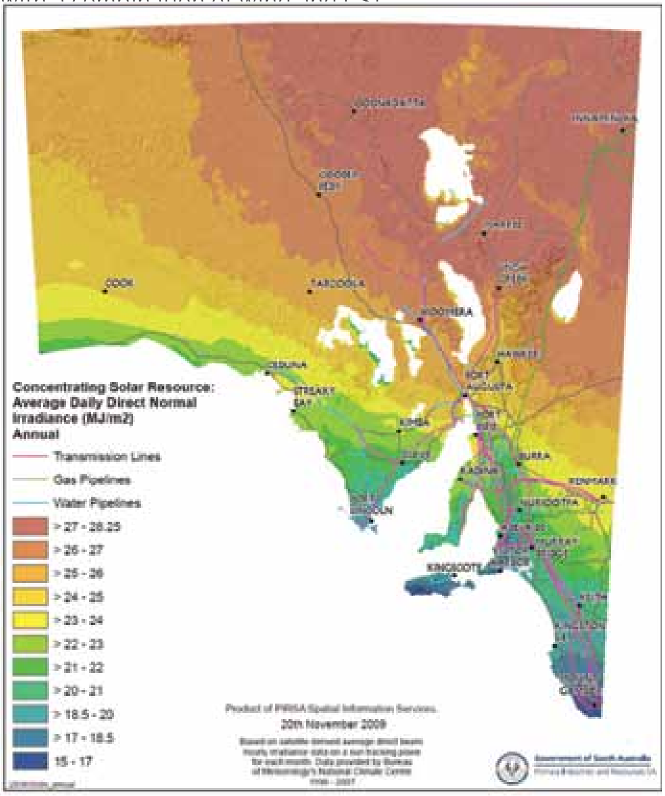


Figure 2: Solar Resource for South Australia (Direct Normal Incidence) (Source: South Australian Supply Demand Outlook, Australian Energy Market Operator)

18 Trieb, F., et al, (2009), Global Concentrating Solar Power Potentials, DLR (German Aerospace Centre), Available at: http://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-16596/

19 International Energy Agency, (2010), Technology Roadmap: Concentrating Solar Power, Available at: www.iea.org/papers/2010/csp_roadmap.pdf

20 Department of Environment Water Heritage and the Arts, 2008, 'Mean Wind Speed at 80m above ground level', Available at: http://www.environment.gov.au/settlements/renewable/atlas/pubs/mean-wind-speed.pdf

21 Electric Power Research Institute (2010), Australian Electricity Generation Technology Costs – Reference Case 2010, Department of Resources Energy and Tourism, Available at: www.ret.gov.au/energy/Documents/AEGTC%202010.pdf

22 Australian Energy Market Operator (2010), South Australian Supply and Demand Outlook, available at: http://www.aemo.com.au/planning/SASDO2011/chapters.html

3.3. Closure of Playford and Northern

Both Playford and Northern have been earmarked for closure, though timelines remain uncertain. There are number of factors contributing to their closure, including air pollution and environmental damage, increasing health impacts, diminishing coal resources, and reduced commercial viability as a result of the Clean Energy Future Package and the price on carbon.

Treasury modelling projects declining profits for brown coal generators, and indicates that emission-intensive brown coal generators will find the additional cost of the carbon price reduces their profitability (and economic viability), causing retirement[23].

Ultimately the ageing plants will be closed, with the Australian Energy Market Operator anticipating that Playford B will cease operating in 2017[24], and treasury forecasting "early closure of the most emissions intensive brown coal power stations" and "eventual retirement of all existing emission-intensive brown coal generators". Some industry experts also believe that Northern Power Station could also be forced to close by 2015[25].

Under the Clean Energy Future Package there is a 'contracts for closure program', whereby 2,000MW of dirty brown coal generation will be taken offline across Australia (and compensation paid by the government). The Playford B power plant is one of the dirtiest power plants in the country, and Alinta has submitted an Expression of Interest for Federal funds to retire Playford B, under this program[26]. It is highly likely that this plant will successfully close under the contracts for closure program, with the "Commonwealth [making] it quite plain that Playford B will have to be decommissioned"[27].

Given the need to reliably power South Australia and maintain employment opportunities in the Port Augusta region, there is a pressing need to develop new, clean and renewable power infrastructure and projects, and provide new job opportunities as the old plants are closed.

23 Australian Treasury (2011), Modelling a Carbon Price, Chapter 5 – Australia with Carbon Pricing, Federal Government of Australia, Available at: http://www.treasury.gov.au/carbonpricemodelling/content/report/09chapter5.asp

24 Australian Energy Market Operator (2011), National Transmission Network Development Plan, Supply Input Spreadsheets: Available at: http://www.aemo.com.au/planning/0418-0013.zip

25 Kelton, G 2011, Threatened power supply paints dim future for state, The Advertiser, April 13. Available at: http://www.adelaidenow.com.au/threatened-power-supply-paints-dim-future-for-state/story-e6frea6u-1226038168485

26 Department of Resources Energy and Tourism, 2012, Contracts for Closure Program, Available at: http://www.ret.gov.au/energy/clean/contract/Pages/ContractforClosure.aspx

27 Hon. Michael O'Brien MP, (South Australia's previous Energy Minister) Future of SA's power supplies at stake, Interview on Radio National ABC, transcript available at: http://www.abc.net.au/pm/content/2011/s3266745.htm

3.4. Port Augusta: Renewable Energy Super Power

The 'Zero Carbon Australia 2020 Plan' (ZCA2020)[28] outlined a roadmap for transitioning Australia to a 100% renewable powered economy within ten years. The plan illustrates the need to transition the economy from dirty coal and gas based technologies, and demonstrates how a combination of solar thermal and wind technology could achieve this.

The unique combination of geographical factors at Port Augusta creates an opportunity to begin realising the ZCA2020 plan (and a unique opportunity for developing alternative industry in Port Augusta). The cross-road created by the need to replace dirty brown coal capacity, and the local renewable energy resources presents an ideal proposition for beginning the transition to a 100% renewable energy economy. Port Augusta can facilitate the development of concentrating solar thermal technology in Australia, making it a world leading hub for baseload solar thermal power.

The following sections outline the different technologies, a scenario for replacement and the policy options available to enable its deployment.

Above: Heliostat mirrors, Torresol Gemasolar power plant, Spain. Image courtesy Markel Rodondo

28 Beyond Zero Emissions (2010), Zero Carbon Australia 2020 Plan, available at: http://media.beyondzeroemissions.org/ZCA2020_Stationary_Energy_Report_v1.pdf

4. Technology Overview

4.1. Concentrating Solar Thermal

The Port Augusta power stations, particularly Northern, generate a fairly constant amount of electricity, playing the role of "baseload" electricity generators. This means they are able to provide electricity 24 hours a day to meet consumer demand. To maintain Port Augusta's current role as a reliable energy supplier, an energy technology that can provide a consistent and reliable supply of electricity is required. Concentrating Solar Thermal (CST) power is a commercial, "off the shelf", technology that can meet this requirement. With energy storage capability, CST allows for the reliable dispatchable generation of renewable electricity 24 hours a day, and is a direct alternative to baseload coal and gas plants.

Figure 3: Gemasolar solar thermal plant in Spain

4.1.1. How solar thermal works

The basic concept of CST power is to capture the sun's energy to create heat, and create electricity using the generated heat. This is significantly different to solar photovoltaic (PV) which directly converts sunlight to electricity (using PV panels).

There are a number of different types of CST technologies, however they all operate on the same basic principle: to concentrate sunlight to a focus using mirrors, use the resultant heat to create steam, and use the steam to drive a turbine to create electricity. Solar thermal plants are in fact very similar to coal plants. Like a coal plant, a solar thermal plant uses a steam cycle to convert heat into electricity. However, instead of burning coal to create the heat, CST uses mirrors to concentrate the sun's energy. Essentially, the mirror field replaces the coal mine, and the receiver replaces the boiler, whilst the steam turbine uses exactly the same technology as existing coal fired generation plants

A key attribute and value of solar thermal technologies is the ability to readily incorporate storage technologies. Electricity itself is very difficult and expensive to store, particularly at a large scale. Heat however can be stored cost effectively and with fairly low losses over time, by heating up a storage medium and storing it in large highly insulated tanks. 'Molten salt' storage, whereby the storage medium is a salt mixture heated to a liquid, has proven to be particularly effective. Two tank molten-salt thermal storage systems are the current state-of-the-art for power towers[29].

When the sun is shining, the storage medium can be heated ('charged') by surplus solar energy which is not being used to directly create electricity. When the sun goes down, or during cloudy periods, the stored heat can be dispatched to continue the electricity generation process. Typically the heat is used to create steam, which drives a turbine, which in turn drives a generator. Electricity can thereby be dispatched as needed, to our homes, businesses and industry, while the sun isn't shining.

The energy stored by a solar thermal power plant can be dispatched quickly to provide electricity as it is required, so solar thermal power plants can also provide the same service as a gas open cycle or "peaking" plant, which is designed to provide power at times of high demand.

29 Sandia National Laboratories, 2011, Power Tower Technology Roadmap and Cost Reduction Plan, US Department of Energy, Available at: prod.sandia.gov/techlib/access-control.cgi/2011/112419.pdf

4.1.2. Case Study: Molten Salt Storage and the Gemasolar Power Plant

Industrial scale molten salt energy storage was developed by the US Department of Energy's Sandia Laboratories during their Solar Two program. This program was run by Lockheed Martin and the US National Renewable Energy Laboratories in collaboration with major industrial firms including Boeing, Bechtel Rocketdyne and others[30].

However, this technology was first deployed commercially in Spain. The Spanish engineering company SENER attached molten salt storage to a series of parabolic trough plants that were built in Spain, the first being the Andasol-1 plant that began power production at the end of 2008. As at March 2012 there are eleven 50MW parabolic trough plants each with 7.5 hours of storage operating in Spain. Torresol Energy's 20MW Gemasolar plant near Seville has applied molten salt storage in their central receiver "power tower" configuration. It stores enough energy to operate at full capacity for 17 hours without sun, allowing it to operate at full capacity for 74% of the hours of the year. This is equivalent to the capacity factor of a black coal fleet[31].

The Gemasolar Plant uses two tanks, situated at the base of the tower (see Figure 4). They both contain an industrial salt made of potassium nitrate and sodium nitrate. This salt is heated to a liquid state, and kept in the "cold" tank at about 220˚C.

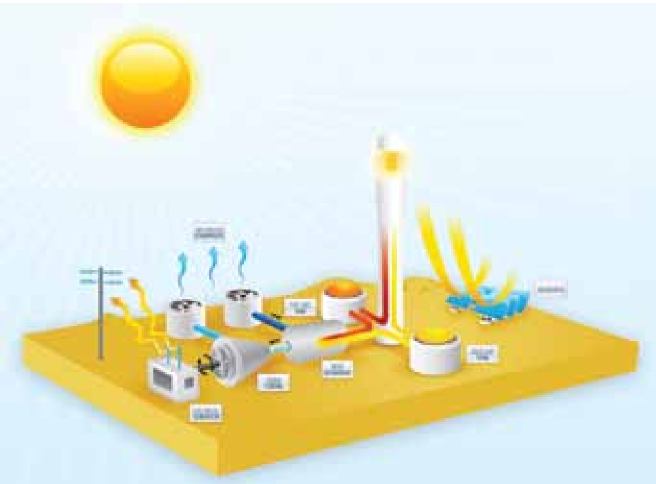
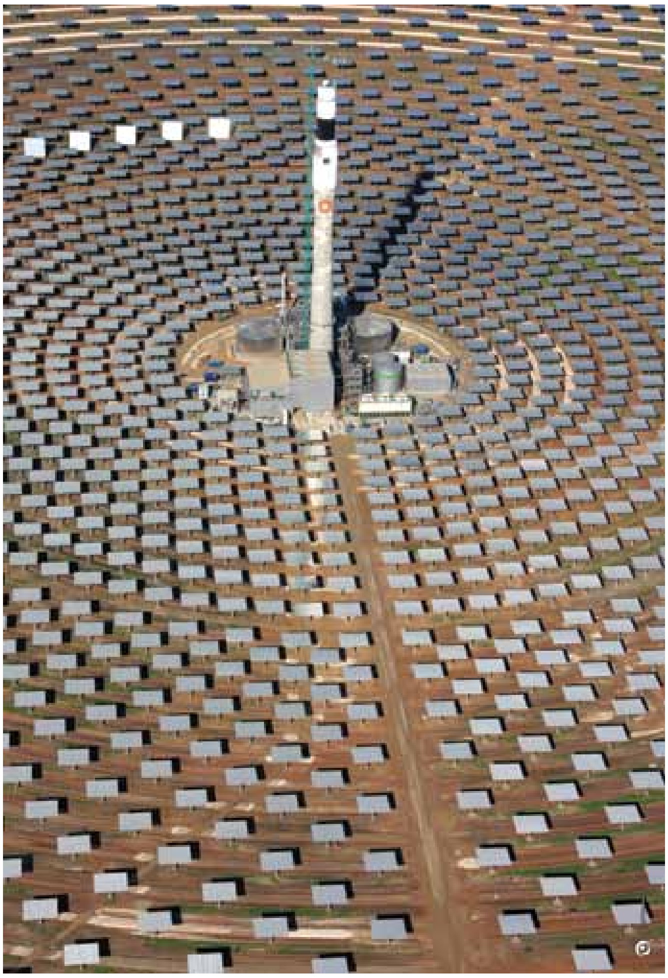


Figure 4: Diagram of a baseload CST tower plant, with molten salt storage

When the sun is shining, the liquid salt is pumped from the 'cold tank' up to the top of the tower, where it runs through a series of pipes and is heated by the concentrated solar energy focused on that point to around 565°C[32]. This a suitable temperature to run conventional steam turbines used at coal plants. It is then pumped back down to the "hot tank" and stored.

When the sun goes down, or during cloudy periods, the hot salt is sent through pipes to a heat exchanger, where it is used to heat water and create steam. This steam, created on demand, can be used to drive a turbine, which in turn drives a generator, creating consistent and reliable electricity. The Gemasolar plant has achieved uninterrupted, 24 hours a day electricity production.[33] The Gemasolar plant is able to operate at full output for 17 hours without sun.



Above: Receiver tower, storage tanks and generation infrastructure at the Torresol Gemasolar power plant, Spain. Image courtesy of Torresol Energy

30 J. Pacheco, R. Bradshaw, D. Dawson, W. De la Rosa, R. Gilbert, S. Goods, M. J. Hale, P. Jacobs, S. Jones, G. Kolb, M. Prairie, H. Reilly, S. Showalter, and L. Vant-Hull, "Final test and evaluation results from the Solar Two project," Solar Thermal Technol. Dept., Sandia Nat. Labs., NM, Tech. Rep. SAND2002-0120. [Online]. Available: http://www.osti.gov/bridge/product.biblio.jsp?osti_id=793226

31 Protermosolar, 2012. Localización de Centrales Termosolares en España (Location of Solar Thermal Power Plants in Spain) http://www.protermosolar.com/mapa.html retrieved 14 Mar 2012. Note 'almacenamiento (horas)' is 'storage (hours)'.

32 R. I. Dunn, P. J. Hearps and M. N. Wright, "Molten-Salt Power Towers: Newly Commercial Concentrating Solar Storage," Proceedings of the IEEE vol 100 (2), pp 504 – 515, Feb 2012.

33 Torresol Energy, 2011, Gemasolar Solar Power Plant Reaches-24 hours of uninterrupted production,media release, Available at: http://www.torresolenergy.com/TORRESOL/NewsTS/gemasolar-solar-power-plant-reaches-24-hours-of-uninterrupted-production

4.1.3. Types of Solar Thermal

The different types of solar thermal technology are essentially different configurations of the mirrors that focus the sun's energy, and the receivers that the sun is focused onto to collect the heat. So for instance, a parabolic trough plant has long trough shaped mirrors that focus the sun's energy onto long receivers filled with the heating fluid that run the entire length of the mirrors. Tower plants on the other hand have flat mirrors that track the sun and focus it onto a single point at the top of the tower. There are four major CST technologies available as follows:

Central Receiver System

A heliostat field, comprising flat mirrors which track the sun, concentrates the solar radiation on a receiver located on the upper part of a tall tower. Heat is transferred to a fluid (water or molten salts) generating steam that drives a turbine.

- Heliostats track the sun in two axes, so that in winter their cosine losses are much smaller than for troughs or linear fresnel concentrators. Therefore winter solar collection is higher with towers.
- Receiver fluid can operate at 565°C, and potentially 650°C, the same temperature as conventional superheated steam turbines.
- Central receiver minimises area through which heat is lost from re-radiation.
- Molten salt thermal storage has been demonstrated with power towers.

Parabolic Trough Collectors

Sunlight reflected from parabolic mirrors is concentrated onto a receiver tube, which runs parallel to the mirrors and contains a working fluid. A mature technology with over 20 years commercial history.

- Track the sun on one axis, aligned north-south in the horizontal plane.
- Operate at around 400°C currently, aiming for 550ºC with the Archimedes project.
- Use a line-focusing system (extensive piping in the field).
- Pipe plumbing requires specialised moving joints.
- Molten salt thermal storage already operational.
- Curved mirrors and specialised vacuum absorber tubes are relatively complex to manufacture.

Compact Linear Fresnel

Compact Linear Fresnel systems (CLFR) consist of multiple rows of flat mirrors that track the sun, approximating the shape of a parabolic trough. Sunlight is concentrated a long receiver which runs parallel to the mirrors and contains a working fluid.

- Tracks the sun on one axis, aligned north-south in the horizontal plane.
- Operates at 290-450°C, and can require specialized low temperature turbines.
- Line-focusing system.
- Pipe plumbing is fixed, not moving with the mirrors.
- Uses relatively flat mirrors which are cheaper to manufacture than curved troughs.
- Requires less land area than parabolic troughs as mirrors are more closely spaced.
- Molten salt thermal storage not demonstrated commercially with CLFR.

Paraboloidal Dish

A parabolic mirror in the shape of a dish collects and concentrates the solar radiation onto a small area where a receiver is located. Heat is collected from the receivers on multiple dishes and then runs a steam turbine (with or without storage).

- Tracks the sun on two axes, with a higher optical efficiency than central receivers.
- Can operate at very high temperatures (greater than 650°C).
- Yet to be proven and commercialised in terms of installation cost and scale—challenges include wind loadings in large mirror systems and complexity of construction.
- Are available in a light-weight resource-efficient design, (has the lowest resource requirements of the solar technologies).
- Energy storage is not yet demonstrated commercially, though it is compatible with molten salt storage.

4.1.4. Global Experience

The current installed capacity globally is 1.8GW[34]. Spain is leading the charge with 1300MW currently installed, a further 1,302 MW under construction and a projected additional 5,000 MW by 2020. The USA falls closely behind Spain, with over 500 MW currently installed and a further 1,000 MW under construction. India is planning 500MW (in Phase 1 Jawaharlal Nehru National Solar Mission alongside 500MW of PV) and South Africa has 600 MW under development, with an additional projected 1,200 MW in their Integrated Resource Plan out to 2020. In Morocco, there is 125-160 MW under development. According to independent consultants A.T. Kearney, under a best case scenario, there is expected to be 12,000 MW installed worldwide by 2014, and in the worst case there is expected to be 6,500MW by 2014. The industry is continuing to grow rapidly despite globally challenging economic circumstances.

The current installed capacity of CST is largely dominated by trough technology. Many of the latest projects are using Power Tower (Central Receiver) technology, similar to that used at the Spanish Gemasolar Plant. The US company 'Solar Reserve' is currently constructing a tower (with molten salt storage) with a rated output of 110MW, in its "Crescent Dunes" project in Tonopah Nevada. It also has future CST projects in the pipeline, including a 150MW tower in Rice (California) and a 50MW tower in Alcazar (Spain). Another US company (Brightsource) is also constructing 3 separate central receiver plants with a combined capacity of 392 MW, in its "Ivanpah" project in California.

Figure 5: Torresol Gemasolar plant Spain, courtesy Torresol

Figure 6: Solar Reserve Crescent Dunes project Tonopah Nevada USA [Source: SolarReserve]

Above: Andosol 1 and 2 solar thermal power plants, Spain (photo courtesy of Greenpeace)

34 Protermo Solar, Macroeconomic impact of the Solar Thermal Electricity Industry in Spain, Available at: http://www.estelasolar.eu/fileadmin/ESTELAdocs/documents/Publications/Macroeconomic_impact_of_the_Solar_Thermal_Electricity_Industry_in_Spain_Protermo_Solar_Deloitte_21x21.pdf

4.1.5. Which Solar Thermal Technology?

This proposal recommends CST power towers, with heliostat mirror fields, using molten salt as a working fluid. This recommendation is made on the basis of a number of technical advantages discussed below.

Capturing more solar energy in winter: The Projection Effect

One of the key differences between the different solar collection technologies is the ability to track the elevation of the sun (which varies with seasons), as well as the east-west daily path of the sun. The difference relates to when the sun is low in the sky in the winter time. During these periods beams of light hitting a horizontal surface are scattered over a larger area, compared to a surface at right angles to the sun's rays.

This is known as the 'projection effect'. Systems which track the sun's elevation can collect more than twice the energy per square metre of mirror surface during winter than systems which remain horizontal; the exact ratio depends upon the latitude of the site (see Figure 7 below).

A horizontal surface receives less radiation per square metre than a surface perpendicular to the sun's rays. To put it another way, a horizontal collection system requires more mirror surface (i.e. paying for more glass, steel etc) to collect the same amount of energy as an elevation-tracking system.

Parabolic trough and linear Fresnel systems do not track the sun's elevation, so receive significantly less energy in the winter months. Heliostat and paraboloidal dish systems track sun elevation, with heliostats or dishes spaced further apart to allow for shading. A dish is a near-perfect solar receiver, as it is always pointed directly at the sun. Heliostats bounce light at an angle onto a central receiver tower, and approximate the performance of a dish. They therefore lose some energy compared to a dish, but still have a much greater wintertime collection than a trough or fresnel system.

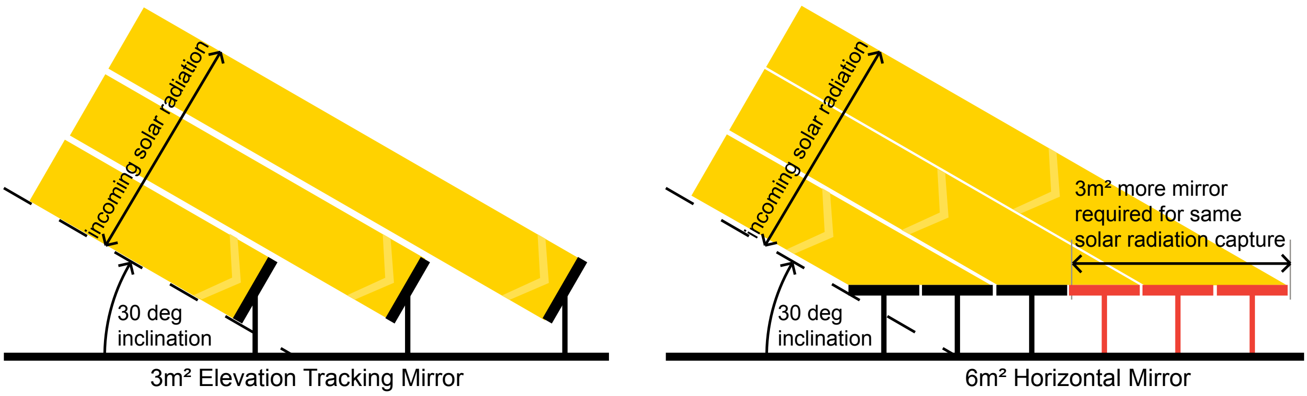


Figure 7: The Projection Effect: diagram showing the advantages of DNI collection of GHI collection

Higher Temperatures

Tower systems achieve heating temperatures between 550-565˚C; higher than parabolic trough and linear Fresnel systems, but lower than dish systems. These temperatures allow the use of standard and readily available double reheat supercritical steam turbine technology (already deployed globally in coal, gas and nuclear facilities) to generate electricity. Using standard coal plant turbine technology means "off-the-shelf" technology can be used, and ultimately results in lower costs. Higher temperatures also mean higher thermal efficiency of energy conversion to electricity, and a smaller parasitic load (for cooling) and smaller water use requirement (on a per kWhr basis).

Lower heat and parasitic losses

With parabolic troughs and linear fresnel systems, the receivers run the entire length of the mirrors, leading to far greater heat losses along the pipeline and greater parasitic losses (due to the pumping requirements). Tower systems concentrate the sun's energy onto a single point, meaning that the working fluid only needs to travel from the cold tank to the receiver at the top of the tower and back down to the cold tank. This reduces the pumping requirements (parasitic load) and the heat losses along the pipe.

Simplicity

The flat mirrors that are used in the heliostats for tower plants are simpler and more cost effective to manufacture on a large scale than parabolic trough or dish collectors.

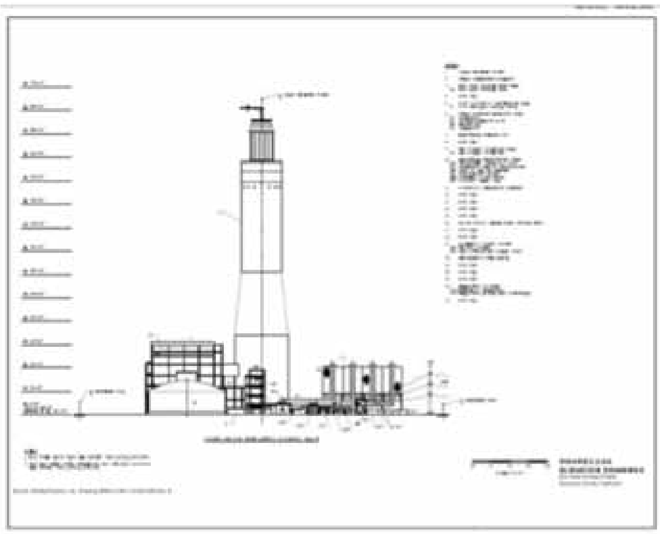


Figure 8: Schematic of Solar Reserves 150MW Power Tower [Source: SolarReserve]

4.1.6. Companies providing the technology

The main providers of this technology are:

Torresol Energy: Founded in 2008 through an alliance between SENER Grupo de Ingeniería, S.A., a Spanish multinational technology leader (with a 60% share in the company), and MASDAR, an alternative power company in Abu Dhabi (with a 40% share in Terresol Energy).

Solar Reserve: Commercialising US DoE Sandia Laboratories power tower with molten salt storage technology, currently constructing a 110MW plant in Tonopah Nevada, with plans for developments in Rice, California and Alcazar, Spain.

Brightsource: The world's leading and longest running solar thermal provider, which recently announced it would provide solar thermal tower technology with molten salt storage.

4.2. Wind Power

Wind power is the lowest cost renewable energy technology in Australia today. Wind power is not only cheap and efficient; it is also widely utilized all over the world, and well understood. The global boom in wind energy has seen significant cost reductions over the past 30 years and it is the most mature of the renewable energy technologies, with over 200 GW installed globally. International studies have shown that a high percentage of wind power can be reliably and economically integrated into the grid. Wind is currently positioned as the cheapest and most effective way to increase renewable energy generation in Australia.

4.2.1. Which Technology?

The turbines specified for Repower Port Augusta are technologically advanced 7.5 MW onshore wind turbines, such as the Enercon E-126 turbines. These are currently the largest commercially available turbines. Their size enables the extraction of more energy from a given site by tapping into stronger and more consistent wind resource at greater heights. It is favourable to use fewer large turbines than many smaller turbines as there are less moving parts to maintain. Also, and of increasing importance, the smaller number of turbines means less aesthetic impacts (and consequential community engagement issues). The Enercon E-126 has a hub height of 138 metres, and a blade diameter of 127 metres.

Figure 9: Enercon E-126 in Belgium [Source: Enercon]

4.3. Gas: A false Choice

Gas is currently being promoted as a 'clean', risk free alternative to coal[35]. This however, could not be farther from the truth. Generating electricity from gas exposes the electricity market and price to the volatility and price rises occurring in the gas market, and introduces further energy security issues. Additionally, the continued use of gas has significant environmental and greenhouse gas emission ramifications.

Context: South Australia's Gas Supply

South Australia has traditionally sourced natural gas from the Cooper and Eromanga Basins[36]. Based on current South Australian gas consumption rates this basin would be exhausted in 13 years. However, South Australia also imports gas via an interconnected pipeline network from Victoria and Queensland. Gas can flow from Queensland to South Australia via the South West Queensland Pipeline and on to the Adelaide demand centre via the Moomba to Adelaide Pipeline. Gas can also be imported to South Australia from Victoria via the South East Australia Gas Pipeline[36].

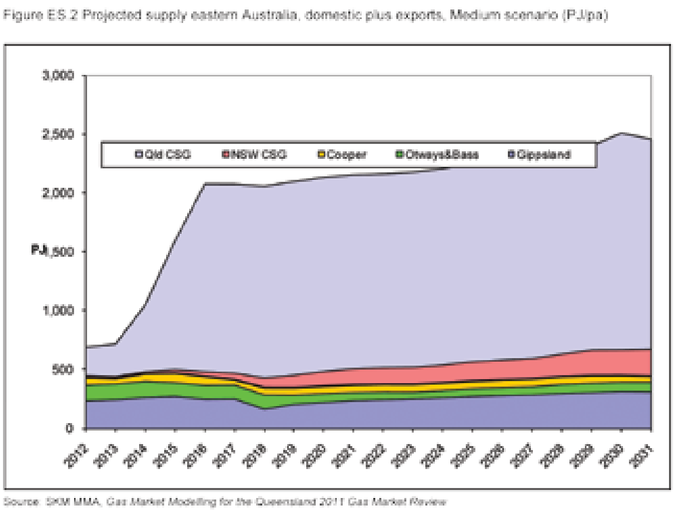


Figure 10: Projected supply of gas from eastern Australia. (Source: SKM MMA Gas Market Modelling for the Queensland 2011 Gas Market Review.)

Currently, controversial Coal Seam Gas (CSG) makes up 84% of the interstate reserves[36], and the projected supply of gas from eastern Australia is largely dominated by Queensland Coal Seam Gas (QLD CSG), (see Figure 10 below). Gas producers are currently investigating additional unconventional gas (including shale gas) resources within South Australia. There is a high likelihood that any gas used to power a new gas fired power station in Port Augusta would use this unconventional and highly controversial coal seam gas in future.

South Australia has large reserves of shale gas. Shale gas is a low grade source of energy that exists 1-2 kilometres below ground level. Given its low quality and the difficulty of extraction its use is at least twice the cost of any current gas project in Australia[37]. Once extracted, shale gas will be linked to the international prices as a result of of LNG export market. (Santos).

Above: Santos operated coal seam gas well, Pilliga State Forest, New South Wales.

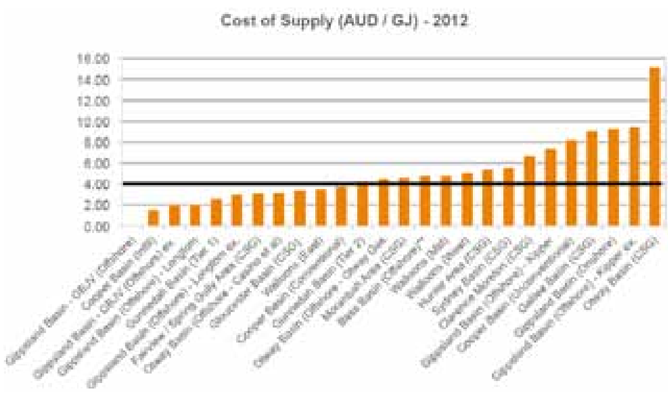


Figure 11: Comparison of costs of supplying gas across Australian basins.

35 Department Resource Energy and Tourism, (2011), Energy White Paper , available at: http://www.ret.gov.au/energy/Documents/ewp/draft-ewp-2011/Draft-EWP.pdf

36 South Australian Supply Demand Outlook, AEMO, available at: http://www.aemo.com.au/planning/SASDO2011/documents/SASDO2011.pdf

37 Gas Production Costs, (2012), Core Energy Group, www.coreenergygroup.com.au

4.3.1. Gas Price Volatility and Risk

International Parity

Australia has traditionally enjoyed low gas prices due to the abundance of gas relative to domestic demand, but the emerging LNG export industry could change this significantly. Companies producing gas for export will have little incentive to supply gas to domestic consumers for a price less than they can get from overseas export customers. The expectation is for Australian domestic gas prices to head to international parity.

The current domestic gas price in Australia is around $3-4 per GJ. In 2008 the international gas price was around $12 per GJ. Figure 12 illustrates the fluctuations and price rises in international gas prices since 1993. The variation in price between the different gas markets reflects the different sources of gas. The US gas market is called the "Henry Hub" and has been lower than other international markets over recent years due to the large supply of shale gas in that country. Japan on the other hand relies entirely on LNG imports, which are more expensive due to processing and transport costs.

Australia is currently exporting LNG into Asian markets, and this will be expanded over the coming years. This relationship drives gas prices up, consequently leading to domestic consumers and electricity generators paying prices in line with higher Asian market prices.

Above: Coal seam gas fields Wyoming USA. Gas fields similar to this are planned to cover an area of more than 20,000 square kilometres in Queensland.

Figure 12: International gas prices 1993-2010

Oil Linked Pricing

Traditionally, the global gas price has fluctuated in line with oil prices, though the correlation is not strong. In part this is because conventional gas is extracted from the same fields as oils and the same companies are extracting it. Gas companies measure their reserves in Barrels of Oil Equivalent (BOE). Currently, gas prices are moving more in line with oil prices, which introduces more volatility to the gas market (whilst increasing price).

Gas developer Santos has informed its investors that 70% of its reserves will be linked to the international oil price by 2015[37] due to increasing "production exposure to oil prices". The remaining 30% are tied-up in legacy domestic gas contracts. This implies that all new or renegotiated gas contracts to domestic consumers will be linked to climbing oil price, see Figure 13 below.

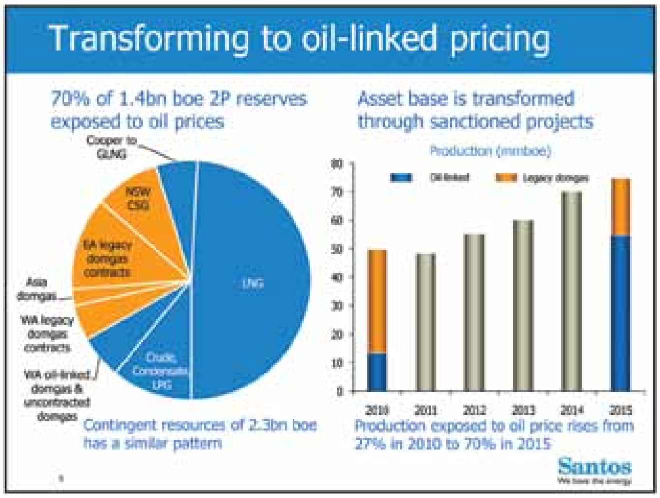


Figure 13: Oil LInked Pricing (Source: Santos)

Australian Gas Prices

SKM MMA modelling for the Queensland Government shows that eastern Australian gas prices could increase steeply to around $7- $8 per GJ over the next few years. They then predict a drop in prices in the mid-2020s as the full expansion of CSG comes on line, but then ongoing increases from the late 2020s onwards due to increasing scarcity of the reserves.

The SKM modelling considers three scenarios (High, Medium and Low), which represent both high, medium and low domestic demands and exports. In the high scenario (high demand and high exports), the price is expected to increase substantially from 2013,to over $7 per GJ (falling to $6 per GJ by 2030).

If Port Augusta (and more generally Australia) was to lock in gas power infrastructure and generation capacity (with a 50-year life technical life expectancy) then as the price of gas goes up, electricity customers will be exposed to these rising prices. This price rise is coupled with and additional to the price rise due to carbon pricing. Alternative power generation from renewables does not suffer these same price uncertainties as their feedstock (the sun or the wind) is free (and carry no emissions liability).

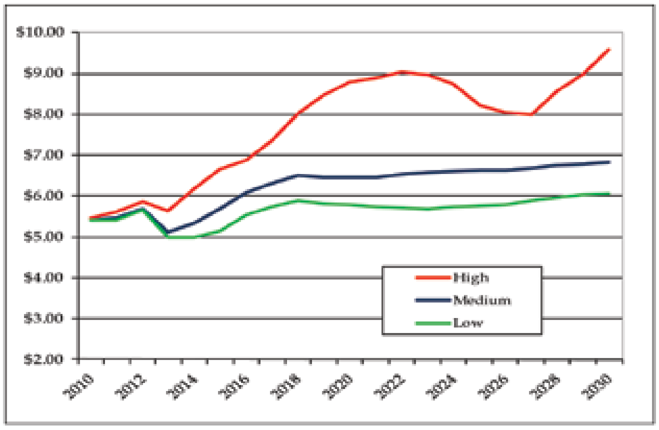


Figure 14: Project new contract prices for Southern States ($/GJ, $2010). (Source: SKM MMA Gas Market Modelling for QLD Gas Market Review[38])

38 SKM MMA, 2011, Gas Market Modelling for QLD Gas Market Review, Available at: http://www.deedi.qld.gov.au/energy/gas-market-rev.htm

4.3.2. Coal Seam Gas: Environmental Issues

The environmental risks and impacts of extracting unconventional gas have received widespread mainstream media coverage and comment in Australia. An entire standalone report could be written on this issue, however only a very brief outline of a small sample of these issues is highlighted in media coverage. The issues that have received most coverage have been the broad risks associated with the drilling for gas in coal seams, particularly with respect to water use and hydraulic fracturing. Developing a gas plant at Northern and Playford B exposes and links Port Augusta to additional environmental liabilities.

Hydraulic Fracturing

In Queensland, where the vast majority of CSG will be extracted, the state government and industry has said that between 10 per cent and 40 per cent of the estimated 35,000 wells to be drilled there will need to be "fracked"[39]. Hydraulic fracturing involves a mix of water, chemicals and sand being pumped into the coal seams to further open fissures between the coal rock to allow the gas to flow more freely. The air, soil and water can also be polluted with fracking chemicals as a by-product of the extraction process[40]. Volatile compounds found in coal gas seams are also released as a result of the process, including benzene, toluene, ethylbenzene, xylene (BTEX). BTEX chemicals are hazardous in the short term, causing skin irritations and problems in the central nervous system.

The fracking process can release BTEX from the natural-gas reservoirs, which can then penetrate into the groundwater aquifers or volatilise into air[40]. Landowners and campaigners say these toxic chemicals are not being fully disclosed and present significant contamination risks to groundwater aquifers.

Water

All coal seam gas mining involves contaminated water. In order to access CSG , the water trapping it there must be extracted. This water is high in salt - which kills the productive quality of soil - and methane. It can also contain toxic and radioactive compounds and heavy metals.

The CSG industry will be an enormous user of water. The Federal Government's Water Group estimates - based on modelling of industry figures - that the CSG industry will use 5,400 gigalitres of water per year. By comparison Australia's annual household water use is 1,872 gigalitres per year.

4.3.3. Greenhouse Gas Emissions

Gas is a fossil fuel, and as such, replacing Northern and Playford B with gas will still result in Port Augusta generating greenhouse gases, and contributing to Australia's carbon emissions. The direct emissions from the combustion of gas will be lower than those produced by brown coal. However, when taking the lifecycle emissions into consideration, the emission savings are potentially non-consequential and questionable.

There are significant uncertainties relating to the lifecycle emissions (including fugitive emissions, venting and flaring and other processing emissions) for all gas types, but particularly when considering and unconventional gas, such as Coal Seam Gas.

Fugitive emissions

Generally speaking, fugitive emissions are those relating to leaks or uncontrolled venting throughout the extraction and production process. These emissions are in the form of methane which when released into the atmosphere has 23 times the impact (Global Warming Potential, GWP) of carbon dioxide if its impact is averaged over a 100 year period. Over a shorter time - 20 years- the GWP for methane is 72. (NASA research[43] in 2009 suggests a higher GWP of 105.) The 20-year time horizon is more relevant, as the global climate tipping points will have been reached far earlier than 100 years from now (if we continue using gas, coal and other fossil fuels).

The rate of fugitive emissions is largely unknown, and will vary project to project and pipeline to pipeline. These fugitive emissions have the potential to be significant, with (for example) leaks in the Adelaide distribution network alone being reported to be as high as 7.8%.[41]

39 Readfearn G, 2011, Coal seam groundwater concerns, ABC online, Available at: http://www.abc.net.au/environment/articles/2011/03/22/3169602.htm

40 National Toxics Network, Hydraulic Fracturing in Coal Seam Gas Mining: The Risks to Our Health, Communities, Environment and Climate, available at: http://ntn.org.au/wp-content/uploads/2011/02/NTN-Fracking-Briefing-Paper-2011.pdf

41 South Australia Energy Supply Industry 2009/10, Annual Performance Report, Available at: http://www.escosa.sa.gov.au/library/101124-AnnualPerformanceReport_2009-10.pdf

Fugitive Emissions of Coal Seam Gas

Currently the fugitive emissions of CSG are uncertain (and consequently so are the lifecycle emissions of electricity generated from CSG). There has been very little research conducted anywhere in the world to quantify the fugitive emissions associated with "unconventional" gas production. However, the large number of wells per-unit of gas extracted, (relative to conventional gas), makes it likely that there will be significantly higher fugitive emissions from unconventional coal seam gas than conventional gas.

In Wyoming, in the United States, fugitive emissions from unconventional gas have been found to be up to 30% well yield, and 15% of total field yield[42]. A very recent study by the National Oceanic and Atmospheric Administration (NOAA) in the US based on actual measurements of unconventional gas emissions in Denver, has found rates of fugitive emissions up to 7.7% across the unconventional fields[43]. Major CSG projects being developed in Australia, on the other hand, have assumed extremely optimistic and unverified levels of fugitive emissions of around 0.1%[44].

Figure 15 below shows the impact the fugitive emissions have on the lifecycle emissions of gas fire electricity (Combined Cycle Gas Turbine, assuming 50% thermal efficiency).

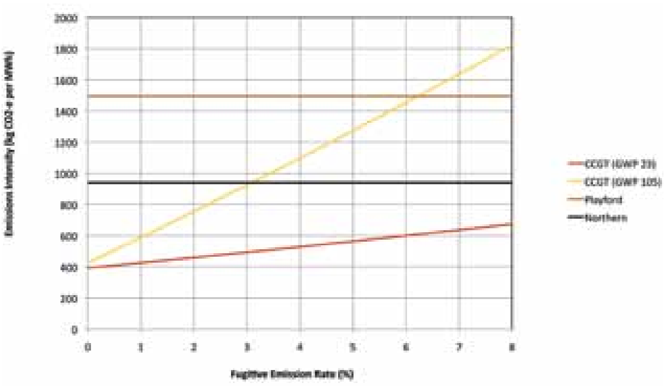


Figure 15: Lifecylce Emissions Intensity as a function of Fugitive Emission Rate

42 HyCap Energy LLC 2010, CBM Gas Separator, Available at: http://www.hycapenergy.com/CBM_Separator.pdf

43 Tollesfson, J 2012, Air sampling reveals high emissions from gas field, Nature, Available at: http://www.nature.com/news/air-sampling-reveals-high-emissions-from-gas-field-1.9982

44 Citigroup, Coal Seam Gas & Greenhouse Emissions 17 August, p13.

Locking in Emissions

The Playford B plant has been operating for 50 years. The technical lifetime of a new gas plant is also 50 years (with an effective life perhaps longer), and it can be expected that (once built) the plant would be operated for this amount of time. No investor would construct a new Combined Cycle Gas Turbine (CCGT), with the knowledge that the plant will be closed in (say) 10 years, well short of its economic or technical life time. Thus, by constructing a new CCGT, emissions would be locked in for (at least) the economic lifetime, and most likely the technical lifetime. In the best case scenario, assuming no fugitive emissions (and a combustion only emissions intensity of around 400kg/MWh[45]), replacing Playford B and Northern with 760 MW of CCGT (and generating the same annual output) would lock in a total of 93 million tonnes over its lifetime. If however the fugitive emissions are 4% as suggested by the NOAA study, the emissions intensity would be worse than the Northern plant, using the 20 year Global Warming Potential factor for gas. The total carbon dioxide equivalents emitted would be 256 million tonnes; worse than leaving the Northern plant operating.

4.3.4. Gas generation and job losses

The limited employment opportunities for gas fired power plants would result in a significant job loss in the Port Augusta community. A gas plant would provide 76 permanent jobs, compared to the current 250 working at the coal plants. Concentrated solar thermal and wind would create 360 permanent jobs. In terms of employment in construction and manufacturing the Repower Port Augusta proposal is also beneficial, with 1300 construction jobs and 225 manufacturing jobs over the 6 year construction period. This compares with only 380 construction jobs in gas (over two year period), with no manufacturing jobs as the components for the gas plant will be imported.

4.3.5. Energy Security

Introduction of baseload CCGT could present significant health, safety and security issues to South Australia. In recent years, Australia has been faced with significant loss of gas-based electricity supply, along with substantial health and safety incidents affecting a significant portion of the community. In particular, a major gas explosion occurred at the Varanus Island processing facility, located about 115 km off Dampier in the North West of Western Australia in 2008. This explosion caused the 2008 Western Australian Gas Crisis, with gas supply from the Varanus plant (which usually supplies 30% of Western Australia's domestic gas[46]) cut for two whole months.

45 ACIL Tasman, 2009, Fuel resource, new entry and generation costs in the NEM, available at: http://www.aemo.com.au/planning/419-0035.pdf

46 Department of Mines and Petroleum, Government of WA, Varanus Island Incident, Available at: http://www.dmp.wa.gov.au/7202.aspx

Figure 16: The explosion at the Varanus Island gas hub cut Western Australia's gas supplies for months

The gas shortage had a significant impact on Western Australian industry, due to the state's heavy reliance on a continuous gas supply for industrial processing, manufacturing and electricity production. According to the Chamber of Commerce and Industry of Western Australia, the cost of the crisis to the Western Australian Economy was $2.4 billion in the 2 months of the cut supply alone[47], with other reports suggesting the overall total cost could be as high as $6.7 billion[48]. A Chamber of Commerce and Industry survey found that 50% of business had been affected by the incidence (with 17% directly affected and a further 33% indirectly affected51). Production declined by an average of just over 30% for the businesses affected by the outage.

The Varanus Island explosion is not an isolated incident. The catastrophic explosion of the Longford gas processing plant in Victoria in 1998 resulted in the death of two workers and had a similar impact on the Victorian economy. An explosion at South Australia's Moomba gas fields in 2004 cut off gas supplies from the Moomba gas fields.

Developing further gas infrastructure and gas electricity generation in Port Augusta will increase South Australia's reliance and dependence on gas in the longer term. South Australian gas consumption was approximately 105 PJ in 2010, (61% of which was used for electricity generation)[49]. Increasing this dependency represents an energy security risk, exposing industry and the public to potential gas incidences which could have a significant impact on South Australia's economy. The risks to energy security and the economy are further exposed by the impact of exporting gas, and the associated international and oil linked pricing, (and even the price risks associated with correct accounting of fugitive emissions).

47 Parliament of Australia (Senate), Report: Matters relating to the gas explosion at Varanus Island WA Available at: http://www.aph.gov.au/senate/committee/economics_ctte/wa_gas_08/report/c02.pdf

48 WA faces $6.7b gas bill, The Age, July 10, 2008. Available at: http://www.smh.com.au/business/wa-faces-67b-gas-bill-20080710-3cxn.html

49 South Australian Supply Demand Outlook (2010), AEMO, available at: http://www.aemo.com.au/planning/SASDO2011/documents/SASDO2011.pdf

5. Repowering Port Augusta

Above: Enercon E126 7.5 MW wind turbines at Estinnes, Belgium. Courtesy Enercon

The following scenario outlines how both the capacity and energy generation of the Northern and Playford B could be replaced with a combination of Solar Thermal and Wind. The objective of the scenario is to present how to maintain the capacity of the supply at 760 MW (equivalent to existing capacity) and deliver a total of 4,650 MWhrs of electricity (equivalent to the average annual output of the Northern and Playford B Power stations).

5.1. Technologies and Specifications

The replacement scenario utilizes central receiver power towers and wind turbines, for reasons previously discussed. For this analysis, we have used the Solar Reserve module plant design as a rough basis for CST tower calculations, and the Enercon E-126 for wind calculations.

5.1.1. Concentrating Solar Thermal

The Solar Reserve plant modules are designed to deliver roughly 480GWhrs to the grid annually. The specific configuration of the plants however can vary. For example, the Tonopah plant has a nameplate capacity of 110MW, and capacity factor of 50%[50], whilst the Rice plant has a nameplate capacity of 150MW and a capacity factor of roughly 35%[51]. Each CST plant consists of a 180 meter high tower surrounded by a mirror field extending around a kilometre from the tower at its widest point. Each plant would contain around 17,000 mirrors, each about 140 square meters in size (that individually track the sun). These plants are assumed to have a 2.5 year construction timeline.

50 Solar Reserve, 2012, Tonopah Solar, Available at: http://www.tonopahsolar.com/

51 Solar Reserve, 2012, Rice Solar Energy Project, Available at: http://www.ricesolarenergy.com/

Above: Heliostat mirrors and central tower reciever at the Torresol Gemasolar power plant, Spain. Image courtesy of Markel Rodondo.

5.1.2. Wind

Each of the Enercon E-126 wind turbines has a nameplate capacity of 7.5MW. Given the significant wind resources found in and around Port Augusta, wind turbines could be expected to have higher capacity factors (greater than 40%[52]) than a typical average capacity factors 30%[53]. As a conservative assumption, it was assumed that the wind turbines and wind farm(s) would only have a capacity factor of 30%.

5.2. Implementing the Replacement

This scenario proposes two phases: Phase 1 would replace the Playford B power station with concentrating solar thermal, and Phase 2 would replace the remaining Northern Power Station with a combination of wind and concentrating solar thermal.

The two phased approach will allow the plants to be replaced in a stage-wise approach, which has some developmental advantages. Firstly, replacing the smaller, older and dirtier plant first will allow 'First of a Kind' (for Australia) solar thermal power tower plants to be built, at a minimised cost. The corresponding experience and potential cost reductions (through "learning by doing") could then flow through to the second phase of the project.

The later plants can leverage existing manufacturing capacity and experience, leading to a more cost efficient development. Replacing the entire Northern and Playford B capacity with 'First of a Kind' plants, would be more expensive. Secondly, at present, there is limited capacity for new wind generation in South Australia due to transmission and distribution limitations. Replacing the dirty, inflexible brown coal Playford B plant with highly responsive and dispatchable solar thermal plants will allow additional wind capacity to be constructed. Early deployment of the load following CST technology can leverage additional (and cheaper) wind power in an otherwise wind constrained grid.

52 Electric Power Research Institute (2010), Australian Electricity Generation Technology Costs – Reference Case 2010, Department of Resources Energy and Tourism, Available at: www.ret.gov.au/energy/Documents/AEGTC%202010.pdf

53 Australian Energy Market Operator (2010), South Australian Supply and Demand Outlook, available at: http://www.aemo.com.au/planning/SASDO2011/chapters.html

5.2.1. Phase 1: Replacing Playford B with Concentrating Solar Thermal

The first phase would replace the 240 MW of the Playford B power station, made up of four 60MW units. This would be achieved with only two power towers. If plants similar to the Solar Reserve Tonopah project were used, two plants would have a nameplate capacity of 220 MW and would deliver over 960 GWhrs of energy. This would annually deliver more energy than is currently delivered by Playford B (but would have a slightly lower capacity). Table 1 below shows the outcome of phase 1.

Table 1: Summary of phase 1

Stage	Technology	Installed Capacity	Deliverable Energy
Phase 1	CST	220 MW	960 GWh/yr

5.2.2. Phase 2: Replacing Northern with Concentrating Solar Thermal and Wind

The second phase would replace the 520 MW Northern power station, (which consists of two 260 MW units), and delivers roughly 4000 GWh of electricity annually - completing the replacement of the existing brown coal generation. This is to be achieved through a combination of both CST and wind.

The overall replacement scenario is designed on the basis that 40%[54] of the total generation output from both Playford B and Northern is replaced by wind, representing 1,840 GWh/year. Based on the conservative 30% capacity factor, this corresponds to a total installed wind capacity of 700MW.

Based on this assumption, the additional solar thermal need only deliver a further 1,850 GWh. In order to maintain the same total 760 MW capacity (to replace both Playford B and Northern, even when the wind isn't blowing) 540 MW of CST capacity is required in addition to the 220 MW of CST specified in phase 1. Four Solar Towers (based on the SolarReserve Tower design) with 135 MW nameplate capacity and 40% capacity factor can be used to achieve this. Table 2 below summarizes the outcome of phase 2.

Table 2: Summary of phase 2

Stage	Technology	Installed Capacity	Deliverable Energy
Phase 1	CST	540 MW	1850 GWhrs/yr
	Wind	700 MW	1840 GWhrs/yr

54 This scenario, similar to the ZCA plan, proposes the highest percentage of wind power that can be reliably and economically integrated into the grid. Research undertaken for the National Grid U.K. suggests that wind variability is not a significant barrier to wind penetration of up to and above 40%. It is assumed for the purpose of this analysis that this penetration is appropriate for the local grid at Port Augusta.

5.2.3. Completion

On completion of both phases, there would be a total of six solar thermal power towers based on SolarReserve modules (equivalent molten salt power towers from other companies could also be used). This would include two plants similar to the Tonapah plant (110 MW capacity and 50% capacity factor), and four based on a module (130 MW and 40% capacity factor), giving a total capacity of 760 MW and output of 2,810 GWh per year. Similarly a total of 95 Enercon E-126 turbines would be constructed to deliver approximately 1840 GWh of energy per year. Table 3 below summarizes the complete replacement scenario.

Table 3: Summary of Replacement Scenario

Stage	Technology	Deliverable Energy
Phase 1	CST	960 GWh/yr
Phase 2	CST	1850 GWh/yr
	Wind	1840 GWh/yr
Total		4650 GWh/yr

5.2.4. The Grid

The current Playford B and Northern power stations are essentially connected to the 275kV line which forms the back bone of the South Australian grid, with a major sub-station ('Davenport') at Port Augusta. This line connects this major power production region to Adelaide (the major power population centre in South Australia) and also to the interconnectors into the other States.

The Australian Energy Market Operator's National Transmission Network Development Plan[55] suggests that overloading of this line is unlikely to occur in within the next 20 years. The plan indicated that this transmission line may need to be upgraded in the period 2025-2030 only under a very particular set of circumstances; in one of the 10 scenarios that they model. This scenario incorporates a medium carbon price scenario (we are currently tracking the low carbon price scenario) and "Fast Rate of Change" (a world where relatively strong emission reduction targets have been agreed internationally by both developed and developing countries, and high sustained economic growth). It is therefore unlikely that major transmission grid up grades (e.g. long distance HVAC/HVDC lines) would be required, particularly given that over the course of the project, two major plants would be taken off line. This underlies the basis for our proposed development capacity.

Minor grid additions may however be required to facilitate the proposed development (particularly the wind development). The cost is unlikely to be a significant, compared with the total investment, due to the relative location of the renewable resources to existing transmission infrastructure.

55 AEMO's National Transmission Network Development Plan 2011. Available at: http://www.aemo.com.au/planning/NTNDP2011_CD/chapters.html

5.2.5. Design Limitations

This is a preliminary design of the approximate wind and CST capacity required to replace the existing brown coal generation capacity. The figures presented are intended to illustrate that both the peak capacity and annual energy generation can be easily replaced with CST and wind. Further work could find a more optimized generation mix (i.e. wind to CST ratio) to better serve South Australia and Port Augusta's requirements. Similarly, the configuration (storage and turbine size) could be optimised better and subjected to intensive analysis of localised conditions. For example, some of the plants could be designed in a more baseload style configuration (e.g. 75 MW nameplate capacity, 75% capacity factor), or more like 'peakers' (e.g. 150MW nameplate capacity, and 35% capacity similar to Solar Reserves 'Rice' project)

5.3. Environmental Impacts

5.3.1. Water use

The sustainable yield of surface water in the Port Augusta region is 6 GL/yr, although the highly variable runoff means that the supply is fairly unreliable[56]. Therefore, the plants selected and constructed would be air cooled, to significantly reduce water consumption.

However, a significant amount of water is used in the steam cycle, and for cleaning mirrors (to maintain efficiency). Water use would be in the order of 0.74 GL/yr which is approximately 15% of the surface water in Port Augusta. This is roughly equivalent to the current fresh water use of the existing coal plants.

5.3.2. Land area

Each of the 110MW solar modules would have a mirror field extending around 1km from the central tower at its furthest point. The entire site would take up a total land area 650 Ha[57]. The total land area required for all 6 modules would be around 3900 Ha (or around 16 square kilometres, (equivalent to a block of land 4 km by 4 km).

There is an impact on vegetation in the land used by solar thermal plant construction. The heliostat mirrors and power block have concrete foundations. There are also access roads and some other associated infrastructure.

However, the site does not have to be graded, as the height of the heliostats can be adjusted on their supports to maintain the correct level. Land with less than a 5 percent overall gradient overall is acceptable. Appropriate sites would need to be carefully chosen to minimise impact in line with regulatory processes applicable to all industrial developments.

5.3.3. Lifecycle emissions

The lifecycle emissions for CST, including those produced in commissioning the solar thermal plants (materials, construction, etc.) and the ongoing operation and maintenance are 20g CO2-e per kWhr[62]. The emissions from construction and decommissioning represent the majority of total lifecycle greenhouse gas emissions[58] and the operating emissions are close to zero. The annual emissions alone from the existing coal plants are around 5 million tonnes each year.[59]

Above: Abengoa PS20 power plant, Spain

Above: RHS Ariel view of Torrsol Gemasolar power plant, Spain, Image courtesy of Torresol Energy

56 Surface Water Management Authority: Mambray Coast, Water Resource Availability, Available at: http://www.anra.gov.au/topics/water/availability/sa/basin-mambray-coast.html

57 Solar Reserve, 2012, Tonopah Solar, Available at: http://www.tonopahsolar.com/

58 Heath, Garvin A. 2011, Meta-analysis of estimates of life cycle greenhouse gas emissions from concentrating solar power, National Renewable Energy Laboratory, available at: http://www.nrel.gov/docs/fy11osti/52191.pdf

59 See Appendix B

5.4. Benefits for Port Augusta and Australia

Building renewable energy stations in Port Augusta would deliver several benefits for the local and the wider Australian community. These include job creation, improved public health, and advancing technology development and emissions reductions. Economists refer to these spill-over benefits as positive externalities' because they are not explicitly accounted for.

5.4.1. Health:

Although the adverse health impacts of coal pollution from Northern and Playford B have not been available for assessment in recent years, research by the Harvard Medical Center demonstrates that those living near to coal mines and coal fired power stations in the USA are exposed to a range of air pollutants especially particulates which result in an increased incidence of diseases of the heart and lungs and reduce life expectancy. These health problems are confirmed in coal communities in other countries[60,61]. The same risks are likely in the residents of Port Augusta and indeed they have an increased incidence of lung cancer and childhood asthma[62].

Gas also has serious health impacts. Gas power plants also emit fine particulates pollution locally, though less than coal. When gas feedstock is derived from coal seams or shale there is significant risks of contamination of ground and surface water and land with pollutants harmful to humans, stock, crops and vegetation[63].

Renewable energy generation would eliminate the pollution emitted by the Northern and Playford B coal plants and remove the significant public health impacts suffered by the Port Augusta community over many years.

5.4.2. Jobs and Manufacturing

Permanent and Construction Jobs

There would be substantial job opportunities created both during construction of the plants and permanent ongoing jobs to maintain and operate them. Preliminary estimations indicate that around **360**[64] direct permanent operations and maintenance jobs would be created, and approximately 1300 construction jobs during the six year construction period (manufacturing industries and indirect jobs are not included).

60 American Lung Association, 2011, Toxic Air The Case for Cleaning Up Coal-fired Power Plants, Available at: http://www.lungusa.org/assets/documents/healthy-air/toxic-air-report.pdf

61 Epstein et al, 2011, Full cost accounting for the life cycle of coal, Annals of the New York Academy of Sciences, available at: http://onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.2010.05890.x/full

62 Sarah Mennie, 2010, Port Augusta is SA's cancer hotspot, Sunday Mail: Available at: http://www.adelaidenow.com.au/news/south-australia/port-augusta-is-sas-cancer-hotspot/story-e6frea83-1225846333836

63 Doctors for the Environment Australia, 2012, Gas as a replacement fossil fuel; Discussion paper on the health aspects of gas, Available at: http://dea.org.au/images/general/Gas_and_Health_Report_01-2012.pdf

64 See Appendix A for more details.

Manufacturing

There is a significant 'first mover' advantage for South Australia in terms of setting up a manufacturing industry to support the construction of these and future plants, both in SA and around the country. The manufacture of the heliostats alone could create 225 ongoing manufacturing jobs[68] (drawing on similarities in tooling and skills from the car manufacturing industry). Setting up manufacturing capacity for Repowering Port Augusta, will establish Port Augusta as a manufacturing centre for clean energy technologies, as future plants are deployed around Australia.

Above: Enercon wind turbine blade factory Portugal

Above: Helistat mirrors being installed at Esolar plant California

5.4.3. Emissions

The Playford B power station, (with thermal efficiency of 21.9%[1]) has an emissions intensity of almost 1,500 kg/MWhr[2] and Northern (with thermal efficiency of 34.9%[69]) has an emissions intensity of around 940 kg/MWhr[70]. Replacing generation (based on the 2008-09 generation levels and profile) with renewable electricity would prevent the emission of roughly 5,000,000 tonnes of CO2 annually[70]. The annual emissions from a new Combined Cycle Gas Turbine would be almost 2 million per year[70], even without accounting for fugitive emissions.

5.4.4. Technological Development

Although perhaps more difficult to quantify, technological development is the main reason for government support of solar thermal technology. As with all power generation technologies, initial power plants cost a lot more to build. This was the case with coal, gas and nuclear, which were all supported by direct government investment to achieve the economies of scale necessary to reduce their costs to today's levels (otherwise known as mature technologies).

Deployment support allows important cost reductions (through economies of scale, volume effects and learning by doing), essential for the continued development of the technology. The point of such a support mechanism is to progress technology along the learning (cost reduction) curve to the point at which support in no longer necessary[3].

The cost reductions achieved by the support of the initial plants will help make solar thermal power more affordable not just for the rest of Australia, but also for developing countries with an adequate solar resource.

There would be around 40-50 full time employees at each of the CST modules.

Above: Enercon permanent magnet factory Portugal

1 Australian Energy Market Operator (2011), National Transmission Network Development Plan, Supply Input Spreadsheets: Available at: http://www.aemo.com.au/planning/0418-0013.zip

2 See Appendix B for more details

3 Melbourne Energy Institute, Renewable Energy Technology Cost Review 2011, Available at: http://www.earthsci.unimelb.edu.au/~rogerd/Renew_Energy_Tech_Cost_Review.pdf

5.5. Summary

Infrastructure

- 6 Solar thermal towers (760 MW)
- 95 wind turbines (700 MW)

Direct Jobs

- 360 permanent Jobs
- 1,300 Construction Jobs
- 225 Manufacturing Jobs

Emissions saved

- 5 million tonnes CO2 avoided every year (per year compared with Business as Usual)
- 2 million tonnes CO2 avoided every year (per year compared with CCGT replacement)
- 93 million tonnes saved (over the lifetime of a replacement CCGT).

Lock in stable electricity prices

Energy security

Eliminate serious coal and gas health impacts for the Port August community

6. Policy and funding opportunities

Solar thermal technology will require the most governmental support under the current proposal. It is assumed that the wind generation is incentivized via the current Large-scale Renewable Energy Target (LRET) scheme. On the completion of phase one (alleviating the constraints on additional wind in SA), new wind projects around the Port Augusta region (with its considerable wind resource) should be facilitated via this scheme (and thus do not need further support). Support mechanisms and policy directives should predominantly focus on CST projects.

6.1. Financing CST

In order to successfully develop any renewable energy project a Power Purchase Agreement (PPA) with a utility is required. This PPA comprises a wholesale electricity component and a Large-scale Generation Certificates (LGC) component, assuming the project is eligible for LGC's, under the LRET. The wholesale component should be (in theory) reflective of the wholesale Volume Weighted Price (VWP) or the market value of the energy. The LGC should bridge the gap between the Long Run Marginal Cost (LRMC) of the renewable technology and this VWP (or the price of a competing fossil project). The LRMC represents the revenue required (per unit of energy) for power plant to cover all costs, including operation and maintenance costs and fuel costs (for fossil fuel plants), whilst delivering a return to the investors (at competitive debt and equity interest rates).

Currently, the lowest cost renewable technology is wind, with a LRMC of around $90-$110/MWhr, (based on commercial cost of capital rates, at around 8.1% (in real terms)[65]. The VWP varies by region (typically between $50 and $70/MWh), suggesting the LGC price is in the range of $40 (as is roughly observed in the LGC spot market[66]). South Australia typically has a higher underlying wholesale price then other regions in NEM (and more high price events)[67]. Dispatchable renewable energy technologies, such as CST with storage, should be able to take advantage of this higher price volatile market. Table 4 below shows the volume weighted prices for different dispatch periods in South Australia (for 2009 and 2010).

Table 4: Volume Weighted Prices for different dispatch periods from 2009 [data source: AEMO[68]]

Dispatch Period	Volume Weighted Price ($/MWhr)
Overall	69.6
10am-10pm	99.6
10am-8pm	111.5
10am-6pm	128.0
12noon-6pm	151.7
12noon to 8pm	126.3

Dispatchable solar thermal plants in South Australia should be able to secure higher price PPA's (in line with these VWP's), given its ability to shift dispatch to these high price periods. Unfortunately this price alone (even when combined with the value of Renewable Energy Certificates) is not sufficient to finance a CST plant alone. Based on current debt and equity lending rates, the solar thermal electricity produced would have a LRMC of $250-$300 per MWhr[69]. They would require a PPA in this order of magnitude for the investment to be justified, and project finance being approved.

In order for a CST project to receive financing, and thus be constructed, a variety of policy options may be enabled. The price received for electricity produced by the plants can be guaranteed (via a 'feed-in tariff') at an appropriate value (e.g. the LRMC) that facilitates investment. Alternatively, the overall cost of the plant can be reduced (e.g. the LRMC is reduced), through a direct grant reducing the upfront cost) or through loan guarantees or low interest loans (reducing the cost of capital). These policies can be used in isolation or in combination to help finalise financing, and enable construction of a solar thermal plant.

A feed-in tariff (FiT) ensures that project developers receive a guaranteed price for their electricity (in $/MWh) over a period of time in order to attract investors and provide certainty of an income stream for the project. Typically, FiTs are funded by imposing a small levy on all consumers of electricity. FiTs can either be paid as a premium value (in $/MWh) over and above the market price for electricity including the value of renewable energy certificates). Alternatively, they can be a fixed price.

65 Melbourne Energy Institute, Renewable Energy Technology Cost Review 2011, Available at: http://www.earthsci.unimelb.edu.au/~rogerd/Renew_Energy_Tech_Cost_Review.pdf

66 Green Energy Markets, 2012, Market Spot Price, Available at: http://www.greenmarkets.com.au/

67 Australian Energy Market Operator (2010), South Australian Supply and Demand Outlook, available at: http://www.aemo.com.au/planning/SASDO2011/chapters.html

68 AEMO, 2012, Price and Demand Data Sets, Available at: http://www.aemo.com.au/data/price_demand.html

69 Melbourne Energy Institute, Renewable Energy Technology Cost Review 2011, Available at: http://www.earthsci.unimelb.edu.au/~rogerd/Renew_Energy_Tech_Cost_Review.pdf

6.2 Solar Initiative Policy Proposal

The newly proposed Clean Energy Finance corporation could, lower the cost of capital for renewable energy projects, though equity investment, low interest loans, or loan guarantees. In the most optimistic case, (and delivering a return to the CEFC) the equity investment or low interest loans would be available at the risk free rate (government bond rate). The greater the amount of low interest CEFC funding, the lower the LRMC of the project, which reduces the required feed-in tariff rate.

Policy Proposal

The proposed solar thermal power plants in Port Augusta will be "first of a kind" builds for Australia. As with all technologies, the first plants are more expensive. Deployment drives rapid and well understood cost reductions[1], through economies of scale and industrial learning.

For this reason, these initial plants will require policy support to bridge the gap between the market price for electricity, and the cost from these initial plants.

A national large scale feed-in tariff would be the most effective policy to build these plants, however current electricity market arrangements mean that a national system will be difficult to achieve in the short term. For this reason a two phase strategy is proposed.

1 Hearps and McConell, Renewable Energy Technology Cost Review Melbourne Energy Institute Technical Paper Series March 2011, http://www.garnautreview.org.au/update-2011/commissioned-work/renewable-energy-technology-cost-review.pdf

6.2.1 Phase 1: Replacing Playford B

Option 1: State based feed-in tariff only

A state based feed-in tariff scheme to replace Playford B with solar thermal power would raise electricity prices in South Australia by 0.7 cents per kWh, from current electricity prices. However, any replacement option for Playford (including gas) will raise electricity prices, potentially as much as the feed-in tariff option.

The two 110 MW CST plants required to replace the Playford power station would need approximately a $110/MWh premium feed-in tariff to be financed. This does not include the impacts of CEFC financing, but does include revenue from the LRET scheme and a small premium based on the value of dispatchable CST electricity into the market. Table 1 illustrates the volume weighted prices for the different dispatch periods a CST plant could operate over, and Figure 1 illustrates how the CST plants could be financed by through a combination of wholesale price, LGC revenue and premium feed-in tariff.

If this tariff was enabled through a state based feed-in tariff scheme, and the costs were levied over South Australian end users only, the price rise would be around 0.7 cents per kWh (~ 3.5% price rise).

Dispatch Period	Volume Weighted Price ($/MWhr)
Overall	69.6
10am-10pm	99.6
10am-8pm	111.5
10am-6pm	128.0
12noon-6pm	151.7
12noon to 8pm	126.3

Table 1: Volume Weighted Prices for different dispatch periods in SA

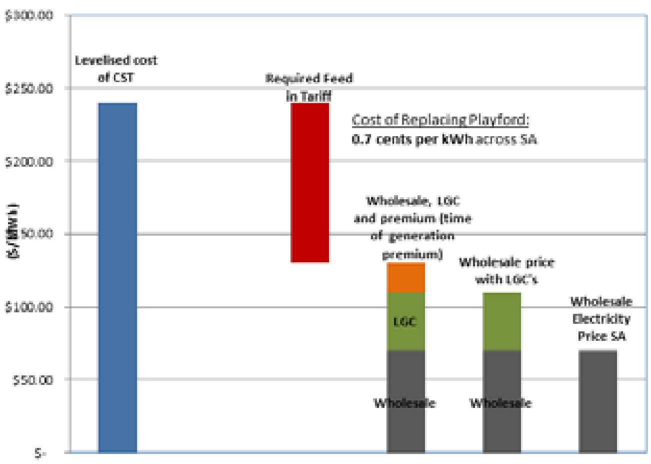


Figure 1: Financing the Playford Replacement with feed-in tariffs.

Option 2: Feed-in tariff in combination with the Clean Energy Finance Corporation

The Clean Energy Finance Corporation (CEFC) should be able to provide low interest loans for such projects. If the CEFC was able to invest in the project at the government bond rate, and a substantial proportion of the project could be financed through the CEFC, then the cost of the feed-in tariffs can be reduced. Figure 2 shows the impact of 25% CEFC financing and Figure 3 shows the impact of 50% CEFC financing.

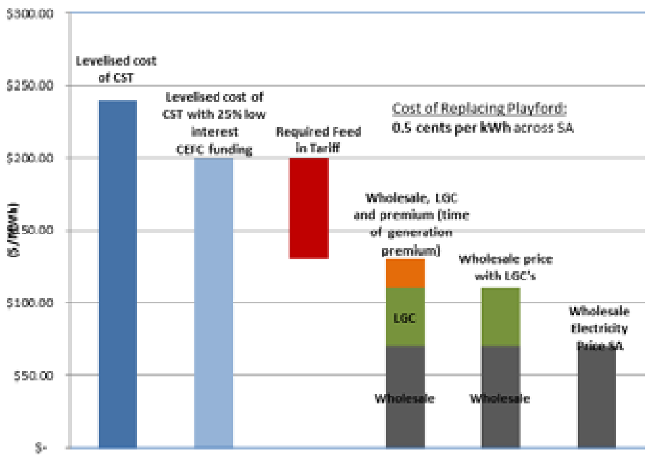


Figure 2: Financing the Playford Replacement with feed-in tariffs and 25% CEFC funding.

With 25% CEFC funding, the required premium feed-in tariff rate could be reduced to approximately $70/MWh. This would reduce the levy on South Australian energy users to 0.5 cents per kWh (if enabled through a state based feed-in tariff). This would require a $400 million dollar low interest loan from the CEFC.

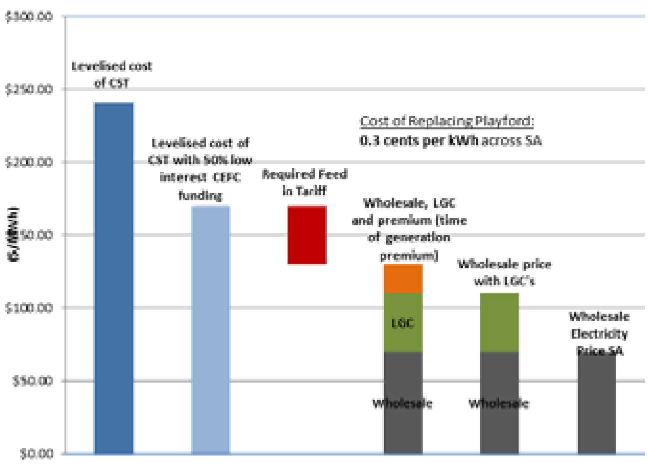


Figure 3: Financing the Playford Replacement with feed-in tariffs and 50% CEFC funding.

With 50% CEFC funding, the required premium feed-in tariff rate could be reduced to almost $40/MWh. This would reduce the levy on South Australian energy users to just 0.3 cents per kWh (if enabled through a state based feed-in tariff). This would require an $800 million low interest loan from the CEFC.

6.2.2 Phase 2: National Large Scale feed-in tariff to replace Northern power station

The most effective policy would be a national feed-in tariff. As mentioned, the current market arrangements would need to be modified to enable a national feed-in tariff, however this has been achieved internationally (and COAG has been considering national feed-in tariffs for many years).

The replacement of Northern power station could be completed through a national feed-in tariff. With a national feed-in tariff scheme, this cost, spread across the entire electricity user base would result in a price increase of around 0.15 cents per kWh (less than 0.7% of an average electricity retail rate in Australia).

For context, the Australian Electricity Market Commission is projecting a 38% electricity price rise across the National Electricity Market by the end of 2013[1].

Feed-in Tariffs: Overview

1. International context

Feed in tariffs have proven to be extremely effective and efficient in supporting renewable energy generation across the world. Over 80 countries worldwide now have a feed-in tariff mechanism, and in Europe 24 countries use feed-in tariffs.

The majority of newly installed wind and solar capacity in Europe has been driven by such Feed-in Tariff support: nearly 100% of all photovoltaic capacity installed in Europe and 93% of onshore wind capacity were initiated by feed-in tariff systems.

In Australia, the state-wide solar photovoltaic (PV) feed-in tariff policies have also been effective in deploying small scale solar PV across the rooftops of Australia. In the 2010/11 financial year alone, 800 MW of PV was installed due to feed-in tariff policies, and $4 billion was invested in the solar sector.

2. Advantages of Feed in Tariffs

Feed-in tariff schemes have proven to be an effective, cost efficient support mechanism for renewable technologies when well designed. This mechanism could be utilised in Australia for large scale systems, including Concentrating Solar Thermal power stations. A national feed-in tariff could provide the financial support that solar thermal (and other renewable power plants) require.

Feed-in tariff schemes offer superior characteristics compared with other government support mechanisms:

- Off Budget: Feed-in tariff systems are usually funded completely off budget. No consolidated revenue or direct government funding is required: the private sector (debt and equity markets) provide all capital necessary to a project.
- Risk free: Government bodies do not carry any risks associated with the development of a project: private project developers alone carry the risk.
- Private Enterprise: Depending on design, any prospective developer can access a feed-in tariff on completion of a project. The private sector can determine the best project design to maximise its returns: the government does not have to go through a selection process or 'pick winners'.
- Competition: Again, depending on design, feed-in tariffs can provide a competitive platform on which private enterprise can compete. Setting an annual installed capacity target (or similar) ensures healthy competition between multiple prospective project developers, leading to optimum cost outcomes.

3. How they work

Feed-in tariffs are typically designed to offer a set electricity price (tariff) to renewable energy projects of a particular type. There is an obligation for retail electricity companies to buy the renewable energy electricity at the tariff rate for a set period of time (a 'purchase obligation'). The cost is typically passed through to all electricity uses (as a small charge, spread across a large user base). There are many different design options.

A key consideration is the determination of a tariff rate itself. The tariff rate should be flexible (reduce over time), to reflect the cost reductions that occur within a given industry. (The lack of flexibility was a problem with the static state based feed-in tariffs in Australia, which did not change to reflect the substantial cost reductions in the PV sector).

Well designed schemes (such as the German scheme), have a set 'regression' rate - rate at which the tariff decreases - and can also modify that the rate based on industry development. Should installation rates increase beyond a target range, the tariffs are reduced at a faster rate. This optimisation ensures tariff prices reflect technology costs, prevent cost blowouts to consumers, stops windfall profits to selected project developers, and ensures a low impact on electricity users.

1 Australian Energy Market Commission, Future Possible Retail Electricity Price Movements, Available at: http://www.aemc.gov.au/Market Reviews/, Completed/ Future-Possible-Retail-Electricity-Price-Movements-1-July-2010-to-30-June-201

7. Conclusion

Repowering Port Augusta demonstrates that renewable energy technologies offer a significant and unique economic opportunity to the Port Augusta community. The proposed scenario illustrates that the dirty (and soon to be closed) Playford B and Northern brown coal power plants can be replaced with a combination of wind and concentrating solar thermal generation.

Replacing the brown coal plants with the proposed renewables would create substantial permanent job opportunities (in the operation and maintenance the renewable plants) and component manufacturing, along with around 1,300 temporary jobs in the construction phase. The permanent job opportunities in the solar plants will offset the impacts of closing the brown coal plants. Building the required manufacturing capacity will enable South Australia to develop as a renewable energy manufacturing centre, as the future plants are established in SA, and more broadly across Australia. By replacing brown coal capacity with renewables, reported health problems from fossil fuel emissions can be completely eliminated. A renewable energy option will also increase energy security and decrease dependence on fossil fuels.

On the other hand, replacing the brown coal plants with gas has limited job opportunities, with a 90% reduction in power generation jobs. Gas fired electricity also links the electricity price to volatile and increasing gas prices, as domestic supplies link to international prices (and increasingly to oil prices as sources as expand). Gas generation also increases South Australia's dependence on unconventional gas from interstate or high cost and emissions intensive shale gas from the Cooper Basin. With significant fugitive emissions and environmental concerns, this represents a significant liability with no environmental benefit: proper accounting of fugitive emissions may result in gas generation having higher emission intensity than coal, thus establishing a significant carbon liability. More generally, increasing dependence on gas represents an energy security (and safety) issue, by exposing South Australia to potential catastrophic incidents.

The cost of the replacement of Playford with two solar thermal plants would be equivalent to 0.7c/kWh power price increase if the cost were levelled across South Australian electricity consumers. The cost of the replacement of Northern with four solar thermal plants and ninety five wind turbines would be 0.15c/kWh levelled across national electricity consumers. This is a fraction of the 36% price rise predicted by the AEMC to occur out to 2013[70].

The replacement scenario is a proposition for enhanced energy security, power price stability, increased jobs, emissions reductions and beneficial economic and health outcomes. It is achievable and affordable. It would establish Port Augusta as a world leading baseload solar hub in Australia, and take advantage of Australia's natural competitive advantage of abundant solar energy. This is an opportunity to begin the transition to a zero emissions renewable economy and is an opportunity our state and federal governments should capitalise upon.

70 Australian Energy Market Commission, Future Possible Retail Electricity Price Movements, Available at: http://www.aemc.gov.au/Market-Reviews/Completed/Future-Possible-Retail-Electricity-Price-Movements-1-July-2010-to-30-June-2013.html

8. Appendix A: Employment Opportunities

8.1. Construction Jobs

Table 6: Overall Construction Jobs

Wind Installation Jobs	1.2 job-yrs per MW[79]
Wind Capacity	700 MW
CST Installation Job	9.3 job-yrs
CST Capacity	760 MW[80,81]
Total Job Years	7908 job-yrs
Construction Period	6 years
Construction Jobs	**1318**

Table 7: Construction Jobs for a single CST plant

Capacity	110 MW
Installation jobs	9.3 Job-years per MW[80,81]
Construction Period (per plant)	2.5 years
Construction Jobs (per plant)	**410***

*This is in line with the numbers suggested by Solar Reserve[74]

8.2. Permanent Jobs

Table 8: Permanent Job Opportunities created by Wind and CST

	CST
Number of plants	6
Permanent Jobs per plant	40[82]
Total Jobs	**240**
	Wind
Total MW	700
Permanent Jobs per MW	0.17[83,79]
Total Jobs	**120**
Total Permanent Jobs	**360**

8.3. Heliostat Manufacturing Jobs:

Table 9: Heliostat manufacturing data [source: Kolb et al[76]]

Heliostat Mirror Area (m2)	*Labour Usage (employee hours per heliostat)*
53	31
95	38
148	46

Table 10: Heliostat requirement: total area and number

Attribute	*Value*
Total Mirror Area per plant	1071361 m^2 [85]
Number of Plants	6
Total Mirror Area	6428166 m^2
Heliostat Area:	148 m2*
Total number of Heliostats	43434

*From Table 9 above

Table 11: Labour Requirements

Attribute	*Value*
Total employee hours	1997964*
Hours per shift	8
Shifts per year	223[86]
Total employee years	1120
Initial manufacturing period	5 years
Total Manufacturing jobs	**225**

*Calculated from Table 9 and Table 10 above

71 EWEA, 2009, 'Wind at Work: Wind energy and job creation in the EU', Table 3, p9, Available at: http://www.ewea.org/fileadmin/ewea_documents/documents/publications/Wind_at_work_FINAL.pdf

72 Solar Reserve, Executive Summary, Rice Solar Energy Project Power Plan Licensing Case: Application For Certification, Document Number 09-AFC-10' p10, California Energy Commission, Available at: http://www.energy.ca.gov/sitingcases/ricesolar/documents/applicant/afc/Volume_1/RSEP_0%200_Executive_Summary.pdf

73 Beyond Zero Emissions (2010), Zero Carbon Australia 2020 Plan, available at: http://media.beyondzeroemissions.org/ZCA2020_Stationary_Energy_Report_v1.pdf

74 Solar Reserve, 2012, Tonopah Solar, Available at: http://www.tonopahsolar.com/

75 Kammen et al, 2009, Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate, Journal of Energy Policy, doi:10.1016/j.enpol.2009.10.044

76 Source: Kolb, J. et al, 2007, 'Heliostat Cost Reduction Study', p126, Sandia National Laboratories, http://prod.sandia.gov/techlib/access-control.cgi/2007/073293.pdf

77National Renewable Energy Laboratories, 2012, Concentrating Solar Thermal Projects, Tonopah, Available at: http://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=60

78 Beyond Zero Emissions (2010), Zero Carbon Australia 2020 Plan, available at: http://media.beyondzeroemissions.org/ZCA2020_Stationary_Energy_Report_v1.pdf

9. Appendix B: Emissions of Coal and Gas

Table 12: Emissions intensity of Northern and Playford B

Playford B	
Combustion Emissions (brown coal)	91 kg CO2-e / GJ[87]
Thermal Efficiency (sent out basis)	21.9%[87]
Emissions Intensity	1495.9 kg CO2-e / MWh
Northern	
Thermal Efficiency	34.9%[87]
Emission Intensity	938.7 kg CO2-e / MWh

Table 13: Total annual emissions of Northern and Playford B

Playford B	
Annual Output	3641 GWh
Annual Emissions	3417741 Tonnes CO2-e
Northern	
Annual Output	1009 GWh
Annual Emissions	1509353 Tonnes CO2-e
Total	
Annual Emissions	4927094 Tonnes CO2-e

Table 14: Emissions Intensity of a new CCGT

Emissions Intensity	400 kg/MWh[88]
Total Output	4650 GWh
Total Annual Emissions	1860000 Tonnes CO2-e

79 Australian Energy Market Operator (2011), National Transmission Network Development Plan, Supply Input Spreadsheets: Available at: http://www.aemo.com.au/planning/0418-0013.zip

80 ACIL Tasman, 2009, Fuel resource, new entry and generation costs in the NEM, available at: http://www.aemo.com.au/planning/419-0035.pdf

10. Appendix C: Feed-in Tariff Calculations

The tables below outline the calculations of feed in tariff for both Phase One and Phase Two of the proposed scenario without CEFC funding. Similar modelling was completed for the 25% and 50% CEFC funding options.

Table 15: Feed-in Tariff Levy Phase One: Replacing Playford (without CEFC)

Premium Feed-in Tariff required	$100	/MWh
Annual Energy Generated (CST)	960	GWhrs
South Australia		
Energy Demand SA (projected 2012)	13303	GWhrs
FiT Levy (per MWh)	$7.22	/MWh
Fit levy (per kWh)	0.7	c/kWh
NEM		
Energy Demand NEM (projected 2012)	201111	GWhrs
FiT Levy (per MWh)	$0.48	/MWh
Fit levy (per kWh)	0.05	c/kWh

Table 16: Feed-in Tariff Levy Phase One: Replacing Northern (without CEFC)

Premium Feed-in Tariff required	$100	/MWh
Annual Energy Generated (CST)	2810	GWhrs
NEM		
Energy Demand NEM (projected 2012)	201111	GWhrs
FiT Levy (per MWh)	$1.40	/MWh
Fit levy (per kWh)	0.14	c/kWh

81 ACIL Tasman, 2011, National Electricity Market Modelling: Projecting changes to prices with changes to electricity contracting levels, available at: http://www.esaa.com.au/Library/PageContentFiles/305dd0f1-d2f7-41c4-927e-75473c3d967b/20110830_ACIL_Tasman_report_ESAA.pdf

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