New Power for North of the Gulf and South Australia

By Lloyd Butler VK5BR

Power has been generated in the north of South Australia using brown coal from Leigh Creek for many years. The coal mine is near the end of its life but there are a number of different non polluting sources sources of energy which might be used to replace the coal fired power stations. Some of these latent energy sources are of such a size that they also have the potential to feed a large amount power to the national grid

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Introduction

As time moves on, there is need for more and more energy in the form of electrical power. However our supply of coal and convention gas, taken from under the ground to generate that energy, is gradually being depleted. There is also pressure to reduce the polution of the air we breath caused by the combustion of these fuels. Added to this is the theory that the continuing addition of these polutants to our atmosphere, increases the global temperature.

The electricity transmission network in South Australia extends across some 200,000 square kilometres of diverse and rugged terrain and operates at voltages of 275,000, 132,000 and 66,000 Volts.

The National Electricity Market (NEM) operates across interconnected regions of power grids which largely follow the state boundaries including South Australia. Other regions include Queensland, New South Wales and its Snowy Mountains (Hydro) region, Victoria, and Tasmania. The interconnected regions are made up of a total of about 5,600 kilometres of transmission lines.

There is a lot of work going on towards the replacent of polluting fossil fuels with natural energy sources such as the sun, the wind, and from latent heat deep down in the bowels of the earth. The article looks at investigations and projects under way in South Australia to achieve these aims.

The article first introduces the ageing coal fired power stations near Port Augusta, previously owned by the Electricity Trust of South Australia and now the domain of power company Alinta Energy. The article leads on to some of of the newer power generation developments. There is already a large expansion of wind power in the State of South Australia. But there are a number of other power systems which could be considered for the State. In fact, if some of the sources could be tapped, there is potential to also supply the eastern states with power for many years to come.

A report (Ref. 1), probably the work of Alinta Energy, has been prepared on possible power development which could replace the coal fired system. The report looks at the merits of different systems and ultimately recommends the renewable solar thermal power system, proven now in operation in Spain, and being installed in several other countries.

The proposal of the solar thermal plant has the support of the community of Port Augusta and its Council. Much of the work in the town comes from the power stations and the power system and they look to fill the gap when the coal runs out and the existing power stations close. There is also the loss of work at Leigh Creek. It has been said that the Solar Thermal plant would create 1800 job and save many tonnes of greenhouse gas emissions. But what are the other options to generate power in South Australia?

Whilst this article refers to parts of the Ref 1 report on natural gas fired power and solar thermal power, it also discusses the merits of nuclear power, photovoltaic solar power, and energy from hot rocks.

Coal Power

Two power stations near Port Augusta using Leigh Creek Coal have supplied power to the South Australian power grid for many years. Playford B was opened in 1963 and is rated at 240 Mw capacity. The Northern power station was commissioned in 1989 and is rated at 520 Mw capacity. The two stations had supplied about 40% of the State power load.

The Playford station, one of the most polluting in the country, was put in mothballs around 2012. This was partly due to the pressure on carbon emission and the carbon tax, and partly giving regard to the limited life of the Leigh Creek coal mine. It was also somewhat non competitive with the cheaper power being supplied from the many wind farms being built within the State and the influx of photovoltaic rooftop panels. The Northern station is now running for six months of the year. The mothballed Playford station could be put back into service, if needed.

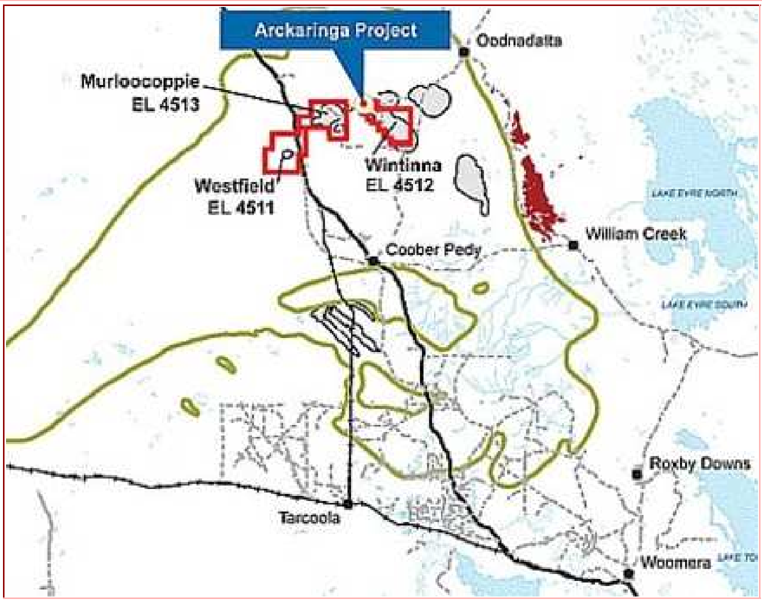
There have been estimates given, that on present coal consumption, the Leigh Creek coal would run out in 2017. A more recent report (Ref 2) gives some detail on geotechnical work now being done by Alinta to develop a low quality coal deposit at Leigh Creek. Work is continuing to see if they can blend this coal (previously considered unsuitable) with current deposits and assess whether the blend would be suitable for the Northern power station. It is hoped that this could extend the life of the station for two decades and give the company more time to develop a Solar Thermal system.

The Playford Power Station at Port Augusta
(Placed in mothballs around 2012)

The Northern Power Station,
Port Augusta

Another interesting coal power exploration relates to the conversion of coal to liquid for use as energy (ref 7). In 2005, Altona Energy (not to be confused with Alinta Energy) acquired a 100% interest in three exploration licences covering 2,500 sq. kms in the northern portion of the Arckaringa Basin in South Australia. This included three coal deposits, Westfield, Wintinna and Murloocoppie, which are all near to the Adelaide to Darwin railroad and the Stuart Highway. Containing more than 7.8 billion tonnes of coal, , the company's Arckaringa coal deposits are effectively one of the world's largest undeveloped energy banks, capable of conversion into clean liquid fuels, low cost power, and high value coal.

Altona's current focus is the completion of a feasibility Study for an integrated Coal to Liquid plant with a co-generation power facility from an open cut mine at Wintinna (Ref 8). It is estimated that a plant would produce 10 million tons per annum of coal, ten million tons per annum of liquid fuels (mainly ultra clean diesel), and 1140 Mw of power, including 560 Mw for the national electricity grid.



Map of Arckaringa Coal Deposits

Wind Power

The most efficient and polution free power source seems to be wind power. The largest of individual wind turbines are rated at 7.5 Mw. Wind farms have been spread out across South Australia with a total output capacity of around 1200 Mw. In high winds they produce peaks of much more. By 2012, wind generators were supplying 26% of the State's electricity. On one windy night in September 2013, they supplied three quarters of the State's night load.

The only limitation with wind generation is that there is no power generated when there is no wind. Small systems can store electrical energy by chemical means in the well known storage batteries. But it is not easy to store large amounts of electrical energy. One way is to pump water from one level to a higher level when power is being generated. The water is released to drive a turbine when power is required. Tumut 3 Power Station in the Snowy Mountains operates a pump-storage scheme which uses low priced off-peak electrical energy to pump water to a reservoir on a higher level. This water is released through turbines to generate electricity when prices are higher. In this case, the scheme is a profit generating system for the power company.

In February 2014, news was released that the Government had approved a project for a German company to build and instal 197 additional wind turbines on land near Black Point on the Yorke Peninsula. The new wind farm would add 600 Mw of power capacity to the existing 1200 wind powered source (Ref 6). Power would be fed across the gulf to Adelaide via 60 km of undersea cable. There were objections raised by several organisation groups that the State was going a bit too far with the wind source. The basis of their criticism seemed to be that the intermittent output capacity of wind machines would encourage the jacking up of power prices on peak loads from generators (such as coal fired). They were referring to generators that were not designed for best efficiency when ramping their output up and down to balance the load.

The land used by the wind farms is still useable for agricultural use, and the payment made to the farmers for the use of their land, adds to the profit they earn. There have been complaints from residents, living close to wind farms, of being irritated by low frequency noise generated. To offset this, the State Government energy plan does not allow wind farms any closer to any home than one Kilometre.

Starfish Hill Wind Farm
Near Cape Jervis in South Australia

Photovoltaic solar Panels

The other common polution free power source, which is taken up by many consumers, is the use of the photovoltaic rooftop panels. From the power of the sun, these generate electricity which is fed across the consumers power mains via a DC to AC inverter. No doubt, the electricity power company could set up a complete farm of photovoltaic cells to supply bulk electrical power. But like the wind farm, it can't supply power all the time, and only when there is sun to actuate the panels.

But here is where our Solar Thermal system wins out. As we will discuss later, it does make use of an energy storage system.

A report from the South Australian Government Department of Maufacturing, Trade Resources and Energy, dated February 2014, stated that the State currently had more than 130,000 installed photovoltaic solar systems on homes and businesses. If they all operated together in open sun, with say an average power of 2.5 kw, they would replace 325 Mw of power otherwise consumed from the power grid.

Natural Gas

A further possibility to replace Leigh Creek Coal is the use of natural gas as already used by the other two South Australian power stations at Torrens Island. The gas at present supplied to Torrens Island is assumed to be what they call Conventional Gas or gas which is extraced after drilling by natural pressure or pumping operations. Unconventional gas is gas extracted by more complex or difficult operations including coalseam gas and the process of fracking (ref 4). It would appear that at present, Torrens Island is supplied with a good clean source of energy. But the report (Ref. 1) raises a number of questions about it use for replacement to feed the northern stations..

First of all, the gas is really not that clean as it emits a significant amount of environmental and greenhouse gas from its combustion. The gas we are now using comes from the Cooper and Eromanga basins. This is expected to be exhausted in 13 years. Gas would probably then have to be piped from the eastern states of which 84% would be coalseam gas.

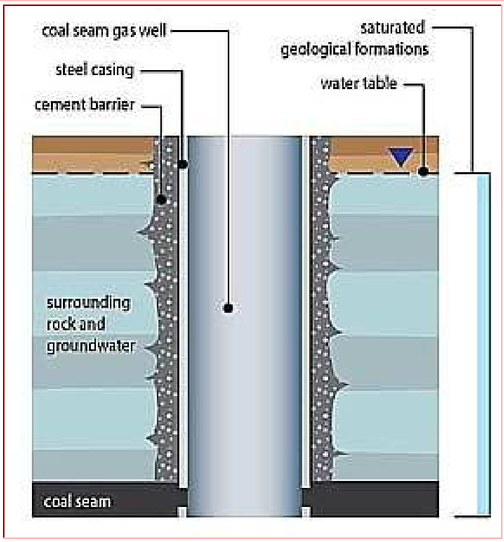
But there is a lot of controversy concerning coalseam gas. There are large reserves of gas in South Australia but it is shale gas, one to two kilometers below ground and not good quality. Because it would be difficult to extract, and because of the poor quality, it would probably cost the consumer about twice the price paid now. Concerning the interstate gas supply, it is expected that it also would be exposed to price volativity.

Coal seam gas is a type of unconventional natural gas. It is made up primarily of methane gas (generally 95-97%) and is found in coal seams at depths of 300m-1000m underground. It is sometimes referred to as coal bed methane (CBM).

Coal seam gas is extracted by drilling a well vertically through rock strata until reaching the coal seam. At which point, the well may also be drilled out horizontally to increase access to the methane gas. Coal seams contain both water and gas. During coal seam gas operations, the water must be pumped out of the coal seam to lower the pressure and allow the gas to flow to the surface.

Because coal seam gas wells are drilled through soil, rock strata, and aquifers, to reach the coal seam, the wells are lined with layers of steel and cement casing. This isolates the gas flow from the aquifers in an effort to prevent cross-contamination. Hydraulic fracturing, more commonly known as fracking or fraccing, is used to stimulate and accelerate the flow of coal seam gas. The process involves high pressured injection of sand, water and chemicals into the coal seam gas well. The injection causes fractures in the coal seam allowing the gas to flow to the surface of the well.

There are significant concerns associated with hydraulic fracturing including the potential to contaminate water sources and cause earthquakes.



Drilling to reach the Coal Seam.
The Well Case is lined with
Steel and Cement

Shale gas extraction differs from conventional gas extraction, in that the gas is not trapped in relatively discrete reservoirs below the surface. Instead the gas is contained in shale rock which often needs to be hydraulically fractured, or "fracked", in a bid to release the gas.

Shale wells are drilled first vertically into the ground, like a traditional well, but then also drilled horizontally, in cases for several kilometres. The shales are fractured along the way to release the gas.

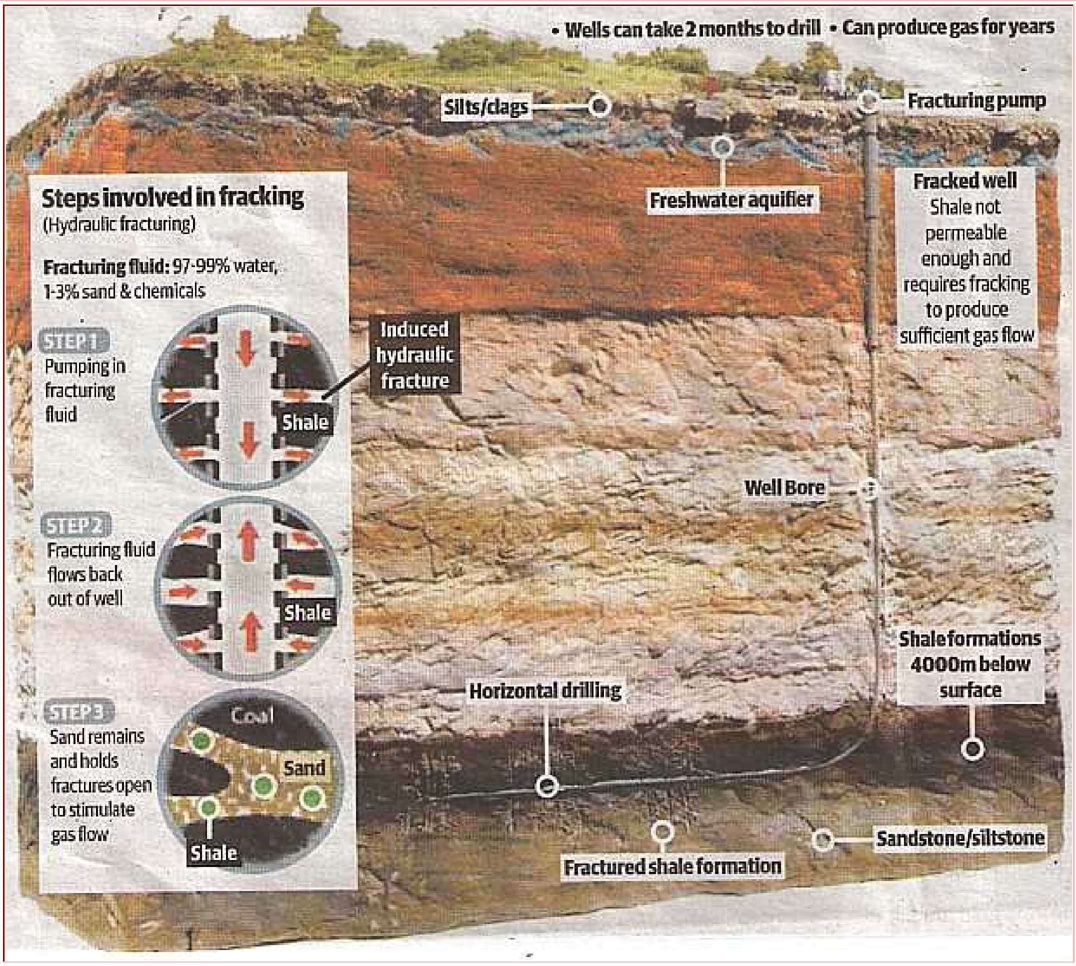
Fracking has been linked to groundwater contamination in the US and this has raised questions about its use in Australia.

Whilst fracking has been used for decades in South Australia's Cooper Basin and around the world, it has become controversial in recent times. The controversy is often in relation to the use of fracking in the extraction of coal seam gas, such as occurs in Queensland and New South Wales (Ref 4).

In South Australia's South Eastern region, farmers have expressed concern that exploration for gas in their region could lead to contamination of their ground water. A representative of Beach Energy has emphasised that their wells are encased in steel and cement to ensure that aquifers are isolated. He said proven and robust protocols have been in place and tested for decades in South Australia.

But the farmers are also concerned that as the process of fracking uses a lot of water, their sparce supply of ground water could be depleted.

No doubt because anticipated rise in price of the gas in future years, and the poorer qualitity of the unconventional gas, the report on the power source to replace the Leigh Creek coal (ref.1) has ruled out gas as a preferred option.



The Fracking Process

Energy from Underground Hot Rocks

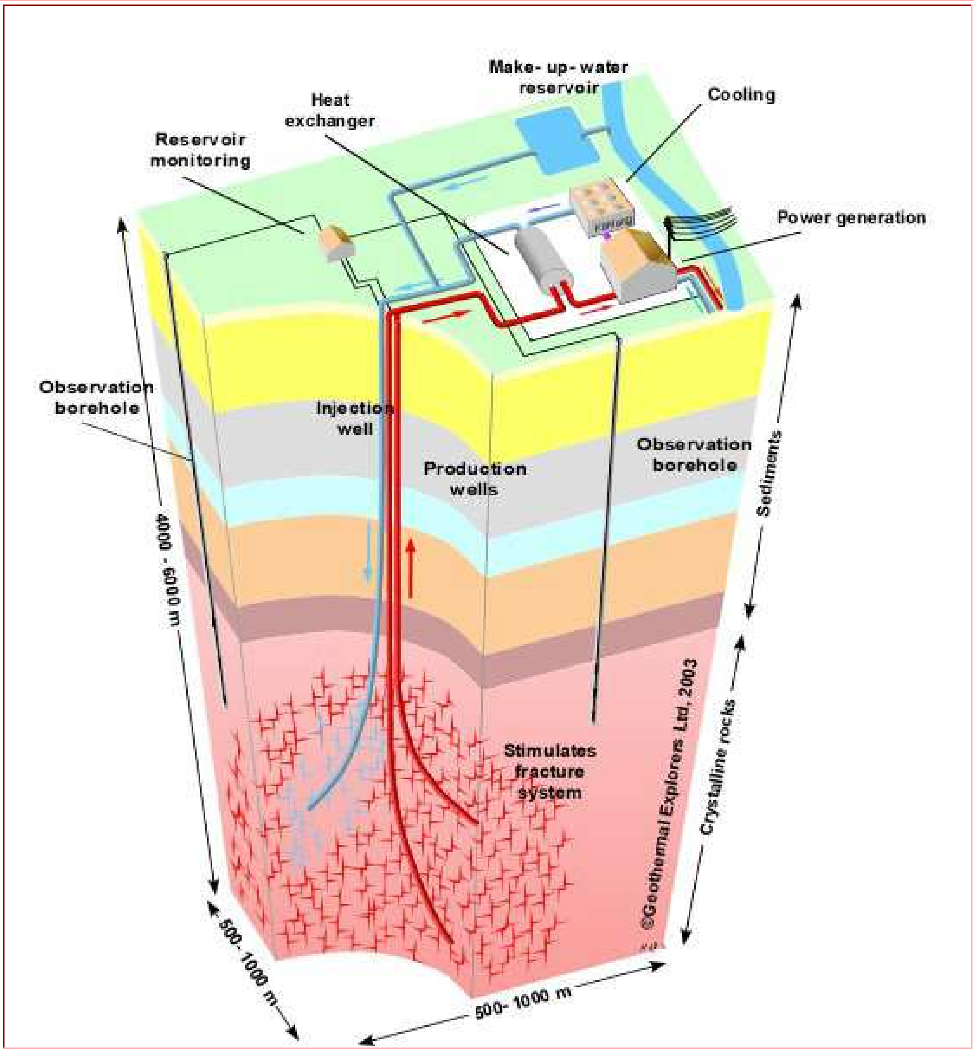
Geothermal energy is produced by extracting the natural, internal heat of the earth to create electricity and heat. This energy can be stored in granite rocks often called 'hot rocks' or trapped in liquids such as water and brine.

"Hot Dry Rock" is what we know as common "granite". These hot underground granites contain enough heat to drive steam turbines and generate electricity. However the rocks contain no water, so to tap in on the energy, cold water from the surface is pumped at high pressure down a hole of around 70 mm diameter. Three-to-five kilometres underground, the cold water is forced sideways under pressure through tiny fractures in the hot dry granite.

Getting the energy from the hot rocks relies on techniques established by the oil and gas industry. Wells are drilled to a depth of 3-5 kilometres below the surface to find the heat-producing granites. Water is then pumped down in the wells and through the cracks in the rocks. The water is heated to a temperature of up to 300 °C , becomes steam and gushes back to the surface where the heat is used to drive a turbine and produce electricity. The water used is recycled.

There are vast deep-seated granite systems in Central Australia that have high temperatures at depth and there are a number of companies carrying out experimental drillings into these rock systems. South Australia has been described as "Australia's hot rock haven". There seems to be great potential in Australia for generation electric power from this energy source. The difficulties are the great depths at which drilling must take place and of course the finance to keep the development going.

It has been quoted that there is enough heat stored in South Australia's hot rocks that the system could produce all of Australia's electricity from this source alone. Whilst the power source technology is yet to be applied on a commercial scale, this could be our clean power source of the future.



Energy Generated from Hot Rocks

Nuclear Power

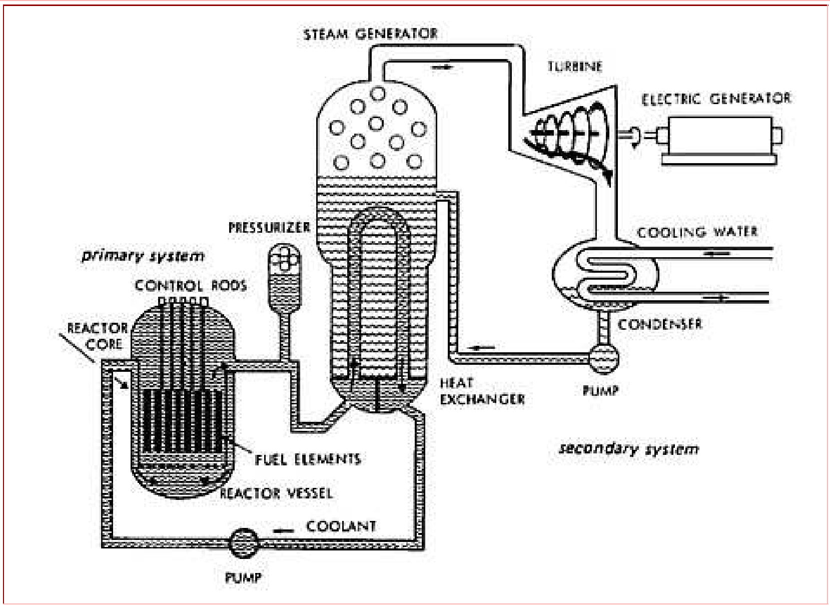
A nuclear power station uses a reactor to generate heat by nuclear fission, releasing energy in the form of heat. Water or carbon dioxide gas is pumped through the reactor and takes away the heat to form steam. This drives turbines coupled to electric generators. The Nuclear Power Station is considered to be an efficient means of generating electrical energy.

Nuclear power stations are operating all over the world, but despite the abundence of raw uranium in Australia, there has not been any great enthusiasm to build these stations within this country. One of the reasons for this is the fact that Australia has been blessed with plenty of accessible coal and gas. Also the numerous accidents in nuclear power stations around the world is a deterrent to building them here. The most well known of these are the Three Mile Island accident in Pennyslvania 1979, the Chernobyl accident in the Ukraine 1989 and the destruction of the power stations in Fukushema in Japan, triggered by earthquake and tsunami, 2011.

We have supporters of nuclear power in Australia. They would argue that the modern design of the nuclear power station is very safe and the probability of accident is very low. But any chance of any accident seems unacceptible. Can anything made by man really be absolutely perfect? As a result of the Chernobyl accident, radio active material was spread over a major section of Europe. The danger of the radio activity is the damage to all forms of life over vast areas. And its not just the accident caused by man. The crust of the earth is always on the move to sometimes wreck what is on its surface. Japan is within boundaries between tectonic plates and highly likely to experience earthquakes. The Fukushema disaster is testament to what an earthquake can do to trigger a power station nuclear emission.

Nuclear power has been promulgated as a clean source of energy, as it does not discharge hazardous emissions in its normal operation. However, there is still the problem of how radio active waste from the power station can be disposed, free from contamination to life on the earth. Some radiating components can radiate thousands of years. Whilst radio active waste can be buried, there is the danger of it getting into water courses and becoming a threat to life.

A nuclear station can supply power 24 hours per day normally without any harmful emissions to the atmosphere. But so can systems being developed such as the energy from hot rocks and the solar thermal power system already proven. There is an adage which says: "anything can go wrong, will go wrong". Why take the gamble that the nuclear station will not develop a fault when the consequences of an accident are so terrible. And when the country has the alternative to tap energy from under the crust of the earth, or from the sun we get every day?



Nuclear Power System

Solar Thermal Power

The solar thermal power system proposed for Port Augusta (Ref. 1) is based on a working system installed by Torresol Energy in Seville, Spain. Whilst there are a number of variants to the system initially installed at Seville, it is the initial proven system which is described following:

The solar energy is received by 2650 heliostats (or flat mirrors) and reflected back to the receiver at the top of the 140 metre central tower. Each heliostat has 120 square metres of reflective surface and is controlled to track the sun in two axes. The receiver is capable of reflecting 95% of the radiant heat it receives.

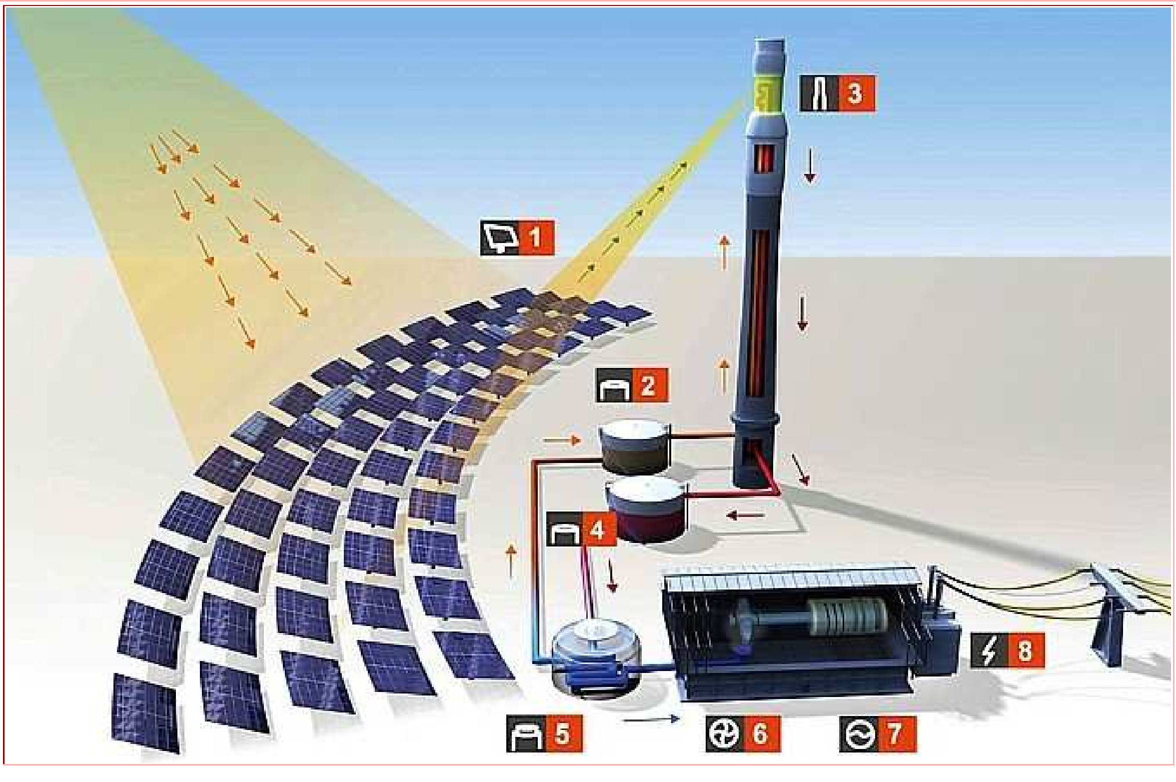
Molten nitrate is pumped through the receiver which is heated by the reflected solar energy to 565 degrees centigrade. The hot fluid is fed through storage tanks where surplus heat energy is stored. This is a feature of the system which enables electricity to continue being generated for 15 hours without sun and a feature not available in the normal photovoltaic solar system.

The hot fluid moves on into a heat exchanger where the heat is transfered to steam which drives the turbine to produce electric power.

Spain was the first country to set up a solar thermal power station. But development of solar thermal stations is also taking place in other countries, such as USA, India, South Africa, and Morocco.

There are a number of different types of solar thermal technologies using different configurations of mirrors to collect the heat. The report (Ref 1) reaches the conclusion that the flat mirrors, of the system described, are simpler and more cost effective to construct than the other receivers examined. That system of heliostats, combined with the central collector, is the system the report (Ref 1) recommends.

Considering the power ratings of Port Augusta coal power stations, Playford B at 240 Mw and the Northern station at 520 Mw, the report (Ref 1) suggests the following: Playford B could be replaced with two solar thermal stations and the Northern station with four solar thermal stations supplemented with 95 wind turbines. The system would be levelled across national grid available to national consumers..



Legend

1. Heliostats
Solar light is reflected by the heliostats towards the receiver, located on top of the tower.
2. Tank 1
Molten salts. at 290°C, are pumped from the cold molten salt tank to the receiver.
3. Tower
Inside the receiver, molten Salts are heated up to 565°C before being stored in the hot molten salt tank
4. Tank 2
The hot molten salt tank keeps the energy accumulated in form of molten salts at very high temperature.
5. Steam Generator
The hot molten salts are delivered to the steam generation system, where they transfer their heat to the water, reducing their temperature.
6. Turbine
The heat transferred transforms the water into high pressure steam to move the turbine.
7. Electric Generator
The turbine powers the electric generator producing electrical energy
8. Electrical Transformer
The electricity is delivered to a transformer to be injected into the distribution grid.

Schematic - Solar Thermal Power Generating System,
Torresol Energy, Spain

Photo Solar Power Plant,
Torresol Energy, Spain

Heliostats & Tower,
Torresol Energy, Spain

Feasibility Study

On January 15, 2014 it was announced that the Australian Renewable Energy Agency (ARENA) and the SA Government would co-fund Alinta Energy to conduct a feasibility study into solar thermal in Port Augusta (Ref 9 & 10).

The $2.3 million project will involve an assessment and technical analysis of the viability of solar thermal generation in Port Augusta, SA. It is supported by a $1 million contribution from ARENA Emerging Renewables Program, as well as a $130,000 grant under the South Australian Government's Enterprise Zone Fund.

So it looks like the investigation for new power in the north will get under way. Whether money can be found to build the Thermal Solar plant is another hurdle.

Summary

Our supply of coal from Leigh Creek is running out and our power stations near Port Augusta are ageing. There is need to introduce new sources of power generation, preferably systems which produce low pollution in the atmosphere.

There is already installed wind power farms on a large scale, and solar power on many power consumer's roofs. Whilst these provide electrical power to replace much of that generated from the coal, it does not replace the base load source needed to maintain supply, when there is no wind, or the sun is not shining.

We have discussed various power sources which could be used to maintain continuous base load power. It appears that we have used up most of Conventional, or easier to obtain, natural gas. The future supplies of gas will be Unconventional, not as clean as the gas we have had, and more difficult to extract with the expectation that it will become more expensive. There is also a lot of opposition to the process of fracking to extract the gas..

Nuclear power has some support, particularly as we have a large source of uranium within Australia. However the consequences of an accident, which might pollute the atmosphere with radio active debris, is not very palatable option when there are other safer and non polluting systems at our doorstep.

Tapping the hot rocks deep under the earth has the potential to make a very large base power source to supply a continuous load, not only for South Australia, but for the whole of the country. The source of heat has to be tapped at large depths below the earth, quite a task. At this stage, it is probably too early to accept it as a system. Investors would probably want to see the system positively demonstrated before putting money into a large scale installation.

Alinta Energy came to the conclusion that the Solar Thermal power system was the one they should pursue to replace the Port Augusta coal power stations. Now announced is the grant they have received to study this system further. The solar thermal power system has been well proven in Spain and hopefully the feasibility study could lead to the first system of this kind in Australia.

Whilst the development of new power sources is important to South Australia, with its power region part of the national grid, the development also beomes important to the future of power for the whole eastern side of Australia.

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Addendum

Over six months have elapsed since I wrote the article on power sources. With the staggering increase in wind farms being added to the national power grid, I now felt a few additional notes were appropriate.

The competition from renewable energy power sources, such as wind and solar, is having quite an effect on the viability of power stations, which for years have operated from coal and natural gas. The wind farms, in particular, are starting to stand out as economical sources of energy, which have reduced the demand on power from established base load power sources.

To quote some examples in South Australia: Playford Power Station (240 MW), using Leigh Creek coal was moth-balled around year 2012. Northern Power Station (520 MW), also using Leigh Creek coal, has now been running for only six months of the year. Pelican Point Power Station (479 MW), running on natural gas, proposed to reduce its supplied output to 230 MW, early in 2015. In December 2014, Torrens Island Power Station (1280 MW) also using natural gas, announced that its A station (480 MW) would be moth-balled.

Base load power comes into the equation when renewable energy cuts out. Solar power clearly needs night time back-up, either in the form of an additional base power source or night time storage. On the surface, wind power systems would seem to also need this back up for when there is no wind. But the big picture looks a bit different. A major power grid is formed throughout South Australia, Victoria, Tasmania, New South Wales and Queensland, connecting the state systems. Wind farms are scattered over diverse locations in the states, connected in to the grid, and sharing the total load. The thoughts are that if wind drops out in a particular location, there will be wind to supply power to the grid from other wind farms. In effect, the wind power network can be expected to supply its own back-up base power source. Wind farms are placed in particularly windy locations and the expectation is that there will always be wind somewhere.

On the basis of being able to provide its own base power back-up, wind power is looking very attractive as a preferred power system option. No doubt, a wind farm is expensive to establish. But once established and running, there is no on-going cost to purchase fuel, a factor hard to match in a gas or coal fired power station. There is also no residue from the operation to be disposed, no atmospheric polution, and no interference with natural waterways.

Commercial interests, encouraged by the Government, continue to add new wind farms. For South Australia, in July, 2014, wind farms supplied 43% of the State load. During conditions of high wind, almost all the State load can be supplied. No wonder that conventional power stations are being moth-balled.