The Renewable Energy Report Card
Don't Sell Australia Short

Written by David Holland

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Photograph: Wind Farm Portland Victoria by David Holland

As more and more energy is needed to accommodate Australian's lifestyle and a realization that a continued use of non-renewable energy sources cannot continue into an indefinite future, many are starting to become alarmed and make a concerted effort to come up to the challenge of producing a higher proportion of Australia's energy needs from renewable sources.

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As part of the familiarization process of renewable energy sources, this paper will investigate ideas for the renewable energy economy.

Discussion Paper

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Executive Summary

The following paper is a designed as a discussion paper on the progress of the uptake of renewable energy in Australia. The purpose of the paper is to highlight the progress Australia has made under government policy settings up to and including 2010.

Under the Renewable Energy Credit scheme (REC) important changes have been made in the variety of renewable energy sources now being used to produce electric power. These are detailed in the paper and include, wind powered generation plants, solar hydro energy plant to produce steam fed directly into existing power station turbines, solar photovoltaic cells to produce domestic power, wave energy utilization to produce power for desalination plant applications, tidal power to produce grid power in various locations around the continent, thermal or hot rock installations to harness heat energy to produce base load grid electrical power and a cutting edge form of power generation known as convection energy systems.

Convection energy is sourced simply but harnessing the power of rising hot air. Some of these convection power plants are designed to be enormous. The paper outlines how at least one United States of America (USA) state has embraced this technology that was first developed in Australia.

The paper also introduces a little thought of area of power generation known as micro renewable energy power systems. These are systems that might be called scavenger power system. The paper explores a range of applications that could be implemented to use power that is a byproduct of other applications and processes to generate power; systems similar to water or sewage flowing down conduits or the process of decomposition within a waste dump. These micro generating systems use available resources to generate electricity.

The paper touches on a new technology in its infancy where the applications are not fully realized or evaluated. This technology utilized vibration to produce small amounts of electrical energy. At present this technology has only produced one commercially viable product, but even this application of the technology has enormous potential.

The paper explains the introduction of RECs, and how the federal government introduced a correction to the scheme to avoid a collapse of the REC trading market. It introduces the New South Wales Feed in Tariff (FIT) scheme. This scheme allows domestic generating power systems to be connected to the main grid enabling this power to be bought by the grid power supplier. This renewable power is then sold on to other power uses. This seems to be a good idea, but when it comes to larger non-domestic producers like local councils the power companies disallow these systems to be connected into the grid through the FIT scheme.

The paper finally shows some inequity in this type of policy, highlighting that with a more flexible approach to organizations like local councils, opportunities of collaboration between the power companies and councils could better utilize unused power available in scavenger power systems when power demands are higher than the supply from renewable sources. This means that at these times of high demand, power companies will need to source electrical energy from conventional sources such as coal fired power stations, diesel generators or gas turbine plants connected to the grid.

The Renewable Energy Report Card

Don’t Sell Australia Short

Discussion Paper

This discussion paper was written in the interests of encouraging sustainable natural energy resource management and the implementation of best practice energy infrastructure planning for the continued development of a renewable and clean energy industry within Australia.

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Introduction

When thinking about renewable energy generation we realize that Australia largely uses non-renewable energy for most of its energy needs. In Australia we acknowledge the renewable nature of hydroelectric schemes such as the Snowy River hydro scheme and The Hydro Tasmanian electricity generation scheme and some other hydro power plants dotted around the country like the Hume Weir in northern Victoria on the Murray River. But for Australia overwhelmingly coal fired power stations are used for the bulk of our generation of electricity.

Again when we think of the energy used for automotive uses we think of diesel and petrol fuels. However we should acknowledge that most city train and tram networks operated by electric power. These networks use electric power often generated from small power plants using gas or oil as the fuel, as in the example of the Melbourne train and tram network that use a gas turbine to propel the electric generator powering the system.

However, as more and more energy is needed to accommodate Australian’s lifestyle and a realization that a continued use of non-renewable energy sources cannot continue into an indefinite future, many are starting to become alarmed and make a concerted effort to come up to the challenge of producing a higher proportion of Australia’s energy needs from renewable sources.

Concerns that are not only about the threat of climate change and our need to reduce carbon emission, but concerns about the fact that we have just about reached the point with oil production that we call peak oil, where the rest of the oil still in the ground will be more expensive to retrieve than any previous year’s retrieval costs. This fact points to a future of rising costs of petroleum products, chief among them being petrol and diesel. These are the main fuels used by road transportation of goods around the country. Any disruption to the supply or the cost of these two commodities will drastically affect Australia’s economy by driving up the costs of all production that has a transport component within it.

But we also should be concerned about the health of our nation and the amount of carbon particulate pollution being put into the air we breathe by these hydrocarbon fuels.

We should also be concerned about reductions in the worlds biota brought about by the deforestation happening in developing counties due to economic forces driving their peoples to cut down the forest for a cheap energy source in a world where oil based fuels are even now too expensive.

It is about time we take a good hard look at how we produce energy on this planet to further our life styles, and consider what we are leaving our children in tomorrow's world. Let's earnestly consider looking for renewable sources for our energy needs.

As part of the familiarization process of renewable energy sources, this paper will investigate ideas for the renewable energy economy.

The specific kind of energy harvesting that is the concern of this paper is renewable energy.

Renewable Energy Credits program is driving new development in Australia

Australia has agreed to produce 20% of its electricity through renewable energy sources before the year 2020. The Federal Government has put in place a credit system to help achieve this target.

These renewable energy credits (REC) are produced each time a new renewable energy plant is install and becomes operational.

Until recently most of the installations were for bigger power generation plants. Investors in this type of plant would rely on the RECs as a form of guarantee or collateral, against which the banks would advance loans for the projects. Banks would lend to these investors expecting that the REC's would be sold within an acceptable price range at the end of the installation of the renewable energy plant.

However, since the Federal government introduced the large rebates on domestic solar voltaic systems and water heaters, and each system is able to produce RECs, there had been a flood of renewable energy credits hitting the market in the latter parts of 2009. This has meant that the price of the REC had dropped. Investors in large renewable energy projects like those that are outlined in this paper had started to become unable to repay all the investment debt anticipated on the completion of the project by the sale of the RECs generated by the project. In addition speculators would be unable to secure loans sufficient to support a new project because banks would become nervous at the lack of collateral available in the project through the sale of the REC's.

This situation also means that the attractiveness of commissioning plans for new renewable projects was reduced thus discouraging the planning of new renewable energy plants.

To fix this market anomaly the Federal government announced on the 26th February 2010 a solution which fixed the price of small renewable systems. (i.e. Domestic Systems) This price for an REC was then fixed at $40. Any larger non domestic system will still rely on the market for a return. This larger project component of the renewable sector for electricity generation will produce the 20% target at about 41 thousand gigawatt hours.

The domestic installation of renewable energy systems will be an open ended target.

The identification of renewable energy applications within the environment

This paper however, will not be dealing with all the types of renewable energies currently available. Some energy harvesting that can be considered renewable such as burning regenerated forest will not be considered in this paper. This is because of the potential of the processes associated with them may affect the natural environment. In addition the byproducts from them would not be considered clean.

This paper will be confined to clean energy sources, but not any kind of clean energy source. Clean energy is derived from energy sources that do not produce pollutants such as particulates and carcinogens as a byproduct of the conversion process from energy source to electric power.

A clean energy source could be the production of methane from crop fermentation. However, with respect to this process this paper must now introduce another criterion, and that is, the process to convert energy to power must be considered a clean energy process.

The kind of clean energy discussed in this paper must be compatible with the world's need to cut green house gases, therefore those energy sources that include production of CO_2 to produce clean energy will not be discussed. This paper will only discuss non carbon dioxide producing processes that produce power.

As discussed above the Federal Government has made a 20% renewable energy target to be achieved by the year 2020. With the incentive of the REC program investors have been building a range of energy devices to convert an energy source to power that is by definition renewable.

Following are a number of examples of the technologies used currently in Australia or proposed to be used by enterprising companies and concerns in Australia.

Harvesting energy from the environment

As this paper is essentially about energy for Australia, the paper will generally be confined to the environments within Australia and its coastal environs controlled by the Commonwealth of Australia.

Energy Opportunities created and projects underway for Renewable Energy:

Wind power

In many locations around Australia an abundant supply of wind is available. Many of these locations have been identified as useful for power generation.

Through progress made by both State and Federal governments, recognizing the pressures on the environment by burning coal to power the electric generation processes, flexibility has been made to allowing new providers of renewably sourced electric power into the market. This coupled with a Federal Government initiative providing the REC market, is encouraging many new investments to build wind farms.

A number of these new farms are located along the coast from the York Peninsula in South Australia to Port Fairy in Western Victoria. In addition many have been built or planned for other areas.

One of the design criteria to keep the costs of installation lower is to locate these farms not too far from existing main power grids. Inevitably though, installations on good wind sites further from the grid will become more attractive in the future as the technology becomes cheaper. This eventuality will tend to increase the grid but at the same time add to the cost of these new projects the cost of the new grid connection.

The term wind farm has been coined to describe a new income stream for land holders. Farm and land managers in appropriate environments to harvest wind may have an opportunity to combine more traditional farm incomes with the installation of wind turbines. These installations could be seen to look like giant crops on the landscape, hence the term related to wind powered generation of electricity, ‘wind farm’.

The installation of these farms had been going on since the late 1990s, but has intensified in the last three years. Some of the earlier installations built in the early 2000’s stood up to 80 meters high to the tip of the sail. (A sail being a fan like blade to catch the wind) Examples of these installations can be seen along the foreshore of Portland Bay Victoria.

South Australia has 11 wind farm installations and 3 under construction. The South Australian government claim to have already reach 20% of their total power

generated in the State to be by wind generators, the largest proportion of power generated by wind than any other State in Australia. By the year 2015 they expect to generate between 1500 to 2000 MW in this way. That is almost equivalent to the output of the giant Loy Yang A brown coal power station in the Latrobe Valley Victoria.

Recent installations in places like Cape Nelson and Cape Bridgewater near Portland Victoria have wind generators standing 110 meters high with three sails, each 30 meter long. A farm of 29 of these units can power 35,000 houses.

Others have been located inland around Ballarat in Victoria, Goulburn NSW, Bundendore on the east side of Lake George near Canberra and Stockton near Newcastle New South Wales.

Solar Hydro

This is a technology that uses the suns energy to heat water to super heated temperatures approaching 285 degrees Centigrade.

Water heated above its boiling point of 100 degrees Centigrade is called super heated water. This means that the water will not form steam if the water is kept under pressure and not allowed to be vented into the atmosphere. Instead it will continue to heat in a liquid form, as it heats the liquid water increases in pressure.

When the water is finally vented into a lower pressure of the atmosphere it will then form steam but with an increased expansion providing a large force. This force can then be used to turn a turbine to generate electricity.

This process is already used in coal fired power stations, but produces the steam from boilers heated by the burning of coal to super heat the water.

However, solar technology allows the super heated steam to be generated by concentrating the energy from the sun and magnifying the sun's energy by large concave reflectors. The super heated steam produced is then fed straight into the existing power station process.

One pilot plant in Australia has successfully demonstrated this technology. Liddel power station in NSW has developed an array of solar hydro collectors that cover an area of about 1500m^2 feeding straight into the main plant steam systems, thus offsetting some of the coal fired process' production of steam. (ref. Letter to Prime Minister Rudd: Dated 30 Jan 2009)

This process could be used anywhere where there is sufficient sunlight produced from the sun. Often the places where there is long periods of direct sunlight are not the places that have close proximity to major population centers situated along the coasts of Australia or necessarily close to existing power station. Power stations

were built100 years ago close to coal fields and populations, for the same reasons new solar plants will need to consider optimum resource availability and supply costs.

This may mean that new installations need to be built in more suited location to harvest the suns energy resource, however as existing infrastructure around existing power stations is still needed for solar, consideration should be given to the utilization of this infrastructure in the interim, even though solar efficiency will not be maximized.

Solar Voltaic

This technology converts light directly into electrical current. The process is often called photovoltaic's. Panels of silicon sheet cells harness the light components of the sun's rays and convert these rays into electrical current. The electric power produced is then used in various devices and for a myriad of applications.

Many remote low powered devices now use this technology. These include remote lighting applications, communications and various types of sensors for weather recording, remote switching devices and traffic control systems.

In times past, energy planners thought of this type of energy as a possible adjunct to coal fired power stations. The thinking was that with increases of efficiency in these units and cost reductions due to mass production, large arrays could be built, enabling solar photovoltaic technology to drastically reduce the need to use as much power produced from coal fired power stations, thus reducing both the CO^2 produced by the coal fired process and the carbon foot print for power generated.

In recent years the realization has hit home that these technologies, although improved, have not delivered the efficiencies needed to address the required power for modern cultures due to four reasons:

1. Base power loads cannot be carried by this technology due to the unavailability of the light resource at night.

2. Large scale installations would be considered an expensive way to generate power when considering the useful life of a solar panel, which is thought to be between 15 and 25 years.

3. Other cheaper renewable energy processes now on the horizon would out perform these installations.

4. The power generated from these devices only utilizes the light component of the sun's rays. As the device heats up due to the heat component of the sun's

rays, anecdotal evidence has shown a decrease in the efficiency of the panels.

However, these panels have an inherent quality that gives them an advantage in some applications. They are a passive energy collector. They require little maintenance during their working life and can easily be installed on any roof surface.

Providing the sun is able to present rays to them, they will be able to generate power as long as the sun is shining.

As the demand for panels increase, costs of roof top installations will fall and even though there have been efficiency issues related to the technology, continued research is slowly increasing the efficiencies of the panels. Vast amounts of power can potentially be presented to the grid through this technology, given the right incentives to install the panels on unutilized roof space.

Recently the Australian government has provided incentives to help this energy source develop, by allowing private land owners to install these devices and connect them to the grid, providing a small savings on their power bills.

In addition the Australian Government has provided an added incentive to cover the installation of these relatively expensive systems. The average system would be between 1 and 2 kilowatts at a cost of between $10,000 and $16,000. With a rebate from the government this cost is reduced the to the householder.

The solar installation could save a householder up to one third of the normal power bill in 2010 or as in the case of NSW the total amount of the power produced can be sold to the energy supplier at a higher tariff thus reducing the payback time on the installation costs.

Wave powered energy systems

Wave power generation is starting to be used in Australia. Sites off the coast of Wonthaggi in Victoria's South Gippsland region and off the coast of Port Fairy in Victoria's far Western district are planned or currently in operation.

The Wonthaggi site is proposed to use the Pelamis P-750 wave energy converter system. This is a system that uses barrel like floats joined together and anchored perpendicular to the wave. As the wave moves over the device the upward and downward movement of the wave is transferred to the joints between the floats. This energy in the joints is then transferred to electrical energy. The proposal was to power a desalinization plant. Unfortunately the desalination plant has a lot of public protest surrounding its construction which may delay the construction of the power plant.

Currently a large scale installation of this device is proposed for the waters off Scotland. This installation will produce power equivalent to a 600MW power station.

The other announcement in Victoria is the Portland / Port Fairy project, proposed to produce 19 MW.

Two more wave energy projects have just been announced, one off the coast of Port Kembla NSW and another off Perth's Garden Island.

Commentators from the companies investigating new sites, say that wave power is slightly more expensive than using wind, but also say, with carbon trading implemented, it would eventually compete with fossil fuels to produce base load power.

Tide powered Energy Systems

This form of energy harvesting is also planned in Australia. Potentially large investments could be made in Australia to tap into this inexhaustible supply of energy. This energy source could deliver base load power to the various State electricity grids.

Recently, a Darwin based company announced plans for a tidal energy project worth up to $900 million in the Clarence Strait between the Northern Territory mainland and the Tiwi Islands.

This is a sizable investment in renewable energy. It indicates that the northern seas have a great potential to provide base load power to towns and cities in the northern regions of Australia.

A Perth based company is assessing whether power plants that use tidal energy can be built at Warrnambool and Portland. This will indicate a viability of the use of tidal energy harvesting in the southern sea and at the same time increase Victoria's diversity for harvesting renewable energy.

This Perth based company has been encouraged by the South Australian Government, which has stated that it wants to fast track regulations and make South Australia the nation's tidal energy capital of Australia. As a consequence the Perth based company has investigated a number of sites for the harvesting of tidal energy in South Australia.

It is evident that this renewable energy sector is about to come on line as a significant player in the market place to provide base load power.

Thermal or hot rock energy systems

Thermal energy is sounding a very exciting prospect in Australia. Australia seems to be well suited to this kind of energy usage since the country has a number of shallower hot rock locations, more than in the USA and other countries.

Already there are dozens of non ASX listed companies plus eleven listed ASX companies preparing to produce power from Australian hot rock deposits. One project is set to start production in 2012 in the outback town of Innaminca Queensland with a 50MW pilot plant. By 2015 production with new plant is expected to reach 500MW in 2015.

Although the start up costs to produce this kind of power is relatively high, when compared with solar and wind energy systems, it is potentially able to produce power over a much longer period without significant extra capital costs and at a continuously constant reliable rate.

Not to get too excited, it is still a technology in its infancy and yet to find proven long term techniques to effectively and efficiently produce reliable power deep deposits underground, however in some number of locations in the USA hot rocks are producing power today.

Being a new technology, hot rock exploitation has revealed some dangers. These include disturbing deep contaminants and releasing them into the ground water systems. The use of closed heat systems will help eliminate these problems.

Two of these closed systems are called:

- Flash steam power plants and
- Binary cycle power plants.

A Flash steam power plant is one that pumps water to the hot rocks and diverts the hot water or steam to a turbine, expending the energy of the steam and returning the hot liquid water back to the hot rocks to be reheated.

The second is described by commentators as more suited to many of the Australian deposits due to the lower heat yields of the deposits. The binary cycle power plants work by pumping water to the hot rocks and receiving the heated water back to a closed heat exchange. The heat exchange then heats a liquid with a lower boiling point than water, to a gas which is then forced through a turbine returning the expended gas/liquid back to the heat exchange to be reheated.

One such company about to embark in the exploitation of hot rock energy is Greenearth Energy based in a small town just north of Angelsea in south western Victoria near the City of Geelong.

See: www.greenearthenergy.com.au/

The company has just received a drilling grant from the Federal government of $7M.

The Victoria State Government also awarded the company a $5M payment for a proof of recourse study and will award an additional $20M for the construction of a 12 MW geothermal energy demonstration plant.

Although hot rock power generation is in its infancy, it is enthusiastically supported by both State and Federal governments and could prove to be a major contributor to clean renewable base power for Australia.

Convection energy systems

This is a technology that uses the physics of hot air rising and cool air falling, to produce air movement past a wind turbine. There are a number of designs that take advantage of this natural phenomenon.

Some use Water sprays to create a temperature differential between the top of a tower and the bottom, thus inducing an air flow from the hot ground during the day.

A more complex system has been designed that relies on heat exchanges using Ammonia as a catalyst to heat air in the top parts of a vertical draft tunnel to induce air flow from the bottom of the chimney up past a wind turbine. This design has been conceived for colder ground temperatures.

For hotter ground temperatures, the sun during the day and geothermal heat sources at night are used to drive the updraft in this concept design. Various technologies for storing heat for use during night hours have also been designed.

A small experimental plant has been constructed in Spain in 1982, producing about 50 MW from about 11 acres of land enclosed in glass and heated by the sun, similar to a greenhouse and a 195 m high tower.

However, in Australia a project of mammoth proportions has been design and conceived to be built at a location 25 km north of Mildura in southwestern New South Wales. The concept had been planned from 2001. It was to get some equity investment from a Californian company in 2007 according to a Wikipedia source, however the deal collapsed. Then again in August 2008 the company was listed on the Australian stock exchange and the merger with the Californian Company seemed to be going ahead, along with plans to build a plant in Texas.

The concept is being called “Solar Updraft tower” technology and is said to be ideal for smaller remote third world locations, however EnviroMission plans to build units on such a scale that it will produce power of such magnitude that they say it will save the world. They believe that the units could potentially produce both power and food.

It could potentially produce food using the vast glass covered area constructed as part of the unit, as a giant green house.

The newly announced plant proposed for La Paz County Arizona is hoped to produce 200MW.

See: http://www.inhabitat.com/2010/01/06/enviromission-plans-massive-solar-updraft-towers-for-arizona/

South California Public power Authority seems to have a lot of interest in the technology because they have just recently made EnviroMission one of their approved suppliers.

This technology has a large potential in Australia in our less populated areas. It seems that given the addition of water, it could not only produce foods using green house design in more temperate climates but both solar photovoltaic and solar thermal systems could be piggy backed on the design concept. Even in the right location geothermal could be used within the system of greenhouse like structures.

Micro Energy Generation Systems

These systems are often installed in an urban environment to supplement the household electricity supply. These systems are mainly solar photovoltaic systems.

In New South Wales (NSW), as in many other states in Australia and even around the world, governments have provided a means by which any excess power generated by these systems can be purchased by the power provider in the locality of the installed system.

In NSW a scheme called 'Feed in Tariff (FIT)' enables this to be done. This arrangement was implemented in January 2010. Subsequent to this, a buy back scheme was set up to purchase the entire amount of power produced by a solar system installed on a domestic dwelling.

In the future it is envisaged that other designs of domestic power harvesting systems will be installed in the urban environment. Small wind turbines are available that could be adapted to an urban situation. Small convection systems would be an ideal adaptation for the domestic house considering the heat the sun applies to the roof on most houses during the day.

With advances in technology, pressure will be put on local councils to approve these installations. Now is the time for councils to investigate options for householders and owners of commercial building, through council programs to encourage efficient use of power in the built environment.

Although photovoltaic installations have little impact on neighborhood visual amenity, it is time councils considered various renewable power generating devices that can be installed and will not affect the accepted visual amenity of the local street environment.

Micro renewable power systems using available resources otherwise wasted

There are opportunities in urban areas and some coastal Council that can be considered for the utilization of power generation.

Because most coastal councils are close to the existing electricity grid and it is notionally an easy option of joining any power generated to the FIT scheme, there are a lot of opportunities for councils to make some extra revenue and add to the States target of renewable energy.

As the renewable energy power supply continues to grow it is important for energy suppliers to have a variety of renewable energy sources feeding into the grid. For example, if all the energy feed into the grid was from Solar Photovoltaic systems then when the sky was cloudy the power from renewable energy systems feed into the grid will be reduced, thus causing the supplier to have a fossil fuel backup system.

To reduce the amount of backup systems needed, a variety of sources of renewable energy must be feeding into the grid.

Councils are well placed to do this through a variety of imaginative power generating opportunities.

These include:

- The utilization of methane gas from waste tips.
- Utilize storm water flowing down large but steep drains into the sea. A micro hydro application could be installed in the storm water pipe and provide power.
- The utilization of raw water diverted from storage reservoirs in the mountains to lower reservoirs during dry times for domestic uses. This power could offset the costs associated with pumping harvested water on the coast when pumping it to the mountain reservoir.
- The utilization of a sewerage system in a similar way to the above application.
- A new technology is emerging, deriving power from vibrations. This technology is called piezoelectric generation.The amount of power harvested

from this is relatively small, however with research; systems could be developed to harvest the vibrations of major roads in the local government area.

One of the most attractive aspects of the above renewable power generating systems for an electricity supplier is that the power generated by the above systems are often during low sunlight conditions when power from photovoltaic systems are low. In addition Councils filling lower reservoirs, as described above can produce power at anytime when water is needed in the lower reservoirs. To help the electricity suppliers, this flow could be done at night when lower renewable power levels are usually present due to solar systems being off line.

Unfortunately, it seems that Councils are ineligible to use the FIT scheme. Energy Australia in a article in the Express Advocate Newspaper rejected an application by Wyong Council on the Central Coast of NSW to feed back into the grid from solar photovoltaic panels that it had installed on three public facilities at least one being an animal care facility.

Energy Australia disallowed this buy back of electricity from council explaining that the Council was not a small retail customer and therefore not eligible. This area of eligibility related to who can supply electricity to the grid is still a little confusing since Integral Energy has provided a rebate on the buyback of electricity from similar panels to Fairfield Council near Sydney.

Instead of disallowing larger and non-domestic systems from supplying to the grid, a more flexible supply arrangement for renewable energy should be allowed under a license arrangement to supplement renewable supplies of electricity in times of low renewable electricity supply. This would encourage the utilization of unused energy resources and the installation of micro and scavenger renewable energy electricity generation plants by councils and industry.

Conclusion

Australia has a vast and wide array of electricity generation options. With good and continued government policy settings for the construction of renewable energy conversion systems investment can flow into Australia ensuring that Australia gets a 100% renewable energy mix in the next 20 years not only for domestic use but for automobile and transport.

This will enable Australia to lead the way in this important move to ensure the future for Australia’s environment and also the worlds. This can be said when considering potential reductions in carbon emission, attempting to mitigate the effects of climate change and reductions in air pollution and environmental damage due to the burning wood and coal.

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Rocking on with hot rocks geothermal energy
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