What Australia is Like in the Year 2050 – Having Overcome the Challenge of Climate Change

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Introduction

In 2009, as a first year engineering student, I won a bursary from the Australian Power Institute to support my undergraduate studies in Power Engineering and to encourage me to work in Australia's Power Industry.

I remember being attracted by the challenge to "make a real difference to society and the world by helping to solve the world's climate change problems". This was reinforced by an invitation to write an essay on what Australia would be like at the end of my career, had Australia been successful in overcoming climate change challenges.

Looking back, this started me on an exciting and rewarding life time pursuit which is only now reaching its goal.

The Challenge

Forty years ago the world was locked into an unsustainable future due to continuous growth in population, energy usage and green house gas emissions that were driving climate change. The outlook was loss of ecological diversity, environmental degradation and worldwide pollution on an ever increasing scale. The Great Barrier Reef was threatened with extinction within a hundred years due to global warming and coral bleaching.

Climate change was being caused by the increased releases of green house gases into the earth's atmosphere. As shown in Figure 1, half of the Australia's greenhouse gas emissions were due to electricity generation and other stationary energy applications including minerals processing. Other sources of greenhouse gases included transport (14%), agriculture (16%) and land use (6%).

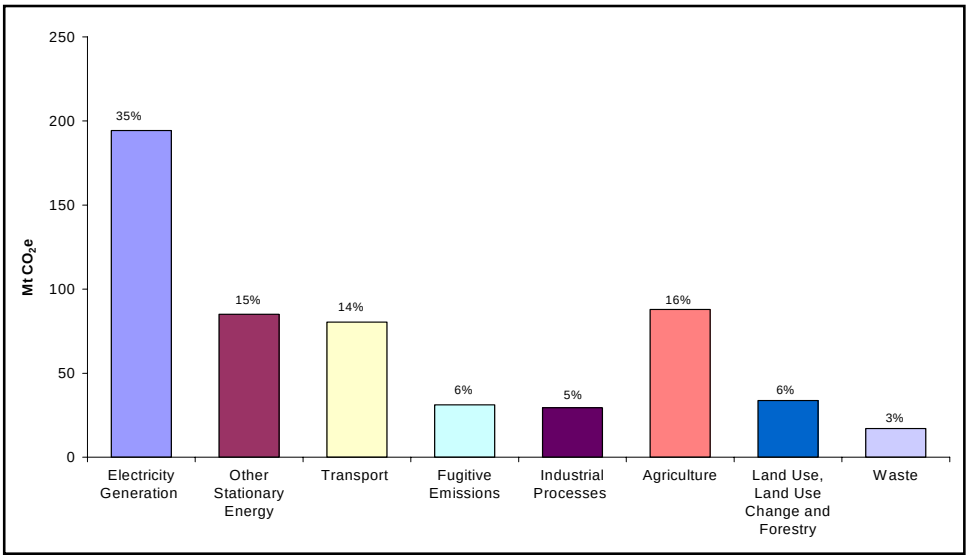

Figure 1: *Australia's greenhouse gas emissions*

A plethora of possible technologies were being proposed to address climate change, including energy conservation, smart networks, carbon capture and sequestration, nuclear power, wind-power, geothermal, solar-thermal, solar voltaic, biomass, electric vehicles and energy storage. Each technology was claimed to lead to the Promised Land, however, there were substantial technical and commercial obstacles to be overcome along the route. There were insufficient funds to research each technology and insufficient backing from industry to develop large scale prototypes to prove commercial viability.

Rather than providing direction on the most suitable clean energy solution, Australia's Governments simply introduced a 20% renewable energy target and a Carbon Pollution Reduction Scheme following years of debate and compromise. Whilst these policies initiated a slow and cumbersome movement of Australia's Power Industry towards a cleaner future, the industry was left to stumble along making its own path at an excruciatingly slow pace. Alternative technologies were investigated, slowly implemented, only to be superseded.

Whether Australia could have progressed more rapidly and directly along the path to solve climate change is arguable, however, more efficient progress could have been made by closer co-operation and collaboration with the world's current superpowers China and India.

Eventually global solutions were found to what was always a global problem and Australian technologists and engineers played an important role in these achievements.

Decade One – Conventional Technologies - 2010 to 2020

My engineering career commenced in the dynamic Coal Seam Methane Gas Industry where I helped develop new wells and associated gas fired power stations in Queensland's Surat Basin and contributed to a booming new export industry of shipping liquefied gas to Asia. Later, I moved to western Victoria and South Australia to build and operate large wind farms.

These cleaner power generation sources, together with the new carbon trading scheme exerted sufficient financial pressures on the older brown coal fired power stations in Victoria to bring about their closure.

Towards the end of the decade I moved into electricity distribution in NSW to introduce Smart meters to households in the Sydney area and to develop a Smarter Distribution Grid using the new optical fiber telecommunication network funded by the National Broadband Network (NBN).

At this stage, I was also involved in promoting energy conservation to both households and industry. Figure 2 illustrates the significance of more efficient energy usage. It demonstrates that once electricity has reached households, about 68% of the power has already been lost. A significant improvement in energy usage and efficiency was achieved by the national programs to insulate households, replace the 12% inefficient incandescent lighting with compact fluorescent lamps and LEDs, replace electric water heating with gas and solar and more efficient appliances particularly air-conditioning.

A particular focus of Australia's energy conservation program was the minerals industry including mining, extraction, transport, refining and smelting due to their large energy usage.

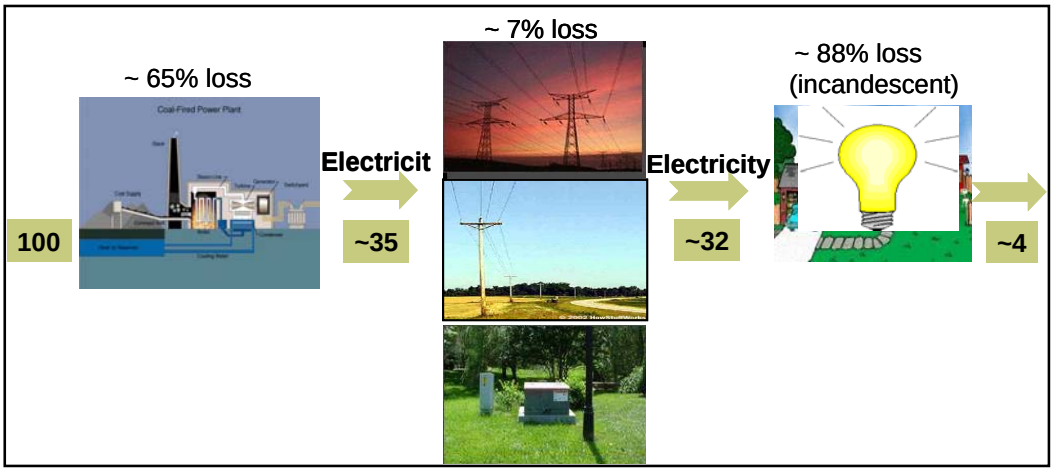

Figure 2: *The efficiency of electricity produced by coal-fired power plants, transmitted by powerlines long distances and used by incandescent light bulbs.*

By the end of my first decade, I had helped with technical advances that reduced Australia's greenhouse gas emissions by 20%. Whilst this was a great achievement, the world was still facing a bleak future because of the continued growth of coal-fired power generation in China and India and the Barrier Reef continued to deteriorate. This is due to Australia only contributing to a small portion of the carbon dioxide emissions as evident in Figure 3.

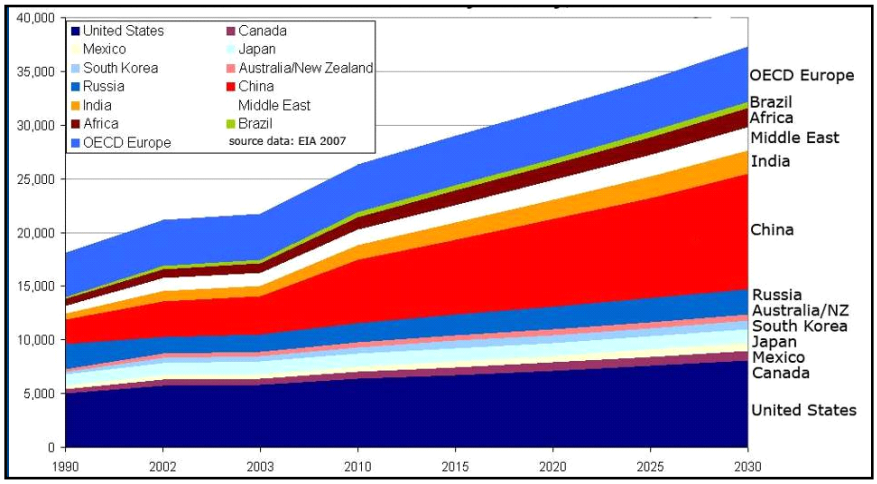

Figure 3: *World carbon dioxide emissions by country between 1990 and 2030*

Decade Two - Remote Renewable Generation - 2020 to 2030

With the Government increasing Renewable Energy Targets to 40% and the price of carbon emissions to $50/tonne, the next decade witnessed the development of large power stations based on very remote renewable energy resources including wind, geothermal and solar.

In central Australia, very remote geothermal power plants became commercially viable due to the changes in the governments policies. Large scale solar-thermal power stations were also developed in central Australia where there was high solar intensity and available land.

The intermittent nature of wind and solar energy led to power system security problems due to the difficulty in matching power generation to overall power consumption. Winds are strongest overnight and there is often little wind at time of peak demand. Solar power is only available in the daytime but can be adversely affected by overcast days and dust storms.

At this stage I joined a leading transmission line construction company to help build the long distance High Voltage Direct Current (HVDC) network to interconnect the new remote renewable energy power stations to the existing 500KV networks in the eastern states. The very high transmission costs required special regulatory treatment by the Australian Energy Regulator to smear its costs across all Australian energy users to make the remote renewable power stations viable.

The increasing commercial pressures on the remaining coal fired power stations forced the closure of most black coal stations which had been located near the load centers in eastern Australia. This increased reliance on power generation from the remote and intermittent renewable energy resources in Central Australia, South Australia and Tasmania and the associated long distance HVDC transmission technologies.

The turning point for Australia undoubtedly came in 2028, when catastrophic and repeated power system collapses occurred across Australia crippling industry and blacking out major cities in eastern Australia. This confirmed overseas reliability concerns with intermittent renewable generation and the vulnerability of long distance HVDC transmission.

By this stage of my career I had joined the Australian Energy Market Commission and played a key role in the national inquiry. It recommended the immediate installation of distributed energy storage devices and enhancements to the smart networks. This helped co-ordinate intermittent generation, distributed energy storage devices, and the control of appliances in homes to help address system security and intermittent generation as shown in Figure 4.

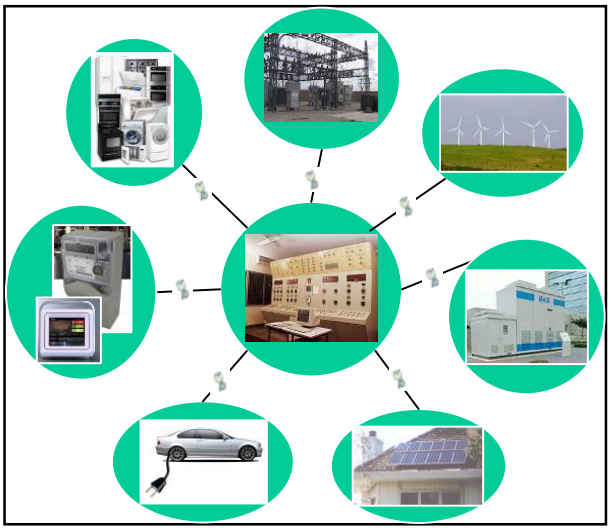

Figure 4: *Smart network*

By the end of the 2020's CO_2 emissions from Australia's Power Industry had reduced by 50%. However, there were still growing emissions from the transport industry and from China and India that continued to threaten the world. Serious bleaching of the Barrier Reef in the hotter waters north of Townsville was impacting tourism and tropical cyclones had become a regular and serious threat as far south as Brisbane.

Decade Three - Clean Coal and Nuclear Generation - 2030 to 2040

Widespread public concerns following the 2028 power system collapses brought about a change in political control of Australia leading to wide scale changes in Australia's energy policies. Clean coal and nuclear power technologies which had been progressed in China and India became the favored technologies in Australia due to their ability to operate continuously and reliably and to be located close to the load centers to eliminate dependence on long distance HVDC transmission.

Of particular importance was carbon sequestration using the oceans algae to convert CO_2 back to oxygen as the endothermic chemical reaction helped cool the coastal waters along the Barrier Reef and reverse coral bleaching trends.

By the early 2030's nuclear power stations had been approved for construction in the eastern states on the sites of decommissioned coal fired power stations located more that 100 kilometres from the major population centres. This reduced costs by utilising existing transmission networks and other infrastructure.

I worked on the construction of Australia's first nuclear power plant in the Latrobe Valley, Victoria involved in the installation, testing and commissioning of the many safety systems that monitor and control the pressurized heavy water reactor.

The rapid implementation of clean-coal and nuclear power in China and India meant that by the late 2030's the world started to see a turning point for CO_2 emissions and climate change.

Decade Four - Final Challenges Overcome - 2040 to 2050

By the early 2040's technological advances in batteries led to electric vehicles quickly replacing liquid fuelled vehicles. Not only did this further reduce worldwide CO_2 emissions but it introduced distributed energy storage devices that could be used by smart networks to store and generate power locally.

Australia's power industry moved towards a two level system where base load power is supplied from clean and reliable geothermal, clean coal and nuclear sources, with a meshed and intelligent distribution network utilising smart networks to optimise the time-of-use and allocation of power

between customer loads and local storage devices. As seen in Figure 5, the current worldwide electricity source directly correlates to a pre 2010 study of each of the various power supply options. It illustrates that the most affordable clean power sources were clean coal with CCS, nuclear and geothermal.

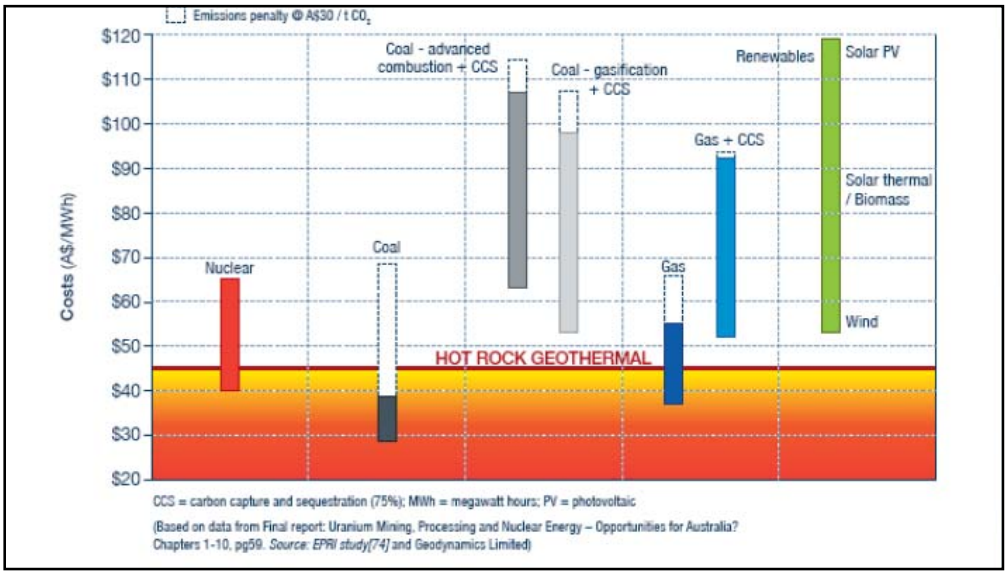

Figure 5: *Evaluation of Australia's power options*

My last job involved working for an international manufacturer installing wireless electricity transmission and distribution systems in Queensland. This new technology uses short directed bursts of electro-magnetic radiation to transmit electricity through space without the need for any transmission lines. Power can be distributed directly to each and every household, vehicle and personal aircraft. It relies on Maxwell's equations and a ubiquitous telecommunications and intelligent network.

Smaller bursts of power can now be directed straight to each customer safely, reliably and efficiently. Energy is stored at each home or electric vehicle for later re-use. Base load energy continues to be generated by clean technologies which over time is expected to include nuclear fusion located in remote locations and possibly in orbiting satellites

Conclusion

As I approach retirement from the power industry, I am proud to have been part of the successful battle against climate change which has been achieved by the united efforts of engineers and technologists around the world. It may have taken a lifetime, but I believe I have met the challenge put to me by the API 40 years ago to really make a difference to the world and society.