Engineering Challenges
and
Innovation
in
Power Engineering

Perspectives from my 2009 Vocational Employment Experience

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I take the vision which comes from dreams
and apply the magic of science and mathematics,
adding the heritage of my profession
and my knowledge of nature's materials
to create a design.

I organise the efforts and skills of my fellow workers
employing the capital of the thrifty
and the products of many industries,
and together we work toward our goal
undaunted by hazards and obstacles.

And when we have completed our task
all can see
that the dreams and plans have materialised
for the comfort and welfare of all.

I am an Engineer.
I serve mankind
by making dreams come true.

- *Anon*

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It has been often said that engineers bring science to the people. All the greatest ideas, theorems, hypotheses; none would receive the recognition they deserve without the work of the engineers in creating them into something that people can see, understand and touch. Engineering takes the challenges - the dreams and hopes of mankind - and through innovation creates the useful and the new. The world would not move forward without it. Coincidentally, the moving forward of the world itself evokes a greater need for engineering. New challenges arise everyday in all fields of engineering, but today, with the world's concern regarding climate change, the environment and the economy, power engineering in particular is a field which must prepare to move forward, to keep up with the growing needs of our population and our planet. The reliance on power engineering in the world today is immense. A single hour of power loss in a big city causes chaos. Lives are literally put at risk. It is beyond question that the power industry must keep ahead of future issues to provide a stable source of power to all of its users. In order to do so, challenges facing the industry need to be identified, scrutinised and addressed in such a way as to provide the best outcome for all parties. To find the best outcome, issues must be looked at globally, as well as within each affected company.

Thanks to the API Bursary Program, I was lucky enough to undertake 2 weeks of vocational employment with VENCorp during the summer of 2009. Due to the fact that VENCorp will soon be joining with NEMMCO, along with several other electricity and gas distribution companies, to form AEMO later this year, I also spent 2 days of my fortnight of vacation work at

NEMMCO. This wonderful opportunity, as well as giving me an insightful glance into several facets of the power industry, allowed me to research the challenges facing VENCorp, NEMMCO, and possibly many more power based companies, in today's world. It might be guessed that one of these challenges is dealing with the impact of power production on the environment. As well as the pollution of the atmosphere, the inevitable exhaustion of the world's fuel supplies must be considered. Both these issues bring into question the types of renewable energy sources that would be best to utilise in the future. At the same time, power should continue to be affordable, and the price of 'going green' must be considered. Of course, nothing can be achieved without the work of skilled engineers, and the skills shortage currently apparent in Australia must be addressed. Lastly, the effect of extreme circumstances, such as natural disasters and unpredictable temperatures, on the power grid, should be able to be managed effectively if the need arises. These challenges provide incentive for invention and innovation within the industry, and should be seen as a stepping stone towards the future of power engineering. After all, what is an engineer without a challenge?

Challenge 1:
Climate Change

While some argue about the amount of global warming that has occurred, and the role humans have had in bringing it about, looking at the city skyline on a smoggy morning or, worse still, taking a deep breath at such a time, will definitely convince you that pollutants being released into the air by factories and cars every day are not healthy or desirable. With more than 90% of Australian power being produced through the burning of fossil fuels[1], the potential for a greener way of living is evident. The production of electricity accounts for approximately 37% of greenhouse pollution in Australia each year[2]. There are basically 2 ways of combating the effects of these emissions - either removing the pollutant gases from the air, or producing less of them. Both methods are being discussed as the global community becomes more aware of the effects of global warming, and will be looked into in some detail here.

Carbon Capture

Removing greenhouse gases from the atmosphere as we create them is one way to restore the balance of gases in the atmosphere required. Everyone can help with this to an extent - from individuals to companies to governments. One of the easiest ways to contribute is by the planting of trees and other vegetation, which can be done by anyone. Plants naturally remove carbon dioxide from the air and store, or sequester, it as carbon. The rate of carbon sequestration depends on many factors, such as the species of the plant, its health, location, rate of growth and its age. While every little bit helps, more substantial solutions are required to offset the mass of carbon dioxide released each year. With the electricity industry producing such a high percentage of carbon dioxide each, power plants running on fossil fuels are a prime candidate for the use of new carbon capture technology.

[1] http://www.vencorp.com.au/index.php?sectionID=7825&pageID=10831
[2] http://www.acfonline.org.au/consumptionatlas/

The technologies used for carbon capture can be divided into 3 main categories, based on the way in which the carbon is captured[3]. Post-combustion capture is achieved through the capture of the flue gas after the fuel is burnt, and could be utilised in many conventional power stations today. Pre-combustion capture requires the fossil fuel be first turned into syngas, mainly made up of carbon dioxide, carbon monoxide and hydrogen. This is done by exposing the fossil fuel to water vapour. Carbon dioxide is removed from the syngas before burning, and there are plants in existence today that employ this method of carbon capture already. This method can be further improved by the use of an additional reactor, to convert the carbon monoxide present in the syngas into carbon dioxide and hydrogen, by exposure to water vapour. When this is done in a coal power plant, the fuel must first be gasified. Techniques for achieving this include the Integrated Gasification Combined Cycle (IGCC), which is currently being trialed in several areas around Australia[4]. The third type of carbon capture is known as oxy-firing combustion capture. This is done by burning the fuel in pure oxygen rather than in air, which reduces the amount of flue gas produced and simplifies the separation of the carbon dioxide from the remainder of this gas.

As stated, some methods of carbon capture are already being used, and others are being trialed around the world. If this is to be an effective way of controlling greenhouse gas emissions, it will need the support of everyone. While anyone can plant a tree, bigger projects in carbon capture require specific steps from the bodies in power to succeed. A new power plant cannot be built in a day, and new technologies require trial and testing before they can be effectively used. Since power engineering produces some of the largest amounts of carbon emissions in the country, innovation in carbon capture will be something this industry will need to keep their eye on in the future, to reduce their impact on climate change in the most efficient and effective way available.

Reducing emissions

Of course, there would not be anything to capture if we could reduce the amount of carbon dioxide emissions in the first place. Being conscious of the emissions we are producing every day, and eliminating their production wherever possible, is just as effective as, and much more efficient than, removing the emissions already in the air. Ideally, both reduction of carbon emissions, and carbon capture of the emissions that are unavoidable, should be taking place. Once again, this can be done on many levels. Everyone can use an energy efficient light globe, or turn off the television when they are not using it. At the same time, the power industry must look towards using green energy sources and running as efficiently as possible. Standing over this, the government must support and encourage both individuals and companies to do their part for the planet.

According to the VENCorp Review of Climate Change Policy[5], the Australian government is considering what steps it must take to combat climate change, and is making targets and planning incentives for others to do the same. For example, the government is targeting a 60% reduction in carbon dioxide emissions by 2050. An Emission Trading Scheme (ETS) is also being

[3] http://www.co2crc.com.au/dls/factsheets/CO2CRC_FactSheet_02.pdf
[4] http://www.co2crc.com.au/research/demo_precombustion.html
[5] http://www.vencorp.com.au/index.php?action=filemanager&folder_id=1009&pageID=7790&sectionID=8246

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discussed, with the details still being decided upon. An ETS would mean that businesses, organisations and companies would need to pay for the carbon emissions that they emit each year[6]. This should give an incentive to all companies to think carefully about the way they operate and to reduce their impact as much as possible. Power plants may be the hardest hit in this scheme, due to the high amounts of emissions they make, and it will be interesting to see how the industry deals with this future challenge. Power planning companies such as VENCorp, and AEMO in the future, need to make predictions about how the industry will react to an ETS, to ensure Victoria's power is not adversely affected. If the severe penalties imposed on power plants using fossil fuels cause them to shut down, the current renewable energy sources will not be enough to provide the required power for Victoria or Australia. The move to green energy needs to be monitored and dealt with carefully, to ensure our power remains reliable.

Hopefully, this scheme will not impact upon the power industry so greatly that power plants are left with no option but to cease operation. Instead, the ETS should push the power plants using fossil fuels to do so more efficiently, and to perhaps utilise some of the carbon capture methods previously discussed. Of course, the plants are not the only area that needs to find more efficient methods of operation. Transmission, distribution and consumption of the power must be done with thought placed on the carbon cost of the process. VENCorp, in planning transmission and distribution, has the opportunity here of making a real difference. This will also be true of AEMO, when it is formed later this year. AEMO will be in control of the longest power network in the world, running from Tasmania through to Queensland. Long distances obviously mean power loss, and planning the grid will need to take into account this factor, while still ensuring there are sufficient lines to keep our nations power supply reliable.

While much potential for efficiency lies in this area, in a 2007 survey of power utility executives from 114 power companies from around the world[7], the majority interviewed believed that the greatest savings could come from the end customers. Individuals, industry and businesses must do their part to use power more efficiently. Public awareness campaigns such as Earth Hour are helping to encourage people to think about how much of the power they use is really essential, and events and promotions such as this should continue to push down power consumption in all facets of society. However, there is only so much the end user can do. What is really required is an alternative to the way we get power today. In other words, green energy needs to be considered, and the potential for its growth should be prepared for. Some types of renewable energy production, and the effect of their use on the power industry, will be discussed below.

Challenge 2:
Limited Resources

The carbon emissions being produced are not the only reason greener power generation needs to be implemented. The fossil fuels being used in power production are slowly running out, and one day there will not be any left to use. While there may be enough for several generations to come,

[6] http://www.acfonline.org.au/articles/news.asp?news_id=1817&c=254725

[7] http://pepei.pennnet.com/Articles/Article_Display.cfm?Section=ARTCL&PUBLICATION_ID=6&ARTICLE_ID=309289&C=Power:

the switch to renewable energy cannot be made in a day, so the future must be planned for now. New types of renewable energy must be researched, and the current sources of green power need to be further explored and grown.

One of the most popular renewable energy sources at the moment is wind power. There are already several wind farms around Victoria and the world, and in general these have been found to be an excellent source of power when running. However, there are many challenges in extending the amount of wind power being generated. Some communities have expressed concern in the placement of wind farms near their houses, but the main issue for the power industry is the reliability of this power source. NEMMCO regards wind power as an unscheduled power source, as the amount of wind on any particular day is hard to predict, and so at the moment, wind power can only be counted on as a supplementary source of power. However, there are hopes that the Australian Wind Energy Forecasting System (AWEFS) project will help improve wind forecasting systems and reliability[8]. This project was established due to the increasing impact wind power is having on the National Electricity Market (NEM) forecasting done by NEMMCO. VENCorp also predicted the growth of wind power in their Vision 2030 report[9], and this was further explored in a study on the capabilities of the Victorian electricity network to incorporate wind power[10]. The study found that as well as the variability of wind forecasting, other concerns included the quality of electricity produced by wind turbines, and fault level control. However, it also stated that technology in this area was being developed rapidly, and high levels of wind based power could be integrated into the network when the technical solutions could be applied.

Other renewable energy sources are also possible for development. One source sometimes forgotten is generation through biomass, either through the burning of the biomass products, or through converting them into other fuel products. Biomass crops can be grown specifically, like corn and sugar cane. Alternatively, biomass plants can run on the waste products left over from growing these crops for other purposes, or general household waste can be used. While biomass generation does produce carbon emissions, it is seen as carbon neutral because while the crops are growing they are absorbing other emissions from the air. Biomass is a good substitute for generation through the burning of fossil fuels, as long as the methane exhausts are captured, and is a reliable energy source. Hydro power is usually also another reliable source of renewable power. The Snowy Mountain hydro plant was a significant part of the Victorian and New South Wales power supplies for several years. However, in recent times, the drought has meant that there is insufficient water to keep the plant running, and so other alternatives must also be explored. The other popular renewable energy source is solar. Unlike the others, solar power is not usually generated on a large scale. Solar panels are usually installed directly where the power is needed - on the roofs of the buildings that want to use it. The increased use of solar power in another challenge VENCorp, and AEMO, will have to consider in the future. Hours of sunlight will need to be predicted, and calculations made as to the impact of personal power generation on the grid. As quite a sunny country, the possibility of ‘sun farms’ should also be explored as a supplementary power source in Australia.

[8] http://www.nemmco.com.au/psplanning/awefs.html
[9] http://www.vencorp.com.au/index.php?action=filemanager&folder_id=576&pageID=7790&sectionID=8246
[10] http://www.vencorp.com.au/index.php?action=filemanager&folder_id=926&pageID=7790&sectionID=8246

Lastly, nuclear power, while not renewable, is another option to help supplement our current power sources. Of course, this is a hotly debatable topic, as many fear a disaster similar to that at Chernobyl, and there are questions as to how best to dispose of the nuclear waste. Whether or not the Australian government decides to bring nuclear power to Australia, it should not be seen as a solution, as uranium will, too, one day run out. While none of the renewable energy sources discussed is a perfect solution, they should all be developed and used as much as possible to extend the life of our fossil fuels, and the growth of these supplies needs to be taken into account by the power industry. Perhaps one day a truly renewable and reliable power source without negative effects can be discovered, and the problem solved more acceptably.

Challenge 3:
Affordability

While going for greener energy is a wonderful long term solution, especially in terms of reducing pollution and securing power supplies for the future, it may have some short term side effects that are not so desirable. The switch to renewable energy may be an expensive one, and care must be taken that power retains its affordability. Building new generation plants is expensive, and reducing the output of current power plants increases this expense, as it decreases the efficiency of each plant. Not only must the balance of different types of generation be monitored as we move towards a greener future, but other steps must be taken by those with power to ensure that electricity remains affordable to everyone.

One step already in place is that NEMMCO is currently working on introducing a system of smart metering to the NEM[11]. This would enable consumers to have the market fluctuations reflected in their energy prices, rather than paying a set price for their electricity. This would definitely benefit many customers, who could choose to run only when power is cheaper, and would probably produce some interesting effects in terms of price competition on the NEM. Balancing costs is definitely an important aspect of managing the power network, and should be done by all areas of the power industry, from generation to supply. Innovative ideas, such as the smart metering scheme, provide opportunity for customers to be more in control of how much they are paying for their power, and provide more incentive for generators to produce electricity as cheaply as possible.

Challenge 4:
Skills Shortage

It is all very well and good to say which areas of the power industry need improvement, or where there is room for innovation. However, nothing can be achieved without a steady supply of power engineers entering the industry, and supplying their skills. Sadly, the power industry workforce is aging, and if nothing is done, soon there will simply not be enough people to keep the system running. There are fewer and fewer graduates going into power, while the demand and investment in this area is growing. It is estimated that around 1000 new power engineers are

[11] http://www.nemmco.com.au/met_sett_sra/smartmeter.html

needed over the next 5 years[12].

The API bursary program is one way to attract new engineers into power. Supplying incentives such as bursary payment to engineering students, as well as the vacation work offered each summer, increases awareness and interest in the power industry. The companies taking part in the program, including NEMMCO and VENCorp, are also doing their part. As well as taking on API students, giving them insight and exposure to the power industry, many power companies take on other summer vacation students, and have graduate programs designed to appeal to graduate engineers entering the workforce. These programs typically include rotations around areas of the company, allowing young engineers to experience several areas before deciding on which area they prefer. However, more could be done by the government to further advertise the power engineering industry as an option for engineering students. Companies need to better promote positions they have available to university students, and need to ensure that their workplace is an attractive option for young engineers. Currently, many skilled engineers are being sourced from overseas, and while this may be a quick solution, it would no doubt help to attract some of our own home grown students into the industry. If steps are not taken in this area, the industry cannot grow. This challenge was also explored in the VENCorp 2030 report, and it was concluded that the issue needs to be looked into further, and steps taken to find where in the industry the demand is, so that the needs can be better met.

Challenge 5:
Extreme Conditions

Unfortunately, signs of global warming are already being seen, and spikes in weather are becoming more common, with more frequent days of extreme heat in summer. Coupled with an increase of air conditioners being bought, the amount of electricity being used could reach extreme proportions on days of extreme heat. Companies such as VENCorp, that rely on weather prediction, and must try to provide enough electricity for everyone in these circumstances, are being put under more and more strain as this 'extreme peaking' grows, as discussed in the Vision 2030 report. Having a power network such as ours, with connections to other states, is helpful in such circumstances, where power can be sourced from New South Wales or Tasmania when Victoria's supply is in need. Weather forecasting also must be utilised to better plan for days where shortages may occur. Unfortunately, since most green power sources are unpredictable in terms of how much they will supply on any given day, this is a problem that may continue and grow in the future, and we should definitely look at some more reliable power sources with capacities high enough for our needs. Planning of the power system must include allowance for growth of power use. At the same time, individuals and industry must try to limit their power use, and inventions such as the energy efficient light bulb will undoubtedly help in this regard.

There are other circumstances when the power network is tested, when companies such as NEMMCO and VENCorp need to take control to make the impact on the user as small as possible. In events of disaster, such as the recent bushfires, some areas may become cut off from power, and it is up to the power transmission planning companies to decide on how best to plan for and cope with these possibilities. If more small renewable sources of power are built, such as

[12] http://www.apesma.asn.au/summit/papers/API_challenge_power_industry.pdf

windmills and personal solar panels, the impact of these events can be lessened, as communities may have more than one source of power, should the main transmission lines to their towns be cut off. In the worst case, should all power plants be lost, the system must be able to recover, and the implications of a 'black start' must be researched. VENCorp often runs simulations, exploring which power stations can perform a black start, and which require power, so as to best predict how long it would take for Victoria's power to be restored to normal operating conditions after the worst case scenario. The increases of renewable energy sources should also make recovering from an extreme circumstance easier.

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An engineer is nothing without a challenge - engineering thrives and grows through the solving of the worlds problems. It is with the knowledge that challenges are only opportunities in disguise that we must look at the issues in the power industry today, and decide to make the world a better place. As the world grows, so do the opportunities in power engineering to be innovative in the way power is generated, transmitted, distributed and used. There is also scope for the government to provide incentives to companies to find a better way of doing things, and by doing so, to benefit everyone. The end customers must not be forgotten, for the way in which everyone uses power governs how the industry should act to accommodate their behaviour, and it is the little things everyone can do at home that can make a direct and immediate difference. Contrastingly, each issue should also be looked at on a global scale, since it is only by working together that we can truly solve the challenges facing our planet today. Without this perspective, each challenge might seem impossible to overcome.

As society moves forward, different industries will be experiencing different sorts of new challenges. Even within the power industry, the different sectors such as generation, transmission and distribution, will all be trying to handle their own individual issues. From my time at VENCorp and NEMMCO over the summer in 2 weeks of vacation work, I found that there were 5 different, but much interlinked, issues that VENCorp were looking to face in the future. Climate change is something we are all becoming more aware of, and along with the threat of declining resources of fossil fuels, green and renewable energy sources are something that both need to be developed, and also planned for, in the power industry. At the same time, power costs should be maintained at a low as possible level for the consumer, which means balancing the cost of green energy against its benefits. The demand for power engineers to develop these new greener and more efficient means of power generation and transmission is growing, but the power engineering workforce is aging, causing a gap that must be filled with new graduate engineers. Greater incentives and advertising of the industry must be supported by governments and business to secure the workforce for the future. Finally, those working in power distribution and transmission need to be prepared to cope with increases in spiked demands of electricity in the summer months, and also to deal with disasters that may impact on the supply of power to different areas of our power grid.

Power literally runs our society. Without it, it is hard to imagine what our world would be like. It is of the utmost importance, then, that this resource is protected and developed to meet our needs as our world changes. The power engineer should not be taken for granted. Innovation in power should be promoted in all its forms, and change should be provided for, and welcomed, as we all

endeavour to improve the life we live.
We should serve mankind by making their dreams of a better, greener, more reliable and efficient power system come true.
We are engineers.