Embedded generation - fact or future

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Abstract

This paper considers the difference between the traditional centralised power utility and the future of personal responsibility in having access to power generation.

The drivers for change are discussed and a scenario promoted that offers an explanation of an evolving pattern of change that is already occurring.

The oil and gas industry stands to gain very significantly if it can promote these concepts in an environmentally and socially responsible manner.

Background

This paper is the result of several years of research into the future development direction of power utility systems and the way they evolve. Many of the results are common to all utilities and in general terms are size independent.

It all started as a 'risk management' exercise to establish the robustness of the centralised power transmission system in New Zealand, and thereby assess its ongoing value, and it continues to evolve as advances in materials technology allow new opportunities in smaller scale generation.

I will examine the current and future roles of the centralised utility and then discuss the way the traditional model can be defeated and is likely to alter as a result of changes in the way the need for 'connectivity' is perceived.

The oil and gas industry is not only a source of good examples in this regard it is also a supplier to and a competitor for the power industry.

This paper is not about 'distributed generation', although naturally there are similarities.

No, the embedding of generation brings with it absolutely fundamental changes in the way power is produced, why, where, by whom and at what cost in terms of fuel, the environment and efficiency. It is also clear that all sectors of the economy are affected by the opportunities and that change will occur in different areas at different paces and times. This is not an instant revolution but it is a revolution.

There are, of course, millions of embedded generators in existence today. They are not necessarily considered to be generators, neither do they supply power for direct use, but generators they are, nevertheless.

The first example is the motor car. There are 65million cars in the USA. An interesting piece of lateral thinking is that if you take the surplus stored energy in all the car batteries, over that needed to start the engines once, and could harness it, there would be 112 Terawatts of power available which exceeds the entire generating capacity of the power industry in America.

We shall have a look at what that could mean and why change is inevitable.

The Centralised Utility

I have to state up front that the centralised power utility will always have a role in supplying or securing power. The reasons for this are efficiency of the mix of power sources, reliability, security and stability, and heavy load switching ability.

You could try to run a steel mill off wind mills but I wouldn't recommend it. In fact critical industry may have to be off-grid as many Indian yarn mills have found where the voltage and frequency control on-grid is so poor that the yarn diameter changes too much to meet international standards.

Huge power demand fluctuations do occur during a day in the life pf the utility and require support to prevent collapse of the system.

Nevertheless there are interesting problems with centralised utilities in the following areas:-

1. ownership
2. valuation
3. development

4. efficiency of use
5. regulations
6. national investment efficiency
7. risk

Ownership brings with it a conundrum as to who actually owns a centralised utility. Is it the government, the taxpayer, or the industry that feeds it or uses it? The rate of return on investment demanded by each of these parties differs substantially.

The valuation of the utility influences the charges it can legitimately pass on. However to work that out it is first necessary to establish the contribution the utility makes to each part of the economy it influences. It is also important to recognise intangible benefits. An example is a national power grid. If you merely look at the ageing utility, its value depreciates. If you include, for example the effects of the Kyoto agreement in the form of transmission of 'low environmental impact' (a somewhat subjective term) hydro-power from South Island to North Island then the value may increase. If you consider the security aspects then the cost of supplying a back-up is the base and if you simply say what is "the cost of the alternative" you get a different number.

Other political considerations may be to do with the spreading of costs across the community to allow easy and affordable access to all citizens and even 'what is it worth if we sell it'.

Development of a utility is also a can of worms. There are many considerations here but some of the more interesting ones involve:-

- free riding
- the utility of the utility- 'up to date-ness' of the assets
- expansion options – for greater capacity
- extension options – to allow more connections further from the source

Who pays for this type of work always causes discussion, often heated…

Efficiency of the utility is a variable. The natural life cycle in the power industry is for individual sections of a power system to develop locally, such as Reefton. Then they get connected up as they grow closer together and finally through some nationalisation route become a centralised utility 'for the good of the Nation'. As time goes on and demand increases the centralisation brings with it some efficiency in investment and operation but as the system matures the utility, it eventually becomes overcapitalised and loses its flexibility. At which point the shifts in technology that have happened along the way, for utilities are long lived 'beasts', frequently call into question the sanity, capability and usefulness of the operator and allow endless opportunity for harmless fun poking ridicule at how out of date things are and how much better if could be, if only. Ignoring all the while the vast investment involved in getting to this point.

Power is one of those few industries that have continued to grow ever since they were started. It is only in recent times that some maturity has developed, but only in the age of the utility regrettably.

Regulation is an area where the utility eventually falls victim to its own success in controlling the market. Inevitably a centralised utility does just that, and it needs to be run by a benevolent dictator or its monopoly position can be exploited.

Regulation is also not usually kept up to date proactively. Most regulators react to public or political pressure and regulations that seemed a good idea at the time can stifle the efficient use of a utility that may have become unfashionably monopolistic. Plenty of examples abound, a local one being the inability of improvements to be made to the national grid if they deviate from a narrow definition of 'maintenance' and excluding betterment due to new technology. In the case of power transmission this means keeping the 'Model T' Ford as the life span of the system is such that spares that perform as badly as the original equipment 50 years later, usually have to be made especially.

National Investment Efficiency is a term most people don't use or understand. However in the context of the overall asset base and investments of a Nation, taken as whole, it means trying to not waste money on redundant systems, or duplication. The only area spare capacity can be tolerated is where the cost of the alternative is too high or there is a need for some redundancy to protect the 'business as usual' case.

Clearly if it were possible to create the perfect system there would only be one option and it would be operated at maximum efficiency and at lowest cost. Real life isn't like that but nevertheless it behoves any government to encourage, through good policy, wise investment in assets that enhance the national economy rather than perpetuate the past.

Risk is such a broad based term these days that the centralised utility has to accept that it should only be concerned with sovereign risk issues and allow some partial failure. The critical part of that stance is to ensure that the management of the risk of failure is borne by the correct party. Usually that means the one who is best able to correct the problem. Most centralised utilities see the government shouldering the responsibility. This unfortunately means either it doesn't do it very well or it manages the risk by developing over capacity and charging accordingly. Those who bleat about high costs of supply or access usually have themselves to blame by insisting on unnecessary quality and quantity of supply. Many people and businesses are more risk tolerant than they realise and have merely grown used to high performance.

The future, or is it fact already?

We have all taken responsibility for our personal clothes washing, heating, hot water, entertainment etc. Why not power?

The main reasons are that it is cheaper and easier to just ‘log on’ to the power company.

Or it was. Remember when it used to be cheaper to use a fixed wired telephone. Now with new connection fees, monthly rental etc and user charges it may not be cheaper and cellphones have made big inroads.

In some countries, such as Malaysia, cellphones have even stopped the continuing development of the copper telecoms system.

It is not really visionary to suggest that power may be the next area where the individual assumes responsibility for their own source as it has happened where economics have forced it already.

Look at the cost of rural power connection these days and the change in the market that, well into the future for most of us, relieves the power network companies of being obliged to connect you up. At $25 000/km and running cost it soon becomes economic to do it yourself, particularly when you consider the advances that have been made in energy storage and emissions control at the domestic level.

That is where embedding generation at the domestic level is the key. But wait there’s more!

The first thing to consider is that embedded generation need not be sized just for the power load. To get the maximum effectiveness you need to consider the heat, power and efficiency all together. Combined Heat and Power (CHP) is the buzzword. For households it is micro CHP.

Firstly, 40% of the average household power bill is for hot water. Most of the other capacity requirements are in the cooking range or space heating. But hot water can be trickle charged using waste heat or solar energy.

Entertainment systems are moving towards lower power requirements all the time. Many LCD systems hardly use any power. Digital clocks likewise and why do we use 240V for lights when there are plenty of 12V systems? Modern materials technology is moving rapidly towards organic and LED lighting systems that use almost no power at all.

It does not take a great stretch of imagination to see a low power future for many domestic situations and then the world really can be changed. Lower power demand, and better storage of heat, in particular but cold as well, means less capacity requirement per unit.

In the traditional model we have seen the development of efficiency in the production of a unit of power. The bigger plant can be more efficient than the smaller ones. The only problem is that the investment in big plant is much riskier, the cost of failure is greater and the market effect of bringing big plant on stream in a small economy can be very significant.

The future is where the cost of a unit of generating capacity is low enough, like a washing machine, for the average household to afford it. The source of demand for these domestic plant is not the developed nations but more likely the developing nations where the cost is less than the alternative of installing the centralised infrastructure. India, China, and Indonesia account for half the world’s population. Could we see a reverse technology uptake by the developed nations as these counties move to increased electrification by embedding generation at the household or village level?

It should also be pointed out that most of us waste huge amounts of investment value by owning a car and connecting to the grid. Oddly enough most cars now have enough computing power to manage your household environment, hot water temperature, communications systems and provide the power to supply all you need in the way of electricity and heat. All we need is a sort of docking system to hook up the car to the house. The exhaust goes up the flue where it is catalytically cleaned. Better than wood and coal burners and easier to manage. Maximum investment efficiency can be gained by using you car 12 hours a day instead of the 1 or 2 it does today… And it could be connected in at the office too in exchange for car parking.

You may think this is fanciful but when originally proposed as a means of showing how a utility could be demolished over time, it actually had the effect of creating change. We thought it may take 25 years but within 5 all of the options have occurred. There have been huge advances in materials technology that allow these small devices to be built. Closer to home, Designline Buses in Ashburton have harnessed the Capstone Micro Turbine as a motive power source and demonstrated it in their buses used in Sydney at the Olympics and in Christchurch where they are a favourite with tourists because they are so quiet.

At 25 kW this is about what is needed for the maximum capacity of a fully electric household and, of course, it also generates another 70kW of heat that can be used in water heating as well as space heating and refrigeration. For a small group of houses in a new subdivision maybe there is potential for a small district scheme and the emissions are at ULEV or almost zero level. Ultra capacitors and deep draw batteries can provide temporary back-up and internal, to the house that is, peak shaving.

For the oil and gas companies the possibility of self sufficiency of power generation opens up huge potential as the individual can carry their own power source and fuel supply anywhere, thereby extending the already almost universal range of distribution. The low emissions can be seen as a contribution to the environment compared to major power stations. The use of power may even reduce as individuals become self regulating to use it only when they need it to be available.

Where are the constraints? Well the obvious one is the status quo; the biggest competitor to change ever. The second is the sceptics, the third and by no means an inconsiderable one is the need to either allow export of power from individual households and pay for it, or to simply disconnect from the network.

The truly embedded generator stands alone!! Embedded in the user not the system.

What will drive change?

Economic rationality?

Investment Efficiency?

Environmental considerations?

Maybe all of these will be embedded in the move but I predict it will be fashion and individual responsibility promoted by greater wealth, at least in New Zealand.

For the rest of the world where nearly two thirds of the people are not connected it will be necessity.

Just like it was for Mr Wilkes who designed the LandRover for use on his remote farm in North Wales and equipped it with a generator, power take off and so on in 1948.

What goes around, comes around…..

Authors

O'BRIEN CONSULTING LTD (OCL), was formed in 1987 by Dr Roger O'Brien. The Company undertakes advanced research into future business scenarios based on the advances in high technology materials and systems. It is also involved in oil and gas field development, petrochemicals and infrastructure project management, and the authoring of technical educational resources in material engineering.

ROGER O'BRIEN has a First Class degree in Metallurgy and a PhD in Fracture Mechanics from the University of Leeds UK. He is a Chartered Engineer (CEng) and a Member of the Institute of Materials, Minerals and Mining (MIMMM).

He worked in the oil industry, Shell International Petroleum and New Zealand Oil and Gas, for over 28 years. He was General Manager, Research at Transpower NZ Ltd, prior to establishing OCL. He is a Director of the Centre for Advanced Engineering at Canterbury University.