Worth Noting

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Worth Noting is the fortnightly journal of research and conferences company L21. It is focused on issues of relevance and interest to senior executives.

In a second edition on insights ahead for the energy industry, we look at nuclear power.

Nuclear power is nothing new. The energy that held subatomic particles together was, as we all know, deployed devastatingly way back in 1945 and has been harnessed as an energy alternative since then.

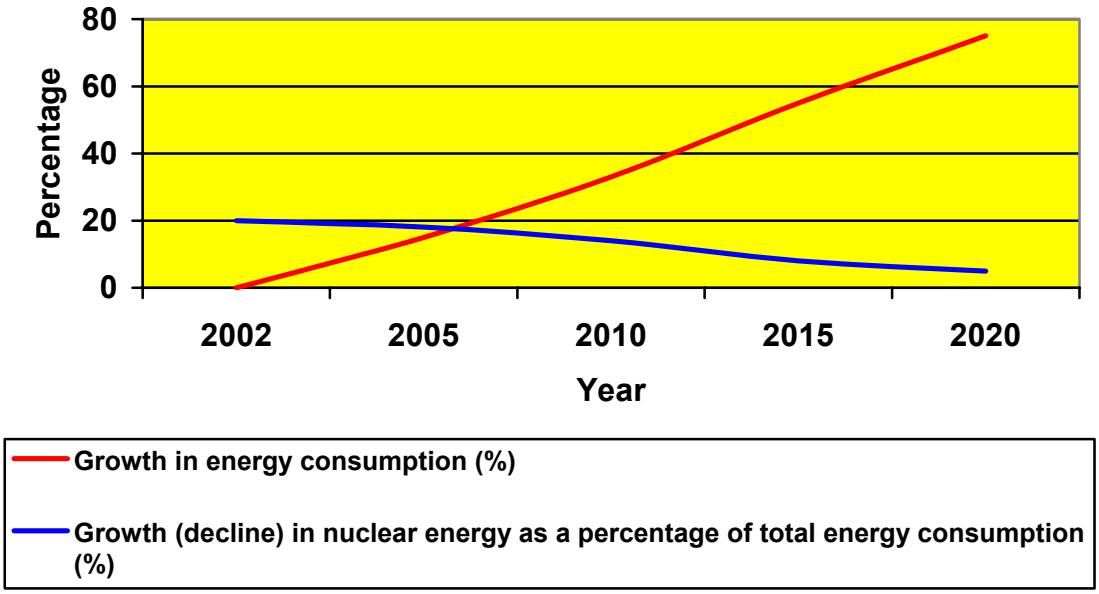
Last year, nuclear power supplied 17 percent of the world's electricity consumption and 20 percent in the U.S. We do not hear much about nuclear energy in Australia but it is a major global industry.

On the face of it, nuclear power is an attractive source of energy. Physicists tell us that subatomic energy is one of the basic and innate energies that hold the universe together. Tapping into this energy source is virtually limitless and in theory could supply us with an inexhaustible reserve of power. Moreover, given the concern about CO2 emissions and other atmospheric pollutants, nuclear energy is a clean energy in this regard. There are no 'atmospheric' pollutants released.

However, despite this early optimism, the nuclear power industry is in decline. As the chart below shows, whilst energy consumption is forecast to grow significantly over the next 20 years, nuclear energy consumption is forecast to fall significantly as a percentage of overall energy use.

Let us look at the reasons for decline in nuclear energy.

Growth of energy consumption vs. decline in nuclear energy consumption



Source: MIT Study, 2003

Reasons for decline of nuclear energy

Poor image in the community

Nuclear power has failed in the community relations test. From what was once seen as a clean alternative, community perceptions of nuclear power now range from suspicion of nuclear technology to downright fear of its impact.

The Chernobyl meltdown has not helped and even though nuclear power station designs in most Western countries are different to the outdated and unsafe former Soviet designs, the image of Chernobyl and its after effects have deeply scarred community attitudes to nuclear power.

High cost

In deregulated markets, nuclear power is now NOT cost competitive with coal and natural gas. The nuclear power industry has not been vigilant enough over the past few decades with cost reduction and it is possible that cost savings in the form of updated designs and processes could narrow the gap.

The wildcard in terms of costs comparisons is also global agreements such as the currently stalled Kyoto Agreement. Carbon emission credits, if adopted, can give nuclear power a cost advantage.

Safety Issues

Modern reactor designs promise a very low risk of serious incidents. The problem is that the amount of 'risk' tolerated by the community for nuclear reactors is basically none. Hence, the nuclear industry has a hard time convincing the community that reactors are 'safe'.

Waste

The waste from nuclear energy is another issue that is of concern for communities. While the safe disposal of nuclear waste is technically possible, the community and regulatory bodies have yet to be convinced that the safe and efficient disposal of waste has been carried out in all cases – probably because it hasn't. No nuclear energy countries have implemented processes for the disposal of spent fuel or high level radioactive waste created at ALL stages of the nuclear fuel cycle. Since these radioactive wastes present a danger to present and future generations, the spread of nuclear power plants are generally rigorously opposed by communities.

Proliferation and security concerns

The current international safeguards regime cannot guarantee that technology, processes and materials won't get into the hands of rouge states and other groups who seek to acquire nuclear capability for offensive purposes. At the moment the reprocessing system used in Europe, Japan and Russia involves a system involving separation and recycling of plutonium. Fuel cycles that involve the chemical reprocessing of spent fuel to separate weapons-usable plutonium and uranium enrichment technologies are of immediate concern. This presents, in the current global political environment, an unacceptable risk of proliferation of nuclear fissile materials that can be used to build a bomb.

Is the future all bad for nuclear power?

This depends largely on the nuclear industry itself – whether the industry can change itself in time. The world will need more energy – that much is clear. If nuclear power wants itself to be heavily in the global energy mix of the future, it must address the above problems associated with ***costs***, ***safety***, ***waste*** and ***proliferation***.

Let's look at the issues and decisions that will affect several or all of the above problems.

Fuel Cycle Choices

The choice of what type of fuel is used and how it is used is crucial. The decision affects all four concerns above.

There are basically three existing technologies the industry can use:

1. Conventional thermal reactors that use radioactive material once and 'once-through' spent fuel is disposed straight after.
2. Thermal reactors which separate waste products from unused fissionable material that is recycled as fuel into reactors.
3. Thermal reactors operated world-wide in 'once-through' mode and a number of 'fast reactors' that destroy by-products separated from the thermal reactor fuel.

We don't have to be too familiar with these technologies. The basic difference is that the first process uses the radioactive material once and disposes of it straight after. The second and third processes separate waste products from useful reusable products. The second and third processes are known in the industry as 'closed fuel cycles'. The basic difference between the second and third technologies is that with the 'fast reactor' of the third, more fissionable fuel is possible because it utilises higher energy neutrons.

Like most things, there are advantages and disadvantages to all three technologies.

The first 'once-through' technology has clear advantages in terms of cost, proliferation and processing safety. The downside is that long-term waste disposal of by-products is a problem.

The second and third technologies have advantages only in the long-term aspects of by-product waste disposal. But these technologies are more expensive, have the potential to provide fissile material for weapons proliferation and the fuel cycle process is less safe.

The second and third closed fuel cycle technologies do extend fuel supplies since material is recycled. The relative importance of this factor depends on the amount of uranium available at attractive prices.

There are currently 366 nuclear energy reactors in the world. Current estimates forecast that there is enough economically available uranium from known sources for 1000 reactors over the next 50 years. These 1000 reactors based on the available uranium will have a production shelf life of 40 years. In other words, running out of known uranium is not going to be the problem for the next few decades.

We believe that cost and proliferation is most likely to be the two main determinants that drive the nuclear industry. Why?

First, the recent record has shown that the nuclear industry is in relative decline because it is a more expensive energy source to produce compared to other energy types. The battle between different energy sources will be largely one of economy – which can product the cheapest energy.

Second, Western Governments now view nuclear proliferation and the acquiring of nuclear capability by rouge states and terrorist groups as the security threat facing us. This is not just the view of the U.S. Bush Administration. Iraq war politics aside, countries like France, Germany and Russia have consistently agreed that this is the most critical threat our societies are facing. Hence, processes that increase the chances of proliferation will be discouraged.

For these reasons, we believe that the first 'once through and dispose of' fuel cycle technology will be the way of the future for the nuclear industry. This forecast contradicts recent trends which rely on closed cycle technologies but we believe this will occur because running out of radioactive material is not a major concern. This technology is both he cheapest and the most proliferation resistant option of the three.

Proliferation is difficult because no radioactive, fissile material is isolated and retain unlike the other two technologies.

For example, the plans from Iran to build a nuclear reactor was of concern because the technology they wanted to employ would have facilitated the production of possible weapons grade radioactive material through the closed fuel cycle technology. A nuclear threat involves three things: having the radioactive material to build a nuclear bomb; having the know-how to build one; delivering or deploying the bomb. Efforts against proliferation are generally focused on the first and third aspects.

Public Attitudes

It's all very well to have the potential of an efficient nuclear industry but further reliance on nuclear power needs the community's acceptance of the industry. Nuclear energy might have advantages in cost if penalties for carbon emissions are imposed but not if community suspicion of the industry remains. And this is where the question of nuclear waste comes in.

Surveys done in the U.S. strongly suggest that negative community attitudes towards nuclear technology is mainly shaped by perceptions of the dangers of nuclear wastes rather than issues of proliferation, or other inherent objections to nuclear power. Interestingly, communities concerned with emission pollutants do

not think about nuclear energy as a pollutant free alternative. The lesson here seems clear: communities do not like the nuclear industry because of toxic wastes issues and the fact that producing nuclear power is carbon free does not help the perception of the nuclear industry.

This means that as far as promoting nuclear power as an energy source is concerned, new technologies must be developed that aid the safe disposal of nuclear waste.

> *In fact, we believe that nuclear waste disposal is the dominant issue determining whether the nuclear power industry grows or declines over the next few decades.*

At present, no country has yet been successful in implementing a system for disposing of nuclear waste effectively. So far, plans for waste disposal have been band-aid ones that would not be suitable for a large-scale increase in the use of nuclear power. For example, the U.S. has spent the last 15 years focusing on a proposed repository site at Yucca Mountain in Nevada. This would not address repository needs if there were significant expansion of the nuclear industry.

Advances in depository needs involved two things:

1. More depository sites that are safe – (ie., isolate the waste material from the biosphere)
2. Newer and better technology that reduces the amount of toxic waste or reduces the time waste needs to be isolated from the biosphere.

Nuclear processes in terms of waste by-products have changed relatively little over the past few decades. Producing 'cleaner' waste has not been a really strong priority.

For the nuclear power industry to grow based on the once-through fuel cycle technology, we would need multiple disposal facilities built. These disposal facilities are not just large holes in the ground. They require significant investment, technology and cooperation between many bodies for it to happen. For example, to dispose of the fuel from 1000 reactors, we would need one depository facility the size of Yucca Mountain to be developed every 3-4 years. A reminder that the U.S. has been discussing the Yucca Mountain site for about 15 years.

All of this suggests that if the nuclear industry wants to survive, it's got to get cleaner and cheaper. This means being honest about waste fallout issues, R&D spend on these issues to improve technology and better coordination between the nuclear power industry and regulatory bodies.

If the will from either the nuclear industry or political bodies is lacking here, then the industry deserves to, and will, decline. Our energy needs will rise quickly. The point is that nuclear energy can only provide us with an increasing share of our energy needs if the industry undergoes significant changes.

The reality is that advances in nuclear energy technology is driven by advances in nuclear weapons technology and testing. There has been less of that compared to three, four decades ago.

Moreover, the earlier promises of clean, limitless energy have not been fulfilled causing cynicism about the industry. This is because we have yet to work out a way of harnessing nuclear *fusion* where the waste is negligible. That is the Holy Grail. Nuclear technology is currently *fission* (where particles are split, not fused.)

Presently, on a global level, the industry is an aging, drifting one and seems to have run out of ideas and motivation to innovate. Any momentum to innovate would require specific coordination between Governments of industrialised countries to put nuclear energy back to the top of the agenda and pour money into the industry.