Nuclear Energy: The Lessons from Fukushima

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The year 2011 was an eventful one on the energy front, both regionally and globally. Regionally, announcements were made regarding a huge gas discovery in Mozambican waters and an equally significant oil find in Namibian waters, and South Africa approved a massive new power generation build that will see a trillion rand being invested over the next twenty years. Globally, the resurgent nuclear industry suffered a blow as a result of the damage inflicted on the Fukushima Daiichi reactors as a result of a massive tsunami produced by an earthquake off the coast of Japan.

This article is an attempt to contextualise Fukushima in a portfolio of risks that the modern world faces in its complex task of balancing developmental, environmental and social considerations. The lessons we draw from Fukushima tell us as much about ourselves as they do about objective dangers.

Nuclear Energy in South Africa's Energy Mix

The Integrated Resource Plan (IRP) for Electricity Generation was approved by Cabinet in March 2011 and gazetted in May 2011. This plan optimises a range of criteria, such as economic growth requirements, carbon emission commitments, local environmental impact, cost, and geographic availability of different generation options (coal, gas, hydro, wind etc) and sets a blueprint for a generational mix in a new power build over the next twenty years. The IRP involved substantial public consultation and expert input, and established a benchmark for South African public policy documents in that it sets a quantitative framework using a scientific methodology to produce an optimal scenario by balancing a complex set of criteria. The optimal breakdown of the new build generation mix was determined to be: 42% renewables, 23% nuclear, 15% gas, 15% coal and 6% hydroelectric.

There is no global "right answer" to the question of what is the best electricity generation mix. Each country must find its own best fit, depending on its location, resources and circumstances. South Africa and Australia have large coal deposits, and have traditionally depended on them for their electricity generation. California has plenty of sunshine, and in Britain the ocean tides are exploitable. In Chile, in the 1990s the Minister responsible for Energy was fired because of a drought! He had not diversified sufficiently away from hydro, and there were blackouts in Santiago. Because of the very compact nature of nuclear fuel – a hundred tons of it is equal to ten million tons of coal – transport factors do not inhibit the location of nuclear power plants. Nuclear power is therefore often a favoured option in those countries without indigenous energy resources. South Korea and Japan fall into this category. However, nuclear power requires an abundance of technically skilled people and sophisticated regulatory systems, putting it beyond the immediate reach of many countries.

Regional electricity grids and continental gas pipelines are an increasingly important development. Given the fluid nature of both gas and electrical current, regional markets are easy to establish. Spot markets and longer term supply agreements provide more choice but can also seduce a country into dependency. Germany can close nuclear power stations because it can import gas from Eastern Europe and nuclear power from France. But, just as easily, Russia can turn the gas taps off to a politically non-compliant Ukraine. However, many countries do not have the option of tapping into power imported from their region. South Korea is an obvious example, where a hostile northern neighbour prevents access to the Chinese grid. South Africa's neighbours are less economically developed than we are, putting us in an isolated position with respect to power generation too. The rule of thumb has traditionally been that it is safe for a country to import power up to a level equal to its reserve margin, meaning that it is buffered against the caprices of its neighbours. In regions (e.g. the European Union) where countries have decided to cooperate in a tightly coupled way, this precaution is often forgotten: one can imagine an energy supply crisis akin to the current European financial crisis arising because of knock-on effects in such a system.

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When we examine the historical fatalities associated with the various generation technologies the following statistics emerge: according to an International Energy Agency study (2002): for every 10 billion kWh of energy generated, there were 33 coal deaths (many of these due to pollution), 55 hydro deaths (mainly due to catastrophic dam failures in China), 1.6 natural gas deaths and 1.2 nuclear deaths. From a pollution perspective, it is interesting to note that the equivalent of half the uranium mined each year (25 000 tons) goes into the atmosphere as a result of electricity related coal combustion!

The South African Cabinet decided on a relatively high percentage of nuclear power in the future generation mix at a very difficult time for the global nuclear industry. The tsunami that damaged the Fukushima plants occurred on 11 March 2011, and Cabinet approved IRP2010 on 16 March. This took some courage, given decisions by Germany, Italy and Switzerland at this time. But it was correct to stick to the plan. Even if climate change considerations are neglected, certain regions in South Africa, particularly the Western Cape and the Eastern Cape, do not have other sensible baseload options. In the months following, stress testing of Eskom's Koeberg nuclear power station indicated a high level of preparedness for a Fukushima-type disaster, with greater redundancy of independent power supplies and a higher elevation above the high water mark than was the case at Fukushima. Moreover, the fault off the Cape coast is a shear fault rather than a subduction fault, and therefore cannot produce the size of wave that engulfed the coast of north eastern Japan last year. Geomorphological evidence going back centuries corroborates this.

As a result, South Africa intends to build the power equivalent of five or six Koebergs over the next twenty years. This is good from a climate change mitigation perspective, and it is also good from the point of view of expanding the technology base of our country. We are being overtaken in the region as a powerhouse of primary industry. Namibia and Botswana have mining industries that are rising rather than declining. Mozambique has massive gas deposits. Zambia and Kenya have rapidly growing agricultural sectors. South Africa's contribution must be in

Koeberg

knowledge and in technology. Investing in nuclear power is a positive step towards embracing this future.

Nuclear Power and Climate Change

According to the Intergovernmental Panel on Climate Change (IPCC), an average global temperature rise of more than 3°C will trigger runaway impacts, mostly negative, in all regions of the world. Large numbers of species will face extinction and new pathogens will abound. Geographic climate shifts-more rapid than we can adapt to from a planning and funding perspective-will affect the whole world. In our region, the Western Cape will become as arid as Namaqualand and the West Coast. Storms will increase in severity, with massive associated infrastructure damage, human misery and financial loss. The world therefore faces a huge mitigation challenge to keep carbon dioxide levels from rising above 500 parts per million. This can only be done by burning less oil, coal and gas and by capturing the carbon dioxide that results from burning these fossil fuels.

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The IPCC has estimated that nuclear power has the largest and lowest cost greenhouse gas reduction effect in electricity generation. If the 104 nuclear power plants in the United States were replaced by coal fired plants, this would be equivalent, from a carbon dioxide generation perspective, to doubling the number of vehicles on American roads. If the nuclear plants were replaced by gas, this would be the same as increasing the number of cars by 60%.

Why then has the United Nations system of decision making organs (the various COPs, etc) not embraced nuclear power generation as the preferred option? The answer, of course, is politics. There is no natural multilateral block of countries in the United Nations that could become a nuclear lobby. JUSCANZ (Japan, US, Canada, Australia, New Zealand) has stood together on other issues, but its members differ decidedly on nuclear power. Both the European Union and the

developing world coalition G77 suffer from a similar lack of coherence on this matter. It is also highly unlikely, given the potential dual use (civilian and military) of nuclear technology that a dedicated nuclear power lobby would be allowed to emerge in global multilateral structures. The idea of the United States and Iran (both civil nuclear advocates) sitting on such a body together is too far-fetched to contemplate.

Five Lessons Fukushima Has Taught Us

On the international stage cracks began to appear several years ago in environmental movements regarding nuclear issues. The determining factor was climate change. Many key leaders of the global environmental movement (James Lovelock, Patrick Moore who co-founded Greenpeace International and Stewart Brand, to name but three) have come out strongly in favour of nuclear power as the single greatest potential contributor towards the mitigation of climate change.

However, the recent "black swan" event of earthquake followed by tsunami in Japan has caused the pendulum of public opinion to reverse once more. But what are the facts here? Over 27 000 people were crushed to death or drowned in the disaster. Although radionuclides were indeed released significantly above regulated levels into the environment, not a single nuclear death has been reported. The World Health Organisation (WHO) has labelled the mental health impact of Chernobyl as "the largest public health problem created by the accident" and partially attributes this damaging psychological impact to a lack of accurate information. These problems manifest as negative self-assessments of health, belief in a shortened life expectancy, lack of initiative, and dependency on assistance from the state. These symptoms, experienced most acutely by the 350 000 evacuees, will doubtless play out in Japan too.

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In this context, the following lessons emerge:

1. Do Not Promise that there will Never be another Incident

It is over optimistic-even foolish-to assert that another incident will never occur. For example, if an asteroid 10 kilometres in diameter were to strike near any structure built by humans, there would be nothing left of this structure afterwards. Such incidents have indeed happened to planet earth. In massive disasters, however, everything is affected, and we need to compare the nuclear component of the damage with all the other damage, not lift it out and consider it in its own right. As Jon Ritch, Director- General of the World Nuclear Association has said: "We must establish technically, and explain convincingly, that nuclear events are both increasingly low in probability and increasingly low in consequence. That will be true and must be presented believably".

2. Nuclear Power is Safe

At Fukushima three operating reactors and one reactor shut down early in 2011-all between 30 and 40 years old-were subject to the worst earthquake in Japan's history, followed by a devastating tsunami, which flooded the backup diesel generators at the reactors. There was widespread devastation throughout the Fukushima area. Highly precautionary evacuation policies and safety standards in Japan make it extremely

likely that not a single radiation fatality will result from this major (category 7) nuclear incident. This needs to be placed in the context of the two hundred odd annual fatalities on South Africa's mines and the thousand or so who die in taxi accidents each year. In any rational analysis, where costs and benefits are soberly considered, the verdict would have to be that nuclear power is safe.

3. The Need for Redundant Independent Cooling Systems

Electricity is needed after the shutdown of a reactor to power cooling systems to deal with the heat generated by the slower decay of fission products that were produced before the nuclear reaction was stopped. Approximately 1% of the power in a nuclear reactor comes from this source. In the case of the 784MW Fukushima Daiichi-4 reactor, this amounts to about 8MW, equivalent to the power from two large wind turbines operating at full power.

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The huge earthquake knocked out the grid power supply to the reactors at Fukushima Daichi, which were also automatically shut down, whereupon the backup diesel generators kicked in. An hour later the 14 metre high tsunami flooded the generators. Batteries were then brought in. The batteries lasted a few hours. There was no cooling after this until grid power was re-established to pump sea water into reactor cores and spent fuel ponds. During this period some fuel melted and radioactivity was released.

The lesson here is that all reactors need multiple independent backup cooling systems. The International Atomic Energy Agency is establishing best practice in this regard.

4. Weak Public Understanding of Nuclear Technology

Radiation is part of our natural environment and we have evolved in its presence. All of us are exposed to natural radioactivity every minute, mostly from rocks and soil. Our radiation exposure goes up 10% when we sleep next to another human. The contribution the entire global nuclear industry makes to our annual dose is about 1%, and medical procedures, such as X-rays, contribute about 14%. Usually the annual radiation dose limit for a nuclear worker is set at a level 20 times higher than for a member of the public. But in the Iranian town of Ramsar, natural radioactivity as a result of radon gas brought to the surface by hot springs is at least 10 times the level permitted globally for nuclear workers. Ramsar has been populated since time immemorial. Epidemiological studies have been conducted. No adverse effects have been found. Recent in vitro studies indicate that DNA strands damaged by radiation are repaired in the cellular environment, unless damaged a second time before the repair is complete. This implies that high doses of radiation are indeed harmful, but low doses are dealt with as part of "normal housekeeping" by the human body.

Fukushima has taught us that this correct understanding of the effects of radiation is not held by the public at large. In fact, a staggering feature of the disaster in Japan was that the nuclear incident, which killed nobody, has been given significantly more coverage by global media than the tragedy of 27 000 people who lost their lives in the earthquake and the tsunami. How could this happen? The engine of publicity works by feeding on public preconceptions and deeply held fears and

desires, however far-fetched these might be. If someone gets attacked by a shark while bathing at Fish Hoek, the waters will be empty of people for days thereafter. But if there was a fatal car accident nearby, this would not deter a single one of these people from driving home. The fear of being killed and eaten is a very deep and primeval one and we will not be dissuaded from it by arguments based on probability. Ionising radiation is an otherworldly thing for us humans. We were not even aware of it until just over a hundred years ago, because none of our five senses can detect it. In the public view, radiation is not natural but emanates from spooky labs and unnatural man made industries. There has also been a wrong conflation of nuclear weapons and nuclear power in the public consciousness.

5. The Nuclear Industry is a Bad Communicator

The nuclear industry is its own worst enemy in that it apologises for everything, thereby appearing to take the blame. The wider public respond to how you present yourself as much as what you actually say. We need to observe how other high technology industries, for example aviation, deal with serious incidents. Our endless backpedalling results in an 'over-the-top' syndrome. We impose unnecessary conditions on ourselves, in the hope that we will be deemed responsible, not understanding that progress is not always about logic and reason. Giving concessions to pathological opponents is much like giving beer to alcoholics – however much is never enough. And then when we apply for a licence to bury casks of spent fuel 800 metres underground, who can be blamed for ridiculing us when we tell them that these casks are more or less harmless?

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One of the saddest stories of Fukushima involves a combination of poor understanding and poor communication. The police, acting on instructions to evacuate everyone within a 20 kilometre radius of Fukushima, removed a large number of people from a hospital for the elderly. Their judgment was that removing these patients from life support and putting them on buses was less risky than leaving them to face the radiation plume which was yet to arrive. As a result, 45 of them died. Another sad story involves the suicide of a cabbage farmer whose entire crop was embargoed because it was contaminated above the absurdly low limits imposed by the nuclear safety regulator. He would have had to eat his entire crop himself to have been even mildly at risk from radioactive contamination.

The nuclear industry treats the world like a big science class, exciting a few people, alienating others and paralysing the vast majority with reams of facts. A more lateral marketing approach built on the confidence-building participation of ordinary people the public can identify with is more likely to yield results than aiming for the mirage of public understanding. Public confidence we can certainly achieve over time, public understanding possibly not.

Where To from Here?

Fukushima has been a shocking reality check for all of us. What we need to understand, however, is that progress will always involve balancing risks. If we do not continue to invest in the nuclear renaissance, we will not meet our climate change mitigation targets. Simply, looked at objectively, nuclear power is safe when

compared with other options. But as a species we have become afraid of it for a range of reasons I have tried to elaborate on in this article. Some years ago when I was at Chernobyl I was struck by how nature has taken over again in the exclusion zone. There is an abundance of wildlife that has not existed there for over a hundred years. Four decontamination workers were attacked by a wolf a few weeks before our arrival! The deeply disconcerting truth is that low levels of radiation (25 years after the accident) without the presence of humans provide more advantageous conditions for survival for most species than does "normal" human activity.

South Africa should continue on its IRP trajectory. A solid investment in nuclear and renewables shows our commitment to our international obligations, and provides the platform for the technological development of South Africa. It will also free up our gas and coal reserves so that we can use them via our cutting edge gas to liquid and coal to liquid technologies to produce petrol and diesel, thereby reducing our dependence on foreign oil imports.