Effects of Fukushima on Global Nuclear Development – 14621

Charles McCombie, MCM Consulting

ABSTRACT

The Fukushima accident in Japan was a huge shock for people inside the nuclear industry. Scenarios with complete loss of electrical power at a nuclear plant – which was the ultimate cause of the accident - had been looked at in the past. But having to cope with loss of power at a reactor site cut off in the middle of an area devastated by an unprecedented earthquake and tsunami was not a scenario that had been considered. The meltdown in 3 reactor cores that resulted from this situation was a disastrous nuclear industrial accident never before contemplated in a highly developed nation. The human tragedy of tens of thousands of Japanese subsequently being evacuated in order to minimise long-term health impacts from contamination was associated by many with the huge death toll from the real disasters, the earthquake and tsunami. In fact, despite the impressions conveyed by the media to the general public, there were no radiation related deaths during the Fukushima accident and , according the UN Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) it is unlikely to be able to attribute any health effects in the future among the general public and the vast majority of workers.

In the present paper, however, the focus is not on the effects of the accident in Japan, but rather on the global consequences of the accident. These are of two types, technical and political. The former is dealt with relatively briefly the latter is covered more comprehensively, including specific details for two countries, Germany and Switzerland, where reactions have been most extreme. A summary of the global consequences of the Fukushima accident includes the following points:

- Fukushima was a major industrial accident that has necessitated a hugely expensive clean up, but radiation effects on humans are relatively small.
- The sheltering and evacuation measures taken at Fukushima reduced the radiation doses received by the public in an effective way; lessons will be learned by other nuclear nations. However, experience at Fukushima has confirmed earlier observations from Chernobyl which indicate that the stress induced by forced evacuations can lead to more damaging health effects than the low levels of radiation that are experienced.
- Some countries, in a panic reaction to Fukushima, have rejected nuclear power and will now struggle to tackle the social and economic consequences of this decision. However. many more countries have assessed the situation and concluded that their goals for the production of clean energy justify – or even necessitate – the use of nuclear power.

INTRODUCTION

The Fukushima accident in Japan was a huge shock for people inside the nuclear industry. Scenarios with complete loss of electrical power at a nuclear plant – which was the ultimate cause of the accident - had been looked at in the past. But having to cope with loss of power at a reactor site cut off in the middle of an area devastated by an unprecedented earthquake and tsunami was not a scenario that had been considered. The meltdown in 3 reactor cores that resulted from this situation was a disastrous nuclear industrial accident never before contemplated in a highly developed nation.

For the public across the globe, the shock was even greater as people watched the dramatic pictures of a natural disaster overwhelming whole communities and leading to over 20000 dead or

missing. The human tragedy of tens of thousands of Japanese subsequently being evacuated in order to minimise long-term health impacts from contamination was associated by many with the huge death toll from the real disasters, the earthquake and tsunami. In fact, despite the impressions conveyed by the media to the general public, there were no radiation related deaths during the Fukushima accident. Moreover, two years after the accident, the conclusions of the independent experts of the UN Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) are that "Radiation exposure following the nuclear accident at Fukushima Daiichi did not cause any immediate health effects. It is unlikely to be able to attribute any health effects in the future among the general public and the vast majority of workers." [1].

In the present paper, however, the focus is not on the effects of the accident in Japan, but rather on the global consequences of the accident. These are of two types, technical and political. The former is dealt with relatively briefly below; the latter is covered more comprehensively, including specific details for two countries, Germany and Switzerland, where reactions have been most extreme.

GLOBAL TECHNICAL CONSEQUENCES OF FUKUSHIMA

There have been a number of studies on the technical lessons to be learned from Fukushima. Some relate directly to nuclear power plants. Immediately apparent during the course of the accident was that loss of a power supply to the site over a period of days was a scenario to which too little attention had been devoted in the nuclear community. Another clear weakness was the hazard potential of spent fuel storage ponds with large inventories of fuel elements in relatively vulnerable locations above the reactor– an issue which had been debated at some length in the USA ten years earlier [2,3,4]. Recent analyses by the USNRC [16] are, however, rather positive concerning the risks of releases from an earthquake damaged spent fuel pool at a BWR. More extensive lists of safety issues were thereafter examined, for example, in the course of the Stress Tests which were undertaken at nuclear power plants throughout Europe. These tests, performed by multinational teams using a common methodology, carried out assessments of extreme natural events. In all, 145 plants in 17 countries were studied. The good news was that no plants had to be shut down for safety reasons. However, there was a need for improvements in almost all of them and, at an estimated cost of up to EUR 200M per reactor, the financial requirements are over EUR 25B [5].

The other equally important global technical consequence of Fukushima may be that a more realistic approach is taken to off-site emergency planning in the event of accidental radiation releases. The question of what level of contamination justifies evacuation has been much discussed in the wake of Fukushima where persons were evacuated because their potential annual doses exceeded a limit of 20mSv/year [6]. The risk posed by being exposed to such doses can be judged by comparison with natural background radiation or with the average probability of developing cancer. Global average natural background doses are around 3mSv/y, but there are many areas of the world where population are exposed to 100 and more mSv/y with no observable effects on their health. Even more striking is the fact that the probability of dying from cancers from all causes for an average human is around 30% and that, using conservative estimates of the increase due to receiving an additional radiation dose of 20mSv/ year, this probability rises only to 30.1%. The report quoted above gives the detailed example of a postulated girl under one year of age who did not evacuate and continued life as normal for four months after the accident. Such a child's theoretical risk of developing breast cancer by age 89 would be increased from 29.04% to 30.20%, according to the WHO's analysis. If given the choice of leaving one’s home or accepting these small increases in risk, it is not clear that the former is the logical choice. The indications are that the stress induced by the process of evacuation and living for long periods in temporary shelters may be the most significant lasting influence of

Fukushima on the Japanese population. This has led the NCRP and the EPA in the USA to issue document recommending changes to emergency planning procedures [7,8]. The EPA emphasises that an important principle is to balance protection with other important factors and ensure that actions result in more benefit than harm. The NCRP points out that, when an incident has into the late phase, the situation should be considered an existing exposure situation in which dose limits do not apply because existing exposure situations cannot be managed in a priori fashion.

GLOBAL POLICY CONSEQUENCES OF FUKUSHIMA

How did political leaders around the world react to the tumultuous events in March 2011? Basically, three types of responses emerged. One could characterise these as “instant panic”, “premature complacency” and “measured response”. In all three cases, the drivers for the decision makers in many countries were not only public reactions, but also specific national political considerations.

The clearest examples of the instant panic case were in Switzerland and Germany and the situation in these two countries is discussed in more detail below. They belong to a relatively small group of countries that have radically changed their policy because of Fukushima. Belgium has also announced a phase-out policy. Spain decided not, after all, to reverse its existing non-nuclear strategy. Kuwait postponed its nuclear development project and several Asian countries have slowed down their nuclear development plans. But these national policy decisions are exceptions; the global outlook for nuclear has not changed radically. The great majority of countries which use, or plan to use, nuclear power have made no significant changes in their policies.

In some cases, the decision to continue with nuclear came rather too quickly or even prematurely – before, in fact, there had been time to assimilate the lessons from Fukushima. One reason often cited was that “we don’t have major earthquakes and certainly not tsunamis”. This complacent reaction neglects two facts: one was that the Fukushima accident resulted from total loss of on-site power so that all potential causes leading to this scenario should be studied; the other was that large tsunamis can be shown to have occurred at coastal regions all around the world, if one examines a sufficiently long geological record.

A more measured response of the nuclear community to the Fukushima accident was the organisation of the “stress tests” mentioned above that were carried out to ensure that the lessons learned from Japan will help to enhance nuclear reactor safety everywhere. Confidence that nuclear reactor accidents, however severe, cannot lead to a global environmental catastrophe is a pre-requisite for responsible use of nuclear energy. Experience has now shown again that even extreme nuclear accidents such as Fukushima do not have global effects. On the other hand, there are serious concerns that climate change may well affect the entire planet, so that there is still a strong driver for responsible nations to use nuclear rather than fossil fuels.

In most cases, the decisions by governments to continue with or to introduce nuclear power are based on the realisation that large scale electricity base-load plants are necessary and that low-carbon hydro or nuclear plants provide the best protection of the future environment. The truth acknowledged by energy experts today is that “renewable” energy sources alone cannot for a long time into the future, if ever, provide enough energy for our societies. This truth, however, is denied so strongly and frequently, by the powerful lobbies for solar, wind, tide and geothermal - and by over-optimistic politicians - that the public is fooled. A global poll of 23 000 persons in 23 countries found that 71% believed their country “could almost entirely replace coal and nuclear energy within 20 years by becoming highly energy-efficient and focusing on generating energy

from the sun and wind" [9]. This discrepancy between expert opinion and public views must be one of the greatest of our times.

And so, what is the predominant global nuclear trend today. Expansion is still the name of the game, despite Fukushima. The table below (based on March 2013 data from the World Nuclear Association - www.world-nuclear .org) summarises the status of the large number of countries that have decided to expand or introduce nuclear power. Important examples of expansion are in the UK and the USA (where, incidentally, public opinion has also altered least since Fukushima and the perceived challenges to nuclear growth are related to financial risks rather than to public opposition [1]). More important are countries like China and India where massive nuclear expansion may mitigate the global danger presented by CO2 from the rapidly growing use of fossil fuels. Another interesting example is the Arabian Gulf region where the UAE has embarked on an 8 reactor programme and Saudi Arabia has announced plans for around 16 reactors. These sunny and oil-rich States have realised that solar will not suffice and that the oil will one day run out. What's more, before it runs out it will become much more expensive and these countries want to be in the market as vendors of this valuable commodity rather than users.

TABLE I: World Nuclear Power Status and Plans

COUNTRY	OPERATING OR IN CONSTRUCTION	PLANNED OR PROPOSED	COUNTRY	OPERATING OR IN CONSTRUCTION	PLANNED OR PROPOSED
Argentina	3	3	North Korea DPRK	0	1
Armenia	1	1	South Korea ROK	27	6
Bangladesh	0	2	Lithuania	0	1
Belarus	0	4	Malaysia	0	2
Belgium	7	0	Mexico	2	2
Brazil	3	4	Netherlands	1	1
Bulgaria	2	1	Pakistan	5	2
Canada	19	5	Poland	0	6
Chile	0	4	Romania	2	3
China	45	169	Russia	43	44

[1] The debate about the economics of nuclear power varies strongly from country to country. The World Nuclear Association states that "*Nuclear power is cost competitive with other forms of electricity generation, except where there is direct access to low-cost fossil fuels."* The USA, with its coal reserves and now increasing production of shale gas, may be one of these exceptions. In many studies however, the life cycle costs of nuclear are shown to be lower than competitors. In free market economies where the large capital sums required at the outset can be difficult to raise and where the capital is at risk, financing nuclear build is difficult. In the UK, the Government has recently retreated from its hard line that no help will be provided and is now prepared to discuss "contract for difference" agreements that will assure a long-term market.

Czech Republic	6	3	Saudi Arabia	0	16
Egypt	0	2	Slovakia	6	1
Finland	5	2	Slovenia	1	1
France	59	2	South Africa	2	6
Germany	9	0	Spain	7	0
Hungary	4	2	Sweden	10	0
India	27	57	Switzerland	5	0
Indonesia	0	6	Thailand	0	5
Iran	1	3	Turkey	0	8
Israel	0	1	Ukraine	15	13
Italy	0	10	UAE	1	13
Japan	53	12	United Kingdom	16	13
Jordan	0	1	USA	106	24
Kazakhstan	0	4	Vietnam	0	10
World	**501**	**476**			

Reflecting this situation, the IAEA has predicted in 2012 that in its high scenario nuclear capacity will reach 740 GWe by 2040. Projected growth is strongest in East Asia, including China and South Korea, where regional capacity is forecast to grow from 80 GWe at the end of 2011 to 153 GWe in 2030 [10].

GERMAN AND SWISS POLITICALLY BASED DECISION MAKING

As stated above, the fastest and most extreme policy changes took place in Switzerland and Germany. In both cases, the decision making was strongly influenced by political expediency. In Switzerland, the initial reactions of the technical safety authority were actually some of the most logical and prompt steps taken anywhere in the world. Despite the fact that Swiss nuclear plants have world class protection against the station blackout (SBO) scenario, i.e. the complete loss of power [15], further measures were taken. They immediately required that the nuclear power plants organise for additional back-up power supplies, borated water, pumps etc. to be readied at a position from which they could be transferred by helicopter to any of the Swiss nuclear plants. Meanwhile, however, the government acted precipitously. It immediately suspended license applications for new nuclear plants (although these were in the early stages of the years of desk work required for their preparation and review). It then, only 12 days after the accident, requested a study of options including shutting down the Swiss nuclear stations. After a further 8 weeks, without publishing detailed results of the study, the decision was taken to go non-nuclear in “order to reduce the risk to the Swiss population”, but only after the existing plants have operated for

their full lifetime – because “their safe operation is currently guaranteed”! In the opinion of some observers, the radical decision taken was not unconnected with the facts that the 7 person Council of Ministers had at the time a majority of female members and that the political party of the energy minister was facing problems in the elections due in the autumn of 2011.

In the German case, the Government decision to reverse an earlier policy of extending reactor lifetimes and to initiate a rapid shut-down was even more closely related to election issues. German elections in which the party of the Chancellor was under pressure took place on the 27th March, only 16 days after Fukushima. Already on the 14th of March a 3 month nuclear moratorium was announced. Since then, 8 nuclear plants have been permanently closed and a complete shut-down of the remaining 9 plants is planned by 2022.

Since these decisions were taken – ironically both in advanced countries with excellent safety records – governments in both countries have been struggling to establish credible future strategies that will enable them to forego nuclear. Both have also been remarkably silent about some of the consequences of their hasty decisions. In particular, neither Government likes to emphasise that its dependence on fossil fuels will rise. Germany has opened new brown-coal fired plants and Switzerland will aim for gas fired plants – a particularly distressing development in a country which to date has generated all its electricity CO2 free from hydro(60%) or nuclear (40%) stations.

Some other consequences are even more likely to be hidden as far as possible from the public view. Germany, when it shut down the nuclear plants, abruptly changed from normally being a net exporter of electricity to a net importer (including imports of nuclear electricity from its European neighbours). Germany also has already the highest household electricity prices in Europe – largely due to expensive wind and solar power (apart from Denmark which has even more wind power) [11]. In its rush to renewable energy, Germany has also been installed large wind and solar capacities which lead, at off-peak times, to an overproduction since there are contracts preventing shutting down the wind and solar producers and it is uneconomic to reduce the output of large base load stations. The excess electricity must be passed on to its fortunate neighbours at prices that are not just low – but are sometimes negative, i.e. Germany pays for others to take excess power off their hands and pays again to buy power back on dull and non-windy days!

In Switzerland, the situation is almost as bizarre. Recently the Energy Ministry acknowledged that the assumptions which it had naively made about increased public readiness to develop new hydro projects were “too optimistic”. The result would have been a gap in the targeted post-nuclear hydroelectricity production capacity. But no! On the same day they also stated that the gap could be partly filled because existing hydro schemes are expected to provide more water – thanks to the faster melting of glaciers resulting from upward estimates of climate change! Increasing global temperatures that only a year ago were judged as serious threat to future generations now come to the rescue of our nuclear-free electricity scenarios! The Swiss government decisions have been taken despite the fact that public opinion polling in the country in 2013 indicates that 74% of the population is convinced that the power plants are safe and believes that Switzerland should not have to rely on imported electricity, which will be the case with the new energy strategy without nuclear [12]. To further exemplify the contradictions that sudden policy changes can lead to, Table 2 summarises some of the relevant Swiss issues [18].

TABLE II: Impacts of Fukushima decisions on Swiss Policy

Policy pre-Fukushima	Post-Fukushima Position
Current Swiss NPPs are safe	No new NPPs – residual risks unacceptable
CO2- ambitious reduction goals	Gas-fired stations to be built
Electricity supply autonomous	Import strategy unavoidable
Strong environmental protection laws	New laws to ease wind and solar permitting[22]
Economic production of electricity	Large planned increases in prices
Fair treatment of all consumers	Households subsidise industry

A further cold shower will certainly arrive in the coming years for both Germany and Switzerland as the true costs of phasing out nuclear power become apparent. German costs have been estimated at a total of around EUR 1 trillion, with feed-in tariffs alone accounting for EUR 650B (or, if the originally promised allowance is reduced, 450B). Upgrading the German grid to cope with distributed renewable production sources will cost EUR (27.5 – 42.5) billion [13]. In Switzerland, the Government has estimated that phasing out nuclear energy will cost it around EUR 20 billion by 2050 [14]. But, in the middle of Europe, energy is still not a major item in the average family budget. Accordingly, the financial impacts of these hasty and politically driven decisions are less momentous than the signals which these rich, developed countries are sending to the rest of the world. The message is that they are more concerned about localised risks to present generations than they are about long term risks that affect the future of our planet. Short term electoral gains appear to be more important to politicians than avoiding a potential future global catastrophe.

SUMMARY OF GLOBAL CONSEQUENCES

How then can we summarise the impact of the Fukushima accident on the prospects for nuclear power around the world? The key messages that need to be put in order to better inform the public are:

- Fukushima was a major industrial accident that has necessitated a hugely expensive clean up. The primary cause was a catastrophic natural event. But poor organizational and management practices by TEPCO are acknowledged to have been a significant factor contributing to failures to gain control more quickly. Poor communication practices have also increased public anxieties in Japan.
- However, there were no radiation deaths during the event and any late cancers will be impossible to distinguish from the massively greater background of natural cancer cases. It is quite possible that health risks from tsunami-distributed raw sewage and the stress of evacuation of older residents will outweigh any effects of radiation.
- The sheltering and evacuation measures taken at Fukushima reduced the radiation doses received by the public in an effective way; lessons will be learned by other nuclear nations.
- However, the potential need for evacuation of large populations raises anxiety, especially in densely populated countries. Experience at Fukushima has confirmed earlier observations from Chernobyl which indicate that the stress induced by forced evacuations can lead to more damaging health effects than the low levels of radiation that are experienced.

[22] The proposed new Swiss Energy Act [17] states that “new installations for renewable energy are in the national interest to the same or a greater degree than protection of the environment or preservation of cultural heritage”

- The understandable anxieties raised by Fukushima have led to stress tests and serious reviews that will enhance further the safety of existing and future reactors.
- Some countries, in a panic reaction to Fukushima, have rejected nuclear power and will now struggle to tackle the social and economic consequences of this decision.
- Many more countries have assessed the situation and concluded that their goals for the production of clean energy justify – or even necessitate – the use of nuclear power.

REFERENCES

1	WNA, Fear and stress outweigh Fukushima radiation risk, 31 May 2013, http://www.world-nuclear-news.org/RS_Fear_and_stress_outweigh_Fukushima_radiation_risk_3105131.html
2	Alvarez R., Beyea J., Janberg K., Kang J., Lyman E., Macfarlane A., Thompson G. and von Hippel F.: Reducing the hazards from stored spent power-reactor fuel in the United States. Science and Global Security 11, pp. 1-51, 2003.
3	US NRC: NRC review of “Reducing the hazards from stored spent power-reactor fuel in the United States”. Science and Global Security 11, pp. 203-211. 2003.
4	Alvarez R., Beyea J., Janberg K., Kang J., Lyman E., Macfarlane A., Thompson G. and von Hippel F.: Response by the authors to the NRC review of “Reducing the hazards from stored spent power-reactor fuel in the United States”. Science and Global Security 11, pp. 213-223, 2003.
5	http://www.independent.co.uk/news/world/europe/europes-dangerous-nuclear-plants-need-25bn-safety-refit-8196457.html
6	Wilson R., Four lessons from Fukushima: Improving emergency response, Bulletin of Atomic Scientists, 6 July 2011
7	NCRP, Decision Making for Late-Phase Recovery from Nuclear or Radiological Incidents, NCRP SC 5-1 Draft Report
8	EPA, PAG Manual Protective Action Guides And Planning Guidance For Radiological Incidents, March 2013
9	(http://nuclear-news.net/2011/11/27/)
10	IAEA, Energy, Electricity and Nuclear Power Estimates for the Period up to 2050, 2012 Edition http://www-pub.iaea.org/MTCD/Publications/PDF/IAEA-RDS-1-32_web.pdf
11	European Commission, Electricity Prices for Household Consumers http://epp.eurostat.ec.europa.eu
12	Swissnuclear, Bevölkerung hält Schweizer Kernenergie für sicher, notwendig und günstig, 31.1.2013, http://www.swissnuclear.ch/upload/cms/user/FinalCommuniquEckwert2012_de.pdf
13	WNA, Trillion-euro cost of German energy transition, http://www.world-nuclear-news.org/np-trillion-euro_cost_of_german_energy_transition-2002137.html
14	WNA http://www.world-nuclear-news.org/NP-33_dollar_billion_cost_of_Swiss_no_nuclear_new_build_decision-1904124.html
15	Chao J. and Johnson D., A Fundamental Cause for the Fukushima Accident and A Proposed Effective Remedy, Presented at PSAM, Tokyo, April 15 – 18, 2013
16	USNRC, Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool at a Selected US Mark I Boiling Water Reactor (Spent Fuel Pool Study), Interim

	Report (Draft), dated June 2012 (ADAMS Accession No. ML12159A180).
17	Swiss Government, Energiegesetz, http://www.admin.ch/ch/d/gg/pc/documents/2210/Energiestrategie-2050_Vernehmlassungsvorlage_de.pdf
18	WNA, Swiss Energy Strategy relies on Imports and Gas, http://www.world-nuclear-news.org/NP-Swiss_energy_strategy_relies_on_gas-0110127.html