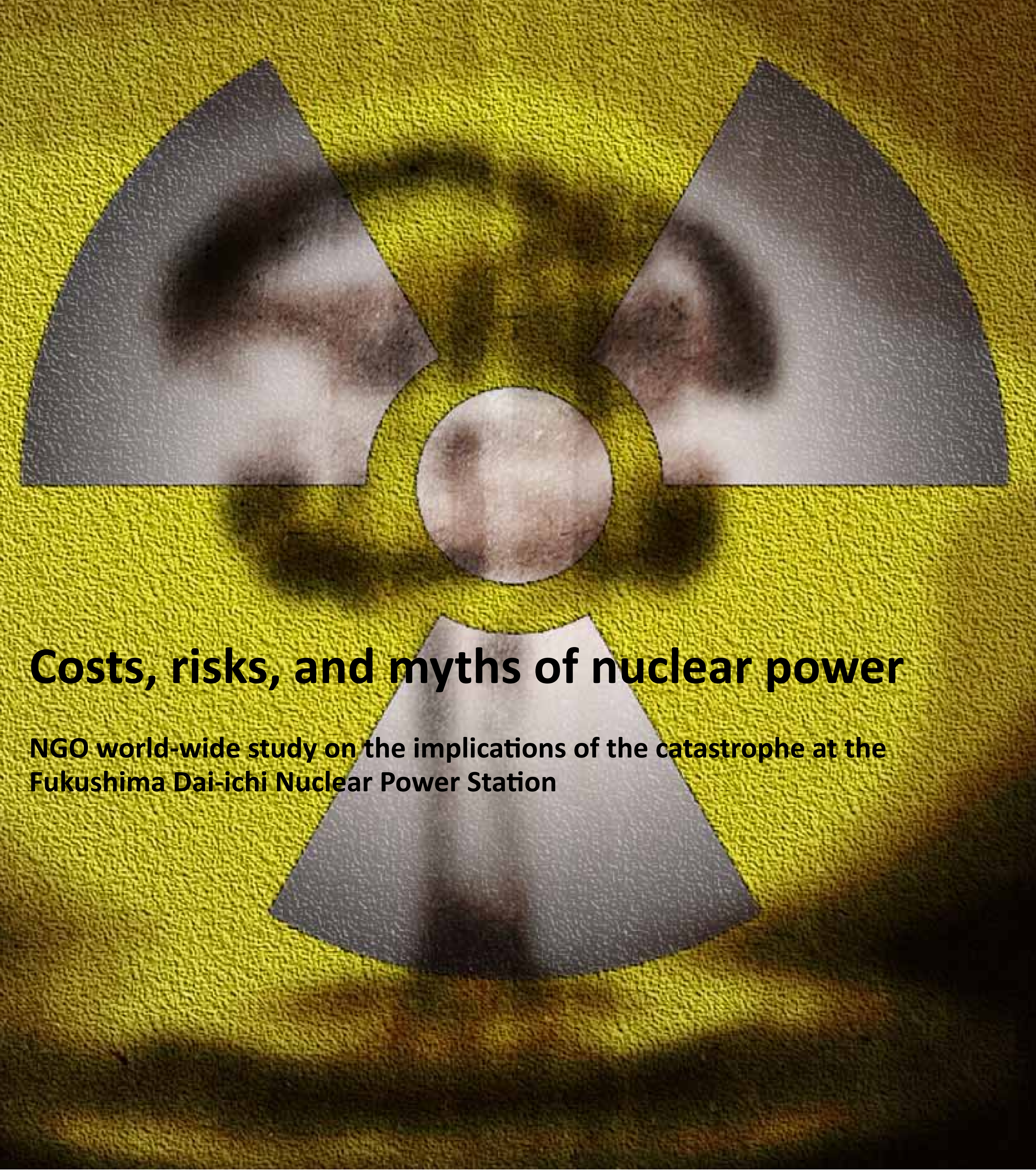

Costs, risks, and myths of nuclear power

NGO world-wide study on the implications of the catastrophe at the Fukushima Dai-ichi Nuclear Power Station

coordinated by

Reaching Critical Will

a project of the

Women's International League for Peace and Freedom

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Costs, risks, and myths of nuclear power

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To the victims of the tsunami, earthquake, and nuclear disaster that struck Japan on 11 March 2011

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Preface

Kozue Akibayashi

Six months have already passed since the earthquake and tsunami that literally devastated the Tohoku, the northeast area of Japan, on 11 March 2011. In Japan, not a single day has gone by without hearing about the victims. More than 20,000 people have died or are still missing as a result of the magnitude 9.0 earthquake and a series of tsunamis that surpassed what had been predicted. More than 80,000 have lost their homes and in many cases their entire community, and remain displaced to this day. Even to the people of Japan—possibly the best-prepared for large-scale earthquakes and tsunamis because of the country's long earthquake-prone history—the power of this catastrophe was beyond our imagination. The reconstruction of the region will require long-term efforts of the entire nation and international cooperation.

The earthquake and tsunamis are gone, but we are now left to cope with something very different: radiation. The Fukushima Dai-ichi Nuclear Power Station, one of the oldest nuclear power plants in Japan, with some of its reactors having been in operation for nearly 40 years, was severely wrecked by the earthquake and tsunami on 11 March 2011. Soon after that, the plant managers lost control; explosions, meltdowns, and the release of radioactive materials followed. We were not told what was actually going on at the time. The Japanese government's daily press conference did not confirm what many suspected: that massive radiation was leaking into the soil, water, and air. We first learned from foreign sources about the hydrogen explosions of the plant's containment buildings on 14 March and after.

It has been an extremely frustrating six months, particularly for those living in the vicinity of Fukushima Dai-ichi who have been displaced, not knowing what will happen nor when or even if they will ever return home. Nobody in a responsible position has provided necessary information to the public about the status of the radiation leaks, anticipated impacts, or policies to ensure the safety of people. The nuclear scientists who have been working for years to point out the dangers of nuclear energy despite the difficulties of being ostracized in the industry because of their criticism of nuclear energy and its policies, desperately tried to disseminate information on the Internet because that was the only possible media outlet for them. Major media did not report their analyses of the plant's conditions nor radiation leak.

It has been reported recently that many residents in the surrounding areas of the Fukushima Dai-ichi plant had to make decisions about evacuation without sufficient information and headed to locations that were later revealed to have been contaminated with higher levels of radiation, because their assumption of the wind direction was incorrect. If the Japanese government, the Nuclear Safety Committee, the Ministry of Economy, Trade and Industry, the Nuclear and Industrial Safety Agency, and the Tokyo Electric Power Company had provided the information on wind direction and the simulation of radiation spread that they had already had, these residents could have made different decisions. Now many residents are struggling with very little help to figure out what safety measures they can take, especially to protect children who are more vulnerable to radiation. Such stories of undermining the safety of people are, very unfortunately, legion, and even to this day we feel left in dark with no good information.

photo: NHK Tv; A member of the 'Fukushima 50,' workers who remained onsite after the disaster to bring the reactors under control.

Now we, in Japan, are facing serious radiation spread nationwide, if not worldwide. The leak and contamination have been continuing. Radioactive cesium has been detected in beef from the region that was earlier considered far enough from the Fukushima Dai-ichi

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plant. Agricultural soils contaminated with cesium have already been sold throughout Japan. With the rice harvest season approaching, everyone is anxious to know whether our staple food will be safe. Farmers, fishermen, and dairy farmers in Fukushima and adjacent areas are struggling because their products may not be safe, or may not be sold as consumers are deeply dubious about the food safety and fearful of exposure to radiation, contrary to the government's repeated comment that the low-level radiation, even when detected, will not have immediate danger to our health. But who can ensure long-term safety?

It is such a deep irony that Japan is now suffering from this radiation. Japan was twice bombed with atomic bombs in the Asia-Pacific War at Hiroshima and Nagasaki in 1945. In 1954, the Fifth Lucky Dragon fishing boat was exposed to the fallout from the hydrogen bomb testing in the Bikini Atoll. We have learned much, though maybe not enough, about the danger and long-lasting damages radiation causes.

In retrospect, many people are regretting that we did not pay enough attention to nuclear energy safety.

photo: Asahi Shimbun/epa/Corbis; A baby is tested for radiation exposure

Nuclear power plants were introduced to Japan in the 1950s by the United States government and the nuclear industry. Those campaigning for nuclear energy were quick to make a distinction between nuclear bombs and nuclear energy. They promoted nuclear energy as safer and cheaper energy in the "Atoms for Peace" campaign. Some Japanese politicians, hoping for Japan to become a stronger economy and to increase its military power, cooperated with this campaign. And they were successful. Now there are more than 50 nuclear power plants in Japan, a country where earthquakes are a part of everyday life. The general public, including many peace activists like myself, have not been keen enough about nuclear "safety" when it comes to nuclear energy.

It is a hard fact to acknowledge, but we now live in a radiation-contaminated country. It is such a heavy truth that the nuclear power plants of our country have emitted and are still releasing radiation into the environment. It continues to pose risks to those living now and generations to come.

Yet, the country now seems strangely calm. If you were not directly affected by the earthquake or tsunami, you may be leading a "normal" life. Many people may be in denial about the nuclear crisis, because the calamity we face is too enormous to think about head on, to acknowledge. Thinking squarely about it may only make you numb. It is more tempting not to worry for the moment. But we all know something has deeply changed since 11 March 2011.

What saddened and raged me most is that not all these events were unavoidable. The natural disasters of the earthquake and tsunami were indeed unavoidable. We all know that they will happen someday, but we cannot know when. It has not been successful to predict the timing of their occurrence. So the best policy is to prepare in case they actually occur. On the other hand, the nuclear crisis we are going through was caused by human errors and it was a result of poor policies. It could have been avoided if adequate policies had been planned and implemented. It is one of the hardest lessons we have learned, and the lesson needs to be shared widely so that nuclear crisis will not be repeated.

In conclusion of this preface, I pose some questions: What is nuclear safety? How will the safety and the livelihood of people to which we all are entitled be ensured with regard to nuclear power? Would ensuring safety be possible at all? These are not rhetorical questions but real ones. We need to have clearer answers to these questions, not in the future, but now.

Introduction

Ray Acheson

At 2:46 pm on 11 March 2011, a massive earthquake struck the northeast of Japan, causing a tsunami of immense devastation and leading to the disaster at the Fukushima Dai-ichi Nuclear Power Station. The loss of life, livelihoods, homes, and communities was catastrophic. And while the human spirit begins to rebuild from the natural disasters, piecing lives and homes back together, the effects of the nuclear disaster will go on for generations. Just as we learned of the details of the situation at Fukushima Dai-ichi only after the worst had happened, so too will the Japanese people and their neighbours only later discover the full effects of the radiation released from the meltdowns and explosions.

In response to the Fukushima Dai-ichi disaster, UN Secretary-General Ban Ki-moon called for a high-level meeting on nuclear safety and security, which will convene in New York on 22 September 2011. He also called for a UN system-wide study on the implications of the Fukushima disaster, indicating that this study "will address a variety of areas, including environment, health, food security, sustainable development and the nexus between nuclear safety and nuclear security."[1] In his earlier remarks at a summit in Ukraine to mark the 25th anniversary of the nuclear disaster at Chernobyl, Secretary-General Ban also called for "a new cost-benefit analysis of nuclear energy"[2] and argued that the international community must "think very seriously about a global debate on the future of nuclear energy."[3] In his speech at Sophia University, he characterized the September high-level meeting as being the forum for this global debate.[4]

Inspired by the Secretary-General's call for a global debate on nuclear energy, Reaching Critical Will, a project of the Women's International League for Peace and Freedom, has coordinated an international civil society study in order to provide non-government perspectives of the range of issues related to nuclear power. This report includes civil society analysis of nuclear power infrastructure and government policies from around the world. It also articulates arguments against the common myths of nuclear power in its relationship to safety, the environment, renewable energy, climate change, economics, and more.

Several excellent studies from civil society have been released post-Fukushima—many of which are listed in the additional resources section of this document. This report does not try to replicate their detailed work on specific aspects of nuclear power. Instead, we sought to bring together a range of academic, scientific, and activist voices from around the world that are working to end the nuclear age in the name of human security and environmental sustainability. Reaching Critical Will has prepared this report to coincide with the UN system-wide study and the high-level meeting on nuclear safety and security in the hopes that it can contribute to the global debate on nuclear energy that is so desperately needed. We are releasing it on 11 September 2011, to mark the six month anniversary of the disaster at Fukushima.

From the perspective of the authors of this report, nuclear power is the most expensive and dangerous way to boil water to turn a turbine. Nuclear power contains the inherent potential for catastrophe. There is no such thing as a safe nuclear reactor. All aspects of the nuclear fuel chain, from mining uranium ore to dropping an atomic bomb to storing radioactive waste, are devastating for the earth and all species living upon it.

Radiation is long lasting and has inter-generational effects, as the survivors of Hiroshima and Nagasaki know only too well. In February 2011, a group of *Hibakusha*, atomic bomb survivors from Japan, asserted that radiation, whatever its source, is a major threat to humanity and the environment and called for phasing-out all sources of radiation—from uranium mining, nuclear reactors, nuclear accidents, nuclear weapons development and testing, and nuclear waste—and for investment in renewable, clean energy for a sustainable future.[5] It is a terrible tragedy that the very country that sustained and survived an attack with nuclear weapons is today sustaining radiation exposure and contamination from nuclear power.[6]

"It was a disaster waiting to happen—it was only a matter of time, and unless nuclear power is phased out, it will not be the last." – Tilman Ruff[16]

One purpose of this report is to assess how this tragedy occurred—not in a technical sense, but in a political and economic one. Through the various country reports and thematic chapters on several aspects of nuclear power, it becomes evident *why* nuclear power was developed in the only country to have directly suffered attacks with nuclear weapons, in a country prone to earthquakes, in a country with other options of renewable, sustainable energy sources. The answers are not all unique to Japan, but rather, they apply to every country that includes nuclear power in its energy mix, or that contributes in some way to the nuclear fuel chain.

In a June 2011 prize-acceptance speech in Barcelona,

Ray Acheson is the director of Reaching Critical Will, a project of the Women's International League for Peace and Freedom (WILPF), and is editor of this report.

Japanese novelist Haruki Murakami argued that Japan developed nuclear power, even after its experience in World War II, because it could bring electrical power companies profit. These companies relied on the government's doubt of the stability of petroleum supplies for its support of nuclear power and spent colossal sums on advertisements to "indoctrinate the Japanese people with the illusion that nuclear power generation was completely safe."[7]

> **"Nuclear power plants, which were supposed to be efficient, instead offer us a vision of hell."**
> **– Haruki Murakami[13]**

For the nuclear power industry, whether in Japan or elsewhere, the primary motive for operation is profit. Increasing profit is often best achieved in ways that are not consistent with designing or operating the relevant equipment for the lowest risk. It is less likely to be achieved by honestly exploring alternative sources of energy that might necessitate initial investments, or that might not be eligible for the same government (i.e. taxpayer-funded) subsidies as nuclear is in many countries. Profit is also less likely to be achieved by designing economically-efficient, need-oriented, and environmentally sound sources of energy. Scientists and activists alike have noted that nuclear power, which produces energy "in large, expensive, centralized facilities" is not useful "for solving the energy needs of the vast majority of [the world's] population, much less so in a way that offers any net environmental gains."[8]

"In a sense, these defective nuclear power plants were a kind of capitalism bomb of Fukushima," said US political prisoner Mumia Abu-Jamal in a statement in solidarity with the Japanese people. "These structures are often built by government grants for private profits and then, when they fail, they destroy everything within miles, even at a molecular level."[9]

Corporations are not only interested in the profit margins of producing nuclear power—they are also interested in how to make money from managing nuclear disasters. A Japanese activist, Sabu Kohso, has written about how the management of nuclear disaster may develop into a strategy for profit-making, arguing, "Capitalism has no intention of abolishing nuclear power. Instead, it is re-organizing the technocratic bureaucracy to manage it primarily by managing nuclear disaster, forcing people to live with different forms and degrees of radiation."[10] He notes that the science magazine *Nature* estimates that the clean-up may take a century. The Japan Center for Economic Research puts the costs over the next 10 years at $71 to $250 billion. "Japan's government will likely assume the liabilities of the Tokyo Electric Power Company (TEPCO), meaning the public will pay. Those funds will flow to corporations, while capital will pressure the government in coming years to

make the huge swaths of land now rendered inhospitable available for profit-making enterprises."[11]

These profit-seekers, argues Richard Falk of Princeton University, minimize the risks of nuclear energy, "then scurry madly at the time of disaster to shift responsibilities to the victims.... These predatory forces are made more formidable because they have cajoled most politicians into complicity and have many corporatized allies in the media that overwhelm the publics of the world with steady doses of misinformation."[12]

"Nuclear power plants, which were supposed to be efficient," Murakami said, "instead offer us a vision of hell."[13]

While those who call for a phase-out of nuclear power and the development instead of sustainable sources of energy as well as energy conservation are often called "unrealistic dreamers," this is merely the propaganda of an industry seeking to preserve its profits. Indeed, many governments have already embraced this "unrealistic dream". We are encouraged by the 25 May 2011 declaration by the governments of Austria, Greece, Ireland, Latvia, Liechtenstein, Luxembourg, Malta, and Portgual, in which they argued that nuclear power is not compatible with the concept of sustainable development and called for energy conservation and a switch to renewable sources of energy worldwide.[14] Likewise, we welcomed announcements from several countries following the Fukushima disaster that they would phase-out nuclear power from their energy mixes.

photo: Felicity Hill; Anti-nuclear activist Ka

As Murakami said in his speech in June,

> We must not be afraid to dream. We should never allow the crazed dogs named "efficiency" and "convenience" to catch up with us. We must be "unrealistic dreamers", who stride forward vigorously. Human beings will die and disappear, but humanity will prevail and will be constantly regenerated. Above all, we must believe in this force.[15]

Acknowledgements

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Notes

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Who, what, where: the nuclear fuel cycle's footprint

Research conducted by Beatrice Fihn, Reaching Critical Will of WILPF

Country	Uranium mining[1]	Uranium enrichment[2]	Plutonium reprocessing[3]	Power reactors[4]	Research reactors[5]
Afghanistan	0	0	0	0	0
Albania	0	0	0	plans to build reactors	0
Algeria	deposits	0	0	0	2
Andorra	0	0	0	0	0
Angola	0	0	0	0	0
Antigua and Barbuda	0	0	0	0	0
Argentina	yes	yes	0	2 existing, 1 under construction, 2 planned, 1 proposed	6
Armenia	0	0	0	1 existing, 1 planned	0
Australia	5900 tonnes in 2010	0	0	0	1
Austria	0	0	0	0	1
Azerbaijan	0	0	0	0	0
Bahamas, The	0	0	0	0	0
Bahrain	0	0	0	0	0
Bangladesh	0	0	0	2 planned	1
Barbados	0	0	0	0	0
Belarus	0	0	0	2 planned and 2 proposed	2
Belgium	0	0	1 shut down in 1974	7 existing	2
Belize	0	0	0	0	0
Benin	0	0	0	0	0
Bhutan	0	0	0	0	0
Bolivia	0	0	0	0	0
Bosnia and Herzegovina	0	0	0	0	0
Botswana	0	0	0	0	0
Brazil	148 tonnes in 2010	yes	0	2 existing, 1 under construction, 4 proposed	4
Brunei	0	0	0	0	0
Bulgaria	0	0	0	2 existing, 2 planned	0
Burkina Faso	0	0	0	0	0
Burma	0	0	0	0	0
Burundi	0	0	0	0	0
Cambodia	0	0	0	0	0
Cameroon	0	0	0	0	0
Canada	9783 tonnes in 2010	0	0	18 existing, 2 under construction, 3 planned, 3 proposed	8
Cape Verde	0	0	0	0	0
Central African Republic	yes	0	0	0	0
Chad	0	0	0	0	0
Chile	0	0	0	4 proposed; signed cooperation agreement with the US in 2011	1
China	827 tonnes in 2010	yes	1 existing, 1 shut down in 1970s	14 existing, 26 under construction, 52 planned, 120 proposed	17
Colombia	0	0	0	0	1
Comoros	0	0	0	0	0
Congo (Brazzaville)	0	0	0	0	0
Congo (Kinshasa)	0	0	0	0	0
Costa Rica	0	0	0	0	0
Cote d'Ivoire	0	0	0	0	0
Croatia	0	0	0	0	0
Cuba	0	0	0	0	0
Cyprus	0	0	0	0	0
Czech Republic	254 tonnes in 2010	0	0	6 existing, 2 planned, 1 proposed	3
Denmark	0	0	0	0	0
Djibouti	0	0	0	0	0
Dominica	0	0	0	0	0
Dominican Republic	0	0	0	0	0
Ecuador	0	0	0	0	0
Egypt	0	0	0	1 planned, 1 proposed	2
El Salvador	0	0	0	0	0
Equatorial Guinea	0	0	0	0	0
Eritrea	0	0	0	0	0
Estonia	0	0	0	0	0
Ethiopia	0	0	0	0	0
Fiji	0	0	0	0	0
Finland	yes	0	0	4 existing, 1 under construction, 2 proposed	1
France	7 tonnes in 2010	yes	3 existing, 3 shut down in 74, 90, 94	58 existing, 1 under construction, 1 planned, 1 proposed	11, 1 under constructio
Gabon	yes	0	0	0	0
Gambia, The	0	0	0	0	0
Georgia	0	0	0	0	0
Germany	0	yes	1 shut down in 1990	17 existing	9
Ghana	0	0	0	0	1
Greece	0	0	0	0	1
Grenada	0	0	0	0	0
Guatemala	0	0	0	0	0
Guinea	0	0	0	0	0
Guinea-Bissau	0	0	0	0	0
Guyana	0	0	0	0	0
Haiti	0	0	0	0	0
Holy See	0	0	0	0	0
Honduras	0	0	0	0	0
Hong Kong	0	0	0	0	0
Hungary	0	0	0	4 existing, 2 proposed	2
Iceland	0	0	0	0	0
India	400 tonnes in 2010	yes	4 existing	20 existing, 5 under construction, 18 planned, 40 proposed	6

Country	Uranium mining[1]	Uranium enrichment[2]	Plutonium reprocessing[3]	Power reactors[4]	Research reactors[5]
Indonesia	yes	0	0	2 planned, 4 proposed	3
Iran	0	yes	0	1 under construction, 2 planned, 1 proposed	5
Iraq	0	0	0	0	0
Ireland	0	0	0	0	0
Israel	0	0	0	1 proposed	1
Italy	yes	0	1 shut down in 1968	10 proposed	5
Jamaica	0	0	0	0	0
Japan	0	yes	2 existing	51 existing, 2 under construction, 10 planned, 5 proposed	13
Jordan	0	0	0	1 planned	1 under construction, 1
Kazakhstan	17803 tonnes in 2010	0	0	2 planned, 2 proposed	3
Kenya	0	0	0	0	0
Kiribati	0	0	0	0	0
Korea, North	0	yes	0	1 proposed	1
Korea, South	0	0	0	21 existing, 5 under construction, 6 planned	2
Kosovo	0	0	0	0	0
Kuwait	0	0	0	0	0
Kyrgyzstan	0	0	0	0	0
Laos	0	0	0	0	0
Latvia	0	0	0	0	0
Lebanon	0	0	0	0	0
Lesotho	0	0	0	0	0
Liberia	0	0	0	0	0
Libya	0	0	0	0	1
Liechtenstein	0	0	0	0	0
Lithuania	0	0	0	1 proposed	0
Luxembourg	0	0	0	0	0
Macau	0	0	0	0	0
Macedonia	0	0	0	0	0
Madagascar	0	0	0	0	0
Malawi	670 tonnes in 2010	0	0	0	0
Malaysia	0	0	0	1 proposed	1
Maldives	0	0	0	0	0
Mali	0	0	0	0	0
Malta	0	0	0	0	0
Marshall Islands	0	0	0	0	0
Mauritania	0	0	0	0	0
Mauritius	0	0	0	0	0
Mexico	0	0	0	2 existing, 2 proposed	3
Micronesia	0	0	0	0	0
Moldova	0	0	0	0	0
Monaco	0	0	0	0	0
Mongolia	yes	0	0	0	0
Montenegro	0	0	0	0	0
Morocco	0	0	0	0	1
Mozambique	0	0	0	0	0
Namibia	4496 tonnes in 2010	0	0	0	0
Nauru	0	0	0	0	0
Nepal	0	0	0	0	0
Netherlands	0	yes	0	1 existing, 1 proposed	3 + 1 planned
Netherlands Antilles	0	0	0	0	0
New Zealand	0	0	0	0	0
Nicaragua	0	0	0	0	0
Niger	yes	0	0	0	0
Nigeria	0	0	0	0	1
North Korea	0	yes	0	1 proposed	1
Norway	0	0	0	0	2
Oman	0	0	0	0	0
Pakistan	45 tonnes in 2010	yes	2 existing	3 existing, 1 under construction, 1 planned, 2 proposed	2
Palau	0	0	0	0	0
Palestinian Territories	0	0	0	0	0
Panama	0	0	0	0	0
Papua New Guinea	0	0	0	0	0
Paraguay	0	0	0	0	0
Peru	yes	0	0	0	2
Philippines	0	0	0	0	0
Poland	0	0	0	6 planned	1
Portugal	yes	0	0	0	1
Qatar	0	0	0	0	0
Romania	77 tonnes in 2010	0	0	2 existing, 2 planned, 1 proposed	2
Russia	3562 tonnes in 2010	yes	1 existing, 1 under construction, 1 shu	32 existing, 10 under construction, 14 planned, 30 proposed	47 existing, 1 under cor
Rwanda	0	0	0	0	0
Saint Kitts and Nevis	0	0	0	0	0
Saint Lucia	0	0	0	0	0
Saint Vincent and the Grenadine	0	0	0	0	0
Samoa	0	0	0	0	0
San Marino	0	0	0	0	0
Sao Tome and Principe	0	0	0	0	0
Saudi Arabia	0	0	0	0	0
Senegal	0	0	0	0	0

Country	Uranium mining[1]	Uranium enrichment[2]	Plutonium reprocessing[3]	Power reactors[4]	Research reactors[5]
Serbia	0	0	0	0	1
Seychelles	0	0	0	0	0
Sierra Leone	0	0	0	0	0
Singapore	0	0	0	0	0
Slovakia	0	0	0	4 existing, 2 under construction, 1 proposed	0
Slovenia	yes	0	0	1 existing, 1 proposed	1
Solomon Islands	0	0	0	0	0
Somalia	0	0	0	0	0
South Africa	583 tonnes in 2010	0	0	2 existing, 6 proposed	1
South Korea	0	0	0	21 existing, 5 under construction, 6 planned	2
Spain	yes	0	0	8 existing	0
Sri Lanka	0	0	0	0	0
Sudan	0	0	0	0	0
Suriname	0	0	0	0	0
Swaziland	0	0	0	0	0
Sweden	yes	0	0	10 existing	0
Switzerland	0	0	0	5 existing	3
Syria	0	0	0	0	1
Taiwan	0	0	0	0	1
Tajikistan	0	0	0	0	0
Tanzania	0	0	0	0	0
Thailand	0	0	0	5 proposed	1
Timor-Leste	0	0	0	0	0
Togo	0	0	0	0	0
Tonga	0	0	0	0	0
Trinidad and Tobago	0	0	0	0	0
Tunisia	0	0	0	0	0
Turkey	yes	0	0	4 planned, 4 proposed	1
Turkmenistan	0	0	0	0	0
Tuvalu	0	0	0	0	0
Uganda	0	0	0	0	0
Ukraine	850 tonnes in 2010	0	0	15 existing, 2 planned, 20 proposed	3
United Arab Emirates	0	0	0	4 planned, 10 proposed	0
United Kingdom	0	yes	2 existing, 2 shut down in 62 and 80	18 existing, 4 planned, 8 proposed	1
United States	1660 tonnes in 2010	yes	1 existing, 2 shut down in 72 and 2002	104 existing, 1 under construction, 6 planned, 28 propsed	41
Uruguay	0	0	0	0	0
Uzbekistan	2400 tonnes in 2010	0	0	0	2
Vanuatu	0	0	0	0	0
Venezuela	0	0	0	0	0
Vietnam	0	0	0	2 planned, 12 proposed	1
Yemen	0	0	0	0	0
Zambia	0	0	0	0	0
Zimbabwe	0	0	0	0	0

Notes

1. World Nuclear Organization, World Uranium Mining - updated April 2011, www.world-nuclear.org/info/inf23.html
2. International Panel on Fissile Materials, Global Fissile Material Report 2010, www.fissilematerial.org
3. http://en.wikipedia.org/wiki/Nuclear_reprocessing#List_of_sites
4. Includes only future reactors in specific plans and proposals, and expecting to be operating by 2030, www.worldnuclear.org/info/reactors.html
5. http://nucleus.iaea.org/RRDB/RR/ReactorSearch.aspx

photo: Adam Dempsy; Olympic Dam Tailings, South Australia

Overview of the Fukushima nuclear disaster

Philip White

The 11 March 2011 magnitude 9.0 Great East Japan Earthquake and the Fukushima Dai-ichi nuclear disaster that followed have thrown Japan into its greatest crisis since World War II. By early June about 25,000 people were reported to be dead or missing.1 Immediately after the earthquake it was reported that about 370,000 people had evacuated their homes[2] and there were still 166,000 evacuees in shelters at the beginning of April.[3] No complete estimate of the economic cost has been published, but the Cabinet Office estimated that rebuilding of infrastructure, housing, and other facilities ravaged by the 11 March earthquake and tsunami would cost around ¥16.9 trillion, not including damage from the nuclear crisis.[4]

So far no radiation-related deaths have been reported. However it would be a great mistake to interpret that to mean that the impact of the nuclear accident was insignificant in comparison with the direct impact of the earthquake and tsunami. As discussed in Section 4 below, the radioactive material released from Tokyo Electric Power Company's (TEPCO) Fukushima Dai-ichi Nuclear Power Station (NPS) will have a lasting impact on the people of Fukushima Prefecture and beyond. There is a grave risk that many workers and civilians will develop cancer and other illnesses as a result of their exposure to radiation; the agriculture and fishing sectors have suffered a devastating blow due to radioactive contamination of their produce, as well as reputation damage; and it is likely that a large tract of land around the nuclear power plant will be uninhabitable for many years.

The nuclear aspect of the disaster was the direct result of the negligence and resistance to outside ideas of Japan's nuclear fraternity. Any benefits that may have been gained as a result of nuclear energy in the 40 odd years since Japan's first nuclear power plant began operating have been undone in a single blow. Measured in financial terms alone, the disaster may have wiped out 38 years worth of nuclear earnings for TEPCO.

Impact of the earthquake and tsunami on Japan's nuclear power plants

1.1 Down for the count

As of 10 March 2011, Japan had 54 operational reactors, with a total generating capacity of 49,112 MW, at 17 nuclear power stations. As a result of the earthquake that struck Japan's Tohoku Region at 14:46 on 11 March and the aftershocks and tsunamis that followed, all 15 reactors (total generating capacity of 13,470 MW) at the five nuclear power stations in the Tohoku and Kanto Regions will be out of action for the foreseeable future.[5]

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When the earthquake struck, four of these reactors were undergoing periodic inspections. The others were either operating or starting up.

The four units of the Fukushima Dai-ichi NPS where explosions occurred will never operate again. No official decision has been made about the future of the other reactors. In the midst of the disaster at Fukushima Dai-ichi, very little attention has been given to the condition of these plants, but just because there are no reports of leaks of radioactive material does not mean they escaped damage. None of them will be allowed to restart without undergoing an extensive safety review process. Certainly they will not contribute to Japan's electric power supply for a long time. By contrast, wind turbines in the Tohoku Region survived both the earthquake and the tsunamis.[6] It is ironic that nuclear power, which was sold to the Japanese public in the name of "energy security", turned out to be more vulnerable than wind power, which has been maligned in Japan for its alleged unreliability.

1.2 The road to melt down

The timeline in the Table 1 below is based on a report submitted by the Japanese government to the International Atomic Energy Commission (IAEA) early in June 2011.[7] Itoffers an outline of the sequence of events leading to explosions at Units 1 to 4 of the Fukushima Dai-ichi Nuclear Power Station. Units 1 to 3 suffered meltdowns. It is suspected that the fuel melted right through the reactor pressure vessel (RPV) and accumulated at the bottom of the primary containment vessel (PCV). There was no fuel in the RPV of Unit 4, which was undergoing a periodic inspection, but a hydrogen explosion blew the roof off, exposing the spent fuel pool. No explosions occurred at Units 5 and 6, but they struggled for many days due to failure of most of their power supply, rising reactor pressure and overheating spent fuel pools.

Table 1: Timeline to meltdown and explosions

Fukushima	Unit 1	Unit 2	Unit 3	Unit 4
11 March	*14:46* Scram and loss of external power *15:37* Loss of emergency diesel generators *17:00* Fuel exposed leading to rapid melt down	*14:47* Scram and loss of external power *15:41* Loss of emergency diesel generators *14:50* Reactor Core Isolation Cooling System operates on and off	*14:47* SScram and loss of external power *15:41* Loss of emergency diesel generators *15:05* Reactor Core Isolation Cooling System operates on and off	Periodic inspection *15:38* Loss of emergency diesel generators
12 March	*05:46* Fresh water injection *14: 30* Venting of containment vessel		*11:36* Reactor Core Isolation Cooling System stopped	

Fukushima	Unit 1	Unit 2	Unit 3	Unit 4
12 March cont'd	*15:36* Hydrogen explosion *19:04* Seawater injection		*12:35* High Pressure Core Injection System started	
13 March		*11:00* Wet vent of containment vessel	*02:42* High Pressure Core Injection System stopped *08:00* Fuel exposed leading to fuel melt *09:25* Injection of water with boric acid	
14 March		13:25 Reactor Core Isolation Cooling System stopped 18:00 Fuel exposed leading to fuel melt 19:54 Seawater injection started	05:20 Wet well vent 11:01 Hydrogen explosion	
15 March		06:00-06:10 Explosion around containment vessel suppression chamber		06:00-06:10 Explosion in reactor building 09:38 Fire on 4th floor

In addition to the above timeline, it has been suggested that a second meltdown may have occurred in Unit 3 starting 21 March. This theory was proposed by Fumiya Tanabe, a former senior researcher at the Japan Atomic Energy Research Institute (now Japan Atomic Energy Agency).[8]

1.3 Other nuclear power stations not spared

Reactors at nuclear power stations other than Fukushima Dai-ichi came dangerously close to suffering a similar fate, due to loss of offsite power and the failure of some of their backup diesel generators. In particular, three of the reactors at the Fukushima Dai-ni NPS struggled for three days before achieving cold shutdown. A magnitude 7.4 aftershock on 7 April again threatened reactors in the Tohoku Region, knocking out offsite power supplies to the Onagawa (two of three external power lines) and Higashidori stations (both remaining external power lines). Higashidori's only operational backup diesel generator worked for a while, but broke down due to a maintenance error. Fortunately, it operated just long enough for external power to be restored.

Causes

2.1 Starting point: earthquake or tsunami?

A debate has arisen about the initial cause of the accident. Did the accident begin as a direct result of the earthquake, or was the integrity of the plant maintained until the tsunamis struck? At this stage it is not possible to answer this question conclusively, but due to the regulatory implications of the "earthquake start" theory, TEPCO has so far resisted pressure to countenance this theory.

Independent analysts have pointed to suspicious circumstances that suggest that things were already going seriously wrong before the tsunamis overwhelmed the diesel generators, causing a total loss of AC power. Nuclear engineer Mitsuhiko Tanaka[9] and others[10] have drawn particular attention to Unit 1, the first unit to suffer a meltdown of its nuclear fuel. Based on anomalous data relating to the pressure inside the RPV and the PCV, the reactor coolant water level and the strange operation of various cooling systems, they suggest that the earthquake itself might have caused damage leading to a loss of coolant. If they are right, safety checks of Japan's nuclear power plants must go far beyond those demanded so far. Comments made by Fukushima Dai-ichi plant manager, Masao Yoshida, reinforce this conclusion. In frank interviews with Shukan Asahi (Asahi Weekly)[11], which exposed deep rifts between TEPCO's head office and workers at the site, Yoshida, who has a reputation of knowing everything there is to know about the Fukushima Nuclear Power Station, said,

> If you ask me which caused the problems at Fuku-ichi (Fukushima Dai-ichi Nuclear Power Station), the earthquake or the tsunami, it is a fact that in the first place the facilities incurred considerable damage to buildings, pipes, electrical systems, and so on from the earthquake. Immediately after the earthquake, we were inundated by urgent reports saying, "the pipes are done for" and "there's material that's fallen down". It was a terrible situation in the control room too. There were reports from the control room saying, 'pipes and electrical systems have stopped working.' Many workers fled. It can't be denied that there were problems with the plants' seismic resistance.[12]

On 30 March the Nuclear Industrial and Safety Agency (NISA) directed electric utilities to take emergency measures to secure nuclear power plants against tsunamis[13] and on 8 June the Minister of Economy, Trade and Industry directed electric utility companies to implement measures in response to severe accidents.[14] However, if a severe accident was already in progress at Fukushima Dai-ichi Unit 1 before the tsunami struck, that would represent a far more fundamental challenge to the seismic safety standards, which relate to all buildings, machinery, and equipment in Japan's nuclear power plants.

Key details of the sequence of events in the first few hours after the earthquake struck are unavailable. Some data is missing altogether as a result of damage to measuring devices and there are doubts about the accuracy of other data. Some things will not be known until it is possible to look inside the reactor. Other things may never be known. When seeking to apply lessons from Fukushima Dai-ichi to other nuclear power plants, it is important to resist the temptation to draw conclusions on the basis of insufficient evidence. However, TEPCO and the Japanese government are already trying to minimize the regulatory impact by responding on the assumption that the integrity of the plant was maintained until it was struck by the tsunami.

2.2 Siting problems

Japan is a small densely populated country and getting local approval for controversial projects such as nuclear power stations is difficult, so the emphasis was on building more and more plants at existing sites. The folly of this approach was starkly illustrated during the unfolding crisis at Fukushima Dai-ichi.

Units 1 to 4 are all lined up close together. Radiation and rubble from one plant hampered operations at the other plants. When the situation at one plant rapidly deteriorated, attention was drawn away from problems developing at other plants. In the case of the explosion that blew the roof off the Unit 4 reactor building, it is believed that this could have been triggered by hydrogen gas from Unit 3. Hydrogen discharged by venting of the primary containment vessel of Unit 3 may have flowed into the Unit 4 reactor building via the piping of their shared ventilation stack.[15] Safety planning was based on single nuclear power plants. The notion that several could melt down in series was never seriously entertained by nuclear safety officials. Clearly this was a case of mistaken optimism.

2.3 Natural or human made disaster?

TEPCO asserted that the nuclear accident was the result of a natural disaster and that the size of the earthquake and tsunami which struck the Fukushima Nuclear Power Stations was beyond what could have reasonably been predicted. The government took a different view. It immediately pinned the blame on TEPCO. Most particularly, it rejected any suggestion that TEPCO should be able to escape by taking advantage of a loophole in Japan's nuclear liability laws exempting the operator of nuclear facilities from liability for damages caused by extraordinarily large natural disasters. TEPCO expressed the view that the earthquake could be interpreted as exempting it from liability, but in the face of public outrage, it has not pressed the point in public. For its part the government has come up with a compensation scheme which, at least for the time being, preserves the integrity of TEPCO as a company.

By that reckoning the nuclear accident was human made. But haggling over who foots the compensation bill does not clarify the true source of the problem. For that one has to look at TEPCO's failure to adequately predict and prepare for major earthquakes and tsunamis, the failure of regulatory bodies to identify problems and demand corrective action, and the refusal of both industry and government to heed repeated warnings from experts and citizens alike.

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It was common knowledge that Japan was prone to earthquakes and tsunamis. However, since the earliest days of Japan's nuclear power program, estimates of the potential severity of earthquakes and tsunamis that were incorporated into the design basis of nuclear facilities were systematically minimized in order to facilitate license approval. The Great Hanshin-Awaji Earthquake that hit Kobe in January 1995 precipitated a review of the seismic design guidelines. New guidelines were finally adopted in 2006, but the revised guidelines failed to solve the problem. Tsunamis are given only a cursory mention in the very last sub-clause of the guidelines.

Meanwhile, previously unidentified active faults were discovered near nuclear facilities, known faults were shown to be longer than previously believed and earthquakes exceeding the design basis occurred one after the other. Most notably the Chuetsu-oki Earthquake in July 2007 led to the extended shut down of the Kashiwazaki-Kariwa Nuclear Power Station. Three of the seven units still have not restarted. Despite these challenges to Japan's seismic safety principles, at every turn both government and industry adopted an attitude of denial, or went on the defensive. The current nuclear disaster should be seen as the inevitable outcome of these institutional failures.[16]

The ground motion recorded during the Great East Japan Earthquake exceeded the design basis for Units 2, 3 and 5 of the Fukushima Dai-ichi NPS and for all three units of the Onagawa NPS, but was within the design basis for all units at Fukushima Dai-ni, Tokai Dai-ni and Higashidori. The deficiency was less pronounced than for the Kashiwazaki-Kariwa NPS during the Chuetsu-oki Earthquake, but nevertheless points to the possibility that equipment could have been damaged by the earthquake itself (see Section 2.2).

In regard to the tsunami, the following account, quoted from the summary of the Japanese Government's June 2011 report to the IAEA, illustrates how grossly inadequate the tsunami standards were:

> The license for the establishment of nuclear reactors in Fukushima Dai-ichi NPS was based on the assumption that the maximum size of expected tsunami is 3.1m on the design-basis. The assessment

in 2002 based on 'Tsunami Assessment Method for Nuclear Power Plants in Japan' proposed by the Japan Society of Civil Engineers (JSCE) showed that the maximum water level would be 5.7m, and TEPCO rose the height of seawater pump installation in Unit 6 responding to that assessment. However, the actual tsunami height this time was 14 to 15m, and the seawater pump facilities for cooling auxiliary systems in all units were submerged and stopped their functions.[17]

There is an apparent contradiction between the summary report and the full report in relation to the distinction between the height of the tsunami and the flood height, but suffice to say the design basis was well below the height of the tsunami and the tsunami flooded the Dai-ichi NPS.

There were repeated warnings from critical academics and citizens about the inadequacy of Japan's seismic standards, the deficiencies in the design basis of specific facilities, and the inappropriateness of operating nuclear power plants in an earthquake prone country like Japan. Even research by official agencies should have alerted the government to the serious inadequacy of its tsunami design standards. For example, in December 2010 the Japan Nuclear Energy Safety Organization released a report which concluded that at an unspecified BWR plant, a tsunami over a given height (7m with no seawall, or 15m with a 13m seawall) would give rise to a 100% probability of damage to the reactor core.[18]

The most significant critic was seismologist and Kobe University Emeritus Professor Katsuhiko Ishibashi. He was a member of the committee that produced the current seismic design guidelines, but he refused to endorse the draft guidelines, resigning in dissatisfaction at the committee's final meeting.

"There were repeated warnings from critical academics and citizens about the inadequacy of Japan's seismic standards, the deficiencies in the design basis of specific facilities, and the inappropriateness of operating nuclear power plants in an earthquake prone country like Japan."

At a public hearing on 23 February 2005 of the House of Representatives Budget Committee, Professor Ishibashi gave a presentation with the prophetic title, "Impending era of violent earthquakes will bring about an unprecedented national crisis: from technological disaster prevention to fundamental reform of national policy and the social economic system".[19] During the presentation he explained to Diet Members the concept of 'gempatsu-shinsai', a term which he coined in 1997 to refer to a multiple disaster involving an earthquake and a quake-induced nuclear accident. He pointed out that common-cause failures would arise during such a disaster and many different places would be damaged. These would combine to overcome the multi-layered defenses and safety mechanisms, potentially leading to a core meltdown, or a runaway nuclear reaction. When people attempted to escape the radiation they would be unable to do so, due to destruction of roads and bridges by tsunamis and liquefaction of the soil. Furthermore, management of the nuclear power plant would be impossible.

Most of what Professor Ishibashi said to Japan's elected representatives came to pass, but he was ignored at the time.

Radiological impact on people and the environment

3.1 Radioactive releases and Chernobyl comparison

Initially the government assessed the accident as level 3 on the International Nuclear and Radiological Event Scale (INES). On 12 March, the day after the earthquake, it elevated its assessment to level 4, then on 18 March, to the astonishment of all, it raised its assessment just one step to level 5, assessing each unit separately. On 12 April, the Japanese Government belatedly acknowledged what everyone already knew, namely that we were witnessing a level 7 nuclear disaster. Much as it wished to avoid the comparison, the Japanese government could no longer escape the conclusion that Fukushima Dai-ichi shared the distinction with Chernobyl of being deserving of the highest possible INES rating. Nevertheless, it was at pains to point out that the amount of radioactive material released was only 10 percent of that released from Chernobyl.

The wording in the Ministry of Economy, Trade and Industry's (METI) news release closely followed the wording in the INES Manual. METI stated, "the value representing radiation impact, which is converted to the amount equivalent to 131I (Iodine), exceeds several tens of thousands of tera-becquerel (of the order of magnitude as 1016 Bq)."[20]

The figures quoted in METI's 12 April news release were increased in the Japanese government's June 2011 report to the IAEA. The figures given in the latter report are "approx. 1.6x1017Bq for Iodine 131 and approx. 1.5x1016Bq for Cesium 137".[21] Applying the same conversion rate (x40) from Cesium 137 to Iodine 131 as that used in METI's INES assessment gives a total figure of 7.6x1017Bq of radioactive material released to the air.

The INES manual assesses the significance of releases on such a scale as follows:

> With such a release, stochastic health effects over a wide area, perhaps involving more than one country, are expected, and there is a possibility of deterministic health effects. Long-term environmental consequences are also likely, and it is very likely that protective action such as sheltering and evacuation will be judged necessary to prevent or limit health effects on members of the public.[22]

The INES assessment did not include radioactivity released to sea. In its June 2011 report to the IAEA, the Japanese government quoted figures for discharge to sea that were two orders of magnitude lower than the total amount discharged into the air. Almost all the radioactivity released to sea appears to have occurred in the period 1–6 April, when approximately 520m3 of highly concentrated radioactive materials leaked into the sea from Unit 2. The amount of radioactivity was estimated at 4.7x1015Bq. Other known discharges were a few orders of magnitude lower again. A leak of an estimated 250m3 from Unit 3 in the period 10–11 May was estimated at 2.0x1013Bq, while a much criticized deliberate release of about 10,393 tons of "low-level radioactive water" in the period 4–10 April was assessed to be about 1.5x1011Bq.[23]

It is important to bear in mind that a huge quantity of radioactively contaminated water has accumulated in the plant and that there is a danger that some of this will be released to sea, or into the groundwater in future. It is by no means inconceivable that in the long run more radioactivity could be released into the environment via these routes than is released directly into the atmosphere. Given that the accident has not yet been brought under control, it could still exceed Chernobyl, though the pathways are different.

3.2 SPEEDI spread of radiation

Radiation levels within the reactor building of Fukushima Dai-ichi Unit 1 began to rise very quickly, reaching as high as 300 milli-sieverts/hour (mSv/h) on the night of 11 March.[24] Data published by TEPCO shows a sudden increase in gamma radiation at the main gate from 69 nano-Grays/hour (nGy/h) at 04:00 to 866 nGy/h at 04:40 on the morning of 12 March. This was followed by spikes of up to 385.5 micro-Sieverts/hour (μSv/h) between 10:20 and 10:40.[25] From these readings it is clear that significant releases of radioactivity into the environment began well before venting of the containment vessel at 14:30 and the explosion in the reactor building at 15:36.

Over the ensuing days, venting, explosions, and fires released massive quantities of radioactive material into the atmosphere. This was picked up by the wind and deposited unevenly by rain over a wide area. Predictions of the pattern of distribution were made using the System for Predicting Environmental Emergency Dose Information (SPEEDI), but the results were not communicated to the public until 23 March. In its June 2011 report to the IAEA the Japanese Government said of SPEEDI, "...it did not conduct quantitative forecast of atmospheric concentration of radioactive materials and air dose rate because release source information through ERSS (Emergency Response Support System) could not be obtained in this accident."[26]

That is a damning enough admission in itself, but it also sounds suspiciously like an excuse. The government has come in for a great deal of criticism for not using the SPEEDI system to warn the public and guide the evacuation.[27,28] The belatedly released SPEEDI maps showed radioactivity spreading predominantly to the northwest, but by then many people had fled less contaminated areas closer to the Fukushima Dai-ichi NPS to more distant, but more contaminated regions. Had SPEEDI been used effectively, people would have been advised to flee from more contaminated areas to less contaminated areas, rather than simply run away from Fukushima Dai-ichi, and they would have been told to stay in doors when radiation levels outside were high.

3.3 Tardy evacuation and lax radiation protection standards

The zone of "unconditional (obligatory) resettlement" around Chernobyl is based on a projected annual dose of 5 milli-Sievert/year (mSv/y). Radiation around the Fukushima plant is comparable with the most contaminated areas of Chernobyl,[29] but the Japanese government has resisted pressure to adopt a similar standard. Instead, it established zones based on a standard of 20 mSv/y. This standard only takes into account external dose, disregarding internal exposure from contaminated food and water, or external and internal exposure from immersion in the radiation plume as it spread from the devastated NPS. The government used a statement in response to the Fukushima Dai-ichi disaster issued on 21 March 2011 by the International Commission on Radiological Protection (ICRP)[30] to justify this figure, although it is doubtful whether ICRP intended its statement to be used to support an evacuation standard of 20 mSv/y.[31] Many people are critical of the role ICRP has played over the years in influencing radiological protection standards, but one longstanding and widely supported ICRP recommendation is that the annual dose limit for members of the general public should be 1 mSv. ICRP's 21 March statement recommends a "long-term goal of reducing reference levels to 1 mSv per year (ICRP 2009b, paragraphs 48-50)."

In its 21 March statement, ICRP said, "For the protection of the public during emergencies the Commission continues to recommend that national authorities set reference levels for the highest planned residual dose in the band of 20 to 100 millisieverts (mSv) (ICRP 2007, Table 8)." It went on to recommend "choosing reference levels in the band of 1 to 20 mSv per year" when "the radiation source is under control". The government claims to have chosen the bottom of the higher range, while critics interpret it as the top of the lower range. In a 2008 publication ICRP "recommends that the reference level for the optimization of protection of people living in contaminated areas should be selected from the lower part of the 1–20 mSv/year band,"[32] so it seems reasonable to conclude that the level chosen by the Japanese government is very high.

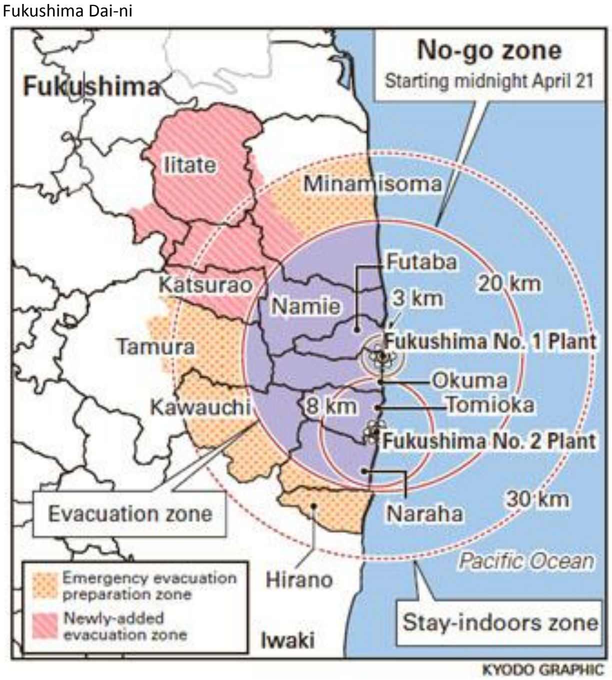
The government took a long time to clarify its policy and begin evacuating people from highly contaminated areas as far away as 45 kilometers northwest of the

Fukushima Dai-ichi NPS. In the early days there was imminent danger that the situation could deteriorate suddenly. The government's response appeared to be reactive, using projected doses based on radioactive material already released, when it should have been proactive, taking into account radioactive doses that were likely considering the dire situation at the NPS. The government failed to frankly communicate the health risks and, as it became clear that radiation exposure would continue for an extended period of time, to facilitate speedy evacuation from many of the most contaminated areas. Table 2 shows how the evacuation zone has gradually expanded, while the map below shows the regions affected.

Table 2: Evacuation zone time line

11 March, 20:50	Evacuation of 2 km zone (F-I)
11 March, 21:23	Evacuation of 3 km zone, stay indoors within 10 km zone (F-I)
12 March, 05:54	Evacuation of 10 km zone (F-I)
12 March, 07:45	Evacuation of 3 km zone, stay indoors within 10 km zone (F-II)
12 March, 17:39	Evacuation of 10 km zone (F-II)
12 March, 18:25	Evacuation of 20 km zone (F-I)
15 March, 11:00	Evacuation of 20 km zone, stay indoors within 30 km zone
21 April	Announcement of ban on entry into 20 km zone (F-I)
21 April	Reduc of evac. zone 10km to 8km (F-II)
22 April	Announcement re planned evacuation and emergency evacuation preparation zones beyond 20 km (F-I)
22 April	Lifting of stay indoors order for 20 km to 30 km zone (F-I)
16 June	Announcement of policy of designating "Specific Spots Recommended for Evacuation" for hot spots where air dose is estimated to exceed 20mSv/y.

* F-I refers to zone the around Fukushima Dai-ichi and F-II refers to the zone around Fukushima Dai-ni



3.4 Exposing the most vulnerable

The government has consistently understated the potential health effects of low doses of radiation. Immediately after the accident, officials and pro-nuclear commentators asserted that doses below 100 mSv/y were not detrimental to health. Accused of defying international scientific opinion, the government modified its statements, saying that such levels of exposure are not "immediately" deleterious to health. It thus acknowledged by implication that low doses of radiation can adversely affect health in the long term, without informing the public of the nature and likelihood of these adverse effects. However, Japan has a famous history of grappling with radiation-induced illness, so the public was not fooled. Instead the government and pro-nuclear academics lost the public's trust and exacerbated the panic that they claimed to be trying to prevent.

A particularly contentious issue has been the high levels of exposure that children are being subjected to. On 19 April the Nuclear Emergency Response Headquarters issued an interim opinion regarding use of schools in Fukushima Prefecture. The opinion followed the same 20 mSv/y standard as that used to guide the evacuation. Children would be able to study and play as usual in schools where the projected dose was less than 20 mSv/y. If the dose was projected to exceed this level, precautionary measures, such as restricting the time spent out of doors, should be adopted. An ambient dose rate of 3.8 μSv/h, measured 50cm above the ground for kindergartens, child-care centers, and elementary schools and 1m above the ground for junior high schools, was set as the benchmark for assessing whether the annual dose would exceed 20 mSv.

This assessment provoked outrage. It was a major factor triggering the resignation of Toshiso Kosako, an advisor to the Prime Minister on radiation safety issues.[33] The United States doctors group Physicians for Social Responsibility issued a statement criticizing the decision, arguing, "Children are much more vulnerable than adults to the effects of radiation, and fetuses are even more vulnerable. It is unconscionable to increase the allowable dose for children to 20 millisieverts (mSv). Twenty mSv exposes an adult to a one in 500 risk of getting cancer; this dose for children exposes them to a 1 in 200 risk of getting cancer."[34]

Meanwhile, protests in Tokyo by Fukushima parents and NGOs forced the government into a partial back down. On 27 May the Ministry of Education, Culture, Sports, Science and Technology issued a statement saying that it would issue dosimeters to all schools in Fukushima Prefecture and aim during this academic year to limit the radiation doses incurred by children at school to 1 mSv/y. However, the statement did not actually withdraw the 20 mSv/y standard and children continue to attend contaminated schools.

3.5 Sacrificial labor

Images like the famous footage of liquidators dousing the gutted Chernobyl Reactor 4 with concrete have not appeared on this occasion. Whereas the aim at Chernobyl, which blew up and caught fire, was to entomb the reactor, the aim at Fukushima Dai-ichi has been to maintain cooling of the reactors and spent fuel pools. This task, along with removal of rubble obstructing operations, has been carried out by courageous workers in appalling conditions amidst levels of radiation that are unthinkable for the general public.

Faced with a situation where there might not be enough workers to prevent an even greater disaster, the government raised the dose limit. In Japan the usual dose limit for radiation workers is 50 mSv in a single year, or 100 mSv over five years, but in emergency situations it is permitted for workers to be exposed to up to 100 mSv. For the Fukushima Dai-ichi emergency, this limit was raised to 250 mSv, which is considered to be the lowest dose at which "deterministic effects" (often of an acute nature) might be seen. Below that it is believed that only "stochastic effects" (random, or probabilistic) may be incurred long after the exposure takes place.

Already alarming patterns are emerging. On 24 March two workers stepped into a puddle of water that had accumulated in the Unit 3 turbine building. The radiation doses to the skin of their legs were estimated to be "less than 2 or 3 Sv".[35] On 10 June TEPCO announced that two workers had received cumulative doses of 678 mSv and 643 mSv respectively. High levels of radioactive iodine were found in their thyroids. The exposure was incurred in the first few days after the accident, but was not noticed until the end of May. The workers continued to work at the plant and add to their cumulative dose. One wonders how many more such cases there may be. Another problem is maintaining records of worker exposure. It is reported that TEPCO has lost track of, or cannot confirm the identity of around 70 people who have worked at Fukushima Dai-chi since the accident.

The workers who have risked their lives to contain the damage from the Fukushima Dai-ichi disaster must not be abandoned. Those responsible for exposing them to danger must be held to account. Unfortunately, history gives little cause for optimism on that score. Japan's atomic and hydrogen bomb *hibakusha* and also Japanese nuclear industry workers, who have suffered radiation-induced illnesses, have been abandoned in the past.

3.6 Contaminated food and water

Radioactive contamination soon showed up in milk, vegetables, fish, and water. On 21 March the government issued an indefinite ban on sales of milk and leafy vegetables spinach and "kakina" from Fukushima and neighboring prefectures after samples were found to be abnormally radioactive. In the ensuing days and weeks the list of restricted foods grew rapidly. For a brief period in late March, tap water in Tokyo, 220 kilometers south west of Fukushima-Daiichi, was found to contain levels of iodine-131 considered unsafe for infants. At the beginning of April, sand lance (a type of fish) caught offshore from Kita-Ibaraki, about 70 kilometers south of Fukushima Dai-ichi, recorded levels of iodine and cesium contamination well above regulatory limits. Not surprisingly, all this created panic among consumers. There were more food scares in July when it was discovered that beef from cattle fed with contaminated straw had been distributed throughout Japan. Meat contaminated with up to 4,350 Bq/kg of radioactive cesium, over eight times higher than the provisional ceiling of 500 Bq/kg, was found. As a result, sale of Fukushima beef was banned completely.

On 17 March the Ministry of Health, Labour and Welfare (MHLW) issued a notice to governors and mayors outlining the food and water standards that should be applied.[36] The maximum permitted levels of contamination are shown in Table 3 below.

Table 3: Indices relating to limits on food and drink ingestion

Nuclide	Index values relating to ingestion limits in guidelines for coping with disasters at nuclear facilities (Bq/kg)
Radioactive iodine (representative radio-nuclides among mixed radio-nuclides: ^{131}I	Drinking water: 300 Milk, dairy products*: 300 Vegetables (except root vegetables and tubers): 2,000
Radioactive cesium	Drinking water: 200 Milk, dairy products: 200 Vegetables: 500 Grains: 500 Meat, eggs, fish: 500
Uranium	Infant foods: 20 Drinking water: 20 Milk, dairy products: 20 Vegetables: 100 Grains: 100 Meat, eggs, fish: 100
Alpha-emitting nuclides of plutonium and transuranic elements (Total radioactive construction of ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Am, ^{242}Cm, ^{243}Cm, ^{244}Cm)	Infant foods: 1 Drinking water: 1 Milk, dairy products: 1 Vegetables: 10 Grains: 10 Meat, eggs, fish: 10

* Provide guidance so that materials exceeding 100 Bq/kg are not used in milk supplied for use in powdered baby formula or for direct drinking to baby.

+Added on 5 April 2011[37]

These levels should not be seen as "safe" levels. They are taken from the Nuclear Safety Commission of Japan's (NSC) emergency guidelines. They are not designed to address long term contamination.[38] It has been pointed out that these standards "even if applied rigorously, could result in a total radiation dose of up to 17 mSv per year".[39] That is on top of external radiation exposure.

With Japanese consumers wary of products from contaminated regions and countries around the world placing restrictions on imports from Japan, the prognosis for Japan's agriculture and fishing industries is grim. Producers suffer reputational damage, even in areas that are not contaminated. A particularly serious concern is the predicted contamination of Japan's staple food: rice.[40] Bans have already been placed on the planting of rice in contaminated areas, so Japan's level of self-sufficiency in rice is likely to fall.

3.7 Living with radiological contamination

How should the Japanese people deal with this situation? There are no easy answers. France's Institute for Radiological Protection and Nuclear Safety (IRSN) estimated that if the standard for evacuation were lowered to 10 mSv/y about 70,000 people would have to be evacuated, compared to about 15,000 to 20,000 under the Japanese Government's 20 mSv/y standard. This would afford significant extra protection. IRSN estimates, "An evacuation one year after the accident would result in a 59% decrease of the projected external dose for this population; evacuation three months after the accident would result in an 82% decrease."[41]

Civil society groups are concerned that the government is trying to erode radiation protection standards, including the pre-existing standard for the general public of 1 mSv/y. This is not only a problem for Japan. Precedents set now by Japan could potentially lead to an erosion of standards worldwide. Civil society groups are not explicitly calling for the evacuation of all areas were annual doses are projected to exceed 1 mSv. That would involve evacuating a large percentage of Fukushima Prefecture, probably including the prefectural capital Fukushima City.[42] But they are demanding strict adherence to this standard for schools and for regulation of food and drink and that both external and internal radiation be included in calculations.[43]

Of course, there are many other issues besides radioactive contamination for the people of Fukushima to consider. The psychological, social, and economic consequences for people uprooted from the soil that nurtured them are not difficult to imagine. Perhaps Tetsuji Imanaka, Assistant Professor at the Kyoto University Research Reactor Institute, expressed the dilemma better than anyone in a presentation at the Iitate-mura Radioactive Contamination Study Report Meeting on 4 June:

> The thing that concerns you all most is, 'When can we return to Iitate-mura?' I'm afraid we don't have an answer for you. We can talk about the nature of radioactivity, about radiation exposure and about the sort of risks that might conceivably be involved. But in the end I think the answer depends on how we approach radioactivity, on how much radioactive contamination and how much radioactivity we are willing to accept. I can speak for myself. I can say how much exposure I am willing to put up with. For me it's an occupational hazard. But as for how much you should tolerate, I can't say.[44]

Imanaka went on to give the audience an honest account of the radiological issues they need to understand in order to make informed decisions. This is something the government and the embedded experts have not done. People need to understand the radiological issues in order to make the right decisions for themselves considering the totality of their circumstances. Above all what is required now is a process the end result of which will be informed consent, both for individuals and for communities. The government's approach has been to impose its will on the general public on the basis of misinformation, or highly selective information. In the initial stages there was no time for full-scale participatory processes, but now, for the preservation of public health, to rebuild lives and communities, and to recover the trust that is so important for the reconstruction of the Tohoku Region, it is imperative that citizens be given a chance to think and make decisions for themselves. This should include an option for people living in areas which are outside designated evacuation zones, but which are nevertheless significantly contaminated, to receive government support for evacuation: something along the lines of Chernobyl's "zone of a guaranteed voluntary resettlement," which covers effective doses of between 1 mSv/y to 5 mSv/y.

Another essential step is to establish a system for tracing the health of people who have been exposed to radiation. The Fukushima Prefectural government has started conducting health checkups and has launched an unprecedented effort to continuously monitor the health of its residents for several decades.[45] The central government plans to establish a ¥103 billion fund to track the health of all Fukushima Prefecture residents for 30 years. These are encouraging moves. It is vital that, unlike the radiological studies following the atomic bombing of Hiroshima and Nagasaki, the focus not be restricted to refining our understanding of radiological risk, although that will be an important outcome. The main purpose should be to facilitate support for the victims, bearing in mind that most radiation induced illnesses will not manifest themselves for many years. That requires a long-term financial commitment with bipartisan political support.

Disaster response

4.1 Government response

The government and in particular Prime Minister Kan have come in for a great deal of criticism for their handling of the disaster. Criticisms cover the full spectrum of issues, including lack of overall coordination and leadership, slowness in responding to the unfolding crisis and spread of radiation, failure to make effective use of key data (see section 3.2), tardy release of information (see section 3.2), lax radiation protection standards (see sections 3.3–3.7), underestimation of the seriousness of the situation, and bad judgment and untimely interference with on site operations. Enough information has leaked out to suggest that there is substance in all these allegations.

It is important to learn lessons from the failures of the government's post-crisis management, but it would be a mistake to focus exclusively on this at the expense of even greater pre-crisis failures. Section 2 above highlights defective safety standards and an attitude of ignoring critical perspectives. These problems are not restricted to the current Japanese Government. The seeds of the Fukushima Dai-ichi disaster were planted very early in the history of Japan's nuclear programme.

Apart from the failure to take action to reduce the probability of severe accidents in the first place, the inadequacy of the disaster response strategy made chaotic crisis management virtually inevitable. Despite pressure from local communities, emergency drills were only carried out within an 8~10 km radius around nuclear facilities. The Local Nuclear Emergency Response Headquarters was set up in the offsite center in the town of Okuma about 5 km from the Fukushima Dai-ichi NPS. Not surprisingly, the center had to be moved to Fukushima Prefectural Office in Fukushima City due to high-level radiation as the nuclear disaster escalated. In the light of what has happened, the absurdity of these arrangements has become plain for all to see. It is hard to believe that the people who developed the disaster response system in the first place did not recognize the absurdity at the time. Were they duped by their own propaganda, or was there a more sinister reason? Many people believe they refused to develop more realistic plans because to do so would be bad publicity for the nuclear industry. If that is true, in the light of what has happened, it must be seen as criminal negligence.

4.2 TEPCO's response

In terms of containing the chain of events once the accident started, the post-earthquake data suggests non-optimal responses at several points, such as inappropriately shutting down the isolation condenser of Unit 1 and delays opening vents to release pressure (see Section 2.1). No doubt the onsite operators made many mistakes. In such a crisis situation it would be surprising if they did not. But in terms of operator responsibility, it is probably more relevant to focus on examples of inadequate disaster preparation. The lack of training and manuals addressing predictable scenarios is one example.[46]

In regard to publication of information, there is copious data in both Japanese and English on TEPCO's web site. A cursory glance at the English web sites of the other utilities directly affected by the earthquake and tsunami (Tohoku Electric Power and Japan Atomic Power Company) reveals that they have made zero information publicly accessible to the non-Japanese speaking world. But despite TEPCO's comparative openness, as the disaster escalated it failed to frankly explain in understandable language the seriousness of the situation. At its press conferences it gave the impression that the situation was under control, only to report further deterioration the next day. In some cases the data released was inaccurate and had to be retracted. (For example, erroneous data on iodine-134 concentrations in water in the Unit 2 turbine building was given.) Perhaps the most serious accusation so far is that although TEPCO knew there could be an explosion at the No. 3 reactor the day before it happened, it did not report the possibility to authorities.[47] If so, the public was deprived of advance warning of the danger.

The absence of key data was a major problem. It took two months for TEPCO to release data regarding reactor pressure and water level for 11 March, the day of the earthquake. Radioactivity measurements were unavailable because of loss of power to monitoring posts, ventilation systems, sampling facilities, etc. Without such basic information it was impossible to know what was really happening.

The nadir was reached when TEPCO admitted on 15 May that Unit 1 had suffered a total meltdown the day after the earthquake. It subsequently admitted on 24 May that meltdowns had also occurred at Units 2 and 3. Breach of the primary containment vessel (PCV) of Unit 1 and possibly of Unit 3 (in addition to the breach of Unit 2's PCV, which was already known) was also acknowledged. These admissions of what had long been assumed by most experts were the last straw for the Japanese public.

Of crucial importance now is TEPCO's implementation of its roadmap to bring the accident under control. It has released four roadmaps at monthly intervals, the first on 17 April. Each roadmap has maintained a target of bringing all reactors to a state of cold shut down within six to nine months of the release of the first roadmap. The biggest change since the original plan was the decision to develop a system to re-circulate the massive quantities of irradiated water flooding the basements of the turbine buildings as a coolant for the reactors. Operation of "accumulated water processing facilities" began on 17 June, but so far the system has been plagued with problems. Without effective cycling of this water, there is a danger that more and more radioactive water will accumulate and eventually spill into the ocean, potentially causing far more serious contamination than has occurred so far. Although the accumulated water processing facility has operated well below its advertised capacity, according to the latest roadmap, released on 19 July, the step 1 target of "stable cooling" was achieved within the target time of 3 months. Maintaining "stable operation of accumulated water processing facility" is said to be a step 2 target to be achieved within 6 to 9 months.

Other key features of the roadmap include installing a reactor building cover and later a container to prevent radioactive releases into the atmosphere, as well as a shielding wall under the plant to prevent seepage into groundwater. Hiroaki Koide, an assistant professor at the Kyoto University Reactor Research Institute, has highlighted the latter as a top priority task. He said, "We have to install a barrier deep in the soil and build a subterranean dam as soon as possible to prevent groundwater contaminated with radioactive materials from leaking into the ocean." Some believe that this is not being progressed fast enough because TEPCO is reluctant to foot the bill.[48]

This raises the issue of the cost of the nuclear disaster. Kenichi Oshima, an environmental economist and professor at Kyoto-based Ritsumeikan University, estimates that over the 38 years that TEPCO has been operating nuclear power plants it earned just less than ¥4 trillion from nuclear power generation. He says this is possibly equal to or less than the amount it must pay farmers, fishermen, evacuees, and others affected by the nuclear crisis.[49] Bank of America Corp.'s Merrill Lynch unit offers an even more pessimistic assessment. It says TEPCO may face as much as ¥11 trillion in compensation claims.[50] Normally such a company would go into receivership, but TEPCO is using all its political leverage to ensure its own survival. So far it is succeeding.

before

after

4.3 Independent assessment

It is essential that a full and independent analysis of the causes of the accident and the accident response be carried out. On 7 June, the government established the "Investigation Committee on the Accident at the Fukushima Nuclear Power Stations of Tokyo Electric Power Company".[51] It claims that the process will be "transparent and neutral". On June 22 at the Japan National Press Club the committee's chairman, Yotaro Hatamura, expressed a desire to include simultaneous English interpretation at some meetings. Whether or not the committee operates in a truly independent fashion, hopefully at least it will facilitate access to sufficient information to enable critical review by experts around the world.

Conclusions and questions

A key question that arises from the above account is, "Can nuclear energy be made safe?" This question cannot be answered on purely technical grounds. It must consider the social context, including human error, financial constraints, vested interests, corruption, and politics in general. If it turns out that nuclear energy can never be made completely safe, the next question is, "How serious is the risk and are the benefits worth it?"

These are not questions that have been asked by nuclear proponents in Japan. The furthest they have been willing to go beyond blunt assertions of absolute safety is to ask, "What can be done to improve the safety of nuclear energy?" The question is always framed in such a way as to exclude the possibility that nuclear energy might be rejected on the grounds that it cannot be made safe. As former Governor of Fukushima Prefecture Eisaku Sato said recently, "Japan's nuclear energy policy followed from a different set of premises. Their logic was as follows: Nuclear power generation is absolutely necessary. So nuclear power generation must be seen as being absolutely safe." He goes on to say, "there is this inflexible mindset of one absolute following another, carried onto its extreme consequences. Those who say that nuclear power is dangerous, like myself, are then treated as state enemies."[52]

Nuclear proponents in Japan have been reluctant to expand the range of debate to include people who might ask more fundamental questions. When unavoidable, lip service is paid to public debate, but the real decisions are made behind the scenes. This defensive attitude has closed the door to independent scrutiny of safety standards. Cosmetic changes are made under sufferance in the face of highly public scandals and accidents, but similar problems keep recurring. Again quoting Eisaku Sato, "When an absolute logic which brooks no criticism is created, attempts to reasonably measure and deal with risk are crushed."

Note: Since this articls was written, Japan's Prime Minister has been replaced. It is not clear what position Yoshihiko Noda, the new Prime Minister, will take on nuclear energy policy, but he is likely to be less positive towards phasing out nuclear power than his predecessor, Naoto Kan.

Notes

1. *Report of Japanese Government to the IAEA Ministerial Conference on Nuclear Safety: The Accident at TEPCO's Fukushima Nuclear Power Stations*, Nuclear Emergency Response Headquarters, Government of Japan, June 2011, Summary p. 4.
2. "Japan - Quake evacuees reach 370,000 in Tohoku," *NHK World*, 13 March 2011. "About 380,000 people have evacuated their homes in northeastern Japan. NHK's survey has found that 377,576 people were taking refuge at 2,047 evacuation centers in 6 Tohoku prefectures as of 11 AM on Sunday. The actual number of evacuees may be bigger."
3. *The 2011 off the Pacific coast of Tohoku Earthquake: Situation Report 12*, SEEDS Asia, 4 April 2011, at http://www.seedsasia.org/eng/sit_12.pdf.
4. Kyodo News, "Rebuilding to cost ¥16.9 trillion", *The Japan Times*, 25 June 2011.
5. Fukushima Dai-ichi Nuclear Power Station (6 BWR reactors, total generating capacity 4,696 MW), Fukushima Dai-ini Nuclear Power Station (4 BWR reactors, total 4,400 MW), Onagawa Nuclear Power Station (3 BWR reactors, total 2,174 MW), Higashidori Nuclear Power Station (1 BWR reactor, 1,100 MW), Tokai Dai-ni Nuclear Power Station (1 BWR reactor, 1,100 MW).
6. Kelly Rigg, "Battle-proof Wind Farms Survive Japan's Trial by Fire," *Huffington Post*, 17 March 2011, at http://www.huffingtonpost.com/kelly-rigg/battleproof-wind-farms-su_b_837172.html.
7. Nuclear Emergency Response Headquarters, *op. cit.*
8. Tomooki Yasuda, "Report suggests second meltdown at reactor at Fukushima plant," *Asahi Shimbun*, 9 August 2011, at http://www.asahi.com/english/TKY201108080276.html. "...between March 21 and 23, only about 24 tons of water was pumped in, while on March 24, about 69 tons entered the reactor. ... According to Tanabe ... the volume of water pumped in on those days was only between 11 and 32 percent of the amount needed to remove decay heat from the nuclear fuel in the core. In such a situation, the fuel could reach high enough temperatures to begin melting again in just one day. Tanabe also estimates that the second meltdown led to the release of large amounts of radioactive materials, and that much of the fuel fell through the pressure vessel to the surrounding containment vessel. ... One factor used by Tanabe in speculating that a second meltdown occurred is the increase in radiation levels from the morning of March 21 in areas downwind from the Fukushima No. 1 plant..."
9. Mitsuhiko Tanaka is a science writer who formerly worked as a nuclear engineer for Babcock Hitachi and helped design the Fukushima Daiichi reactor pressure vessel. His comments can be heard in Japanese and English on Ustream on the following URL. (English interpreting begins after about 11 minutes 30 seconds into the broadcast.) http://www.ustream.tv/recorded/16467539. The Ustream broadcast took place 6 August 2011 and includes critical analysis of aspects of Japan's June 2011 submission to the IAEA. Below is a link to an unofficial English translation of extracts of an article he wrote before the above Ustream broadcast. "Fukushima Daiichi Nuclear Power Plants' (NPP) Accident was Never Beyond Assumption— Vulnerability of Earthquake Resistance of NPP Core Structure Which is not Discussed", *Kagaku*, May 2011, at http://abolition-of-nuclear.blogspot.com/.
10. Kyodo News, "Tepco detected sharp rise in radiation in reactor 1 immediately after temblor struck Quake 'hurt reactors before tsunami'," *The Japan Times*, 16 May 2011, at http://search.japantimes.co.jp/mail/nn20110516a3.html.
11. A series of two articles based on interviews with Masao Yoshida, plant manager of the Fukushima Nuclear Power Station, were published in Shukan Asahi in July. The articles can be found in Japanese on the following web sites: 22 July 2011 at http://www.wa-dan.com/article/2011/07/post-135.php and 29 July 2011 at http://www.wa-dan.com/article/2011/07/post-138.php.
12. Ibid (22 July 2011). Translation by Philip White, the author of this paper.
13. Paraphrased from letter dated 30 March 2011 by Minister of Economy, Trade and Industry Banri Kaieda to electric utilities: *Regarding the Implementation of Emergency Safety Measures for the Other Power Stations Considering the Accident of Fukushima Dai-ichi and Dai-ni Nuclear Power Stations in 2011 (Direction)*
   • implement emergency inspections;
   • implement review and drills of emergency preparedness plans;
   • ensure emergency power sources;
   • ensure final heat removal function in emergencies;
   • ensure spent fuel cooling function in emergencies; and
   • implement necessary measures taking into account the structural configuration of each nuclear power station site.
14. From letter dated 7 June 2011 by Minister of Economy, Trade and Industry Banri Kaieda to electric utilities: *Regarding Implementation of Preparatory Measures for Severe Accidents in Other NPSs Taking into Account the 2011 Accident at Fukushima Dai-ichi NPS (Direction)*
   • secure the working environment in the Main Control Room;
   • secure the means of communication inside the NPS premises in case of emergency;
   • secure supplies and equipment such as high-level radiation protective gear, and develop a system for radiation dose management;
   • establish measures to prevent hydrogen explosion; and
   • deploy heavy machinery for removing rubble.
15. Nuclear Emergency Response Headquarters, *op. cit.*, Chapter IV, p. 90.
16. For information about the troubled history of the relationship between earthquakes and Japan's nuclear program see the following page of the web site of Citizens' Nuclear Information Center: http://cnic.jp/english/topics/safety/earthquake/index.html.
17. Nuclear Emergency Response Headquarters *op. cit.*, Summary p. 5.
18. Japan Nuclear Energy Safety Organization, *Fiscal Year 2010, Improvement of Probabilistic Safety Assessment Method in relation to Earthquakes: Trial Analysis of BWR Accident Sequence*, December 2010 (title translated by Philip White)
19. The following English article refers to this presentation: Jun Hongo, "World right to slam nuke program mismanagement: expert," *The Japan Times*, 14 April 2011, at http://search.japantimes.co.jp/cgi-bin/nn20110414a6.html.
20. Ministry of Economy, Trade and Industry, *INES (the International Nuclear and Radiological Event Scale) Rating on the Events in Fukushima Dai-ichi Nuclear Power Station by the Tohoku District - off the Pacific Ocean Earthquake*, 12 April 2011.
21. Nuclear Emergency Response Headqrts. *op. cit.*, Chapter VI p. 1.
22. *International Nuclear and Radiological Event Scale Users Manual*, 2008 Edition, p. 17.
23. Nuclear Emergency Response Headquarters *op. cit.*, Chapter VI p. 4, 5.
24. Kyodo News, "Tepco detected sharp rise in radiation in reactor 1 immediately after temblor struck: Quake 'hurt reactors before tsunami'," *The Japan Times*, 16 May 2011, at http://search.japantimes.co.jp/mail/nn20110516a3.html. "Workers entered the No. 1 reactor building during the night to assess the damage only to hear their dosimeter alarms go off a few seconds later, sources at Tokyo Electric Power Co. said....Based on the dosimeter readings, the radiation level was about 300 millisieverts per hour, the source said, suggesting that a large amount of radioactive material had already been released from the core."
25. TEPCO initially shows figures in nano-Grays per hour, then changes to micro-Sieverts per hour. For gamma rays, the value for

Grays and Sieverts is the same, the former representing the "absorbed dose" of radiation and the latter representing the "equivalent dose", which takes into account the different weighting factors for different types of radiation. 1 Sievert = 1,000 milli-Sieverts = 1,000,000 micro-Sieverts = 1,000,000,000 nano-Sieverts.
26. Nuclear Emergency Response Headquarters *op. cit.*, Chapter V p. 2.
27. Kyodo News, "Crisis center kept in dark on SPEEDI data," *The Japan Times*, 21 May 2011, at http://search.japantimes.co.jp/mail/nn20110521a4.html.
28. Yuka Hayashi, "Radiation Expert Predicts More Threats," *Wall Street Journal*, 2 July 2011, at http://online.wsj.com/article/SB10001424052702304450604576419560689685524.html.
29. Institute for Radiological Protection and Nuclear Safety (IRSN), *Assessment on the 66th Day of Projected External Doses for Populations Living in the North-West Fallout Zone of the Fukushima Nuclear Accident: outcome of population evacuation measures*, Report DRPH2011/10, p. 4. "On the 56th day after the accident, MEXT published the first maps of caesium depositions. They revealed high values comparable with the most contaminated areas of Chernobyl, even beyond the initial 20 km-radius evacuation zone around the Fukushima plant."
30. International Commission on Radiological Protection, *Fukushima Nuclear Power Plant Accident*, ICRP ref: 4847-5603-4313, 21 March 2011.
31. The term "evacuation standard" used here should not be confused with the standard used for the initial evacuation. The standard for initial evacuation, specified in Nuclear Safety Commission of *Japan's Regulatory Guide: Emergency Preparedness for Nuclear Facilities*, is a projected external dose of 50 mSv. However, it was soon realized that elevated radiation levels would continue for an extended period of time in Fukushima Prefecture, so a stricter longer-term standard was called for.
32. International Commission on Radiological Protection, *Application of the Commission's Recommendations to the Protection of People Living in Long-term Contaminated Areas after a Nuclear Accident or a Radiation Emergency*, ICRP Publication 111, October 2008, p.30.
33. Yuka Hayashi *op. cit.* "Specifically, Mr. Kosako said the government set a relatively high ceiling for acceptable radiation in school yards, so that only 17 schools exceeded that limit. If the government had set the lower ceiling he had advocated, thousands of schools would have required a full cleanup."
34. Physicians for Social Responsibility, Statement on the Increase of Allowable Dose of Ionizing Radiation to Children in Fukushima Prefecture, 29 April 2011, at http://www.psr.org/assets/pdfs/psr-statement-on-fukushima-children.pdf.
35. Nuclear Emergency Response Headquarters, *op. cit.*, Chapter VII, p. 5.
36. Ministry of Health, Labour and Welfare, *Handling of food contaminated by radioactivity (Relating to the accident at the Fukushima Nuclear Power Plant)*, and *Notice No. 0317 Article 3 of the Department of Food Safety*, 17 March 2011.
37. Ministry of Health, Labour and Welfare, *Notice No. 1-0405 of the Department of Food Safety*, 5 April 2011 (updates *Notice No. 0317 Article 3 of the Department of Food Safety*, 17 March 2011 – see reference 27 above).
38. Nuclear Safety Commission of Japan, *Regulatory Guide: Emergency Preparedness for Nuclear Facilities, 1980* (last updated August 2010). (Some people have translated the title of this document as *Disaster Prevention Measures for Nuclear Power Facilities*.)
39. Emergency Petition to Protect the Children of Fukushima Petition, launched on 1 July and addressed to the following people: Naoto KAN, Director-General of Nuclear Emergency Response Headquarters ; Yuhei SATO, Governor, Fukushima Prefecture ; Yoshiaki TAKAGI, Minister of Education, Culture, Sports, Science and Technology; and Ritsuo HOSOKAWA, Minister of Health, Labour and Welfare. http://fukushima.greenaction-japan.com/2011/07/01/petition-02-protect-the-children-of-fukushima/#more-76.
40. Yuka Hayashi *op. cit.* (quote from Toshiso Kosako, ex radiation safety advisor to Prime Minster Kan) "Come the harvest season in the fall, there will be a chaos," Mr. Kosako said. "Among the rice harvested, there will certainly be some radiation contamination—though I don't know at what levels—setting off a scandal. If people stop buying rice from Tohoku ... we'll have a tricky problem."
41. Institute for Radiological Protection and Nuclear Safety *op. cit.*, p. 5.
42. Tomoya Yamauchi, *Radioactive Contamination Survey Results Report: the level of radioactive contamination in Fukushima City – localized concentration of radioactive cesium*, 26 June 2011. (Japanese), at http://dl.dropbox.com/u/23151586/110705_fukushima_dojoosen_yamauchi_report.pdf.
43. Emergency Petition to Protect the Children of Fukushima Petition *op. cit.*
44. Tetsuji Imanaka, presentation to the Iitate-mura Radioactive Contamination Study Report Meeting, 4 June 2011 (Japanese only, translated by Philip White, author of this paper), at http://space.geocities.jp/iitate0311/0604.html. For a more detailed report in English, see the following: Tetsuji Imanaka, *Interim Report on Radiation Survey in Iitate Village area conducted on March 28th and 29th*, 4 April 2011, at http://www.rri.kyoto-u.ac.jp/NSRG/seminar/No110/Iitate-interim-report110404.pdf (Japanese version: http://www.rri.kyoto-u.ac.jp/NSRG/seminar/No110/iitatereport11-4-4.pdf).
45. Kyodo News, "Fukushima starts health checks", *The Japan Times*, 28 June 2011, at http://search.japantimes.co.jp/mail/nn20110628a2.html.
46. Reiji Yoshida, "Tepco report reveals lack of preparedness: New timeline details early days of crisis", *The Japan Times*, 20 June 2011, at http://search.japantimes.co.jp/mail/nn20110620a2.html. "According to Tepco, plant director Masao Yoshida ordered staff to prepare to lower the pressure in reactor No. 1 by venting steam from its containment vessel at 12:06 a.m. on March 12, more than eight hours after the 9.0-magnitude earthquake and tsunami knocked out power to the plant and triggered the crisis. But Tepco's records, released Saturday, show it did not have crisis-management manuals that detailed the procedure for manually opening the valves in the event of full power loss."
47. "TEPCO failed to report possible hydrogen explosion", Asahi Shimbun, 26 June 2011, at http://www.asahi.com/english/TKY201106250160.html.
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No escape from accidents

M.V. Ramana

In the aftermath of Fukushima and, twenty five years earlier, Chernobyl, it should be obvious that nuclear power is capable of catastrophic accidents whose effects could reach across space and time. Yet, many proponents of nuclear energy keep arguing that reactors can be operated safely without accidents. However, the key question is not whether it *can* be safe, but whether it *will* be safe—across countries, across many facilities operated by a variety of organizations with multiple priorities, including cost-cutting and profit-making, and using multiple technologies, each with its own vulnerabilities.

There are two ways of approaching this question. First, there is a history of small and large accidents at nuclear reactors. This history shows us that accidents occur in most, if not all, countries, involving various reactor designs, initiated by internal and external events, and with different patterns of progressions. Many of these accidents did not escalate purely by chance, often involving the intervention of human operators rather than any technical safety feature. Such interventions cannot be taken for granted and so it seems all but inevitable that nuclear reactors will experience accidents.

Second, at a deeper level, all nuclear power plants share some common structural features, though to different extents. The most influential work that explored these features was Charles Perrow's conceptualization of what happened at Three Mile Island in 1979 as a "normal accident" whose origins lay in the structural characteristics of the system.[1] Normal Accident Theory (NAT) identifies two characteristics, interactive complexity and tight coupling, that make nuclear reactors and similar technologies prone to catastrophic accidents. Interactive complexity pertains to the potential for hidden and unexpected interactions between different parts of the system, and tight coupling refers to the time dependency of the system and the presence of strictly prescribed steps and invariant sequences in operation that cannot be changed. According to Perrow, these are inherent features of nuclear reactors, and there is a limit to how far they can be reduced through engineering efforts.

How then is it that the nuclear industry claims that nuclear reactors are safe? Engineers and other technical experts rely primarily on the use of multiple protective systems, all of which would have to fail before a radioactive release could occur. This approach is known as "defense-in-depth," and it is often advertised as an assurance of nuclear safety.[2] However, as demonstrated at Fukushima, there are occasions when multiple safety systems *do* fail at the same time—and these occur far more frequently than technical analysts seem to assume.

Most people conceive of risk as multidimensional, encompassing several characteristics of the hazard—such as its catastrophic potential, its controllability, and its threat to future generations. Technical analysts, on the other hand, have a narrow conception of risk, viewing it as a mathematical product of the likelihood of an adverse occurrence, and the consequence of that occurrence. To quantify risks at complex systems such as nuclear power plants, analysts rely on a mathematical method known as probabilistic risk assessment (PRA). The probabilistic risk assessment method conceives of accidents as resulting from one of many combinations of a series of failures, and computes the probability of a severe accident resulting from these.

It is based on such risk assessments that the nuclear establishment makes claims about the frequency of severe accidents at various reactors. For example, the French nuclear company Areva asserts that with its EPR (formerly called European or Evolutionary Pressurized Reactor), now under construction in Europe and China, "the probability of an accident leading to core melt, already extremely small with the previous-generation reactors, becomes infinitesimal."[3] In its application to the United Kingdom's safety regulator, Areva estimates an average of one core-damage incident per reactor in 1.6 million years.[4] Likewise, Westinghouse claims that its AP1000 reactor offers "unequalled safety" in part because the company's probabilistic risk assessment calculated that the core melt frequency is roughly one incident per reactor in 2 million years.[5] Older reactors in the US are estimated to have higher frequencies; for example, the NRC calculated an average of about one incident in 10,000 years for the Peach Bottom reactor in Pennsylvania, which is a boiling water reactor with a Mark 1 containment like the reactors at Fukushima Dai-ichi.[6]

There are both empirical and theoretical reasons to doubt these numbers. A 2003 study on the future of nuclear power carried out by the Massachusetts Institute of Technology points out that "uncertainties in PRA methods and data bases make it prudent to keep actual historical risk experience in mind when making judgments about safety."[7] What does history tell us? Globally, there have been close to 15,000 reactor-years of experience, with well-known severe accidents at five commercial power reactors—three of them in Fukushima. However, depending on how core damage is defined, there are other accidents that should be included and the actuarial frequency of severe accidents may be as high as 1 in 1,400 reactor-years.[8] At that rate, we can

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expect an accident involving core damage every 1.4 years if nuclear power expands from today's 440 commercial power reactors to the 1,000-reactor scenario laid out in the MIT study. In either case, though, our experience is too limited to make any reliable predictions.

single event, the tsunami, resulted in a number of failures that set the stage for the accidents. These failures included the loss of offsite electrical power to the reactor complex, the loss of oil tanks and replacement fuel for diesel generators, the flooding of the electrical switchyard, and perhaps damage to the inlets that brought in cooling water from the ocean. As a result, even though there were multiple ways of removing heat from the core, all of them failed.

"The key question is not whether it *can* be safe, but whether it *will* be safe—across countries, across many facilities operated by a variety of organizations with multiple priorities, including cost-cutting and profit-making, and using multiple technologies, each with its own vulnerabilities."

Theoretically, the probabilistic risk assessment method suffers from a number of problems. Nancy Leveson of MIT and her collaborators have argued that the chain-of-event conception of accidents typically used for such risk assessments cannot account for the indirect, non-linear, and feedback relationships that characterize many accidents in complex systems.[9] These risk assessments do a poor job of modeling human actions and their impact on known, let alone unknown, failure modes. Also, as a 1978 Risk Assessment Review Group Report to the NRC pointed out, it is "conceptually impossible to be complete in a mathematical sense in the construction of event-trees and fault-trees....This inherent limitation means that any calculation using this methodology is always subject to revision and to doubt as to its completeness."[10]

Probabilistic risk assessment models do not account for unexpected failure modes during many accidents. At Japan's Kashiwazaki Kariwa reactors, for example, after the 2007 Chuetsu earthquake some radioactive materials escaped into the sea when ground subsidence pulled underground electric cables downward and created an opening in the reactor's basement wall. As a Tokyo Electric Power Co. official remarked then, "It was beyond our imagination that a space could be made in the hole on the outer wall for the electric cables."[11]

Yet when it comes to future safety, nuclear designers and operators always seem to assume that they know what is likely to happen. This is what allows them to assert that they have planned for all possible contingencies. Or, as the chairman of the Indian Atomic Energy Commission asserted in the aftermath of Fukushima, nuclear reactors [in India] are "one hundred percent" safe.[12]

If there is one weakness of the probabilistic risk assessment method that has been emphatically demonstrated at Fukushima, it is the difficulty of modeling common-cause or common-mode failures.[13] From most reports it seems clear that a

The probabilistic risk assessment method does try to incorporate common-cause failures, but this is not always satisfactory. For example, the probabilistic risk assessment for the EPR calculates the frequency of core damage following a total loss of offsite power to be one incident per reactor in 12 million years.[14] This low number is a result of assuming that failures other than offsite power loss occur essentially at random and independently of each other. But at Fukushima the same event that knocked out external power also caused the failure of other systems for cooling the core.

If probabilistic risk assessments were just esoteric exercises performed by nuclear engineers for internal consumption, there would not be much reason to be concerned with their lack of reliability except that it creates overconfidence among those designing and operating reactors. The problem is that the small numbers produced by this exercise, widely seen as involving complicated calculations, have the effect of what might be termed false or misplaced concreteness, especially on policy makers and the general public. This is pro-

photo: Daylife; Fukushima Nuclear Power Station foundly misleading and was most tragically revealed in the Chernobyl accident. Just three years earlier, B. A. Semenov, the head of the International Atomic Energy Agency's safety division, had written about the RBMK reactor design used at Chernobyl: "The design feature of having more than 1,000 individual primary circuits increases the safety of the reactor system—a serious loss-of-coolant accident is practically impossible".[15] The similarity between this assertion and claims about the safety of nuclear reactors currently being built is striking.

Fukushima also demonstrated one of the perverse impacts of using multiple systems to ensure greater levels of safety: redundancy can sometimes make things worse. At Fukushima, as with most reactors around the world, zirconium cladding surrounded and protected the fuel, preventing the escape of radioactive materials up till very high temperatures. But when the cooling systems stopped working, the zirconium cladding overheated. Hot zirconium interacted with water or steam, producing hydrogen gas. When this hydrogen came into contact with air in the containment building, it caused an explosion that reportedly damaged the suppression pool beneath the reactor, another protective system.[16] In other words, in complex systems such as nuclear reactors, redundancy may have unexpected and negative consequences for safety, as scholars including Charles Perrow and especially Scott Sagan have pointed out in the past.[17]

Such perverse consequences of relying on redundancy have been observed in a number of arenas. Perhaps the oldest recorded example was provided by Galileo, who observed that stone marble columns when laid down horizontally and supported by three instead of two piles of timbers or stones would break in the middle from cracks that develop on the top of the beam rather than in the bottom.[18] In the financial arena, a number of instruments introduced in order to reduce risk, credit default swaps, for example, ended up causing the catastrophic failure of the entire banking industry.[19] Two analysts of the chemical industry put it aptly: "no good deed goes unpunished" because "any change to a system, including adding a safety feature (a good deed), introduces new failure modes and mechanisms (punishment)."[20]

This characteristic of complex systems is one of the problems with the many well-meaning efforts to produce lists of recommendations to make nuclear facilities safer: these improvements are often intended as add-on measures to be stuck onto existing systems, and will likely lead to unanticipated failure modes that have not been protected against. This means that while the system may be classified as safer, because one particular failure mode has been protected against, it remains vulnerable to other failure modes, and is thus not safe, i.e., immune to accidents. Should that approach be acceptable for nuclear power, in which accidents can re-

sult in catastrophic consequences?

There is another error of understanding involved in producing these lists of recommendations—the idea that organizations that operate nuclear facilities or other high-hazard technologies would want to implement these in the first place. The problem is that for most organizations, “the mission is something other than safety, such as producing and selling products.... In addition, it is often the case that the non-safety goals are best achieved in ways that are not consistent with designing or operating for lowest risk.”[21] In the case of nuclear designers and operators, it could be to produce the most amount of nuclear electricity at the least possible cost, or to build many reactors rapidly so as to capture a large fraction of the electricity sector and achieve concomitant political power. This is yet another serious challenge to achieving accident-free operations at nuclear facilities.

In just about every country that has a significant nuclear sector, those organizations that build or operate nuclear reactors and other facilities wield significant political power. This power manifests itself in a variety of ways including weaker regulation, often made weaker through regulatory capture, and mechanisms allowing the externalization and socialization of costs while privatizing profits (for example, liability laws that cap the extent to which nuclear organizations have to pay for accident-related damage). Neither of these features is conducive to the improvement of safety. More broadly, one of the themes coming out in the wake of Fukushima is the history of TEPCO’s many ways of undermining safety at its plants and covering these up. TEPCO is unlikely to be unique in this respect; any nuclear utility that is subject to such careful investigation will likely demonstrate similar, though not identical, patterns of behavior.

For the reasons laid out here, the answer to the question we began with, i.e., will nuclear power be safe, has to negative. Catastrophic accidents are inevitable with nuclear power. While these may not be frequent in an absolute sense, there are good reasons to believe that they will be far more frequent than quantitative tools such as probabilistic risk assessments predict. Any discussion about the future of nuclear power ought to start with that realization.

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Nuclear weapons and nuclear power

Ray Acheson

The nuclear age began with the first test of a nuclear bomb by the United States in Alamogordo, New Mexico on 16 July 1945. It exploded onto the world stage with use of nuclear weapons by the United States against the cities of Hiroshima and Nagasaki in Japan on 6 and 9 August 1945 and has continued with the development, testing, and deployment of these weapons throughout the world. Today, nine countries are believed to have nuclear explosive devices: China, the Democratic People's Republic of Korea, France, India, Israel, Pakistan, Russia, the United Kingdom, and the United States.

But the nuclear age has never been just about weapons and war. It has also produced a dangerous and controversial source of energy. Nuclear weapons and nuclear power are inextricably linked historically, materially, and technologically.

In 1953, just a few years after the United States used two nuclear weapons against Japan, US President Eisenhower launched his Atoms for Peace programme at the United Nations "amid a wave of unbridled atomic optimism."[1] It resulted in the spread of nuclear technology and materials around the world for so-called "peaceful uses"—energy, medicinal uses, research. Along with the consequential devastation caused by radioactive byproducts from mining the raw material through to the waste produced by reactors, this spread of nuclear energy also resulted in the development of nuclear weapons in several countries, to the proliferation of nuclear materials and technology that are susceptible to terrorist attack, and to accidents that result in catastrophic damage, locally and globally.

Nuclear fuel chain

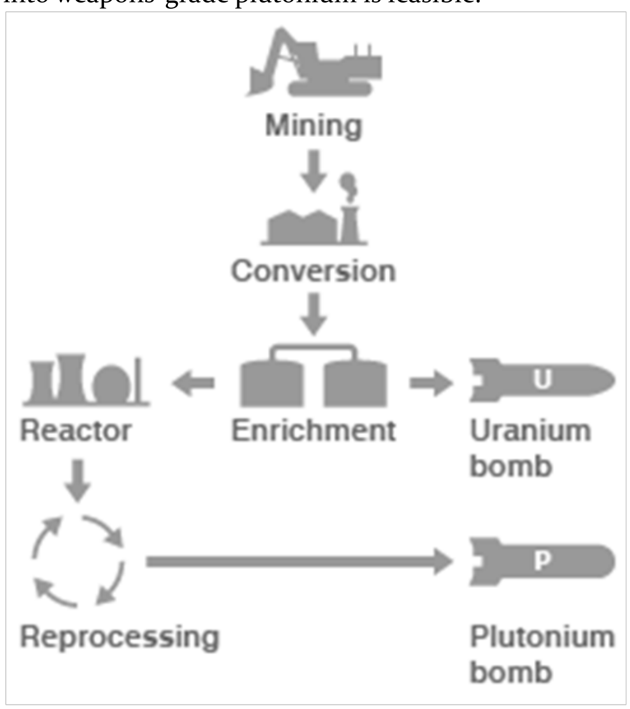
The first step in the process is uranium mining. Natural uranium consists of three radioactive isotopes: uranium-238, -235, and -234. When it is mined from the earth, uranium contains only about 0.7% uranium-235, which is the isotope necessary to create fissile material for power or weapons.

The next steps are milling and conversion. Mined uranium is milled by grinding the uranium ore to a uniform particle size and treating it to extract the uranium by chemical leaching. The milling process yields a dry power of natural uranium, called yellowcake. The milled uranium or yellowcake is then converted to uranium hexafluoride through a chemical process.

The next step is enrichment. The uranium hexafluoride needs to undergo an industrial process that concentrates the amount of U-235 to 3% to 5% for use as fuel in a nuclear reactor. If uranium is enriched to 20% U-235, it is called highly enriched uranium (HEU) and is suitable for use in nuclear weapons, though typically HEU is enriched to 90% for use in weapons. With some adjustment, "the very same facilities and equipment used to produce low-enriched uranium fuel for power reactors can produce high-enriched uranium suitable for use in a nuclear weapon."[2] Numerous technologies have been developed to enrich uranium, such as gaseous-diffusion, centrifuges, and electromagnetic separation. All of these technologies require a large initial investment and large amounts of energy to operate.

A further possible step is reprocessing, which consists of a chemical reaction that separates plutonium and uranium from fuel that has been irradiated in reactors. At this stage, the uranium is a by-product that can be recycled as fuel for reactors. The separated plutonium can be used in nuclear weapons. Scientists have repeatedly pointed out that "virtually any combination of plutonium isotopes can be used to make a nuclear weapon, using a design as simple as that of the Nagasaki bomb."[3]

Plutonium can also be converted into uranium-plutonium oxide fuel (called mixed oxide fuel, or MOX) for use in nuclear power reactors. The conversion of MOX into weapons-grade plutonium is feasible.



According the International Panel on Fissile Materials, as of 2010 the global stockpile of highly enriched uranium was about 1475 ± 125 metric tons, which is "enough for more than 60,000 simple, first generation fission weapons. About 98% of this material is held

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by the nuclear weapon states." Meanwhile, "the global stockpile of separated plutonium in 2010 was about 485 ± 10 [metric] tons. About half of this stockpile was produced for weapons, while the other half has mostly been produced in civilian programs in nuclear weapon states. There are more than 10 [metric] tons of plutonium in the non-weapon states, most of which is in Japan, the only non-weapon state with a large program to separate plutonium from spent nuclear fuel." It is believed that today, only India and Pakistan are producing HEU, while India, Israel, and Pakistan continue to produce separated plutonium.[4]

Inextricable link

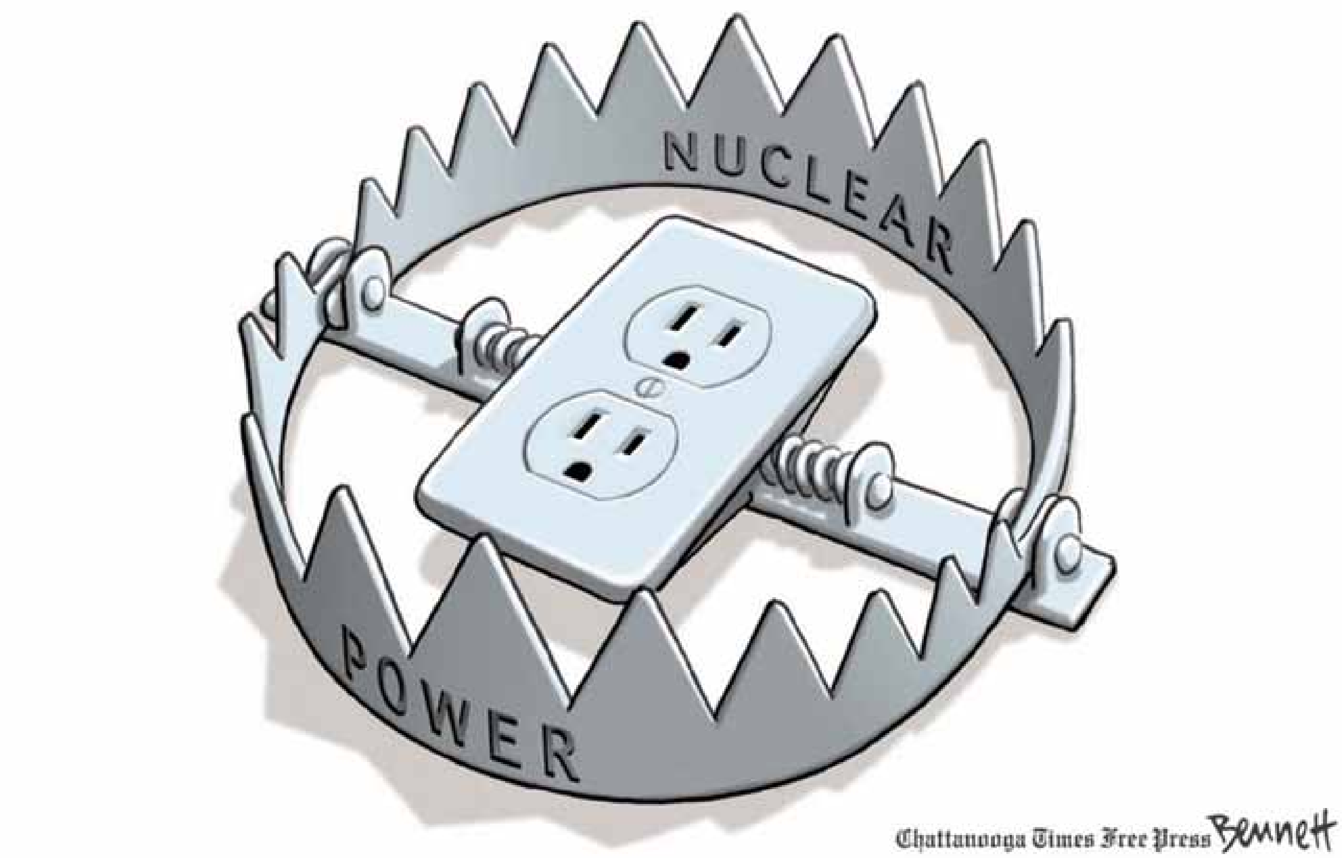
Because the materials and facilities for nuclear weapons and nuclear power are but variations of each other, the proliferation risks are high. While most governments operating nuclear reactors or enrichment processes have not used their facilities or materials to develop nuclear weapons, China, France, Israel, India, Pakistan, and the United Kingdom "built their nuclear weapons programs on an infrastructure developed supposedly for nuclear energy."[5]

Former-nuclear weapons designer Theodore B. Taylor has pointed out that a government that seeks to acquire technology and equipment for nuclear power "may have no intention to acquire nuclear weapons; but that government may be replaced by one that does, or may change its collective mind." At that point, he says, "A country that is actively pursuing nuclear power for peaceful purposes may also secretly develop nuclear explosives to the point where the last stages of assembly and military deployment could be carried out very quickly."[6]

Physicists Zia Mian and Alexander Glaser of Princeton University have explained that the difference in scale between civilian and military nuclear programmes means that a civilian nuclear reactor can often produce more highly enriched uranium or plutonium for weapons than a dedicated military reactor can:

> A 40 MW(th) reactor like CIRUS in India produces enough plutonium for about two nuclear weapons a year, while one of India's small, roughly 700MW(th) power reactors (which produces ca. 200 MW electric power) can yield about ten times that much plutonium a year. A similar case holds for uranium enrichment; about 150 tSWU (or 150,000 separative work units) are required to produce the annual low-enriched uranium fuel for a 1,000 MW(e) nuclear power reactor, while ten percent of this enrichment capacity could produce 100 kg of highly enriched uranium, enough for several nuclear weapons.[7]

While the International Atomic Energy Agency (IAEA) was established in part to ensure that nuclear materials for "peaceful uses" are not diverted to weapons use, the IAEA "has authority only to inspect designated (or in some cases suspected) nuclear facilities, not to interfere physically to prevent a government from breaking its agreements under the treaty if it so



chooses." Furthermore, as Taylor points out, "a major function of the IAEA is also to provide assistance to countries that wish to develop nuclear power and use it. Thus the IAEA simultaneously plays two possibly conflicting roles—one of encouraging latent proliferation and the other of discouraging active proliferation."[8]

Due to all of these factors, experts argue that "any effort to expand nuclear power around the world will inevitably lead to a further increase in large-scale and small-scale research and development (R&D) activities around the world," and that "a nuclear program that is small—or even completely irrelevant—from a commercial perspective is generally large enough to support a substantial nuclear weapons program."[9]

"Whatever its source, the harm to health of ionizing radiation is the same. The same chain reaction drives nuclear fission in reactors and bombs." – Tilman Ruff[10]

Double standards

Some governments are seeking stricter international controls over the spread of fuel cycle capabilities. This is why pressure has been brought to bear on countries such as Iran and Syria, which are suspected of developing nuclear power technology as a precursor to developing nuclear weapons. However, stricter controls over the fuel cycle in the current context is seen as a double standard by many developing countries and by those facing sanctions for developing aspects of the nuclear fuel chain.

In the first place, there has not been any progress by the nuclear weapon states to eliminate their nuclear weapons as required by article VI of the nuclear Non-Proliferation Treaty (NPT). At the same time, under the NPT, non-nuclear weapon states are given the "right" to develop nuclear capabilities for "peaceful" purposes. Non-nuclear weapon states that are party to the NPT do not want to accept stricter regulation of their development of nuclear energy while the nuclear weapons states are not compiling with their obligations on nuclear disarmament. Furthermore, some states parties to the NPT have also violated their obligations not to engage in nuclear trade with non-states parties, namely India. In 2008, the Nuclear Suppliers Group granted India an exemption under its no-trade rules, meaning that other countries have since been able to sell India nuclear fuel for its reactors even though this means it is able to use its own indigenously-produced fuel for its weapons.

While stricter controls over nuclear fuel chain technology and materials are necessary to mitigate the risks posed by their proliferation, it is difficult to negotiate such controls in a two-tiered system, where some states are allowed to have nuclear weapons and others are not, and where the rules are broken for some states but are applied beyond the letter of the law for others.

Conclusion

The continued existence of nuclear fuel cycle facilities, technology, and material makes it extremely difficult to envisage reaching a world free of nuclear weapons. Since 1945, many scientists, activists, and government officials have pointed out that nuclear material, technology, and facilities are dangerous whether they are in weapons form or for "peaceful uses".

"Whatever its source, the harm to health of ionizing radiation is the same. The same chain reaction drives nuclear fission in reactors and bombs," argued Tilman Ruff, co-chair of the International Campaign to Abolish Nuclear Weapons, at a 6 August 2011 commemoration of the atomic bombing of Hiroshima. "Releases of radioactivity similar to or larger than those from a nuclear bomb can come from nuclear reactors and spent fuel ponds."[10] Eliminating all nuclear materials and technology, whatever its designated purpose, is the only way to ensure that it is does not result in catastrophe, by accident or design.

Notes

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Poisoned pathways: the impacts of the nuclear fuel cycle on human health, culture, and the environment

Dave Sweeney and Dimity Hawkins

The nuclear crisis in Fukushima this year has put the nuclear industry into stark relief and comprehensively exposed the myth of the 'peaceful atom'. All stages of the nuclear chain have risks, all are complex and contaminating, and all can have adverse impacts on communities and the environment. At the end of each link in the nuclear chain there remains the problem of radioactive waste that will continue to be a direct human and environmental hazard well into the future.

In response to the Fukushima disaster and following a trip to mark April's 25th anniversary of the Chernobyl nuclear disaster, UN Secretary General Ban Ki-Moon announced a five-point strategy to improve nuclear security. As a strong supporter of nuclear disarmament, he urged the world to treat the issue of nuclear safety as seriously as we do the threat posed by nuclear weapons. Inspired by both the experience of Chernobyl's victims and the recent Fukushima disaster, the Secretary-General stated,

> As we are painfully learning once again, nuclear accidents respect no borders. They pose a direct threat to human health and the environment. They cause economic disruptions affecting everything from agricultural production to trade and global services.[1]

However it is more than accidents that pose problems for our collective security. From the first step, the journey along the nuclear chain is a shadowy and insecure one.

The nuclear journey begins with uranium mining...

While the impacts of uranium mining affect many communities, 70% of the world's uranium lies on Indigenous lands.[2] Therefore Indigenous people bear a disproportionate burden at this end of the nuclear chain. These impacts, which also adversely affect broader communities, can be wide ranging and include both environmental and cultural/social, as shown in Table 1.

Table 1: Uranium mining's adverse impacts

Environmental	Cultural/social
Depletion and/or contamination of ground or surface waters	Removal from traditional lands
Production of large volumes of long-lived radioactive mine tailings	Damage to sacred or significant sites and areas and belief systems
Vegetation clearance and dust generation	Impacts on traditional food sources and water
Disturbance and erosion of the natural environment	Constraints on cultural practice and restrictions on access to sites of significance and traditional lands
Chemical and fuel spills	Erosion of traditional decision-making and social structures
Use of scarce resources to conduct the mining	Community division over development decisions and monetary recompense
Production of large volumes of mine tailings—a long-lived radioactive waste legacy	Impacts of mine related social factors such as consumption of alcohol and other drugs, HIV/AIDS and other health and social impacts
Radiation exposure to workers, local communities, and the environment	
Acid mine drainage and costly, complex, and routinely unrealised rehabilitation needs	

Before mining, the radioactive elements in uranium are generally locked in an impervious rock cocoon, so little radioactivity reaches the open environment. Once these materials are mined, radioactive elements become far more bio-available and can readily escape into waterways and the atmosphere. Uranium is also chemically toxic at high concentrations and can cause damage to internal organs. Uranium has been linked with adverse impacts on reproduction, foetal development, and an increased risk of cancer and leukaemia.

Even after mining ceases, uranium tailings retain about 80% of the radioactivity of the original ore body. These tailings contain over a dozen radioactive materials that pose significant health hazards, including thorium-230, radium-226, and radon gas. These materials can emit radioactivity into the environment for tens of thousands of years. Global experience has shown that most areas exploited for uranium extraction remain contaminated in perpetuity with limited or no effective rehabilitation.

Processing, enrichment, and fabrication

Once mined, uranium is processed to facilitate its use in both the civil and military nuclear sectors. Despite persistent denial by the nuclear industry, these sectors have been and remain inextricably linked. The difference between these two sectors is more an issue of political will rather than technical capacity and remains more psychological than real. With over 20,000 nuclear weapons in the world today, the impacts of this link in

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the nuclear chain cast a huge shadow over humanity and our environment. It diverts precious human, technical, and financial resources into maintaining weapon stockpiles and generates a climate of fear that actively undermines global security. There are now nine identified nuclear weapon states, however, with another 44 holding nuclear power capacity, there is increasing recognition of the potential and risk of nuclear breakout.

The processes required for uranium conversion, enrichment, and fuel fabrication further contribute to environmental and social risks and contamination loads. These processes generate 'routine' emissions, occupational exposures, and liquid, gaseous, and solid radioactive wastes, the management of which remains contentious and unresolved.

"Radiation, by its very nature, is harmful to life. At low doses it can start off only partially understood chains of events which lead to cancer or genetic damage. At high doses, it can kill cells, damage organs and cause rapid death. Radiation doses have to reach a certain level to produce acute injury—but not to cause cancer or genetic damage. In theory, at least, just the smallest dose can be sufficient. So, no level of exposure to radiation can be described as safe." ***– United Nations Environment Program publication 'Radiation - doses, effects, risks,' December 1985***

Reactors

After processing the uranium is ready for use as fuel in nuclear reactors. Currently there are 440[3] reactors operating in the world and despite repeated claims of a 'nuclear renaissance', there is little factual data to support this. Following the Fukushima tragedy the international industry has come and will remain under increased public, governmental, and regulatory scrutiny. Several nations have committed to end, reduce, or defer reactor programmes. Germany's commitment in May to close its nuclear reactors within 11 years has provided a welcome sign of international leadership following the Fukushima emergency.

Reactor operations at the continuing facilities around the world are responsible for site-specific and regional public health and environmental impacts. These are exacerbated by the fact that many of the existing plants are aging facilities rapidly reaching the end of their approved operating life. Attempts to extend the operations of these facilities have led to increased concerns about their vulnerability.

Radiation, risks, and realities

Emissions, risks of accident and mishap, and the intractable problem of radioactive waste are some of the problems with 'routine' operations within the nuclear industry. Fukushima again highlights that even in facilities that enjoy regulatory approval and supervision in countries that have a high level of technological sophistication, economic capacity, and resources such as Japan, things can and do go wrong. Accidents, errors, natural disasters, and the potential of terrorism targeted at nuclear facilities are ever present and very real scenarios on any nuclear journey.

The events in Fukushima have shown the unpredictability, severity, and longevity of consequences when things in the nuclear industry do not go as expected. Such situations are increasingly likely in a world facing the unpredictable but very real consequences of a changing climate. The Fukushima situation arose initially from massive and unforeseen natural disasters, exacerbated by inadequate scenario modeling and human error in the crucial first days and weeks. However Fukushima is not alone in suffering from the capricious impacts of a changing environment. Already 2011 has seen a number of severe climate related events which have affected other nuclear facilities, including reactors being threatened or shut down in France because drought had reduced cooling water capacity[4] and an emergency shut down of two nuclear plants in Nebraska caused by extensive flooding of the Missouri River system.[5] Experts are raising concerns over the impact of increased storm and wave surges or activity along coastal areas, given many nuclear reactors are located in these zones.

A complicating factor in effective monitoring and documentation of the impacts of the nuclear fuel chain is the nature of the material. Radiation is unable to be smelt, tasted, or seen by exposed communities in any immediate or tangible way and the principle manifestations of radiation-related ill health often have considerable lag times. Therefore it is difficult in any emergency situation or even when subjected to 'routine' exposures to take effective self-managed precautions.

There is an increasing body of scientific and medical evidence highlighting the health risks to communities and workers from exposure to ionizing radiation, with many medical and scientific experts agreeing that there is no safe level of exposure to ionizing radiation. Radioactive contamination does not respect national boundaries and the carriage through air, water, and the food chain can have profound and adverse effects on human health. Exposure increases the risk of damage to tissues, cells, DNA, and other vital molecules. This can result in programmed cell death (apoptosis), genetic mutations, cancers, leukaemias, birth defects, and reproductive, immune, cardiovascular, and endocrine system disorders.

Several significant epidemiological studies have

photo: Dr. Gavin Mudd

been made about the impacts to children's health in proximity to nuclear reactors in European countries. Two such studies concluded in 2007 and 2008 showed startling evidence of childhood leukemias in children within 5km of German nuclear reactors over 20 years.[6] However, there remains a lack of comprehensive public information about these health risks.

While these studies are significant, there remain insufficient independent long-term medical and scientific studies into the impacts of the broader nuclear industry on health and the environment. Along with the 'spin' placed on the issues by those with vested interests and a lack of independence on the part of many inter/national regulatory agencies and mechanisms, the comprehensive monitoring of public and environmental safety is made more difficult.

...and at the end, radioactive waste

At the conclusion of all stages of the nuclear chain, we are left with both the intractable human and environmental menace and the profound management challenge that is radioactive waste. Radioactive waste is a long-lived and serious environmental hazard and its production should be minimised or halted. As a society we need to move from an unrealistic concept of 'disposal' towards a sense of stewardship and long-term isolation and management of existing radioactive waste.

Just as the nuclear fuel chain becomes increasingly complex the further down the road it travels, the wastes generated also get more complex. They become more concentrated, dangerous, and difficult to manage and isolate. A fundamental principle in dealing with dangerous industrial wastes is reduction at source. Instead of seeking to catch what comes out of the polluted pipe, it makes far more sense to turn off the toxic tap. Open and inclusive processes to develop an effective approach to radioactive waste management are urgently required. Such an approach would be based on the adoption of best international standards and practices, non-imposition of transport or storage of radioactive waste, and active waste minimisation.

Looking forward

Any serious strategy to examine and address nuclear safety will need focused attention to the human, environmental, and cultural impacts of all stages of the nuclear industry. All member states of the United Nations, whether they are users or suppliers in the nuclear chain, should actively undertake independent assessments of the environmental, cultural, and health implications of the sourcing of their uranium, as the very beginning of the chain. Such studies were given important recognition in a European Parliament resolution in 1998[7] and in the context of the latest nuclear tragedy at Fukushima the need for such assessment is stark.

Yvonne Margarula, the senior Traditional Owner of the Mirarr People in Australia's Northern Territory, whose concerns over uranium mining were at the heart of the European Parliament resolution, wrote a letter to the UN Secretary-General in April 2011 expressing the sorrow of her people for those in Japan affected by the Fukushima nuclear disaster. Imposed mining operations on Mirarr land currently produces around 10% of the world's mined uranium. Ms Margarula, who has won international recognition for her work to protect her country and culture from uranium mining, expressed the Mirarr's sadness that uranium from their lands may well have contributed to the Fukushima disaster. In her letter, she stated,

> I am writing to you to convey our solidarity and support with all those people across the world who see in the events at Fukushima a dire warning of the risks posed by the nuclear industry. This is an industry that we have never supported in the past and that we want no part of into the future. We are all diminished by the awful events now unfolding at Fukushima. I urge you to consider our viewpoint in your deliberations with governments in relation the Fukushima emergency and the nuclear industry in general.[8]

Conclusion

Seven decades into the nuclear experiment, it is increasingly clear that while the benefits promoted by the industry have not materialized, the extensive hazards created by the industry have. From uranium exploration to the permanent problem of radioactive waste management, the path promoted and pushed by the nuclear industry burdens, threatens, and degrades our shared human and natural environment.

The lived Indigenous experience of this reality is summed up powerfully by Yvonne Margarula's observation that the "promises never last, but the problems always do." Fukushima is a global reminder of the urgent need to move beyond the nuclear age and it is now time for the nuclear industry to stop producing problems and stop breaking promises.

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photo: Felicity Hill

Nuclear energy and climate change: limits and risks

Jürgen Scheffran

In the future, nuclear and climate risks may interfere with each other in a mutually enforcing way. Rather than being a direct cause of war, climate change significantly affects the delicate balance between social and environmental systems in a way that could undermine human security and societal stability with potentially grave consequences for international security[1] that could create more incentives for states to rely on military force, including nuclear weapons. A renewed nuclear arms race would consume considerable resources and undermine the conditions for tackling the problem of climate change in a cooperative manner. Nuclear war itself would severely destabilize human societies and the environment, not to speak of the possibility of a nuclear winter that would disrupt the atmosphere. Increased reliance on nuclear energy to reduce carbon emissions will contribute to the risks of nuclear proliferation. This article discusses the linkages between climate change and nuclear energy, including the limits of nuclear power in addressing the climate crisis and nuclear risks associated with a potential growth of nuclear power.

Nuclear power: no solution to the climate crisis

Nuclear power is often presented as a solution to the problem of climate change, which is caused by greenhouse gas emissions from fossil energy use and other sources. Nuclear energy has been proposed as a carbon-free technology with the potential for a safe, clean, and cheap supply of electric power that is able to mitigate climate change. Due to various problems this is unlikely to happen.[2]

1. Given the high economic costs of nuclear power, cheap nuclear electricity has remained a fiction. Although nuclear power has been heavily subsidized by governments and external costs have not been internalised into its market price, nuclear energy is not commercially competitive compared to advanced renewable energies that receive similar financial support. In a comprehensive environmental and economic assessment, including external costs from waste disposal, uranium mining, fuel processing, and radioactive emissions during normal operations, most renewable energy sources look better than nuclear energy.

2. Because of the long planning cycles and its inadequacy for use in combustion and as transportation fuel, nuclear energy cannot replace in a reasonable timeframe the large amounts of fossil fuel currently consumed. Since uranium resources are limited, a sustainable energy supply based on nuclear energy cannot be realized with a once¬-through cycle that avoids plutonium reprocessing. Even a drastic increase in nuclear energy could not compensate for the current growth in energy consumption; it would come too late for preventing climate change and lead to an enormous increase in plutonium stocks.

3. Due to the expected shut-downs of aging power plants, it will already be challenging to replace these plants, not to mention multiplying their capacity. In its low-use reference scenario for the nuclear power outlook, the International Atomic Energy Agency predicts that the installed capacity of nuclear power will remain nearly constant by the year 2030. In its high-use scenario, almost a doubling of nuclear power capacity is projected. In either case, the share of nuclear power in total energy generation and the CO_2 reduction will remain only a few percent. This net effect would easily be negated by the energy growth in the global South. What is actually required is a reduction of CO_2 emissions by at least 50 percent by 2050. Even without a massive expansion of nuclear energy, uranium resources will be consumed within the next five decades.

4.Nuclear power is not carbon-free if the whole life-cycle of electricity production is taken into consideration. According to the GEMIS (Global Emission Model for Integrated Systems) database of the German Öko-Institut, a 1 GWe nuclear power reactor plant in Germany causes indirect emissions of 200,000 tonnes of CO_2 per year, which is comparable to hydropower, lower than photovoltaic, and higher than for wind or improved efficiency of electricity generation and use.[3] Thus, nuclear power is not an effective means to mitigate climate change and there are alternatives that avoid its negative side effects.

Risks of the nuclear complex

The nuclear "fuel cycle" (which is more a chain or a spiral than a closed cycle) contains a variety of problems and risks.[4]

1. Radioactive materials are released and accumulated at each stage of the chain, including uranium mining and fuel rod production, reactor operation and reprocessing, and transport and disposal. Even under

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normal operations, it is difficult to avoid radioactive materials from being released into the environment, not to speak of the dangers of repeated errors and accidents throughout the process. These radioactive emissions present a conflict potential with international dimensions. An increasing number of countries acquiring nuclear power as part of a "nuclear renaissance" would multiply the nuclear safety, health, and proliferation risks.

2. As several natural disasters in recent years have demonstrated, extreme weather events, environmental degradation, and major seismic events can directly cause dangers for nuclear safety and security. The wildfires that spread through Russia in the summer of 2010 posed a severe risk to the country when they were on their way to engulf key nuclear sites. In addition, there was widespread concern that radionuclides from land contaminated by the 1986 Chernobyl nuclear disaster could rise together with combustion particles, resulting in a new pollution zone. Luckily, the authorities managed to contain the fires in time. Another example is the earthquake that hit Chile in February 2010. As was later revealed, at the time of the quake, a team dispatched by the US National Nuclear Security Administration (NNSA) was on a top-secret mission in Chile to gather up dangerous nuclear stock. Only twelve hours before the earthquake, the NNSA engineers had secured the irradiated uranium by fitting protective impact limiters on it and placing it in an airtight cask. Thus, the release of radioactive substances was luckily averted.[5]

photo: Southern Energy Network

3. Japan was less fortunate when a 9.0-magnitude earthquake and subsequent tsunami hit the country on 11 March 2011 and caused major damage to the Fukushima Dai-ichi Nuclear Power Station, disabling the reactor cooling systems and triggering a widespread evacuation surrounding the plant. Neither the electric power company TEPCO nor the government were able to control the crisis and avoid serious radioactive contamination of the population. Worryingly, the Fukushima nuclear power plant is not the only facility located in a natural disaster-prone area. Research conducted by the International Atomic Energy Agency reveals that 20 percent of the world's 442 working nuclear power stations are in areas of "significant" seismic activity. These events confirm what many intuitively already feel: in this seismically active world, characterized by an increasingly unpredictable environment, nuclear facilities, weapons and materials represent a highly volatile variable in an already unstable equation.[6]

4. Nuclear power is also inextricably linked to nuclear weapons development, which means that the linkages between civilian and military nuclear technologies and programmes contain potentially high security risks[7] (see the chapter on nuclear weapons and nuclear power).

5. The long-term risks of nuclear energy become obvious at the end of the nuclear fuel chain. Nuclear waste disposal (whether from nuclear power production, nuclear weapons programmes, or nuclear disarmament) will remain a problem over thousands of years, and many future generations will have to bear this load without having the short-¬term "benefit" of the current generation. To decay half of the amount of plutonium¬ 239, which is the primary fissile isotope used for the production of nuclear weapons, it takes around 24000 years or 1000 human generations, much longer than the known history of homo sapiens. After decades of nuclear energy production, the pile of nuclear waste is still growing, even though worldwide not a single site for final disposal of spent fuels is operating and temporary storage is continuously being extended. It is uncertain whether and when a responsible solution to the long-¬term disposal of radioactive waste can be found.[8]

6. All the solution concepts on the table are burdened with problems: dropping the nuclear waste into the deep ocean, storing it in the ice of Antarctica, launching it into outer space, injecting liquid waste under ground¬water bearing layers and different variants of underground storage have all been taken into consideration. In the 1970s the concept of "safe" disposal in deep geological formations was explored. This would provide long-term isolation and containment without any future maintenance. While many governments and international organizations prefer this approach, others want to keep the waste in a retrievable and controlled form, combined with long-¬term surveillance. In any case, it is highly uncertain whether the evidence for a final repository can ever be proven to sufficiently guarantee long-term safety and security.

Nuclear waste disposal is an end-of-the-pipe approach, similar to climate engineering that is offered as a solution for reducing dangerous climate change by deliberately modifying the Earth System. Suggested measures include carbon capture and sequestration in biomass, soil, underground, or in the ocean; aerosol emissions to absorb sunlight in higher layers of the atmosphere (similar to volcano eruptions); and other means of changing the Earth's radiation balance by reflecting sunlight, e.g. through large mirrors in outer space. To varying degrees, these measures have unknown costs and risks. Moving from involuntarily changing the atmosphere through emissions to the intentional manipulation of the climate system and the regulation of global temperature (like in a "global air conditioning system") opens a Pandora's Box of competing actions between countries. If these developments are not avoided or controlled, climate engineering measures could turn into security risks or trigger conflicts for current and future generations. What appears to be a remote possibility may turn into a real danger if the climate intervention techniques by one state severely affect the interests of other states.

Towards integrated solutions

Given the safety and security risks of nuclear power and its limited ability and economic viability in addressing global warming, replacing fossil fuels with nuclear fuels is not a viable alternative. The massive "nuclear renaissance" required for a significant impact would be highly unlikely to take place for economic and security reasons. At the moment, the trend is going in the opposite direction. The numerous problems associated with nuclear power explain the apparent slowdown of or withdrawal from nuclear power in industrialized countries and their diminished interest in a further build-up. The investment risk has further increased due to nuclear accidents, protests against nuclear energy and the higher requirements of governmental licensing procedures (especially in the US and Germany).

Rather than burying or correcting the consequences of nuclear and fossil energies through nuclear waste disposal and climate engineering, it is more appropriate to avoid the problems in the first place. To this end, it is essential to establish a nuclear-free, carbon-free, and sustainable energy system.[9] Because of the adverse linkages between nuclear and climate risks, it is time to develop a new thinking that synergizes solutions in both nuclear security and climate policy with an integrated framework of sustainable peace.

Finding solutions to one problem area could help to find solutions in the other. Preventing the dangers of climate change and nuclear war requires an integrated set of strategies that address the causes as well as the impacts on the natural and social environment. Institutions are needed to strengthen common, ecological, and human security, build and reinforce conflict-resolution mechanisms and low-carbon energy alternatives, and create sustainable lifecycles that respect the capabilities of the living world.

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A sustainable planet: shifting the energy paradigm

Alice Slater

We are at a critical moment in history. Accelerating weather catastrophes—tsunamis, hurricanes, drought, the melting of the polar ice caps—underline the urgency of heeding the scientific consensus that we are endangering our very survival on the planet with the continued use of carbon based fuels. Dependency on fossil fuels creates political and economic instability across the globe. Depleting resources and price volatility place growing strains on energy security concerns. Moreover, the tragic catastrophe at Fukishima is a wake-up call to the world that relying on nuclear power, despite the recent commercial drive for a "nuclear renaissance," would be a foolhardy solution to climate change, apart from nuclear power's economic and strategic disadvantages as a replacement source for clean, safe, renewable energy.

We read increasingly disturbing reports of food riots in dozens of poor countries around the planet,[1] caused by food shortages due to drastic changing weather conditions and tragic efforts to grow food crops for fuel.

We are pitting car owners of the world against the two billion poor on our planet who struggle to get enough to eat, without even offering any benefits to the environment, since, for example, growing corn to make ethanol uses huge quantities of fuel, fertilizer, pesticides, and water, and degrades the soil.[2] The push for biofuels is driven by massive industrial agricultural corporations, seeking ever larger profits, as they misrepresent the actual costs. In league with the fossil and nuclear fuel industries, with their huge public relations operations, these dirty energy corporations are grinding out false facts and promoting a fake narrative in expensive advertising campaigns. They seek to undermine the possibilities for harnessing abundant free energy from the sun, wind, tides, and geothermal, essentially because they would be unable to control its production and make profits from its sale. Who can sell the sun, wind, tides?

Every 30 minutes, enough of the sun's energy reaches the earth's surface to meet global energy demand for an entire year. Wind can satisfy the world's electricity needs 40 times over and meet all global energy demands five times over. The geothermal energy stored in the top six miles of the earth's crust contains 50,000 times the energy of the world's known oil and gas resources. Tidal, wave, and small hydropower can also provide vast stores of energy everywhere on earth, abundant and free for every person on our planet, rich and poor alike. From water, broken down by solar or wind-powered electrolysis into hydrogen and oxygen, we can make and store hydrogen fuel in cells to be used when the sun doesn't shine and the wind doesn't blow. When hydrogen fuel is burned, it recombines with oxygen and produces water vapor, pure enough to drink, with no contamination added to the planet. Iceland plans to be completely sustainable by 2050, using hydrogen in its vehicles, trains, buses, and ships, made from geothermal and marine energy.[3]

New research and reports are affirming the possibilities for shifting the global energy paradigm. Scientific American reported a plan in 2009 to power 100% of the planet by 2050 with only solar, wind, and water renewables, calling for millions of wind turbines, water machines, and solar installations to accomplish that task. The authors, Mark Jacobson and Mark Delucchi, assert that "the scale is not an insurmountable hurdle; society has achieved massive transformations before," reminding us that "[d]uring World War II, the U.S retooled automobile factories to produce 300,000 aircraft and other countries produced 486,000 more." They also cited the example of the US Interstate Highway System, which after 35 years extended for 47,000 miles. Their scenario for 2050 contemplates, in part, building 3.8 million windmills to provide 51% of the world's energy demand which would take up less than 50 square kilometers (smaller than Manhattan). They reassure us that even though the number seems enormous, the world manufactures 73 million cars and lights trucks every year.

The authors review the national policies that would need to be in place to make the energy transition, such as taxes on fossil fuels, or at least the elimination of existing subsidies for fossil and nuclear energy to level the playing field, and an intelligently expanded grid to ensure rapid deployment of clean energy sources.[4]

In 2011 the World Wildlife Fund (WWF) also issued a report, 100% Renewable Energy, which outlined a scenario for relying on sustainable energy by 2050 that, unlike the Scientific American plan, included biofuels as renewable energy.[5] The WWF Director for Global Energy Policy, Stephan Singer, took issue with another report issued this year from the UN Intergovernmental Panel on Climate Change, which predicted that the world could meet 80% of its energy needs from renewables by 2050. Singer cited the WWF study that looked at a scenario for going to 100% renewables in that timeframe.[6]

Other hopeful plans for hastening the energy revolution have been burgeoning. The Institute for Energy and Environmental Research in its report, Carbon-Free and Nuclear-Free: A Roadmap for U.S. Energy Policy, lays out a series of steps and policies that would enable

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the United States to wean itself off fossil and nuclear fuel by 2050.[7] The City University of New York launched its solar map diagramming the solar capacity of all the rooftops in New York City, which, if installed, would meet over 40% of the city's peak electricity demand.[8] And under the East River, a stones' throw from the United Nations, six underwater turbines have been experimentally harnessing the tidal flow to deliver power to Roosevelt Island. A recent NY State Environmental Assessment reported that there were no adverse impacts from the turbines, paving the way for a benign tidal energy power plant to contribute to New York's energy supply.[9]

The Renewable Energy Policy Network for the 21st Century (REN), released their Renewables Global Status Report in July 2011. Despite countervailing factors like the continuing economic recession, incentive cuts for implementing sustainable energy measures, and low natural-gas prices, there was much encouraging news to report for 2010:

- Existing solar water and space heating capacity increased by 16%;
- Global solar photovoltaic (PV) production and markets doubled from 2009;
- Germany installed more PV than the entire world in 2009; PV markets in Japan and the US doubled;
- At least 119 countries had enacted renewable national policies, compared to 55 countries in 2005;
- Investment was $211 billion in renewables, compared to $160 billion in 2009, five times that in 2005;
- Investments in developing countries surpassed developed nations for the first time;
- Renewable capacity comprises one quarter of total global power generating capacity; and
- China led the world in wind, solar, and hydropower production, increasing 13% over 2009.[10]

In the wake of the Fukishima disaster, Germany, Italy, and other countries have pledged to give up their reliance on nuclear power, and are making plans to increase their reliance on renewable energy and energy efficiency, which, like renewables will contribute to our ability to wean ourselves from nuclear and fossil fuels. Better insulation, retrofitting leaky buildings, more conscious use of energy, using energy efficient appliances, can have a surprisingly large impact on our energy needs. Increased energy efficiency is a key factor in the numerous scenarios for shifting to a carbon-free and nuclear-free energy regime.

In July 2011, the International Renewal Energy Agency (IRENA), launched in 2009, had its inaugural meeting, having rapidly gained the required number of state ratifications.[11] By August 2011, 149 nations have signed the IRENA statute and 81 members have ratified it. Until now, the world had only the International Atomic Energy Agency to address issues of nuclear power, and the 28 member International Energy Agency, established during the 1973 oil crisis to address the disruptions of the global oil supply. IRENA's mission is to empower developing countries with the ability to access the free energy of the sun, wind, marine, and geothermal sources. It will train, educate, and disseminate information about implementing sustainable energy programs, organize and enable the transfer of science and know-how of renewable energy technologies, and generally be responsible for helping the world make the critical transition to a sustainable energy future. IRENA has done a pilot energy project in Tonga, and is working on capacity building for the Pacific Islands to develop their sustainable energy resources.[12] Since Irene is the Greek word for peace, this new institution is especially well named.

While it is inspiring to know of the many initiatives, both private and public, that have the capacity to reorder our energy economy in a safer new millennium, there are enormous forces we must overcome. We are at a time that the eco-philosopher Joanna Macy describes as "the great turning". In shifting the energy paradigm we would essentially be turning away from "the industrial growth society to a life-sustaining civilization," foregoing a failed economic model that " measures its performance in terms of ever-increasing corporate profits—in other words by how fast materials can be extracted from Earth and turned into consumer products, weapons, and waste."[13] Relying on the inexhaustible abundance of the sun, wind, tides, and heat of the earth for our energy needs, freely available to all, will diminish the competitive, industrial, consumer society that is threatening our planetary survival. By ending our dependence on the old structures, beginning with the compelling urgency to transform the way we meet our energy needs, we may finally be able to put an end to war as well.

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Nuclear power vs. renewable energy

Antony Froggatt and Mycle Schneider

The Cancun Summit in December 2010 agreed that "climate change is one of the greatest challenges of our time and that all Parties share a vision for long-term cooperative action."[1] For the first time under the UN framework, it

> further recognize[d] that deep cuts in global greenhouse gas emissions are required according to science, and as documented in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, with a view to reducing global greenhouse gas emissions so as to hold the increase in global average temperature below 2°C above pre-industrial levels.

To meet UN targets, emissions must be cut by about 80% by 2050 which will require an effectively decarbonised energy sector. At the same time, traditional energy forecasts anticipate rapid increases in energy demand driven primarily by the need to fuel the growing economies in Asia, particularly China and, to a lesser extent, India. The International Energy Agency (IEA) assumes that global energy demand will increase by 47% by 2035. Finally, the availability of suitable resources, and the associated impact on prices and physical availability for consumers is pressing, especially for liquid fuels.

In order to sufficiently reduce CO2 emissions from the energy sector and decrease the risk of energy insecurity there will need to be a massive shift away from fossil fuels as well as a fundamental change in the way in which energy is produced, transmitted, accounted, and used. However, as a result of the triple melt-down of reactors at the Fukushima nuclear power plant in Japan following the earthquake and tsunami, further reconsideration of the potential role of nuclear power within this energy transformation is taking place.

Status of nuclear power

As of 1 July 2011, there were 430 nuclear reactors operating in the world—fourteen fewer than in 2002. The International Atomic Energy Agency (IAEA) currently lists 65 reactors as "under construction" in 14 countries.

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By comparison, at the peak of the industry's growth phase in 1979, there were 233 reactors being built concurrently. In 2008, for the first time since the beginning of the nuclear age, no new unit was started up, while two were added in 2009, five in 2010, and three in the first six months of 2011.[2] During the same time period, 19 reactors were shut down. In the European Union, as of 1 July 2011, there were 134 reactors officially operational, down from a historical maximum of 177 units in 1989.

In 2010 nuclear power plants generated 2,767 terawatt-hours (TWh) of electricity, less than that of 2006, providing for about 13% of the world's electricity generation and 5.5% of the commercial primary energy. In 2010, 16 of the 30 countries operating nuclear power plants (one fewer than in previous years due to the closure of the last reactor in Lithuania) maintained their nuclear share in electricity generation, while nine decreased their share and five increased their share.[3]

The average age of the world's operating nuclear power plants is 26 years. Some nuclear utilities envisage reactor lifetimes of 40 years or more. Considering that the average age of the 130 units that already have been closed is about 22 years, the projected doubling of the operational lifetime appears rather optimistic. One obvious effect of the Fukushima disaster is that operating age will be looked at in a quite different manner.

While the impact of Fukushima on the nuclear industry cannot be fully determined, it is possible to see a few clear examples of where governments have changed their policies, in particular in Europe. The most clear is in Germany, where the government, under a previously pro-nuclear Chancellor Angela Merkel, immediately suspended the countries seven oldest reactors following Fukushima. Then in June agreement was reached within the government and subsequently approved by the Parliament that these reactors would not re-open and that all of the remaining reactors would be closed by 2022. In order to meet Germany's energy service needs and its climate change targets, its renewable energy plans were strengthened and an ambitious programme of energy efficiency introduced. Jürgen Becker, the deputy environment minister, stated, "Japan has shown that even if there is a miniscule occurrence, the residual risk is too high to justify the continuation of nuclear power.... It is better to go for other energy services in a civilized country"[4] (see the chapter on Germany for more information). In Italy, in mid-June 2011 a referendum was held on a number of issues including the reintroduction of nuclear power. Despite attempts by the government to boycott the plebiscite, 54% of the population voted—above the 50% threshold—and over 94% were against the reintroduction of nuclear power (see the chapter on Italy for more information). In Switzerland, the cabinet decided not to allow replacement of the existing reactors and if the policy is adopted by the parliament it would mean the cessation of nuclear electricity production in the mid 2030s.[5] In the EU as a whole, a 'stress test' on all nuclear facilities will be undertaken during 2011, while reviews on current and future programmes have been called for in a number of countries including China, India, and Russia.

In Japan, the government announced in May 2011 that it was necessary to entirely review its thinking on energy policy and abandoned its plans to build more nuclear reactors. Furthermore, it proposed that it would expand the use of renewable energy and address the way in which energy is used, to reduce energy consumption. Since then, Prime Minister Kan has stated that he would favour phasing out nuclear power altogether. In fact, of the pre-Fukushima 54 Japanese operating reactors, only 18 were operating as of 15 July 2011 and the fate of the stalled units remains uncertain (see the chapter on Japan for more information).

Prospects for nuclear new build

Prior to Fukushima many commentators were buoyant for the prospects for nuclear and highlighted that there are 65 reactors under construction, which is the highest number in many years. However, 40% of these are in one country, China, with only three other countries having what could be described as an active nuclear build programme (India, Russia, and South Korea). In the other ten countries, construction is limited to one or two reactors, and even then many of these are taking a long time, sometimes decades, to build. In the EU, of the four countries that have reactors officially under construction, Bulgaria and Slovakia have restarted construction on Russian-designed and part-built units at Belene and Mochovce respectively, while two European Pressurized Water Reactors (EPR) are being built in Finland and France.

Finland currently operates four units, which supply 28% of its electricity. In December 2003, it became the first western European country in 15 years to order a new nuclear reactor. Construction started in August 2005, with electricity generation expected in 2009. However, the project is about four years behind schedule and at least 90% over budget the loss for the provider being estimated at €2.7 billion. A similar problem of delays and cost over-runs is found at the French building site. As of July 2011, the Flamanville project was running four years behind schedule after three and a half years' construction, with costs admittedly over 80% or €2.7 billion over-budget.[6]

"The use of renewable energy has shown that it is a key set of technologies for reducing greenhouse gas emissions from the power sector."

Iran is the only country currently building nuclear power plants that does not already produce nuclear electricity. The country's nuclear programme has been hit by numerous delays, and when the Bushehr reactor went critical on 8 May 2011 it marked the end of a 36-year construction programme.

Status of renewable energy

Annual renewable energy capacity additions have been outpacing nuclear start-ups for 15 years. For example, in the United States the share of renewables in new capacity additions skyrocketed from 2% in 2004 to 55% in 2009, with no new nuclear reactors coming on line. As a result, electricity from renewable sources exceeded that of nuclear for the first time in the first quarter of 2011. In 2009 in Europe, €13 billion of wind investment was made, which led to wind power plants accounting for 39% of new power production installations—the second year running that more wind power was installed than any other generating technology. Furthermore, renewable power installations in general accounted for 61% of new EU grid connections in 2009. In 2010 there was a slight slowdown in the rate of increase of wind power as a delayed consequence of the economic crisis, but there was a massive increase in solar PV installations and also a very large (28 GW[7]) level of investment in new gas facilities.

Globally in 2010, for the first time, worldwide cumulated installed capacity of wind turbines (193 GW), biomass and waste-to-energy plants (65 GW), small hydro (80 GW, excluding large hydro), and solar power (43 GW) reached 381 GW, outpacing the installed nuclear capacity of 375 GW prior to the Fukushima disaster. Total investment in renewable energy technologies has been estimated at US$243 billion in 2010, a 30% increase over the previous year. What was remarkable in this year was the increase in investment in small-scale, distributed generation projects that really took off in 2010, surging by 91% to $59.6 billion.[8]

While it is clear that some countries are more successful than others in their renewable energy deployment, there is a global attempt to increase the use of the technology, with policy targets for renewable energy existing in at least 73 countries. Importantly, many developing countries are at the forefront of the manufacturing and use of renewable energy. China already leads the world in the use of solar thermal, is expected to become the largest manufacturer of wind turbines shortly and, in 2009 and 2010, was responsible for the largest increase in installed wind capacity. Furthermore, the use of renewable energy in Europe is expected to treble in the coming decade and significantly increase in most OECD countries.

The use of renewable energy has shown that it is a key set of technologies for reducing greenhouse gas emissions from the power sector. However, to date, its role for other sectors, in particular for transport and heat and cooling, has yet to be fully recognized and exploited.

Nuclear or Renewables?

Post-Fukushima public support for nuclear power fell significantly, with a global opinion poll undertaken by Ipsos-Mori showing a 16 point fall to just 38% of the population supporting the technology. While this fall is not that surprising, the survey did find some quite remarkable views. Firstly, that 95% of the people surveyed, across 24 countries, had seen, read, or heard of the damage to the Fukushima reactors. Secondly, that 69% of those citizens agree that "what happened at the nuclear plant in Japan demonstrates that all nuclear facilities are vulnerable to unforeseen events that could have a deadly impact on those who live in and around them. As a result we should stop all plans to build nuclear plants anywhere." Finally, that when asked to rate their support or opposition to various technologies, 97% supported solar power, 93% wind power, and hydro 91%.[9] These levels of support are important for governments, as they can help determine or guide the level and types of financial and regulatory support that they provide to different technologies.

Nuclear power has already been and continues to be the recipient of large government interventions. As one example notes, in their first 15 years, nuclear and wind technologies produced comparable amounts of energy in the United States (nuclear: 2.6 billion kWh; wind: 1.9 billion kWh), but the subsidies to nuclear outweighed that to wind by a factor of over 40 (US$39.4 billion to US$900 million).[10] Even today, with the demise of new orders for nuclear power reactors and the rise of other technologies, nuclear power continues to enjoy unparalleled access to government research and development funding.

Furthermore, it continues to receive large, indirect subsidies[11] through the lack of inclusion of environmental costs into the electricity prices, particularly through government guarantees for the final storage or disposal of radioactive waste. More direct financial assistance is made available through the limitations and government financial guarantees for third-party liability insurance, though export credit agency guarantees, production tax credits, or loan guarantees.

Even prior to Fukushima, global experience of nuclear construction shows a tendency of cost overruns and delays. The history of the world's two largest construction programmes, that of the United States and France, shows a five- and threefold increase in construction costs respectively. This cannot be put down to first-of-a-kind costs or teething problems, but systemic problems associated with such large, political, and complicated projects. Recent experience, in Olkiluoto in Finland and the Flamanville project in France, highlight the fact that this remains a problem. The increased costs and delays of nuclear reactor construction not only absorb greater and greater amounts of investment, but the delays increase the emissions from the sector.

photo: Adam Dempsy

It is important to note the differences in construction of a wind farm (and many other renewable energy schemes) compared to conventional power stations. The European Wind Energy Association likens building a wind farm to the purchase of a fleet of trucks: the turbines are bought at an agreed fixed cost and on an established delivery schedule, and the electrical infrastructure can be specified well in advance. Although some variable costs are associated with the civil works, these are very small compared to the overall project cost.[12] The construction time for onshore wind turbines is relatively quick, with smaller farms being completed in a few months, and most well within a year.

Are nuclear and renewable compatible?

From a systemic point of view there is a conflict between an electricity grid that is designed and operated with nuclear at its core to one that focuses on a combination of energy efficiency and renewables. This is becoming increasingly transparent in countries or regions where renewable energy is taking a large share of electricity generation, i.e. in Germany and Spain. The main reasons are as follows.

- *Competition for limited investment funds.* A euro, dollar, or yuan can only be spent once and it should be spent for the options that provide the largest emission reductions the fastest. Nuclear power is not only one of the most expensive but also the slowest option.

- *Overcapacity kills efficiency incentives.* Centralized, large, power-generation units tend to lead to structural overcapacities. Overcapacities leave no room for efficiency.
- *Flexible complementary capacity needed.* Increasing levels of renewable electricity sources will need flexible, medium-load complementary facilities and not inflexible, large, baseload power plants.
- *Future grids go both ways.* Smart metering, smart appliances and smart grids are on their way. The logic is an entirely redesigned system where the user gets also a generation and storage function. This is radically different from the top-down centralized approach.

For future planning purposes, in particular for developing countries, it is crucial that the contradictory systemic characteristics of the nuclear versus the energy efficiency and renewable energy strategies are clearly identified. There are numerous system effects that have so far been insufficiently documented or even understood. Future research and analysis in this area is urgently needed.

This is particularly important at the current time because the next decade will be vital in determining the sustainability, security and financial viability of the energy sector for at least a generation. Three key policy drivers and considerations have come together that must transform the way in which energy services are provided and energy carriers (electricity, hydrogen) and fuels are generated, transported, and used. These are:

- the growing awareness of the need for action to reduce the threats of dangerous climate change and the realization of the important contribution of the energy sector;
- increased and expected further increases in global competition for traditional energy resources, with this increased demand not being matched by new discoveries of larger resource reserves; and
- a need for accelerated investment in the energy sector, in OECD countries, as a result of the obsolescence of existing infrastructure, and in developing countries as a result of accelerated urbanization and demand for different and amplified energy.

It is crucial, however, to realize that renewable energy policies will not achieve the indispensable emission reduction results without a massive effort in energy efficiency throughout all energy systems. Confidence in the longevity and effectiveness of government policies are vital if private finance is to be attracted to the energy efficiency and renewable energy sector. "Investment grade"[13] renewable energy policies must remain in place and be extended into the long term. Ideally, these policies and targets should spell out the opportunities and objectives for each renewable energy sector, reflecting the status of the market and each technology, to ensure that adequate, but not excessive, support is made available. However, the relatively low contribution of non-hydro renewable energy to the global electricity supply demonstrates both the potential market that exists and the scale of investment that will be needed on the short- and long term. Therefore long-term, clear signals must be introduced that demonstrate the commitments by governments to this sector. Sending mixed signals with proposals to blend renewable energy targets with "low-carbon" objectives will create uncertainty and undoubtedly delay or halt investment.

Notes

1. UNFCCC 2010, "Outcome of the work of the Ad Hoc Working Group on long-term Cooperative Action under the Convention, Draft decision, CP 16, at http://unfccc.int/files/meetings/cop_16/application/pdf/cop16_lca.pdf.
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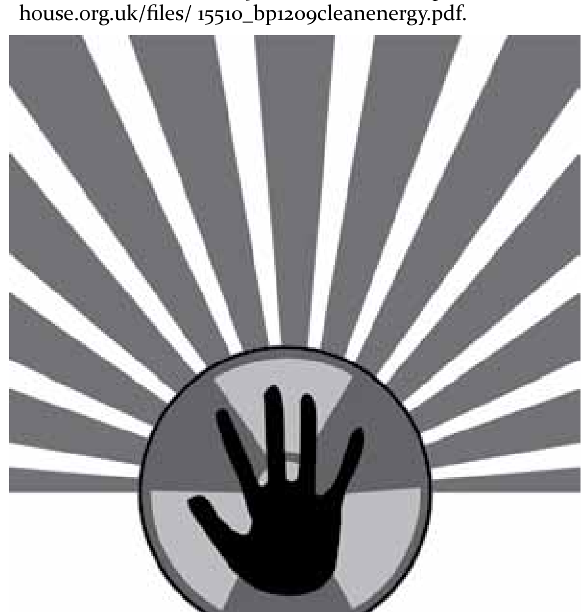

art: Dimty Hawkins

Australia

Felicity Hill

In promoting nuclear disarmament while utilising the US nuclear umbrella and in rejecting nuclear power while exporting uranium, Australia's nuclear policies are deeply contradictory.

Despite Australian uranium fuelling nuclear programmes overseas, all major Australian political parties either hold reservations or reject the nuclear option for electricity generation at home. Australia has only one small reactor for research and medical and industrial isotope production. Located in Sydney, this facility has been the subject of four separate inquiries within the last 12 months into a series of accidents, incidents, and occupational health and safety standard breaches.[1]

Since 2007 the Australian government has sought to rapidly expand uranium mining and export, however the uranium market has been hard hit since the Fukushima disaster. The uranium spot price has gone from AUD$70 to around $50 dollars. One company presenting to the August 2011 Australia Uranium Conference held in Western Australia reported that its share prices have fallen from $22 to $4; another company held shares worth $1.20 on 11 March that fell to 70 cents three days later and were at 31 cents in August.

The Australian government has sought to emphasise nuclear safety issues in the wake of Fukushima, however, Australian uranium mines have a very poor environmental track record that is detailed below.

Despite championing nuclear disarmament at the international level, Australia continues to maintain a domestic defence policy that uses and values US nuclear weapons through the US nuclear umbrella arrangement that was reaffirmed in the 2009 Defence White Paper.[2]

Australia does not host US nuclear weapons permanently on its territory, unlike the six European countries under NATO "nuclear sharing" arrangements, however for decades Australia has accepted a "neither confirm nor deny" policy about the presence of nuclear weapons on US warships visiting its harbours. The several dozen US installations and spy facilities in Australia are integral to the US nuclear war fighting apparatus in terms of satellite communications, intelligence gathering, planning, and training for the use of nuclear weapons.

International nuclear disarmament advocacy is always worthwhile, however, messages are mixed and certainly less credible when domestic policy lends weight, credence, and operational support to the deeply flawed idea that nuclear weapons bring security.

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Australia has around 40% of the world's uranium reserves and supplies around 20% of the global market by exporting approximately 10,000 tonnes a year

Australia sells uranium to nuclear weapon states—China, France, Russia, the United Kingdom, and the United States—for which safeguards assurances are extremely limited due to the purely voluntary safeguards arrangements nuclear weapon states have with the International Atomic Energy Agency (IAEA). Australia also sells uranium to 11 other countries: Japan, Taiwan, South Korea, Canada, South Africa, Belgium, Finland, Germany, Spain and Sweden. There is now an active policy debate in Australia over moves to sell uranium to India despite it not being a signatory to the nuclear Non-Proliferation Treaty.

As Australian uranium is sold to Japanese nuclear utilities, including the Tokyo Electric Power Company (TEPCO), it is likely that it is Australian uranium is among the fissile material irradiating people in Japan and contaminating the environment. Yvonne Margarula, the Mirarr Aboriginal Traditional Owner of the lands on which Rio Tinto's Ranger uranium mine operates in Kakadu National Park, expressed a sense of responsibility in her March 2011 letter to UN Secretary General Ban Ki Moon, expressing profound sadness that radiation problems at Fukushima were possibly fuelled by uranium derived from her traditional lands (see Annex 1). Many share her regret that Australia exports radioactive poison.

Uranium mining is controversial in Australia and has been strongly contested on environmental, social, cultural, and proliferation grounds.

A 2003 Senate Inquiry into the regulation of uranium mining in Australia reported "a pattern of under-performance and non-compliance," identified "many gaps in knowledge and found an absence of reliable data on which to measure the extent of contamination or its impact on the environment," and concluded that changes were necessary "in order to protect the environment and its inhabitants from serious or irreversible damage." Australian taxpayers continue to fund the clean-up of a mine that closed 40 years ago called Rum Jungle. The 2010 budget saw $7 million allocated over four years just to determine how to deal with the defunct uranium mine's toxic legacy—rehabilitation costs will be much higher.

In addition, the uranium mining industry has a poor track record in its dealings with Aboriginal Traditional Owners. Aboriginal and environmental groups have formed the Australian Nuclear Free Alliance to co-ordinate efforts to end this pattern of "radioactive racism".

Australia has three operating, leaking, and polluting uranium mines

The Olympic Dam mine in South Australia is owned by BHP Billiton and located in the driest state on the driest continent on earth. Licenced to use 42 million litres of water per day, the mine uses 33 million litres for which BHP, recently boasting over $A20 billion in profits at a time of global recession, pays nothing.

The State government has granted BHP Billiton legal exemptions from key environmental and Aboriginal heritage protections including the Aboriginal Heritage Act 1988, the Environmental Protection Act 1993, the Freedom of Information Act 1991, the Natural Resources Act 2004 (including water management issues), the Development Act 1993, and the Mining Act 1971.

On 10 March 2006 The Australian newspaper reported on documents obtained under Freedom of Information legislation. The documents, written by scientific consultants to BHP, state that the mine needs urgent improvements in radioactive waste management and monitoring. They call on government regulators to "encourage" changes to the tailings management, noting that radioactive slurry was deposited "partially off" a lined area of a storage pond, thereby contributing to greater seepage and rising ground water levels.

BHP plans to expand the mine to triple the output and to replace the current underground mining with a massive open-cut operation. If the expansion goes through it will create the biggest uranium mine in the world—a hole of 9 cubic kilometres—and will increase the rate of radioactive tailings production from nine million tonnes annually to 68 million tonnes.

The Ranger mine in the Northern Territory is owned by ERA - Energy Resources Australia (majority owned by Rio Tinto) and has seen over 200 leaks, spills, and license breaches since it opened in 1981. One incident that attracted widespread attention occurred in 2004, when 150 workers were exposed to drinking water containing uranium levels 400 times greater than the Australian safety standard. ERA was fined $A150,000—a rare example of a uranium mining company being prosecuted for breaching operating conditions.

Located within Australia's largest National Park, the World Heritage Site-listed Kakadu, ERA's Ranger mine has had ongoing problems with water management given the seasonal tropical rain experienced in Australia's north. In 2010 the mine released contaminated water with a uranium concentration about 5,400 times

photo: Australian Greens Senator Scott Ludlam; The first day of a 1000 km walk against uranium in Western Australia, 19 August–27 October 2011 the normal level into Kakadu National Park. In 2009 at an Australian Senate Committee hearing, the federal government appointed Office of the Supervising Scientist confirmed Ranger was leaking 100,000 litres of contaminated tailings liquid into the ground on a daily basis.

The mine was forced to shut in January 2011 due to inundation and was only opened again in mid-June 2011. When the mine is finally closed permanently, the company is required by law to safeguard its large volumes of radioactive mine tailings for "a period of not less than 10,000 years". Whilst clearly a challenge to realize and verify this is a positive standard that environmental advocates promote as a minimum for other uranium mines.

Yvonne Margarula, Mirarr Senior Traditional Owner of the Ranger area, wrote in a 2005 submission to an Australian parliamentary uranium inquiry:

> Along with other Aboriginal people the Mirarr opposed uranium mining when the Government approached us in the 1970s. The old people were worried about the damage mining would do to country and the problems that mining would bring for Aboriginal people. The Government would not listen and forced the Ranger uranium mine on us, but the old people were right and today we are dealing with everything they were worried about. Uranium mining has completely upturned our lives – bringing a town, many non-Aboriginal people, greater access to alcohol and many arguments between Aboriginal people, mostly about money. Uranium mining has also taken our country away from us and destroyed it – billabongs and creeks are gone forever, there are hills of poisonous rock and great holes in the ground with poisonous mud where there used to be nothing but bush. I do not like visiting the Ranger mine and seeing what has happened to my father's country. Although the uranium mining at Ranger is taking place on Mirarr country, overall we have not truly benefited from the mine. Mining and millions of dollars in royalties have not improved our quality of life.... None of the promises last but the problems always do.

The Beverley mine owned by Heathgate Resources (owned by US-based General Atomics) is located in South Australia and uses the polluting acid leach mining technique. Heathgate Resources effectively imposed the mine on the Adnyamathanha people in the late 1990s by negotiating with a small number of Native Title claimants but not recognising the will of the community as a whole. This divide-and-rule strategy, coupled with the joint might of industry and government, resulted in inadequate and selective consultation with the Adnyamathanha people.

Beverley is an acid in-situ leach (ISL) mine. ISL involves pumping acid into an aquifer, which dissolves the uranium ore and other heavy metals, and the solution is then pumped back to the surface. The small amount of uranium is separated at the surface. The liquid radioactive waste—containing radioactive particles, heavy metals and acid—is simply dumped in groundwater. From being inert and immobile in the ore body, the radionuclides and heavy metals are now bioavailable and mobile in the aquifer.

Heathgate has no plans or regulatory obligation to clean up the aquifer as it is claimed that the pollution will "attenuate" and that the aquifer will return to its pre- mining state over time. This claim has been recently queried by the scientific community as being highly speculative with no firm science behind it.

Another feature of ISL mining is surface contamination from spills and leaks of radioactive solutions. There have been over 20 spills at Beverley, such as the spill of 62,000 litres of contaminated water in January 2002 after a pipe burst, and the spill of 15,000 litres of contaminated water in May 2002.

A deposit north of Beverley (Beverley Four Mile) received government approval in December 2010 but commercial operations have not begun at the contested site.

photo: Felicity Hill

Australia's uranium exports are shrouded in secrecy

Examples include the refusal to release:

- Country-by-country information on the separation and stockpiling of the plutonium produced from Australian uranium;
- "Administrative arrangements," which contain vital information about safeguards arrangements;
- Information on nuclear accounting discrepancies including the volumes of nuclear materials unac-

counted for, countries involved and reasons given to explain discrepancies;

- The quantities of Australian uranium (and its by-products) in each country; and
- Some, if not all, export agreements allow for further secrecy under the rubric of "state secrets".

The uranium sector's claim that Australia's uranium exports are subject to the most stringent safeguards is not validated in practise. There are some useful clauses in the bilateral agreements—such as requirements for prior consent before reprocessing or enrichment beyond 20% uranium-235—but permission to reprocess spent fuel (thereby separating plutonium) has never once been denied even when it leads to plutonium stockpiling.

Workers in uranium mines

Over the years the permitted levels of radiation exposure for workers and the public have dropped dramatically as research, particularly from radiation biologists, indicates harmful effects still exist at much lower exposure levels. For workers the permitted dose was set at 500 millisieverts per year in 1934, 150 mSv in 1950, 50 mSv in 1956, and 20 mSv (averaged over five years) in 1991. The limit for members of the public is just 1 mSv.

The Australian National Radiation Dose Register was an election policy for the current government in the 2007 election and was announced as operational in 2011 and is a welcome and long overdue initiative. The system records the lifetime radiation dose of workers throughout their career in uranium mining and milling in Australia, enabling workers to access their own dose histories and notifying regulators when an individual has exceeded their annual dose limit. One major flaw is that the workers at the Ranger uranium mine are not included, which is a huge crack in the system.

Nuclear waste disposal

The current Australian Labor Party (ALP) government expressed outrage when then-Prime Minister John Howard rushed legislation through the Australian parliament that empowered the government to force Australia's nuclear waste on unwilling remote Aboriginal communities. At that time, the ALP called Howard's legislation "extreme, arrogant, heavy-handed, draconian, sorry, sordid, extraordinary and profoundly shameful," and promised to repeal it. However, with some minor changes, the ALP replicated the legislation and has targeted one particular location called Muckaty Station in the Northern Territory. The matter is strongly contested by local Traditional owners and key unresolved issues of ownership, consultation and consent are currently before the Federal Court. Nuclear-free advocates have called for a "process not postcard" approach for responsibly and scientifically dealing with such a long-lasting toxic legacy through an Independent Commission on the Long Term Safe Storage, Transport, and Management of Australia's Radioactive Waste.

Notes

1. The Independent Review into the current state of health and safety, reported 31 May; The Independent review of the Comcare report Investigation Number 4245; Federal Health Department Audit and Fraud Control Branch investigation into ARPANSA's investigations of incidents at ANSTO; Dr. Douglas Chapin's review initiated by the ANSTO Board and conducted out of the office of the ANSTO Director Mr. Patterson with a scope of work to cover current policies, programs, processes, procedures and practices in use at ANSTO's radiopharmaceutical production facility as well as examining typical work products.
2. Australian Defence White Paper, May 2009, at http://www.defence.gov.au/whitepaper/docs/defence_white_paper_2009.pdf. "It is the Government's judgment that stable nuclear deterrence will continue to be a feature of the international system for the foreseeable future, and in this context extended deterrence will continue to be viable."

photo: Felicity Hill; Australian Nuclear Free Alliance

Brazil

André Amaral and Cinthia Heanna

After initial international agreements with the USA and West Germany, Brazil sought to develop independent technology for its nuclear aspirations. In the 1980s, the country achieved the capacity to enrich uranium via ultracentrifugation through the efforts of the Naval Forces, raising proliferation concerns from experts worldwide.

Almost 30 years later, nuclear still remains a small portion of the national energy production. In spite of the country's abundant natural resources, expansion of nuclear technology is in the plans of the Brazilian government. It is considered to be part of the search for economic growth as a developing country and is linked with the government's desire to develop nuclear submarines, considered an essential part of the national defence strategy.

Origins of nuclear energy in Brazil

Brazil's first nuclear power plant, Angra I, started to be planned in 1968 in the city of Angra dos Reis, Rio de Janeiro, in close cooperation with the USA. From the 1972 Agreement for the Civilian Uses of Nuclear Energy, Brazil acquired a 627 MW pressurized water reactor from Westinghouse, and would receive the necessary enriched uranium in exchange for natural uranium up to a limit of 12,300 kg in 30 years. After the Brazilian refusal to sign the nuclear Non-Proliferation Treaty (NPT) and the oil crisis in 1973, the USA suspended the guarantees for the supply of enriched uranium for new reactors in the country, leading Brazil to seek a new partner and reawakening the country's desire to develop independent nuclear capacity.

It is believed that at that period only West Germany showed willingness to negotiate an agreement that included technology transfer, motivated by the desire to expand the German nuclear industry. The agreement between the two countries was concluded in 1975, through which a joint program was to be developed for the construction of eight 1,300 MW(e) reactors (PWR Biblis B type) over the period of 15 years. Two of those reactors (Angra II and III) were to be built mostly from components imported from Kraftwerk Union (KWU), and the rest of the plants "were to contain 90% Brazilian-made components".[1]

Financial, geological, and infrastructural problems affected the construction of Angra II, postponing the plans for Angra III and causing general delay in the implementation of the agreement. Only these two plants ever got into the initial stage of building, instead of the eight originally foreseen.

Dissatisfaction with the agreement, combined with a perceived inefficiency in the German jet nozzle technology, led to the instauration of a Parliamentary Investigation Commission (CPI)[2] in the Brazilian Senate in 1978.[3] The CPI's conclusion suggested that the nuclear programme should be divided in two: one, to fulfil all the terms of the commitments with Germany, and the other, "entirely independent, for the research and development activities".[4] That was the starting point for the parallel nuclear programme in Brazil. With the main goal of developing the know-how for uranium enrichment, in 1979 the National Commission for Nuclear Energy (CNEN) and the military institutes for technological research[5] were called upon to integrate the new programme.

With the secret assistance of China, which provided the necessary uranium enriched to 43% for the research reactors,[6] the Navy achieved the desired technology in the 1980s. The official declaration that the country had mastered the technology of uranium enrichment via ultracentrifugation came in 1987, by President Jose Sarney. At this occasion, the parallel program was taken out of the clandestinity and became publicly recognized as part of the official institutions of Brazil,[7] which was further consolidated with the incorporation of their activities into the newly formed Brazilian Nuclear Industries (INB) through Federal Act 2464/1988.

Composition of the Brazilian nuclear energy programme

map: IAEA; Brazilian Nuclear Installations

The reactor Angra I has a total capacity of 640 MW[8] and started commercial service in 1985, 15 years after it started being built.[9] Three years after its inauguration,

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it had been paralyzed 22 times due to problems with its components, generating public criticism. It was only in 1999 that the reactor generated profits for the first time by functioning during 96% of the year.[10]

Angra II initiated commercial operations in February 2001,[11] after a 25-year long construction process caused by difficulties in the edification, lack of infrastructure, and environmental concerns. It has a capacity of 1350 MW.[12]

According to official sources, the two power reactors represent 1.64% of the total Brazilian capacity.[13]

Table 2: Uranium Reserves in Brazil

Uranium Reserves in Brazil					
Occurrence	Confirmed and Measured			Presumed	Total
Deposits	<40US$/kg U	<80US$/kg U	Sub-Total	<80US$/kg U	
Caldas (MG)		500t	500t	4,000t	4,500t
Lagoa Real/ Caetité (BA)	24,200t	69,800t	94,000t	6,770t	100,770t
Santa Quitéria (CE)	42,000t	41,000t	83,000t	59,500t	142,500t
Others				61,600t	61,600t
Total	66,200t	111,300t	177,500t	131,870t	309,370t

Source : Industrias Nucleares do Brasil

Table 1: Electricity production in Brazil (Tw.h)

	Total	Thermal	Hydro	Nuclear
1970	45.46	5.6	36.86	
1980	139.49	10.58	128.91	
1990	222.82	14.06	206.71	2.06
2000	349.15	38.42	304.69	6.05
2001	359.4	38.72	306.33	14.35
2007	444.6	58.2	374	12.35
1970-1990 average annual growth rate (%)	8.27	4.71	8.58	
2000-2007 average annual growth rate (%)	3.91	7.35	3.25	14.88

Source: IAEA Country Profile: Brazil

Angra III, for which the reactor was purchased from KWU in 1976, is still today not concluded. Aside from the difficulties inherent to the location chosen to construct the power plant, funds allocated for its edification ended up being re-located in order to enable the completion of Angra II.[14] The official website of Eletronuclear, the subcompany of the Brazilian Energy Companies (Eletrobras) responsible for the construction and operation of nuclear power plants, states that 30% of the work has been concluded and estimates still 58 months until it is finalized.[15]

Uranium reserves and enrichment facilities

Brazil retains the world's 7th largest uranium reserves, with about 309,000 tons of uranium mainly concentrated in Bahia, Ceara, Paraná, and Minas Gerais. Until the present date, however, studies have only been conducted in 25% of the national territory,[16] which could indicate that other reserves remain undiscovered.

Some steps for the production of nuclear fuel still need to be done with foreign assistance. While yellowcake is produced in the country, the material must be sent abroad for gasification and enrichment. The Navy is working on a pilot project to develop gasification technology at the Aramar Unit, but those efforts, if they succeed, will initially only be used for the nuclear submarine project.[17]

The technology developed by the Navy to enrich uranium via ultracentrifugation is being used at the industrial fuel fabrication plant in Resende (RJ). While the first cascade was inaugurated in May 2006,[18] it is foreseen for the end of 2012 the completion of the 10 cascades needed to provide for Angra I and II, according to the Brazilian Nuclear Industries (INB).[19] While the Resende unit is an integral part of INB, uranium enrichment is conducted in cooperation with the Naval Forces.[20]

Public concerns about the nuclear programme

Criticisms are often expressed at the lack of transparency in nuclear policy-making in Brazil. Greenpeace and other non-governmental actors claim that there is lack of access to information on the nuclear programme, and that many accidents have taken place without public information.

In the summer of 2004, abundant rainfall in the region of the uranium mine of Caetité (northeast Brazil) led the retention pool to flood 7 times, causing leaks of uranium-238, thorium-232, and e radium-226 into the environment. Since 2008, several radioactive contaminations of water have been found in the mine's surroundings. Despite confirmation by the state government, federal officials have denied the incidents. NGOs have been alerting that until today there is no knowledge of the origins and extent of the contamination. In August 2011, the Ministry of Labour shut parts of Caetité down because of the exposure of workers to radiation and noted that the installations "are not efficient and allows radioactive material to escape to the external environment."[21]

One of the greatest concerns expressed by experts is that the nuclear regulator CNEN (National Nuclear Energy Commission) is the holder of INB and NUCLEP, the companies that provide fuel and components to Angra's reactors. In fact, INB and NUCLEP are part of the CNEN structure, thus generating criticism that there's a conflict in view of CNEN's commercial interests. CNEN, as the regulator, also has the authority to issue licenses to the operator of the power plants, Eletronuclear, and to its companies and research institutes, as well as analyze the impact of accidents occurring in all nuclear facilities. Since the 1970s, organizations, including the Brazilian Physics Society and the IAEA, have been arguing that CNEN should become a separate, independent body.

In 2007, the Brazilian Congress built an expert panel to investigate safety and fiscalization in the nuclear sector. Lack of transparency and fiscalization were the main topics exposed in the report released by the deputies, where the CNEN president recognizes that there are thousands of lost radioactive sources spread over the country.[22] One of those, the Goiânia accident with Cesium 137, has caused one of the biggest radiological accidents in the world and still today, 24 years after the tragedy, some victims were not recognized as such and did not received any compensation for the damages. Legislation was recommended to address these problems, but to date no concrete action resulted from this initiative.

The decision to move forward with the construction of Angra III has been a controversial issue both for the financial, as for the security implications of the project. Aside from questioning the convenience of the R$10 billion from the public budget that is still to be invested for the completion of the plant, experts point out that equipment for Angra III was purchased in the 1970s and that plans are still based on the technology available at that time, i.e. before the new security standards that followed the accident of Three Mile Island. Revision of the plans was requested by the Federal and State Attorneys, which also demanded CNEN and Eletronuclear to further present documents that detail the prevention and reduction of severe accidents. The lack of these studies, however, did not prevent Eletronuclear from receiving a construction license from CNEN.[23] Moreover, the legality and constitutionality of the construction has been contested, as there has been no Congressional approval and government decree to authorize the construction.

The future of nuclear energy in the post-Fukushima context

Press coverage on the Fukushima tragedy raised public concern on the dangers posed by nuclear technology, breaking the media's general nuclear optimism from the past years. Following the events, Brazilian authorities have been keen in denying that the country's nuclear power plants could face similar security problems. The Minister of Mines and Energy, Edison Lobão, argued that there is no need to review the nuclear programme because Brazilian plants have higher protection than in Japan. Affirming that Angra I and II were built "in the best existing technology," he claims that for their construction "there was an evaluation on the behaviour of the seas over what could happen in a period of one thousand years. A barrier in the sea was raised [...] for this possibility."[24] According to CNEN, Angra I and II were designed to support earthquakes of up to 6.5 degrees in the Richter scale, and waves of up to 7 meters high.

Despite official declarations, experts have been contesting the safety of the Angra complex. Currently, the evacuation area around the facilities remains as a 5km radius. The area in which the facilities were built is considered geologically unstable due to high probability of landslides, which could also block the main exit route at the BR 101 road. Plans to expand the security zone have been verbally announced, as well as the construction of docks for evacuation through the sea,[25] but critics point out the difficulty of the actual implementation of these plans, as the centre of the city of Angra dos Reis, located 12km from the plants, would include a population of 170,000 inhabitants.

The Fukushima accident increased the visibility and organisation of civil society demonstrations against nuclear energy. In several Brazilian cities, open protests were held in March with the assistance of Greenpeace, Matilha Cultural, 350.org , Ecogreens, and other organisations. Greenpeace also handed a manifest addressed to President Dilma Roussef, asking for the suspension of the construction of Angra III. In June 2011, a Brazilian Antinuclear Articulation was founded in a meeting with antinuclear and nuclear victims movements mediated by the Heinrich Boell Stiftung. Composed and supported by over 100 organisations and institutions from all over the country, the articulation publicly presented a manifest calling for the end of nuclear energy in Brazil.[26] A similar coalition was created in São Paulo mainly with deputies and professors from the São Paulo University.

Concerns on nuclear safety also led to the organisation of a public hearing at the Brazilian Senate in April 2011. After the exposure to academics, non-governmental actors, and CNEN and Eletronuclear, some Senators began to work to clarify governmental plans on the nuclear expansion. Representatives of some states of Brazil expressed worries with the expansion plans, as it will lead to more reactors, mining, and production of nuclear waste. New law projects are being proposed in the Congress and in some states to ban nuclear energy.

However, even with a growing antinuclear movement and vast opposition from the Brazilian population, Brazil still seems to remain firm in its plans to expand the use and production of nuclear energy, as foreseen in the 2008 National Energy Plan. Without the approval of the Congress, more than R$50 million was invested in studies for the construction of at least four more power plants until 2030. The states considered for hosting them are São Paulo and Minas Gerais, in the southeast region, and Bahia, Sergipe, Alagoas, and Pernambuco, in the northeast—even though all the north-eastern states have prohibitive constitutions for nuclear energy.

As a developing country, the consumption of energy in Brazil should grow 3.7% per year until 2030, according to official sources. From the total national energy production, governmental plans aim to raise nuclear energy from the current 2% to 5%. Following these studies, the emissions from the energy sector will triple by 2030.

Going opposite to the international trend, Brazil's nuclear plans raise criticism in face of abundant resources for other types of energy. Experts in the field of renewable technology point out that only with onshore wind turbines, Brazil could reach more than 350 GW,[27] equivalent to three times its current consumption, and ten times this potential in offshore wind turbines.[28] According to these studies, even without a law or regular auctions to subside this kind of energy, the prices for wind energy are the lowest in the world. A project of law to subsidise renewables, such as implementation of the feed-in tariff, has been proposed in 2003, but remains waiting for an action from the National Congress.

The lack of open discussion on the plans for the implementation of new nuclear power plants, and the close relation of the nuclear energy programme to the Navy's nuclear submarine programme, could suggest that Brazilian decisions are less driven by economic sense or energy needs, but by geo-political strategic interests. In the light of the aspirations for economic growth, Brazilian officials have been gathering support and guaranteeing the allocation of funds for the continuity of the nuclear submarine project—one of the main pillars of the 2008 Brazilian National Defense Strategy—based on the duality of the nuclear technology.[29] As former President Luis Inacio Lula da Silva noted in 2007 upon the decision to invest R$130 million in the Navy's plans, the nuclear submarine project could be "the embryo for all we need from nuclear energy. [...] Brazil can afford the luxury to be one of the few countries in the world to dominate all the technology of the uranium enrichment cycle and, from there, I believe we will be a lot more valorized as a nation, as the world power we want to be."[30] Current President Dilma Roussef, Lula's successor, has been giving continuity to these plans, having inaugurated the Submarine Development Plan in July 2011.

Notes

1. "Country Profile: Brazil," International Atomic Energy Agency, at http://bit.ly/n9JMzM (last access 08/08/2011).
2. The creation of CPIs was foreseen in the old Brazilian Constitution of 1946 in article 53. It has the attribution to investigate a specific situation that affects the public interest, giving the power to the Legislative to call upon hearings and analyse information.
3. The specific mandate of this CPI was to "investigate the accusations formulated by the *Der Spiegel* magazine, from Germany, over the execution of the Brazil-Germany Nuclear Agreement." See the website of the Brazilian Senate (in Portuguese) at http://bit.ly/qdK1bA (last access 07/07/2008).
4. Odete Maria Oliveira, *Os Descaminhos do Brasil Nuclear*, Rio Grande do Sul: Unisul, 1999, p. 49 (in Portuguese).
5. According to the speech of Pedro Paulo Leoni Ramos, secretary for Strategic Issues of the Presidency, made by the occasion of the CPI in 1990, the military institutes were chosen due to their location, physical security and the security they offered for the information. The university institutes were considered under the necessary stage of development. In: Odete Maria Oliveira, ibid., p. 290.
6. The name of the country who had supplied the uranium was revealed at the CPI by General Danilo Venturini, who had been head of the Military Cabinet and Secretary of the National Security Council at the mandate of President Joao Baptista Figueiredo. His version was later confirmed by others involved in the parallel program, such as the Secretary for Sciences and Technology, Jose Goldenberg. President Joao Baptista Figueiredo took personal responsibility for the contract that had been firmed with China, through which 300 kilos of uranium hexafluoride was acquired. In: Ibid, p. 461.
7. Cf. "Bomba Atomica no Brasil", *Veja*, 9 September 1987.
8. Eletronuclear, Dados de operação, at http://www.eletronuclear.gov.br/inicio/index.php (last access 08/08/2011).
9. IAEA Power Reactor Information System. Nuclear Power Reactor Details – Angra I, at http://www.iaea.org/programmes/a2/.
10. "Angra", *Veja*, 5 September 1986.
11. IAEA. Power Reactor Information System, ibid.
12. Eletronuclear, ibid.
13. "Empreendimentos em operação," *Aneel*, at http://bit.ly/34mQA0.
14. Ibid, p. 231.
15. Eletronuclear: Angra III.
16. "Reservas – Brasil e Mundo," Indústrias Nucleares do Brasil, at http://www.inb.gov.br/inb/WebForms/Interna2.aspx?secao_id=48 (last access 08/08/2011).
17. Janaina Simoes, "Marinha deve iniciar em setembro produção de combustível para submarino nuclear," *Inovação Unicamp*, 3 April 2011, at http://www.inovacao.unicamp.br/noticia.php?id=923 (last access 08/09/11).
18. "Country Profile: Brazil," IAEA, ibid.
19. INB, FCN Enriquecimento, at http://www.inb.gov.br/inb/WebForms/Interna2.aspx?secao_id=59 (last access 08/08/2011).
20. INB, FCN Nuclear Fuel Factory, at http://www.inb.gov.br/english/resendeEnriquecimento.asp (last access 23/06/2008).
21. Pedro Leal Fonseca, "Fiscalização interdita instalações de indústria nuclear na Bahia," *Folha.com*, 3 August 2011, at http://bit.ly/nqa50m (last access 08/09/2011).
22. Câmara dos Deputados, "Relatório do grupo de trabalho fiscalização e segurança nuclear," March 2006, at http://www.camara.gov.br/sileg/integras/389875.pdf.
23. Alana Gandra, "MPF cobra apresentação de estudo com medidas de prevenção de acidentes para Angra 3," *EcoDebate*, 10 August 2010, at http://bit.ly/9bPZpX (last access 09/09/2011).
24. Cf Mario Sergio Lima, "Lobão confirma que programa nuclear brasileiro não será freado," *Folha.com*, 14 March 2011, at http://bit.ly/emhsqI (last access 09/08/11).
25. "Riscos e benefícios de usinas dividem moradores de Angra," *BBC Brasil*, 26 April 2011, at http://bit.ly/qXp02j(last access 09/08/2011).
26. A list of all institutions and organisations that support the manifest can be found at http://antinuclearbr.blogspot.com/.
27. Gilson Mauriz Gomes, ENERGIA EÓLICA: EM BUSCA DA SUSTENTABILIDAD, at http://bit.ly/rkJ3Lq.
28. "Potencial eólico suoera 600GW," GESEL, at http://bit.ly/rkJ3Lq.
29. Andre Luis Ferreira Marques, "O Submarino que Da Luz" (in Portuguese) In: *Revista Pesquisa FAPESP* (Claudia Izique), September 2007, at http://bit.ly/q0yJMQ(last access 24/06/2008).
30. Cf Luis Inacio da Silv,"Lula anuncia liberação de recursos para programa nuclear da Marinha," Folha.com, 10 July 2007, at http://www1.folha.uol.com.br/folha/dinheiro/ult91u310853.shtml.

Canada

Zach Ruiter

In 1933, at Port Radium on the shores of Great Bear Lake in Canada's North West Territories, home to the Indigenous Sahtu-Dene people, Canada became the first country to begin mining uranium. By 1942, the mine supplied uranium to the Manhattan Project, which built the "Big Boy" and "Little Boy" bombs that the United States dropped over Hiroshima and Nagasaki in August 1945.[1] In 1998, the Sahtu-Dene sent a delegation of elders to Japan. On behalf of their people and land, they apologized to the survivors of the atomic bombs.

Canadian "Atoms for Peace"

Canada's first reactor was built in Chalk River in 1944 for the purpose of plutonium production. To maintain export revenue from uranium mining, the Chalk River design was retooled to produce electricity and became known as the CANDU (CANada Deuterium-Uranium) boiled water reactor (BWR). This came at a time when American and British demand for Canadian uranium had dropped once an 'overkill' level of atomic weapons were stockpiled. The military genesis of the reactor design "explains why the CANDU reactor typically produces 2.6 grams of plutonium per kilogram of used uranium fuel—the highest ratio among all commercial reactor designs."[2] According to the World Nuclear Association, there are 32 CANDU power reactors in seven countries, as well as 13 'CANDU derivative' reactors in India. Export CANDU sales have been made to South Korea, Romania, India, Pakistan, Argentina, and China.[3]

Canada and nuclear proliferation

In 1974, India exploded its first atomic bomb, the "Smiling Buddha," triggered with plutonium from a donated CANDU reactor. This was followed in 1998 by Pakistan's "Sword of Islam" test bomb, which was also made with plutonium from CANDU technology. Today, India has amassed 60-80 nuclear warheads, yet still refuses to sign the nuclear Non-Proliferation Treaty. Despite this, the Canadian government signed a nuclear cooperation agreement with India in 2009 that includes uranium sales to the country[4] and allegedly offered uranium and CANDU reactors to Pakistan at the same time.[5]

In 1994, then-Canadian Prime Minister Jean Chrétien signed a nuclear cooperation agreement with Chinese leader Li Peng, who later sold Canadian nuclear technology for military applications to Pakistan, North Korea, Libya, and Iran.[6]

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Canadian uranium

In the Athabasca Basin in Northern Saskatchewan, Canadian Cameco Corporation and French Areva NC (formerly Cogema) operate mines that produce up to 40% of the world's uranium. These deposits are among the richest in the world, with concentrations as high as 20%. No Canadian or international body conducts actual audits of the uranium exported to foreign enrichment plants for energy and military use.[7] In its October 1993 report, the Joint Federal-Provincial Panel on Uranium Mining Developments in Northern Saskatchewan noted: "The Nuclear Non-Proliferation Treaty, of which Canada is a signatory, prohibits the use of uranium for military applications. However, there is no process whereby exported Canadian uranium can be separated from uranium derived from other sources. Therefore, no proven method exists for preventing incorporation of Canadian uranium into military applications."[8]

Dr. Jim Harding, retired Director and Professor of Justice Studies at the University of Regina authored Canada's Deadly Secret Saskatchewan Uranium and the Global Nuclear System, in which he alleges, "There is still no baseline data which is the first step in any credible social or health impact research and the industry continues to be allowed to operate in the dark without fundamental ecological or legal accountability."[9]

The Pembina Institute report Nuclear Power in Canada: An Examination of Risks, Impacts and Sustainability states there are 575,000 tonnes of tailings produced annually by uranium mines in Canada, which add to an estimated 213 million tonnes in storage as of 2006.[10] These tailings contain radioactive and chemical hazards that have substantial air, water, land, and health impacts for both humans and wildlife. Yellowcake, dried concentrated uranium, travels 2000 km from Saskatchewan to Blind River, Ontario to be refined and further processed for international shipment from Cameco Refineries in Port Hope, Ontario.

The provinces of British Columbia and Nova Scotia have either declared a moratorium or a ban on uranium mining within their jurisdictions. Physicians in Sept Iles, Quebec, the site of a possible uranium mine, pressured the Quebec government by threatening to relocate outside the province if a moratorium on uranium mining was not put in place regionally, and the Quebec government agreed.

More than 20 mining companies are currently staking claims, covering 30,000 acres, to uranium in Ontario, including at Sharbot Lake, which is 122 km south west of Ottawa, Canada's capital. According to the unchanged 1870's mining law, prospectors can stake mining claims on most properties while the owners have only surface rights. In 2008, an Ontario court sentenced

Ardoch Algonquin co-chiefs Paula Sherman and Robert Lovelace to six month terms in prison for contempt of court for breaking an injunction that restricts Aboriginal and non-Aboriginal activists from venturing within 200 metres of the proposed mine site. Mining corporation Frontenac Ventures is suing the Algonquin tribe for $77 million.[11]

Canadian energy supply and cost

According to the World Nuclear Association, approximately 15% of Canada's electricity (or 12,600 MW) comes from nuclear energy.[12] The sum total of public subsidy to our nuclear technology and operation is unknown, although realistic estimates start at a minimum of $21 billion, accounting for as much as 12% of the federal debt. Before the federal government put Atomic Energy of Canada Limited (AECL) up for sale to the private sector at a press conference in June 2009, Kory Teneycke, the communications director and chief spokesperson for Prime Minister Stephen Harper, referred to AECL as a "dysfunctional" thirty-billion-dollar "sinkhole". [13]

Ontario's atomic debt is estimated to be at least $35 billion.[14] According to the Ontario Clean Air Alliance, an NGO, "every nuclear project in Ontario's history has gone massively over budget," on average 2.5 times higher than originally estimated.[15] Ontario taxpayers are currently paying $1.8 billion per year in debt retirement charges for past nuclear reactor cost overruns.[16] A report called Renewable is Doable prepared by Greenpeace Canada and the Pembina Institute analyzed the cost-benefits of nuclear energy in comparison to renewable forms of alternative energy. The report found that "a mix of green energy technologies and conservation acquired through the government's Green Energy Act would be 12 to 48 per cent cheaper than buying new reactors to replace the aging Pickering nuclear station, which is set to close in 2020 due to high maintenance costs."[17]

Nuclear reactors in Canada

There are 22 nuclear power reactors in Canada: 20 in Ontario, one in Quebec, and one in New Brunswick. Seven of the 20 reactors in Ontario were shut down in 1998 due to poor performance and safety problems. Since then four reactors have come back online. Ontario Power Generation has applied to the Canadian Nuclear Safety Commission to build up to four new reactors at the Darlington Nuclear Power Station; the successful bid came in at $26 billion. They also plan to refurbish the existing four reactors at Darlington. Two reactors at Bruce Nuclear Station are presently being refurbished; currently they are $2 billion over-budget and a year late.[18]

The Bruce Nuclear Power Station recently postponed plans to ship radioactive steam generators to be "recycled," or rather melted and mixed into the metals waste stream in Sweden. The plan resulted in a storm of protest by municipalities, NGOs, and First Nations communities en route. *Anishinabe Kweag: Protecting Our Future* is a group of Aboriginal women that argued against the shipment of the contaminated radioactive generators over the waters of Lake Huron, St. Lawrence River, and Atlantic Ocean.[19] Bruce Power has not fully explained the reason for the postponement.

Of the two original reactors in Quebec, Gentilly 1 is decommissioned, and Gentilly 2 is at the end of its lifecycle. In June of this year the CNSC approved the renewal and refurbishment of the Gentilly 2 reactor. The Quebec government expects to spend upwards of $1.8 billion on the project.[20]

The New Brunswick Point Lepreau reactor was scheduled to be closed in 2008 and is currently undergoing a $1.4 billion refurbishment. It is now two years late and $1 billion over-budget. The province is suing the federal government for compensation.[21]

Accident preparedness

The most recent radiation accident occurred at the Pickering A Nuclear Generating Station near Toronto, Ontario. On 14 March 2011, a leak of 73,000 litres of de-mineralized water, caused by a faulty pump seal, poured into Lake Ontario. The Canadian Nuclear Safety Commission (CNSC) said in a statement, "The radiological risk to the environment and people's health is negligible."[22]

The Canadian Medical Association Journal published an article "Canada Ill-Prepared for Radiation Emergencies" on 14 June 2011, which noted "Most Canadian hospitals are ill-prepared to handle the surge of patients that could result from a large-scale radiation emergency.... The ongoing radiation threat in Japan, the result of damage to a nuclear power plant during the country's recent earthquake, has rekindled concerns about the lackadaisical approach to preparing for such an event in Canada."[23]

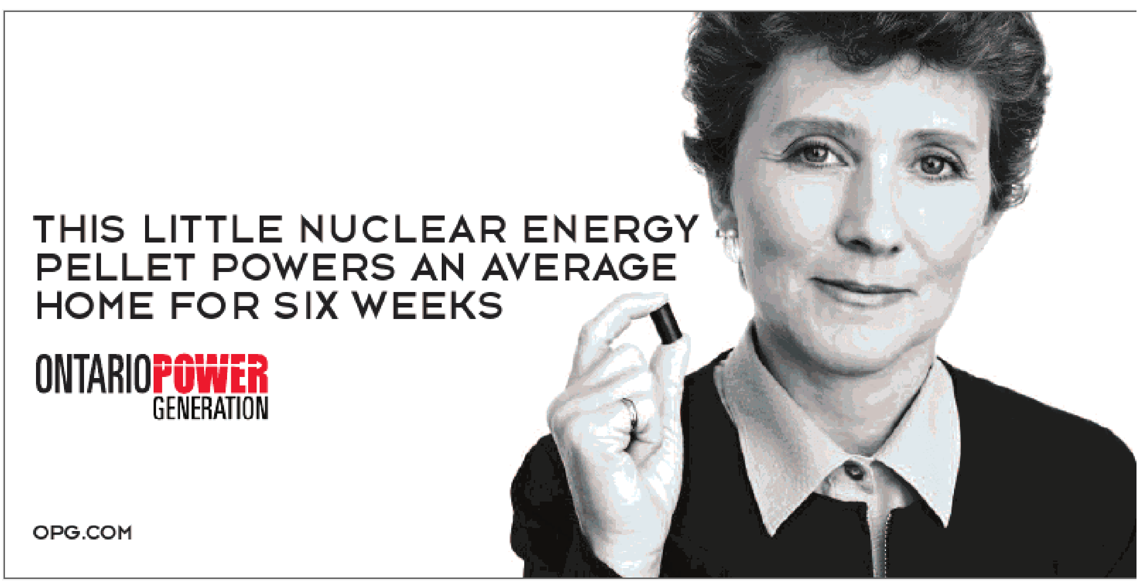
On 24 March 2011, during the Joint Review Panel hearings for the expansion of the Darlington Nuclear Power Station, anti-nuclear activist Angela Bischoff directed a question to the proponent, Ontario Power Generation (OPG). Bischoff asked OPG "whether [the] Fukushima [accident] was or would be considered credible or incredible?" OPG representative Dr. Jack Vecchiarelli answered, "the likelihood of having a failure to shut down, for example is incredible ... that is an event that so many things going wrong could occur once in a million years."[24]

Natural Resources Canada estimates that in a decade, eastern Canada will, on average, experience three seismic events greater than magnitude 5.0 magnitude on the Richter scale.[25] The Darlington Nuclear Station sits directly on a fault line discovered by geologist Dr. Joe Wallach, who has named it the Niagara-Pickering Linear Zone. "It goes beneath both the Niagara Peninsula and Pickering. It extends northward at least to Minden, on the Canadian Shield and southwestward into Ohio."[26] The Fukushima Dai-ichi catastrophe is evidence that the safety of nuclear power plants cannot be measured by previous scientific and regulatory standards set by the nuclear industry, yet according to Ms. Laurie Swami, head of nuclear licensing for OPG, "Criticality events outside of the core are not considered credible for our project."[27]

have been smaller than the normal day to day fluctuations from background radiation."[29] Health Canada's Radiation Monitoring Data website[30] censored readings from the Canadian Comprehensive Nuclear Test Ban Treaty Monitoring Stations. Rather than sharing the readings with the public, the readings from these stations are sent automatically to the UN's Comprehensive Nuclear Test Ban Treaty Organization offices in Vienna. According to the organization's public information officer, Kristen Haupt, only member states have access and discretion to release the data.

According to Professor Arthur Schafer, Director of the Centre for Professional and Applied Ethics at the University of Manitoba, "[Health Canada's] prime concern is not the health of Canadians or the duty to provide timely and accurate information to the public."[31]

Roy Brady of the Council of Canadians and SAGE (Safe and Green Energy Peterborough) notes that Health Canada chose to limit the data from the Canadian test-ban monitoring stations to "one day per week, beginning in May, just when the results could actually be increasing in harm."[32] Health Canada provides no readings for the entire month of July; in tables where the data should be reported, each reading is represented by a hyphen—which according to the chart's table means the data was "not measured or not detected." On 3 and 10 August, data from the Sidney Radionuclide Station Treaty Code "RN14" station "was not collected due to problems with equipment."[33] According to Eric Pellerin, a representative of the Radiation Protection Bureau of Health Canada, "effective August 11th, we will actually completely discontinue the posting of monitoring data on Health Canada's web site.... The rationale for the change is: (1) conditions of plants in Japan are under better control and emissions are low; (2) all radiation measurements over last few months have been within the range of normal background lev-



A 2007 billboard advertisement from an Ontario Power Generation Marketing Campaign, pictured is Mr. Laurie Swami, head of nuclear licensing for OPG

Response to Fukushima

Immediately after the Fukushima catastrophe the Canadian government went into damage-control. Health Canada's Dr. Paul Gully hastily stated on CBC news, "The assessment is that the risk to Canadians in Canada is negligible and will remain negligible, even in the worst-case scenario."[28] Health Canada stated, "The very slight increases in radiation across the country els, therefore the extra costs of operating, maintenance and reporting are no longer justified."

Sale of Atomic Energy of Canada Limited (AECL)

In June 2011, the federal government announced the sale of the commercial power division of AECL to SNC-Lavalin. The sale price paid from SNC-Lavalin to the government was $15 million. The sale came with an agreement for the government to provide an immediate $75 million in subsidies towards the development of an untested prototype "Enhanced" CANDU 6 reactor.[34] SNC-Lavalin is an engineering contract firm. Most recently SNC-Lavalin had been working for Col. Gadaffi in Libya, constructing a human-made river and building mega-prisons.[35]

Nuclear waste management and the NWMO

To date, all high-level nuclear waste is stored on site of each of Canada's nuclear power plants. Low- and intermediate-level wastes from reactors in Ontario are all shipped to the Bruce power site for compaction, incineration, and storage.

In 2002, the federal government mandated an agency, controlled by the nuclear waste owners, to investigate waste management options. This new industry body, the Nuclear Waste Management Organization (NWMO), in 2005 submitted its recommendation for "Adaptive Phase Management". It proposed a 300-year phased approach moving from storage at nuclear plants, to centralized storage, and finally to deep rock disposal. The federal government approved this recommendation in 2007 without seeking any public input. The NWMO estimated the project could require the transportation of 3.6 million fuel bundles, or 19,080 shipments. Subsequent projections are even higher. According to Brenda L. Murphy and Richard Kuhn, "transportation will inevitably be delayed by protests, bad weather, and other circumstances."[36]

In 2010, the industry launched its search for a nuclear waste site, a deep geological repository. Five communities in northern Ontario and three communities in northern Saskatchewan have entered into the NWMO "learn more" programme.

The anti-nuclear movement in Canada

The anti-nuclear movement in Canada swelled in the 1980s, and then slowed somewhat in the 1990s. Now that the past generation of nuclear reactors is coming to the end of its natural life, governments and industry are revving up for a new generation. Although the current anti-nuclear movement is relatively small, it has recently been reignited, and is represented by a number of public organizations that mount media campaigns and challenge government and industry information. These groups include but are not limited to: Canadian Coalition for Nuclear Responsibility, Northwatch, Greenpeace Canada, Pembina Institute, FARE (Port Hope Families Against Radiation Exposure), SAGE (Safe and Green Energy Peterborough), Ontario Clean Air Alliance, Community Coalition Against Mining Uranium, Sierra Club of Canada, Lake Ontario Water Keeper, and the Assembly of First Nations. The Inuit Tapiriit Kanatami, western Indian Treaty Alliance, and Ontario Metis Association have asserted that their participation in any public consultation with the government must be based on the caveat that nuclear power generation cease and that alternative energy sources be actively sought.

Some of these groups are calling for a non-partisan Royal Commission of Inquiry into the future of the nuclear industry in Canada, "in the hopes that people of Canada will be adequately consulted on the future of this inherently dangerous industry" and that they "have an opportunity to voice their views on nuclear power and to explore the implications of alternative non-nuclear energy technologies and strategies."[37]

photo: CTV News/CP/Kevin Frayer; A woman sunbathes next to the Pickering Nuclear Power Plant near Toronto, 2010

Aboriginal issues

The inclusion of Aboriginal issues into dominant pro-nuclear interests in Canada serves as "a kind of embellishment ... offering symbolic cover, but not seriously penetrating and shaping the choices and policies."[38] For example, Bruce Power is sited within the territory of Saugeen and Nawash First Nations, yet "the Aboriginal communities were not consulted when the Bruce Plant was built, and later, in the 1990's, when the facility owners applied for an expansion, the Aboriginal communities were unable to trigger a full-panel environmental assessment despite the earlier siting infringement."[39] Despite the fact that First Nations communities have borne the brunt of toxic mining and tailings without their consent, now they are dealing with their colonialists efforts to bribe their communities to be "willing hosts" to Canada's radioactive waste.

Conclusion

The Canadian government and nuclear industry have tried to "greenwash" nuclear power as a solution to climate change. This, plus massive government subsidies all along the production chain, serves to disadvantage the growing market share of renewable energy. Canadian scientist and environmentalist Dr. David Suzuki has said, "The conjunction of multiple issues—economic meltdown, climate change, peak oil, escalating energy demand, health issues—has created a huge crisis. But this can also be an opportunity to look at the entire picture and get it right."[40] Canada's nuclear expertise comes from being the first and largest producer of uranium, as well as a long history of direct and indirect government investment in research, development, education, and marketing. It also leaves a legacy of environmental devastation and debt. Indeed, investing in new nuclear is an investment in debt, and if it is allowed to proceed, this financial, ecological, and cultural debt will be incurred by future generations without their consent.

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Democratic Republic of the Congo

Annie Matundu Mbambi

The Democratic Republic of the Congo (DRC) has large uranium deposits in Katanga, a southern province. It has also produced uranium from the Shinkolobwe mine, located close to Zambia. Since the 1920s, uranium has been mined and exported from the DRC. In 1945, at the end of World War II and the beginning of the Cold War, nuclear weapons used uranium from the DRC. Uranium from Shinkolobwe was used in the Manhattan project. From the 1940s to the 1960s, the Belgian colonial mining company Union Minière du Haut-Katanga extracted approximately 40,000 tons of uranium from this mine. The mine was closed in 1960 when the DRC was granted independence; today uranium comes from Katanga.[1]

Some contracts have been signed between the government of the DRC and energy companies to exploit the uranium resources, but the details of these contracts remain secret. In 2010, the government signed such a contract with the French company Areva. Others have noted that Areva has reportedly "bought the right to the unlimited export of the Congolese uranium reserves."[2] Today, nuclear power is discussed intensively because of the catastrophes of Chernobyl and Fukushima. The incalculable impact of the disaster at the Fukushima Dai-ichi Nuclear Power Station in Japan has served as a dreadful reminder that events thought unlikely can and do happen everywhere nuclear reactors operate. In the DRC, there has been no government reaction or public debate in response to the Fukushima disaster.

While there are no nuclear reactors in the DRC, the country's uranium mines serve to perpetuate the future of nuclear energy. The mines also have a negative impact on the health of the population that works in this area, as drinking water and polluted air contain toxic substances that can cause severe health disorders, such as urogenital disorders, leukemia, or forms of cancer and deformation in unborn babies.[3] Katanga province "shows abnormally high levels of radiation, with the highest concentrations at the immediate vicinity of the towns of Luiswishi, Shinkolobwe, Kambove, Menda, Tatara, Swambo, Kamoto, Lakongwe, Mashamba-ouest, and Musonoi, where also high reserves of cobalt copper and zinc exist."[4]

Yet the exploitation of workers is tolerated in the DRC.[5] About one million artisanal miners are active in the DRC. Artisanal mining is characterized by exploitation of small deposits not accessible by mechanized mining; physically demanding work; low level of safety, health care, or environmental standards; poor qualifications or training; low salary; and women and children are frequently found working on the site.[6]

Women's rights activists in the DRC do not reflect on nuclear power or uranium mining. They are not informed about the dangers of running nuclear power stations, or the final storage of nuclear waste. There is no significant movement in the DRC against nuclear power, nor even any grassroots activists working on this issue. Sometimes nuclear power is discussed by organizations that advocate on climate change issues, but they have no real access to information and they do not have any possibility to exert their influence in the political decision-making process.

The forefront of this challenge is for women's rights activists everywhere to challenge the nuclear power industry. The scientists know well enough that nuclear power can cause the worst damages to the environment; they must spread this information. We are all witnesses to what is happening in Japan, we realize the gravity of this disaster and we must work to change to the status quo urgently. The nuclear power crisis at Japan's Fukushima Dai-ichi Nuclear Power Station has been a big lesson and should give governments an impetus to act to avoid similar calamities at nuclear reactors elsewhere in the world.

Every dollar going to nuclear power or nuclear arsenals should be used to build schools, hospitals, and other social services to the millions of the world's population that go hungry or are denied access to basic medicines. Those resources must be allocated towards meeting human needs.

Annie Matundu Mbambi is president of WILPF Democratic Republic of the Congo.

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France

Dominique Lalanne

Nuclear power is the primary source of electricity in France; in 2010, its 58 reactors produced 74.1% of the country's electricity.[1] The country generates close to half of the EU's nuclear production,[2] and it operates the equivalent of about ten reactors for electricity export.[3]

With 58 nuclear reactors working, a new European Pressurized Reactor (EPR) under construction at the Flamanville Nuclear Power Plant, a reprocessing plant to extract plutonium, fuel fabrication, uranium conversion, and uranium enrichment facilities, France has all the aspects of nuclear power.

Public opinion in France has been shocked by the Fukushima disaster and is now very questioning about safety issues involving its own reactors. The recent decision of Germany to close all nuclear power plants by 2022 is even more dramatic for the nuclear lobby, proving that the future may be non-nuclear. Many politicians realize these days that the energy technologies of the next decade are not nuclear but renewable. In the context of presidential elections next year (2012), this gives the basis for a very strong debate. For the first time in France nuclear issues are being discussed. Unfortunately, the debate does not yet include nuclear weapons even though many non-governmental groups are trying to change this.

photo: Sortir du nucléaire Paris; Demonstration against nuclear power, June 2011

Prime Minister François Fillon has requested the Nuclear Safety Authority (ASN) to carry out a safety assessment of all 58 French operating reactors, which ASN has said "will be consistent with the EU initiative for 'stress tests'."[4]

French President Nicolas Sarkozy has stated that it would be "obviously out of the question to phase out nuclear [power]."[5] Others have been more critical. Martine Aubry with the French Socialist Party said she was "personally in favor of phasing out nuclear power," although her party was still debating the question.[6] François Bayrou, president of the MODEM party, said that "the rethink must put into question [France's] 100-percent-nuclear option."[7] Meanwhile, the Green Party's participation in a governmental coalition is impossible without the decision of phasing out nuclear power.

The new reactor, the EPR, is just a new version of the traditional pressurized water reactor (PWR), but is proposed by the French President to all countries as the "solution against green gases", and as a perfect facility for "security issues", trying to show that Fukushima type accidents cannot occur with such a reactor. This reactor, with production of 250kg of plutonium per year, can be a good tool for a nuclear weapon programme.

In France, the government's policy on nuclear power is closely linked to that on nuclear weapons. In fact the same state body, the Commissariat à l'Energie Atomique (CEA), under direct government control, is in charge of both the civilian nuclear programme (via AREVA) and the military one (via DAM, Direction des Applications Militaires).

The CEA is preparing breeder reactors and advertising that they will be the best because they work with plutonium. Breeder reactors use a plutonium core in order to increase the neutron flux. Around the core is installed an uranium jacket (using natural uranium or depleted uranium). In this uranium, under the influence of the neutron flux, there is a production of plutonium 239, which is military grade plutonium (no mixing with plutonium 240 or heavier). With a breeder reactor the blanket is easy to remove in order to extract the "good" plutonium, the military-grade plutonium. That makes proliferation much easier and so this is an easy reactor to sell to many states.

Dominique Lalanne is chair of Abolition 2000-Europe.

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Germany

Xanthe Hall and Karin Wurzbacher

According to the International Atomic Energy Agency (IAEA), Germany had 17 power reactors in operation and 19 power reactors had been shut down by the end of 2006.[1] Only nine nuclear power plants (NPPs) are operating now in Germany. As a result of the disaster at the Fukushima Dai-ichi Nuclear Power Station in March 2011, the coalition conservative-liberal government conducted a safety review, resulting in the closure of eight of the seventeen NPPs that were officially still in operation. The government now plans to gradually phase out all remaining NPPs by 2022.

Production and energy mix

The 17 NPPs still running in 2010 had a net production of just over 20,000 MWe. Nuclear energy provided 10.9% of primary energy production and 22.5% of electricity consumed in Germany in 2010. But after the closure of the seven oldest NPPs and the most accident-prone one, Kruemmel, production has likely dropped to about 12,000 MWe net.

Figures on production and consumption are not yet available to show what the energy mix now in 2011 is, since the closure of eight NPPs. However, the figures from 2010 show that renewable energy was already catching up on nuclear energy, providing 9.4% of primary energy (compared with 1.3% in 1990) and 16.4% of electricity. Figures for the first half of 2011 already showed a further improvement when compared with the first half of 2010 with renewables covering about 20% of gross electricity production (Nickel, 2011).[2]

Table 1: Primary energy consumption in Germany by energy source, 2010

Energy source	Share in %
Oil	33.6
Gas	21.8
Coal	12.1
Nuclear	10.9
Lignite	10.7
Renewable	9.4
Others (incl balance from electricity trading)	1.5
Total	**100.0**

Source: AG Energiebilanzen (as of 31 March 2011)

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Karin Wurzbacher is a physicist at the Munich Environmental Institute.

Table 2: Gross electricity consumption in Germany by energy source, 2010

Energy source	Share in %
Oil	1.3
Gas	13.4
Coal	18.8
Nuclear	22.5
Lignite	23.4
Renewable	16.4
Others (incl balance from electricity trading	4.2
Total	**100.0**

Source: AG Energiebilanzen (as of 31 March 2011)

Decision on abandonment of nuclear energy

The first decision to abandon nuclear energy was made under a social democrat-green coalition government, when on 14 June 2000 a "nuclear consensus" between government and the nuclear industry was signed, later cemented by an act of parliament in 2002 (Nuclear Act). This act was overturned in 2010 by the conservative-liberal government despite massive popular protest. After the disaster in Japan, this government reviewed its policy and decided to abandon nuclear energy fully over the next ten to eleven years, so that the last NPP would close its doors by 31 December 2022.

In the original plan, the last NPP was scheduled to be closed by 2022, but there were loopholes in the agreement that meant that the operating companies could trade off lost production from older reactors, once shut down, and add their residual life time onto newer ones, thus extending their operating times. This meant that some reactors could have kept running till 2030, and the phase-out "consensus" was heavily criticised by environmental organisations as taking too long. However, the revised 2002 Nuclear Act halted reprocessing of used nuclear fuel from German reactors in France and Great Britain, and with the establishment of the Renewable Energy Act the success story of solar and wind energy began in Germany.

The life-extension plan that was agreed on in 2010 would have allowed the nine newer reactors to continue production way past 2030, and even more worryingly, some of the very old and accident-prone reactors to continue operating between eight and fourteen years longer. This decision provoked massive demonstrations and actions both in the capital and at the NPPs themselves. The German affiliate of International Physicians for the Prevention of Nuclear War (IPPNW) sponsored a civil suit against the operator to get Biblis B, one of the oldest reactors, closed down for safety reasons as a test case.

The new post-Fukushima phase-out plan resulted in eight reactors—already offline for three months whilst a review was conducted by a special commission—being shut down in May 2011: the seven oldest and Kruemmel, which was severely accident-prone. Nine NPPs will continue to run until 2015, when the phase-out begins. However, six of the nine NPPs will continue to operate till 2021 and three of them till 2022 (see table below). Also a tax has been introduced on reactor fuel.

Anti-nuclear critics of the plan say that this means that the decision could once again be overturned in ten years time, still leaving six NPPs operating. Most NPPs have effectively received a life-extension of one or two years. In the case of the two Boiling Water Reactors (BWR) Gundremmingen, originally scheduled to be shut down in 2016, only Gundremmingen B will close in 2017 whereas Gundremmingen C will remain in operation until 2021. The Gundremmingen reactors are the same type of reactors as those at Fukushima. Also, it has been proposed that some older reactors could be held in "cold reserve" to help out if the next two winters are too severe for Germany to cope.

take too long. Greenpeace, for instance, reckons that all NPPs could be shut down by 2015 and fossil energy ended by 2040 in their "Plan".[3] The report by Ökoinstitut for WWF reaches the conclusion that nuclear energy could be abandoned by 2015 to 2020.[4]

Of course, the nuclear industry has been strongly critical of the government decision, even threatening court action.[5] The economic effect on the energy producing companies is also beginning to show. RWE lost nearly 40% of its net profit in the first half of 2011 and e.on has announced that it will be cutting up to 11,000 jobs worldwide.[6] However, there are signs that the tide is also turning within such companies. The outgoing chief executive of RWE, Juergen Grossman, said that German energy companies had been too slow to take up the energy shift and should have invested more in renewable energy in the past. Renewables make up only 2.6% of RWEs electricity production and the company now wants to invest more in these energy sources.

Table 3: Nuclear reactors in Germany

Plant	Type	MWe (net)	Began commercial operation	Operator	Provisionally scheduled shut-down 2001	2010 agreed shut-down	March 2011 shutdown & May closure plan
Biblis-A	PWR	1167	2/1975	RWE	2008	2016	yes
Neckarwestheim-1	PWR	785	12/1976	EnBW	2009	2017	yes
Brunsbüttel	BWR	771	2/1977	Vattenfall	2009	2018	yes
Biblis-B	PWR	1240	1/1977	RWE	2011	2018	yes
Isar-1	BWR	878	3/1979	E.ON	2011	2019	yes
Unterweser	PWR	1345	9/1979	E.ON	2012	2020	yes
Phillipsburg-1	BWR	890	3/1980	EnBW	2012	2026	yes
Grafenrheinfeld	PWR	1275	6/1982	E.ON	2014	2028	2015
Krummel	BWR	1260	3/1984	Vattenfall	2016	2030	yes
Gundremmingen-B	BWR	1284	4/1984	RWE	2016	2030	2017
Gundremmingen-C	BWR	1288	1/1985	RWE	2016	2030	2021
Gröhnde	PWR	1360	2/1985	E.ON	2017	2031	2021
Phillipsburg-2	PWR	1392	4/1985	EnBW	2018	2032	2019
Brokdorf	PWR	1370	12/1986	E.ON	2019	2033	2021
Isar-2	PWR	1400	4/1988	E.ON	2020	2034	2022
Emsland	PWR	1329	6/1988	RWE	2021	2035	2022
Neckarwestheim-2	PWR	1305	4/1989	EnBW	2022	2036	2022

Source: World Nuclear Association, August 2011

The government plan envisages increasing the amount that renewable energy contributes to electricity production to at least 35% by the year 2020. The main investment will be in offshore wind parks, hydroelectricity, and geothermal energy, as well as in new fossil energy. At the same time, however, investment is being reduced in inland wind parks, biomass and photovoltaic, which has drawn criticism. The goals are also seen as lacking in ambition, with Friends of the Earth Germany (BUND) calling for 45% by 2020.

The government plan to phase out nuclear energy is still considered by environmental organisations to

Rise and fall of nuclear energy in Germany

Nuclear power began in the 1950s in Germany, the first NPP beginning operation in 1961 (Kahl). As in many other countries, the belief was that nuclear power would change lives, providing endless amounts of cheap energy. But already by the 1970s the German anti-nuclear movement was growing. Mostly protests were at sites of planned NPPs or nuclear dumps, sometimes successfully hindering their construction.

The largest mass protests were in 1985 to 1989 against the planned construction of a reprocessing plant at Wackersdorf, a project that was highly controversial. These protests succeeded in stopping the plant from being built. Also very famous were the protests that stopped the building of NPP Brokdorf in 1976, only to be recommenced in 1980, leading to a demonstration of over 100,000 people in 1981. Despite this, the NPP was completed in 1986. Equally large were the protests against a nuclear dump in Gorleben in Wendland, Lower Saxony, which also attracted mass demonstrations of the same order as Brokdorf. Protests against the dump at Gorleben have remained unabated over the years, still attracting thousands of demonstrators and regular actions of civil disobedience. The waste transports in "Castor" containers from Le Hague to Gorleben went on to become a red flag to the anti-nuclear movement in the 1990s. These tranports are frequently blockaded by protesters, requiring massive police presence at an enormous cost.

The growth of the Green party, which emerged from the peace and anti-nuclear movements, led to a coalition government with the Social Democratic Party in 1998. One of their main election promises was the phasing out of nuclear power. Talks with the nuclear industry to try to reach an agreement on energy had already begun in the early 1990s under Helmut Kohl's government, but had not reached any consensus. With the red-green government an agreement was reached that each NPP could only generate a certain amount in total of electric energy in its lifetime and then would be closed down. It was possible, however, for operating companies to transfer amounts of energy production from one NPP to another.

After the agreement was reached in 2000 and a new nuclear act was passed in parliament in 2002, the anti-nuclear movement waned. Environmental organisations like BUND, Robin Wood, IPPNW, and Greenpeace, as well as local action groups, remained highly critical of the phase-out plan and feared that the nuclear industry would not keep its side of the bargain. After the electricity market was liberalised, NGOs cooperated to launch a campaign entitled "Do it Yourself—Abandon Nuclear Energy"[7] and called on consumers to simply change their electricity provider to one that only supplied energy from renewable sources. This became very popular, not only for individual households, but also for some city councils and many public buildings. The German population began to vote with their feet on the nuclear issue.

Danger to health

The accidents at Three Mile Island in 1979 and Chernobyl in 1986 strengthened the anti-nuclear movement and increased the fear of radiation and nuclear accident in the general population. Southern Germany received large amounts of fallout from the Chernobyl accident that can still be measured in fungi, berries, and wild boar today. In 1987 five percent more newborn babies died than in other years. A study also showed that the rate of trisomy 21 (Downs syndrome) in Berlin significantly increased in children who were in-utero at the time of the Chernobyl disaster.[8]

In 2007, a report was published by the German Childhood Cancer Registry which showed "clear evidence that the risk of cancer, especially of leukaemia for children under the age of 5 increases with decreasing distance of their homes to a nuclear power plant site."[9] The so-called KiKK (Kinderkrebs in der Umgebung von Kernkraftwerken) study was in part motivated by pressure from IPPNW doctors to investigate

photo: Associated Press; Demonstration against nuclear power in Berlin on 28 July 2011

the evidence that the risk of childhood cancer in the vicinity of Bavarian NPPs had increased. IPPNW had also earlier found a cluster of childhood leukaemia in the Elbmarsch area around NPP Kruemmel. However, this later turned out to probably have been caused by an accident in 1986 at the Geesthacht nuclear installation, which released radioactive isotopes into the area.[10] Nevertheless, the KiKK report confirmed IPPNW's suspicion that there is indeed a connection between the normal operation of NPPs and childhood cancer. De-

photo: Greenpeace, 2010

spite this, the German Office for Radiation Protection concluded in 2009 that there was no causality between radioactive emissions from the NPPs and the increase in cancer rates, there were only indications.

Dumping nuclear waste—an unresolved problem

One of the major issues of concern for the German population is the question of how to deal with radioactive waste and the legacy for future generations. The nuclear dump at Asse hit the headlines in 2008 when it became clear that water had been leaking into the waste depository for twenty years, had rusted the barrels through, and radioactive brine was leaching into the ground water as a result. The dump contains about 126,000 barrels of low- and intermediate-level radioactive waste, although it is unclear exactly how many of each. The site operator had known about the leak but not revealed it, compounding the problem. In 2010 it became known that there were also leukaemia and thyroid cancer cases in the surrounding area. In April 2011 caesium levels were measured at 240,000 Bq/l, 24 times the permitted level. In 2008 they had measured 90,000 Bq/l, showing that radiation had more than doubled in the last three years and posing a danger to the surrounding community and ground water.

In July 2011 the authorities made up their mind to extract the waste out of the dump using remotely controlled machines, a process that could take more than ten years and cost billions of Euros. The waste would then be taken to the dump at Schacht Konrad, although it is not yet certain if there is enough room for it all there.

Conclusion

There is no doubt that, even before the Fukushima disaster, the German population was in favour of phasing out nuclear energy. The only point of contention was about how long it should take. Even despite the agreement in 2000 to phase-out, NGOs remained active in pushing for a faster phase-out and a significant part of the population supported their campaigns and took part in actions, repeatedly drawing attention to the problems of nuclear waste and dangers to health of nuclear energy. The decision to extend the regulatory lifespan of NPPs by the present government sparked off huge demonstrations and concerted actions all across Germany. Finally, the disaster in Japan tipped the scales, so that a societal consensus emerged that nuclear energy must be phased out much faster and an energy shift to renewables be accelerated. Nevertheless, there remains much dissatisfaction about the new government plan and NGOs continue to exert political pressure on the government to accelerate the abandonment of nuclear energy.

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India

Suvrat Raju

Over the past few years, the question of nuclear energy has occupied center-stage in India's polity. In 2005, the Manmohan Singh government and the Bush administration initiated an Indo-US nuclear deal. Within India, the deal was projected as a means of helping the country attain its rightful place as a "great power". However, as explored below it contained very little of tangible benefit to the country. Instead, it served to tie the country to a strategic vision which would bring it closer to the West and take it away from its traditional policy of non-alignment.

Since this vision—although preferred by sections of the country's corporate and political elite—would hardly find broad political support, the government sold the deal as being essential for energy. For example, Sonia Gandhi—the head of the ruling Congress party—explained that electricity was required for development and the nuclear deal was required for electricity. Consequently, opponents of the deal were "enemies of progress and development".[1]

photo: Press Trust of India; Villagers march against Jaitapur nuclear power plant

The Indian Department of Atomic Energy (DAE) produced various dubious figures to back these claims. As the debate around the deal reached a climax in 2008, the head of the DAE, Anil Kakodkar, prepared a presentation projecting that, with the help of the nuclear deal, atomic energy in India would grow by a factor of 150 from about 4.12GW to 650GW by 2050.[2] The Indian defence minister, Pranab Mukherjee, used these figures in the concluding parliamentary discussion on the issue, explaining that without the deal, "our energy deficit would be 4,12,000 megawatts." Nuclear power would "reduce the deficit … to only 7000 megawatts" and hence solve the energy crisis.[3]

Unfortunately, while the DAE has promised to end the energy crisis through massive nuclear expansions several times in the past, it has a sordid record of keeping its promises. Homi Bhabha, the first secretary of the DAE, announced in 1962 that installed capacity would be 18–20 GW by 1987.[4] Alas, by 1987, the DAE succeeded in installing only 1.06 GW—about 5% of Bhabha's predictions.[5] Vikram Sarabhai, who succeeded Bhabha, admitted that "the program has slipped badly in relation to targets" and said that "we have a formidable task to provide a new atomic power station of approximately 500 MW capacity each year after 1972– 73."[6] In fact, India's first 500 MW reactor—Tarapur 4—went online in 2005, almost 35 years later. Anil Kakodkar, who gloriously predicted a 150-fold expansion by 2050, also predicted in 2003 that "in about four years from now, DAE will reach an installed capacity of 6800 Mwe."[7] Eight years later, the DAE's nuclear capacity is only 4780 MW.[8]

Not only has the DAE failed to produce energy on a large scale, but the little it has produced has not been economically competitive. A detailed study by Ramana, D'Sa, and Reddy showed that, when various subsidies are taken into account, nuclear power produced in India's indigenous plants is not cost-competitive with coal even for (real) discount rates as low as 3 per cent.[9]

The government plans to use its new found access to international nuclear markets to import various reactors.

However, these promise to be even more expensive. The first set of plants to be installed under the aegis of the nuclear deal are a set of European Pressurized Reactors (EPRs) designed by the French company Areva. The government is planing a massive nuclear complex in Jaitapur (Maharashtra), where it will put together 6 EPRs with a total capacity of almost 10,000 MW. It is rather strange that the Indian government has such ambitious plans involving the EPR, since not a single such reactor is in commercial operation anywhere in the world. Both EPRs currently under construction—one in Olkiluoto (Finland) and the other in Flamanville (France)—are years behind schedule and heavily over their already exorbitant budgets. The latest estimates for their construction costs are around 8 billion USD. It is hard to imagine that with such heavy capital costs, these reactors will be even close to competitive in India.

The other problem is that the local people of Jaitapur are determined in their opposition to this nuclear

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complex. According to media reports, of the 2,375 families eligible for compensation, only 114 have accepted the package offered by the government.[10] When Maharashtra's Chief Minister visited Jaitapur in February, he was rebuffed by a large number of protestors.[11]

The government's response to these protests has been repressive. In December 2010, one activist died when he mysteriously met with an accident involving a police jeep.[12] In April 2011, another activist died in police firing,[13] and a yatra from Tarapur to Jaitapur led by activists and several eminent citizens was blocked by the police.[14] Several others, including the sarpanch of Madban, a village close to the proposed reactor site, have been served notices asking them to leave the area.[15] According to media reports, Narayan Rane, a former chief minister of Maharashtra, threatened activists from neighbouring districts, saying, "No outsider who comes to Jaitapur to oppose the project will return"![16]

"after Fukushima, the head of the [Department of Atomic Energy] explained that there was no need to link the disaster to nuclear safety at all since what had happened was 'purely a chemical reaction and not a nuclear emergency'."[21]

Similar protests have started at other sites where the government plans to plant the fruits of the nuclear deal, including the two sites that have been reserved for US-made reactors—Kovvada in Andhra Pradesh and Mithi Virdi in Gujarat. In Mithi Virdi, local villages are closely monitoring roads leading to the area, to keep government surveyors from entering the territory.[17] At Kovvada, according to media reports, a navy helicopter crew was confronted by fisherfolk who were under the impression they were from the DAE.[18]

These protests only gained momentum after the disaster in Fukushima. However, the government has repeatedly clarified that it will ignore these expressions of popular will. In fact, as concerns about the nuclear expansion gathered steam, the government held an important meeting on 26 April 2011— the 25th anniversary of Chernobyl—involving Prime Minister Manmohan Singh, Chief Minister of Maharashtra, and several other senior members of his government, and reiterated its determination to forge ahead without any change of plans.[19]

One of the major concerns of the local people has to do with safety, but the government dismisses this. Very recently, in August 2011, the Prime Minister explained in parliament that there was no reason to worry about the safety of Indian nuclear facilities, which are "world class".[20] It is hard to take this at face value, given that after Fukushima, the head of the DAE explained that there was no need to link the disaster to nuclear safety at all since what had happened was "purely a chemical reaction and not a nuclear emergency."[21]

In fact, the government of India is well aware, as are nuclear manufacturers, that their plants can undergo massive accidents. This is why it spent several months in 2010—keeping aside almost all other legislative work in the parliament—framing a nuclear liability law that would protect the interests of multinational suppliers in the event of an accident. The major feature of this bill is that it prevents Indian victims from filing compensation claims against nuclear suppliers.[22] These claims must be directed towards the Indian company that operates the plants, but even the liability of the operator is limited to Rs. 1,500 crores (about USD 300 million). This is absurdly low compared to estimates of the damage that will be caused by a Fukushima-type accident, which run into hundreds of billions of dollars.

Why would the Indian government, given the history of the Bhopal disaster, expend political capital in passing a law that takes away a fundamental right of Indian citizens and protects multinational suppliers from the consequence of an accident in one of their reactors? Who does this law benefit?

The answer was laid out by Robert Blake, a senior official in the US State Department, who sternly told the Indian government in May 2010 that the US expected India to pass legislation "consistent with the Convention on Supplementary Compensation (CSC)" since this "would provide a very important legal protection and open the way for billions of dollars in American reactor exports and thousands of jobs [in America]."[23] Four days later, India's Foreign Minister SM Krishna genuflected in front of the US-India Business Council, assuring it that "The Government [of India] is committed to put in place a nuclear liability regime ... [and] we look forward to US companies investing in India."[24]

In fact it is this desire to please the US and other Western countries at any cost that explains the Manmohan Singh government's actions in favour of nuclear energy. A close reading of the government's statements reveals a clear understanding of this process. For example, writing for Sakaal Times, in Marathi, Anil Kakodkar candidly explained, "we also have to keep in mind the commercial interests of foreign countries and of the companies there ... America, Russia and France were the countries that we made mediators in these efforts to lift sanctions, and hence, for the nurturing of their business interests, we made deals with them for nuclear projects."[25]

Evidently, this nurturing of foreign business interests has been so important to the Manmohan Singh government that it has been more than willing to sacrifice the rights of its citizens. Hence, the question of nuclear energy in India is, at its heart, a political question. The ruling Congress party and even the major opposition Bhartiya Janta Party share a vision in which India will rise to dominance in South Asia, with American help, and by fulfilling the American need for a counterweight to China. The planned nuclear expansion, which involves the purchase of billions of dollars of Western reactors, ties India up into Western-controlled fuel markets and serves as a symbolic flagship for this vision. However, it is clear that the end of this road does not involve India's emergence as a "great power" but rather as a subordinate client state. While this status certainly holds benefits for a small but influential minority of the population, it comes at a tremendous cost to the Indian people. Arrayed against this vision are the various peoples' resistance movements, including those that are working to stop the Indian nuclear expansion. If they succeed, they will not only win a local victory but take an important step towards articulating an alternate vision for India—one that rejects capitalist and imperialist dominance and is instead based on equity and representative democracy.

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photo: Press Trust of India

Israel

Sharon Dolev

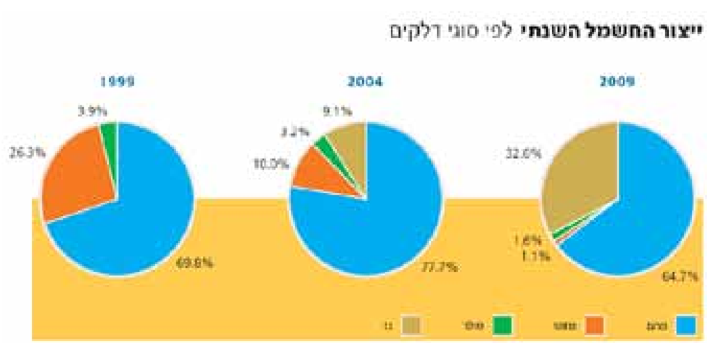
Although Israel has an Atomic Energy Commission and two nuclear reactors, it does not have nuclear energy. The electricity market in Israel today produces approximately 11,000 Megawatts per-hour and is expected to double itself by the year 2030.[1]

Currently, 99.9% of the total mix of fuels used in Israel for electricity comes from fossil fuels and 0.01% from renewable energy sources, despite a government decision in November 2002 that by 2007, 2% of the electricity produced in Israel would come from renewable energy sources and that this figure would increase by 1% every three years.

Approximately 60% of the electricity produced in Israel comes from coal-burning power plants and the remainder mostly from power plants that operate on steam or gas turbines and plants that had in the past burned diesel or oil fuel and are gradually being converted to natural gas plants.

Until recently, Israel was receiving a steady supply of natural gas from Egypt, but the pipeline for this gas has been repeatedly cut following the Egyptian revolution. In late 2010, natural gas reserves were discovered off the shores of Israel with the finds expected to provide a growing proportion of Israel's electricity (although Israel and Lebanon assert competing territorial claims regarding some of these reserves). Plans to construct a new coal power plan in Ashkelon were cancelled and replaced with plans for the construction of a gas power plant that could be converted to coal if necessary.[2]

Graph 1: Electricity production per annum by fuel type



Blue: coal; Red: oil; Green: disel; Brown: gas
Source: Israeli electricity company report, 2009

The electricity market in Israel is a unique type of "energy island," as the country cannot receive electricity directly from its neighbors. The need to diversify fuel sources and the importance of energy independence, not to mention the need to cut carbon emissions, have not in recent years prompted Israeli administrations to encourage renewable development through providing adequate subsidies and financial incentives for renewable energy.[3]

Forecasts for Israel's electricity market

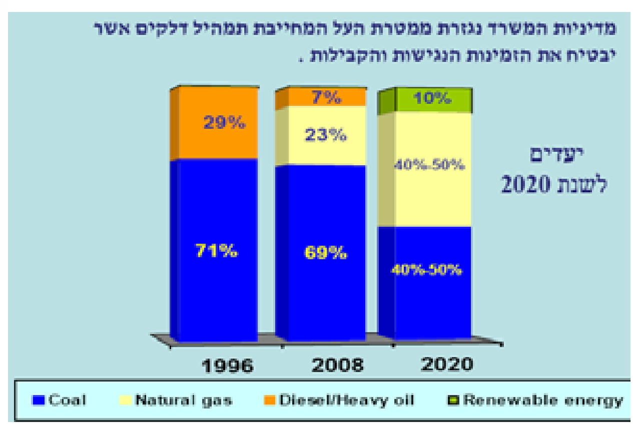
Since the creation of the state, Israel's electricity market has been designed to meet electricity needs reliably and without blackouts. The demand for electricity, however, is inconsistent with and subject to change throughout the day and in accordance with industry needs and the weather. The demand for electricity usually peaks during a few days in the summer and in the winter, when the weather is at its most extreme.[4]

These few hours or days of the year are the principal justification for claims by the Ministry of National Infrastructure and the Israel Electric Corporation that starting in 2013, Israel will experience "electricity droughts". On the basis of this justification, these bodies are calling for the construction of new power plants: coal-burning power plants and nuclear power plants.[5]

As part of its efforts to address Israel's electricity problems, the government decided in September 2008 to construct a "virtual power plant," that is, to invest in economical and efficient approaches aimed at reducing expected electricity production by 20% by the year 2020.[6]

Air conditioning in nearly every home, modernization, and the steep rate of population growth (resulting from high birth and immigration rates) are the principal factors behind the continual increase in electricity demand, which is even predicted to double over the next 20 years.[7]

Graph 2: Government policy—Projected goals for 2010



Source: The National Infrastructure Ministry[8]

A classified document of the Ministry of National Infrastructures, which was leaked approximately three ago, stated that by the year 2020, approximately 10% of the electricity in Israel (presumably measuring 16,000 Megawatts/hour) would come from nuclear energy.

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Israel and Chernobyl

Although a nuclear discourse hardly exists in Israel, almost every Israeli has heard of Chernobyl, the most salient nuclear disaster prior to Fukushima. Israel has the fourth largest number of Chernobyl survivors (after Russia, Belarus, and the Ukraine) because of the large immigrant influx from the former Soviet Union. In addition, Israel is home to approximately 1,200 liquidators, those engineers and workers who were dispatched to seal off and cool the reactor after the accident. Although liquidators have been granted many rights in the Ukraine, they lost all such rights when they immigrated to Israel, where they live in poverty. The liquidators' organization in Israel has been struggling for many years to have their suffering recognized and compensated, and—symbolically and chillingly—succeeded in their demands during the very week in which the Fukushima disaster occurred.

The Immigrants' Health Center in Haifa monitors the condition of liquidators and Chernobyl survivors. According to the data it has gathered, approximately 330,000 immigrants from the contaminated area—in Russia, the Ukraine, and Belarus—reside in Israel today. In recent years, over 80,000 immigrants (23,000 of whom are children) have sought assistance from the center. In contrast to the assessment of other Israeli experts, the center has found that the rate of cancer among its clients is 15% higher than that of the general Israeli public. Tests conducted in cooperation with the Carmel Medical Center found that the rate of illness among "Chernobyl children" was significantly higher than the rate among children born in Israel. "We wrote letters to the Ministry of Health and the national healthcare programs requesting attention to these problems," Dr. Vladimir Ganish of the center told *Haaretz* newspaper, but "to date, we have not received any reply."[9]

"Although the word "Chernobyl" still frightens most Israelis, scientists and the nuclear lobby in Israel argue that the Chernobyl reactor was old and the cause of the accident was human error that could not occur in Israel."

Although the word "Chernobyl" still frightens most Israelis, scientists and the nuclear lobby in Israel argue that the Chernobyl reactor was old and the cause of the accident was human error that could not occur in Israel. Moreover, according to nuclear energy proponents, Chernobyl and Fukushima are isolated accidents in a world where hundreds of nuclear reactors operate.

Reactions to Fukushima

Since the 1950s, Israel's policy of nuclear ambiguity has dominated the Israeli discourse on all nuclear matters—civil as well as military—that relate to Israel in any way. The Israeli perception is that nuclear weapons are the foundation of the country's survival and, therefore, any discussion of the matter could undermine ambiguity and endanger the state.

The policy of ambiguity results not only in a paucity of discourse but also in a media that is ignorant of nuclear issues and does not know how to ask the right questions. It also results in a dearth of expert interviewees who can speak about nuclear energy from a critical perspective. Thus, during the 10 days following the Fukushima disaster, when the Israeli media did address the nuclear issue, there were no more than eight interviewees who repeatedly met on the various panels or surfaced in the media stories dealing with this issue. These included two or three opponents, one energy expert who refused to take a stand one way or the other, and professors of nuclear physics who have some tie, past or present, to the reactor in Dimona and who defended nuclear energy while playing down the impact of the Fukushima disaster.

The Fukushima disaster was an inauspicious springboard to a public debate on the nuclear issue within Israel. Approximately four days after the disaster, Prime Minister Binyamin Netanyahu stated in an interview with CNN that the situation in Japan "is a confluence of a natural disaster and a man-made disaster,"[10] adding that "the cloud of radioactivity and the uncertainty of what will happen is the cloud that hangs over the people of Japan, and I think right now, hangs over the world."[11] According to the Israeli prime minister, the severe effects of the earthquake on the Fukushima reactors "certainly caused me to reconsider the projects of building civil nuclear power plants. I have to tell you I was a lot more enthusiastic about it than I am now."[12]

Simultaneously, and perhaps not coincidentally, the chairman of the Israeli Electric Corporation, Yiftach Ron-Tal, stated in a conference in Eilat, held on 14 March 2011, only two days after the Fukushima disaster, that "in a decade we'll have an advanced nuclear reactor in the northern Negev. To the best of my understanding, Israel should construct a reactor and already has a planned location—Shivta."

One of the changes within Israel since the Fukushima disaster is the degree of citizens' concern about radioactivity. Once a matter that was not heard about or discussed, radioactivity has now become a hot topic in the news. Dr. Gustavo Hakim, head of radiation safety at the Soreq Research Center, told reporters that not only does the Ministry of Health intend to send food samples from Japan to be tested before marketing them in Israel, but also that his department has been receiving calls from citizens asking whether the Toyotas or iPhones they ordered are safe.

Such examples might be trivial elsewhere, but the questioning of nuclear issues in Israel is a novel and noteworthy development.

We have a Commission, but where is the energy?

As noted, Israel has an Atomic Energy Commission but no atomic energy. Israel has two nuclear reactors: the first began operating in 1960 at the Soreq Nuclear Research Center and is subject to International Atomic Energy Agency (IAEA) safeguards. The 5 Megawatt reactor is operated six hours per day, two days a week, forty weeks per year for the purposes of nuclear research and the production of diagnostic and medical materials. The reactor is scheduled to be shut down and replaced with a small particle accelerator. In 1990 an accident at the reactor led to the death of a worker who was exposed to radiation.[13]

The second reactor, constructed with a capacity of 26 Megawatts using French technology and operating since 1963, is located at the Negev Nuclear Research Center near Dimona. According to foreign sources, its primary purpose is the production of nuclear weapons. The reactor is not subject to IAEA safeguards. In recent years, at least 45 lawsuits have been filed by former employees of the center (or their surviving family members) against the Atomic Energy Commission, claiming that they received inadequate protection while working with radioactive materials. Most of these claims were not successful, and those that were successful (resulting in out-of-court settlements) usually entailed confidentiality agreements requiring secrecy on the part of former employees or their families.[14]

According to various publications, the reactor's capacity has been significantly increased since construction. Considering that its original lifespan was 40 years (i.e. until 2003), questions about the safety of continued operation surface from time to time. The location of the reactor, adjacent to the Syrian-African Rift, also raises questions about its ability to withstand a natural disaster even though it operates at a significantly lower capacity than the large reactors in Japan. The Atomic Energy Commission has responded only by saying that there is no cause for concern.

Israeli plans to construct a nuclear power plant date back to the 1960s. A site considered geologically and environmentally appropriate—near Shivta in the Negev—was chosen and has been retained for this purpose to this day. Another site that has been identified as appropriate for a civilian nuclear reactor is located in Halutza (also in the Negev), where there is enough land for four reactors operating at 1,000 Megawatts each.

Since the mid-1970s, various agreements have been signed or pursued for energy reactor construction, but were eventually unsuccessful. The first of these, an agreement with Westinghouse for the purchase of a 900 Megawatt reactor, was cancelled following a decision by the Carter administration that assistance in nuclear technology would only be granted to members states of the nuclear Non-Proliferation Treaty, which Israel has refused to sign. In 1983 Israel undertook ini-

photo: Dimona nuclear facility

tial contacts towards the purchase of two 950 Megawatt units produced by the French company Framatome, but after the election of President Jacques Chirac, this channel too was frozen. Another effort, aimed at German-Israeli cooperation in the development of a fourth generation pebble-bed modulated reactor, was abandoned after the German Greens came to power. Contacts with senior officials of the former Soviet Union for the purchase of a Russian reactor were also fruitless.

Will Israel acquire nuclear energy?

Israeli plans for a civilian nuclear program have been on the shelf for many years and will apparently remain on the shelf for years to come. Efforts to advance nuclear energy in Israel seem to come in waves—the last wave having begun approximately three years ago with the leak of a purportedly secret document detailing the projected energy market for 2020. The document, which found its way to the e-mail inbox of a reporter who covers environmental issues, explicitly describes nuclear energy as accounting for 10% of the energy sources in Israel in the year 2020.

That document was followed by other developments that included the lengthy and well publicized visit of French President Nicolas Sarkozy, who was simultaneously promoting the European Pressurized Reactor (EPR); the US-India deal, which motivated Israel to explore the criteria by which it might also be considered a "responsible" nuclear state;[15] the announcement at a conference in France by then-Minister of National Infrastructure Uzi Landau that Israel would also rely on nuclear energy; and the more recent announcements by the chairman of the Israel Electric Corporation. These developments combine to form the most visible pro-nuclear energy wave in Israel since the creation of the state. It appears that a small dam has burst within the murky rivers of ambiguity.

Nuclear energy has enthusiastic proponents within Israel. The nuclear lobby comprises members of the Atomic Energy Commission, Israeli nuclear scientists, the Ministry of National Infrastructure (particularly Chief Scientist Shlomo Wald, who worked at Dimona), and most of the professional staff engaged in preparing reports and recommendations for the Knesset (parliament), institutes, and conferences dealing with Israel's energy future. The statement by President Shimon Peres at the 2009 UN Climate Change Conference in Copenhagen, in which he said that Israel would reduce its greenhouse gas emissions by 20% by the year 2020, also encouraged the nuclear lobby, which argues that nuclear energy is a preferred approach for reducing such emissions in Israel.

At the same time, the Fukushima disaster as well as the dismal reports about progress in the construction of EPR reactors have caused the drafters of various reports to qualify their recommendations and support for nuclear energy in Israel, asserting that fourth generation reactors would be preferable. Israel is a small country located on the Syrian-African Rift. A nuclear meltdown in a large reactor would endanger the entire country. Yet, it seems that with all of the above, that the Ministry of National Infrastructure is preparing a new push for an energy reactor plant. It was revealed in September 2011, that the Ministry had commissioned an external body to conduct a feasibility study for the construction of a reactor with a 1,200MW capacity. The study will deal, among other things, with the possibility of declaring the extra-territoriality of the intended reactor plant site at Shivta.[16] Other sources revealed that the 10 month contract for the study was issued without a public tendering process and cost circa US$32,200.[17]

However, the wait for what is essentially futuristic technology, combined with Israel's unwillingness to submit its nuclear facilities to inspection or even discussion; the difficulty of finding partners for nuclear deals; and the complexities inherent in constructing a nuclear reactor, makes it highly doubtful that Israel's 2020 energy mix will include nuclear power. If nuclear power does become part of this mix, it will only be towards the year 2030, but that too is doubtful.

Notes

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3. Ibid.
4. Mor Amit, Sarousy Shimon, and Laster Yuval, A*lternative Energy and Open Spaces*, Report of Eco-Energy for the Deshe Institute, 2008 (Hebrew).
5. Ibid.
6. National Plan for Energy Efficiency, Ministry of National Infrastructures, 2010 (Hebrew).
7. *Towards 2030, op. cit.*
8. *National Plan for Energy Efficiency*, Ministry of National Infrastructures, 2010 (Hebrew).
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11. Ibid.
12. Ibid.
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14. Ibid.
15. Lavi Aviv, "Doesn't stop in Green", *Maariv*, 18 March 2011.
16. Gutma Lior and Avital Tomer, "Gov't reexamining nuclear power plant," *Calcalist*, 30 August 2011.
17. Bar Eli Avi, "Infrastructure ministry hired an advisor for a nuclear power plant," *The Marker*, 1 September 2011.

Italy

Roberto Meregalli and Lisa Clark

In 2009 Italy's energy consumption was 180.3 Mtoe.[1] The energy mix is: 41% oil, 35.5% gas, 7% coal.

- Sources of oil: 35.2% from Africa, 34.1% from former Soviet Union countries, 26.6% from the Middle East.
- Sources of natural gas: about 33% from Russia, 30% from Algeria, 13% from Libya.
- Sources of coal: 38.8% from Indonesia, 25.8% from South Africa, 11% from Colombia.
- Energy from renewables is constantly increasing: in 2009 it accounted for 11% of the total.

About 55 Mtoe of primary energy are used to generate electricity, accounting for 15.4% of the total in 1990 and 18.8% in 2008. Electricity consumption in 2009 was 299.9 billion kWh, plus 20.4 billion lost in the transmission grid: thus, total demand was 320.3 TWh. This figure is 5.7% lower than 2008; but in 2010 demand rose again, reaching 326 Twh.[2] The trend in Italy is comparable to the rest of Europe, where the decline in 2009 was 4.9% and the increase in 2010 was 3.6% (Eurostat).

In electricity generation, the share of renewable energy sources (RES) is twice as high as in the overall energy consumption. In 2009 the RES share was 21.2%; fossil fuels accounted for 63.4%, primarily natural gas (44.7%), followed by coal and a residual share of fuel oil (7.5%), being phased out. According to Enerdata (www.enerdata.net) the share of electricity generated from RES increased to 26.3% in 2010, placing Italy in fourth place worldwide (the official Italian figures from Terna are lower). Italy was also fourth in the world in 2010 in terms of year-on-year growth of RES electricity capacity installed.

The yearly growth rate of electricity demand has decreased: in 1960–1969 it was 8.3% per year, in 2000–2009 it had dropped to 1.2%. The reduction over the past two years has certainly been influenced by the global crisis, but the decrease is definitely part of a long-term trend. Terna (the Italian TSO that manages the transmission grid) forecasts a mean annual growth rate of electricity demand at more or less 1.3%, giving a figure of 370.0 TWh for 2020. The National Action Plan for Renewables, presented by the government in June 2010, has set a goal of 99 TWh[3] from RES for 2020, which would be 26,7% of total demand — a rather modest goal, considering that in 2010 it was already 26.3% (according to Enerdata) or 24.69% (according to Terna).

The development of RES benefits from the support and incentives provided by local government authorities (essentially Regions), but was hampered in 2010 and 2011 by the national government, which announced, then cancelled, then partially re-instated subsidies and incentives, making large-scale and long-term planning very difficult.

Table 1: Gross electricity generation 2005–2010 (GWh)[4]

	2005	2008	2010
Hydro	42,297	47,227	53,771
Oil	35,846	19,195	10,850
Gas	149,259	172,697	153,800
Nuclear	-	-	-
Renewables	12,517	16,541	24,688
Coal	43,606	43,074	37,900
Other-Thermal	19,517	20,396	17,200

The Italian Nuclear Experience (Old Nuclear)

This historical experience is linked to Enrico Fermi: in the 1930s he brought together at Rome University a group of brilliant young researchers including Franco Rasetti, Emilio Segrè, Edoardo Amaldi, as well as Ettore Majorana (whose sudden disappearance has never been explained), and later Bruno Pontecorvo. These researchers were known as the Via Panisperna Group, but their work ended when Fermi moved to the USA to escape the consequences of the infamous Italian Race Laws, passed in 1938. It was in Chicago, on 2 December 1942, that Enrico Fermi achieved the first controlled chain reaction. The first experimental reactor, however, was not built until 1959 at Ispra (handed over to Euratom as a Joint Research Centre in 1960).

Over the following years Italy commissioned three commercial reactors, with different technologies: a PWR from Westinghouse (USA) for Trino Vercellese; a BWR from General Electric (USA) for Garigliano, and a Magnox GCR from NPCC (UK) for Latina. They all entered into activity in 1963–64. (It is worth noting that the site for the Trino plant had to be changed due to strong local opposition near Genova, where it had originally been planned.)

In the 1970s, the Ministry of Industry drafted several national Energy Plans envisaging the construction of further plants. By the end of the 1970s, the only one of these new plants to begin production was the 830 MW BWR at Caorso, built by Ansaldo on a project by General Electric. And by late 1986 the only other plant whose construction was reasonably advanced was the one at Montalto di Castro (construction was many years behind schedule due to opposition by public opinion).

The nuclear accident at Three Mile Island in 1979 further raised the concern of public opinion and the Chernobyl explosion in 1986 consolidated a broad-based opposition to nuclear energy production in the country.

In 1987 a referendum was held (the Italian Constitution allows for referenda to be held in order to repeal

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existing laws, not to draft new ones). There were three questions: 1. repeal the option for the Government to overrule a Local Authority in deciding where to locate a nuclear power plant; 2. repeal the decision to compensate economically local communities for hosting a nuclear power plant on their territory; 3. repeal the authorization given to ENEL to participate in nuclear power joint ventures abroad. Although the campaign was launched initially (long before Chernobyl) by environmentalists, by the time it came to the vote (November 1987) all major political parties supported the first two questions (and the parties of the left supported the third). Although technically the people's vote did not spell the immediate end of nuclear power, the referendum made it impossible to proceed with new plants. Futhermore, the campaign had won over all major parliamentary parties. The Chamber of Deputies (Lower House of Parliament) voted on 12 June 1990 to shut down indefinitely the two nuclear power plants that were still in activity at the time, Trino Vercellese and Caorso, and to stop construction work on the plant at Montalto di Castro.

photo: hidden side/flickr; Demonstration against nuclear power in Italy, 2011

Table 3: Italy's nuclear power plants[5]

	Borgo Sabotino (Latina)	Garigliano (Caserta)	Trino Vercellese	Caorso (Piacenza)
Reactor type	GCR	BWR	PWR	BWR
Net power MW	153	150	260	860
Connected to grid	May 1963	January 1964	October 1964	May 1978
Closed down	December 1987	March 1982	July 1990	July 1990
Total MWh produced	25,489.2 GWh	12,246 GWh	24,307.1 GWh	27,725.8 GWh

Several research reactors are still apparently operating including one at the University of Pavia and another at the ENEA Centre at Casaccia, just outside Rome.[6] Furthermore, at Saluggia (in the Region of Piedmont) there is a no-longer-active ENEA EUREX (Enriched Uranium Extraction) plant for the reprocessing of nuclear fuel. Within this facility there is also an inactive research nuclear reactor belonging to FIAT-Avio. The radio-chemical facilities of SORIN Biomedica, which began as a nuclear research company owned primarily by FIAT, still hold wastes and liquid resins that were used for the extraction of uranium and radioactive residue.

The Italian government's planned nuclear revival (2008–2011)

After the 1987 referendum, Italy's nuclear energy production appeared to be consigned to history. During the 2001–2006 Berlusconi Government there was much talk of a nuclear revival, but the only legislative action undertaken was in 2004, when a law was passed enabling ENEL to enter into joint ventures in nuclear power plants abroad.

In a bid to pave the way for reintroduction of nuclear plants in the country, the government also attempted to find a shortcut for the disposal of the nuclear wastes from the plants shut down in the 1980s and in 1990. Fierce popular opposition (not just from the locals) scuppered the plan to site a nuclear waste repository for the country's low- and intermediate-level waste in an old salt deposit at Scanzano Jonico. The site was also to house an interim store for the country's high-level waste and used fuel.

The Berlusconi government that came to power in 2008, however, launched a Nuclear Revival through a Ministerial Decree (25 June 2008) called "Urgent provisions for the economic development of the country". In the text, the government undertook to draw up a new National Energy Plan to include "the construction of nuclear energy production plants on national territory."

Further legislation was adopted, including the establishment of a national Nuclear Safety Agency (operational from July 2010); the physician and cancer specialist Umberto Veronesi was appointed President.

The government's strategic plan envisaged the construction of a sufficient number of reactors to supply 25% of the country's electricity demand, i.e. eight 1600 MW European Pressurized Reactors (EPRs). Italy's state-controlled electricity company, ENEL Spa, had already signed joint venture agreements with French EDF to build four of these plants, based on their existing partnership in the construction of a similar reactor in Flamanville, France.

Public campaigning against the re-introduction of nuclear power plants was, once again, initially led by environmental groups, but gradually garnered the support of a broad base of public opinion. The main points of the anti-nuclear campaigners[7] were: concerns over safety and nuclear wastes disposal; the potential of RES as capable of providing for an increasingly large share of electricity needs; awareness that even smaller investments in RES would create far more jobs than the huge investments needed for nuclear power stations; concerns over the lack of accountability of transnational Utilities. The campaign began before Fukushima but gained momentum thereafter: in December 2010, the Supreme Court ruled that the referendum was legitimate and could be held. The government attempted in several ways to obstruct it, including: 1. (in the attempt to curtail turn-out) setting the date for the consultation in mid-June, instead of holding the referendum on the same dates in May as the planned local elections; 2. shortly before the set date, the government amended its own law, declaring a one year moratorium, thereby making the proposed question on the (already printed) ballot papers unusable (referenda in Italy can only repeal laws, and the law the referendum aimed to repeal was no longer on the books). The Supreme Court, however, ruled on 1 June that the referendum could go ahead with a new wording to reflect the amendment in the law, and the ballot papers were reprinted at the last minute (Italians voting abroad, who had been sent their ballot papers earlier, had their votes cancelled).

Also worth noting is that, at the same time, the people were called upon to vote for other referenda, including against the privatization of water utilities. The two issues became closely interrelated during the campaign, mutually enriching the debate and public activism towards a new vision of the close connection between environmental and safety concerns and the need for greater democratization in the management and protection of the commons. The law on referenda in Italy requires a voter turn-out of over 50% of the electorate: in the event, over 57% of those eligible went to the polls on 12–13 June 2011, and 94.05% of voters confirmed that nuclear energy had no role in their vision of the future.

Italy's Nuclear Revival was stopped democratically before it ever began. And civil society benefited from a campaign that provided education, increased awareness, debate, and democratic participation in crucial decisions for the future of the country.

photo: Associated Press; Referendum sign in Florence, Italy: "Stop nuclear power, vote yes"

ENEL's international nuclear business

Although Italy no longer has any commercial reactors, Italy does own one of the main electricity utilities in the world: ENEL Spa, in which the Italian Government has a controlling interest of 31%, held by the Treasury and the CDP (Cassa Depositi e Prestiti, Italy's equivalent of a state investment bank). ENEL is an international group present in 40 countries on four continents; in Europe it is the second largest listed utility (for installed capacity). It produces, distributes, and sells electricity and gas globally, supplying more than 61 million clients with a net installed capacity of over 97,000 MW. Listed on the Milan Stock Exchange it is the Italian company with the largest number of shareholders: about 1.5 million in 2010.[8]

In 2010 ENEL produced 290.2 TWh, 14.2% from seven nuclear power plants in Spain and Slovakia.[9] ENEL is currently participating in the construction of its eighth plant (Flamanville) in France; and in Slovakia it is building two new VVER 440/213 reactors, involving an investment of 2.775 billion euros for a total capacity of 880 MW. These two reactors are identical to the first two, completed in the 1990s. The construction plan was approved in 1987, but work was suspended in 1992 due to lack of financing.

ENEL is also involved in the Cernavoda nuclear plant in Romania, a facility originally planned by former Dictator Ceausescu: five CANDU reactors, only two completed. Originally planned in 1980, the electricity generated in this plant was intended for sale abroad. The facility is located in a seismic area—there have been three strong quakes in the zone since 1979. ENEL holds a 9% interest in the consortium for the third and fourth reactors, each with a capacity of 750 MW. The entire project has been plagued by controversy: since 20 January 2010, ENEL is the only foreign company left in the consortium (the French GDF SUEZ, the German RWE and the Spanish Iberdrola have all pulled out).

ENEL is also involved in nuclear projects in Russia. On 26 April 2010, ENEL and Inter RAO UES signed an Agreement which includes the construction of a new nuclear power plant in Kaliningrad, the Russian exclave on the Baltic Sea. This plant will be the first public-private partnership in the nuclear sector in Russia and will comprise two 1,170 MW reactors, using third generation VVER 1.200 technology. Production is due to begin in 2016–18. But the project and location are opposed by a majority of the inhabitants, who cite the risk of water table contamination; hazards in transport of fuel/spent fuel to and from the enclave; the fact that the area lies under a busy international flightpath; and the lack of adequate safety provisions.

Decommissioning and nuclear waste disposal

In Italy, the decommissioning of the four nuclear power plants is underway. Experts estimate that total wastes will be about 60,000 cubic metres, subdivided as follows:

- 45,000 m3 of category 2 waste (ILW)
- 7,500 m3 of category 3 waste (HLW)

The Italian plan for the decommissioning of its nuclear power plants was drawn up by SOGIN (www.sogin.it). Italy has yet to establish a national repository. Originally the plan envisaged completion by 2019 for a total cost estimated at 4.3 billion euros. The estimate included three separate cost centres: 1. the disposal of fuel from the plants at Trino, Caorso and Garigliano, to be sent to France for re-processing; after treatment, will be stored in the national repository; 2. the disposal of SOGIN's share of spent fuel from the Creys-Malville plant; and 3. the disposal of fuel previously sent to the UK for treatment in the national repository.

- Estimated cost of decommissioning 4 nuclear power plants: 1,647 million euros;
- Estimated cost required for the shutdown of the fuel cycle: 1,193 million euros;
- Estimated cost for the decommissioning of fuel cycle plants: 1,042 million euros; and
- Estimated overheads to keep the national programme running: 447 million euros.

All costs are paid for through an additional levy, added to the electricity bills of all Italian customers.

To date, the fuel from Caorso plant has been entirely transferred to France and shipment of the fuel from Saluggia (the temporary repository) is ongoing. Shipment is mostly by train; and Italian authorities do not issue advance warning. French railway workers have lodged formal complaints. In an attempt to pre-empt demonstrations, Italian authorities tried to change the route, but Switzerland refused to grant permission onto its territory.

The wastes will be shipped back to Italy by 31 December 2025; by that date, a national repository must be operational. The overall cost estimate has—to date—risen to 5.2 billion euros, but it is unlikely that timing and costs will remain unchanged. Recently, the CEO of SOGIN, Giuseppe Nucci, expressed his concern: without an increase in investments, he stated, it will take 90 years to complete the process. If one were to take his statement literally, this would mean that, in the end, the entire plan will end up costing 100% more than the original estimate.

Notes

1. 2009 figure, from Italian Ministry of Economic Development report
2. Terna, FY2010 Consolidated Results, March 2011
3. 98.885 TWh to be precise
4. Figures from Terna
5. Source: IAEA International Atomic Energy Agency
6. The research reactor TRIGA Mark II, called RC-1, which stands for Reattore Casaccia 1, was built in the early 1960s by General Atomics: its power was originally 100 kW, increased to 1 MW in 1966.
7. See http://www.fermiamoilnucleare.it/
8. See www.enel.com.
9. Enel holds 92.06% of ENDESA and 66% of SE (Slovakia), as well as a 12.5% stake in the EPR (France).
10. Nucci's words, as quoted by Quotidianoenergia.it, 20 January 2011: "out of a totale value of 5 or 5.5 billion we are proceeding at a rate of 60 million a year. At this rate it will take us 90 years."

Japan

Philip White

Japan's first budget for nuclear energy was allocated in 1954. It was set at 235 million yen to match the mass number of uranium-235.[1] Nuclear energy was no easy sell just a decade after the dropping of the atomic bombs on Hiroshima and Nagasaki. The task was made even more difficult by the 1954 Bikini Atoll hydrogen bomb test. Fallout exposed the crew of Japanese fishing vessel the *Fifth Lucky Dragon* to radiation and consumers were panicked by contaminated tuna caught in the Pacific Ocean. In the face of these obstacles, an aggressive public relations campaign was launched. It was backed by the US government[2] and driven by Yasuhiro Nakasone, a young politician who later became a powerful prime minister, and Matsutaro Shoriki,[3] owner of the *Yomiuri Shimbun* newspaper. Public resistance was overcome and the movement against nuclear weapons was split between those who supported nuclear energy in its so-called "peaceful" form and those who opposed the use of nuclear energy for both weapons and civilian purposes. This prevented the development of a powerful national opposition campaign before nuclear energy became firmly ensconced politically and industrially.

Pre-Fukushima Dai-ichi: Japan in a nuclear league of its own

1.1 Unrealistic ambitions for greater reliance on nuclear power

Japan's first research reactor, JRR-1, located at Tokai Village about 120 kilometers north of Tokyo, achieved criticality for the first time on 27 August 1957. The first power reactor, Tokai-1 (166 MW), was connected to the grid in November 1965 and permanently shut down in 1998. It was a British-designed gas-cooled magnox reactor. All subsequent commercial power reactors were light water reactors. The first, Tsuruga-1 (BWR, 357 MW), began commercial operations in March 1970 and is still operating. The early light water reactors were built by US companies with Japanese participation. Gradually Japanese companies took over and now Japan's three nuclear power plant makers, Mitsubishi Heavy Industries, Toshiba, and Hitachi are leading players on the international stage.

Before the Fukushima Dai-ichi nuclear disaster, Japan had 54 operational power reactors, 30 boiling water reactors (BWR) and 24 pressurized water reactors (PWR), with a combined capacity of 49,112 MW. Together they generated around 30% of Japan's electricity. Three reactors were under construction, or about to begin construction and a further 11 were in the planning or licensing stages. Under the government's June 2010 Basic Energy Plan nuclear energy was slated to supply about 50 percent of electrical power by 2030. Increased reliance on nuclear energy was a central part of Japan's climate change response policy. However, peak demand for electricity has fallen steadily in recent years and plans for new reactors published annually in the Electric Supply Plan have been delayed year after year. Some proposed plants are decades behind schedule. To make matters worse, a series of scandals, accidents, and earthquakes has foiled every attempt to increase the capacity factor of existing plants.

1.2 Failed nuclear fuel cycle

Japan enjoyed a privileged position in the league of nuclear nations. It was the only country without nuclear weapons to have the full range of back-end nuclear fuel cycle facilities, from uranium enrichment to reprocessing and fast breeder reactors. In the late 1970s, just as the United States was moving to abandon reprocessing of spent nuclear fuel itself and encouraging other countries to relinquish their ambitions too, Japan was preparing to start up a research grade reprocessing facility at Tokai Village. Japan lobbied the US government vigorously, claiming that it was "a matter of life and death for Japan". Eventually the US government relented. It agreed to let Japan reprocess US-flagged spent fuel.

The full nuclear fuel cycle, including reprocessing and fast breeder reactors, was included in Japan's first nuclear energy plan in 1956. The general thrust of this policy has remained unchanged to this day, even though the fuel cycle component has been a conspicuous failure. The fast breeder reactor, the holy grail of nuclear power that is supposed to provide a virtually endless supply of energy by turning all the non-fissile uranium-238 into fissile plutonium-239, is 70 years behind schedule[4] and Japan still has not mastered reprocessing technology. The Rokkasho Enrichment Plant has underperformed and now no centrifuges are operating.

Japan Atomic Energy Agency's Monju prototype fast breeder reactor (280 MW) was shut down for over 13 years after a sodium leak and fire in December 1995. It was finally restarted on 6 May 2010, but on 26 August, less than four months later, there was an accident involving a device for loading and removing fuel and the reactor has been shut down ever since. It is uncertain whether it will be possible to fix the problem. Meanwhile, the commencement of commercial operations at Japan Nuclear Fuel Ltd's Rokkasho Reprocessing Plant, which is supposed to supply the plutonium for the fast

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Note: Since this articls was written, Japan's Prime Minister has been replaced. It is not clear what position Yoshihiko Noda, the new Prime Minister, will take on nuclear energy policy, but he is likely to be less positive towards phasing out nuclear power than his predecessor, Naoto Kan.

breeder reactor, has been delayed 18 times.[5] Problems with the Japanese-developed technology used in the high-level liquid waste vitrification facility may turn out to be unsolvable. The other key element of the plutonium use programme, referred to in Japan as "pluthermal" (the use of plutonium in light water reactors), started a decade late in November 2009, but it is uneconomic and can only ever make a marginal contribution to Japan's electricity supply.[6]

Post-Fukushima Dai-ichi: the tug of war

2.1 The fight for control of the energy policy review process

Responding to the Fukushima Dai-ichi nuclear earthquake disaster, on 18 April 2011 Prime Minister Naoto Kan stated that Japan's nuclear power policy would be sent back to the drawing board. In mid-March both the leader of the Opposition, Sadakazu Tanigaki, and the Chief Cabinet Secretary, Yukio Edano, had already questioned the viability of the existing policy. Prime Minister Kan clarified his position at a press conference on 13 July, stating that he believed Japan "should aim for a society that is not dependent on nuclear energy." He gave no details of how or by when this should be achieved. His statement has been interpreted as the personal opinion of a lame duck Prime Minister, but despite Kan's low popularity and differing views within his own Cabinet, the idea of a phase-out of nuclear power has attracted widespread support. This was inconceivable before the Fukushima Dai-ichi earthquake.

A review of the Basic Energy Plan commenced in June 2011. The panel that is leading the review handed down its interim report on 29 July. The interim report calls for reduced dependence on nuclear energy, but falls short of recommending a phase-out. It states that there will be no sacred cows and that sensitive issues, such as the nuclear fuel cycle, electric utilities' monopoly status over regional power markets, and the possibility of separating power transmission from generation, will be considered. It only offers basic principles, leaving the task of working out the details to the next stage of the review process. The aim is to propose a basic policy by the end of 2011 and finalize a "revolutionary energy and environment strategy" in 2012. A detailed policy proposal will be developed with input from bureaucratic entities, including METI's Resources and Energy Advisory Committee and the Japan Atomic Energy Commission. Based on the past records of these organizations, one would expect them to seek to minimize change.

There appears to be a tug of war for control of the review process between the Prime Minister and those seeking fundamental reform on the one side and industry and the mainstream majority within the Ministry of Economy, Trade and Industry (METI) on the other. A key issue is whether the process will be transparent, with room for public input. The Prime Minister has expressed his strong support for renewable energy and energy efficiency, appealing directly to the public through online internet discussions with live input from the public and participating in public meetings organized by civil society. During these events he expressed his belief that nuclear energy and pro-nuclear forces have been an obstacle to the dissemination of renewable energy and energy efficiency. So far no indication has been given of how civil society might have meaningful input into the official policy review process, but the involvement of the Prime Minister and other politicians in parallel civil society processes will make it harder to insulate the official process from outside views.

2.2 Uncertain future of Japan's nuclear power plants

Tokyo Electric Power Company (TEPCO), owner and operator of the Fukushima Dai-ichi Nuclear Power Station, has announced that Units 1–4 will be permanently shut down. This was unavoidable given that the reactor buildings of Units 1, 3, and 4 were destroyed by hydrogen explosions and Units 1–3 suffered core meltdowns. TEPCO has made no formal announcement about Units 5 and 6, but there is no prospect of receiving approval for the resumption of operations at these plants. The anger against TEPCO is too great. Fukushima Prefecture indicated its intention to shift away from nuclear power plants in a vision for reconstruction released for public comment on 15 July. Without support from the prefecture and local governments, TEPCO will have to abandon any hopes it might have entertained of restarting Fukushima Dai-ni Nuclear Power Station as well.

The situation regarding other nuclear power plants directly affected by the earthquake and tsunamis (Onagawa 1, 2, and 3, Higashidori, Tokai-2) remains unclear, but if the experience at the Kashiwazaki-Kariwa Nuclear Power Station after the 2007 Chuetsu-oki Earthquake is anything to go by, they will not be restarted for a long time, if ever.

The key questions concerning nuclear power plants not directly affected by the earthquake and tsunami are as follows:

- What will happen to currently operating nuclear power plants?
- What will happen to nuclear power plants currently under construction?
- What will happen to planned nuclear power plants?

There have been some major developments in regard to the first of these questions. The first dramatic move was Prime Minister Kan's 6 May 2011 announcement that he had requested Chubu Electric Power Company to shut down its three operating nuclear power plants at Hamaoka until the utility takes medium to long-term measures to protect against natural disasters, including tsunamis. Hamaoka was singled out because there is said to be an 87% probability of a magnitude

8 class earthquake occurring in its vicinity within the next 30 years. This was known before the Great East Japan Earthquake, but it was treated as an inconvenient detail that could be ignored. Kan's request to Chubu Electric had no legal force, but Chubu Electric reluctantly complied.

Other nuclear power plants were allowed to continue operating until their next periodic inspection falls due, but there is great uncertainty about whether local and prefectural governments will approve their restart after inspections are completed. On 18 June, the Minister for Economy, Trade and Industry, Banri Kaieda made a statement requesting local and prefectural governments to approve restart if plants are ruled to be safe by the central government. However, on 6 July Kaieda reversed his position under orders from the Prime Minster, stating that plants must first undergo stress tests along the lines of those to be conducted in Europe.

There is still no clear indication regarding the second question, except that construction will be delayed. There are two plants currently under construction and one which has received safety approval, but (depending on the definition) has not formally commenced construction. The two under construction are Ohma in Aomori Prefecture in the far north east of the island of Honshu and Shimane-3 in the south west of the same island. A new plant at Higashidori (owned by TEPCO, not to be confused with the plant of the same name owned by Tohoku Electric) was given safety approval on 24 December 2010.

It is generally assumed that plants that have not yet received approval will not be built, certainly not for the foreseeable future. The most advanced plan was the Kaminoseki Nuclear Power Plant on the Seto Inland Sea in the west of Honshu. Although it is still undergoing a pre-construction safety review, it has already received local approval for preliminary landfill and sea reclamation work. Little progress has been made due to determined grass roots opposition. The Kaminoseki campaign has received strong support from national and international scientific groups who are concerned about the damage to the ecology of the Seto Inland Sea. Three days after the Fukushima 11 March earthquake, the governor of Yamaguchi Prefecture, where the plant is located, called for a halt to the landfill and sea reclamation work.

2.3 Nuclear fuel cycle a litmus test

As a result of the 11 March earthquake, offsite power was lost at nuclear fuel cycle facilities in Rokkasho, Aomori Prefecture and spent fuel pools at the Rokkasho Reprocessing Plant overflowed, but no serious damage was reported. That is probably why initially there was little public discussion of the implications of the Fukushima Dai-ichi disaster for nuclear fuel cycle policy. However, in the context of the wider review of energy policy, nuclear fuel cycle facilities are coming under increasing scrutiny.

The future of the fast breeder reactor (FBR) programme was put in doubt when target dates for the FBR demonstration reactor to succeed Monju and commercialization of FBRs were deleted from the latest Science and Technology White Paper, approved by Cabinet on 12 July. A few days later, on 15 July the Minister for Education, Culture, Sports, Science and Technology, Yoshiaki Takaki, responded in the affirmative to questions by reporters about whether the possibility of abandoning Monju would be considered in the energy policy review. It is impossible at this stage to predict what the outcome of that review will be. However, given the centrality of the fast breeder to Japan's existing nuclear policy, in spite of the failure of the program by any objective measure, its treatment in the current policy review could be a litmus test to show just how much the nuclear lobby's power has been dented by Fukushima Dai-ichi.

photo: Anti-nuclear protest in Tokyo, April 2011

There has been some public attention to the fact that Fukushima Dai-ichi Unit 3 was operating with a load of MOX (mixed oxide of plutonium and uranium) fuel when the earthquake struck. So far it is too early to say whether this made a significant difference, but in theory it could have made the situation worse. MOX fuel has a lower melting point than regular uranium fuel, so the risk of meltdown is higher. As noted in the chapter on the Fukushima Dai-chi nuclear disaster, it has been suggested that there was a second meltdown at Unit 3 several days after the initial meltdown and hydrogen explosion. Another problem with a reactor operating on MOX fuel is that the inventory of radioactive material is higher than for uranium fuel. This difference becomes increasingly significant the longer the fuel is irradiated. In the case of Fukushima Unit 3, the reactor was started up with its first load of MOX fuel on 18 September 2010, just six months before the accident. It was fortunate in this case that there was no spent MOX fuel in the spent fuel pool of Unit 3, because the current load was the first time MOX fuel had been used.

2.4 Public opinion favors a phase-out

According to recent public opinion polls, about 80 percent of people are in favor of a phase-out of nuclear power.[7] The shift would probably have been even more dramatic if the Japanese population had not been indoctrinated over the past fifty years to believe that "resource poor Japan" has no choice but to rely on nuclear power. Countering this perception are high profile people such as Masayoshi Son, President of Softbank Corp and Japan's richest man. Son has garnered the support of 36 of Japan's 47 prefectures for an initiative to reduce dependence on nuclear power by promoting renewable energy, including building solar power plants on idle farmland.

Issues

3.1 Short, medium and long-term management of Fukushima Dai-ichi

The top priority for the short to medium term will be cooling the reactors and preventing further releases of radioactivity. Radioactivity continues to leak out of the plant, though at a greatly reduced rate. The potential remains for further massive releases, particularly to sea, and even when the reactors are brought to cold shutdown they will still have to be cooled for many years.

Decommissioning the plant will challenge the ingenuity of scientists, technicians, and administrators for decades. Removing nuclear fuel from full-scale power reactors when the fuel has melted down and probably melted right through the pressure containment vessel will be particularly difficult. Clean-up of the site as a whole, which is contaminated with radioactive rubble, sludge and water, will be a massive undertaking. Nobody knows to what extent such a cleanup will be possible. No doubt there will be plenty of work for the nuclear industry cleaning up its mess.

3.2 Protecting the public

Japan is currently applying emergency radiation standards for workers at the Fukushima Dai-ichi Nuclear Power Station, evacuation of the general public, and food and water regulation. The radiation doses permitted under these standards are very high and certainly inappropriate in the long term, but the government does not have a strategy for returning to pre-Fukushima standards. The government has a responsibility to protect the public and to minimize the impact on health and welfare, but Japanese society as a whole must be fully involved in judging tolerable levels of radiation exposure and determining how to respond to the problems created by the Fukushima Dai-ichi disaster.

3.3 Generating political will for a phase-out

There is public support for a nuclear phase-out, but it is far from certain that this will be translated into political action. Japan is already on a nuclear phase-out trajectory. Assuming that approval for reactor life extensions beyond 40 years is not granted, in the absence of new build the last nuclear power plant will shut down by 2049. But Japan has to move faster than this if it wants to capitalize on the global shift to renewable energy and energy efficiency.

The policy review process as it currently stands is neither transparent, nor open to meaningful public engagement. For the time being, pressure from outside is sufficiently strong that public opinion cannot be completely ignored, but unless the process is democratized, it is doubtful that even a proactive prime minister will have the power to set Japan on the path to becoming a nuclear free society.

3.3 Improving safety of existing nuclear facilities

The debate about stress tests and doubts about local approval for restart after periodic inspections creates the potential for nearly all of Japan's nuclear power plants to be shut down at once. (As of 10 August 2011 only 15 of Japan's 54 reactors were operating.) Some people believe that it is both possible and desirable to shut down all Japan's nuclear power plants now, but unless public opposition to restart reaches unprecedented proportions, Japan is likely to continue to operate some nuclear power plants for the foreseeable future.

None of the existing nuclear facilities are designed to withstand an earthquake of the magnitude of the Great East Japan Earthquake. The reason for this gross regulatory failure is that Japan's nuclear regulatory system was compromised from the start. The regulator and promoter of nuclear power are part of the same organization, so construction and operation of nuclear power plants and nuclear fuel cycle facilities have been prioritized over safety.[8] The first step to asserting the primacy of safety is to separate the nuclear promotion function from the nuclear regulation function. Given the incestuous nature of the nuclear industry, bureaucracy, and academy and the vested interests involved, few believe this will be enough, but it is an essential first step.

If the Japanese government wants to avoid the situation where all nuclear power plants are shut down by next spring, it will have to complete stress tests before this bureaucratic separation is complete, but there is no chance that the public will trust the outcome of stress tests assessed under the existing regulatory system. One possible way of addressing this problem is to institute an international review process. The final decision would remain with Japanese authorities, but exposing their decisions to international scrutiny would force them to justify their judgments. On 28 July, Yukiya Amano, Director General of the International Atomic Energy Agency (IAEA), offered to have his agency review the results of Japan's stress tests. He also touched on the issue in his statement to the IAEA Ministerial Conference on Nuclear Safety on 20 June. International scrutiny of the Fukushima Dai-ichi disaster has already forced Japan to divulge more information and to change its tune on some issues, so one would expect IAEA scrutiny to have a positive effect on the way Japan conducts its stress tests, especially if the IAEA's review process is public. However the IAEA is not an independent body. It is compromised in much the same way as Japan's regulators, so IAEA review alone will not guarantee public confidence in the outcome of the stress tests.

3.4 Radioactive waste - the millennial problem

Japan has made little progress on addressing the problem of what to do with high-level radioactive waste, transuranic waste, and some categories of low-level radioactive waste. Fukushima Dai-ichi has complicated the problem by creating new types of radioactive waste: for example, contaminated topsoil, radioactive sludge from treatment plants, contaminated animals and plants, etc. Some of the material will remain dangerous for thousands of years. Obstacles to resolving the impasse are both political and technical. The most important first step is to stop producing more radioactive waste.

3.5 Creating space for renewables and energy efficiency

In the short term Japan will rely on fossil fuels to cover the reduced output from its nuclear power plants, but in the long term removing the structural barriers that have blocked the introduction of renewables and energy efficiency will enable Japan to drastically reduce its carbon footprint. Nuclear energy has been an obstacle to shifting to a sustainable energy system. The most important single structural change that is required is to separate electricity generation from transmission and distribution. The electric power companies control over transmission and distribution must be broken to enable free access to the grid for power generated from sustainable energy sources.

Conclusion

The people of Japan stand at the crossroads. Their yearning to escape the recurring nuclear nightmare that has haunted them since 1945 could inspire them to commit themselves to an alternative path and lead the world to a sustainable future based on renewable energy and energy efficiency. On the other hand, they could sink into despair and allow their creativity to be stifled by dysfunctional structures and vested interests. Japan's highly educated, innovative, and hard-working people are perfectly capable of choosing the former path. Doing so would be a powerful act of self-determination. It would liberate them from two great oppressions—from the undemocratic centralized power structures that led them to the devastation of World War I and Fukushima Dai-ichi and from their inferiority complex towards the western world. With these monkeys off their backs, they would flourish as never before. Friends of the Japanese people, distressed to see their present suffering, wish them nothing less.

Notes

1. Yasuhiro Nakasone, *The Sentient World – 50 Years of Postwar Politics*, 1996. Quoted in "Espionage behind Japan's first nuclear reactor", *Japan Press Weekly*, 8 June 2011, at http://www.japan-press.co.jp/modules/news/index.php?id=1926.
2. Yuki Tanaka and Peter Kuznick, "Japan, the Atomic Bomb, and the 'Peaceful Uses of Nuclear Power'," *The Asia-Pacific Journal* Vol 9, Issue 18 No 1, 2 May 2011, at http://japanfocus.org/-Yuki-TANAKA/3521.
3. Peter Kuznick, "Japan's nuclear history in perspective: Eisenhower and atoms for war and peace", *Bulletin of the Atomic Scientists*, 13 April 2011, at http://thebulletin.org/web-edition/features/japans-nuclear-history-perspective-eisenhower-and-atoms-war-and-peace.
3. "Espionage behind Japan's first nuclear reactor", *Japan Press Weekly*, 8 June 2011, at http://www.japan-press.co.jp/modules/news/index.php?id=1926. He used "all the power and influence of the *Yomiuri Shimbun* and NTV to have the topic reported in a favorable manner in order to drastically change public opinion." (Matsutaro Shoriki's statement, Ten years in the development of atomic power, 1965.)
4. The 1961 *Long-Term Plan for Research, Development and Utilization of Nuclear Energy* predicted that Fast Breeder Reactors would be in use sometime around 1980. The target date for commercialization of fast breeder reactors in the 2005 Framework for Nuclear Energy Policy was 2050.
5. The Rokkasho Reprocessing Plant is due to complete active tests (the final stage before beginning commercial operations) in October 2012. The official completion date was postponed for the 18th time on 10 September 2010. When the plant was first approved it was supposed to be completed by December 1997.
6. (a) Cost: Using MOX fuel in light water reactors is much more expensive than using uranium fuel, as can be seen from the following assessment by Matthew Bunn, Steve Fetter, John P. Holdren and Bob van der Zwaan in *The Economics of Reprocessing vs. Direct Disposal of Spent Nuclear Fuel*, Project on Managing the Atom, Belfer Center for Science and International Affairs (John F. Kennedy School of Government, Harvard University), December 2003. "At a reprocessing price of $1000 per kilogram of heavy metal (kgHM), and with our other central estimates for the key fuel cycle parameters, reprocessing and recycling plutonium in existing light-water reactors (LWRs) will be more expensive than direct disposal of spent fuel until the uranium price reaches over $360 per kilogram of uranium (kgU)—a price that is not likely to be seen for many decades, if then." (Executive Summary, p. ix)

   (b) Contribution to electricity supply (in terms of uranium resource saved): In its 12 November 2004 Interim Report, the Nuclear Policy Planning Council which produced Japan's 2005 *Framework for Nuclear Energy Policy* assessed that there would only be a 10%-20% reduction in the requirement for uranium as a result of the pluthermal program. The following web site contains an unofficial translation of an evaluation of four scenarios considered for this Interim Report. It also contains comments by Citizens' Nuclear Information Center, which was represented on the Council. See http://cnic.jp/english/topics/policy/chokei/longterm4scenarios.html.
7. A Tokyo Shimbun survey found 82 percent favored a phase out of nuclear power while Asahi Shimbun found 77 percent. Reference to the Asahi Shimbun figure in Yoshinori Onoki, "Seeking a society without nuclear power generation: Japan must change course to create a nuclear-free society", Editorial published in *The Asahi Shimbun*, 14 July 2011, at http://www.asahi.com/english/TKY201107130354.html. Reference to the Tokyo Shimbun figure in Martin Fackler, "A Governor's Power to Shape the Future of a Nuclear Japan", *New York Times*, 2 July 2011, at http://www.nytimes.com/2011/07/03/world/asia/03japan.html
8. Currently the Agency for Natural Resources and Industry is responsible for the promotion of nuclear energy, while the Nuclear and Industrial Safety Agency regulates nuclear energy. Both now fall under the Ministry of Economy, Trade and Industry. The Ministry of Education, Sports, Science and Technology has responsibility for the regulation of research and test reactors, and use of nuclear source material and nuclear fuel material, but it also promotes nuclear power as the ministry responsible for Japan's principle nuclear research and development body, the Japan Atomic Energy Agency. The Nuclear Safety Commission of Japan, which is within the Cabinet Office, provides a second check. It claims to be "an independent and autonomous body", but in practice it has not behaved as such.

Namibia

Bertchen Kohrs

Namibia has emerged as a frontier for foreign investors in uranium mining and is experiencing a uranium rush that could well turn into a "uranium crush" if not managed properly. With a production of about 5,200tons of yellow cake (U3O8) in 2010 by two operating mines, Namibia is the world's fourth largest uranium producer. The uranium deposits are mainly found in the Namib Desert in the Erongo Region, part of the coastal area recently proclaimed by the Ministry of Environment and Tourism as the protected Dorob Park, where legally no heavy industrial development should take place. 61 exploration and five mining licences have been granted by Ministry of Mines and Energy in the past and more licences are expected to be issued after regulations and policies for the nuclear industry are in place.

A Strategic Environmental Assessment (SEA), conducted in 2009–2010 by the Southern African Institute for Environmental Assessment (SAIEA), investigated three possible scenarios. By 2020, four to 12 uranium mines could be operating in the proclaimed Dorob Park. The construction of four factories to produce chemicals used by the uranium mining industry is planned at the coast. Both uranium mines and chemical plants are in stark conflict with environmental conservation and tourism. The demand of huge volumes of potable water and electricity is planned to be met by the construction of a second desalination plant and a coal-fired power plant at the coast. Even a nuclear power plant is under discussion.[1] (See Table 1 below for more details.)

Uranium mining provides short-term income and long-term impacts. Of primary concern is the destruction of the natural environment, the high demand of water in an arid area, the health risks for the mine workers, and the non-existence of relevant infrastructure at the coastal region.

Brief history on uranium in Namibia

Uranium was discovered for the first time in Namibia in 1928. Radioactive ore containing uranium and radium was found in the Namib Desert, about 60km inland. However, there was no real interest in the mineral until 1954, when exploration revealed huge reserves of uranium in the area of the Roessing-mountains. In 1966, Rio Tinto Zinc (RTZ) in London got the concession to mine uranium at Roessing. It took another 10 years of geological analysis and planning until production of uranium could start. Financing for the mine did not only come from RTZ; Canada, France, Germany, and South Africa were involved with credits and security. South African Apartheid Regime governed Namibia (then South West Africa) and exempted Rössing from paying taxes for nine years until investments turned into profits.[2]

Why the uranium rush?

A new "rush" on uranium has started. Global demand for uranium has increased dramatically. Concerns about the depletion of fossil fuels, peak oil, and climate change have sent uranium prices at times skyrocketing.

Namibia, amongst other African countries, has emerged as a new frontier for foreign investors in uranium mining. Although uranium deposits in Namibia are of low grade, generally between 100 and 600 ppm (0.01 to 0.06%), the deposits are considered worth mining. In comparison, the highest ore grades of 200,000 ppm (20%) are found in Canada.[3]

To a large extent, the uranium deposits are situated in the protected Namib Naukluft Park and the recently proclaimed Dorob Park, pristine tourist destinations. Uranium mining, like any other mining activity, creates an imbalance between economic benefits and ecologic conservation. The natural environment is Namibia's most precious and fragile resource and is being sacrificed for short-term economic profits for a few.

Namibia, with a production of 5,429tons of uranium oxide (U3O8) in 2009 (valued US$ 148 million) and 4,496tons in 2010, is presently the world's fourth largest uranium producer after Kazakhstan, Canada, and Australia. If the planned projects get off the ground, Namibia could be producing 11,000 tons per annum by 2030, reaching a global market share of 12%. The Namibian government has granted 65 exploration licences (EPL) to 21 foreign companies from Australia, Canada, France, Britain, China, and Russia in areas of Erongo, Karas, and Kunene. In 2007, the Ministry of Mines and Energy has stopped issuing EPLs and will lift the temporary ban only once a nuclear policy has been drafted with the help of the International Atomic Energy Agency (IAEA) and the government of Finland.

The reason foreign companies come to Africa is obvious; they make huge and quick profits. John Borshoff, Managing Director of Australia's mining company Paladin Energy, expressed it clearly: "The Canadians and the Australians have become over sophisticated in their environmental and social concerns over uranium mining, the future of uranium is in Africa."[4]

Most African countries don't have proper legislation. Taxes and royalties are significantly lower than in western countries. In Africa, the rate of unemployment is high, labour is cheap, and mine workers are not or little informed about the health risks they are exposed to. In Namibia, uranium has been mined, milled, transported, and exported since 1976 in the absence

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of legislation regulating the uranium industry. Mining of uranium can take place under the same conditions than any other mineral. It is up to the respective mining company to comply with international standards or not.

Uranium mines in Namibia

Uranium in Namibia is mostly situated near the surface and mined by open pit method. Because of the low grade of uranium ore, huge amounts of rock have to be moved. For the mining process it is necessary to work with ore of almost identical uranium grade. Ore with higher grade is mixed with ore of lower grade. Very low grade ore is not profitable to be processed and is dumped as waste rock. About 10,000 to 20,000 and at places even 30,000 tons of rock need to be moved to produce one ton of uranium.

The mined uranium ore is crushed into small particles and irrigated with chemicals. In this process the uranium is leached by either acid or alkaline solutions, some of which are released into the environment. The uranium is converted to U3O8, the famous yellow cake. This is Namibia's final product exported to different countries for further treatment. The possibility of proliferation (production of nuclear weapons) cannot be ruled out completely.

The resulting slurry is pumped into tailing dams. Only the uranium is extracted in the milling process. Due to the 14 uranium decay products (also named nuclides, daughter products, or progenies) about 85% of the original radioactivity stays behind in the tailings and will remain for tens of thousands of years because of the 80,000 years half-life of thorium-230. Other nuclides have shorter half-life. The tailings present the most serious long-term hazard of the entire mining process and have to be managed extremely carefully for more than 1,000 years.

Bad management as well as heavy rainfalls can cause the tailings to overflow contaminating surrounding areas. Leaching can cause soil, surface, and groundwater pollution. Dust being blown to the surroundings contains radioactive and toxic constituents, such as radium-226 and arsenic. Radon-222, a colourless, tasteless and odourless gas is continuously formed by decay of radium-226; some fraction of the radon gas is being released and dispersed over large areas. If inhaled, the gas can cause lung cancer.[5]

Presently two uranium mines are operating in Namibia. A third mine is under construction and will start full operation in 2013.

photo: Rossing Uranium Mine

Rössing Uranium Mine (Rössing)

Rössing is the first uranium mine in Namibia and has been operating since 1976. The mine is 69% owned by Rio Tinto; other shareholders are the government of Namibia with 3% (51% voting rights), the government of Iran with 15%, the Industrial Development Corporation (IDC) of South Africa with 10%, and local individual shareholders with 3%.[6]

Millions of US dollars of dividends, due to Iran as shareholder, are deposited in a local bank account, blocked by the Bank of Namibia. The state-owned Iran Foreign Investment Company has owned the 15% shares since 1975, before the 1979 Islamic Revolution. According to a cable to the United States from the US Ambassador in Namibia, Rössing conveyed a request for advice on how they could get rid of the controversial Iranian partner. This was passed on by WikiLeaks in 2010.[7]

At the time Rio Tinto started uranium mining at Rössing, then South West Africa (today's Namibia) was ruled under South African Apartheid Regime. At this point of time, Environmental Impact Assessments were not the order of the day. Safety measures, protection of mine workers' health, and consideration of environmental and social impacts were absent. This condition only changed in later years when mine workers complained about increased illnesses. Today many workers claim that they suffer of bad health due to the unsafe working conditions.

Rössing operates the largest open pit uranium mine and is the third largest uranium mine worldwide with a production of 3,628 tons of U3O8 in 2010. For this, 11,598,000 tons of ore were processed and 41,955,000 tons of waste rock were removed (ratio 1:14,761), and 2,870,000m3 of fresh water was used. In 2010, Rössing employed 1,592 workers and spent NAM$15,527,087 on trade bursaries and training programs of which a total of 417 participants benefitted.[8]

Two cases of theft of yellow cake are known. In 2004, about 28kg of U3O8 were stolen and again in 2009, the amount of 170kg of U3O8 was stolen. It was obvious to the police that the suspects were not aware of the danger of the stolen material.[9]

Langer Heinrich Uranium (LHU)

LHU is 100% owned by the Australian company Paladin Energy Ltd and commenced production in 2007. The mine is located in the protected Namib Naukluft

Table 1: Strategic Environmental Assessment scenarios

		Possible Scenarios by 2020		
	Present (2011) 3 mines	**Scenario 1 4 mines**	**Scenario 2 5-7 mines**	**Scenario 3 8-12 mines**
Uranium mines	Rössing	Rössing (no extensions)	Rössing + SK Expansion	Rössing + SK Expansion
	Langer Heinrich + Stages I & II	Langer Heinrich + Stages I & II	Langer Heinrich + Stages I, II & III	Langer Heinrich + Stages I, II, III & IV
	Trekkopje	Trekkopje	Trekkopje	Trekkopje + Expansion
		Valencia	Valencia	Valencia
			Husab	Husab
			Etango/ Bannerman	Etango/ Bannerman
				Reptile Uranium 1 - 3 mines
				Marenica
Associated industries	$20m^3/a$ desalination plant Trekkopje	$20m^3/a$ desalination plant Trekkopje	$20m^3/a$ desalination plant Trekkopje	$20m^3/a$ desalination plant Trekkopje
			$20m^3/a$ desalination plant NamWater	$20m^3/a$ desalination plant NamWater
		200 MW coal-fired power station	400 MW coal-fired power station	800 MW coal-fired power station
			Gecko Mining & Chemicals	Gecko Mining & Chemicals
U_3O_8 production in mill pounds/a	10.7	24 (around 2016)	>47 (by 2015)	appr. 60 (from 2016)
Export value in bill N$		12.1 (2015)	17.9 (2015)	19.0 (2015)
Revenue in bill N$		1.35 (2015)	2.4 (2020)	2.8
Employment	2,200	Peak 4,000 (2011-12)	Peak 8,500 (2011-12) later 6,000	Peak 9,000 (2011-12) later 7,000
Water demand in mill m^3/a	13	>20 (2012-17)	35 (by 2020)	40-45 (2014 onwards)
Power demand in MW	80	120	>300	340
Increase in traffic in % on all roads		44-58	47-72	56-80

Park, which is of great concern to many Namibians, especially the tourist companies and environmentalists.

The Environmental Impact Assessment was of poor quality. Experts of the Oeko-Institute in Germany reviewed part of the report on Earthlife's request. The findings were that the radiation doses were underestimated by a factor of four and the proposed tailings management concept contained serious flaws. The Oeko Institute concluded that, given these circumstances, a licence should not have been granted.[10]

A second stage is in operation; ramp-up for a third stage is currently underway. This is supposed to increase current production of 3.7 million pounds of U3O8 to about 10 million pounds per annum by 2014.

Residents of the coastal town Swakopmund, about 80km west of the mine, are worried about increased water extraction from the Swakop River. The damage already done to the fragile desert landscape through massive water withdrawal will get worse because of even more water usage by the mines expansion.

Trekkopje Uranium Project

UraMin Inc. explored for the Trekkopje Uranium Project and in 2008 sold the project to French uranium giant Areva for US$2.5 billion on the Toronto Stock Exchange.

The proven and probable reserves are 49,952 tons of U3O8 at a grade of 126ppm of uranium; that is less than half of the grade at the Rössing mine. Trekkopje will be the first mine in Namibia making use of the heap leaching process using a sodium carbonate/bicarbonate solution to extract uranium from the ore. The mine will require 14 million m3 of water per year which will be supplied via a 48km pipeline by a desalination plant that has been built by Areva. The mining and processing cost is estimated at US$55.00 per pound of U3O8. Trekkopje will go into production by end 2013, two years later than initially planned.

In 2010, a carpet of dead mussels and nautilus was found over a 3km stretch of the beach at the north of the brine outfall line of the desalination plant. It is still unclear whether the brine, a by-product of desalination, is responsible for the deaths in huge numbers.

Other projects[11]

Valencia Uranium Project by Forsys Metals Corp received a 25 year mining licence in 2010 and plans to mine 116.8million tons of ore at a grade of 0.119kg of U3O8 (0.01% uranium).

Husab Uranium Project by Australian Extract Resources' Namibian subsidiary Swakop Uranium plans to start production in 2014. Husab is said to contain one of the largest uranium deposits in the world. Because Husab is located in the unique "Moon-landscape", a pristine tourist area, tourist companies are opposing the project.

Etango Project by Bannerman Resources Ltd will only be feasible at a spot market price of approx. US$60/pound U3O8.

Reptile Uranium Project by Reptile Uranium announced that the company is set to become one of the country's largest uranium and iron producers.

Marenica Uranium Project by Marenica Uranium plans to deliver 1,346tons of uranium per annum at the highly competitive operating cost of US$38/pound U3O8, and could produce a total of 17,308tons of uranium over a 13-year life.

Prospecting for uranium is taking place at many more sites, all located in the recently proclaimed Dorob National Park, a Category One protected area that should legally not be used for heavy industrial development.

Conclusion

Environmental and social devastation is taking place on a daily basis. Namibian citizens complain about loss of biodiversity, contamination of ground and surface water, pollution of soil and air, exploitation of already scarce water resources, increase of traffic and noise, loss of income through tourism, and other negative circumstances. Many mine workers say the exposure to radiation and toxic dust is responsible for their deteriorating health condition. Their families, living 13km away from the Rössing mine, claim that they have allergies, respiratory problems, and other complications.

Leave the uranium in the ground and opt for renewable energy, says Earthlife Namibia.

Notes

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11. "New Uranium Mining Projects—Nambia," WISE Uranium Project, last updated 1 September 2001, at http://www.wise-uranium.org/upna.html.

Netherlands

Susi Snyder and Carolien van de Stadt

There is only one nuclear energy plant in the Netherlands, situated in Borssele, in the southern part of Holland in Zeeland province. The reactor is jointly owned by Delta and Essent, and operated by Elektriciteits-Produktiemaatschappij Zuid-Nederland (EPZ). The plant is situated close to the border of Belgium.

The Borssele reactor began operating in 1973. Nuclear power has a small role in the Dutch electricity supply, with the Borssele reactor providing about 4% of total generation. Another 4-5% of Dutch electricity supply is purchased from German reactors. The Borssele reactor has a pressurized water reactor with an output capacity of 485 MW, output 3,625 GWh/yr.

The reactor received a turbine upgrade in 2006, at which time its life was also extended until 2034. The conditions for the extension of the reactor included a requirement for its owners (Delta and Essent) to invest EUR 250 million towards sustainable energy projects and increase the operational safety standards at the site.

The first commercial nuclear energy plant was a 55MWe boiling water reactor in Dodewaard. This reactor started construction in 1965 and went online in 1968. It was run by Joint Nuclear Power Plant Netherlands Ltd (GKN) and was operational until it closed for economic reasons in 1997. In 2003 the last fissionable material was removed and parts of the plant were demolished. The main part will be sealed and monitored until 2045, before being demolished.

Dutch nuclear waste policy was decided in 1984 and commits to a policy of long term (100 years)interim storage. In 1984 the Central Organisation for Radioactive Waste (COVRA) was established, also based in Borsselle close to existing facilities. The government policy is to eventually store high-level waste underground and to progress towards that in a way that every step is reversible. A decision on the final disposal site is expected in 2016.

Spent nuclear fuel from Dodewaard was sent to the Thorp facility at Sellafield for recycling. Borssele's waste is sent to the French facility at La Hague, after it has been temporarily stored by the reactor for a number of years. A contract for the Borssele waste between EPZ and Areva NC will remain in place until 2015. EPZ is currently seeking approval to use mixed oxide (MOX) fuel.

Origins of nuclear energy in the Netherlands

Since the 1930s research has been ongoing in the Netherlands about ways to use nuclear technology. Early research at the Technical University in Delft was done with a small amount of indigenous uranium. Construction began on the country's first research reactor, the High Flux Reactor at Petten, in 1955, which is still in operation. After the meltdown at Chernobyl in 1986, the government decided not to build another commercial plant, a decision reversed in recent years.

Dutch nuclear politics

Nuclear energy is placed under the responsibility of the Ministry of Economics, Agriculture and Innovation. The same goes for nuclear medical treatments.

In general, all political parties have expressed concern about risks related to terrorism around nuclear facilities and about the storage of nuclear wastes. The Socialist Party, Social Christian Party, Green Party, and the Party for Animal Welfare have objected to the construction of any new nuclear power plants—at least until a safe and secure storage plan for nuclear waste can be agreed. The right-wing Party for Freedom and Democracy (VVD) is supportive of the construction of new nuclear reactors. In April 2011, a joint petition circulated by a number of peace and environmental organisations gathered more than 93,500 signatures opposing nuclear energy in the Netherlands.

Responses to Fukushima Dai-ichi disaster

The Dutch Minister of Economics, Agriculture and Innovation, a week after the meltdown in Japan, said, "there could be no doubt that because of Fukushima the plans for a new nuclear plant that had already been decided by the government , would be uncertain or for discussion again. We will learn from the results of the investigations of Fukushima, but continue in the meantime. More precise safety rules will be made later."

Future of Dutch nuclear energy?

There are a number of proposals pending for new reactor construction. Delta and Energy Resources Holding (ERH) have put forward two bids for construction. At Borssele, there is currently only space for one more reactor, and there has been talk of building a new site near Vlissingen. The current plans are to begin construction no sooner than 2015.

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Susi Snyder and Carolien van de Stadt are members of WILPF Netherlands.

Norway

Edel Havin Beukes

As of August 2011, there are two research nuclear reactors in operation in Norway: one at Kjeller outside Oslo (JEEP2) and another at Halden, near the Swedish border. Both reactors are old. The Kjeller reactor is used primarily for the production of isotopes and stores used fuel rods. Both nuclear reactors use heavy water as moderator and as coolant. The Halden reactor tests mixed oxide fuel (MOX) and thorium fuel for the international nuclear industry and uses highly enriched uranium (HEU) as fuel.

Previously there was a considerable discharge of liquid radioactive waste materials into the local Nitelven (Nit River). Some 1000 drums of radioactive waste materials were deposited at the premises of the reactor, but these have since been dug up and moved to a temporary depository for medium and low-level nuclear waste in Himdalen. There are no concrete plans for the construction in Norway of a permanent depository for high-level nuclear waste.[1]

The Parliament of Norway (Stortinget) has determined that no nuclear power plants are to be built in Norway. Yet money from the taxation of Norwegian citizens is used for costly research into and support for the development of nuclear power in other countries.[2]

Nuclear waste

The operation of the two reactors, in addition to two more that had been decommissioned (JEEP1 and NORA), has produced some 17 tons of high-level waste materials, of which 12 tons are described as highly unstable.[3]

In February 2011 a government appointed commission (the Stranden Commission) proposed that the waste be sent for reprocessing to La Hague in France. Eight environmental NGOs—Internasjonal Kvinneliga for Fred og Frihet (IKFF-WILPF-Norway) and seven others—adopted a common stand against sending the nuclear waste to La Hague, or anywhere else.[4] The reasons given were as follows:

- Reprocessing is the most polluting part of the nuclear power cycle: it annually leads to great quantities of radioactive substances being expelled into the environment;
- The reprocessing of spent fuel creates great quantities of high-level waste materials as well as plutonium, which are difficult to handle. To store such waste in turn creates demanding security as well as environmental challenges;
- Transportation to and from the La Hague complex increases the risks of environmental damage and the spread of nuclear weapons;
- To send nuclear waste from Norway to La Hague would be to undermine the political aim, supported by a united Stortinget, of obtaining the closure of the British reprocessing plant at Sellafield; and
- Norwegian nuclear waste is a matter of Norwegian responsibility, the solution to which must be found nationally.

La Hague is a French facility located on the coast of the Cotenin peninsula, 15 kilometers east of Cherbourg-Octeville. Originally constructed for the production of plutonium to supply France's nuclear weapons industry, it now processes the spent fuel from the country's nuclear power plants.

Alongside the British reprocessing plant at Sellafield, La Hague is considered Western Europe's largest source of radioactive pollution. Together the pollutants they produce exceed by far that of ordinary nuclear power plants.

An analysis conducted by the European Parliament in 2001 showed that the radioactive discharges from La Hague alone are 7000 times higher than from any ordinary, French-built nuclear power plant. Plutonium, cesium-137, cobalt-60, americium-241, radioactive iodine, and radioactive tritium are contained in the discharges. All these human-made radioactive substances have no place in nature. (3) Plutonium and cesium from La Hague and Sellafield are transported northward by oceanic currents and can be found in seawater and sediments all along the Norwegian coastline and up to the Barents Sea.[5]

The tanks with HAL (high level radioactive waste as a liquid) at La Hague contain 400m3 liquid and at Sellafield 1000 m3.[6] The tank facilities at La Hague and Sellafield are regarded as a high-risk area. If by accident there should be any failure in the cooling systems, overheating and explosions can occur. In 1957, a tank containing highly radioactive waste at the Majak facility in Russia exploded with the force of 75 tons of TNT and polluted an area of 15,000 square kilometers with strontium-90. 10,000 people were evacuated, villages were burnt down to the ground, and the upper soil layers had to be scraped away as waste material.[7]

The Norwegian Radiation Protection Authority (Statens Strålevern) has published a report dealing with the probable consequences for Norway of an accident at Sellafield's tank facility. The report describes the possible environmental consequences for Norway due to a hypothetical accident at the Sellafield complex in UK. An explosion and fire at the B 215 facility resulting in a 1% release of the total HAL inventory of radioactive waste with an air transport and deposition in Norway, the estimated fallout in Norway will be 17 PBq of Cs-137 which is 7 times higher than the fallout from the Chernobyl accident.[8] The possible and probable

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consequences of a similar accident at La Hague have not been considered.

Nuclear power plants

Norway has no commercial nuclear power plants. However, as the country is locked into the common European grid, it participates in the consumption of nuclear power generated in other European countries. Norway is mostly self-sufficient in the production of hydro-electric power and it also produces oil and gas, though only small amounts of these are used for the generation of electricity.

During the 1970s, plans were mooted for the construction of one nuclear power plant every five years. By a majority vote a commission appointed to evaluate the issues involved supported the idea. Responding instead to the work done by environmental organizations, which made clear the inevitably negative consequences of the plans, a majority of the population turned against the idea. In 1987 the Stortinget banned the construction of nuclear power plants in Norway. This decision is still in force.

photo: Halden Research Reactor

However, surrounded by neighbouring countries—Sweden, Finland, Russia, United Kingdom—all operating aging nuclear power plants, Norway has not been spared the consequences of accidents, the accidental or routine discharges of radioactive and poisonous waste products, as well as near-accidents of the gravest kind.

In 2006 the Forsmark power plant in Sweden came to within minutes of a meltdown when an accidental disruption in electricity supply to the plant blacked out all administrative systems. Engineers struggled for more than twenty minutes to get two of the four emergency diesel generators, which should have kicked in automatically, started. Management's prioritisation of profit over the safety of the plant was held responsible for the near catastrophe.[9]

The Barsebäck plant—across the Kattegat from Copenhagen—has been decommissioned, but ten Swedish reactors are still in operation at Ringhals, Forsmark, and Oscarshamn. Across the Baltic Sea at St. Petersburg and in Northern Russia, that country operates 11 reactors of the type that laid Chernobyl waste and spewed radioactive clouds on the northern hemisphere.

Radioactive contamination from the Chernobyl meltdown spread over 40 % of Europe including Norway, and wide territories in Asia, northern Africa, and North America. Nearly 400 million people resided in territories that were contaminated with radioactivity at a level higher than 4 kBq/m2 from April to July 1986. Nearly 5 million people (including 1 million children) still live with dangerous levels of radioactive contamination in Belarus, Ukraine, and European Russia.[10]

Farmers in parts of southern Norway still have to "feed down" sheep before slaughter—to reduce the content of radioactive cesium in meat that is to be marketed.[11] But the part of the population that is most heavily affected by the fallout—from power plants as well as from earlier nuclear weapons tests—are the Sami people of northern Scandinavia, as well as the native peoples of Northern Russia, who are dependent on reindeer, fish, berries, and mushrooms for the greater part of their diets.

Notes

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Pakistan

Zia Mian and Abdul H. Nayyar

At the time of independence in 1947, Pakistan inherited a total of 60 MW of electricity generation capacity, in the form of a small hydroelectric facility and a thermal power plant. It now has about 20,000 MW of installed capacity. An estimated 60% of its population of about 180 million people has some access to electricity. Pakistan's nuclear energy programme, which is now over fifty years old, has been a very small part of the energy mix so far. There ambitious plans for a much larger nuclear energy programme.

In 2005, the government offered a 25-year plan for electricity generation up to 2030 that expects an eightfold increase in installed capacity, to over 162,000 MW. The plan (Table 1) called for an enormous increase in reliance on coal, by a factor of over 100. There is also a twenty-two fold increase planned for the use of nuclear energy, and large expansion in the use of natural gas, hydroelectricity, and renewables. Pakistan already has fallen behind the targets in this plan, however.

Table 1: Pakistan's electricity generation plans 2005–2030 (MW)[1]

	2005	2010	2020	2030
Hydro	6,460	7,720	19,990	32,660
Oil	6,400	6,560	7,160	7,760
Gas	5,940	10,800	30,910	83,760
Nuclear	400	400	2,880	8,800
Renewables	180	880	3,150	9,700
Coal	160	1,060	8,260	72,270
Total	**19,540**	**27,420**	**72,270**	**162,590**

Origins of nuclear energy in Pakistan

Pakistan's nuclear programme was launched in October 1954, when the government announced the creation of an atomic energy research and development programme. The announcement came on the same day and was reported alongside a meeting between Pakistan's prime minister and US president Eisenhower at the White House. In December 1953, President Eisenhower had proposed his *Atoms for Peace* initiative, a way to win allies in the Cold War by sharing American nuclear technology with developing countries and so helping them participate in what was described as an imminent "atomic age". Signing up for *Atoms for Peace* offered an easy way to show support for Eisenhower and Pakistan's leaders were seeking to build an alliance with the United States that would deliver military and economic aid and political support that Pakistan could use to bolster its position in its conflict with India.

Pakistan quickly began to receive military equipment and military advisors as well as economic advisers who came to help it prepare its economic development plans. The Pakistan Atomic Energy Commission (PAEC) was set up to manage the effort. It used the *Atoms for Peace* programme to send young scientists and engineers for training in nuclear science and engineering to the United States, and in time received a US-supplied research reactor. The first power reactor, *Kanupp*, a 137 MWe pressurized heavy water reactor, was designed and built by Canada, near Karachi in 1970. Pakistan's refusal to sign the 1970 nuclear Non-Proliferation Treaty (NPT), especially after India's 1974 nuclear test raised fears of a matching Pakistani nuclear weapons programme, caused Canada to end its supply of fuel for *Kanupp*. This forced Pakistan to develop its own nuclear fuel technology, and look elsewhere for further nuclear reactors.

A 300 MWe light water reactor was provided by China and started operating in 2000, at Chashma in northern Pakistan. A second identical power reactor started operating at the same site in 2011. Both are fuelled by China. Pakistan has signed a deal for two additional 300 MWe Chinese reactors to be built at Chashma at a total cost of $1.9 billion.[2] All these reactors are under international safeguards.

The most significant public debate over nuclear energy in Pakistan was triggered in 1999 by a technical study assessing the safety and possible consequences of a potential accident at the Chashma nuclear power plant.[3] The study identified a number of safety concerns; these included evidence of earthquake hazards at the site, the questionable reliability of the design given that it was based on a Chinese prototype with an uncertain operational history; and the questionable quality of the reactor components, some of which had never been manufactured in China before. The study estimated the possible radioactivity release that might follow a melt-down and containment failure at Chashma and data on wind patterns, local population density and standard cancer risks from radiation exposure to estimate that there could be 12,000-30,000 cancer deaths in the event of a major accident at the plant. The radioactivity that would be released could also contaminate the near-by Indus River, a crucial source of water for much of the country.

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The debate around the safety of the Chashma reactor site led to a push for a more independent nuclear regulatory body. Until 2001 Pakistan's nuclear regulatory mechanism was a department of PAEC. Even though it is now nominally an independent body, it is staffed almost entirely by administrators and engineers from PAEC.

The limits of nuclear politics

PAEC is the most important force shaping policy and attitudes towards nuclear energy in Pakistan. A major source of its enormous political power is that the civil and military nuclear programs of Pakistan are intermingled (as is the case in several other countries, particularly India). This has meant that for decades PAEC has been able to claim to represent both national scientific and technological progress and national security. One measure of its continuing success at avoiding accountability is that even as recently as 2005 PAEC refused to provide its budgets to Parliament.[4] Detailed budgets continue to be unavailable to the public.

PAEC has remained largely unchallenged by other branches of government, civil society, and public opinion. This is despite the fact that it commands a disproportionate share of national economic and technical resources and functions as a state within a state. PAEC controls the overwhelming majority of scientific activity in the country, in terms of numbers of scientists and access to financial resources. This has historically given it a capacity to influence policy making in science and science related areas, as well as in nuclear energy and national security. PAEC has a near-monopoly on nuclear expertise; it runs its own training institutes while nuclear engineering courses are not offered in most universities. As a result there is no academic community able to offer independent peer review of PAEC claims, and no significant critical technical input into public debate and policy making on nuclear issues.

There is no significant movement in Pakistan against nuclear energy, nor even any full-time independent research institutions or grassroots activists working on this issue. Fears over the environmental and health impacts of uranium mining and nuclear waste disposal have led to local community protest, however. In 2006, for instance, a law suit was filed by villagers from Bagalchur, Pakistan's first uranium mining site, which operated from 1978 to 2000, complaining that PAEC had been dumping uranium mining waste and other radioactive wastes in the disused mine tunnels.[5] The villagers cited increases in infant mortality, and disease and premature death in farm animals due to the waste dumping. The case was referred to Pakistan's Supreme Court. At PAEC's request, the court hearings were closed to the public.

This is not unique to nuclear energy issues, however. The growth of an extensive civil society and social movements has been hampered by successive military regimes and authoritarian civil governments. Political energies and resources have been directed to organizing for basic economic and social needs, democracy, and human rights, especially the rights of women. The emergence of a small environmental movement in the 1990s with both think-tanks and grassroots organizations, and the network of groups mobilized against nuclear weapons (the Pakistan Peace Coalition) that took shape after the 1998 nuclear tests suggest things may be starting to change. But it is likely to be a long time before a broad, resilient, and capable civil society capable of contending with the nuclear state will emerge.

Responses to Chernobyl and Fukushima

The 1986 Chernobyl disaster served to create some doubts among the Pakistani elite about the safety of nuclear facilities in Pakistan but had no enduring impact on policy or public attitudes. In the days immediately following news of the accident, there was no comment from PAEC or other government officials. PAEC's first public response came in late May 1986, almost a month after the accident. The chairman of PAEC announced at a press conference that some increase in radioactivity had been detected, and that food and vegetation had been tested and found to be safe.[6] He explained that PAEC had been instructed by the government to improve safety at its nuclear facilities, and that this required compliance with strict safety procedures. The implication was that no new measures were required. He also emphasized the difference in the design of *Kanupp* from that of the Chernobyl reactor, presumably to suggest that it could not have a comparable accident.

"as explosions tore through the nuclear complex, the 'experts' flatly declared that a Fukushima could never happen in Pakistan."[8]

However, questions were asked. A Karachi news magazine carried an article by a leading physicist, who asked, "Could a Chernobyl-like disaster occur in Karachi?" and used the disaster to raise concerns about the site of the reactor, pointing out that "even high-ranking PAEC officials now admit that Karachi's reactor is badly sited", emphasized the need for evacuation plans, and criticized the lack of an independent nuclear safety body.[7]

There has been a similar set of reactions to the meltdowns at the Fukushima Dai-ichi nuclear plant in Japan in March 2011. PAEC released a statement that the safety of its reactors was checked by foreign experts, including those from the World Association of Nuclear Operators. It did not mention that the owner and operator of Fukushima, the Tokyo Electric Power Company, is a member of the World Association of Nuclear Operators. Pakistani nuclear physicist Pervez Hoodbhoy noted the "shoulder-shrugging nonchalance of Pakistani authorities during the Japan disaster," explaining that even "as explosions tore through the nuclear complex, the 'experts' flatly declared that a Fukushima could never happen in Pakistan."[8] Others warned that *Kanupp* is located on the coast and is vulnerable to earthquakes and tsunamis and noted that there are now many housing schemes close to the site that could not be quickly and safely evacuated.[9] The *Kanupp* reactor is not scheduled to for shutdown until 2019, when it will be about fifty years old.

The future of nuclear energy in Pakistan

As is the case in other countries, the need to address greenhouse gas emissions responsible for climate change is being used as a way to further promote nuclear energy in Pakistan. The former Chairman of PAEC, and now special advisor to the Prime Minister, argued for example that "in the wake of irreversible global warming, it is nuclear energy alone which offers a viable and sustainable solution to the looming disaster predicted by the International (Intergovernmental) Panel on Climate Change. Nuclear energy is proven technology that is non-polluting, safe, and cost-competitive."[10] However, it is clear from the massive increase in coal use envisaged in its energy plan for 2030 that Pakistan's government is not serious about an energy future that is sensitive to the climate change challenge.

Pakistan plans to increase its nuclear capacity to 8,800 MW by 2030, enhancing the contribution of nuclear energy from the present 0.8% to 4.2%. These ambitious expansion plans face several potential obstacles. The first of these is that as a state that is not a signatory of the NPT, nor one that has all its nuclear facilities under International Atomic Energy Agency (IAEA) safeguards, Pakistan is not eligible to purchase nuclear reactors from states that are members of the Nuclear Suppliers Group (NSG). China joined the NSG in 2004 and is no longer allowed to sell reactors to Pakistan. Despite the sale of the Chashma-3 and Chashma-4 reactors, it is not clear how many more reactors China can provide without creating a crisis for current NSG rules.

Secondly, nuclear power plants are capital intensive with high construction costs and long construction times. Pakistan has relied on cheap credit from Canada and from China respectively in purchasing its nuclear power reactors. China is providing 80% of the cost of Chashma-3 and Chashma-4 as a low-interest 20 year loan. The funding problem is likely to get worse if Pakistan tries to purchase a large number of bigger and more expensive reactors to meet its goals. Funding for new nuclear reactors will have to compete against the demand for money for generating capacity that is cheaper to build and could come online more quickly. The United States and other donors are funding energy projects in Pakistan but will not include nuclear power reactors as part of this mix. To promote investment in its nuclear energy sector, in 2005, PAEC proposed that foreign companies be invited to build, own, and operate nuclear power plants in Pakistan with equity sharing in "nuclear power parks".[11] Given the security situation and instability in Pakistan, it is unlikely it will find any takers.

Despite the many obstacles, PAEC is hoping to build 10–12 new reactors and is already considering sites for them along the Indus River and the coast.[12] It also has proposed building a large civilian (i.e. safeguarded by the IAEA) enrichment plant and a nuclear fuel production facility as part of this expansion.[13] If plans do take shape, they are likely to create opportunities for public debate and engagement on nuclear energy on a much larger scale than anything seen before as local communities wrestle with issues of living with potential risks and accidents and their hopes for employment and prosperity.

Pakistan finds itself in an energy trap, caught between the ever more energy intensive development path it has chosen, its lack of access to high quality energy resources, its political history and location, and poor governance. The widespread and worsening electricity shortages in 2010 and 2011 are seen as a deficit of supply and as a justification for more generating capacity, including new nuclear plants. In fact, the electricity sector is suffering from chronic mismanagement, with only 60% of the installed capacity actually available because electricity suppliers are short of funds to purchase oil and gas as fuel as a result of government departments and agencies not paying electricity bills.

"A necessary condition for a viable energy policy in Pakistan is that it be built on foundations of democracy and social justice and watched over by a vigilant and powerful civil society."

Its efforts to meet its energy needs reflect and in important ways have worsened the many contradictions and crises Pakistan has failed to resolve as it has sought to modernize and develop as a society, a state structure, and an economy. Nuclear energy is a small, almost negligible part of Pakistan's energy sector, in terms of generating capacity. It has become important because of the enormous and unaccountable power of the Pakistan Atomic Energy Commission that manages it, and through the link to the nuclear weapons programme. These factors have made it difficult to create or sustain a significant, critical policy debate or mass mobilization on nuclear energy and its role in Pakistan's future, despite its potential for catastrophic failure, the unresolved problems of waste disposal, and the distortions that it creates in energy planning because of its need for large amounts of scarce capital and skilled personnel for long periods of time.

Pakistan's energy plans are ambitious and appear unrealistic. It is hard to see how it can generate and sustain the vast capital investments it would need to meet its energy goals, given its political instability, poor governance, and myriad groups that are willing to use violence against the state because democratic processes have not been allowed to develop. Should funds become available, and current plans begin to be put into effect, conflicts will likely worsen. A necessary condition for a viable energy policy in Pakistan is that it be built on foundations of democracy and social justice and watched over by a vigilant and powerful civil society. These basic political foundations still need to be laid and the social movements need to be built.

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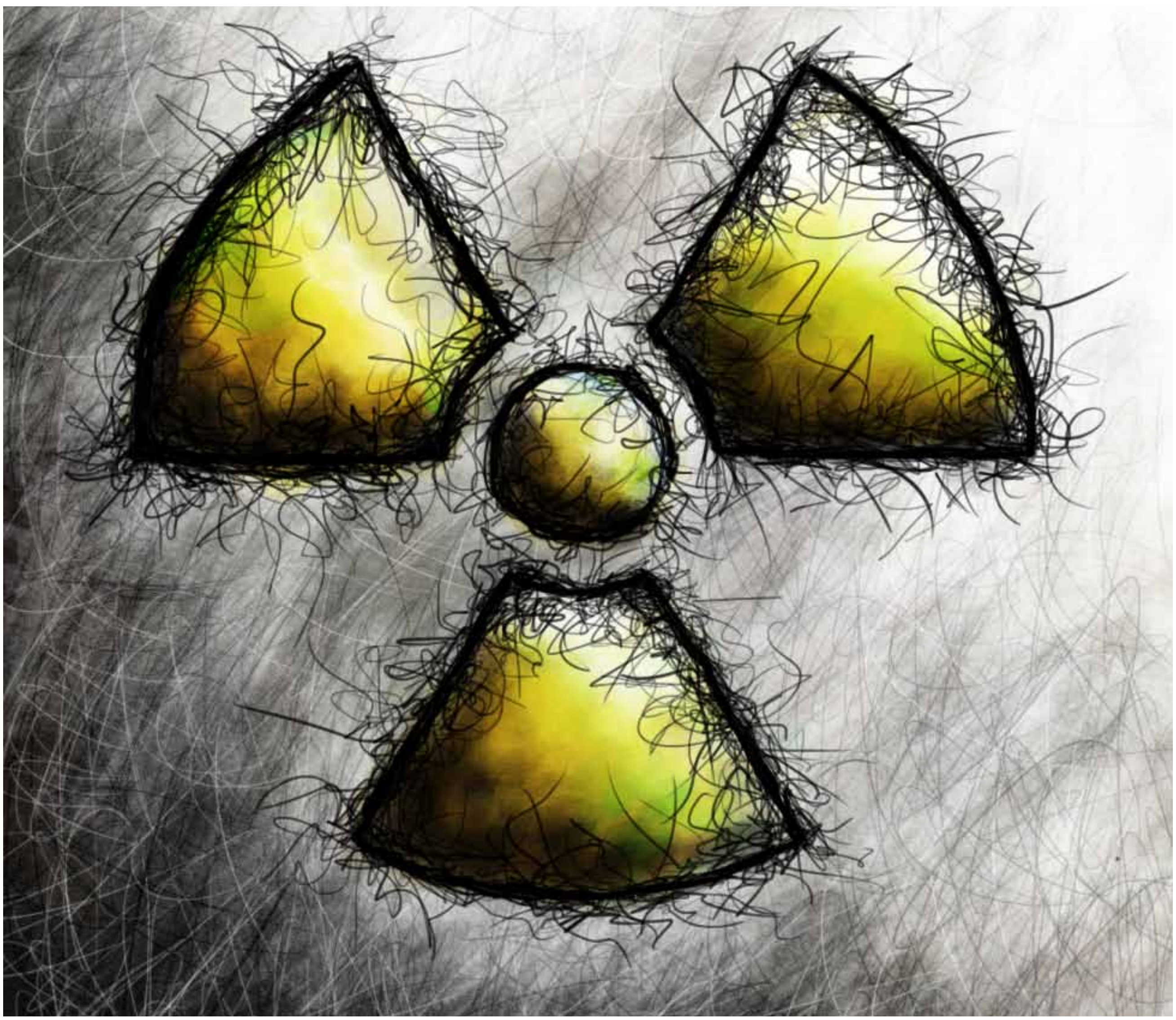
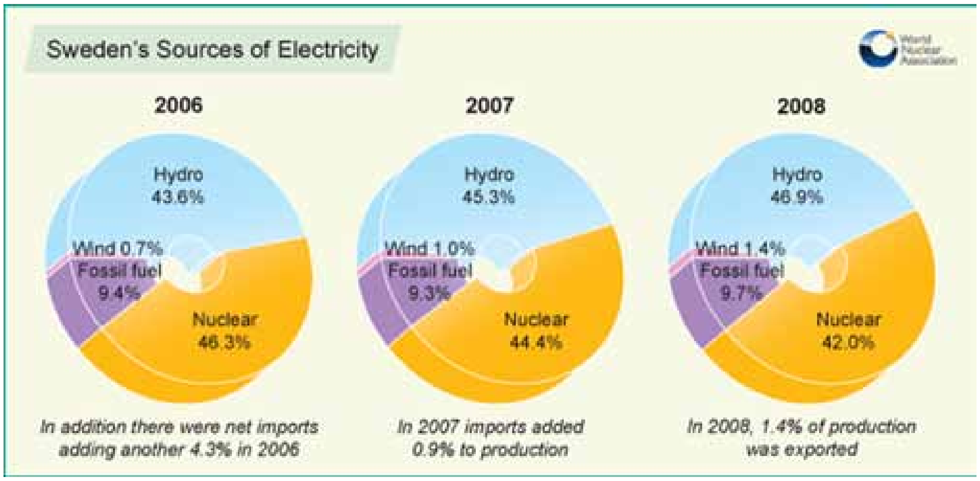


image: Lance Page / t r u t h o u t . o r g

Sweden

Emma Rosengren

Sweden currently has ten operating nuclear power reactors providing over 40% of its electricity. The reactors are located at Ringhals, Forsmark, and Oscarshamn. Hydro represents up to half of Sweden's annual generation of electricty, depending on the season., with fossil fuels and wind making up the difference.[1]



Fuel chain

Sweden imports most of its nuclear fuel. Westinghouse has a fuel fabrication plant at Västerås, which produces about 400 tonnes of boiling water reactor and pressurized water reactor fuel per year. Sweden has no uranium mines though it does have some deposits, incling at Pleutajokk, near the Arctic Circle and the Hotagen District of northern Sweden, where Canada's Mawson Resources has identified several small deposits. Australia's Aura Energy in August 2011 announced deposits in the Alum black shales at Haggan near Storasen and Vasterasen in central Sweden.[2]

Nuclear waste is manged by the Swedish Nuclear Fuel and Waste Management Company (Svensk Kärnbränslehantering AB). Some low-level waste is disposed of at reactor sites, while some is incinerated at the Studsvik RadWaste incineration facility in Nyköping. Intermediate-level radioactive waste and medical and industrial radioactive wastes is stored near Forsmark. It is one of the locations proposed for a final high-level waste repository. High-level wasted is stored at Oskarshamn under water in an underground rock cavern for 40–50 years, and is then "encapsulated in copper and stainless steel canisters for final emplacement packed with bentonite clay in a 500 metre deep repository in granite."[3]

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Accidents

On 25 July 2006, a shortcircuit in the switchyard outside Forsmark 1 resulted in severe voltage fluctuations that spread to several electrical systems in the plant:

> The voltage fluctuation resulted in Forsmark 1 being disconnected from the external grid, and the reactor being scrammed. Parts of the battery backed AC internal distribution network were knocked out, and only two of the four diesel driven generators started automatically. After 22 minutes, power was restored manually from the control room, after which the two other diesel units started. Some of the control room equipment had also been partially knocked out, with the result that, initially, the control room operators were unable to obtain a full overview of the situation.[4]

While the reactor pressure valve and reactor core did not experience trouble, "the defence-in-depth reactor safety systems did not operate satisfactorily. Several safety systems that are intended to operate independently of each other failed to do so as the result of a common external fault."[5] The incident was assigned a rating of Level 2 on the International Nuclear Event Scale (INES).[6]

Government policy and public opinion

In a referendum in 1980, Swedish citizens voted in favor of a step by step phase-out of nuclear power. The result of the referendum also made clear that no new reactors were to be built. However, in 2010, the Swedish government led by a conservative majority coalition decided to change the phase-out policy and to allow for new reactors to be built where old reactors have been situated in the past. The opposition and a few parliamentarians within the ruling parties criticized the decision. The policy change will cost Swedish citizens substantial money, as nuclear power plants are dependent on government funding, and will threaten future generations for many years to come.

One of the opponents within the conservative coalition was WILPF Sweden's vice president and professor of nuclear physics Eva Selin Lindgren, who at the time was a parliamentarian of the Center party. In the past, the Center party has had phase-out of nuclear power as one of their main objectives, but in 2010, they decided to conform to the majority will of the conservative coalition. In a very strong manner, Eva Selin Lindgren resisted the change of her party's position, and debated publicly against the law reform that made it possible for new reactors to be built.

In a debate article published in one of the leading Swedish newspapers, Mrs. Lindgren stated

> in recent years, the nuclear power industry has successfully been able to cover the strong connection between nuclear power and nuclear weapons [...]. However, the connection between nuclear power and nuclear weapons has been known since the first day of the nuclear bomb. [...] The plutonium that exists in Sweden today could be used to produce hundreds of nuclear weapons.[7]

The recent nuclear accident in Japan clearly shows that nuclear power is not a safe source of energy. Furthermore, the connection between nuclear power and nuclear weapons clearly makes the risks even worse. That is why the abolition of nuclear weapons and nuclear power go hand in hand, and why citizens, parliamentarians, and organizations need to promote the allocation of resources from nuclear investments to investments in peace and sustainability. It is necessary to challenge the will of ruling elites, in Sweden as well as in other countries, who choose to prioritize dangerous nuclear energy instead of human security and sustainability.

photo: Greenpeace; Activists break into Forsmark Nuclear Power Plant, June 2010

Notes

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photo: Forsmark Nuclear Power Plant

United Kingdom

Marguerite Finn

Nuclear power in the United Kingdom started at Calder Hall in Cumbria, which was opened by HM Queen Elizabeth II on 17 October 1956. The official programme on that day stated: "Calder Hall was built as a requirement for more military plutonium and as an experiment to investigate the possibilities of adapting nuclear energy to the production of electrical power quickly, cheaply and safely." In other words, the power station was needed to fuel the nuclear weapons programme and electricity was a useful by-product. To generate support for the new atomic age, the British public was promised electricity that would be too cheap to meter. 55 years on, consumers are still waiting for cheap power while the government and the nuclear industry grapple with the realities of nuclear power, nuclear waste, and nuclear proliferation.

The current state of nuclear power in Britain today

Nuclear power currently generates around a sixth—or 18%—of the United Kingdom's electricity. As of July 2011, there are 18 working reactors at 9 sites in Britain with a total generating capacity of 11 gigawatts (GWe) of electricity. All but one of these will be closed by 2023—the exception being Sizewell B on the Suffolk Coast.[1] Sizewell B is the UK's only pressurised water reactor; it began operationing in 1995.[2] However, there are plans to build up to 16GW of new nuclear capacity in the UK, with the first of the new reactors expected to be operational by 2018.[3]

There are three reactor types in use in the UK: Advanced Gas Cooled Reactors (AGRs), Magnox Reactors, and a Pressurised Water Reactor (PWR). The last three Magnox reactors are due to shut down by the end of 2012, leaving seven twin-unit AGRs and the one PWR.

It was originally intended that the PWR at Sizewell would be the first of a fleet of PWRs, but these plans were abandoned in the 1990s. From then on, the question of nuclear new build was effectively ruled out until 2006, on the grounds of cost and adverse public opinion following the Chernobyl accident. But in 2006, a review of energy policy reversed the government's opposition to new nuclear build. This change of direction was influenced by the twin problems of a secure energy supply and climate change—exacerbated by the absence of any will on the part of the government to alter the parameters of society in ways that might enable the UK to live within its planetary limits and according to the precautionary principle. The same government refused to consider encouraging members of the public to reduce their consumption of electricity on the grounds that it would interfere with their 'lifestyle'. In 2010, the UK government gave the go-ahead for a new generation of eight nuclear power stations to be built.

The UK government's position

Government policy in England and Wales is very supportive of nuclear power. The Scottish Parliament is not in favour of nuclear power and is aiming eventually for a nuclear-free Scotland. The UK government has introduced a new planning regime to facilitate the installation of new nuclear plants and other significant new infrastructure projects such as railways, harbours, airports, large wind farms, etc. Under the Planning Act 2008, the need for new infrastructure was to be addressed through National Policy Statements (NPS). The local impacts of a particular development were to be handled by an Independent Infrastructure Planning Commission (IPC) rather than by Ministers or local planning authorities. The IPC was formed in 2009 under the Labour government, but the new coalition government that took office after the general election in May 2010, said it would replace the IPC with an advisory body and return decision-making power to the responsible Minister. MPs approved the NPS in a vote which took place in Parliament on Monday 18 July 2011. However, the NPS for nuclear power remains deeply flawed by its presumption that a number of big problems have been solved when they clearly have not.

The eight sites for proposed new build included in the nuclear NPS are: Hinkley Point, Oldbury, Sellafield, Sizewell, Wylfa, Bradwell, Hartlepool, and Heysham. The new generation of reactors are being provided by overseas providers (primarily Westinghouse and Areva), but the UK supply chain should be able to capture a significant market share in areas where it has existing capabilities or can rapidly develop new capabilities.

If finally approved, the new reactors will be built by the following three largely foreign consortia:

- *EDF Energy* in partnership with Centrica is proposing to build two Areva EPRs at Hinkley Point in Somerset and two at Sizewell in Suffolk;
- *Horizon Nuclear Power*, a joint venture with German company EoN UK and RWE npower, is planning to build at both Wylfa in Anglesey and Oldbury in Gloucestershire; and
- *NuGeneration*, a joint venture between Iberdrola, GDF Suez, and Scottish and Southern Energy, is intending to build at Sellafield in Cumbria.

But the EDF-Centrica partnership is already in trouble. Centrica is the parent company of British Gas and has no previous involvement with nuclear power. It has been advised to withdraw from its £4 billion commitment to build nuclear power stations with EDF Energy in the UK, because of soaring costs and delays at a prototype reactor at Flamanville in France. City of London

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financial advisors have said that Centrica should not "touch with a barge pole" the new nuclear build joint venture with EDF to build four new plants in Britain.[4] Lakis Athanasiou, utilities analyst with Evolution Securities, said: "Centrica is a minority holder in a technology in which it has no institutional understanding and where, as emphasised by Flamanville, construction risk is notorious." The Evolution Securities' view reinforces concerns expressed by other investment specialists such as Citigroup, which has previously questioned the economics of building new nuclear plants. Lakis Athanasiou estimates that each new nuclear power station will cost around £5.5billion. These comments are an unwelcome embarrassment for the government in its determination to build new nuclear power stations at any cost.

Politicians at the national level seemed oblivious of the risks associated with climate change and sea level rise in relation to the eight sites for new nuclear plant, which were designated in 2010. They voted through a motion in the House of Commons agreeing to the Justification for Nuclear and then, in the height of a scandal on phone hacking, on the last day before the House broke up for the 2011 summer recess, they nodded through another agreement to allow permission for the new sites to be used by utility companies to build new nuclear plant. This happened in June 2011 before the final report on the implications of Fukushima disaster by Mike Weightman is to be published and before the UK Health and Safety Executive has issued a clean bill of health on two generic designs for plant, put forward by two contenders: Westinghouse from the USA and by Energie de France, subsidised by the French government.[10]

Lydia Meryll, National Assembly of Women, WILPF United Kingdom, and SERA

In much the same way, the Fukushima nuclear disaster caused such a panic in Whitehall that the government's business and energy departments worked closely behind the scenes with EDF Energy, Areva, and Westinghouse to try and ensure that the accident did not derail their plans for a new generation of nuclear plants. "This has the potential to set the nuclear industry back globally," wrote one official at the Department for Business, Innovation and Skills. "We need to ensure that the anti-nuclear chaps and chapesses do not gain ground on this. We need to occupy the territory and hold it. We really need to show the safety of nuclear."[5]

The business department emailed the nuclear firms and their representative body, the Nuclear Industry Association (NIA), on 13 March, two days after the disaster knocked out nuclear plants and their backup safety systems at Fukushima. The department argued that it was not as bad as the "dramatic" TV pictures made it look, even though the consequences of the accident were still unfolding and two major explosions at the reactors on site were yet to happen. "Radiation released has been controlled—the reactor has been protected," they said, when in actual fact the reactors were close to meltdown.[6]

The government commissioned from the Chief Nuclear Regulator, Mike Weightman, a report on the lessons to be learnt by the UK from Fukushima, to be presented September 2011. Hoping for reassuring news to prevent the delay of important steps towards the building of new reactors, the government asked for an interim report in May—only five weeks after the disaster struck and while the situation was still out of control. The bland statements in this interim report confirm the fear that the UK nuclear regulators are far too close to the government for safety—a major cause of the troubles that led to Fukushima.

What some of the problems are

Auctioning off state assets

The government is struggling to deal with a financial crisis and a mountain of debt. It does not have the capacity to deal with the spiralling cost—and interminable delays—of building new nuclear power stations.

One example of its desperation in tackling this problem is the forthcoming auction of the government's £1 billion stake in Urenco, the company that enriches uranium for nuclear power stations. Urenco, based at Capenhurst near Chester, is one of the few remaining state-owned assets that could generate a big payday for HM Treasury. The state owns one-third, with the rest split between the Dutch government and two German utilities, EoN and RWE. Chris Huhne, the Secretary of State for Energy, announced the sale last year but it has been delayed by opposition from some government departments—particularly the Foreign Office and the Ministry of Defence. Their concerns centred on worries of giving up state control of such a sensitive technology and because enriched uranium is also used to build nuclear weapons.[7]

Funding a low-carbon economy

Another problem stems from the government's promise—to an anxious House of Commons and a sceptical public—that there would be no government subsidy for nuclear power. On 12 July 2011, the government launched its long-awaited white paper on electricity market reform and almost immediately was forced to reassure MPs that its plans to overhaul the electricity market will indeed deliver the £110 billion investment required over the next decade to move to a low-carbon economy—and that this was not an underhand way to give a hidden subsidy to the nuclear industry.

Dealing with radioactive waste

There is a vast and increasing radioactive waste mountain in the UK—with all the health risks, intergenerational risks, and terrorist risks that entails. NIREX, a body set up by the nuclear industry in 1982 to examine aspects of disposal of intermediate-level and low-level radioactive waste in a deep geological facility, notoriously failed to prove its case and was rejected by the Secretary of State in 1997. In 2001, the government set up a Committee on Radioactive Waste Management (CoRWM 1) to investigate the long-term management of higher activity radioactive waste. Its recommendations in 2006 were not nearly as positive as the government sought. In identifying a process towards a long-term solution based upon deep disposal, CoRWM 1 insisted that the process should embody both an intensified programme of research and development and the finding of a suitable site based upon the principle of community volunteerism. There was also a significant minority view from CoRWM 1 that was far more reserved still.

While CoRWM 1 was working the government did its about turn and decided it wanted new nuclear build after all, but CoRWM 1 explicitly stated that its recommendations should be applied to legacy wastes only and not to any wastes from new build, which would, it said, require a quite separate process.

The government has not put in place either the intensified research or the processes necessary for developing volunteerism, and has wilfully conflated the issue of new build wastes with legacy wastes and thereby intends that CoRWM 1's proposals should apply to both. It has also appointed a CoRWM 2 body, that it hopes will be much more favourable in its recommendations.

Justification

A challenge has been mounted to the government's justification for nuclear new build. Under European law, any proposed development that might impact upon the environment has to be formally justified by, among other things, showing that the benefits of it would outweigh the detriments. The UK government's formal statement in late 2010 that nuclear new build was justified in these terms is being challenged in an application for a judicial review of the decision.

The case centres on whether the government should have first measured "health detriment" including radiation-linked diseases being inflicted upon people, especially children in the vicinity of nuclear power stations. If there were a judicial verdict against the government's decision then it would be unlawful for it to continue with new build or to issue licences for it. At present a judge is considering the application, which has been submitted via a well-known firm of solicitors, after the large deposit of money required by the court before such a legal process is undertaken, was urgently found by opponents of new build.

Much of the evidence behind the challenge is based upon the 2007 German KiKK Study, which found significantly raised incidence of childhood leukaemia in the vicinity of all the German nuclear stations. There is also sustained criticism of the validity of the scientific model of human radiation risk favoured by the government, which, it is argued, sets the level of radiation before damage may be done far too high. The government has stone-walled against all such arguments, rallying alternative scientific views to back it up, and it remains to be seen whether legal argument may prevail against it.

And then there is Sellafield ...

The Sellafield plant in West Cumbria has been shrouded in controversy since its inception. It was originally called Windscale and was established to burn uranium and produce plutonium quickly for the UK's first home grown nuclear bomb. Windscale was also the site of the UK's first serious nuclear accident in 1957, when in an attempt to cut corners and increase the rate of plutonium production, some uranium cartridges overheated and a fire broke out in the reactor. Personnel were unable to extinguish the fire for several days and a plume of radioactive contamination was released into the atmosphere, falling on cities in the north of England.

Sellafield today is a vast, leaky nuclear complex, which includes Calder Hall and the original Windscale plant. In 1994, a Thermal Oxide Reprocessing Plant (THORP) was opened at Sellafield to reprocess irradiated oxide nuclear fuel from both the UK and foreign reactors. In 2005, however, 83,000 litres of radioactive waste was found to have leaked from a cracked pipe in the Thorp plant into a huge stainless-steel container lined concrete chamber built to contain leaks. A discrepancy between the amount of material entering and exiting the Thorp processing system was first noticed in August 2004 but no action was taken at the time. It was not until ten months later in April 2005, that operators discovered the enormity of the leak, which amounted to some 19 tonnes of uranium and 160 kilograms of plutonium. Although no radiation was released into the environment, the event was given a Level 3 rating on the International Nuclear Event scale and Sizewell Ltd was fined £500,000 for breaching health and safety laws.

Sellafield was allowed to restart the Thorp plant in 2007 but it has been ear-marked for permanent closure in August 2011 with the loss of 600 jobs. Thorp was designed to produce 120 tonnes of reactor fuel each year but had been so beset by technical problems that it managed only 13.8 tonnes in its entire lifetime. The cost to the taxpayer of this mammoth failure was £1.34billion. As a result of the closure, Britain will be left with about 13 tonnes of Japanese plutonium for decades. The plant was supposed to convert the plutonium into MOX (mixed oxide) fuel to be shipped back to Japan but instead will have to be kept in storage in the UK. In addition to the 13 tonnes of Japanese plutonium, the UK also has 110 tonnes of plutonium from reactors built up over the past 50 years—the biggest civilian stockpile of plutonium in the world. There is no evidence whatsoever that sufficient MOX demand worldwide exists or will exist—particularly in the UK where many of the proposed new reactors may never get built. Yet the Nuclear Decommissioning Authority (NDA) is currently considering building a new reprocessing plant in place of the old one and Areva of France has already submitted a proposal to build the facility at the cost (to the taxpayer) of around £1.4 billion.

The decision to build a new MOX reprocessing plant in addition to a new nuclear power plant at Sellafield will not find any favour with neighbouring countries. The Irish, Norwegian, and Manx governments are all seeking closure of the whole facility because the east coast of Ireland and the coastlines of Norway and the Isle of Mann are all vulnerable to radioactive discharges from Sellafield. Monitoring undertaken by the Norwegian Protection Authority has shown that the prevailing sea currents transport radioactive materials leaked into the sea at Sellafield along the entire coast of Norway and water samples have shown up to ten-fold increases in such materials as Technetium-99.

What is civil society doing about the government's headlong dash for nuclear power?

Despite the government's determination to proceed with building eight new nuclear power stations, there are many strong and well-established anti-nuclear groups in Britain working to prevent them.

One example of the success of their protests is the fact that trains carrying radioactive material from nuclear plants on a line through the Olympic Park and on to Hackney are to be suspended throughout the London 2012 games. The trains carry spent nuclear fuel rods in 30cm thick reinforced steel lead-lined flasks from Suffolk's Sizewell-A reactor along the former North London Line en route to Sellafield, in Cumbria, to be reprocessed. For over 30 years anti-nuclear protestors have campaigned to halt the transportation of the hazardous material by rail through the centre of London claiming it was a potential disaster risk and a terrorist target, with the Olympics heightening that threat. Rail operators Direct Rail Services confirmed the suspension following discussions with the Olympic Delivery Authority and Magnox Ltd, which manages the nuclear plants. It stressed the decision had nothing to do with terrorist fears explaining it was designed to free up space for more passenger trains because of the increased demand during the nine week period of the Olympics and Paralympics.[8] The blatant dishonesty in this statement illustrates the background against which civil society's current attitude towards nuclear power needs to be seen.

Even in the early days when the government was convinced it had to go for nuclear power in order to develop the bomb as a national necessity, ethical and environmental concerns were raised about nuclear power. By the time Margaret Thatcher in 1979 decided the UK must have ten new nuclear reactors, there was such a well-informed and devoted anti-nuclear lobby, formed around Greenpeace, Friends of the Earth, and several groups local to the proposed sites and to Sellafield, that the Sizewell B public inquiry became the longest ever held. Even though the decision to build Sizewell B was eventually taken on the grounds of national necessity, the anti-nuclear argument was so hugely reinforced by the Chernobyl disaster that Sizewell B was the only one of Thatcher's ten stations built. However, that was also partly because the extra safety requirements for nuclear reactors following Chernobyl made nuclear power impossibly expensive for the state to consider.

With the inconclusive Hinkley Point inquiry, the privatisation of the nuclear industry, difficult financial times, the failure of NIREX to solve the waste problem, and the steady work by the anti-nuclear lobby to inform civil society of the dangers of nuclear power and of the alternatives to it for generating electricity, by 2003 the Tony Blair government was saying that nuclear power was not an immediate necessity at all. When a year or two later, Blair suddenly decided that nuclear power was, after all, to form a central part of future electricity generation, there could be no genuine or honest argument of necessity or of environmental or social benefit; it was an expedient ideological switch based upon the Blair government's perceived need for the international status conferred by staying in the nuclear club. Such a position needed a very different form of PR to carry it through, and the PR adopted was to play upon civil society's aspirations and image of itself. The message was that we needed new nuclear power to keep the lights on. And by and large civil society swallowed it, never bothering to question whether in fact we did need either to keep all the lights on or nuclear power to do it. From that time on too, poll after poll has been brought out to show that a majority of people favoured new nuclear power.

At the same time, the government developed a series of departments devoted to promoting new nuclear build, and to inventing one spurious consultation after another, loaded with biased information to keep the anti-nuclear lobby busy countering them. At the same time, the government's lack of leadership in tackling climate change and peak oil allowed the myth of "keeping the light on" to keep the public fairly firmly in favour of new nuclear build.

It was entirely of a piece therefore that, within two days of the Fukushima disaster erupting, the government called in the entire nuclear establishment to coordinate a massive and continuing PR scam to ensure that the disaster did not impact on UK's new nuclear programme. A poll published on 4 August 2011, conducted for the Nuclear Industry Association, indicated that 68% agree that "Britain needs a mix of energy sources to ensure a reliable supply of electricity, including nuclear power and renewable energy sources," while just 12% disagree. The pollster notes, "This is despite a decline in both favourable opinion of the nuclear industry and support for replacement nuclear newbuild since the Fukushima incident. In fact, there remains more favourable opinion than unfavourable opinion (28% compared to 24%) and more support than opposition for newbuild (36% compared to 28%)."[9]

Resources

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Campaign for Nuclear Disarmament , SERA, WILPF, and the National Assembly of Women are adding strength to the voices of the local anti-nuclear groups who live and campaign near to each of the existing power stations. Women's voices are particularly important, as we have seen in Japan, where cleaning up after the tsunami has been followed by the fear of irradiated milk and of the air their children are breathing.

Women make up a large number of the voices of dissent in the UK. We are those who are direct neighbours of a nuclear power station (or "stakeholders", as the NDA calls us) and we have additional Trades Union and national NGO views of the risks. We feel under-informed and under-prepared for any emergency. The recent attempt to put all DECC and NDA deliberations up on the internet does not convince us that the introduction of new plants, however safe the generic design may seem, will be implemented safely through companies subject to market forces and fickle bank lending regimes. Nor do we believe that there will be no government subsidies for the new nuclear industry. The insurance has been underwritten by the state and the planning costs have been avoided. There is no guarantee that in 60 years time, each nuclear company will have saved enough to be able to carry the costs of decommissioning and waste disposal. We know how long it will take for the existing legacy waste to become radiologically "safe". We have no faith that in hundreds of generations' time, there will be the expertise of understanding to be able to deal with leaking waste flasks, corroded containers, geological shift, and water table pollution through incursion into repositories. Nor do we believe that when the repository in the UK is due to be completed in 120 years time, it will be designed to contain inter-reacting kinds of radioactive material. So, as mothers and grandmothers, we are particularly concerned that short term profit and the scare of the lights going off in rich countries is held against the ethics of protecting our children's children. This is an ethical as well as a practical dilemma, for which we see the only way forward is to abandon the new nuclear plans and make safe the dangerous substances we have already produced.

Lydia Meryll, National Assembly of Women, WILPF United Kingdom, and SERA

United States

Mary Olson

Nuclear energy is often falsely promoted as a cure-all in the United States and around the world. The "Peaceful Atom" was to be the antidote to nuclear conflict, yet massive stocks of weapons-usable plutonium have been generated through the process of making electricity;[1] then a cure for world poverty was promised from the most costly form of centralized power generation to date.[2] Today, nuclear proponents claim a cure for the climate crisis, when in fact, nuclear is not carbon-free and new nuclear capacity is one of the least effective investments both in terms of cost and timeline for reducing greenhouse emissions.[3] In addition, the atomic age has been punctuated by enormously catastrophic events resulting in massive release of radioactivity[4] to our environment, exposing human populations and resulting in many additional cancers, more leukemia, birth defects, and barriers to reproduction (sterility or spontaneous abortion of a mutant fetus).[5] Radiation inflicts disproportionate harm to children[6] and women.[7] Indeed, there is no safe dose of radiation.[8] Radioactivity is routinely released from all industrial nuclear sites even during non-accident operations. Massive new radioactivity is generated by "24/7" fission at power reactors and accounts for more than 95% of the hazard in total US radioactive waste.[9]

Two atomic catastrophes in 1957 were kept secret. A Soviet nuclear waste storage tank in Mayak exploded, and in Scotland a tritium-production reactor called Windscale burned.[10] The 1966 partial meltdown of Fermi-1, a plutonium breeder-reactor near Detroit, Michigan was also kept quiet.[11] The first nuclear meltdown with TV news coverage was the Three Mile Island (TMI) reactor in Pennsylvania in 1979.[12] In 1986, the explosion at the Soviet reactor called Chernobyl became the largest industrial accident in history, measured in health consequences, expense, and area impacted.[13]

Nuclear accidents have a starting point, but in reality these events have no end; interdiction is permanent. Tragically, the people of Japan bear the burden of both the first atomic catastrophes—the atomic bombing of Hiroshima and Nagasaki—and now the ongoing nuclear disaster in Fukushima.

Military action in 1945, and the subsequent reconstruction-period when US corporations introduced nuclear energy to Japan (including the General Electric Mark-1[14] design in Fukushima) give the United States of America a causal role in the nuclear events in Japan. This chapter will focus on nuclear energy in the USA, so the global dimension of US nuclear operations will not be expanded further, but must be acknowledged. Reactor designs by General Electric (GE) and Westinghouse remain key products in global nuclear sales.

The roller coaster of nuclear power development in the USA

President Nixon in 1973 predicted 1000 nuclear power reactors would be operating in the USA in the year 2000. A total of 132 power reactors have been tied to power grids in the USA; in the year 2000 only 103 reactors had operating licenses. In 1973 the last order was made for a new reactor that actually came on-line. The US nuclear industry has been at a standstill; in fact, it has been shrinking since 1974, when the first of ninety-eight nuclear construction permits, including many partially constructed units was canceled. Billions of investment dollars were lost. In addition, twenty-nine operating nuclear reactor licenses were terminated before the 40 year expiration, including 26 closed by aging and/or economic concerns, one by voter referendum, and two (Fermi 1 and TMI) due to core melt. Communities in New York,[15] New Jersey, and Vermont[16] are working hard to close three more aging reactors at the end of the 40 year operating license.

What caused the nuclear downturn? Primarily this: corporate financial officers had hard data from the first decade and more of nuclear operations showing that nuclear is not a viable way to make a profit. Three Mile Island (TMI), where a reactor turned to nuclear waste overnight and many people were exposed to radiation,[17] was a forceful illustration of this point. TMI also brought additional federal safety regulations that further increased the cost of reactor operation.

In 1985, a *Forbes Magazine* cover story entitled "Nuclear Follies"[18] argued that nuclear energy is the largest managerial failure in human history, with a price tag on the first round that has been estimated at more than $100 billion. Public Service Co. of New Hampshire went bankrupt trying to build the Seabrook nuclear complex; Washington Public Power Supply System defaulted on billions of dollars of bonds; and several utilities were forced to eat billions in "imprudent" costs. Unprofitable reactors were written off, or with very little disclosure under electricity deregulation laws, "socialized" by spreading the "stranded cost" across a larger consumer base than was ever served by the facility.

While TMI helped turn the energy industry, it did not (as is sometimes alleged) trigger the civil society "No Nukes" movement in the USA. In 1977, two years before the TMI meltdown, 1414 people were taken into custody for non-violent refusal to break camp on the construction site of the Seabrook reactor in New Hampshire.[19] Group incarceration was used by these activists to organize a network to promote non-nuclear energy

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policy through the end of the 20th century. Grassroots groups in impacted communities remain actively engaged to phase-out nuclear energy today, particularly those living near the twenty-three GE Mark-1 reactors (Fukushima Dai-ichi[20] clones) and those on known fault lines.[21]

Energy development is largely a matter of money, while there are even more real costs. In many reactor communities the latency periods for cancer are up and house after house has cancer victims. It has been 30 years since the one (and only) US government study of public health around commercial nuclear power reactors was published. This 1988 poorly-defined National Cancer Institute study[22] failed to identify effluent pathways and used downwind and downstream sectors as part of the control groups. It is perhaps no surprise that no correlation between reactor location and cancer was found.[23]

Today the aging reactor fleet is generating cash due to a variety of cost-cuts and the write-down of debt, but most of the major impacts like water displacement, thermal pollution, health and reproductive consequences, and long-term waste consequences are externalized. Large reactor components including steam generators and even reactor vessel heads have been replaced due to aging, substandard materials and corrosion.

Wall Street investors and credit agencies remember the enormous losses of the 1970s, '80s and '90s and are not planning to invest in more nuclear development.[24] The large energy companies themselves also will not risk their own assets to build new nuclear, so nuclear expansion in the US, if it happens, will have the financial risk transferred to the public.

The enduring product of atomic power

Splitting atoms results in two categories of fission products—smaller radioactive atoms formed from the fragments of the original atom and also bigger, heavier elements formed when a particle is absorbed and the uranium does not split. These bigger "transuranics" include weapons-usable plutonium and other elements that are not found in nature. The smaller atoms are a long list of elements like cesium and strontium and are much more radioactive than the pure uranium fuel that the process begins with.

Routinely, even without an accident, the fission products leak out of the fuel rods, contaminating everything in the reactor system with high-levels of radioactivity. Any part that must be replaced is considered by US regulations to be "low-level" waste, even items so radioactive that a lethal dose can result in minutes.[25]

In the USA, "low-level" waste may be sent to "processors" for treatments, including incineration. Burning does not reduce radioactivity, but does compact the waste, releasing radioactivity to our environment in the process. Some of the processed waste may be deregulated and sent to ordinary municipal landfills, or even recycled into consumer products.[26] Regulated waste is routinely buried in un-lined trenches, resulting in ground water contamination at these sites.[27]

Irradiated (also called "spent") nuclear fuel is the most concentrated form of radioactive waste. In the USA it contains nearly all the radioactivity from all sources, including nuclear weapons production. The US has no permanent facility for this deadly waste. Like "low-level" waste, it presents a health hazard for hundreds, even thousands of millennia.[28] For twenty years, the plan was to send this waste to Yucca Mountain on traditional native land in Nevada. Nevada and the Western Shoshone people fought this plan and won in 2010, when the US Department of Energy filed a motion to withdraw the license application for this $13 billion boondoggle. Now a Presidentially mandated Blue Ribbon Commission (BRC)[29] is making recommendations for a new policy. The same safe energy advocates working to phase-out nuclear energy offered the BRC recommendations.[30]

New generations

Today, nuclear power constitutes about 20% of total US electric power generation. In 2011, renewable generation exceeded nuclear in terms of share of overall energy production.[31] Advertised as a "nuclear resurgence," 29 proposed new nuclear licenses are now pending before the US Nuclear Regulatory Commission (NRC).[32] Nonetheless, no new license has been granted in the eight-year period since the first new sites were announced (2003). All of these new reactors have been challenged legally on the basis of potential personal harm by people that would be impacted, many represented by non-government organizations (NGOs).[33]

If economics drove the first round, this round is no different. Now reactor construction costs have accelerated to more than $10 billion per new reactor unit on average. The only change is that the federal government has decided to help "restart" this industry.

The Energy Policy Act of 2005 changed the terms of US nuclear development by providing federal loans with a guarantee to cover any default (initial allocation, in 2007, was $18.5 billion dollars). In the same year, the Congressional Budget Office projected that such loans had a 50% chance of default.[34] This is the first time that federal dollars have been offered for full-sized civil nuclear power plant construction. The 2005 law also created a limited tax credit for new nuclear generation and new forms of insurance to cover cost of any delays. Both the Bush and Obama administrations have sought (so far unsuccessfully) to expand government support for new reactors to as much as $50 billion in guaranteed loans.

The federal nuclear insurance program known as "Price-Anderson" was also renewed in 2005. This amendment to the Atomic Energy Act creates an initial pool of self-insurance and a mechanism for charging every US reactor owner for a grand total of about $12 billion. Price Anderson then provides a "liability cap" to the industry, beyond which the situation is referred to Congress. There is no coverage at all for "acts of war".

Given the hundreds of billions of dollars of damage caused by the Chernobyl[35] explosion and fire, a $12 billion fund likely means that large portions of any damage would be borne by the victims, much like the true costs of hurricane Katrina and large oil spills.

These provisions substantiate that nuclear energy cannot survive or grow in an open market, requiring the externalization of most real costs, and also effective "socialization" through direct government support. Most analysts agree that new nuclear energy will not be possible in the USA without such government support.[36]

Even with such support, the nuclear "renaissance" may not be achieved in the USA. In 2010, Constellation Energy rejected a federal loan for its proposed Calvert Cliffs-3 reactor (a joint project with Electricite de France) in part because it felt the loan terms were too stringent, and dropped out of the project. (EdF is still trying to continue it, but has been told by the NRC that it cannot obtain a license unless it can find a US partner). Yet the Congressional Budget Office said in August 2011 that loan terms offered so far by the Department of Energy (one loan has been accepted by Southern Company for two new reactors at its Vogtle site in Georgia) are too lax.[37]

Meanwhile, the CEO of Exelon, the nation's largest nuclear utility, said on 15 August 2011, that the economics of new nuclear construction have gotten worse over the past two years.[38]

The Fukushima accident already has claimed one proposed nuclear project in the USA. Shortly after the accident, NRG Energy abandoned its proposed two-reactor South Texas project (considered a frontrunner for the next federal loan). Tokyo Electric Power was a major investor in that project.

The basic technology of new reactor designs being considered for construction in the USA remains the same as the past: low-enriched uranium fuel, pressurized or boiling water reactors. Elaborate "passive safety" systems also introduce new risk factors.[39] Fundamentally nothing has changed, except for the events in Fukushima—likely the largest nuclear accident to date. It remains to be seen the level of response the US federal[40] and other regulators[41] will make to the lessons from the Fukushima disaster, and how this will impact the attempt to expand nuclear energy in the USA.

Along with a new generation of proposed reactors, a new generation of civil society activists has been "woken up" by the unfolding disaster in Japan to the problems of nuclear energy. In the age of social media, the number of sites devoted to nuclear issues has ballooned this year and social engagement on nuclear issues is again on the rise.

We all live in Fukushima

On 11 August 2011 a coordinated legal action[42] was taken by intervenors in each reactor licensing action (both license extensions of aging reactors and proposed new licenses). The action seeks to force the NRC to incorporate information from its own report released by the Near-Term Task Force[43] on the implications of the Fukushima Dai-ichi nuclear disaster in any (and every) license decision. The Task Force report was written by career NRC staff, appointed by the Commission. The executive summary of the report summarizes the findings in this initial assessment.[44]

Many of the NRC recommendations are common sense, reflecting the events in Fukushima during March 2011, including a focus on loss of electric power; recognition that multiple reactor units **can** have concurrent accidents (previously assumed too remote

photo: Treehugger.com; Protest near Grand Central Station, NYC against New York's Indian Point nuclear power plant, August 2011

a probability to consider); and specific upgrades for flooding and earthquakes. Other findings in the report reflect "histrionic" development of the US nuclear safety programme. After the Three Mile Island meltdown, in addition to added federal safety regulations the US nuclear industry instituted its own "voluntary" programme—outside of federal regulation. The industry programme is not subject to government enforcement action. The report calls this a "patchwork" and recommends that all requirements relevant to severe accidents be incorporated into enforceable federal regulation. While this would be an enormous step forward, local communities and NGOs remain concerned that the NRC does not have a strong track record of enforcing regulations of any kind. And unfortunately the majority of the NRC Commissioners, over the protestations of NRC chair Greg Jazcko, have been seeking to slow the pace of consideration of the recommendations, and their implementation, leaving uncertainty as to whether the US government will act to improve nuclear safety.

Members of the NGO community have made their own recommendations this year on how to increase nuclear safety and security in the USA while pursuing a swift, overall phase-out of atomic energy: immediate, permanent closure of the 23 GE Mark-1 reactors, and those built on geologic fault lines; cancellation of all nuclear subsidies, particularly loan guarantees; repeal of the Price Anderson Act; reduction of irradiated fuel in reactor cooling pools; increased security and local community participation in dry fuel storage at reactor sites; no nuclear license extensions; no new licenses including for nuclear fuel chain activities or any style of new (or old) reactor; expansion of emergency evacuation zones out to 50 miles; safety review of Station Blackout; update of US radiation standards reflecting Chernobyl's consequences in radiological impact assessment (internal exposures); end import of foreign radioactive waste; stop incineration of radioactive waste; ensure that all radioactive materials remain regulated.[45] This programme has endorsements from more than 80 NGOs.

It is the deep hope of this author that the people of the world, including top-level decision-makers, will understand the fundamental truth: we all do live in Fukushima. The people in Japan are suffering orders of magnitude more harm, and yet, the radioactivity from TEPCO's reactors has traveled around the Northern Hemisphere several times. We all have an opportunity to be impacted, some of us fatally, by that radioactive fallout. We are one world, and together we must move, peacefully, out of the Atomic Age, together.

Notes

1. Plutonium generation is discussed in section II, an extensive review of civilian plutonium and the challenges it presents, in Arjun Makhijani, "Plutonium End Game," Institute for Energy and Environmental Research, January 2001, at http://www.ieer.org/reports/pu/.
2. For a critique of the impact of nuclear power, including on emerging economies, see a special edition of *The Nuclear Monitor: Globalization of Nuclear Power*, 2000, at http://www.nirs.org/mononline/globehome.htm.
3. For a collection of studies on nuclear energy as a false solution to the climate crisis see Arjun Makhijani, *Carbon Free, Nuclear Free: A Roadmap for US Energy Policy*, 2003, at http://www.ieer.org/carbonfree/index.html and a collection of further papers by Amory Lovins of Rocky Mountain Institute, including the 2005 classic "More Profit with Less Carbon" originally published in *Scientific American*, at http://www.rmi.org/rmi/Library/C05-05_MoreProfitLessCarbon.
4. The Chernobyl reactor dumped more persistent radioactivity into the biosphere of Planet Earth than all of the nuclear weapons tests combined. See Arjun Makhijani et al, "Radioactive Heaven and Earth," Institute for Energy and Environmental Research, 1991.
5. Radiological harm is the basis of federal regulation of commercial nuclear energy. The US Environmental Protection Agency sets overall goals for protection and the US Nuclear Regulatory Commission enacts regulations (found in Chapter 10 of the *Code of Federal Regulations*, Part 20) to meet those goals. Critics have found reason to attack those goals and regulations as insufficiently protective. See John Gofman, *Radiation and Human Health*, 1982; Rosalie Bertell, *No Immediate Danger?*, Summertown Books, 1986; and Helen Caldicott, *Nuclear Madness*, W.W. Norton, 1994.
6. There is a large literature on the greater impact to young bodies, where cells are divided more rapidly. The impact of ionizing radiation on cells is not only to the DNA, but long-term health impacts like cancer are primarily related to this damage. The classic work on this focused on the unborn child, where in the late 1950s Dr. Alice Stewart working at Oxford discovered a 400% increase in subsequent cancer in children born to mothers who were X-rayed during pregnancy. An essay recounting this history is posted at http://www.ratical.org/radiation/SecretFallout/SF-chp2.html. See the sources cited in Note V and also the National Academy of Sciences 2006 report, "BEIR VII—Biological Effects of Ionizing Radiation".
7. Data published in BEIR VII shows that the same dose level of ionizing radiation causes 50% more cancer to women than to men. Likely this is due to the greater amount of reproductive tissue, which is more vulnerable to the impact of radiation. These findings are published in Table 12D-3 on page 312 of the National Academy of Sciences 2007 BEIR VII report. The title of the table is *Lifetime Attributable Risk of Solid Cancer Incidence and Mortality*. A briefing paper on these findings will soon be available from Nuclear Information and Resource Service, at www.nirs.org.
8. The regulation of nuclear activities is required because there is no level of radiation exposure that does not have the potential to cause health consequences. Even death may result from an atomic exposure so small that it cannot be measured; however, more exposure equals greater chance of problems. The US Environmental Protection Agency acknowledges these facts in its *Safe Drinking Water Standards* and the US NRC bases its regulations on a "no threshold"—for zero risk, there must be zero exposure model.
9. US Department of Energy Integrated Spent Nuclear Fuel database. 1992 edition contained a pie chart. This percentage is now low since the USA has not been in large scale nuclear weapons production in the intervening years but has continued full-time civilian power production.
10. Wikipedia has fairly decent accounts of these events at http://en.wikipedia.org/wiki/Kyshtym_disaster and http://en.wikipedia.org/wiki/Windscale_fire. There is also a body of literature that includes these.
11. One account of the Fermi-1 partial core melt is by John Fuller, "We Almost Lost Detroit," *Reader's Digest Press*, 1975.
12. The body of literature on Three Mile Island is large and diverse. As a starting place for NGO information see http://www.nirs.org/reactorwatch/accidents/accidentshome.htm.
14. Chernobyl: see also the above link.
15. See http://www.nirs.org/factsheets/bwrfact.htm.
16. Many NGOs have been working to ensure that the reactors closest to New York City close. The Governor of New York has recently concurred. See Danny Hakim, "Cuomo Takes Tough Stance on Nuclear Reactors," *New York Times*, 28 June 2011, at http://www.nytimes.com/2011/06/29/nyregion/cuomo-emphasizes-aim-to-close-indian-point-plant.html.
17. Many NGOs in Vermont have been working to ensure the closure of Vermont Yankee, lead primarily by Citizen Awareness Network, at http://www.nukebusters.org/. A turning point was the vote by the Vermont state senate, see Matthew L. Wald, "Vermont Senate Votes to Close Nuclear Plant," New York Times, 24 February 2010, at http://www.nytimes.com/2010/02/25/us/25nuke.html.
18. Dr Steven Wing did a reanalysis of data collected around TMI five years after the accident. The scientists who did the original work were constrained by a court order and could not freely examine that data or discover any conclusion other than that ordered by the court. Wing was not constrained and found 400% increases in several cancers and all cancers combined in those living where the primary plume traveled. See Wing et al, "A Reevaluation of

Cancer Incidence Near the Three Mile Island Nuclear Plant: The Collision of Evidence and Assumptions," *Environmental Health Perspectives*, Volume 105, Number 1, January 1997 and David Williamson, "Study suggests Three Mile Island radiation may have injured people living near reactor," *University of North Carolina News*, 24 February 1997, No. 118, at http://www.unc.edu/news/archives/feb97/wing.html.
19. James Cook, "Nuclear Follies, *Forbes Magazine*, 11 February 1985.
20. Documentary footage from this historic event is available at http://www.turningtide.com/SEABROOK.htm.
21. See http://www.nirs.org/reactorwatch/accidents/gemk1reactorsinus.pdf.
22. Ben Casselman and Brian Spegele, "Reactors on Fault Lines Getting Fresh Scrutiny," *Wall Street Journal*, 17 March 2011, at http://online.wsj.com/article/SB10001424052748704396504576204672681780248.html.
23. See: Steve Wing, "Objectivity and Ethics in Environmental Health Science," *Environmental Health Perspectives*, Volume 111, Number 14, November 2003.
24. There is a growing body of literature that does link proximity to reactors that have not had major accidents with cancer and other health impacts. There is of course extensive information on the health consequences of the Chernobyl accident.
25. "Why a future for the nuclear industry is risky," based on presentations of Peter Bradford and David Schlissel, January 2007, at http://www.iccr.org/news/press_releases/pdf%20files/risky_Jan07.pdf. In addition a series of reports from the credit agencies like Standard and Poor and Moody's are available, but not online.
26. See pages 50–52 of the Government Accounting Office report at http://www.gao.gov/corresp/rc98040r.pdf.
27. Diane D'Arrigo and Mary Olson et al, *Out of Control—On Purpose: DOE's Dispersal of Radioactive Waste into Landfills and Consumer Products*, Nuclear Information and Resource Service, Takoma Park, MD, USA, 14 May 2007, at http://www.nirs.org/radwaste/outofcontrol/outofcontrolreport.pdf.
28. See http://www.nirs.org/factsheets/llwfct.htm.
29. See link in note 27 and also the Environmental Protection Agency standard for the now canceled Yucca Mountain repository of one million years. Congress ordered a site-specific standard for Yucca since it flunked every other standard available. EPA posts this information at http://www.epa.gov/radiation/yucca/background.html.
30. See www.brc.gov.
31. See http://www.nirs.org/radwaste/hlw/finalbrcanswers111610.pdf.
32. US Energy Information Administration, "Monthly Energy Review," http://www.eia.gov/totalenergy/data/monthly/index.cfm.
33. See http://www.nrc.gov/reactors/new-reactors/col.html and http://www.nrc.gov/reactors/new-reactors/col/new-reactor-map.html.
34. NRC licensing action and the hearings that result from civil society (and other) interventions, are all posted in the Electronic Hearing Dockets, at http://ehd1.nrc.gov/EHD/. The following page has a default log-in of "guest" and anyone may enter by accepting that option.
35. The default rate is discussed in the 2011 Congressional Budget Office report *Federal Loan Guarantees for the Construction of Nuclear Power Plants*, at http://www.cbo.gov/ftpdocs/122xx/doc12238/08-03-NuclearLoans.pdf.
36. There is a huge literature on Chernobyl; an independent report published on the 30th anniversary is called TORCH (The Other Report on Chernobyl Health impacts), at http://www.nirs.org/c20/torch.pdf; also see one from one of the "fathers" of the Atomic Age, John Gofman, at http://www.ratical.org/radiation/Chernobyl/.
37. A recent addition to the many analyses that make the conclusion that nuclear requires subsidy to be "viable" is from the Union of Concerned Scientists, *Nuclear Power: Still Not Viable Without Subsidies*, 2011 at, http://www.ucsusa.org/nuclear_power/nuclear_power_and_global_warming/nuclear-power-subsidies-report.html.
38. Ryan Tracy, "US Undercharges For Nuclear Loan Guarantees—Congressional Report," *Dow Jones Newswire*, at http://bit.ly/nZBwDh.
39. "Exelon CEO Says Nation Needs Nuclear Power, But Cites Economic Challenges to New Build," *BusinessWire*, 15 August 2011, at http://bit.ly/nKyLLc.
40. For instance, the AP1000 design by Westinghouse creates a "cooling" updraft around the reactor containment, but this same feature may distribute radioactivity faster and farther in the event of containment failure. Arnie Gundersen of Fairewinds Associates has characterized these issues which are pending before the US NRC as concerns in certification of the AP1000 design, at http://www.fairewinds.com/content/ap-1000-press-conference-%E2%80%93-technical-statement.
41. The NRC Commissioners have not as of 15 August 2011 decided to act on any of the NRC staff recommendations for upgrades in NRC regulations.
42. State regulators have no direct jurisdiction over a nuclear reactor, but the state does rule on the need for energy and overall energy policy as well as relevant functions like emergency response.
43. The edition filed at one site is available at http://www.nirs.org/nukerelapse/levy/levyhome.htm.
44. *Recommendations for Enhancing Reactor Safety in the 21st Century*, Report of the NRC Near Term Task Force Review of Insights from the Fukushima Dai-ichi Nuclear Accident, 12 July 2011, at http://www.pbadupws.nrc.gov/docs/ML1118/ML111861807.pdf.
45. Recommendations are offered in the Executive Summary (pages vii-x) of the report noted above. See http://www.nirs.org/nukerelapse/whattodo/postfukushimaprogram.pdf.

Annex 1: Letter from Yvonne Margarula to Ban Ki-moon

GUNDJEIHMI
ABORIGINAL CORPORATION

Ban ki-Moon
Secretary-General United Nations
760 United Nations Plaza
New York, NY USA 10017

Dear Secretary-General,

It was with great sadness that we Mirarr People of the World Heritage listed Kakadu National Park in the Northern Territory of Australia learned of the suffering of the Japanese people due the recent earthquake, tsunami and nuclear crisis. Our thoughts and prayers are with the people of Japan at this most difficult of times. We hope that individuals, families, communities and the nation may rebuild their lives. We also hope for a speedy resolution to the ongoing Fukushima nuclear emergency.

It is known that Aboriginal people have occupied Australia for some 60,000 years because of an archaeological site on my country in Kakadu, where people, including myself as a child, regularly visited and camped. I am the clan leader, or senior traditional owner, in the world's oldest continuing cultural tradition. We Mirarr are the traditional owners of the land now subject to the Ranger Uranium Mine and the site of the proposed Jabiluka uranium mine. The Ranger mine now produces some 10% of the world's mined uranium. We Aboriginal people opposed Ranger's development and even though our opposition was overruled it has never gone away.

A month ago a delegation of this Corporation, comprising three young Indigenous women from Kakadu, visited Tokyo, Hiroshima and Nagasaki as part of the 72nd Global Peace Voyage of the Peace Boat. Here they met with Hibakusha (survivors of the atomic bombings of Hiroshima and Nagasaki) and people and organisations concerned with nuclear and peace issues. This recent visit heightens the sense of solidarity we feel for the people of Japan in their suffering and reinforces the Mirarr People's position against further uranium mining in Kakadu.

In the early 1970s the Australian Government, as part of its negotiations with Japanese Prime Minister Kakuei Tanaka, committed to the export of uranium from our land at Ranger to Japan. This commitment came many years before the enactment of Aboriginal land rights in the Northern Territory. We were not consulted about this. We opposed Ranger's development. When the Australian Government introduced land rights legislation in 1976 our ability to stop the Ranger mine was blocked by special provisions of the *Aboriginal Land Rights (Northern Territory) Act*. Given the long history between Japanese nuclear companies and Australian uranium miners, it is likely that the radiation problems at Fukushima are, at least in part, fuelled by uranium derived from our traditional lands. This makes us feel very sad.

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Ranger has operated since 1980 and has brought much hardship to local Aboriginal people and environmental damage to our country. For over 30 years we have experienced and lived with the 'front end' reality of uranium mining and we are opposed to any further mining at the Jabiluka site. From 1998, I led an international coalition of environment, peace, faith and human rights groups against Jabiluka's development. We received a lot of support from international networks and institutions such as UNESCO, the European Parliament and the US Congress. Over an eight-month period in 1998 more than 5000 protesters, including myself and other Mirarr traditional owners, peacefully blockaded the Jabiluka site. All our efforts were recognised that year when I was awarded both the Friends of the Earth International Environment Award and the Nuclear-Free Future Award. In 1999 I jointly received, with Jacqui Katona, the Goldman Environment Prize for my efforts to protect my country from uranium mining. We Mirarr remain opposed to Jabiluka's development; the Fukushima incident only strengthens our resolve.

Today some 12 million litres of radioactive contaminated water lies on site at the Ranger Uranium Mine, upstream of Indigenous communities and internationally recognised Ramsar listed wetlands. The mining company, owned by Rio Tinto, has suspended all milling of uranium due to the persistent water management problems and threats posed to the environment. All this is of great concern and is taking place within Australia's largest national park and our homeland, Kakadu.

I am writing to you to convey our solidarity and support with all those people across the world who see in the events at Fukushima a dire warning of the risks posed by the nuclear industry. This is an industry that we have never supported in the past and that we want no part of into the future. We are all diminished by the awful events now unfolding at Fukushima. I urge you to consider our viewpoint in your deliberations with governments in relation the Fukushima emergency and the nuclear industry in general.

In 2009 the European Commission found that approximately 70% of uranium used in nuclear reactors is sourced from the homelands of Indigenous minorities worldwide. We Mirarr believe that this constitutes an unfair impact on Indigenous people now and into the future. We suffer the dangers and long term impacts of the front end of the nuclear fuel cycle so that others overseas may continue to enjoy lives without the awareness of the impacts this has on the lives of others.

For many thousands of years we Aboriginal people of Kakadu have respected sacred sites where special and dangerous power resides. We call these places and this power *Djang*. There is *Djang* associated with both the Ranger mine area and the site of the proposed Jabiluka mine. We believe and have always believed that when this *Djang* is disturbed a great and dangerous power is unleased upon the entire world. My father warned the Australian Government about this in the 1970s, but no one in positions of power listened to him. We hope that people such as yourself will listen, and act, today.

Yours truly,

Yvonne

Yvonne Margarula

6/4/11

Annex 2: Letter from IPPNW to Prime Minister Kan

INTERNATIONAL PHYSICIANS
FOR THE PREVENTION OF NUCLEAR WAR
66-70 UNION SQ. #204, SOMERVILLE, MA 02143, USA
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22 August 2011

The Hon. Naoto Kan
Prime Minister
Cabinet Secretariat
1-6-1 Nagata-cho, Chiyoda-ku
Tokyo 100 – 8968
Japan

Dear Prime Minister Kan:

IPPNW has been closely following the tragic events in Japan following the earthquake and tsunami of March 11. We would like to express our heartfelt sympathy for the victims of this terrible disaster and for all the Japanese people. At this time of year you commemorate the atomic bombings of Hiroshima and Nagasaki with a national appeal for peace and the abolition of nuclear weapons to prevent the possibility they will ever again be used. We regret that you must mark these anniversaries this year while struggling to recover from a new nuclear disaster at Fukushima. All of us at IPPNW share your grief over these events.

We have been particularly concerned for the past several months with the nuclear power plant disaster at Fukushima Daiichi and with the effects of radiation exposure on the most exposed populations. From the earliest weeks of the crisis, we have expressed our regret that the Japanese public and the international community do not seem to have been fully informed about the nature and extent of radioactive emissions from the crippled reactors; that affected populations may not have been monitored adequately for exposure to radiation; that residents may not have been evacuated from a wide enough area around the reactors; and that exposure limits seem to fall short of what is needed to protect the Japanese people—in particular vulnerable populations such as children and pregnant women—according to international best practice.

We were disturbed to learn from recent reports that questions have been raised about whether government agencies responsible for nuclear safety might have put political and economic interests ahead of the public's health.

As an international organization of physicians concerned first and foremost with the threats to health and survival posed by both nuclear weapons and by nuclear plant disasters such as Fukushima, we urge you to increase the priority given to the health and safety of the Japanese people as you make complex and difficult decisions about how to handle the ongoing crisis. Because nuclear disasters have such severe long-term consequences; and radioactive contamination respects no boundaries and has spread globally from Fukushima through the atmosphere and ocean, the Fukushima disaster has global health impacts and relevance far beyond Japan.

As you have stated, the situation is not yet stable. Until the damaged reactors and spent fuel ponds have their structural integrity restored, stable cooling sustained and are in cold shutdown, there remains a possibility of further releases of radioactivity from the extensively damaged plant, especially in the context of continuing frequent aftershocks. It is therefore vital in our view that comprehensive plans be in place for prompt, large-scale further evacuations within at least 80-100 km of the Fukushima Daiichi plant, should the need arise.

Even without any further widespread airborne releases of radioactivity, however, we urge that the following steps be taken to unequivocally place public health above all other interests without delay, where they are not already underway:

1. A comprehensive, consistent, best-practice approach to radiation protection and care for the population in areas significantly contaminated is urgently needed. Essential elements should include:
    a. Detailed spatial mapping of radioactive contamination.
    b. Management based on actual levels of contamination and anticipated total exposures, both external and internal, not simply distance from the Fukushima Daiichi plant.
    c. Ongoing long-term monitoring with timely, full public reporting of radioactive contamination of the terrestrial and marine environment, and of food, plants and animals and water.
    d. A comprehensive population register of those in significantly contaminated areas and all workers at the Fukushima Daiichi site, with early evaluation of exposures and long-term (life-time) health monitoring. We understand that the Japanese and Fukushima prefectural governments, with the National Institute of Radiological Sciences and Fukushima Medical, Hiroshima and Nagasaki Universities, have recently begun to collaborate on comprehensive population health checks of people in Fukushima. This is welcome, and such data can be important to provide optimal care for individuals, understand and document the long-term consequences of the disaster, and plan and target services to best meet the affected population's health needs. These plans and progress could usefully be shared in detail internationally. We would urge that comprehensive population register - based health monitoring should be long-term, independent, and that all procedures, data and findings should be internationally peer-reviewed and available in a timely fashion in the public domain. The lack of such a rigorous process after the Chernobyl disaster still constitutes a major unmet gap that for example the International Agency for Research on Cancer seeks to address. Ongoing evaluation of internal radiation exposures should be an important element of population monitoring.
    e. The maximum acceptable additional non-medical radiation exposure limit for the general population should be returned to 1 mSv per year in total (i.e., including both internal and external exposures to all radioactive isotopes). This is especially important for children and pregnant women and should occur without delay.
    f. In keeping with the growing weight of evidence of health risks associated with chronic low-level ionising radiation exposure, and radioactive contamination management practices elsewhere, no avoidable non-medical population exposures above a total 5 mSv per year of additional radiation should be accepted. We further recommend that no population exposures greater than 1mSv should be accepted for adults under 50 years beyond the first year after the nuclear disaster.
2. We see no alternative but that additional evacuations will be required to implement best-practice international standards of radiation protection. In order to minimize further avoidable exposures, these evacuations should be planned and undertaken expeditiously, and completed well before the end of 2011, to address the period of highest environmental radioactivity.

3. Relocation assistance should be made available to all likely to receive more than 1 mSv/year additional radiation exposure as a result of the nuclear disaster were they to remain in their normal place of residence, in order to facilitate health protection and avoid additional financial and mental health burdens for many who have already lost a great deal.
4. We remain profoundly concerned that the 20 mSv annual radiation dose limit for members of the public, including children and pregnant women, set by your government in April, unfortunately represents the greatest willingness to accept radiation-related health harm for the general population of any government around the world in recent decades. As physicians, we have an ethical responsibility to state that such a level is associated with unacceptable health risks where these can be avoided.
5. Authoritative information on how citizens can reduce their own and their family members' radiation exposure should be widely promoted. However, it should also be recognized that significant decontamination measures, particularly on a large scale such as in farming areas, will require the resources of government.

We believe that these measures are medically necessary for safeguarding as much as possible the health of those exposed to Fukushima's radioactive fallout, and future generations who will also be at risk. Such clearly articulated and acted-upon priorities would also go a long way to restore confidence, in Japan and internationally, that vested interests are not compromising people's health and well-being. We would greatly welcome assurances from you, Prime Minister, that you not only share this perspective but will also act decisively to put these measures into effect.

Sincerely,

Vappu Taipale
Co-President

Sergey Kolesnikov
Co-President

Robert Mtonga
Co-President

Annex 3: Other important resources

The following is a non-comprehensive collection of recent NGO reports and online resources on subjects related to nuclear power, all of which make an important contribution to the ongoing demand for the phase-out of nuclear power.

Recent reports

The World Nuclear Industry Status Report 2010–2011: Nuclear Power in a Post-Fukushima World, 25 Years After the Chernobyl Accident

Written by Mycle Schneider, Antony Froggatt, and Steve Thomas
Commisioned by the Worldwatch Institute with the support of the Greens-EFA in the European Parliament, 2011
http://www.worldwatch.org/system/files/pdf/WorldNuclearIndustryStatusReport2011_ FINAL.pdf

Nuclear Roulette: The case against a "nuclear renaissance"

Written by Gar Smith
Published by International Forum on Globalization, June 2011
http://ifg.org/pdf/Nuclear_Roulette_book.pdf

Nuclear Power's Other Tragedy: Communities living with uranium mining

Written by Erika Kamptner with contribution from Julia Nania
Published by Earthworks, June 2011
http://earthworksaction.org/pubs/Nuclear-Power-Other-Tragedy-low.pdf

Spent Fuel from Nuclear Power Reactors

Edited by Harold Feiveson, Zia Mian, M.V. Ramana, and Frank von Hippel
An overview of a new study by the International Panel on Fissile Materials, June 2011
http://www.fissilematerials.org/ipfm/site_down/ipfm-spent-fuel-overview-june-2011.pdf

Uranium Mining in the DR Congo

Published by the Ecumenical Network Central Africa, June 2011
http://www.oenz.de/fileadmin/users/oenz/PDF/Studie/Uranium_Mining_in_the_DRC_OENZ_June_2011.pdf

Climate Change, Nuclear Risks and Nuclear Disarmament: From Security Threats to Sustainable Peace

Written by Jürgen Scheffran
Commissioned by the World Future Council, May 2011
http://www.worldfuturecouncil.org/fileadmin/user_upload/PDF/110517_WFC_Scheffran_Report.pdf

Renewables 2011 Global Status Report

Published by the Renewable Energy Policy Network, 2011
http://bit.ly/REN21_GSR2011

System for Change: Nuclear Power vs Energy Efficiency + Renewables

Written by Antony Froggatt with Mycle Schneider
Published by Heinrich-Böll-Stiftung and the Green European Foundation, September 2010
http://www.boell.org/downloads/HBS-Frogatt_web.pdf

The Uncertain Future of Nuclear Energy

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Choose Nuclear Free, Australia
http://www.choosenuclearfree.net

Citizens for Justice, Malawi
http://www.cfjmalawi.org/

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http://www.energyscience.org.au/

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