The Asia-Pacific Journal: Japan Focus
n-depth critical analysis of the forces shaping the Asia-Pacific...and the world.

Getting to Zero: Doing the Nuclear Math about Japan's Ageing Reactors ゼロに到達するには　老朽化する日本の原発についてのニュークリア計算

Martin J. Frid

The Asia-Pacific Journal, Vol 10, Issue 53, No. 2, December 31, 2012.

Getting to Zero: Doing the Nuclear Math about Japan's Ageing Reactors
ゼロに到達するには　老朽化する日本の原発についてのニュークリア計算

Martin J. Frid

By the beginning of 2013, Japan is relying on just two nuclear reactors to fulfill the nation's enormous demand for electricity. There is a strong push to re-start the remaining reactors from Keidanren, the leading business association, and from the electric power companies, while the New Abe administration has already signaled its intention to review the nuclear power program. It is not so much the revelations about earthquake faults and other dangers; there is something wrong with the entire chain of reasoning driving the new energy agenda. This raises an important question. Are the plants really safe? Is even one of them safe? This article reviews the safety situation of every one of Japan's 54 reactors and assesses the logic of restart.

Massive demonstrations in Tokyo and elsewhere have continued to demand "Genpatsu Zero" (Zero Nuclear Power) and a group of nine legislators from seven parties formed the Genpatsu Zero no Kai (Group for Zero Nuclear Power[1]. There was a promise from the DPJ government that the country would cease to rely on nuclear power "by the 2030s"[2]. Citing doubts and concerns, activists both locally and globally are demanding that Japan permanently shut down its many aging nuclear power plants. Concerned scientists are taking a close look at the very ground they stand on, looking for active seismic faults.

The group of politicians has published a list of Japan's most dangerous nuclear reactors[3] which we may use to start our discussion.

Genpatsu Zero no Kai (Group for Zero Nuclear Power), made up of nine politicians from seven political parties, ranked the threat posed by the nation's 50 reactors on a 10-point scale. Oi's two oldest reactors, which are more than 30 years old and located on fault lines that some scientists say may be active, were considered more dangerous than reactors at the Fukushima No. 1, Fukushima No. 2 and Onagawa nuclear plants, which sustained damage from the Great East Japan Earthquake in March last year. The No. 1 and No. 2 reactors at Oi are currently offline and there are no immediate plans to restart them.

This paper is a work in progress since the Abe government has just moved forward its safety screening of off-line reactors until new safety standards are set up in July 2013[4]. What the new government will do during 2013 is anyone's guess.

Prior to the horrific earthquake and tsunami on March 11, 2011, there were 54 operational nuclear power plants in Japan. Four at the Fukushima Dai-ichi plant are in disaster condition. There were major meltdowns at three plants, and no future for the one that got away. Two others (No. 5 and No. 6) at Dai-ichi are from the late 1970s and can hardly be regarded as serious candidates for re-start since they are inside the highly contaminated zone, right next to a disaster area (More about Fukushima Dai-ni below).

Thus, we start our calculation at 54-6=48 possible candidates for re-start, and let's hope people will stop using the outdated number "54" as Fukushima Dai-ichi can never produce electricity again.

Let's start from the north and go south. Tomari[5] is the only nuclear plant in Hokkaido. Earthquake researchers note that if seismic faults move together, the maximum intensity of subsequent earthquakes will be stronger. It turns out that the Tomari power facility in Hokkaido with three reactors says it cannot rule out the possibility that they are "vulnerable"[6].

So, we get 48-3=45

On the northern tip of Honshu, in Aomori Prefecture, there is Higashidori[7]. Only one reactor, but more have been planned. Fortunately, this reactor was in maintenance shutdown in March 2011, but even so, a strong aftershock in the region on April 7 caused the loss of all external power. The plant managed to switch to backup power to supply cooling to the spent fuel pool, where it keeps all the reactor's used (but still very radioactive and thus dangerously hot) fuel rods. It was a close call, in a region that we now know can expect more strong aftershocks and new earthquakes.

In October 2011 a research group under Professor Watanabe Mitsuhisa of the University of Toyo published a report that raised questions about the seismic safety of Higashidori. A number of faults are present under the complex. In this study, it is unclear whether these faults might be active, as some experts noted in a government safety-screening process. In the new study, the researchers said that certain characteristics are typical for the existence of active faults under the plant site. This was confirmed in December 2012, as a panel of nuclear experts found that two faults under the nuclear power plant in northern Japan may be active.

NHK World[8] noted that the findings could keep the plant offline for some time:

The panel of the Nuclear Regulation Authority made the assessment on Thursday after a 2-day on-site survey of the Higashidori plant in Aomori Prefecture last week. The team's 5 experts include regulation authority official Kunihiko Shimazaki. They agreed that the 2 fissures should be deemed active faults.

Shimazaki summed up the survey to conclude that the faults were possibly active.

Doing the math: 45-1. That leaves us with 44 possible candidates.

Also, in July 2007, a massive earthquake had already damaged the Niigata Prefecture power plant at Kashiwazaki-Kariwa (KK), the world's largest. I visited it in 2008, and it looked like a disaster area. There are six reactors there, and three were still off-line when the March 11, 2011 earthquake occurred. My estimate is that we can count them out, too, even though the plant was an important source of electricity for the Tokyo region. Based on the Genpatsu Zero no Kai list that is calling for the entire plant to be decommissioned, and information on Wikipedia[9] and this interview with experts over at CNIC[10], things do not look good for Kashiwazaki-Kariwa:

It is clear that the earthquake safety assessment for KK was flawed. Its license should be withdrawn, but they are proceeding on the assumption that it will be restarted. We must not allow this to happen. They say they are carrying out back checks on all of Japan's nuclear power plants, but any of these plants could be hit by an earthquake like the one that hit KK. They should all be shut down until the back checks are completed. If it is discovered that the safety assessments were flawed, their licenses should be withdrawn. Only then should the question of whether or not the new guidelines are valid be considered. Of course, all the data and the input values and calculation codes used in the analyses should be publicly available. If they say that safety has been confirmed, they should show the data on which they base their conclusion.

A major scandal back in 2002 would indicate that all is not in order at Japan's and the world's largest nuclear power plant. Note that this used to be a possible candidate for the controversial MOX fuel, but that has fortunately been cancelled.

That means we get 44-6= 38.

Next is Onagawa in Miyagi Prefecture, just north of Fukushima. Here we have three reactors, with many "incidents" and minor radioactive leaks. Also, there was a fire due to the March 11, 2011 earthquake, "from the turbine section." Could all three go on line? There have been all kinds of strong aftershocks in the same region. The Genpatsu Zero no Kai list is particularly concerned with the older nuclear reactor from 1984. But, since there have been many problems with pipes and a leak of radioactivity, how can we possibly say this plant is 100% safe?

I would say, no we can't, which leaves us with 38-3=35 possible candidates for re-start.

Next on our list is Fukushima Dai-ni[11].

How about the four reactors at Fukushima Dai-ni, just 11.5 km south of the disaster zone at Fukushima Dai-ichi? After the March 11, 2011 earthquake, the Dai-ni plant was hit by a nine meter tsunami that came close to causing a serious meltdown, according to the Dai-ni plant manager. It took until March 15 for all four reactors to safely reach cold shutdown[12]:

Plant chief Masuda Naohiro, in charge of plant operations since the crisis, told reporters Wednesday, "The No. 2 plant almost suffered the same fate as No. 1 [which led to a severe crisis]." On March 11, a 9-meter-high tsunami struck the No. 2 plant, while the No. 1 plant was hit by a 13-meter-high tsunami. The tsunami caused the No. 2 plant's seawater pumps, used to cool reactors, to fail. Of the plant's four reactors, three were in danger of meltdown. Luckily, one external high-voltage power line still functioned, allowing plant staff in the central control room to monitor data on internal reactor temperatures and water levels. By March 15, the No. 2 plant's four reactors reached a state of cold shutdown without any leakage of radioactive materials.

The oldest reactor at Fukushima Dai-ni is from 1982. That is old. Let's just imagine a Japan without them all, shall we. No way they will be deemed safe by the general public after all the news about huge aftershakes and all kinds of trouble and fires and leaks. It is impossible to imagine that a privately owned insurance company would support a full re-start. This could, however, be a major issue as Tokyo "needs" electricity: Fukushima Dai-ni may become part of a government-led PR battle to bring nuclear power to the capital. The Genpatsu Zero no Kai calls for them to be decommissioned.

Keeping the possible PR battle in mind, we arrive at 35-4=31.

Next, we have Shika in Ishikawa Prefecture, southwest of Kashiwazaki-Kariwa in Niigata. Both these plants are on the coast of the Japan Sea. Shika is not an important supplier of electricity for the Tokyo region, although Nagoya wants it to go online. However, there is a strong possibility that there is an active seismic fault, the S-1 fault, beneath the power station. The Nuclear and Industrial Safety Agency, NISA said in April 2012 that it was concerned about an active fault under the Tsuruga nuclear plant not far from Shika. Also, the plant has been in the courts due to cover-ups of previous incidents and is not to be trusted.

So, better safe than sorry: Let's just exclude them. 31-2=29.

Next we have Tokai[13] in Ibaragi Prefecture. This was Japan's first, proudly built in the early 1960s to a British design, and generated power from 1966 until it was decommissioned in 1998. The old ones are already shut down and not part of the 54 reactor calculation. A second nuclear plant, built at the same site in the 1970s, was the first in Japan to produce over 1000 MW of electricity. This reactor is also off-line. Ibaraki Prefecture, and the city of Mito, 90 km northeast of Tokyo, is particularly prone to large earthquakes. The national Earthquake Research Committee recently released an updated probability map, indicating that for Mito, the probability of a very large earthquake has climbed 31 points from 2010 to 62.3 percent[14].

On October 11, 2011 Murakami Tatsuya, the Mayor of Tokai stated that the Tokai reactor (Construction started in 1973) should be decommissioned, because it was almost 40 years old, and "the people had lost confidence in the nuclear safety commission of the government"[15]. Over 100,000 signatures against the resumption of the plant's operation, halted since last year, were submitted to Ibaraki Governor Hashimoto Masaru. The petition urges the prefectural government not to allow the Tokai nuclear power plant to resume operation, saying, "We should not allow a recurrence of the irretrievable sacrifice and loss as experienced in the Fukushima Dai-ichi nuclear power plant accident."

Thus, we get 29-2=27.

Hamaoka Nuclear Plant has been called the "most dangerous in the world" and I was personally involved in campaigning against it with the Japan Offspring Fund and local groups in 2005. A new, 22 meters high sea wall is planned to protect the three remaining potential reactors from a tsunami. What is worse, the plant is in a very seismically active area, where the very ground is sand, not solid rock. Should an accident happen here, western Japan would be virtually shut off from the eastern parts, as the Shinkansen train lines and other main arteries between Tokyo and Osaka are nearby. Reactors No. 1 and 2 are already being decommissioned; then Prime Minister Kan ordered the entire plant to be shut down after the March 11, 2011 earthquake. Very wise.

An important choice: 27-3= 24.

Next, we have a group of reactors in Fukui Prefecture. Let's start with Mihama[16]. While it seems unclear how bad the seismic faults are, new research into the active Urazoko fault is particularly worrying. The Mihama Nuclear Plant has had all kinds of serious accidents, especially in 2004 when "hot water and steam leaking from a broken pipe killed four workers and resulted in seven others being injured." This is right next to the Tsuruga Nuclear Power Plant that is also on our current map. Based on the Genpatsu Zero no Kai list that is ranking the ageing three Mihama reactors as well as Tsuruga No. 1 as among Japan's six most dangerous, all should be shut down, since the stakes are so high. The MOX-fueled Monju Nuclear Power Plant is in this neighborhood too, and while it is not part of the current reactor calculation, since it does not provide electricity, a major accident in the region would certainly cause severe

damage and distress.

10-20 million people in the Kansai region are dependent on Lake Biwa because it is the source of drinking water for the whole region. A leak here would be a disaster. Also, in August 2011, concerned citizens initiated a lawsuit to keep these Fukui Prefecture plants north of Kyoto, Osaka and Kobe offline, and to have them decommissioned.

Minus three at Mihama and two at Tsuruga, we get 24-5=19.

Note how Kansai cities like Kyoto, Osaka, Kobe have nuclear reactors very close by these large population centers, while Tokyo kept them much further away, in Fukushima and Niigata. Staying in Fukui Prefecture, we then move on to Takahama[17], in Oi district. Two reactors, both from 1985, were re-started in July 2012, igniting huge protests in Tokyo and around the country. The two oldest ones are from 1974 and 1975 and will probably be decommissioned. Thus we would get 19-2=17. But wait!

Jeff Kingston[18] takes another look at this plant, and notes that Oi may be key to how we, the public, feel about Japan's nuclear future. This particular plant is in huge doubt, as it may be located on active earthquake fault lines.

The new nuclear regulatory safety czar is Tanaka Shunichi, former vice chairman of the Japan Atomic Energy Commission, a key organization that strongly influences government nuclear policy. He also served as president of the Atomic Energy Society, an academic society that advocates nuclear energy. In Diet confirmation hearings in July 2012, Tanaka acknowledged that he is a member of Japan's nuclear village, an admission that attracted public criticism, but did not impede his appointment. Tanaka stated he favors decommissioning older reactors (>40 years of operation) and tightening up the provisional safety guidelines hastily cobbled together by the Noda Cabinet at the end of April 2012. He also testified that he would close the Oi reactors if they are found to be located on active fault lines and said the NRA would get more involved in fault line assessments and not rely on the utilities to probe the matter. (Kyodo 8/2/2012) Perhaps, but owing to his background, many critics are skeptical about whether Tanaka is inclined to play a more robust monitoring role and whether regulatory capture will persist.

Where were we? Officially at 17? Or, since it seems that all of the Oi reactors may still be in doubt, shall we make that 15?

As we head further south, how about Shimane, with two nuclear reactors at this plant[19]. Plans to start a plutonium-thermal reactor have been postponed. Shimane 1 is old, from 1974, and the other reactor also ought to be decommissioned since it may be on an active seismic fault, discovered in 2006[20] and the quake estimate for this plant may be too low, according to NISA[21] which gives us 15-2=13.

So far, we have looked at the operational nuclear power plants in Hokkaido and on Honshu, and found that all of them should be shut down permanently and decommissioned. Then there are three more large plants, on the islands of Kyushu and Shikoku: Genkai, Sendai and Ikata.

And Sendai? Construction began in 1979. Two reactors from 1984 and 1985. Are they still fit to stay online?

As for Ikata, three reactors date from the late 1970s. Ikata is one of the plants that may use MOX fuel. How should local people deal with that?

We also know that Rokkasho in Aomori Prefecture may be in serious harm's way[22].

Japan's only reprocessing plant for spent nuclear fuel could sit on an active seismic fault vulnerable to a massive earthquake, experts warned Wednesday. If regulators agree they will have to order its closure and Japan would be without any recycling capacity of its own, a government official told AFP on condition of anonymity. This would leave it dependent on other countries and with no way to deal with waste from the Fukushima plant crippled by last year's earthquake and tsunami. Ikeda Yasutaka, assistant professor of geomorphology at Tokyo University, said a nearly 100-kilometer fault runs under the Rokkasho reprocessing plant in Aomori Prefecture. "Even though experts' opinions are divided on whether this fault is active or not, I think the possibility of it being an active fault is extremely high, given the evidence," Ikeda told AFP. "This fault could cause an 8-magnitude earthquake, so any nuclear-related facilities in the region are in danger," he said, referring to the Shimokita Peninsula where the Rokkasho plant is located. Watanabe Mitsuhisa, professor of geomorphology at Tokyo University, separately told Wednesday's Tokyo Shimbun that part of an active fault runs directly under the Rokkasho plant, warning it is likely to move when the bigger fault moves.

Adding to these problems, it must be noted that spent nuclear fuel rods are stored temporarily at each of the nuclear power plants around the country. These storage pools are close to capacity, meaning most nuclear plants can no longer take care of their used fuel rods. Without a feasible way to store the spent fuel rods even temporarily, not to mention the need for long-term storage, how can anyone argue for continued operation of the plants?

In September, 2012, the Genpatsu Zero no Kai updated its list of Japan's reactors using numerical ranking[23]. They carefully noted the risks, especially new data about active seismic faults. Most dangerous? Tsuruga No. 1 (12.50 points) followed by Oi No. 1 and No. 2 (both at 11.25 points). The rest of the list is not happy reading, either. The three reactors at Mihama, two at Kashiwazaki Kariwa and three reactors at Hamaoka all score above 9.45. Shimane No. 1 gets 9.30 points followed by one more at Kashiwazaki Kariwa that gets 9.20 points. Takahama No. 1 and Shimane No. 2 also score above 9 points. That's one way to list the group of Japan's 15 most dangerous nuclear reactors. A glance at their chart shows that this is closely followed by another group of 22 that score above 6.00 points. None of the reactors are given the green light.

However, experienced anti-nuclear activists may argue that such ranking is a way of giving the nuclear industry the go-ahead to re-start some reactors, especially the newest ones. In an interview with Fresh Currents, Eileen Mioko Smith of the Kyoto-based Green Action warns[24]:

Genpatsu-Zero-no-Kai has analyzed all 50 reactors. Of the total, a dozen or more could end up being targeted by the government for closure. Only a portion of them would be targeted. It's the other 30-odd reactors that are the real question. Will they be kept off?

It is not only the Genpatsu Zero no Kai that has proposed a way forward; at least two other important groups have come forward during 2012. One is Datsu Genpatsu Hou Seitei Zenkoku Network (National Network for Legislation of a Nuclear Phaseout Law), armed with lawyers and intellectuals, including writer Oe Kenzaburo, that want to close down dangerous nuclear reactors, and phase out all by 2025 (or 2030) using tactics such as lawsuits[25]:

A summary bill drafted by the group says nuclear power generation is extremely vulnerable in terms of energy security due to the unresolved issue of waste disposal and because a nuclear accident could cause catastrophic damage, as well as a sudden loss of a huge slice of the nation's power supply.

The draft argues it is essential to establish a stable, nuclear-free power supply that

The Asahi Shimbun

Reactors ranked based on hazard levels

	Reactor	Operator
1	Oi No. 1	Kansai
	Oi No. 2	Kansai
3	Tsuruga No. 1	JAPC
4	Mihama No. 2	Kansai
5	Mihama No. 1	Kansai
6	Mihama No. 3	Kansai
7	Takahama No. 1	Kansai
	Shimane No. 2	Chugoku
9	Takahama No. 2	Kansai
	Shimane No. 1	Chugoku
11	Hamaoka No. 3	Chubu
	Hamaoka No. 4	Chubu
	Hamaoka No. 5	Chubu
14	Tokai No. 2	JAPC
15	Kashiwazaki-Kariwa No. 1	Tokyo
	Kashiwazaki-Kariwa No. 4	Tokyo
17	Onagawa No. 1	Tohoku
18	Kashiwazaki-Kariwa No. 6	Tokyo
19	Kashiwazaki-Kariwa No. 2	Tokyo
	Kashiwazaki-Kariwa No. 5	Tokyo
21	Fukushima No. 1 / No. 5	Tokyo
	Tsuruga No. 2	JAPC
23	Kashiwazaki-Kariwa No. 3	Tokyo
	Kashiwazaki-Kariwa No. 7	Tokyo
	Shika No. 1	Hokuriku

	Reactor	Operator
26	Oi No. 3	Kansai
	Oi No. 4	Kansai
	Ikata No. 1	Shikoku
29	Onagawa No. 2	Tohoku
30	Genkai No. 1	Kyushu
31	Fukushima No. 1 / No. 6	Tokyo
32	Shika No. 2	Hokuriku
33	Tomari No. 3	Hokkaido
34	Fukushima No. 2 / No. 1	Tokyo
35	Takahama No. 3	Kansai
	Takahama No. 4	Kansai
37	Onagawa No. 3	Tohoku
	Ikata No. 3	Shikoku
39	Tomari No. 1	Hokkaido
	Fukushima No. 2 / No. 2	Tokyo
	Fukushima No. 2 / No. 3	Tokyo
	Fukushima No. 2 / No. 4	Tokyo
43	Sendai No. 1	Kyushu
44	Tomari No. 2	Hokkaido
	Sendai No. 2	Kyushu
46	Ikata No. 2	Shikoku
	Genkai No. 2	Kyushu
48	Genkai No. 3	Kyushu
49	Higashidori No. 1	Tohoku
	Genkai No. 4	Kyushu

JAPC: Japan Atomic Power Co.

includes renewable energy to overcome those challenges. To that end, the bill would oblige the government to adopt a basic plan to phase out nuclear energy that would ban the building of new nuclear reactors and limit the operational life of existing reactors to 40 years without exception in order to decommission all nuclear reactors as early as possible, before the end of fiscal 2025.

Submittal of a lawmaker-initiated bill involving budgetary measures requires the approval of 50 or more Lower House members and 20 or more Upper House members. Oe's group expects to reach that target easily, as more than 120 lawmakers from the ruling Democratic Party of Japan alone signed a petition in June calling for reconsideration of the government decision to restart reactors at the Oi nuclear power plant in Fukui Prefecture.

Another group is the radical Hangenren or Shutoken Han-genpatsu Rengo (Metropolitan Coalition Against Nukes) that has staged regular demonstrations throughout 2012 each Friday outside the Prime Minister's Office in Tokyo, and arranged a range of other events. Their stated aim is to immediately decommission all the operational nuclear reactors in Japan, and not allow a single re-start. Hangenren is part of the international Coalition Against Nukes network[26].

To conclude this paper that started as a back-of-a-napkin style exercise: As for nuclear reactors in Japan, there are 13 or fewer, possibly none, that are "maybe safe" and most of them are in western Japan. As I finish writing this paper, I keep wondering what new incident may happen, what discovery of another active seismic fault may come to light, and all kinds of revelations about more problems with Japan's Nuclear Village, that may render this whole calculation terribly redundant. As I found out, it is not just that there are lots of issues with the links: The entire chain is the problem.

Martin J. Frid was born in Sweden and works for Consumers Union of Japan. He is the author of the food guide book *Nippon no Shoku no Anzen 555* (Kodansha) published in 2009. He has participated in food safety meetings on the local, national, and international levels, including as an expert at FAO/WHO Codex Alimentarius Commission meetings. He currently resides in Saitama, Japan.

Recommended citation: Martin Frid, "Getting to Zero: Doing the Nuclear Math about Japan's Ageing Reactors," The Asia-Pacific Journal, Vol 10, Issue 53, No. 2, December 31, 2012.

Articles on related subjects

• Andrew DeWit, Distributed Power and Incentives in Post-Fukushima Japan http://japanfocus.org/-Andrew-DeWit/3861

• John A. Mathews, The Asian Super Grid http://japanfocus.org/-John_A_-Mathews/3858

• Andrew DeWit,Japan's Energy Policy at a Crossroads: A Renewable Energy Future?

• Jeff Kingston, Japan's Nuclear Village

• Andrew Dewit, Japan's Remarkable Energy Drive

• Andrew DeWit, Megasolar Japan: The Prospects for Green Alternatives to Nuclear Power

• Peter Lynch and Andrew DeWit, Feed-in Tariffs the Way Forward for Renewable Energy

• Andrew DeWit, Fallout From the Fukushima Shock: Japan's Emerging Energy Policy

• Kaneko Masaru, The Plan to Rebuild Japan: When You Can't Go Back, You Move Forward. Outline of an Environmental Sound Energy Policy

• Andrew DeWit, The Earthquake in Japanese Energy Policy

• Andrew DeWit and Sven Saaler, Political and Policy Repercussions of Japan's Nuclear and Natural Disasters in Germany

• Andrew DeWit and Iida Tetsunari, The "Power Elite" and Environmental-Energy Policy in Japan

Notes:

[1] Genpatsu Zero no Kai (Blog in Japanese only) <here>

[2] Reuters (20120912) Japan aims for zero nuclear power in 2030s <here>

[3] Asahi Shimbun (20120628) Lawmakers' group identifies Japan's most dangerous nuclear reactors <here>

[4] NHK World 20121220 Reactor screening to begin in July or later <here>

[5] Tomari Nuclear Power Plant (Wikipedia)

[6] NHK World/JAIF (pdf)

[7] Higashidori Nuclear Plant (Wikipedia)

[8] NHK World (20121220) Team finds faults at nuclear plant possibly active <here>

[9] Kashiwazaki-Kariwa Nuclear Power Plant (Wikipedia)

[10] Citizens' Nuclear Information Center: Kashiwazaki-Kariwa Earthquake, Lessons from the Chuetsu-Oki Earthquake <here>

[11] Yomiuri Shimbun (20120210) Fukushima No. 2 plant was 'near meltdown' <here>

[12] Reuters (20120718) Japan to restart second reactor amid faultline concerns <here>

[13] Tokai Nuclear Power Plant (Wikipedia)

[14] Kyodo/The Japan Times (20121222) Probability of strong quakes revised upward for eastern Japan <here>

[15] NHK World/JAIF (pdf)

[16] Mihama Nuclear Power Plant (Wikipedia)

[17] Takahama Nuclear Power Plant (Wikipedia)

[18] Japan Focus: Power Politics: Japan's Resilient Nuclear Village <here>

[19] Shimane Nuclear Power Plant (Wikipedia)

[20] New Scientist (20070728 Where not to build nuclear power plants (Article behind paywall)

[21] Asahi Shimbun (20120620 NISA: Quake estimate for Shimane too low <here>

[22] AFP/Japan Today 20121220 Quake risk seen at Rokkasho nuclear fuel reprocessing plant <here>

[23]Genpatsu Zero no Kai (20120906 Genpatsu Kiken-do Ranking (pdf)

[24] Fresh Currents: Aileen Mioko Smith on Post-Fukushima Realities (pdf)

[25] Asahi Shimbun (20120821) Lawyer, writers call for legislation on nuclear phaseout <here>

[26] Coalition Against Nukes <here>