

Chapter 5

Lessons Learnt from the Fukushima Nuclear Accident



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Abstract Even after 11 years, the Fukushima accident is not completely over yet. Technological challenges for decommissioning of Fukushima are unprecedented. Economic, social, and humanitarian impacts are huge and will remain for a long time. The Fukushima nuclear accident completely changed the energy picture in Japan. Nuclear energy is no longer most reliable, least expensive, “main” power source in Japan. Japan’s long-term energy policy is self-inconsistent, stating “Japan will reduce its dependence on nuclear power as much as possible,” but maintains it as an important option for carbon neutral policy. But mainly due to poor economics, role of nuclear power in carbon neutral policy could be limited. Given the Ukrainian crisis, international community must strengthen international law and norms to protect all nuclear facilities, in particular, sensitive facilities, against military attack. Finally, lessons learned from the Fukushima accidents are: (1) Think unthinkable (2) Engineering risk assessment is not enough (3) Need for independent scientific advice/policy review organization (4) Public trust is essential.

5.1 Introduction

11 years have passed since the Fukushima Daiichi nuclear accident in 2011. Still, there is no clear prospect for decommissioning of the crippled Fukushima reactors and other radioactive wastes generated by decontamination of the land. While evacuation zones have been shrinking steadily, still more than 30,000 people are away from home. Impact of nuclear accident on Japan’s energy profile has been quite significant, and public trust has not been recovered yet. The Japanese government maintains its self-inconsistent energy policy, i.e. reducing dependence on nuclear energy as much as possible, while keeping nuclear power as an important option for policy of “carbon-neutral by 2050”. This paper summarizes the current status of the Fukushima accident (which is not over yet), and draw lessons from the accident.

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5.2 Fukushima Update: The Accident Is Not Over

Many on-site and off-site challenges remain even 11 years after the accident. Here is the short summary of those challenges.

(1) On-site challenges

The removal of spent fuel from cooling pools of Unit 1–4 is the first step to reduce potential risks at the site. So far, removal of spent fuel from Unit 3 and 4 was completed in December 2014 and February 2021 respectively. But spent fuel removal from Unit 1 and 2 has not started yet, and it is currently expected that all spent fuel from both units will be removed by 2031.¹

The biggest short-term on-site challenge is management and disposal of “contaminated water”. Due to continuous cooling of fuel debris at reactors 1–3 and continuous inflow of underground water into the reactor site, contaminated water has been generated and been stored on-site. Through various measures, such as pumping up water by sub-drains, the construction of land-side frozen walls, generation of contaminated water has been gradually decreasing from 350 to 130 m³/day. Still, it means that almost every week a new 1,000 m³ tank is needed.

The plan is to remove most of the radioactive substances (except tritium) by a multi-nuclide removal equipment called Advanced Liquid Processing System (ALPS) and store the “treated water” in tanks. Currently, about 1.3 million m³ of treated water is stored in 1,020 tanks. Although ALPS is supposed to separate most of the radionuclides except tritium, 34% of treated water (total of 1.3 million m³) satisfies regulatory standards and two thirds (about 855,000 m³) of treated water need to be re-purified.² On April 13, 2021, the government decided that treated water containing tritium (and other radionuclides under regulatory standards) will be discharged into the ocean. The treated water needs to be diluted further (at least 100 times or more) so that the tritium concentration after dilution should be below 1,500 Bq (Bq) per liter which is said to be far below the regulatory standard for discharged tritium water.³

Still, before TEPCO can begin with the implementation the discharge plan, local consent will be needed based on pledge made in 2015 that Tokyo Electric Power Co. (TEPCO) would not discharge the water “without gaining an understanding from stakeholders”.⁴ On 5 April 2022, a major fisheries group in Japan told Prime

¹ Ministry of Economy, Trade and Industry (METI), “Status Update of Fukushima Daiichi Commissioning”, March 2022, see https://www.meti.go.jp/english/earthquake/nuclear/decommissioning/pdf/1f_status_20220307.pdf.

² Tokyo Electric Power Co (TEPCO) Holdings, “Treated Water Portal Site”, as of June 9, 2022. <https://www.tepco.co.jp/en/decommission/progress/watertreatment/oceanrelease/index-e.html>.

³ This is reported to be 1/40 of regulatory standard for discharged tritium water. But that statement is somewhat misleading. As the treated water contains other nuclides, 1,500 Bq/L is a regulatory standard for discharge of contaminated water at Fukushima plant, considering the sum of possible exposures from other radioactive nuclides.

⁴ *Asahi Shimbun*, “Japan to release ‘treated water’ from Fukushima plant into the sea”, 13 April 2021, see <https://www.asahi.com/ajw/articles/14329854>, accessed 16 June 2022.

Minister Kishida that they still firmly oppose the discharge of treated water into the sea due to concern over negative impact on the industry.⁵ International concern over discharge of treated water also remains. For example, in April 2022, South Korean Representative Seo Sam-seok made a statement at an international conference, saying “The contaminated water released into the ocean will spread across the entire Pacific Ocean in 10 years and affect almost all of our sea”.⁶

In order to reduce both domestic and international concern, the Japanese government asked International Atomic Energy Agency (IAEA) to review the overall plan. The IAEA Task Force published its first report on 29 April, 2022 and it concluded the risk associated with overall discharge plan is expected to be very low.⁷ Despite such efforts, there is no clear evidence that domestic and international concerns have disappeared.

The most difficult, long-term challenge is what to do with fuel debris. Internal investigation of fuel debris inside the reactor vessels of Unit 1–3 has been postponed several times due to malfunction of remotely operated vehicle (ROV) which is expected to visually confirm existence of fuel debris. There is no clear prospect about what to do with fuel debris at this moment.

(2) Off-site challenges

According to Fukushima Prefecture, as of March 2022, still 32,404 residents are away from home, although the number of evacuees decreased from the peak of 164,865 in May 2011.⁸ Evacuation order has been lifted little by little, and on June 12, 2022, for the first time, the order was lifted for a district designated as “difficult-to-return” zone (an area with high level of radiation higher than 50 mSv/year).⁹ And on June 30, evacuation order was also lifted for the first time for a part of a town, Okuma, which hosts the Fukushima nuclear power plant. The area was designated as “reconstruction and revitalization area” which received special government fund for reconstruction.¹⁰ But it was reported only 13% of residents of Okuma town responded to a survey that they would like to go back to the town.¹¹

⁵ *Kyodo News*, “Fisheries group conveys to PM opposition to Fukushima water release”, 5 April 2022, see <https://english.kyodonews.net/news/2022/04/493cfc399008-fisheries-remain-opposed-to-fukushima-water-discharge.html>, accessed 16 June 2022.

⁶ CGTN, “Int’l community voices concerns over Japan’s wastewater release plan”, April 14, 2022. <https://news.cgtn.com/news/2022-04-14/Intl-community-voices-concerns-over-Japan-s-wastewater-release-plan-19ehhSrxsg8/index.html>.

⁷ IAEA, “IAEA Releases First Report on Safety of Planned Water Discharge from Fukushima Daiichi Site”, Press Release, 29 April 2022, see <https://www.iaea.org/newscenter/pressreleases/iaea-releases-first-report-on-safety-of-planned-water-discharge-from-fukushima-daiichi-site>.

⁸ Fukushima prefecture official statistics, March 2022. <https://www.pref.fukushima.lg.jp/site/portal/list271.html>.

⁹ NHK News, “Evacuation order lifted in part of Fukushima ‘difficult-to-return’ zone”, 12 June 2022, see https://www3.nhk.or.jp/nhkworld/en/news/20220612_11/.

¹⁰ World Nuclear News, 29 June 2022.

¹¹ The Japan News (Yomiuri Shimbun), “Govt lifts evacuation order in part of Okuma”, June 30, 2022. <https://japannews.yomiuri.co.jp/society/general-news/20220630-41883/>.

Nationwide inspection for food contamination continues. In FY 2021, total of 41,361 samples analyzed and only 157 samples (0.38%) was found to exceed the legal limits.¹² Import restrictions of Japanese food due to the Fukushima accident have been relaxed gradually. On February 8, 2022, it was reported that Taiwan would relax a ban on Japanese food imports,¹³ and on June 29, 2022, the UK government announced that it would also lift food import restrictions from Japan.¹⁴

The biggest issue associated with decontamination work is what to do with huge amount of contaminated soil shipped to interim storage sites. The government designated total of 1,600 ha of area as “interim storage site”, and as of May 2022, 79.6% of the area (1,273 ha out of 1,600 ha) has been “contracted” for the establishment of a storage facility.¹⁵ As of the end of May 2022, total of about 13 million m³ of contaminated land was transferred to interim storage facilities.¹⁶ However, there is no clear plan regarding the final disposal of such contaminated soil after interim storage. The government plans to reuse some of the contaminated land which was verified as “below regulatory standards” and started the demonstration program and plan to issue guidelines by FY 2024. But not a single prefecture backs such reuse plan.¹⁷ It shows that there is still a lack of public trust in government plan.

(3) Cost associated with the Fukushima accident

The total cost of the Fukushima accident includes the cost of decommissioning of Fukushima reactors, treatment and disposal of contaminated water, final disposal of radioactive waste, and compensation to victims of the accident. The earliest cost estimate was done by the Committee on Management and Financial Affairs of Tokyo Electric Power Company set up after the accident in 2011. The report, published on October 3, 2011, estimated that total costs would be ¥5.7 trillion. This estimate did not include any expenses for decontamination nor any costs of final disposal of radioactive waste.¹⁸ The second estimate was made in 2014, and its total cost estimate

¹² Ministry of Health, Labor and Welfare, “Sum up of radionuclides monitoring data reported in Japanese fiscal year 2021 (from April 2021 to March 2021)”, as of March 2021, see https://www.mhlw.go.jp/english/topics/2011eq/dl/Sum%20up_March_2022.pdf.

¹³ *Reuters*, “Taiwan to relax Japan nuclear disaster-related food import ban”, as published in *Asahi Shimbun*, 8 February 2022, see <https://www.asahi.com/ajw/articles/14543355>.

¹⁴ World Nuclear News, 29 June 2022.

¹⁵ Ministry of the Environment, “Chukan chozo shisetsu no gaiyou (Outline of Interim storage facilities)”, xx (in Japanese), see <http://josen.env.go.jp/chukanchozou/about/#section03>, accessed 18 June 2022.

¹⁶ Ministry of Environment, “Jokyo dojo nado no yuso (Transportation of contaminated land)” (in Japanese), see <http://josen.env.go.jp/chukanchozou/transportation/index.html>, accessed 18 June 2022.

¹⁷ *Asahi Shimbun*, “Survey: Not a single prefecture backs reuse of radioactive soil”, 28 March 2021, see <https://www.asahi.com/ajw/articles/14311546>, accessed 18 June 2022.

¹⁸ The Committee on Management and Financial Affairs of Tokyo Electric Power Co., “Tinnkai Houkokusho (The Committee Report)”, October 3, 2011 (in Japanese), <http://www.cas.go.jp/jp/seisaku/keieizaimutyousa/dai10/siryou1.pdf>.

was ¥11.6 trillion,¹⁹ and the third estimate made in 2016 done by a “Committee for Reforming TEPCO and Overcoming 1F Challenges” established by the Japanese government was ¥22 trillion yen.²⁰

In 2017, the Japan Center for Economic Research (JCER) came up with their own cost estimate based on a different methodology and assumptions from the ones made by the government. The report concluded that the total cost could rise to ¥50–70 trillion.²¹ In 2019, JCER updated their analysis based on different assumptions and concluded that the cost could go up to ¥30–80 trillion.²²

On 13 July 2021, METI released its latest cost estimates for various power generation sources, including nuclear power.²³ In its report, new estimate of total accident costs was also published. The total cost now included so-called “government administration cost” which is a tax money spent on nuclear power, and was estimated to be ¥23.8 trillion. Other costs were slightly changed but almost the same as 2016 (Fig. 5.1).

In short, the estimates done by the government is neither comprehensive nor up to date and clearly underestimate the total costs. The biggest difference between the government and JCER estimates comes from the fact that the government estimate does not include final disposal costs for radioactive waste generated by decommissioning and decontamination.

(4) Legal cases against TEPCO or the Government

There are many legal cases on the responsibility of the Fukushima accident, and on the re-startup of existing nuclear power plants. The results are mixed, while some are against TEPCO and/or the government some are in favor for them. And there are some decisions to stop operation of existing nuclear power plants while some allowed utilities to start the operation of nuclear power plants.

In 2022, there were two historic court decisions, which can bring significant impacts on future nuclear policy and on nuclear industry, in particular, on operators (utility companies) of nuclear power plant.

¹⁹ NHK News, “Shinsai 3 nen, genpatsu jiko no songai-gaku 11 chou-en ni (3 years after the earthquake, total cost of the nuclear accident will reach over 11 trillion yen)”, (in Japanese), March 11, 2014. http://www3.nhk.or.jp/news/genpatsu-fukushima/20140311/1516_songaigaku.html.

²⁰ The Committee for Reforming TEPCO and Overcoming 1F Challenges, “Recommendations for Reforming TEPCO”, 20 December 2016.

²¹ Japan Center for Economic Research (JCER), “Accident Cleanup Costs May Rise to 50–70 Trillion yen: It’s Time to Examine legal liquidation of TEPCO”, March 7, 2017. <https://www.jcer.or.jp/english/accident-cleanup-costs-may-rise-to-50-70-trillion-yen>.

²² Japan Center for Economic Research (JCER), “Accident Cleanup Costs Rising to 35–80 trillion yen in 40 years: Considering the postponing of decommissioning with ‘Confinement-managing’ scenario as a possible option. Urgent need for measures to manage contaminated water”, July 3, 2019. <https://www.jcer.or.jp/english/accident-cleanup-costs-rising-to-35-80-trillion-yen-in-40-years>.

²³ Ministry of Economy, Trade and Industry, Working Group on Power Generation Cost Assessment, “Kihon Seisaku Bunnkakai ni Taisuru Hatudenn Kosuto To No Kensho ni Kansuru Houkou” (Report on Power Generation Costs etc. to the Basic Policy Committee), 13 July 2021 (in Japanese). https://www.enecho.meti.go.jp/committee/council/basic_policy_subcommittee/2021/045/045_005.pdf.

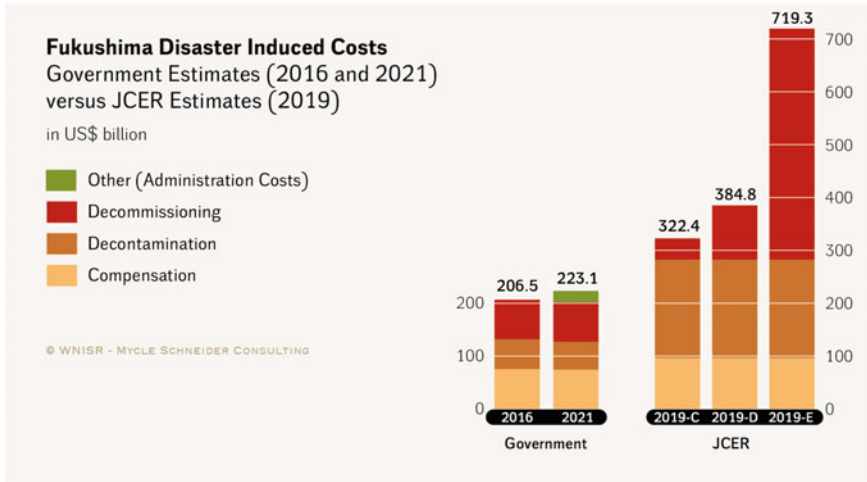


Fig. 5.1 Total cost of Fukushima accident: comparison of government and J CER estimate. *Source* Mycle Schneider et al., “World Nuclear Industry Status Report: 2021”, September 2021. <https://www.worldnuclearreport.org/-World-Nuclear-Industry-Status-Report-2021-.html>

One was the Supreme Court decision made in June 2022, which dismissed the argument that the Japanese government (regulatory agency) was responsible for the accident.²⁴ But the same Supreme Court in March 2022 ordered TEPCO to pay compensation of ¥1.4 billion to about 3,700 people who were heavily affected by the Fukushima accident. This was the first time that the Supreme Court made decisions on the responsibility of the accident.²⁵

The other was the decision made by the Tokyo District Court on July 13, 2022. The Tokyo District Court ordered former executives of TEPCO to pay ¥13 trillion in damages to the operator of the Fukushima Dai-ichi nuclear power plant. The case was brought by TEPCO shareholders and the ruling was the first time a court has found former executives responsible for the nuclear accident. The criminal case against former executives of TEPCO resulted in a different decision that they were not responsible for the accident.²⁶

These rulings mean that a utility company or executives of the operator of nuclear power plants could be legally liable for serious accident, but not the government (or regulator). In fact, under the Japanese nuclear accident compensation law, the

²⁴ *Kyodo News*, “Japan’s top court rules state not liable for Fukushima disaster”, 17 June 2022, see <https://english.kyodonews.net/news/2022/06/e3802f4efbc6-breaking-news-japans-top-court-rules-state-not-liable-for-fukushima-disaster.html>.

²⁵ *Kyodo News*, “Court orders TEPCO to pay 73.5 million yen over Fukushima crisis”, 2 June 2022, see <https://english.kyodonews.net/news/2022/06/2ece2b577eea-court-orders-tepco-compensation-over-fukushima-crisis.html>.

²⁶ *Reuters*, “Tokyo court orders ex-TEPCO execs to pay \$95 bln damages over Fukushima disaster”, July 13, 2022. <https://www.reuters.com/business/environment/tokyo-court-orders-ex-tepco-execs-pay-95-bln-damages-over-fukushima-disaster-nhk-2022-07-13/>.

operator company is responsible for all compensation costs without any cap. But the law also says that the government should assist the operator to pay all related costs. The rulings, however, go beyond the government policy and guidelines for compensation, and it could be interpreted that financial/legal risk of operating nuclear power plants could be much higher than currently expected.

5.3 Impact on Japan's Energy Policy

The Fukushima accident has caused fundamental shift in Japan's energy structure.

Before the Fukushima accident in 2011, 54 nuclear reactors (48.9 GWe) were operating, supplying about 26% of total electricity supply in Japan (2010). Now, only 10 reactors (10.0 GWe) are operating (as of March 2022) and the share of nuclear power dropped to only 3.9% in 2020. Instead, the shares of fossil fuels and renewable energy have increased significantly. Coal's share increased from 28 to 31%, natural gas from 29 to 39%, and renewable energy from 9 to 20% (all from 2010 to 2020).²⁷

Impact on public opinion was also quite remarkable. According to a public survey done by a nuclear industry-affiliated organization, the share of public opinion who thinks "nuclear power is necessary" dropped dramatically from 87.4% in September 2010 to only 24.9% in December 2013. The latest opinion survey done by the same organization shows that public support for nuclear power is still very low; the share of public who thinks "nuclear power should be maintained" is 9.1% and "nuclear power should be expanded" is only 2.2%, while the share of public who thinks "nuclear power should be phased out" is 52.8% and "nuclear power should be shut down immediately" is 7.9%.²⁸

Japan's basic energy policy has also shifted reflecting public opinion but only partially. According to the METI's Strategic Energy Plan published in 2014 (the first Plan published after the Fukushima accident) said in the beginning; "Japan will minimize its dependency on nuclear power. Needless to say, that is the starting point for rebuilding Japan's energy policy", but at the same time it also said "Nuclear power is an important base-load power source as a low carbon and quasi-domestic energy source, contributing to stability of energy supply-demand structure", reversing the previous government's decision to phase out nuclear energy by 2030s.²⁹

The latest METI's Strategic Energy Plan published in 2021 maintains its somewhat "self-inconsistent" policy of "reducing its dependence on nuclear power as much as possible" while keeping nuclear power as "an important base-load power source as a

²⁷ Ministry of Economy, Trade and Industry (METI), News Release, November 26, 2021. https://www.enecho.meti.go.jp/statistics/total_energy/pdf/gaiyou2020fyr.pdf.

²⁸ Japan Atomic Energy Relations Organization (JAERO), "Public Opinion on Nuclear Power: 2021 edition", February 2022 (in Japanese) https://www.jaero.or.jp/data/01jigyoku/pdf/tyousakenkyu2021/results_2021.pdf.

²⁹ Ministry of Economy, Trade and Industry (METI), "Strategic Energy Plan", April, 2014. https://www.enecho.meti.go.jp/en/category/others/basic_plan/pdf/4th_strategic_energy_plan.pdf.

Table 5.1 Power generation cost estimate for newly constructed power plant (2021)

Power source	Coal	Natural gas	Nuclear	Solar PV (industry)	Solar PV (home)	Wind (land)
Ave. power gen. cost (¥/kWh)	13.6–22.4	10.7–14.3	11.7–	8.2–11.8	8.7–14.3	9.9–17.2
Life time and capacity factor	40 yr 70%	40 yr 70%	40 yr 70%	25 yr 17.2%	25 yr 13.8%	25 yr 25.4%

Source METI, Cost Verification Working Group Report, August 2021

https://www.enecho.meti.go.jp/committee/council/basic_policy_subcommittee/mitoshi/cost_wg/2021/data/07_05.pdf

low carbon and quasi-domestic energy source”.³⁰ The government’s target of nuclear share is 20–22% by 2030, which seems impossible to achieve.

One of the noted difficulties that nuclear power is facing is its economic competitiveness. The most recent nuclear electricity cost-estimate by the government (METI) was carried out in 2021 and average power generation cost of newly built nuclear power plant was estimated at >¥11.7/kWh. This included estimated costs associated with Fukushima accident and assumed then those total costs would be limited to ¥23.8 trillion. It was translated into ¥15.7 trillion for a model plant. As a result, for the first time, nuclear power is no longer the cheapest power generation source in Japan. According to the new government estimates, solar PV as the cheapest source at ¥8.2–14.3/kWh followed by LNG at >¥10.7–14.3/kWh³¹ (Table 5.1).

5.4 Ukrainian Crisis and Its Implications

Russian invasion of Ukraine and subsequent attack on nuclear power plants was a shocking event for nuclear safety and security. According to the Article 56 of Additional Protocol of the Geneva Convention, along with dams and dykes, “nuclear electrical generation stations shall not be made the object of attack.” It should be noted that such protection “shall cease if it is used for other than its normal function and in regular, significant and direct support of military operations”.³² So it is critically important that the nuclear power plant is used exclusively for peaceful purpose and under international safeguards.

³⁰ Ministry of Economy, Trade and Industry (METI), “Strategic Energy Plan”, (outline in English), October 2021. https://www.enecho.meti.go.jp/en/category/others/basic_plan/pdf/6th_outline.pdf.

³¹ Working Group on Power Generation Cost Assessment, “Kihon Seisaku Bunnkakai ni Taisuru Hatudenn Kosuto To No Kensho ni Kansuru Houkou” [“Report on Power Generation Costs etc. to the Basic Policy Committee”], METI, 13 July 2021 (in Japanese), see https://www.enecho.meti.go.jp/committee/council/basic_policy_subcommittee/2021/045/045_005.pdf.

³² International Committee of the Red Cross (ICRC), “Protocol Additional to the Geneva Conventions of 12 August 1949” https://www.icrc.org/en/doc/assets/files/other/icrc_002_0321.pdf.

It is also important to point out that the above article is not applicable to non-power generating nuclear facilities, such as research reactors or, more significantly, fuel cycle facilities, including uranium enrichment, reprocessing facilities, spent fuel storage facilities. In particular the latter two facilities could cause substantial radioactive releases, if attacked. The IAEA General Conference adopted a resolution regarding Protection of Nuclear Installations against Armed Attacks, including those non-power generating facilities.³³ While it is important to keep this international norm but it certainly does not have an enforcing power. It is important thus legal protection of nuclear facilities against military attacks must be enhanced to include non-power generation facilities especially reprocessing plant and fuel-storage facilities.³⁴

5.5 Lessons Learnt Updated

Given the current situations described above, I update the lessons learnt from the Fukushima accident as follows.

1. **Think Unthinkable:** This is one of the most important lessons learnt from the Fukushima accident. It is natural that operators and policy makers tend to take actions based on “wishful thinking”, i.e. denying possible failure. This could lead to “unpreparedness” for unexpected events and crisis. In order to prepare “unexpected” events, it would be necessary for operators and policymakers to try hard to “think unthinkable” events. The Ukrainian crisis has proven that this lesson is critically important.
2. **Engineering Risk Assessment is not good enough:** Engineering Risk Assessment is based on probability and possible consequences. The Fukushima accident taught us that the risk assessment methodology is not good enough. First, its probability is not reliable. Second, its consequences may not be quantifiable easily. Social, ethical and cultural impacts should also be included as possible consequences. It is thus necessary to include social scientists and even the public to assess the risk of nuclear power.
3. **Need for independent scientific advice and oversight organization:** As is well known, Japan’s regulatory agency before Fukushima accident was not truly “independent”. Now Japan’s new Nuclear Regulation Authority (NRA) is legally “independent” organization. But Japan still lack an independent scientific advice and policy oversight organization. That is probably one of the major reasons that public trust in government policy or nuclear industry has not been restored.

³³ International Atomic Energy Agency, “Protection of Nuclear Installations Against Armed Attacks”, GC(XXXI)/RES/475, 25 September 1987. https://inis.iaea.org/collection/NCLCollectionStore/_Public/40/082/40082631.pdf?r=1&r=1.

³⁴ Tatsujiro Suzuki, “Implications of Ukraine nuclear crisis for nuclear non-proliferation, security and safety”, The Korea Times, March 30, 2022. https://www.koreatimes.co.kr/www/opinion/2022/03/137_326389.html.

4. **Public Trust is essential:** Finally, the most important lesson is that public trust is essential for any public policy implementation. Even if policy is scientifically reasonable, it will not be easy to implement a policy without public trust. Scientific community itself needs public trust too. The Fukushima accident and the following events described above proved that lack of public trust is a major problem for most of the issues discussed. In order to restore public trust, transparency, independent oversight, and public participation in decision making is necessary.

5.6 Conclusion

11 years have passed since the Fukushima nuclear accident. While there has been significant progress in reconstruction of Fukushima area, lack of public trust is still a major problem for most issues associated with the Fukushima accident. Decommissioning of the Fukushima reactors are moving steadily but much slower than expected, and treatment and disposal of contaminated water has become a major socio-political issue. Cost estimate of Fukushima accident by the government is not reliable and is underestimated as it does not include final disposal cost of radioactive waste. Many legal cases brought by citizens and shareholders continue and the results are mixed. But some critical court decisions may affect future of nuclear policy and nuclear industry operations quite significantly. Impact of the Fukushima accident on Japan's energy picture is also significant, and most importantly, nuclear power is no longer most reliable, least expensive power source in Japan. Although the government would like to maintain nuclear power as an important energy source for its carbon neutral policy, it is probably safe to say that future of nuclear power is uncertain at best, but is likely to play only a marginal role in Japan's carbon neutral policy.

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