Chapter 1: Safety Regulations: An Approach to Uncertainty

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Towards safety regulations that are not the "captive" of anything

After the accident, each of the published accident investigation reports provided the following lessons and recommendations regarding the ideal form of nuclear safety regulation.

The Independent Accident Investigation pointed out that the "national policy/privatize operation caused ambiguity of responsibility, which in turn weakened the crisis management capabilities of the operators as well as governance," eliciting in subsequent investigations and research that the background to this lay in the organizational culture characteristics of Japanese regulatory culture and customs, specifically "the village and governance by osmosis", and "preferring small peace of mind over great safety".

The Parliamentary Accident Investigation also points out that "between the [former] regulatory side and the operator side, there was an unhealthy relationship that was far from 'reducing essential risk' and 'securing safety' and that worked on academics and all sorts of fields when their interests matched in order to prevent plant shutdowns from lawsuits that negated past regulations and the safety of existing reactors."

Moreover, the Government Accident Investigation stressed, "the nuclear safety regulators must be able to effectively and independently make decisions related to nuclear safety and must be separated functionally from organizations that could unduly impact decision making."

In this respect, in September 2012, the Nuclear Regulation Authority was established as an independent regulatory body making decisions from a purely scientific and technical perspective. Based on the exceptional provisions in force during the declared emergency, the chairman and members of the committee were appointed without confirmation by the upper or lower parliamentary houses (the confirmation of both houses was obtained in February 2013).

Three months after its inception, "the newly established Nuclear Regulation Authority announced its organizational philosophy, consisting of its mission "to protect the general public and the environment" and five principles of activity.[1]

[1] Among its principles of action are 1: Independent decision making, 2: Effective action, 3: Transparent and open

This stated, “everyone involved in nuclear energy must have high ethical standards and always aim for the highest level of safety in the world. We are aware of this and pledge to work tirelessly”, upholding as the first of its principles of activity entitled “independent decision-making” to “make independent decisions from a scientific/technical point of view irrespective of all else”.

Members of the Regulatory Authority spoke of their renewed determination.

Shunichi Tanaka, who was elected as the first chairman of the Nuclear Regulation Authority, stated first off, “the most important thing for the Nuclear Regulation Authority is to restore trust in the administration of nuclear safety that hit rock bottom,”[2] speaking of his determination to thoroughly ensure transparency and neutrality.

Toyoshi Fuketa, who later succeeded Tanaka, also expressed his determination, saying “although it was acknowledged even before the Fukushima Daiichi Nuclear Power Plant accident that earthquakes, tsunami, and aircraft collisions were ‘threats’, their strength and probability of occurrence involved ‘uncertainties’［…］, and the magnitude of the ‘uncertainties’ led to wishful thinking and weakened determination to strengthen measures. The Nuclear Regulation Authority will continue to monitor and review in order to prevent these threats from being put off because of their ‘uncertainties’.”[3]

As the legal system underpinning this new regulatory system, the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors, which forms the basis of nuclear safety regulations, was revised, and in response to this, the Nuclear Regulation Authority established new regulatory standards.[4]

Previous wording regarding the planned promotion of the use of nuclear power was deleted and the focus was strengthened to ensuring safety to protect the people and the environment through sound regulation of nuclear power, and regulations such as periodic inspections for nuclear power plants under the Electricity Business Act have been unified under the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors.

Safety regulations have been changed, taking into consideration serious accidents that had previously been outside the scope of regulations until then. They also introduced a “back-fit system” that requires nuclear facilities that have already obtained permission to comply with the latest regulatory standards. This was a switch from the voluntary arrangements of the past, which was called “back check,” where it was the responsibility of the operator when new technical knowledge came to light and regulatory standards were changed to accommodate them at a facility that had already obtained permission, to a compulsory system strongly enforced by the government to comply with the latest standards. If a

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organizational structure, 4: Sense of responsibility and a desire to improve, and 5: Emergency readiness. In Nuclear Regulation Authority, (n.d.) *Soshiki rinen*［Company Principles］*,Genshiryoku kisei iinnkai (Iinnkai homupeji)*［Nuclear Regulation Authority (Authority Homepage)］Retrieved June 30, 2020 from https://www.nsr.go.jp/nra/gaiyou/idea.html (In Japanese.)

[2] Nuclear Regulation Authority, 2012.

[3] Toyoshi Fuketa 2015.

[4] The full name of the law is the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors (Act No. 166, Showa 32). The revisions promulgated on June, Heisei 24 (2012) put in place new regulatory standards as well as a new inspection guide together with its enactment. The new regulatory standards are made up of three requirements regarding major accidents: measures against factors that can lead to major accidents, strengthening of major accident prevention and mitigation, and measures to avoid the leaking of radioactivity into the environment.

facility does not comply with the regulatory standards, the NRA can order the operator to cease operations or modify the facility, and if the order is violated, it can cancel the license or impose a penalty.

Moreover, the period during which the licensee can operate the power reactor was limited to 40 years in principle, starting from the day the operator passed the pre-use inspection. The operating period could be extended only once with approval from the Nuclear Regulation Authority within a period not exceeding 20 years, which was specified by a Cabinet Order.

The newly established regulatory standards required concrete countermeasures for severe accidents (development of facilities and systems for severe accident countermeasures) with extremely low probability, putting thorough in-depth protection first. In order to prevent the loss of safety functions due to common factors, the regulatory standards called for multiplexing and diversification of power sources and core cooling systems capable of coping with natural phenomena such as volcanoes, tornadoes, and forest fires, and non-natural phenomena such as power outages, fires, and internal flooding should a severe accident occur; and countermeasures centered on portable equipment (portable equipment/ distributed connection port arrangements) and the establishment of permanent facilities (designated severe accident response facilities) to back them up for intentional aircraft collisions, among other measures.

Furthermore, as an evaluation for improving the safety of operators, the Regulatory Act mandates that operators themselves implement a regular safety review system, which had been conventionally confirmed by regulatory authorities in daily safety inspections (Periodic Safety Review (PSR) system, which reflects the latest knowledge and regularly checks measures for managing aging), and add safety assessments using the probabilistic risk assessment method in addition to the safety margin assessment to comprehensively assess the safety of nuclear facilities and create a system for reporting to the national government.

In order to operate such a safety regulation system independently, the Nuclear Regulation Authority, which is the core of nuclear safety regulation, was set up as an external institution of the Ministry of the Environment. As a result, administrative matters such as nuclear safety regulations and safeguards for nuclear non-proliferation handled by the Ministry of Education, Culture, Sports, Science and Technology and the Ministry of Land, Infrastructure, Transport and Tourism were consolidated, and the safety regulation system reformed. Accompanying this, the Nuclear Safety Commission and the Nuclear Safety and Security Agency were abolished.

Decent nuclear safety regulation cannot be expected if it is not assured of an institutional barrier from the administrative agencies promoting nuclear power, and without fundamental reform of the enforcing governance and ambiguous relationship between the regulatory side and the regulated side. This was the “lesson” from the Fukushima Daiichi Nuclear Power Plant accident. Major reforms have been implemented regarding the nuclear regulatory system. It can be said that Japan has learned well here.

However, although the mechanism has been revamped, actual operations are still dragged down by the inertia of the old system. Ambiguous authority and responsibility in deciding matters and a highly bureaucratic organizational culture remain unchanged. Using an expression from the *Anatomy of the Yoshida Testimony: The Fukushima Nuclear Crisis as seen through the Yoshida Hearings*, published by the Rebuild Japan Initiative after the Independent Accident Investigation, “the village and governance by osmosis” and “preferring small peace of mind over great safety” are characteristics of Japanese regulatory culture and practices that are not easily eradicated.

Below, we will ask whether the "learning" gained from the circumstances leading up to the Fukushima Daiichi Nuclear Power Plant accident and the experience gained at the time have been effectively utilized in safety regulations, focusing on three themes: 1) new regulatory standards, 2) voluntary safety improvement activities, and 3) organizational culture.

1. From observing "homework" standards to voluntary safety *kaizen*

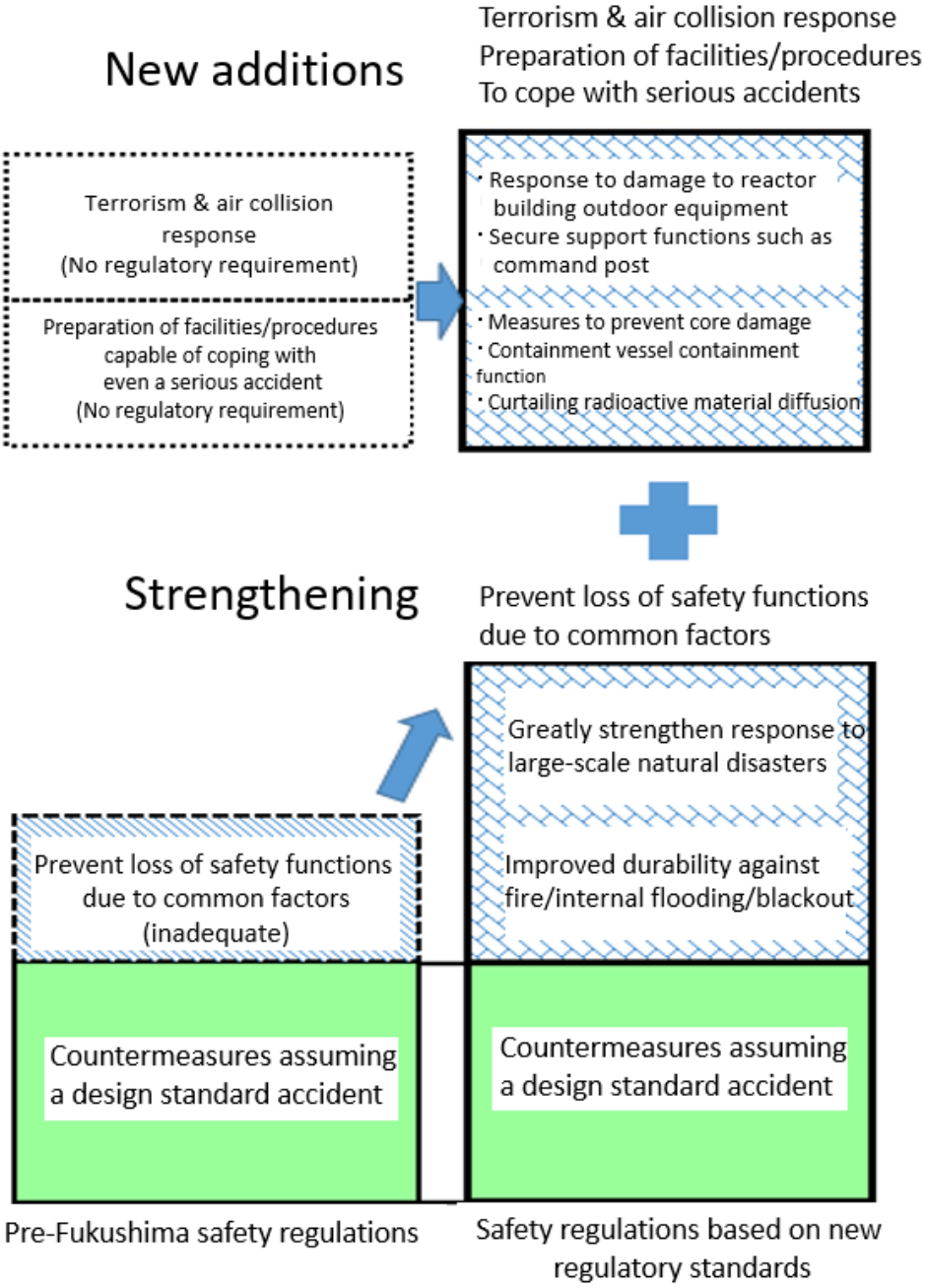
Out of remorse over the Fukushima Daiichi Nuclear Power Plant accident, safety regulations for nuclear power plants have introduced a backfit system, which is legally required by the Regulatory Act to reflect the latest knowledge in existing facilities. In addition, the newly established regulatory standards clearly state that safety measures include measures for severe accidents, and demand that measures be strengthened by significantly increasing the design criteria for large-scale natural disasters so that safety functions would not be lost due to common factors. They also ask measures to be strengthened for non-natural phenomena such as fires, internal flooding, and power outages that might cause a similar loss of function. Furthermore, the regulatory standards demand the preparation of equipment and procedures to cope with serious accidents and response to terrorism and aircraft collisions. Here, we consider the merits and demerits of the normative inspections that check the detailed specifications required under the regulatory standards as well as issues pertaining to the backfit system specified by the Regulatory Act.

<u>Merits and demerits of compliance inspection</u>
The Fukushima Daiichi Nuclear Power Plant accident was a "parallel chain nuclear disaster" (Independent Accident Investigation) in which many safety functions were simultaneously or sequentially lost due to the overlap of a natural disaster involving a large-scale earthquake and tsunami. However, there was insufficient consideration of design and operations for such risks prior to the accident, and response measures for when a severe accident was reached were not covered by the regulations. This is because of the infallibility of regulations that maintained that accidents such as core fusion should rarely occur if the design conditions approved by the regulations are observed and safety is adequately ensured, and these were incompatible with an administrative policy of maintaining continuity and consistency with past measures. Therefore, even if the regulatory authority drew up a guideline (standard) incorporating new knowledge, it was not as a result possible to urge operators to comply with the latest guideline (standard).

Based on such regrets, the newly established Nuclear Regulation Authority has newly established a regulatory standard that it proclaims to be "the highest level of safety in the world"[5] (Tanaka, inaugural Chairman of the Nuclear Regulation Authority) (See Figure 1).

[5] Nuclear Regulatory Authority, 2013.

- Figure 1 Concept of new regulatory standards



Created with reference to the Nuclear Regulation Authority website
https://www.nsr.go.jp/data/000070101.pdf

The Nuclear Regulation Authority is a so-called Article 3 commission prescribed in Article 3 of the National Government Organization Act. It has the right to establish rules necessary for nuclear regulation from an independent and neutral standpoint[6]. In addition, Article 7 of the National Government Organization Act stipulates, "a secretariat can be set up within the commission." This secretariat is the Nuclear Regulatory Agency. Although it is called an agency, it is not an "agency" in the sense of an administrative institution of the country under Clause 2 ofArticle 3 of the National Government Organization Act. The Nuclear Safety Commission before the nuclear accident was

[6] Refer to Article 3–2 of the National Government Organization Act (Act No.120, Showa 23), and Article 26 of the Act of Establishment of the Nuclear Regulation Authority (Act No.47, Heisei 24).

merely a council-based agency that advised and made recommendations to administrative bodies, investigated administrative matters regarding regulations for ensuring the safety of nuclear power use, and made recommendations to the head of the relevant administrative agencies through the Prime Minister when necessary. In addition, the Commission only pointed to weak guidelines (Nuclear Safety Commission internal regulations), which the regulatory agency referred to during the examination, and had no authority to directly implement administrative sanctions even if they discovered legal transgressions (a so-called Article 8 commission).

The Nuclear Regulation Authority has the same strong powers as other ministries such as the right to establish rules, the right to authorize licenses, the right to submit reports, and the right to admonish. The new regulatory standards and examination guidelines established by the Authority show a strong independence from the operators under the framework of the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors, and the technical basis of safety verification has become direct and legally strong. Should the pursuance of its affairs under its jurisdiction require it, it can make recommendations to the head of the relevant administrative agency on matters relating to ensuring safety in the use of nuclear power and request a report be made on the measures taken based on that recommendation.[7] The chair has a fixed term of office of five years in a position free from external pressure, and imposes strong restrictions on firing and dismissals during that period, and guarantees a well-insured status.[8]

The government bill initially planned to set up the Nuclear Regulatory Agency within the Ministry of the Environment based on Clause 2, Article 3 of the National Government Organization Act. However, the Liberal Democratic Party and the Komeito, which were opposition parties at the time, believed it to be desirable that it be a collegial body guaranteed to exercise independent powers, not be under the command or supervision of the Minister of the Environment, where it was to be set up, and submitted a bill to the Diet to set up a commission. As a result of coordination with the government bill, the establishment of the Nuclear Regulation Authority and the Nuclear Regulatory Agency as a secretariat of the authority was approved by the Diet.

Yasuhisa Shiozaki, an LDP member of the House of Representatives, who worked hard to adjust the bill in the Diet to make the Nuclear Regulation Authority an Article 3 body, looked back saying, “I thought the independence of regulations was an urgent issue, and the LDP and Komeito made a joint proposal for the Act for Establishment of the Nuclear Regulation Authority guaranteeing the top post, and the amendment was approved by the LDP, Komeito and the DJP.”[9]

In response to this, Tanaka, who became the inaugural chairman of the Nuclear Regulation Authority commented, “When summoned to the Diet, I was prepared to clearly state as different what I thought was different,”[10] testifying that he tried to be independent from political pressure and stay true to the new organizational philosophy.

On the other hand, the operators have first of all made meeting the requirements of the new regulatory standards for restarting nuclear power generation their most important management task, and have reviewed design conditions, strengthened equipment, and worked on safety assessments. However, due to the strict and conservative attitude of the Nuclear Regulation Authority towards review and inspection, there are sometimes conflicts at the site. For example, from the viewpoint of

[7] Article 4-2 of the Act for Establishment of the Nuclear Regulation Authority (Act No.47, Heisei 24).
[8] Article 4-2 of the Act for Establishment of the Nuclear Regulation Authority (Act No.47, Heisei 24).
[9] Interview with Yasuhisa Shiozaki, March 17, 2020.
[10] Interview with Shunichi Tanaka, November 20, 2019.

diversification of countermeasures, examiners demanded that power supply vehicles and fire engines (water injection pumps) installed on high ground should be secured with chains to prevent falling in the event of an earthquake. An executive of a power company points out, "Intransigent regulatory demands for perfection (zero risk) in individual functions of power supply vehicles that are deployed in the expectation of mobility during a severe accident haven't been tested to see how effective they are for the duration of the entire event."[11] He further cast doubts on the fact that the regulatory authority's hard-and-fast rule like attitude remains unchanged,stating, "I think that after the establishment of the Regulation Authority, it was inevitable that the Regulation Agency's staff would question us as if they were the guard at the Ataka Station in the kabuki play Kanjincho grilling Yoshitsune and his party. It's just that it's been eight years, so now, I'd like them to concentrate as experts just on the one point of making things safer."[12]

In general, it is said that a good administrative officer is one who excels at quickly finding even small risks. It is a requisite quality for a professional inspector. However, it can increase other risks, such as in the example above, when time is lost to remove a chain in an emergency concerning power supply vehicles and fire engines. In this case, there is the danger that in focusing only on the risk right in front of you (partial optimization), such as preventing falling, you may lose sight of the overall larger risk (total optimization). Dissatisfaction and concerns exist in the field regarding the application and operation of these new regulatory standards at the inspector level.

On the other hand, Toyoshi Fuketa, who acts as chairman of the Nuclear Regulation Authority, a council organization of the Nuclear regulatory Authority, said, "If national regulations are only poking at trivial issues, it will discourage improvements. It's important to focus reviews and inspections on key areas of safety, to properly set out priorities and degrees of importance",[13] speaking of regulations that will foster the desire to improve safety, but in the field where reviews and inspections take place, the predominant atmosphere is one of seeking objective criteria that can be easily assessed onsite, in other words tangible specifications, and that this amounts to the fulfillment of regulatory responsibilities. Also, speaking from the perspective of an academic expert, Akio Yamamoto, Chairman of the Nuclear Fuel Safety Special Examination Committee, commented, "picking up from former design guidelines, the current new regulatory standards tend to be more hardware-oriented. The IAEA guidelines also separately cover software, so this kind of area needs to be expanded."[14] He suggests not paying too much attention to the technical details, but rather paying attention to the operation of the software side in the future. It should be noted that not only the operation of regulatory standards with an emphasis on equipment requirements, but also efforts related to organizational culture such as leadership and management are receiving international attention.

The IAEA's Regulatory Evaluation Service (IRRS) uses the term 'less prescriptive' (conformance to standards, but understanding the underlying concepts) regarding the stance of regulatory inspection, and rather than a regulatory inspection that tells you how to do the tiniest detail, recommends aiming at inspections that allow for independent thinking.[15] In addition, an overly conservative stance on the part of regulatory authorities has the side effect of prolonging inspections on conformity to regulatory standards and making it impossible to predict the length of inspection periods. For example, as a countermeasure to terrorism, regulatory standards require the establishment of a facility to cope with

[11] Interview with TEPCO executive, November 27, 2019.
[12] Ibid.
[13] Nuclear Regulation Authority, 2019b.
[14] Nuclear Regulation Authority, 2018a.
[15] IAEA, 2016.

a specific severe accident that can remotely operate the nuclear reactor separately from the control room. The Nuclear Regulatory Authority provided a five-year grace period for completion, but as the end of the period nears, many operators were asking for an extension of the period due to the prolonged examination.

Of course, the regulatory side has its own reasons. Eiji Hiraoka, who was Deputy General Manager of the Nuclear Safety and Safety Agency at the time of the Fukushima Daiichi Nuclear Power Plant accident, said about the current "dialogue" between the NRA and the operators, "the feeling that the regulatory body would give in if you lobbied them enough, which was the attitude of the electric power companies, doesn't seems to have changed that much from before the Fukushima Daiichi nuclear accident. I think the Regulation Authority thought it would be the same thing all over again with the delay in the seismic backcheck at NISA if they allowed this."[16] From the regulator's point of view, this looks like "cajoling" on the part of the operators, in which it only takes some lobbying to pull something off.

Current inspections on safety regulations mainly focus on confirming the status of compliance, which confirms that the facilities and operating conditions of the operators comply with the approved regulations and technical standards, and that they do not violate them. Consequently, the regulatory side is required to comprehensively and impartially check inspection items related to the regulations and standards, and has no discretion to emphasize items and concerns that contribute greatly to nuclear safety. On the operator side, satisfying the current regulatory standards is the priority, and they purposefully do not embark on additional measures to further enhance safety since they would just be a factor accompanied by new reviews and inspection procedures of regulatory standards, which would reduce management efficiency.

As such, the Nuclear Regulation Authority has again made it clear that the primary responsibility for nuclear safety lies with the operator, and is aiming to reform the existing inspection system into one which will motivate the operators into making progress on their own towards greater safety and not merely limiting themselves to meeting and confirming conformity to standards. This new inspection system, which began in fiscal 2020, is modeled on the U.S. inspection concept of performance-based regulations that emphasize the results of safety activities by operators, and risk-informed regulations[17] that ensure effective safety by utilizing risk information.[18] Former NRC Commissioner George Apostolakis said of the American model, "There are keywords in the U.S. regulations that have two purposes: 'adequate protection' and 'safety enhancement'. The former, 'adequate protection', is intentionally left undefined, and assumed to be achieved when compliance with (…) regulations occurs. There is a clear distinction between the two words. Adequate protection requires full compliance, whereas safety enhancements are voluntary."[19]

In addition, to express the degree of maturity in this inspection system, former U.S. NRC regional administrator Charles Casto, who can be said to have come up through the ranks in the field of nuclear safety regulation in the United States, said "there's a difference between being an inspector and a regulator. Inspectors are like auditors, and regulators use and add wisdom. Japan is still at the stage where inspectors audit the performance of the operators."[20]

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[16] Interview with Eiji Hiraoka, November 19, 2019.
[17] This refers to risk-informed and grade-approach.
[18] International Atomic Energy Agency, 2020.
[19] Interview with George Apostolakis, January 29, 2020.
[20] Interview with Charles Casto, August 26, 2019.

A new inspection system involves a "change in thinking" from passive inspection, in which the operator has the state confirm safety, to an active inspection, in which the operator proves safety through its own safety activities. This system took several years or more even in the United States for both regulators and operators to understand its purpose and for it to mature[21], and it is crucial in Japan as well that the principles of regulations and operators are shared.

One of the "lessons" from the Fukushima Daiichi nuclear accident was that a thorough awareness about uncertain phenomena had to be shared by the regulatory side and the operators regarding the way of approaching and operating regulations maintaining all the while the independence of regulations.

Kenji Sumita, Vice Chair of the (then) Nuclear Safety Commission, who spearheaded the team at the scene of the criticality accident at the nuclear fuel processing facility in Tokaimura about 20 years ago, said, "There is a certain inevitability that governments all over the world have intervened greatly in nuclear safety administration and exert powers (...) However, the more regulations are tightened in this kind of way, the more the field loses its spontaneity and gives preference to formal compliance. If there's no balance somewhere, there's a great risk that the substance will be lost. I want you to value the feelings of the field as well,"[22] suggesting a balance between the strict operation of regulatory standards and the motivation of operators.

Regulators have yet to shake off the traditional culture of rigorous inspection of visible standards. Operators remain keen to stick to the basic compliance manual. It is difficult to generate regulatory *kaizen* and innovation through true cooperative work out of this.

It should be noted that yes, the regulatory standard is "to assess whether or not the installation and/or operation of a nuclear facility is permitted", but "this does not mean that absolute safety can be secured by satisfying this".[23] There is no end to the pursuit of nuclear safety, and aiming continually for higher levels is a must. They should be viewed as an attempt to warn operators —and importantly, regulators— not to reassure themselves that it is safe if the regulatory standards have been cleared. Tsuyoshi Shiina, an attorney who acted as the secretariat of the Parliamentary Accident Investigation, uses a student/teacher metaphor to describe this view of regulatory compliance as safety achieved by the operator (and the regulator) as the "homework response"[24]. If operators (and regulators) misunderstand the principles of the new regulatory standards and think that compliance with standards ensures absolute safety, they will not have learned the lessons of the Fukushima Daiichi nuclear accident.

2. From backcheck to backfit

The backfit system is a system for constantly reviewing safety regulations and continuously improving safety, and is an "opposing concept to the safety myth."[25]For example, regarding severe accident response measures (AM), out of remorse over the fact that even if new regulatory standards

[21] Atomic Energy Society of Japan (AESJ) Safety Department, 2019.
[22] Sumida, 2000.
[23] Nuclear Regulation Authority (n.d.) *Shin kisei kijun*［New Regulatory Standards］*Genshiryoku kisei iinnkai (Iinnkai homupeji)*［Nuclear Regulation Authority (Authority Homepage］Retrieved June 30, 2020 from https://www.nsr.go.jp/activity/regulation/tekigousei/ (In Japanese.)
[24] Interview with Tsuyoshi Shīna, October 9, 2019.
[25] Nuclear Regulation Authority, 2017b.

about, say, existing seismic guidelines had come into force, there was no legal basis for requiring new standards to be met by facilities that already had installation (change) permits, and as a result of being left up to the voluntary activities, this led to the Fukushima Daiichi Nuclear Power Plant, backfit was introduced into the 2012 revision of the Act on the Regulations of Nuclear Source Material, Nuclear Fuel Material and Reactors. Until then, there was only a measure called backcheck, in which the regulatory authority asked the operator to check the strength and durability of equipment according to the latest standards. Backcheck was based on the voluntary activities of the operators,but its effectiveness was weak. As pointed out in the Independent Accident Investigation report, when the NISA requested a major urgent safety confirmation based on the backcheck policy at the time when the earthquake-resistant guidelines were revised significantly in 2006, TEPCO had postponed the final report until 2016.

An example of a case where the backfit system, which requires operators to reflect the latest knowledge to existing facilities with legal force, was applied includes the decision by the Nuclear Regulation Authority[26] that demanded a review of the impact of volcanic ash and re-application for safety examination procedures for the Takahama, Ohi, and Mihama power plants, which had already undergone regulatory standard compliance assessment. In research commissioned by the Nuclear Regulation Authority, the scale of volcanic ash eruption originating from Daisen known as "Oyama Namatake Tephra (volcanic ejecta)" was greater than hitherto assumed in inspections. It was found that the safety assessment conditions (maximum ash layer thickness) for these three reactors, which had already completed the regulatory standard compliance assessment, were insufficient, and they were asked to undergo a reassessment of compliance standards.

This is a case that required new knowledge and regulatory standards to be promptly applied to existing reactors, and that the operator voluntarily satisfied the guideline requirements when the seismic guidelines were revised. This became a symbolic case showing the force of safety regulation[27] and a shift from the "guidance" prior to the Fukushima Daiichi Nuclear Power Plant accident that hoped operators would voluntarily meet the new standards indicated by revised seismic guidelines, to a "demand" based on legal grounds. Chairman Fuketa commented during a press conference, "this new finding is not an extremely large change that requires immediate suspension of facility use, but that doesn't mean it's just to be ignored, and it is an example of the Authority's stance on discussing installation changes when a certain change in the situation has occurred."[28]

However, backfitting involves some difficult problems. Chairman Fuketa emphasizes the significance of promptness, saying "if an improvement is found, prompt action is important for regulation and nuclear safety."[29] Certainly, it is quite correct that such a quick and flexible attitude is important, but at the same time, there are many cases where an academic evaluation cannot be established regarding the "uncertainty" of natural phenomena. In such cases, the rationale for backfitting is not necessarily convincing.

On the other hand, both the regulator and the operator are responsible for collecting information on new experience based on operational experience, new knowledge about equipment reliability, research results, redefined external hazards, and various other factors. However, from the point of view of the operator, collecting information for this purpose is laborious and costly.

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[26] Nuclear Regulation Authority, 2019a.

[27] Article 43-3-23 of the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors (Act No.166, Showa 32).

[28] Nuclear Regulation Authority, 2019c.

[29] Ibid. p.5

The U.S. Nuclear Regulatory Commission (NRC) backfitting rules[30] are similar to the Japanese Nuclear Regulation Authority's operation of regulatory standards in that new information on nuclear safety must be reflected in existing facilities. However, what is significantly different from Japan is the existence of a process to set a target value and judge the effect of aiming for that while bearing in mind cost and balance. When the NRC makes this type of request, it is required to invite stakeholders to a hearing and provide a cost-benefit analysis showing that the estimated safety benefits outweigh the costs of systemic or operational changes. Although there are reasons as to why this would be difficult to introduce in Japan due to the high risk of natural phenomena and uncertainty coming from different views on hazard among experts, this cost-benefit perspective is rare in the requirements of Japanese regulators.

3. How far can "independence" be exercised? Independence incorporated into regulations

In order to ensure and enhance nuclear power safety, an effective means for operators to make voluntarily efforts and for those efforts to have a sustainable effect is to introduce and entrench probabilistic risk assessment methods. But here too there are challenges to overcome.

Sustainability of safety improvement evaluation system

The primary responsibility for safety lies with the operators of the nuclear business. Confidence in nuclear safety is created by the fact that the operator takes nuclear safety seriously, confirms it by a third party, and this figure is clearly visible to society. It is difficult to check the safety of a nuclear power generation system that has accumulated highly specialized technology from the perspective of the general public. Its role is left to security regulation by a third party, that is, the state. However, it is not safe and secure if nuclear safety is completely left in the hands of governmental regulatory authorities. In the wake of the Fukushima Daiichi nuclear accident, it became clear that the governance of both the operator and the national safety regulator was insufficient.

The relationship between the two is summarized in "defense in depth as a system", which will be touched on in the section on independence below, so we will only briefly mention it here, but the "primary responsibility for safety" of the operator is the responsibility of the operator to ensure the safety of nuclear power, to enhance it, to keep the risks of nuclear power as low as possible and contribute to the preservation of the lives, health and environment of the people and the security of Japan. In addition to this, to avoid falling into self-righteousness, it is also necessary to improve the quality of one's own activities through peer pressure and peer review from operators at home and abroad. On the other hand, regulation by the state supervises the activities of the above operators, but also fulfills its regulatory obligations through information sharing and advice support activities with overseas organizations and international organizations that have the same regulatory status. Furthermore, the social responsibility of nuclear safety is fulfilled through the functions of a multi-layered governance system in which social stakeholders such as local governments and the news media monitor these activities of the operators and regulators.

After the Fukushima Daiichi Nuclear Power Plant accident, recognizing that it was important for operators who have the primary responsibility for nuclear safety to improve their safety independently, and in order to utilize the autonomy of the operators as well as to monitor their activities at the same time, the Nuclear Regulation Authority set up a safety improvement evaluation system that requires operators to regularly evaluate facility safety themselves, notify the Nuclear Regulation Authority of the results, and publicize those results.

[30] Federal Court of Appeals Decision (United States Court of Appeal) (1987), The Commission may impose "safety enhancement" requirements, but these are subjected to cost-benefit analysis (back-fit rule). (10 CFR 50.109).

This arrangement not only raises operator awareness about safety regulation activities, which bind by compliance or not to new regulatory standards, but also awareness about the leeway for voluntary activities to enhance safety, it being a system that posits the conduct of continuous safety improvement activities by the operators themselves as an obligation within the regulatory legal system.[31] It can be said that this is a system aimed at establishing independence to escape from the trap of the safety myth, which posits that safety can be achieved if the hurdle of regulation is cleared; in other words, it aims to stop this trap of thinking based on self-satisfaction.

Under this system, operators are regularly required to conduct a comprehensive evaluation of activities such as incorporation of the latest findings, probabilistic risk assessment (PRA), safety margin assessment (stress test), and medium- to long-term assessment of safety improvements.

However, a similar system existed some 30 years ago. Initially, it was a regular activity to comprehensively evaluate voluntarily the safety and operational management of facilities against the latest knowledge. However, misconduct at a power station triggered a change in inspections by the regulatory authorities monitoring the activity status of the site. As a result, the original purpose of "incorporating the latest knowledge" into defense in depth concepts at the design stage regressed, and the focus of defense in depth verification shifted from design to operation. In relation to this point, the Government Accident Investigation writes, "the security inspection related to PSR [Periodic Safety Review] by the security inspector (...) failed to act as a direct catalyst for improving the content of AM [accident management] at TEPCO, and TEPCO never considered AM for external events such as earthquakes that exceeded design standard events as a voluntary initiative."

While voluntary activities that evaluate the safety and operational management of this facility in light of the latest knowledge have been changing its operational form, risk assessments using the failure rate of individual plants have not been added to PSR.

The voluntary review actions of the operators were limited to understanding the current state of the plant and the status of their business activities, and did not provide a mechanism for identifying what was lacking for further safety improvement. With the regular reviews, which were expected to analyze operating experience that had occurred inside the facility,take measures against problems specific to the facility, and reflect the latest knowledge in the facility, the original purpose of seeking new knowledge and incorporating it into designs when necessary was to enhance and rationalize the content of report and became a repetitious routine. Furthermore, under a system where the safety inspector inspected the results of the periodic safety evaluation on site, information on tangible results was inevitably verified, and the original idea of expecting mutual exploratory efforts to improve safety became a mere sham.[32]

Where did the problem lie? They needed to be keenly aware that the concept of defense in depth was lost at each of the design and operational stages, and that it was not enough to inspect the operators; they had to be motivated to establish a truly effective safety system together.

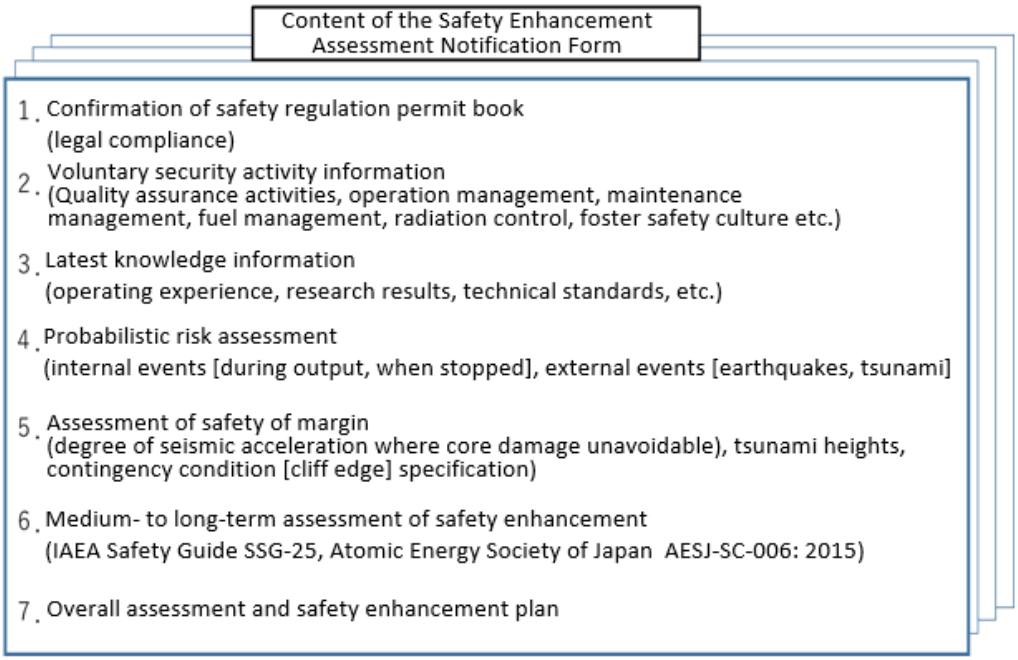
Reflecting on these points, the Nuclear Regulation Authority has made various reforms. Within 6 months of completion of the periodic inspection, a safety improvement evaluation system has been established in which the operator reports to the NRA without delay and this is publicly disclosed. It

[31] Nuclear Regulation Authority, 2017a.
[32] Yamamoto et al., 2018.

refers to the IAEA's regular safety review guidelines (SSG-25)[33] as "voluntary activities within the regulatory framework".

As shown in Fig. 2, in terms of basic design, it was decided to make a comprehensive evaluation by collating and incorporating the latest knowledge, evaluating risk probabilistically, comparing actual safety margins with a limit value[34], and conducting a mid- to long-term evaluation of safety enhancement. By creating an opportunity to make it public and expose it to criticism from society at large, it then became easier to understand the operators' thoughts on new knowledge and safety evaluation.

- Figure 2 Safety Enhancement Assessment Notification Form



On the other hand, regarding the operation of the system, from the outset, notification of safety enhancement assessment results, which is sent from the operator to the Nuclear Regulation Authority, has been made available on the Internet[35]. It is hoped that the notification form contains the results of new knowledge that has been collated. The regulatory authorities have sent a request to the operators that they would like not only passive result information such as accidents, but also proactive reporting on positive operational information.[36] This mechanism is known as "stakeholder oversight" as described in "measures for strengthening deep systems" proposed in document INSAG-27[37] of the

[33] International Atomic Energy Agency, 2013.
[34] This evaluation would assume the occurrence of a beyond design basis accident, including natural disasters, to assess the extent to which the reactor can survive without significant damage to the core or spent-fuel. This will be carried out every 5 years if no changes occur due to, for example, large scale construction.
[35] However, there have been no coordinated meetings regarding the contents of the notification form since the first six meetings. Nuclear Regulation Authority Homepage:
http://www.nsr.go.jp/disclosure/committee/yuushikisya/anzenpower_plants/index.html
[36] Nuclear Regulation Authority, 2018c.
[37] IAEA International Nuclear Safety Group, 2017.

International Nuclear Safety Advisory Group (INSAG), an advisory body of the IAEA Secretary-General, which will be discussed later, and can be said to embody one stage of the third layer.

However, to what extent are the values of this mechanism shared by both parties? Is it possible to create not an enforced safety enhancement assessment system, but the motivation to encourage voluntary activities by operators? If the safety enhancement assessment system, which is an "independent activity within the regulatory framework", consists of no more than questions and requests between the operator and the regulator, and if opinions and evaluations from outside parties are not widely amassed, stakeholder oversight, or "verification by a third party", will end up being pie in the sky.

One successful example of self-regulation is the Institute of Nuclear Power Operations (INPO), which was established after the Three Mile Island accident in the United States under the basic belief that "self-regulation by operators" was important, creating a mechanism for operators to voluntarily improve safety by using the psychological effect of "peer pressure". The U.S. electricity industry accepted INPO injecting strong navy leadership into the industry, and using this as a basis, INPO demanded discipline for the end of mutual aid from companies throughout the industry, positing that all share the same risk environment, regardless of size. The Japan Nuclear Safety Institute (JANSI), which was established by the Japanese industry consensus following the Fukushima Daiichi nuclear accident, is proceeding with the same steps as it learns from the precedent of INPO. However, an attribute of Japanese society's consensus-based decision-making is that it is not good to talk about the weaknesses of peers, and JANSI with the majority of its staff coming from the same industry must play a strict role and overcome this attribute. It is still only midway, however, to utilizing the psychological effect of "peer pressure" if weak points are identified but not frankly accepted.

4. Accepting all-or-nothing risk

In the United States, administrative decisions regarding nuclear safety are based on a balance between quantitative risk assessment and backfit costs.[38] However, the Japanese backfit system does not set goals as the United States does. In addition, due to the lack of reliable data r for verifying equipment failure and human error rates as well as the lack of expert training, probabilistic risk assessment is not explicitly used in the assessment process by the Nuclear Regulatory Authority under the new regulatory standards, considering the risk of misjudgment when comparing an uncertain evaluation result with the standard value. Under the assumption that there is uncertainty in the risk assessment of external events such as natural phenomena, a mature form of safety regulation would be that the regulators and operators discuss and formulate methodologies on how to use the system for safety screening and safety enhancement effectively.

Apostolakis said, "The Japanese people were negative towards nuclear power, (…) the NRA had to show that they were truly independent (…). So, that explains why these regulations are so strict. (…) I think we need more rational regulations and to make the rational you need risk insights."[39] He also pointed out, "the language between the regulators and the industry should be risk,"[40] being expectant especially of a basic agreement and mature dialogue on the concept of risk between regulators and operators, and even stakeholders.

[38] Garrick, 2017.
[39] Apostolakis, 2019.
[40] Ibid.

However, one of the keys regarding risk is whether the concept of probabilistic risk assessment (PRA) required in the safety enhancement assessment system has taken root in Japan after the Fukushima Daiichi accident.

In its report, the Government Accident Investigation examines the history of considering probabilistic risk assessments for external events such as earthquakes and tsunami, and analyzed the background as to why the assessment system could not be used for severe accident response measures (AM). It recommended that comprehensive safety assessments that considered external events be conducted, facility vulnerabilities be identified, effective countermeasures be studied and readied, and the probabilistic risk assessment method be used to evaluate the effectiveness of these countermeasures.[41]

The former method used is known as deterministic safety assessment, a concept that guarantees safety under the strictest design conditions that cover several conservatively assumed events by engineering judgment. On the other hand, the probabilistic risk assessment method, which was born in the United States, organizes the frequency of occurrence of all initiating events and the magnitude of damage that is considered to lead to severe accidents, and evaluates the effectiveness of design specifications based on probability theory.

Activities using probabilistic risk assessment methods for assessing the effectiveness of severe accident response measures (AM) began in Japan as well in the 1990s and early 2000s, but at the time, the best they could do was evaluate the failure of power plant facilities and human error events by staff involved in the operation, and there was insufficient reliable data available for probabilistic risk assessments on natural phenomena such as earthquakes (earthquake PRA). In this way, events that can trigger accidents leading to core damage, melting and loss of containment vessel functionality are called external events, and originate from parts that are not directly related to the operation of the inside and outside of a nuclear facility. External events are broadly classified into natural events such as earthquakes, tsunamis, floods and volcanoes, and human events such as aircraft falls and cyber terrorism. However, events that trigger core damage due to breakage of piping connected to the reactor, equipment failure and human error, etc. are called internal events.

At the time, the device failure rate in the United States was calculated using highly reliable data collected based on the law[42], but such a database is still in the development stage in Japan, and a framework for verifying the reliability of data from a fair and neutral stance as in the United States has not been established. Although the Atomic Energy Society of Japan has been vigorously developing standards[43] for the use of risk information, risk information usage by operators remains limited. Behind this lies the paucity of Japanese business and social environments that allow the use of “uncertain” data as conditions for reference in risk assessment. In Japan, in particular, stricter regulations for quality assurance were promoted to improve operational efficiency due to the detection of a criticality accident at the nuclear fuel processing facility of JCD Tokai Works in 1999 and misconduct by TEPCO in its voluntary inspections in 2002, which created circumstances where it was difficult for society to tolerate operators pursuing management efficiency.

The overall evaluation results after NISA received a summary report of severe accident response measures (AM) from the operator asked for calculations on the probability of core damage and damage to the PCV based on cause events for which data such as equipment failure rate and human error were prepared. If this was within a certain standard value, the severe accident response measure

[41] ICANPS, 2012, pp. 396–398.
[42] Nuclear Regulatory Commission)
[43] Atomic Energy Society of Japan Standards Committee: PSA Parameter Subcommittee, 2010.

(AM) was approved as having been successfully completed[44]. However, this evaluation result does not target risks events involving substantial "uncertainty" such as natural phenomena. This resulted in a mental block where further measures were not considered on the assumption that preparation for a severe accident that rarely occurs is based on convenient information, further strengthening the "safety myth" of nuclear power plants. This cognitive bias was also a cause of distancing the "uncertainty" of such natural disasters from risk assessment targets.

In the United States, external events have been the subject of evaluation in the probabilistic risk assessment of power plants since the 1980s. For example, in a certain plant, it was recognized that the risk of earthquake had a wide range of uncertainty, and so was confirmed as not contributing significantly to total core damage probability.

Checking the contents of the safety enhancement assessment report for a plant that has restarted operation in Japan, although we can see probability risk assessments have been done in addition to the effects of measures readied after the Fukushima Daiichi accident targeting internal events and external events such as earthquakes and tsunami, events experienced in the Fukushima Daiichi accident, such as the vitally important internal flooding, internal fires, superimposition of earthquakes and tsunami, and multiple simultaneous disasters go unreported as they are "to be gradually expanded as PRA methods become more mature." If the degree of "uncertainty" for internal flooding, fire, superimposition of earthquake and tsunami, etc., is not to be checked, and a certain extent of "uncertainty" in technological development is not to be given up, the "lessons" of the Fukushima Daiichi nuclear accident will remain unutilized forever.

Kazaru Saito of the International Institute for Environmental Economics commented, "AM development was designed with internal events in mind, and failed to function effectively for external events such as the earthquakes and tsunami at the Fukushima Daiichi Nuclear Power Plant accident. By not facing up to the question of what the dominant threat is, there will always be huge gaps no matter how much you learn about overseas thinking and methodologies,"[45] explaining the importance of confronting large risks.

In any event, in order to establish probabilistic risk assessment in Japan, operators will need to learn the U.S. NRC Regulations (10CFR50.65 "Requirements for monitoring the effectiveness of maintenance at nuclear power plants") and corresponding industry guidelines (NUMAR93-01 "Industry guideline for monitoring the effectiveness of maintenance at nuclear power plants") , in order to quantitatively show the regulators that using this method during online maintenance will not impair the total safety and reliability of plant equipment, and as a result, have society acknowledge that the utilization rate is improved. Based on U.S. experience, Commissioner Apostolakis noted, "proposals from operators are an important factor in increasing regulatory confidence."[46]

The Nuclear Regulation Authority (NRA) deems information evaluating the effectiveness of severe accident response measures (AM) and showing the weaknesses of facilities obtained from a probabilistic risk assessment to be essential for comprehensively assessing nuclear safety. The Operation Guide for Enhancing Safety of Operating Power Generation Reactors laid down by the NRA, demands as a specific method of investigation and analysis of voluntarily measures taken by operators to enhance safety that 1) an assessment of internal and external events, 2) a deterministic

[44] "With this case, all probabilistic safety assessments regarding AM (accident management) of the 52 existing reactors have been completed." Nuclear and Industrial Safety Agency, Ministry of Economy, Trade and Industry, 2004.
[45] Saitô, 2015.
[46] Nuclear Regulation Authority, 2018b.

safety assessment, 3) a safety margin assessment, and 4) a probabilistic risk assessment of internal and external events be carried out.

Nonetheless, the current probabilistic risk assessments that regulators require of operators are largely limited to internal events such as equipment failure and external events such as earthquakes and tsunami. Assessment of events experienced in the Fukushima Daiichi Nuclear Power Plant accident, such as floods and fires occurring inside the facility, the superimposition of earthquakes and tsunami, and simultaneous multiple disasters, are yet to be put into practical use, there being only a passive attitude of "waiting for future technological developments" as if it were someone else's problem.[47] In order to analyze and evaluate the risk of accidents caused by external events such as natural phenomena, it is necessary to approach risk from the perspective that uncertainties will arise from both physical variations in the natural world and insufficient knowledge. This approach will not be straightforward, but nonetheless this kind of attitude towards problem solving is required.

The fact that the Government Accident Investigation pointed out, "rationalizing the failure to check and implement severe accident measures by citing the immaturity of PSA methods will not be condoned"[48] should be taken very seriously (the Government Accident Investigation uses the term Probabilistic Safety Assessment).

5. Undetermined safety goals

We will also touch on safety goals, which are closely related to probabilistic risk assessment.

In the first of the preparatory meetings before the establishment of the Nuclear Regulation Authority, (then) committee member Fuketa said that discussion on safety goals tended to be avoided as it was a direct discussion that nuclear power damaged the environment and human life, but that we always had to remind ourselves that danger was inherent in using nuclear power, and that he "would like to continue discussing safety goals,"[49] repeatedly making a statement to this effect when the occasion arose.

In fact, in 2013 the Nuclear Regulation Authority designated its safety target: "the value we aim to achieve in pursuing regulation of nuclear facilities is keeping the frequency of an accident where the amount of Caesium-137 released exceeds 100 TBq, about one hundredth of the Fukushima Daiichi nuclear accident, to less than one in one million reactor years in the unlikely event of an accident." This target is significant because it clearly assigns a level of performance that should be sought at the facility, with the Fukushima Daiichi Nuclear Power Plant accident as the basis of that level.

Nevertheless, the NRA is cautious about proposing safety goals in stochastic terms. In other words, its position is that "safety achieved by conformity with regulatory standards cannot be unequivocally shown (in terms of probability theory)."[50] Therefore, in addition to the results of a probabilistic risk assessment, the safety enhancement assessment notification form, which is regularly submitted by

[47] The Nuclear Regulation Authority's Operation Guide states that "the incidents covered by this evaluation will be expanded step by step according to the development and implementation of PRA as a method." The report further clarifies that PRA has not yet been established for the magnitude of earthquakes and tsunamis that caused the Fukushima Daiichi Nuclear Power Plant accident, as well as simultaneous complex disasters. Nuclear Regulation Authority, 2013. Kyushu Electric Power Co., Inc., 2017

[48] ICANPS, 2012, p. 398.

[49] Nuclear Regulation, Authority, 2012, p.11.

[50] Nuclear Regulation Authority, 2018a, p.4.

operators after restarting operations, comprehensively measures safety on a multifaceted scale, including the safety margin, effectiveness assessment results of defense in depth by the deterministic method, operational experience considerations, and organizational factors.

Emphasis here is on the further efforts of operators regarding risk information. "The greatest value of setting quantitative safety targets (performance goals) is to explicitly indicate the existence of risks, and to make people aware of the denial of zero risk and safety myths,"[51] said the NRA Chairman Fuketa. He went on to say, regarding the relationship with the operator, "you can't have a discussion [between the regulator and the operators] if the utilization of risk information is not accompanied by efforts from the operators (…) For example, we haven't had any suggestions [from the operators] regarding standby exclusion time,"[52] stirring the operators along.

This is precisely the importance of the "the language between the regulators and the industry should be risk" pointed out by Apostolakis. Only when both parties use a common language to fight out their opinions will the power of the operator be visible to society, and the real image of voluntary safety enhancement emerge.

However, if that is the case, it may be even more necessary to explicitly place probability theory in the center.

In the United States, there is no logical framework to apply defense in depth without the foundation of safety goals, and they are positioned as a break on the unlimited layers of safety that could be added in their absence. On the other hand, in the case of Japan, operators have not reached the technical or maturity level to discuss the shape of nuclear safety using risk information, and as a result, they regulate directly by regulatory requirements and voluntary activities. The reality is that there is no debate between the authorities and the operators. As mentioned above, there is no debate between the two to recognize the meaning of comparing the risk assessment result of a highly uncertain event such as natural phenomena with a standard value from a safety goal, or on how to utilize risk information effectively for safety assessments and safety enhancement. In short, there is no common safety value measure (risk assessment) between the regulator and the operators, and as a result, communication between the two ends up in never-overlapping unilateral explanations by one another. Despite Fuketa's enthusiasm, the current situation of no debate between the regulatory side and the operator side on the extent to which "uncertainty" can be tolerated by directly looking at major risks remains essentially unchanged from before the Fukushima Daiichi nuclear accident.

6. Have "the village and governance by osmosis" changed? Changes in organizational culture

After the accident, it was the issue of TEPCO's organizational culture that all accident investigations pointed out. How much has TEPCO changed into a "learning organization" since then, has it made a new start as a risk-oriented organization, and through this, has it made defense in depth a sure thing as a system? Here, we consider the organizational culture of TEPCO and its compliance with regulations from these perspectives.

Towards a "learning organization"

The Independent Accident Investigation probed the historical and structural factors of the "safety myth" that led to the accident at the Fukushima Daiichi Nuclear Power Plant, its analysis pointing

[51] Ibid., p.13.

[52] This refers to a regulation that specifies the permissible period of time in which malfunctioning machinery must be fully repaired.

out administrative structures unsuitable for safety regulation and rigid stakeholder relationships[53]. It also considered and made recommendations regarding the lack of safety regulation governance, the ambiguity of "national policy/ private operation", safety without security, crisis management and leadership[54]. Of these, it highlights the importance of reforming latent problems of "organization" at both the operators and the regulators, as well as "not averting one's gaze from inconvenient matters".

Given that the factors that cause organizational accidents may be created not only by the operators but also by the regulatory authorities, the report by the Government Accident Investigation recommends as a challenge for administrative organizations the need for a separation of regulation and industry promotion, a sense of mission for safety, an enhancement of staff with specialized knowledge and understanding on a par with that of the operators, and having the leeway to being able to focus on the wood not just the trees.

Regarding these points, in March 2013 TEPCO launched its Fukushima Nuclear Accident Summary and Safety Reform Plan (hereafter abbreviated to the Anekawa Plan, which is taken from the name of the plan's main author).[55]

In its summary, TEPCO concluded, "we could not prevent an accident that should have been prevented" because of "insufficient ongoing efforts to reduce risk and preparation for severe accidents in terms of equipment and personnel".[56] Furthermore, in order to redress essential problems inherent to the TEPCO organization, that is, the background factors for the accident of a lack of safety awareness, technical skills, and dialogue skills, measures such as improving management's awareness of the special risks of nuclear power, maintaining safety discussions across the organization and building a mechanism to foster cost-effective defense in depth proposal capabilities were to be taken.[57]

The Anekawa Plan was a refutation of the hitherto insistence by TEPCO that the Fukushima Daiichi nuclear accident was "unexpected". It was positioned as a fundamental document symbolizing the rebirth of TEPCO, and its contents were highly commended.

At the same time, the Anekawa Plan appealed that "reforming management" to one "with a high safety awareness that strongly recognizes the special risks of nuclear power and is deeply aware of its responsibility" should be the starting point, citing not only the nuclear power department, but also "measures to break the negative chain of TEPCO's company-wide organizational structure" and the "need to strengthen governance and enhance internal communication". Subsequently, using the Anekawa Plan as a basis, TEPCO held a safety steering conference for management centering on the CEO and managers of the nuclear power and location headquarters, which discussed the causes and countermeasures of accidents and other troubles. In addition, they have begun to study "nuclear safety reform for the next generation" that will consolidate and systematize efforts to date (JFY2019 3rd quarter progress report).

I will leave a detailed analysis of whether or not this has really created a "learning organization" to Chapter 2, confining myself here to introducing one of the seven remarks made by Yotaro Hatamura,

[53] Independent Investigation Commission on the Fukushima Daiichi Nuclear Accident, 2012, Chapter 7,8,9.
[54] Ibid., p.320.
[55] Tokyo Electric Power Company, 2013, pp. 6–9.
[56] Ibid.
[57] Ibid., pp. 7–8.

chairman of the Government Accident Investigation at the end of its report.[58] Regarding organizational culture, Chairman Hatamura noted the pitfalls of "creating a mechanism but not sharing goals" as well as the importance of "creating a culture capable of facing danger head on and discussing it". TEPCO's aforementioned efforts tend to remain at the "mechanism" level. They show that it takes considerable time to reform organizational culture starting from management with a high awareness of nuclear safety, which requires "a will to universalize experience"[59].

An organizational culture that faces risks

The Government Accident Report asked for, "a shift in risk perception where even if an event had a low probability of occurring stochastically, it was necessary to take appropriate measures if the damage caused by an accident or fire was extremely large."[60]

This means changing an attitude of risk perception that discards events with extremely low probabilities of occurrence, but even if that was possible, communication practices would have to be changed in order for an assessment to be shared by the organization.

For example, when reporting to management an event (for example, a tsunami calculation result) that exceeds the preparedness limit and asking the supervisor about the need for countermeasures, there is a strong tendency in Japan to try to convey matters euphemistically to respect harmony and the feelings of the other person. This attitude of using indirect expressions to raise problems euphemistically and leave ambiguity in decision-making as well as a tendency to stress predetermined harmony and not face risks directly is a cultural characteristic of Japanese society. The opening message of the English report stated, "The Fukushima Daiichi Nuclear Power Plant accident was a Made in Japan accident, and its root causes are the reflexive obedience, acceptance of the authority gradient, emphasis on predetermined harmony, collectivism and island mentality inherent in Japanese culture." This was much criticized as being "an irresponsible system theory of national confession hiding behind the theory of 'Japan uniqueness'." Known as a pro-Japan scholar, Gerald Curtis, a professor at Columbia University, wrote in the U.K.'s *Financial Times* criticizing that "To pin the blame on culture is the ultimate cop-out. If culture explains behavior, then no one has to take responsibility", insisting that unless individual responsibility was pursued, it would not lead to a solution of the essential problem.[61] Journalist Yoichi Funabashi also stated in his book *Genpatsu Haisen* (Nuclear War Defeat) that while maintaining that the historical and structural background of institutional culture may illuminate the "essence of failure", "cultural theory (*Nihonjinron*) is not very persuasive when it comes to explaining the main causal relationships"," and was counterproductive to "learning from failure".[62]

However, the Organization for Economic Co-operation and Development/Nuclear Energy Agency (OECD/NEA), in cooperation with the World Association of Nuclear Operators (WANO), have looked at nuclear safety from the broad perspective of national character, and called each country's attention to ensuring that national character does not impact on a deterioration in safety. They have planned a forum[63] for public-private collaboration to consider how national character affects the safety of nuclear power, which they are rolling out to each country.

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[58] ICANPS, 2012, pp. 443–448.
[59] Funabashi, 2014, p. 116.
[60] ICANPS, 2012, p. 413.
[61] Curtis, 2012.
[62] Funabashi, 2014, p. 18, 249.
[63] For example, the Country-Specific Safety Culture Forum was held in January, 2018 in Sweden and in March, 2019 in Finland.

Incidentally, the international definition of the characteristics of safety culture at IAEA, OECD/NEA, WANO and so on has several attributes including "a questioning attitude", "always learning", and "open workplace".

At a forum held in Sweden, bearing in mind these attributes, participants[64] played their respective "roles" in accordance with an accident scenario at a nuclear power plant from symptom stage to accident response, elucidating from their behavior attributes that appeared to be Swedish national characteristics, and discussed their impact on nuclear safety. As a result, the group of participants elucidated that people from their own country have values that emphasize oneness and collective duty performance (*samskap* in Swedish) and equality and justice (*allskap*). During the discussion, for example, it was reported that minutes of a meeting might not be made if the chair asked, "Got it?" and everyone answered "Yes". And while this social attribute of emphasizing this sense of unity and fulfillment of collective duties is a strong advantage, the shared awareness was that caution was required about pressure blocking opposition, that is, the possibility of false agreement. In addition, although follow-up and feedback on decisions are standard practice in the international community, in Swedish society with its strong sense of the values of equality and fairness, there is a strong sense that you should not explore the work of others, the need for further consideration also being a shared awareness. In this way, this forum aims to objectively identify the merits and demerits of national character and to deepen thinking about enhancing nuclear safety in line with national character.

In his greeting to the Forum, Executive Secretary William D. Magwood commented, "Instead of considering the attributes of nuclear safety in a general theory of the world, safety organizations and the nature of individuals rooted in the national characteristics of each country should be considered, and should be considered in the language of that country."[65]

The Japanese government is yet to hold this forum organized by the OECD/NEA. One reasons for this is that the Japanese society's organizational culture for safety, which is said to be poor at looking at risks, has not been deeply discussed by the regulatory side and the operators.

In addition, in the new inspection program that started in 2020, the regulation authority focuses on cultivating and maintaining a safety culture as a cross-sectional activity area for operators. The guide for inspectors recommends looking at the organizational culture from four perspectives: to confirm the demonstration of leadership for fostering and maintaining a sound safety culture, to confirm the efforts of the operators, to confirm the evaluation and improvement of the condition regarding safety culture, and to confirm the ability to maintain a safety culture within the organization. The regulatory authority and the inspectors at the site are required to have a keen eye for verifying whether operators are cultivating an organizational culture that is aware of the lessons learned from the Fukushima Daiichi Nuclear Power Plant accident and is taking action to make universal use of those lessons, as well as other events.

Even if a similar event can be prevented through reflexive (whack-a-mole) measures based on the Fukushima Daiichi Nuclear Power Plant accident, different disasters and accidents will come again. As the Independent Accident Investigation noted in its concluding chapter, "the same crisis will never happen again", and "the same luck will never happen again"."[66] The lesson of that tragedy was meant

[64] Executives from all domestic nuclear industries participated in the Swedish Forum, including Westinghouse Electric Sweden, The Swedish Nuclear Fuel and Waste Management Company, managers from all of the nuclear power plants, Vattenfall, Universe Sweden, and The Swedish Radiation Safety Authority, as well as international organizations.
[65] Magwood, 2018.
[66] Independent Investigation Commission on the Fukushima Daiichi Nuclear Accident, 2012, p. 396.

to be that we continually consider what it means to "face risks and prepare for the unexpected", and create an organizational culture that maintains the "will to universalize experience".

7. What is regulatory "independence"?

As I mentioned at the beginning, the Nuclear Regulation Authority, which was established after the Fukushima Daiichi Nuclear Power Plant accident, held up as its motto "to make independent decisions from a scientific/technical point of view irrespective of all else."

Out of remorse for the lack of safety regulation governance, where the introduction of serious accident response measures (AM) and examination of earthquake and tsunami countermeasures were pointed out to be the "captive of regulation", this is nothing less than an expression of readiness to begin anew and pledging to provide strong leadership regardless of external interference.

The chairman of the Nuclear Regulation Authority was required to have political independence, independence from the "nuclear village", high professionalism, and judgment and leadership possessed of personal insight that remained steady in an emergency. "We had a hard time selecting him,"[67] recalls Goshi Hosono, a member of the House of Representatives involved in this task under the then administration. He said that at the time, there was a strong opinion that given the importance of the independence of scientific and technological knowledge, the chair, as the head of an Article 3 commission, should be given strong authority that did not brook interference by the prime minister, but in the end this was overridden as a collegial system.[68]

As a result, the Nuclear Emergency Preparedness Council chaired by the Prime Minister, which coordinates related organizations in nuclear disaster preparedness measures, was established for normal times, the vice-chairs being the Chief Cabinet Secretary, the Minister of the Environment, Minister of State for Nuclear Emergency Preparedness, and the NRA Chair. In addition, in order to support scientific and objective judgments when nuclear operators, national governments, local governments, etc. formulate plans for nuclear disaster countermeasures and implement those countermeasures, the NRA Chairman plays a role in formulating nuclear disaster countermeasure guidelines that define specialized and technical matters. On the other hand, in the event of an emergency, a Nuclear Emergency Response Headquarters headed by the Prime Minister will be established. At this time, the Act on Special Measures Concerning Nuclear Emergency Preparedness especially stipulates that "judgments based on technical and specialized knowledge shall be excluded"[69] from the instruction authority of the Prime Minister (HQ head). The independence of the NRA Chairman responsible for making decisions based on technical and specialized knowledge in an emergency situation is established here.

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[67] Interview with Goshi Hosono, December 19, 2019.

[68] Shiozaki, 2016.

[69] Article 20, Paragraph 3 Act on Special Measures Concerning Nuclear Emergency Preparedness (Act No.156, Heisei 11) : (3) In addition to the instructions under the provisions of the preceding paragraph, when the director-general of the nuclear emergency response headquarters finds it especially necessary for implementing emergency response measures accurately and promptly in the emergency response measures implementation area covered by said nuclear emergency response headquarters, he/she may, within the limit necessary, give necessary instructions to the heads of the relevant designated administrative organs and the heads of the relevant designated local administrative organs, and the officials of said designated administrative organs and the officials of said designated local administrative organs to whom his/her authority has been delegated pursuant to the provisions of the preceding Article, the heads of local governments and other executive organs, designated public institutions and designated local public institutions, and nuclear operators.

At the same time, it was essential to maintain the independence of the secretariat, the Nuclear Regulatory Agency. Regarding staff, the Agency is working towards training its own professional experts and has thorough no-return rules, ensuring that the Agency does not just become a venue for seconding officers from their original ministries and prevents their return to their former "parents".

It was also necessary to ensure transparency to show independence in the relationship with operators. The NRA, in principle, publishes minutes of exchanges and meetings with operators and other stakeholders, and in some cases, videos of the meeting are available.

However, operators are bewildered by this principle of transparency. In Japanese society, there is a tendency to fear verbal gaffes in public and to hate having things put on record. In addition, there is a perception on the part of some operators that restarting their plants is "hostage" to the regulatory authorities, and it has been voiced that it is difficult to argue strongly with the regulator, who wields the license power.

However, what is important is that it is precisely the guarantee of transparency that allows a third party to assess whether something unreasonable is happening and to speak up as a referee. Based on the lessons learned from the Fukushima Daiichi Nuclear Power Plant accident, the International Nuclear Safety Advisory Group[70], which is an advisory body to the IAEA Executive Director, emphasizes the importance of "institutional oversight" with multi-layers of just such a mechanism.[71]

"Institutional oversight" is a governance mechanism in which a third party audits the activities of the parties from various layers. It is a multi-layered "check-and-balance system" that can openly point out what may be hard for one's self to notice. Points extend not only to technical lessons and systems, but also to personnel and organizational culture. Since the parties concerned "see only what they want to see", they are unaware of the risks they cannot see. Therefore, there must be a function for checking the values that support human behavior, and more specifically, checking whether or not self-justification bias within the organization is working leaving problems abandoned. Here lies the significance of oversight.

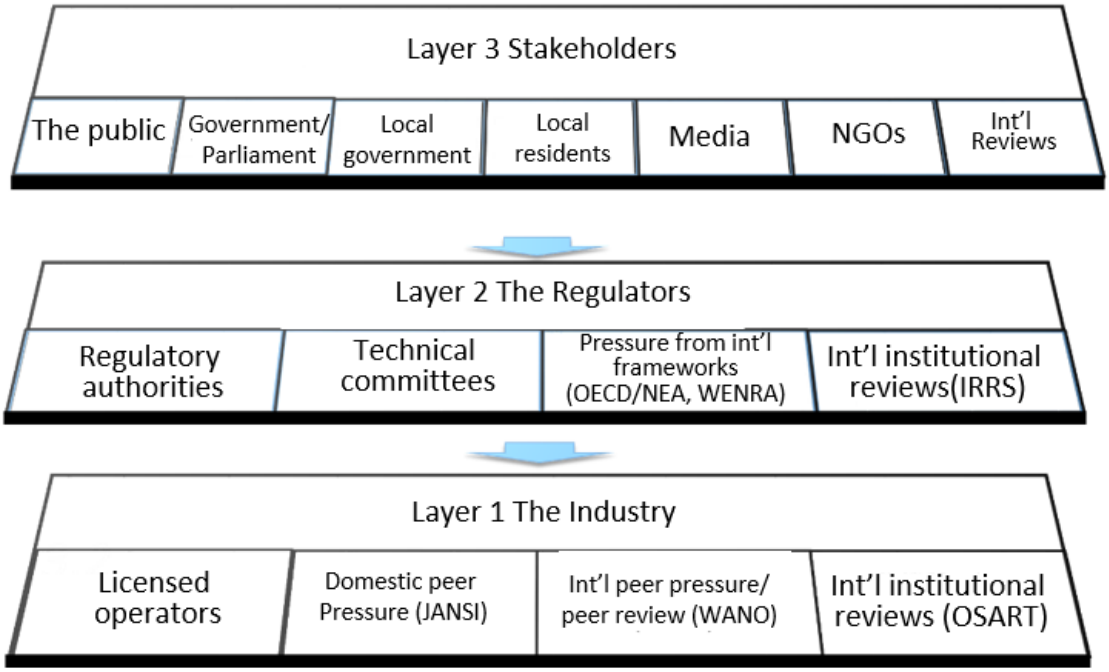
Fig. 3 shows the mechanism for operating the oversight function as a system proposed by the IAEA International Nuclear Safety Advisory Group. There, nuclear-related groups are categorized into three layers: operators, regulators, and society, the first layer being the group that surrounds the operators that have the primary responsibility, and the second layer being the regulators that have the responsibility of supervising the operators and the group surrounding them, and the third layer being the constituent groups of the general public, such as stakeholder communities that are directly affected and media. Each of these groups oversees and restrains the lower layers.

Each layer is comprised of many components and embodies the concept of defense in depth, which constitutes multiple and diverse barriers. For example, the activities of operators in the first layer are as follows: the first step is voluntary safety enhancement activities by operators, the second step is mutual support activity between domestic operators that places pressure on each operator, and the third step is safety assessment activities by international business organizations, and the fourth step recommends securing nuclear safety by conducting self-checks in a multi-step structure with safety assessment activities by various operators as well as inspection and advisory activities by international organizations such as the IAEA.

[70] Consultative body of the IAEA Director General Office (International Nuclear Safety Group, INSAG).
[71] IAEA International Safety Group, 2017.

As a first-layer check function, nuclear operators such as TEPCO carry out peer review activities through, say, the Japan Nuclear Safety Institute (JANSI) and undergo oversight checks by domestic peers, peer review by WANO, a group of international peers, and review by the IAEA Operational Safety Review Team (OSART) in addition to the activities of internal monitoring organizations such as the Nuclear Reform Monitoring Committee and the Nuclear Safety Oversight Office. The second layer monitoring function consists of guidance and supervision by the Nuclear Regulation Authority, the services of supporting international organizations such as OECD/NEA, and the IAEA Integrated Regulatory Review Service (IRRS). Furthermore, the stakeholder monitoring function in the third layer has a wide variety of governance functions that are checked by the government's nuclear-related administrative agencies and local governments, local community group councils, and the media.

- Figure 3 Defense in depth as a system



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-Institutional Strength in Depth –

However, the concept of oversight is a concept born in the West. This system will not function if imported wholesale in a society with the characteristics of it being easier to use ambiguous expressions when it is necessary to communicate something offensive to the other party, a social climate that cares for face and cannot easily accept suggestions from outsiders, and a community-based corporate culture that is far from a global style of management.

In order to make good use of the various guidance and advice obtained from abroad, rather than simply creating a form, there is a need to hold a safety culture forum that discusses nuclear safety, Japanese methods of making and checking points from the viewpoint of the aforementioned social characteristics of the country, as well as joint discussions between the public and private sectors on measures.

Another serious consideration is the establishment of a permanent oversight body for nuclear safety regulations in the Diet. The Parliamentary Accident Investigation recommended an investigation

committee should be set up as a permanent organization, consisting of experts centering on the private sector and independent of nuclear operators and administrative agencies, that would continuously follow up the issues pointed out in the accident investigation and verification (Parliamentary Accident Recommendation 7: Utilization of Independent Investigation Committee).[72]

Certainly, the Lower House has the Nuclear Power Task Force Special Committee (established January 28, 2013), and the Upper House has the Nuclear Power Task Force (established August 7, 2013)[73]. However, neither have the function of checking administrative measures with specialized knowledge, experience and high insight into ensuring safety in the use of nuclear power.

Regarding the current operation of the Nuclear Regulation Authority, Yasuhisa Shiozaki, a member of the House of Representatives, who drafted the LDP/Komeito proposal, compared the present with the ideal at the time of its establishment, and found that the independence of nuclear safety regulations was "still operated from a supply-side [government] perspective. It's not operated from a national perspective like overseas institutions."[74]

Tsuyoshi Shiina, a member of the secretariat of the Parliamentary Accident Investigation, said, "The Nuclear Regulation Authority, which was established with an emphasis on independence, doesn't come under ministerial jurisdiction because it's an Article 3 commission, but it's still an administrative organ. [The purport of the Parliamentary Accident Investigation recommendation was] we expected two roles: the basic idea of the separation of powers by the legislative body selected by the people to monitor the administration, and the asymmetry of information to be monitored by someone with the same level of expertise as the administration."[75]

In order to further increase the independence of nuclear safety regulations, it is desirable to strengthen the check and balance function between the administration and the Diet. The independence of safety regulations should be unequivocally ensured by governance operating through the multi-layered monitoring function from various viewpoints recommended by the International Nuclear Safety Advisory Group (INSAG), an advisory body of the IAEA Secretary General. This should increase the transparency of complex and highly specialized nuclear safety regulations, and thus credibility with the public.

Summary

Common to each accident investigation is the importance of regulatory independence. The greatest problem was regulatory methods and regulatory governance. Today, the system has been revamped, but operations still follow the old system. In terms of form, institutional reforms such as new

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[72] "Recommendation 7: Utilization of an independent investigation committee A Special Investigation Committee on Nuclear Power (tentatively named) should be estab-lished in the Diet as a third party organization. It should be composed of experts mostly from the private sector and independent of the nuclear power operators and administrative organs so that the Committee investigates and discusses important themes that influence public livelihood, such as the investigation into the unexplained causes of the accident, the process towards the settlement of the accident, the prevention of damage escalation, mat-ters not discussed this time, including the decommissioning process of reactors and spent fuel issues. In addition, there should be a mechanism through which the Diet can create such independent investigation committees for different themes, and investigation and examinations should be continuously carried out, uninhibited by conventional ideas" The National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission, 2012, p. 22.

[73] Established at the 183rd session of the National Diet and subsumed by the Special Committee on Reconstruction after the Great East Japan Earthquake.

[74] Interview with Yasuhisa Shiozaki, March 17, 2020.

[75] Interview with Tsuyoshi Shīna, October 9, 2019.

regulatory standards, the backfit system, the safety enhancement assessment notification system, and a new inspection system have been made, but ambiguous authority and responsibility in decision-making, “the village and governance by osmosis”, and a Japanese regulatory culture and practices of “preferring small peace of mind over great safety” remain unchanged. As pointed out by the IAEA's IRRS, it is still dragging along its culture of inspecting trivial specifications and visible forms. It will be difficult to generate regulatory *kaizen* and innovation through true cooperative work from such a situation. If operators (and regulators) misunderstand the principles of the new regulatory standards and think that compliance with standards will ensure absolute safety, this will mean precisely that they have not learned the lesson of the Fukushima Daiichi accident.

Whether a mechanism utilizing operator autonomy can be incorporated into and function within the regulatory system or not will depend on the motivation of the operators. Whether or not regular safety reviews descend into a sham and lessons reducing sensitivity to new knowledge at the basic design stage are utilized depends on how they are conducted in the future. Probabilistic risk assessment of events similar to those seen at the Fukushima Daiichi nuclear accident have not been carried out because of technological immaturity. There is also little debate about safety goals between the regulators and the operators. There is no difference from before the Fukushima Daiichi Nuclear Power Plant accident when no common language existed for discussing safety in terms of how much “uncertainty” could be tolerated by directly confronting major risks.

Although various actions have been carried out with due regard to the independence of the regulators, and we can witness the creation of an environment enhancing human resource expertise and reform in organizational culture, an organizational culture in which the regulators and operators share the same goal of never repeating the same mistakes has yet to be established. In addition, although there is no multi-layered oversight system along the lines of a permanent parliamentary committee, its creation could be expected to increase credibility with the populace.

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Article 4-2 of the Act for Establishment of the Nuclear Regulation Authority (Act No.47, Heisei 24)

Article 4-2 of the Act for Establishment of the Nuclear Regulation Authority (Act No.47, Heisei 24)

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