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Section 3:

The Echo Chamber:
Regulatory Capture and the Fukushima Daiichi Disaster

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While most nuclear power industry commentators have focused on the sequence of technical failures that led to the ongoing release of radioactivity from the three nuclear reactors in the Fukushima-Daiichi nuclear power plant (NPP), a broader and longer-term analysis reveals that the key causes of the three meltdowns were the institutional failures of political influence and industry-led regulation and the nuclear sector's dismissive attitude towards nuclear risks.

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There were numerous red flags indicating potential problems for anyone following TEPCO during the past decade. Crucial vulnerabilities in the Fukushima Daiichi reactor design; substantial governance issues and weak management characterised by major frauds and cover-ups; collusion and loose regulatory supervision; as well as understanding but ignoring earthquake and tsunami warnings, were key ingredients of the March, 2011 disaster. Moreover, all these crucial vulnerabilities had been publicly highlighted years before the disaster occurred. Hence, three main reasons for the disaster can be identified: design and technical issues; governance, management and regulatory weaknesses; and systemic failure of current nuclear safety assessments.

As we will discuss, it was not a simple technological failure or an unpredictable act of Nature that caused the Fukushima Daiichi disaster. A failure of human institutions to acknowledge real reactor risks, a failure to establish and enforce appropriate safety standards and a failure to ultimately protect the public and the environment caused this tragedy. Additionally, it is important to note that institutional failure has been the principal cause of all past nuclear accidents, including Chernobyl and Three Mile Island.[141]

This chapter will show that the heightened risks of earthquakes and tsunamis in Japan and the vulnerabilities of the Mark 1 Boiling Water Reactor (BWR) containment design have been well known to Japanese and international decision makers for decades. Yet TEPCO and its regulators repeatedly ignored these warnings.

It appears that erroneous safety decisions made when Fukushima Daiichi was built in 1970 were perpetuated for more than 40 years because officials did not want to alter the status quo.

Such a conclusion is substantiated by Marc Gerstein in his book Flirting With Disaster, which examines why accidents are rarely accidental. According to Mr. Gerstein:

> ". . . reasonable people, who are not malicious, and whose intent is not to kill or injure other people, will nonetheless risk killing vast numbers of people. And they will do it predictably, with awareness . . . They knew the risks from the beginning, at every stage . . . The leaders chose, in the face of serious warnings, to consciously take chances that risked disaster . . . Men in power are willing to risk any number of human lives to avoid an otherwise certain loss to themselves, a sure reversal of their own prospects in the short run."[142]

Caught between the influence of its governmental mandate to promote nuclear power and TEPCO's desire to minimise costs, Japan's Nuclear Industry and Safety Agency (NISA) failed to enforce existing standards and respond to advancements in scientific knowledge on how to mitigate accidents and tsunami risks. The institutional failures that led to the Fukushima Daiichi disaster also provide a reality check on the nuclear industry's claim of 'safe' nuclear power. While the nuclear industry has always asserted that the chance of a severe reactor accident is acceptably low – one significant meltdown for one million years of reactor operation – estimates based on experience, including the triple meltdown at Fukushima Daiichi, shows that a nuclear accident has on average occurred once every seven years.[143]

Nuclear safety in Japan

Many countries operating or building nuclear plants lack a truly independent, properly resourced nuclear regulator. Even though the international Convention on Nuclear Safety requires that national nuclear regulators are separate from bodies tasked with the promotion of nuclear power, there is no effective international mechanism for monitoring compliance, let alone enforcing the rules. The magnitude of this issue is illustrated by the fact that the international community was totally unable to identify and reign in the collusion between the Japanese nuclear industry and its regulator.

Outside of Japan, Brazil, India and South Africa came under the spotlight at the 2008 Convention on Nuclear Safety review conference because their regulatory bodies were considered too close to organisations that promote nuclear energy.[144]

In fact, in Japan's nuclear industry it is difficult to even differentiate between the regulator and the regulated. The close relationship between the regulator and TEPCO established the conditions for both institutions to fail in their respective mandates to uphold reactor safety.

From the highest level of government policy, the dichotomic objectives of promoting nuclear power and at the same time being the watchdog over nuclear safety are so closely intertwined that the watchdog role eroded slowly but consistently. The Ministry of Economy, Trade and Industry (METI) oversees both the Nuclear and Industrial Safety Agency (NISA), which regulates the safety of nuclear power, and the Agency of Natural Resources and Energy, which is mandated to promote the growth of nuclear power.

Government and industry relations in Japan have a long history of intertwined personal relationships. This relationship has a unique Japanese word to describe it: *amakudari*, which translates literally as 'descent from heaven'. *Amakudari* describes the practice of high-ranking government officials acquiring high paying jobs in the industries they once regulated, while top industry officials are appointed to government advisory committees and able to shape government policy.[145] This practice of revolving doors is one of the key factors in the erosion of nuclear safety in Japan.

With *amakudari*, the safety regulator and the reactor operator are related, familiar and mutually supportive. Such a relationship is fertile for the Echo Chamber effect: the tendency for beliefs to be amplified and even mythologised in an environment where a limited number of similarly interested actors fail to challenge each others' ideas.

The tight links between the promotion and regulation of the nuclear sector created a 'self-regulatory' environment that is a key cause of the Fukushima Daiichi disaster.[146]

The Japanese regulator NISA has also acted to manipulate public consultations in favour of nuclear power. In 2011, an independent committee found that, in 2006, NISA encouraged TEPCO to plant positive questions at public hearings on new nuclear projects. The panel argued that NISA's collusion with industry and its promotional activities with regards to nuclear power are probably due to its desire to please its governing ministry, which seeks to promote nuclear power.[147]

Tolerating TEPCO's cover-ups

TEPCO has a long history of withholding problematic and disturbing information regarding the safety of its reactor fleet, from both the regulator and the Japanese public. Despite this history and the potential disastrous consequences of equipment failure, NISA has continuously tolerated

TEPCO's behaviour and not adhered to its mandate of upholding and regulating nuclear safety. Instead of sanctioning or restraining TEPCO, in some instances NISA even created specific standards that allowed continued operation of TEPCO's deficient reactors. Such lax regulatory conditions created an environment in which TEPCO officials felt they could continue to falsify, omit and withhold information on safety records and inspection records. For example:

- In August 2002, it was revealed that TEPCO had been falsifying inspection records in order to hide cracks in reactor systems at 13 of its 17 nuclear stations, including the Fukushima Daiichi reactors.[148],[149] The Japanese nuclear regulator did not carry out any of its own inspections of the reactor systems, instead it trusted the corporation with these crucial safety inspections. As it turns out, employees had been falsifying inspection records since the 1980s.[150] And, even after the cover-up was revealed, the regulators waved away concerns about increased accident risk based upon calculations supplied by TEPCO. In response to TEPCO's deception NISA adopted a special 'defect standard' to allow the company's reactors to continue operating.[151]

- Later in 2002, TEPCO was found to have falsified test data on the air-tightness of the reactor containments of Fukushima Daiichi Unit 1 in the early 1990s.[152] Preliminary tests on containment integrity had shown that the sealing system was inadequate.[153] On 20 September other damage cover-ups in the re-circulation pipe system were revealed in eight of TEPCO's reactors, as well as Onagawa Unit 1 of Tohoku Electric Power Company and Hamaoka Unit 1 of Chubu Electric Power Company. In addition, other cracks in the core shroud were found at Onagawa Unit 1, Hamaoka Unit 4, Tsuruga Unit 1 (Japan Atomic Power Co, Ltd), and Shimane Unit 1. As has been pointed out, this series of cover-ups showed the scandal was not merely with TEPCO but involved most of the nation's electric companies.[154]

- In 2006, TEPCO admitted to falsifying records on coolant water temperatures between 1985 and 1988.[155]

- In 2007, an earthquake triggered a fire and a spill of radioactive liquid at the Kashiwazaki-Kariwa nuclear power plant. TEPCO at first concealed the extent of the damage, such as the leakage of hundreds of gallons of radioactive wastewater.[156]

- Just two weeks before the Fukushima Daiichi disaster began, NISA accused TEPCO of failing to properly inspect equipment at the Fukushima-Daiichi station, including the cooling system equipment and the spent fuel pools.[157]

Following the scandal surrounding TEPCO's 2002 cover- ups, the Japanese government admitted there was a problem with NISA and promised change. Hiroyuki Hosoda, Minister of State for Science and Technology Policy, told an IAEA conference in 2003:

> "The falsification of self-inspection records by a Japanese nuclear power plant operator was made public in August last year. This has seriously damaged public confidence in nuclear safety. In response, the Japanese government has drastically revised its nuclear safety regulations. The purpose was to improve the effectiveness of its regulatory system and quality assurance on the part of the operators, thereby enhancing the nuclear safety culture. Japan is making efforts to restore public confidence through dialogue and to restart the plants that were shut down for inspections."[158]

The government's promised reform seems to have had little effect. Regulatory records show that prior to the Fukushima Daiichi disaster, TEPCO had been cited for more dangerous operator errors during the previous five years than any other utility.[159] According to assessments carried out after the 2002 scandals, it has become clear that TEPCO's managers tended to put cost savings ahead of plant safety. Despite the ongoing poor performance, there is little regulatory action to improve the situation.[160]

In the dismal aftermath of the Fukushima Daiichi catastrophe, the Japanese government has once again acknowledged its ongoing issues with its safety regulator, specifically citing the negative influence the METI's promotional policies had on NISA. Before leaving his position, former Prime Minister Naoto Kan initiated a process that would make the nuclear regulator an independent organisation.[161]

Failure to adapt to scientific evidence[162]

The Fukushima Daiichi disaster could have been prevented because TEPCO had information prior to the accidents that the nuclear power station could be subject to a 10-metre tsunami. Also prior to the Fukushima Daiichi accidents, NISA had acknowledged the need to re-evaluate and upgrade earthquake and tsunami protection requirements. Both NISA and TEPCO neglected their responsibilities to protect the citizens of Japan by placing profits ahead of safety.

- Since 1990, Tohoku Electric Power Co, Tohoku University and the National Institute of Advanced Industrial Science and Technology have researched the traces left by the 869 Jogan Earthquake.[163] Their studies have shown that the ancient tsunami was on the same scale as the one on 11 March 2011. Before the disaster, scholars had repeatedly warned that a massive tsunami could hit the Tohoku region in the future. However, TEPCO played down and ignored these reports.

- As early as 1997, TEPCO was aware of the tsunami risk at the Fukushima site and chose to ignore the scientific analyses of increased tsunami risk made by seismologists Katsuhiko Ishibashi and Koji Minoura. A TEPCO representative dismissed their concerns: "I understood what Ishibashi was saying, but if we engineered factoring in every possible worst case scenario, nothing would get built."[164]

- On the heels of the 2004 Sumatra earthquake and tsunami, TEPCO launched a study into tsunami risks. The TEPCO team presented their findings in 2007, putting the probability of a tsunami of 6 metres or more at 10% over a 50-year period. The Fukushima reactors were identified as a particular concern.[165]

- In its annual reports, which have been made public since 2008, the Japan Nuclear Energy Safety Organisation (JNES) has predicted possible damage that a tsunami could cause to Mark 1 nuclear reactors that are about the same size as the Nos. 2 and 3 reactors at the Fukushima plant. One report said if a breakwater extending up to 13 metres above sea level was hit by a 15-metres-high tsunami, all power sources would be knocked out – including outside electricity and emergency power generators. In such a situation, the report said, cooling functions would be lost and the reactor's core would be 100% damaged – a meltdown, in other words. The breakwater at the Fukushima No. 1 plant was 5.5 metres high.[166]

In 2006, NISA even published new guidelines for reviewing seismic hazards to nuclear stations. However, following the 2011 disaster, an IAEA investigative team reviewed the guide and noted it was superficial, because it contained no tangible enforceable criteria and simply relied upon voluntary reviews by TEPCO with no oversight or control by NISA. The IAEA report concluded:

> "The guidance provided in 2006 as part of the Seismic Safety Guidelines does not contain any concrete criteria or methodology that could be used in re-evaluation. The only re-evaluation was performed in 2002 by TEPCO on a voluntary basis. Even this work was not reviewed by NISA. Therefore an effective regulatory framework was not available to provide for tsunami safety of the NPPs through their operating life."[167]

Additionally, following the accidents, the IAEA investigators also concluded that the seismic risk to the Fukushima station was underestimated in the original and subsequent evaluations of earthquake hazards because TEPCO failed to consider longer-term historical data, despite this being the recommended practice internationally.[168]

In an unfortunate twist of fate, TEPCO informed NISA that the Fukushima-Daiichi nuclear power plant could be hit by a tsunami exceeding 10 metres while the plant was only designed to withstand a tsunami of 5.7 metres, just four days before the earthquake and tsunami triggered the three meltdowns at the Fukushima Daiichi nuclear station.[169] After the accident, it was revealed that the warning came from an in-house TEPCO 2008 study, that company officials had dismissed and concealed calling it 'unrealistic'.[170]

In its review of the disaster, the IAEA noted the obvious: Japan is internationally recognised for its expertise on tsunami and earthquake risks and Japanese academics and industry experts have assisted countries around the world in understanding and establishing their own tsunami and earthquake risk reviews. In its review, the IAEA, however, observed that 'organisational issues have prevented this expertise to be applied to practical cases' at Fukushima Daiichi, Fukushima Daini and Tokai Dai-ni nuclear power plants.[171]

This institutional failure to apply the Japanese knowledge and expertise on tsunami and earthquake risks to the nuclear sector is underlined by NISA's approval of lifetime extension of a Fukushima Daiichi reactor prior to the accident. Just weeks before 11 March, NISA approved the life-extension Fukushima Daiichi Unit 1 for an additional 10 years without any modifications or even a substantive review of the station's 40-year-old tsunami protections.[172] Nuclear proponents have attempted to absolve the industry of responsibility for the Fukushima disaster by calling the earthquake and tsunami a 'black swan event' – an extremely unlikely and unforeseeable event that could not be planned for in the reactors' design. A review of the events leading up to the Fukushima disaster shows that TEPCO and NISA ignored scientific information on the potential for such a series of events and failed to prepare sufficiently for the unexpected.

The claim of nuclear 'safety' – a false sense of security

At the heart of claims of nuclear safety is an assumption that accidents, which lead to significant releases of radiation, have a very low probability of occurring. International safety regulators have adopted a nuclear safety paradigm under which, for accidents that are categorised as 'design basis' events, the design of a plant must guarantee no significant radioactive releases will occur. These events are also often referred to as 'credible' accidents. Accidents involving significant radiation releases, like those at Fukushima Daiichi are called 'incredible' or 'beyond design basis' events. These are claimed to be of an extraordinary low probability.[173]

These numbers are the results of PSA (probabilistic safety assessment) studies. However, PSAs cannot provide meaningful estimates for accident frequencies (probabilities), since they cannot take into account all relevant factors (e.g. they cannot cover inadequate regulatory oversight) and the factors that are included are beset with huge uncertainties (e.g. regarding earthquakes).

The designs for all reactors in operation, including the Fukushima Daiichi units, were established in the 1960s. The 'design basis' of reactors was based upon 'reasonably foreseeable' accidents, i.e. accidents that, according to industry experts, could be expected.[174] Also the designs applied the antiquated engineering modelling and methodology available during that time period more than 40 years ago.

In the following decades, accidents involving significant radiation releases that were initially deemed as 'incredible' began to occur, such as Three Mile Island (1979) and Chernobyl (1986). Despite some development in nuclear assessments, e.g. in terms of the kind of accidents taken into account, the nuclear sector did not question the safety paradigm but carried on using the model, i.e. the probabilistic risk assessments, to justify the allowance of certain reactor weaknesses and vulnerabilities.

Regulators and the industry call nuclear power 'safe', because their calculational methodology depicts events that could cause a significant accident, like the one that occurred at Fukushima

Daiichi, as extremely unlikely. Reactors were allowed to be constructed in ways that do not allow them to withstand such events. According to probabilistic risk assessments, the chance of a 'beyond design basis' accident, which causes a core melt and a significant radioactive release, is less than once in a million years of reactor operation. The Fukushima Daiichi disaster, however, has shown this theory of nuclear safety to be false.

By 2011, the world had accumulated just over 14,000 years of reactor operating experience.[175] The International Atomic Energy Agency (IAEA) safety guidelines state that the frequency of actual core damage should be less than once in 100,000 years.[176] Hence, with more than 400 reactors operating worldwide, a significant reactor accident would be expected to occur approximately once every 250 years.[177]

Culminating with the Fukushima Daiichi accidents in 2011 there have been five major accidents involving significant fuel melt during the past 33 years: Three Mile Island (a Pressurised Water Reactor) in 1979, Chernobyl (a RBMK design) in 1986, and the three Fukushima Daiichi units (Mark 1 Boiling Water Reactors) in 2011.

Based upon these five meltdowns, the probability of significant accidents is in fact one core-melt for every 2,900 years of reactor operation.[178] Put another way, based upon observed experience with more than 400 reactors operating worldwide, a significant nuclear accident has occurred approximately every seven years.[179]

The theory of nuclear safety espoused by the nuclear power sector has given regulators, reactor operators, and the public a false sense of security. For industries that require a high level of reliability, such as aviation and nuclear generation, institutional failures are the major contributor to real-world accidents. Surveys of nuclear and other high-reliability industries show that 70% of real accident rates are caused by institutional failures.[180] Despite this, the probabilistic risk studies produced by reactor operators to predict the frequency of component failures leading to radioactivity releases do not take into account failures of operators and regulators overseeing the plant. The empirical evidence shows that reactor accidents are more than one order of magnitude more likely than predicted by the nuclear industry's modelling.

This historical record clearly contradicts the industry's claim of nuclear safety. Instead of being low-probability events as asserted by the nuclear industry, reactor meltdowns are regular events with significant consequences. Safety regulators and governments internationally should acknowledge this reality, as was done by Dr Piet Müskens from the Kernfysische Dienst, the nuclear safety regulator in the Netherlands, who stated shortly after the Fukushima accident:

> "Due to the problems with the nuclear plant Fukushima 1 in Japan, all countries in the world having nuclear power plants are going to re-investigate and re-evaluate their calculation of the probability of a nuclear meltdown."[181]

For decades, the nuclear industry and its regulators have convinced themselves that the low

probability of component failures somehow means that the nuclear technology is a low risk industry.

However, risk is typically defined as probability (or frequency) times consequence. Even a low-probability event could be high risk if the consequences are catastrophic. The majority of nuclear risk studies calculate the frequency or probability of events while avoiding true risk assessment that incorporates serious consequences. Such convoluted modeling distorts the public and the institutional understanding of the risk posed by nuclear power stations and encourages risky behaviour. The former president of TEPCO, Tsunehisa Katsumata, described the attitude of allowed deception of regulatory authorities: "The engineers were so confident in their knowledge of nuclear power that they came to hold the erroneous belief that they would not have to report problems to the national government as long as safety was maintained."[182] The overconfidence and denial of nuclear risks are evident in the behaviour of NISA and TEPCO prior to Fukushima.

The international nuclear industry and its regulators have often portrayed public scepticism regarding nuclear safety as irrational. Fukushima, however, has highlighted how public scepticism of industry safety claims is valid. The potential for similar catastrophic disasters is not limited to Japan. Dozens of existing and planned new reactors all over the world are burdened with similar technological weaknesses that proved fatal at Fukushima Daiichi, have substantial governance and management issues, and operate without effective independent supervision.

Industry promotion vs safety at the International Atomic Energy Agency (IAEA)

The IAEA was founded in 1957 under the auspices of the UN, and its status under the UN gives the false perception of an independent organisation in charge of nuclear safety at an international level. However, its watchdog authority only relates to nuclear weapons. As a matter of fact, the IAEA is a UN body that has a mandate and explicit objective to promote and spread nuclear power. The status of the IAEA is declared clearly at the beginning of its UN charter:

> ARTICLE II: Objectives. The Agency shall seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world. It shall ensure, so far as it is able, that assistance provided by it or at its request or under its supervision or control is not used in such a way as to further any military purpose.[183]

The IAEA, as well as some national regulatory agencies, therefore suffers from the very same problem: an inherent conflict of interest. It is expected to regulate a dangerous technology that it was also created to promote. This dual role for the IAEA leads to systemic bias, since the safety recommendations of the agency can never go so far that they would become an obstacle to the expansion of nuclear power. Furthermore, the IAEA has neither enforcement power nor jurisdiction over nuclear power in any country. Therefore it can only recommend, and often its safety standards are set at the lowest common denominator to make them acceptable to its member countries.

IAEA and Fukushima Daiichi

During the Fukushima Daiichi accident, the IAEA's systemic bias became very apparent. The Agency's first team of experts arrived in Japan on 26 March 2011, two weeks after the accident began.[184] One day later, Greenpeace announced that radiation levels in the village of Iitate, located about 40km from the damaged reactors, were so high that they exceeded the thresholds for evacuation.[185] Greenpeace radiation specialists had already been operating and measuring radiation in the Fukushima region, producing the first truly independent radiation measurements. The Japanese government spokesperson, Mr Nishimura, immediately claimed these findings were unreliable and rejected them.[186]

On 30 March, the IAEA confirmed that the radiation levels in the village of Iitate outside the evacuation zone surrounding the stricken Japanese nuclear plant were above evacution limits, and the IAEA urged Japan to reassess the situation.[187] "The first assessment indicates that one of the IAEA's operational criteria for evacuation is exceeded in Iitate village," said the IAEA's head of nuclear safety and security, Denis Flory. Once again, the government rejected those findings and recommendations. The then chief cabinet secretary Yukio Edano told reporters[188] the situation did not 'immediately require such action'.[189]

Only two days later, the IAEA withdrew its statement. The IAEA officials stated that a 'recomputation done on additional data provided by Japan' showed the average figure was below the evacuation standard set by the IAEA.[190] Fortunately for the citizens of Iitate, the Japanese government finally acknowledged the magnitude of the problem, and ordered the evacuation on 22 April[191] – this was four weeks after Greenpeace first highlighted the need for immediate evacuation, and three weeks after the IAEA backpedalled on its recommendation.

This incident clearly illustrates a structural problem within the IAEA: since its very first days, the IAEA has had a tendency to put politics ahead of science and ahead of the protection of public health. Instead of acting independently the IAEA has preferred to align itself with the positions taken by the Japanese government. This attitude is further illustrated by more detailed reports and evaluations produced by the IAEA in the months following the disaster.

One of the IAEA's responses to the ongoing crisis in Japan was to convene a conference of nuclear power industry experts in June 2011.[192]

This was an invitation-only conference: closed to the press, the public, and worst of all not accessible to most of the independent engineering and scientific experts. Therefore, some experts who uncovered significant flaws in Japan's regulatory process and its emergency management radiation response protocols were prohibited from participating in this alleged scientific review. As anticipated by outsiders, the outcome of this restricted conference was that the IAEA announced no major structural changes to the nuclear safety system.

Also in June 2011, the IAEA published its preliminary report of a fact-finding mission in Japan. Despite multiple failures of the Japanese government and its institutions to not only prevent the accident, but also to effectively mitigate its consequences and provide best protection to the people of Japan (described and documented at other parts of this report), the IAEA praised the Japanese government:

> "Japan's response to the nuclear accident has been exemplary . . . Japan's long-term response, including the evacuation of the area around stricken reactors, has been impressive and well organised."[193]

It should not be surprising that on 12 September 2011, six months after the accident began, and two months after speaking highly of the Japanese government's response to the Fukushima disaster, the Agency urged political leaders and nuclear experts to take measures to restore public confidence in the safety of nuclear production that were shaken by the accidents.[194] Note that political leaders were not urged to protect people from nuclear risks, but to restore public confidence in the safety of nuclear power.

In December 2011, the IAEA once again played the dual role of the public advocate and nuclear regulator. The IAEA stated:

> "The reactors at Fukushima Daiichi Nuclear Power Station have achieved a 'cold shutdown condition' and are in a stable state, and that the release of radioactive materials is under control."[195]

Furthermore, the IAEA has continued to commend TEPCO and the Japanese government for their significant progress. The reality is that the nuclear reactors at Fukushima Daiichi are not in cold shutdown, are not in a stable state, and the release of radioactive materials continues to contaminate the ocean as well as migrate throughout the ground water; the radiation continues to contaminate food sources in many varied and unexpected locations including green tea, rice, and beef – to name only a few.[196]

Japan as an example

Before the Fukushima disaster and subsequent nuclear accidents, the IAEA was full of praise for Japan's perfectly functional and reliable nuclear safety regulatory process. According to the IAEA, other countries could learn from Japan in how it enforces proper measures on nuclear reactor operators for major accidents. This report shows that this was clearly not the case.

In June 2007, the IAEA organised the so-called Integrated Regulatory Review Service mission to Japan. Its purpose is 'to help Member States enhance their legislative and regulatory infrastructures, and to harmonise regulatory approaches in all areas of safety'.[197] The IAEA maintained that this process would be 'one of the most effective feedback tools on the application of Agency standards'.[198]

Among its three major findings, the report by this IAEA review team concluded that Japan has 'a comprehensive national legal and governmental framework for nuclear safety in place; the current regulatory framework was recently amended and is continuing to evolve'.[199] It also concluded that 'all important safety elements receive regular due attention by both the licensee and NISA', and stated that, among best practices in Japan, is that 'operating experience for major events has been thoroughly investigated and appropriate countermeasures have been enforced on the licensee'.[200]

Only one month after the 2007 report, a major 7.3 earthquake hit the western coast of Japan and impacted seven operating reactors at the Kaswhiwazaki-Kariwa nuclear power plant site. The IAEA then conducted a study and an evaluation about what lessons were learned from its review. Unfortunately, proper lessons were not identified, rather the Agency used the event to showcase for how safe reactors are, even during a strong earthquake:

> "Safety related structures, systems and components of the plant seem to be in a general condition, much better than might be expected for such a strong earthquake, and there is no visible significant damage . . . The mission found that there is consensus in the scientific community about the causes of the unexpectedly large ground motions experienced at the plant site during the July 2007 earthquake and, consequently, it has been possible to identify the precautions needed to be taken in relation to possible future events."[201]

Later, in 2010 – just one year prior to the Fukushima Daiichi accident – the IAEA held an international workshop and concluded that in 2007 the Kashiwazaki-Kariwa problem was evaluated by NISA, JNES, TEPCO and a large number of specialised institutions and universities as well as experts in different fields, and that the regulations were reviewed and properly applied.

The IAEA has failed to identify any of the institutional problems and deficiencies in the Japanese nuclear regulatory process – on the contrary, as far back as 2007, it has praised Japan as an example for other regulatory agencies and governments to follow.

The IAEA claimed that lessons from previous major earthquakes were properly examined and this review increased the level of seismic safety for nuclear power in Japan and worldwide. Yet only four years later – those supposedly robust reactors suffered multiple meltdowns and major releases of radiation.

The question remains as to what is the value of the IAEA's January 2012 mission to Japan. It is claimed to be a review of the quality of Japan's reactor stress tests required as a condition prior to Japanese reactors restarting their operation. Not surprisingly, the IAEA had words of reassurance:

> "We concluded that NISA's instructions to power plants and its review process for the Comprehensive Safety Assessments are generally consistent with IAEA Safety Standards. The team found a number of good practices in Japan's review process and identified some improvements that would enhance the overall effectiveness of that process."[202]

Conclusions

The Fukushima Daiichi disaster has proven that the nuclear industry's theory of nuclear safety is false. Historical evidence – Fukushima Daiichi, Chernobyl and Three Mile Island – shows a major nuclear accident has occurred somewhere in the world about once every decade. This regular occurrence of reactor accidents contradicts the nuclear industry's claim that such events would occur only once in 250 years.

One lesson, which can be learned again and again from nuclear accidents is: The nuclear industry's risk assessments fail to take institutional failures into account, while human and institutional behaviour are the principal contributor to reactor accidents. A series of these institutional failures set the stage for the Fukushima Daiichi disaster, including a system of industry-led self-regulation, the industry's overconfidence, and its inherently dismissive attitude towards nuclear risks as well as its neglect of scientific evidence.

The standard of self-regulation by the nuclear industry can be found in many places in the world. Also, the Fukushima Daiichi disaster has demonstrated that the safety claims of the nuclear industry and its national as well as international regulators are false.

There are several lessons to be learned from the institutional failures that lead to the Fukushima disaster:

- **Regulatory independence:** The failure of the Japanese regulator to anticipate, acknowledge and enforce standards based upon risks posed to the public was a key cause of the Fukushima Daiichi disaster. This failure can partially be attributed to the Japanese regulator's close affiliation with government policy to promote nuclear policy and its familiar connections with nuclear operators. The nuclear industry is often closely interlinked with its regulators due to the highly specialised nature of nuclear technology. To counteract this tendency, strong structural and policy separation needs to be established between nuclear safety regulators and the industry it purports to regulate.

- **Objective risk assessment and communication:** International governments and regulators should reassess the methodology they use to evaluate nuclear risks, taking into account the empirical record. While nuclear proponents claim a meltdown will only occur once in 250 years, experience has proven that a significant reactor accident has happened once per decade. Such accurate information would assist countries globally to make decisions on their energy futures.

- **Public participation:** As witnessed in Japan, the public assumes the risks of nuclear accidents. While nuclear regulators and operators have viewed reactor risks as a mere mathematical problem, Fukushima Daiichi has given legitimacy to public scepticism of the

risk claims. Greater public participation must become part of the process rather than relying only upon the echo chamber that reinforces the industry's blind belief that catastrophic nuclear accidents are improbable.

- **Rigorous nuclear safety and life-extension reviews:** Reactors all over the world require a rigorous review of the design basis against what would be considered modern standards and the new reality after the triple meltdown at Fukushima Daiichi. Given the risk involved, reactor safety reviews and life-extensions should never be rubber stamp procedures.

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