

Lessons from Fukushima

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image A mother holds her baby at Yonezawa gymnasium, which is providing shelter for 504 people who either lost their homes to the tsunami, or live near the Fukushima nuclear power station.

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**“For a successful
technology,
reality must take
precedence over
public relations,
for nature cannot
be fooled.”**

Richard Feynman





image Iitate village, 40km northwest of the Fukushima Daiichi nuclear plant. Radiation levels found by the Greenpeace monitoring team are far above internationally recommended limits.

Executive Summary

It has been almost 12 months since the Fukushima nuclear disaster began. Although the Great East Japan earthquake and the following tsunami triggered it, **the key causes of the nuclear accident lie in the institutional failures of political influence and industry-led regulation.** It was a failure of human institutions to acknowledge real reactor risks, a failure to establish and enforce appropriate nuclear safety standards and a failure to ultimately protect the public and the environment.

This report, commissioned by Greenpeace International, addresses what lessons can be taken away from this catastrophe. The one-year memorial of the Fukushima accident offers a unique opportunity to ask ourselves what the tragedy – which is far from being over for hundreds of thousands of Japanese people – has taught us. And it also raises the question, are we prepared to learn?

There are broader issues and essential questions that still deserve our attention:

- How it is possible that – despite all assurances – a major nuclear accident on the scale of the Chernobyl disaster of 1986 happened again, in one of the world's most industrially advanced countries?
- Why did emergency and evacuation plans not work to protect people from excessive exposure to the radioactive fallout and resulting contamination? Why is the government still failing to better protect its citizens from radiation one year later?
- Why are the over 100,000 people who suffer the most from the impacts of the nuclear accident still not receiving adequate financial and social support to help them rebuild their homes, lives and communities?

These are the fundamental questions that we need to ask to be able to learn from the Fukushima nuclear disaster. This report looks into them and draws some important conclusions:

1. The Fukushima nuclear accident marks the **end of the 'nuclear safety' paradigm.**
2. The Fukushima nuclear accident exposes the **deep and systemic failure** of the very institutions that are supposed to control nuclear power and protect people from its accidents.

The end of the nuclear safety paradigm

Why do we talk about the end of a paradigm? After what we have seen of the failures in Fukushima, we can conclude that ‘nuclear safety’ does not exist in reality. There are only nuclear risks, inherent to every reactor, and these risks are unpredictable. At any time, an unforeseen combination of technological failures, human errors or natural disasters at any one of the world’s reactors could lead to a reactor quickly getting out of control.

In Fukushima, the multiple barriers that were engineered to keep radiation away from the environment and people failed rapidly. In less than 24 hours following the loss of cooling at the first Fukushima reactor, a major hydrogen explosion blew apart the last remaining barrier between massive amounts of radiation and the open air.

The nuclear industry kept saying that the probability of a major accident like Fukushima was very low. With more than 400 reactors operating worldwide, the probability of a reactor core meltdown would be in the order of one in 250 years.

This assumption proves to be wrong. In fact, an observed frequency based on experience is higher: **a significant nuclear accident has occurred approximately once every decade.**

One of the principles of modern science is that when observations do not match the calculated predictions, the model and theory need to be revised. This is clearly the case for probabilistic risk assessments used in nuclear safety regulations. However, **the nuclear industry continues to rely on the same risk models** and supposedly extremely low probabilities of disasters, justifying the continued operation of reactors in Japan and worldwide.

This report exposes the systemic failures in the nuclear sector, specifically looking into three issues:

- emergency and evacuation planning;
- liability and compensation for damages; and
- nuclear regulators.

Human rights

In the **introduction**, Tessa-Morris Suzuki, Professor of Japanese History in the College of Asia and the Pacific at the Australian National University – who is also a member of the International Council on Human Rights Policy (ICHRP) – concentrates on the human rights angle of the Fukushima tragedy. She details how **disasters tend to reveal a whole range of cracks or weak points in social, economic and political institutions**, not only in the Japanese but also in an international context.

What becomes clear in her text is that the weaknesses in the regulation and management of Japan’s nuclear power industry have not been ‘hidden’ faults in the system. To the contrary, people had been aware of, written and warned about them for decades.

Emergency planning failed

In the **first chapter**, Professor David Boilley, chairman of the French Association ACRO, documents how even Japan, one of the most experienced and equipped countries when it comes to handling large-scale disasters, found that its **emergency planning for a nuclear accident was not functional**, and its evacuation process became chaotic, which led to **many people being unnecessarily exposed to radiation.**

During the height of the crisis, the Japanese government frequently denied there were dangers from radiation releases. For example, on 12 March, the Chief Cabinet Secretary told a news conference that the reactor would not leak a large quantity of radiation, and that people outside a 20km radius would not be affected. Within two weeks of the statement, the government asked people living between a 20 and 30km radius of the disaster to voluntarily evacuate. Then, in late April, the government extended the evacuation zone to specific areas up to 50km. Again in June, July and August, the government asked more people outside the 20km evacuation zone to evacuate.

Governmental data released only later revealed that in a worst-case – but possible – scenario, evacuation would have included the megapolis of Tokyo and other settlements up to 250km away. Clearly, **evacuation planning based on circles with diameters of several kilometres is too rigid and hopelessly inadequate in the case of nuclear power plants.**

Special software for predicting fallout patterns was not used correctly.

In some cases, people were evacuated to areas with more, not less, radiation. For example, the software predicted that a school would be in the path of a radioactive plume, yet the school was used as a temporary evacuation centre. Thousands stayed for days in an area that was very highly contaminated. In addition, radiation fallout scenarios developed in the early days of the crisis were never sent to the office of the Prime Minister, where decisions on managing the disaster were being made.

Evacuation procedures of vulnerable people failed.

Patients from one hospital and a nearby home for the elderly were sent to shelters: 45 of 440 patients died after staff fled. In another incident, more than 90 elderly people were left without caregivers. Hospitals in Fukushima Prefecture have had to suspend services because hundreds of doctors and nurses in the area resigned to avoid radiation.

The Fukushima crisis also exposed that one of the key principles of nuclear emergency plans – confinement (recommending people to stay in their homes to avoid radiation exposure) – simply does not work in practice. Confinement is only possible for a short period of time, but not for 10 days, which turned out to be the necessary period of time as massive releases of radiation from the Fukushima disaster carried on this long. (Also in the case of Chernobyl disaster, the vast radiation release continued for nearly two weeks).

Communities where people were confined ran out of food, as well as fuel needed for eventual evacuation. In addition, specialised workers – such as drivers, nurses, doctors, social workers and firemen, who were needed to help those confined – were not prepared to stay in an area receiving large amounts of radiation.

The post-emergency situation is also riddled with problems. Pragmatic radiation standards introduced by the government are higher than internationally recommended limits. Japanese authorities keep failing to foresee the scale of problems with contaminated food and crops, and are repeatedly being caught by surprise. The government has insufficient programmes for monitoring and screening radiation levels, leading to scandals that further undermined the confidence of the public and caused unnecessary additional economic damages to farmers and fishermen and to their livelihoods. **Decontamination programmes to clean up highly contaminated areas pose big questions in terms of their effectiveness, costs and negative side effects.**

Lack of accountability

The **second chapter**, based on interviews by Dr David McNeill, the Japan correspondent for *The Chronicle of Higher Education* and journalist for *The Independent* and *Irish Times* newspapers, investigates probably the most dreadful face of the Fukushima accident – the human consequences. Over 150,000 people evacuated; they lost nearly everything and are denied sufficient support and compensation to allow them to rebuild their lives.

Most countries limit the liability of reactor operators to only a small fraction of real damages, which allows the nuclear industry to basically escape paying for the consequences of an accident. The Japanese legislation on liability and compensation stipulates that there is no cap on liability for a nuclear reactor operator – in this case TEPCO – for damages caused to third parties. However, it **does not include any detailed rules and procedures about how and when the compensation will be paid**. Nor does it define who is eligible and who is not. This leaves lots of space for interpretation.

TEPCO has so far **managed to escape full liability and fails to properly compensate people and businesses that have been dramatically impacted** by the nuclear accident. The larger compensation scheme excludes dozens of thousands of people who decided to evacuate voluntarily to reduce their risks of radiation exposure. Some have been offered only \$1,043 US dollars as a one-off payment. TEPCO lawyers have also been trying to avoid their duty to pay for decontamination costs by claiming that the radiation, as well as the burden of dealing with it, now belongs to the landowners, not to the company.

Families have been split apart, and have lost their homes and their communities. People have lost their jobs and have had their living costs doubled in some cases – yet the first package of one-time financial support was limited to a rather symbolic \$13,045 and arrived from TEPCO only after people were relocated for several months. What was supposed to be the first package of larger compensations began six months later when TEPCO provided people with a 60-page application form, accompanied by another 150 pages of instructions. Many people struggled to understand it, and many others simply gave up, choosing to forget and move on.

Importantly, Japanese law requires that TEPCO has compulsory insurance to cover \$1.6bn, meaning that anything over this amount may not be available if the company faces inevitable financial difficulties or a bankruptcy. So far, the company has paid out compensation to citizens in the amount of roughly \$3.81bn. The estimates of the real cost of damages are however in the order of \$75 to \$260bn. Overall costs of the Fukushima accident including compensation and decommissioning the Daiichi plant's six reactors have been projected to reach \$500 to \$650bn. It is clear already that the government will be stepping in, one way or the other, to bail out TEPCO. Most of the costs of the damage, if ever compensated, will be shouldered by taxpayers.

It is staggering to witness how the nuclear industry managed to build up a system whereby polluters harvest large profits, while the moment things go wrong, they throw the responsibility to deal with losses and damages to the impacted citizens.

Systemic failures

The **third chapter**, by Arnie Gundersen from Fairewinds Associates, looks into how it is possible that an accident like Fukushima happened at all. It finds that an 'attitude of allowed deception' existed between TEPCO and the state institutions in Japan that were supposed to ensure its citizens' safety. This deception characterises the institutional failures in Japan; failures that include **undue political influence on regulation of the nuclear industry**, allowing industry to lead the development of regulations and a dismissive attitude to the risks of nuclear accidents.

For example, even when the problems, weaknesses and scandals of TEPCO came to the surface, regulators never enforced sufficiently strong measures to avoid the same things from happening again and again. On occasions when regulators finally requested certain modifications, they allowed many years to go by before these were implemented. This is exactly what proved to be fatal in Japan in 2011.



Image A satellite image shows damage at the Fukushima nuclear power plant. The damage was triggered by the offshore earthquake that occurred on 11 March 2011.

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In Japan, the **failure of the human institutions inevitably led to the Fukushima disaster**. The risks of earthquakes and tsunamis were well known years before the disaster. The industry and its regulators reassured the public about the safety of the reactors in the case of a natural disaster for so long that they started to believe it themselves. This is sometimes called the Echo Chamber effect: the tendency for beliefs to be amplified in an environment where a limited number of similarly interested actors fail to challenge each other's 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.

It is symptomatic of this complacent attitude that the first concerns voiced by many of the decision makers and regulators after the accident were about how to restore public confidence in nuclear power – instead of how to protect people from the radiation risks. This has also been the case with the UN's International Atomic Energy Agency (IAEA), which **failed to prioritise protection of people over the political interests of the Japanese government, or over its own mission to promote nuclear power**. The IAEA has systematically praised Japan for its robust regulatory regime and for best practices in its preparedness for major accidents in its findings from missions to Japan as recently as 2007 and 2008.

Lessons to be learned

The institutional failures in Japan are a warning to the rest of the world. These failures are the **main cause of all past nuclear accidents**, including the accident at Three Mile Island in the US and the disaster at Chernobyl in Ukraine. There are a number of similarities between the Chernobyl and Fukushima nuclear disasters: the amounts of released radiation, the number of relocated people, and the long-term contamination of vast areas of land. Also the root causes of the accident are similar: concerned institutions systematically underestimated risks, other interests (political and economic) were prioritised over safety, and both industry and decision makers were not only fatally unprepared, but were allowed to establish an environment in which they existed and operated without any accountability.

Governments, regulators and the nuclear industry have stated they have learnt big lessons from the past. Yet, once again they failed to deliver. How confident can we be that the same will not happen again? But we have a choice. **Mature, robust and affordable renewable energy technologies are available and up to the task of replacing hazardous nuclear reactors**. During the last five years, 22 times more new power generating capacity based on wind and solar was built (230,000MW) compared to nuclear (10,600MW). Renewable power plants built in just the one single year of 2011 are capable of generating as much electricity as 16 large nuclear reactors. This is where the opportunity stands for a nuclear-hazard-free-future.

“For a successful technology, reality must take precedence over public relations, for nature cannot be fooled.”

This statement is by one of the leading physicists of the past century, Nobel Prize winner Richard Feynman, written in 1987 in his minority report for a commission investigating the tragic disaster of the Challenger space shuttle. His analysis has astonishing parallels to the nuclear industry. He explains how the socio-economic influences of modern society led to a massive gap between official predictions and real-world risks of disastrous accidents of complex technologies. He notes the fact that, if things go well and accidents do not happen for a while, there is an inevitable watering down of regulation and precautionary principles. He also calls for the consideration of alternative technologies to do the job.

It took two lethal disasters to phase out the expensive and accident-prone space shuttles. Now, **we are living through the second major nuclear reactor disaster in history**. Let's not fool ourselves again: we have a responsibility to use this critically important moment to finally switch to a **safe and affordable supply of electricity – renewable energy**. All the world's reactors can be replaced within two decades.

In the meantime, we can learn from Fukushima that **nuclear power can never be safe**. If there is yet another major nuclear accident, the people who will suffer can be given better protection if we hold the nuclear industry and regulators fully accountable and liable. We must **put the nuclear regime under close public scrutiny** and require transparency. But again, while doing so, we have to **phase out dangerous nuclear power entirely**, and do so as soon as possible.

image The empty playground of a local day nursing school in Fukushima City. Before the crisis, the school was taking care of 24 children.

The human consequences of such a lethal explosion are strikingly visible in the village of Iitate, situated on a beautiful plateau in the hills of Fukushima Prefecture.

Introduction: Fukushima and Human Rights

Prof. Tessa Morris-Suzuki

When an earthquake strikes any part of the world, it makes visible hidden forces and fissures that have long existed under the earth, but that have, until that moment, remained invisible. The fault lines that lie deep within the bedrock appear beneath our feet as new cracks in the ground. The immense power of our constantly changing, constantly moving earth becomes terrifyingly tangible.

Similarly, when any disaster – an earthquake, tsunami, flood, major hurricane or volcanic eruption – takes place, it exposes the cracks beneath the surface of social and political systems. These cracks may have been invisible, or perhaps we have always been half-aware of their presence, but have up until now been able to ignore them. In the case of the Great East Japan Earthquake, the triple tragedy of quake, tsunami and nuclear accident exposed a whole range of cracks or weak points not only in Japan's social, economic and political institutions, but also in international institutions.

Most obviously, perhaps, the earthquake and tsunami exposed weaknesses in the regulation and management of Japan's nuclear power industry. This was not really a 'hidden' fault in the system. Rather, it was a weakness that many people had been aware of, and had written and warned about for decades. On my bookshelves, for example, I have a copy of the English-language journal *Ampo*, published more than 35 years ago, in 1975. Under the heading 'Nuclear Reactors: Risking the Ultimate Pollution', this article notes the vulnerability of Japan's new nuclear plants to the risk of natural disasters, and points out that in 1971 (the year when the Fukushima Daiichi plant was commissioned) the US government warned that light water reactors like Fukushima were in danger of experiencing a 'lethal nuclear explosion and widely scattered radioactive fallout' if the emergency core cooling system failed.

Today, the human consequences of such a lethal explosion are strikingly visible in the village of Iitate, situated on a beautiful plateau in the hills of Fukushima Prefecture. Trim farmhouses and a small row of shops line the main road through the village. Restaurants tempt passers-by with billboards offering local beef and mountain vegetables. A steady stream of vehicles flows along the road, but none of them stop. The car parks are empty, the fields devoid of crops. No children play in the school playground. Almost a year after the disaster, tall weeds are flourishing in the greenhouses of Iitate village. Although it is 40km away from the Fukushima No. 1 nuclear plant, Iitate is a ghost town.

Outside the litate community hall, the radiation dosimeter carried by one of my travelling companions to measure external radiation reads 13.26 microsieverts an hour – a level around 100 times natural background radiation. When he holds his dosimeter over the drainage culvert in front of the hall, it stops working altogether – the radiation level has gone off the scale. One of the things that you quickly learn in a place like litate is that levels of radiation can vary enormously within a relatively small area. litate has the misfortune to lie in a spot where the winds from the coast meet the mountains, and quickly became a radiation hotspot due to precipitation. Its inhabitants are among the 150,000 people who evacuated from the area affected by the nuclear accident, and have no idea when they will be able to return home.

Much of the research on the effects of the accident in Fukushima Prefecture today is being carried out not by professional scientists but by ordinary local people with no scientific training, who are desperately trying to make sense of the world around them. In the village of Miharu, for example, a group of local farmers – mostly elderly and mostly women – is growing a range of crops and testing them with radiation measuring equipment provided by the village council. The results are startling. Some crops show dramatically high levels of contamination with radioactive caesium, while others show virtually no contamination at all, and will be sold to consumers around the country with the support of cooperative volunteers. The authorities are not able to correctly control and regulate the radioactivity of the various goods that are sold on the market, in particular food.

In a small shopping arcade in downtown Fukushima City, a group of local citizens has been helping to answer local concerns with an impressive battery of radiation measuring equipment, including a whole-body counter imported from Belarus (one of the countries worst affected by the Chernobyl accident). But the Citizen's Radioactivity Measuring Station, funded by donations and staffed by overworked volunteers, struggles to deal with the constant flow of enquiries and requests for advice. As of late 2011, levels of external radiation in parts of Fukushima City were as much as 10 times the level of natural background radiation, but were still within the range which the government had officially declared 'safe'.

In the face of this uncertainty, many families became divided: spouses and children sent to live in other parts of Japan or even overseas, while the wage-earner remained in Fukushima. After all, even if the risk is small, what parent wants to face the possibility that their child may develop cancer because they failed to act in time?

Evacuation, however, carries its own costs. There are obvious psychological burdens: including those of separation and dislocation, particularly for children who have to change schools and move away from relatives and friends. The financial costs are also high and they will be carried by society at large. But there is a catch: TEPCO's current compensation scheme is modelled on the government directive on evacuation. This means only those who have been compulsorily moved are entitled to claim. So, people from the designated evacuation zones will receive compensation from the power company or government but – since it insists that there are no health risks outside the specified evacuation zones – the Japanese government refused to support the costs of those who chose to leave Fukushima City voluntarily.

In December 2011 the government finally accepted the recommendations made by an advisory panel to give limited sums of assistance to residents of 23 municipalities which lie outside the compulsory evacuation zones, but which have high levels of radiation. But the assistance, which is to be paid regardless of whether residents leave or remain in the area, is a mere fraction of the cost incurred in moving away from the contaminated areas.

Over 100,000 nuclear victims from Fukushima will wait as their claims are processed. Those who are allegedly not entitled to compensation might go to court to settle their claims. Many won't receive anything at all. Lawyers and independent observers state the strategy of TEPCO and the government consists of restraining compensation claims by making them as restricted, bureaucratic and difficult as possible for the Fukushima victims.

A volunteer from the local NGO 'Kodomo Fukushima', established in May 2011, eloquently describes the human dimensions of the disaster. The 240 children who attended three schools in Iitate village have been evacuated, many of them to the officially declared safety of Fukushima City, while their school has been moved to a campus down the hill from Iitate in the nearby town of Kawamata (just outside the evacuation zone). To reach their school, the evacuated children now living in Fukushima City have to board a school bus around six in the morning, returning late in the afternoon. While they are at school, they are not allowed to play or have sports lessons out of doors for fear of radiation. When they return to their families' places of evacuation in Fukushima City, they continue to be exposed to levels of radiation up to 10 times normal background levels. Many are showing signs of fatigue and low levels of immunity, though no one can say whether this is the result of the social disruption they have endured or of raised radiation levels.

Kodomo Fukushima is just one of a number of NGOs working to support the children of the region. It is campaigning to establish sanatoria in other parts of Japan and overseas, where particularly vulnerable children (including but not limited to children from evacuation zones like Iitate) can be sent for periods of two months to lower their radiation levels and restore their mental and physical health. The group's members recognise that responses to the disaster are diverse. Some families want to evacuate; others do not. Many people in the Prefecture may indeed be at negligible risk from radiation; but some are in a situation where anxiety cannot be dismissed as 'overreaction' or calmed by repeated injunctions to 'stop worrying'.

The UN Convention on the Rights of the Child requires states to 'recognise the right of the child to the enjoyment of the highest attainable standard of health'. It is time for TEPCO, the company responsible for the Fukushima accident, local and national governments in Japan, and the world community to fulfil their obligations to the children of Fukushima.

Tessa Morris-Suzuki is a Professor of Japanese History in the College of Asia and the Pacific at the Australian National University, and a member of the International Council on Human Rights Policy (ICHRP). She is co-founder of the AsiaRights network of Asia-Pacific human rights researchers and activists, and editor of the online journal *AsiaRights*.

**The catastrophe
has just started in
Japan. All of this
means that the
population has to
learn how to live
in a contaminated
environment for
decades to come.**



01

Emergency Planning and Evacuation

Professor David Boilley

One year after the Fukushima nuclear disaster triggered by the Great East Japan Earthquake on 11 March 2011, Japan continues to struggle with one of the worst nuclear accidents in history. The impacts will last much longer than the consequences of the earthquake and tsunami that triggered the meltdown at the three nuclear reactors in the Fukushima Daiichi nuclear power plant (NPP).

Technology helps Japan to cope with natural disasters. Japan faces about 10% of the world's earthquakes, and the bullet train network, buildings, bridges and other infrastructures have all been adapted to withstand those. But what happened shows that the nuclear industry is not prepared to face natural disasters and societies are not prepared to face nuclear accidents. Even a technologically advanced and organised nation like Japan finds itself unable to address such a disaster.

This chapter describes how the authorities had and still are facing many difficulties in organising the emergency evacuation and decontamination processes, for example:

- The concept of evacuating people based on concentric circles ranging from 5, 20 or even 30km has proven to be too rigid and inadequate.
- Confinement of people is insufficient when dealing with radioactive discharges that last over 10 days.
- Highly contaminated areas had to be evacuated up to 50km from the nuclear plant, and this is still not enough.

- Authorities are not able to adequately control and regulate the radioactivity of the various goods that are sold on the market, in particular food, which can have serious consequences.
- The authorities don't know how to cope with the extended contaminated territories and the huge quantity of radioactive waste.

The full extent of the catastrophe

It is well acknowledged that the Fukushima disaster is a major nuclear accident that has caused long-term contamination to large areas of land and the ocean.

The estimation¹ of the quantity of radioelements released into the environment depends on the organisation that did the calculation. However, they all agree that it is the largest discharge of radioelements into the Pacific Ocean ever observed. The release happened at the junction of two oceanic currents, the Kuroshio and the Oyashio, which increased the distribution of the radioactive pollution. Marine life² and sediments³ continue to be contaminated over large distances. Unfortunately, the situation is still fragile at the plant: TEPCO has faced several small leaks and another major leak⁴ is still a possibility.

The atmospheric release of major radioelements is estimated to be between 10%⁵ and 40%⁶ of the quantity released in the Chernobyl accident. For xenon-133, it is the largest discharge in history, 2.5 times higher than the release at Chernobyl.⁷ Fortunately for the Japanese, about 80% of this release went towards the ocean, where it adds to the marine pollution⁸. The crippled nuclear power plant was still releasing radioactive materials into the air at a rate of 60 million becquerels an hour in December 2011, and 70 million becquerels an hour in January 2012⁹.

Although only 20% of the release fell on Japanese land, large portions of the affected areas will remain highly contaminated for decades. The Japanese government has decided that it will take charge of the decontamination of the land where the external irradiation is higher than one millisievert a year¹⁰, in accordance with the internationally agreed maximum allowable dose for members of the public. This roughly¹¹ represents 13,000km². Assuming that it is even possible practically – and costs aside – the government still does not know how to cope with the resulting radioactive waste, which is roughly estimated to be several tens of millions of cubic metres¹².

As pointed out by the official Investigation Committee on the accidents at the Fukushima Nuclear Power Station¹³, TEPCO was not prepared to face a nuclear accident. If the company and the responsible authorities had not made so many mistakes at the beginning of the catastrophe, the amount of radioactive pollution released in Japan could have been far lower.

On the other hand, the situation could have been even worse. The worst scenario was avoided thanks to brave workers who faced the danger of explosions and radioactive contamination. According to a report¹⁴ from the head of the Japan Atomic Energy Commission, handed to the Prime Minister on 25 March 2011, a scenario based on the meltdown of the irradiated fuel stored in the pool in Reactor No. 4 could have led to a forced evacuation of up to 170km to 250km, including a large portion of the Tokyo megapolis.

Had the same disaster taken place in a nuclear power plant in the Fukui prefecture, which houses 13 reactors¹⁵ on the coast of the Sea of Japan, it would not have been the Pacific Ocean but metropolises such as Kyoto, Osaka, Kobe and Nagoya, and the Biwa Lake (the biggest lake of Japan) that would have been contaminated. The social, human and economic consequences would have been far more severe.

Japan is probably the best-prepared country to cope with natural disasters. In any other country a magnitude 9 earthquake and a large tsunami would have claimed the lives of far more than the 20,000 people in Japan. In addition, there were up to 448,000 refugees in shelters. In less than a year all the evacuees are in temporary housing.¹⁶

However, as we will document below, the Japanese authorities gave the impression they were continuously improvising as the events unfolded during the nuclear disaster. They seemed unable to anticipate the events, as if there had been no emergency planning and no precautionary measures taken to address nuclear accidents.

Outline and analysis of emergency planning: a human tragedy

Sequence of events¹⁷:

Friday 11 March 2011 (note: times are local, JST)

14:46 Magnitude 9 earthquake hundreds of kilometres offshore.

15:27 Several tsunami waves flood the Fukushima nuclear power plant.

16:46 'Nuclear emergency situation' is declared at the Fukushima nuclear power plant.

20:45 Local authorities call for the evacuation in a 2km radius around the nuclear power plant. 2km corresponds to the radius of the emergency drills.

21:23 Central government orders the evacuation in a 3km radius and the confinement of the population within 3 to 10km.

Saturday 12 March 2011

05:44 The Prime Minister issues orders to evacuate in a 10km radius

Around noon: the population seems to be completely evacuated within 3km.

15:36 Hydrogen explosion at the reactor building No. 1.

18:25 The Prime Minister issues orders to evacuate in a 20km radius.

Monday 14 March 2011

475 people remain in hospitals and care centres within the 20km radius.

11:01 Hydrogen explosion at the reactor building No. 3.

The government asks the remaining people within the 20km radius to confine themselves.

Tuesday 15 March 2011

06:14 Hydrogen explosion at the reactor building No. 2.

Early morning: More than 90 patients remain without care in the Futaba hospital.

11:00 During a press conference, the Prime Minister advises the remaining 136,000 people living within 20 to 30km of the nuclear power plant to stay indoors.

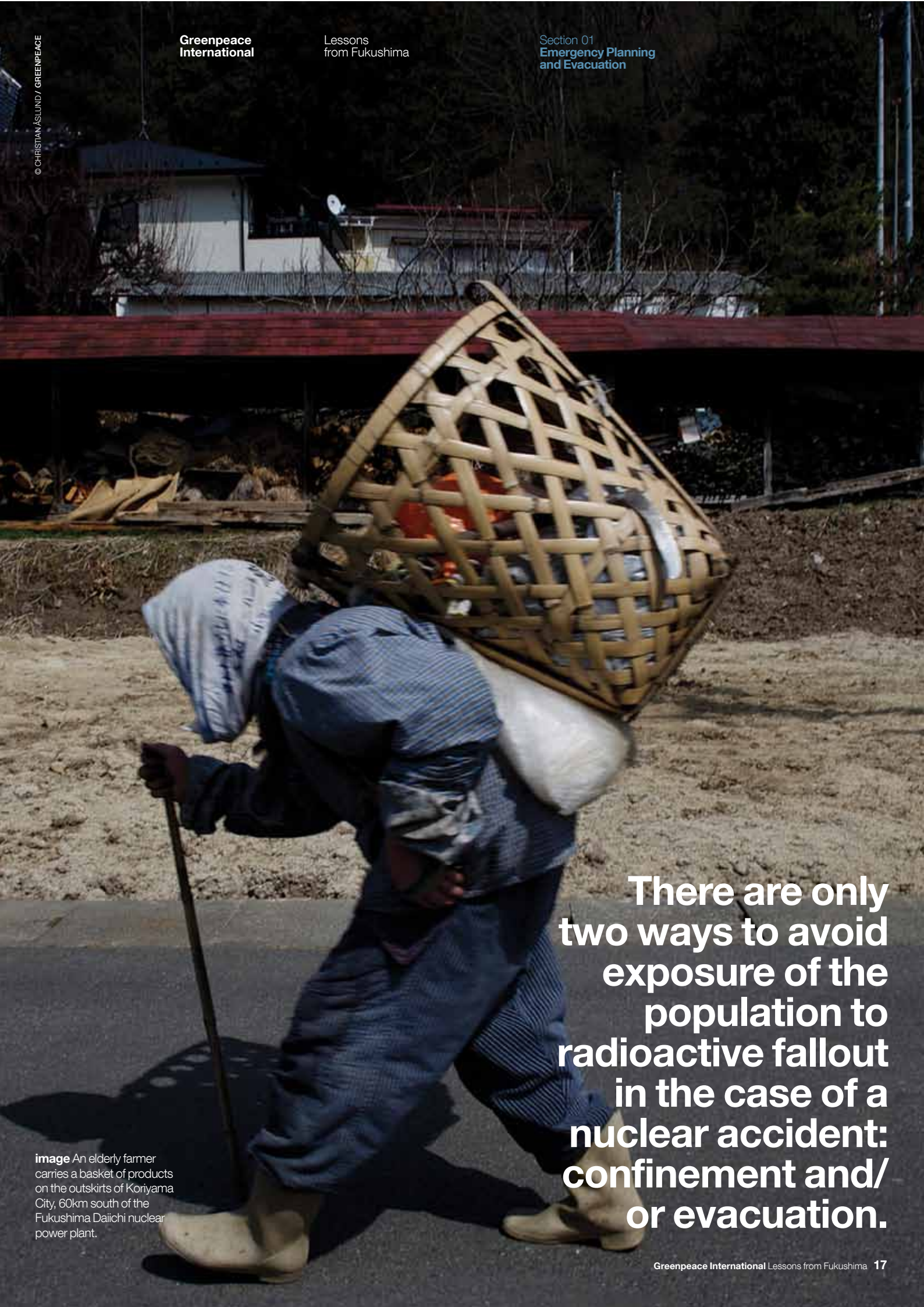
The US embassy asks its citizen to evacuate in a radius of 80km.

Friday 25 March 2011

The government asks people living within 20 and 30km of the NPP to voluntary evacuate because it is very difficult to provide food and care.

Friday 22 April 2011

The government extends the evacuation zone to highly contaminated municipalities (Katsurao, Namie, Iitate and parts of Kawamata and Minami-Soma) up to 50km. It forbids access inside the 20km radius.



There are only two ways to avoid exposure of the population to radioactive fallout in the case of a nuclear accident: confinement and/or evacuation.

image An elderly farmer carries a basket of products on the outskirts of Koriyama City, 60km south of the Fukushima Daiichi nuclear power plant.

There are only two ways to avoid exposure of the population to radioactive fallout in the case of a nuclear accident: confinement and/or evacuation. Confinement is only possible during a limited period and evacuation relies on complex logistics to inform, displace and shelter the population.

Evacuation during emergencies

The Prime Minister issued the evacuation orders in successive concentric circles of up to 20km. At a news conference on the evening of 12 March, Chief Cabinet Secretary Yukio Edano said, "There will be no leakage of radioactive material in a large quantity. Persons in areas outside of the 20km radius will not be affected." But people in the area were urged to take shelter as a precautionary measure.¹⁸

The Fukushima Prefecture began measuring radiation levels at various locations from early in the morning on 12 March. At 9am, measurements in the Sakai district in Namie registered 15 microsieverts an hour, and 14 microsieverts an hour in the Takase district, both located at around 10km from the plant. It was more than six hours before the hydrogen explosion at the No. 1 reactor, and there were many evacuees nearby. These readings were uploaded to the website of the Ministry of Economy, Trade and Industry on 3 June.¹⁹

Later, in April, the authorities extended the evacuation zone to areas up to 50km to the northwest, due to the high contamination of the land. The population living in these territories were directly exposed to the fallout without knowing it. They thought that they were safe, being far beyond the 20km radius. Although Greenpeace specialists measured very high levels of contamination in Iitate, 40km from the damaged reactors, and had already called for its evacuation on the 27 March²⁰ (both radiation levels and the need to evacuate were confirmed a few days later by the IAEA's team²¹, which withdrew its statement again), the authorities suggested the extension of the evacuation zone only on 11 April, and the order came on 22 April.²²

The Japanese government had special software designed to forecast the fallout in case of an accident and in order to help during the decision making process of where to evacuate. The so-called SPEEDI²³ software cost 13bn yen (\$170m US dollars) and theoretically can make predictions of up to 79 hours. Unfortunately, it was not used correctly. Some people were evacuated to places where they were more exposed to the fallout than in their original location.

As officials planned a venting operation at the Fukushima nuclear power plant, certain to release radioactivity into the air, the SPEEDI software predicted that Karino Elementary School would be directly in the path of the plume. The school was not immediately cleared out, but turned into a temporary evacuation centre. So thousands of people stayed for days in areas that were highly contaminated. On the mayor's order, some evacuees were taken by bus to Tsushima. Later on, it appeared that SPEEDI data suggested this area to be dangerous. The evacuees at shelters in the Tsushima district – including about 8,000 residents of Namie – were not told to move farther away until 16 March, five days into the crisis.²⁴

The version of SPEEDI run by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) didn't have the ability to evaluate the quantity of radioelements that was released – so called 'source term'. It then arbitrarily assumed that the source term was at 1 becquerel an hour, which leads to indicative results that have nothing to do with reality.²⁵

The Nuclear and Industrial Safety Agency (NISA) released the first SPEEDI predictions at 9:12pm on 11 March. Following the initial crisis, the Agency produced 173 pages of predictions based on various scenarios calculated up to 16 March. This complete analysis never reached the Prime Minister's office where the decisions were taken.²⁶

Even after the Prime Minister's office learnt of SPEEDI, the results of the simulations were not sufficiently used to protect the populations nor published. During a news conference on 2 May, Goshi Hosono, a special advisor to the Prime Minister, explained that 'there was concern that citizens would panic'²⁷. However, the data was provided to US forces via the Japanese Foreign Ministry from 14 March, but it was not until 23 March that the public was officially informed.²⁸

Even if SPEEDI would have been used correctly, it is not sure that the information would have reached the exposed populations. Following the earthquake, electric lines were cut. Communications, including mobile phones were not available. There are many stories in the Japanese media of people who stayed home because they were not warned.

It is very important to notice that fallout prediction tools proved to be useless and were not ready to model real world situations. There were not enough sufficiently trained people to interpret them, which contributed to chaos in decision making.

The authorities and TEPCO failed to clearly communicate the information as well as practical conclusions and recommendations to the public. As a result, many people were unnecessarily exposed to high levels of radiation.

Weakness of the emergency evacuation

Despite Japan's experience in dealing with natural disasters the evacuations were not as smooth as expected. The earthquake destroyed many roads. Traffic jams slowed down the evacuation as well as the electricity generators loaded onto trucks to rescue the nuclear power plant.

Weak people who could not leave on their own were extremely vulnerable. This is especially the case for patients in hospitals and care centres. The evacuation of the hospital of Futaba turned out to be disastrous: patients who were unable to walk on their own, including bedridden people with serious conditions, were abandoned for three days without care and food.

Evacuated patients were sent to shelters without medical structures to take care of them. Eventually, 45 of the 440 patients of the Futaba hospital and the nearby nursing home for the elderly died.²⁹ This happened despite previously worked out guidelines from the central government for evacuating elderly and handicapped people at the time of a natural disaster. In total, there were 840 people at medical and other facilities in the 20km evacuation zone.³⁰

A total of 573 deaths have been certified as 'nuclear disaster-related' by 13 municipalities affected by the nuclear crisis. Twenty-nine cases remain pending. A disaster-related death certificate is issued when a death is not directly caused by a tragedy, but by fatigue or the aggravation of a chronic disease due to the disaster.³¹

Hospitals, nurseries and other social facilities with a vulnerable population have proven to be extremely difficult to evacuate in case of emergency. In the case of a serious accident at a nuclear power plant, the emergency evacuation zone can become very large, well beyond 20 or 30km, potentially affecting important infrastructural institutions.

Farmers faced the problem of having to abandon their animals. About 3,400 cows, 31,500 pigs and some 630,000 chickens were abandoned in the 20km evacuation zone, according to the Ministry of Agriculture, Forestry and Fisheries.³² Most of them died. Others were released into the wild.

Some farmers refused to leave their animals behind and stayed with them or regularly returned to their farms to feed the animals or milk the cows, exposing themselves to the fallouts of the NPP.

Pets were also not accepted in shelters. Some people had to abandon them. Others went to other locations with their pets.

The emergency measures were unrealistic and non-functional when it came to animals. People who had to relocate didn't feel comfortable leaving their animals behind, and didn't know how to provide care to them, which hampered the evacuation.

Long-term confinement and lack of specialised care

In case of a nuclear accident, the first action is to confine people to avoid direct exposure to the radioactive fallout. To ensure staying inside is as safe as possible; one should avoid, by all means, air and dust entering the building. This means turning off ventilation and taping up doors and windows.

These extreme measures are only possible for a short period of time. The massive releases in Fukushima lasted 10 days³³, similar to Chernobyl³⁴. Even after 10 days, the situation was too uncertain to let the confined population go out. Such a long confinement is practically impossible, especially with regard to food supplies and possibly the need for special care. Providing food to each house implies risks for the people in charge of distribution.

The virtual message-in-a-bottle posted on the internet by the mayor of Minami-Soma caused a buzz.³⁵ His testimony is important to understand the difficulties of the local authorities in coping with the situation. All shops were closed. He had to take charge of 20,000 people at the time of the footage³⁶ (24 March 2011). He particularly complains about the lack of essential supplies for the population ordered to stay indoors as well as the lack of information about the situation at the plant and the dangers they were facing.

According to a survey by an association of Fukushima Prefecture hospitals, conducted in late July, hundreds of doctors and nurses have resigned from nearby facilities since the accident.³⁷ The survey found that 125 full-time doctors had resigned from 24 hospitals in the prefecture, or 12% of all doctors working at those institutions. As for nurses, 407 had quit from 42 hospitals in the prefecture, representing 5% of the nursing staff at those institutions. Their departures have resulted in some hospitals suspending night-time emergency care and other treatment services.

The survey found that the highest number of doctors left from hospitals in Minami-Soma. Thirteen doctors resigned from four hospitals in the city, including one inside the exclusion zone. The figure represents 46% of the four institutions' total doctors. As for nurses, in Minami-Soma 44 left their jobs at four hospitals, or 16% of those institutions' total nursing staff. The association assumes most of the doctors and nurses who resigned did so due to their desire to leave the area amid concern about radiation exposure.³⁸

Experience from both Fukushima and Chernobyl has shown that massive amounts of radiation were being released over 10 days. Confinement, which is one of the key measures in the emergency planning, is practically impossible for these extended periods and authorities don't have alternative solutions in cases of severe accidents. Confined communities in the meantime run out of food and fuel supplies needed. Another major problem is that some of the specialised workers, like drivers, nurses, social workers, medical doctors, and firemen were not prepared to stay in the case of a nuclear disaster.

Screening of the evacuees

Japanese authorities were unprepared to screen the people arriving from the evacuated zones for radioactive contamination. In addition, some evacuees felt uncomfortable being screened by TEPCO employees, while they trusted the university scholars who volunteered for the job.³⁹

On 14 March 2011, the Fukushima prefectural government raised the standard for designating people requiring full-body decontamination from 13,000 counts per minute (cpm) or more, based on its radiation emergency medicine manual, to 100,000 cpm or more (cpm is a measure for the amount of radioactive material found inside a person's body). There were fears that, under the original standard, there would be too many people requiring full-body decontamination, preventing the smooth evacuation due to staff and water shortages. Water necessary for decontamination was in short supply due to the interruption of water services by the earthquake.

However, other prefectures kept the initial limit of 13,000 cpm.⁴⁰ Due to different standards in the different prefectures, some people were accepted in some shelters and not in others, triggering a lot of confusion. In March 2011 about 1,000 people were contaminated at levels between 13,000 and 100,000 cpm and 102 at levels higher than 100,000 cpm.⁴¹

Authorities were unable to handle full-body decontamination of large numbers of people and had to adapt their standards. Changing the decontamination rules in the course of the disaster created a lot of confusion and suspicion.

Distribution of potassium iodine

One of the harmful effects of radiation exposure is an increased risk of thyroid cancer due to radioactive iodine fixing itself on the gland. To counter this, potassium iodine (KI) should be ingested within 24 hours before exposure to radiation, or within 3 hours afterwards for it to have at least 50% efficiency.⁴² To achieve that, accurate predictions of the fallout are necessary, together with a communication system to warn the affected populations.

Some municipalities surrounding the NPP had ample stocks of potassium iodine. Government disaster manuals require those communities to wait for the central government to give the order before distributing the pills. Tokyo didn't order that pills be given out until five days after 11 March. Two of the towns closest to the plant – Futaba and Tomioka – distributed them to residents without awaiting word from Tokyo. Two communities further away from the plant, Iwaki and Miharu, handed out KI pills to their residents based on their own decisions. While Iwaki residents were told to hold off until the government gave instructions, those in Miharu took the pills, leading to a reprimand from prefectural officials.⁴³

The Nuclear Safety Commission (NSC) posted on its website a hand-written note dated 13 March as proof that it recommended distribution and ingestion of the pills. NISA, the main nuclear-regulatory body charged with administering the government's nuclear-disaster headquarters, says the note never came.

Iodine was also not distributed in the shelters. According to official disaster manuals, anyone who has radiation readings of 13,000 cpm should be given KI pills. On 14 March, Fukushima prefecture raised that to 100,000 cpm, in line with its decontamination limit. The NSC was initially cautious about allowing the higher screening benchmark. On 14 March, it issued a statement advising Fukushima to comply with the 13,000 cpm level, noting that this is when the IAEA recommends distributing KI to avoid risking the thyroid gland. However, the NSC relented on 20 March, when in a statement the commission noted 100,000 cpm was permissible according to the IAEA's screening standard in the initial stage of a nuclear emergency.⁴⁴

Iodine pills crucial to prevent future thyroid cancers have proven to be very difficult to administer. Japanese authorities didn't manage to distribute them properly and people were confused about when and whether to use them, all of which in combination with the communication breakdown and loss of trust in authorities led to chaos in implementation. The prophylactic policy based on potassium iodine simply did not work.

Post-crisis evacuation measures: the human tragedy continues

After the initial emergency response came the task of managing the contaminated land. Even though evacuation is a terrible option for the local population, it is a better option than staying in the very contaminated areas. However, in places with low contamination, evacuation is not necessary. In between there is a grey zone where a balance has to be struck between the burden of evacuation and that of radiation exposure or decontamination measures. What should the radioactivity limits be? How should evacuees be best supported? How can the remaining population cope with the threat of radioactivity in their daily life? How should they be informed about radiation risks in a sensitive and balanced way to avoid panic and fear, while at the same time underlining the seriousness to make them stick to measures necessary to reduce the exposure as much as possible?

Evacuation threshold

Massive contamination of the soil can be found far beyond the 20km evacuation limit.⁴⁵ This led the Japanese authorities to expand the evacuation zone to Namie, Katsurao and Iitate, as well as parts of Minami-Soma and Kawamata.⁴⁶ Some hotspots discovered later forced more people to leave their homes: on 30 June 2011, the central government designated 113 households in Date as radioactive hotspots where cumulative radiation is expected to exceed the government standard and recommended that the people living there evacuate. Date is about 80km directly northwest of the Fukushima No. 1 NPP.⁴⁷ On 21 July the government designated 59 households in four areas in the city of Minamisoma, as being located in hot spots recommended for evacuation.⁴⁸ On 3 August, 72 new households of Minamisoma were also recommended to evacuate.⁴⁹ Altogether, some 150,000 people evacuated to protect themselves from the radioactivity.⁵⁰

The Japanese authorities fixed the radiation exposure threshold – which gives evacuees the right to receive compensation after evacuation – at 20 millisieverts a year, due the external irradiation from the ground contamination. This is the equivalent to the annual limit applied to nuclear workers.⁵¹ However, people working in the nuclear energy industry are carefully monitored, and are entitled to medical care. Among the general population, some people are more vulnerable to radiation exposure, such as children, babies or pregnant women. They need far stricter standards, which is why under normal situations the limit for radiation exposure is fixed at 1 millisievert a year (principle of application of dose limits). This is the very maximum, as the dose should be as low as reasonably achievable (principle of optimisation of protection).⁵²

The annual limit set for children of Fukushima is now 20 millisieverts, the same as professional nuclear workers. Just like nuclear workers, school children are equipped with dosimeters to measure the external radiation dose they receive. But, unlike those workers, the children did not choose to be in a contaminated environment.

The population living in the contaminated areas also faces internal contamination as many were directly exposed to the radioactive plume and will continue to be exposed to the risks of inhalation of radioactive dust and ingestion of contaminated food. Independent experts from the French ACRO laboratory have shown that the urine tested from the children of Fukushima is contaminated with caesium.⁵³ They also measured up to 20,000 Bq/kg of caesium in house dust collected by a vacuum cleaner in a house in the district of Watari in Fukushima City, 50km from the Fukushima reactors and 6,000 Bq/kg in dwellings located as far away as 200km.⁵⁴

The estimated maximum cumulative external dose for evacuees who were living in the area of Koakuto, Namie Town up until 10 May 2011 is 50 millisieverts.⁵⁵ As such, the evacuation is justified from the viewpoint of radiation protection. The Fukushima Prefectural government acknowledges that residents near the Fukushima No. 1 plant may have been exposed to up to 19 millisieverts during the first four months of the nuclear crisis. The largest figure corresponds to the residents who evacuated from high-risk areas in the village of Iitate in late June.⁵⁶

The limits set by the government were simply too high and continue to expose especially vulnerable parts of population to unjustifiable risks. The radiation threshold set for the population should include all ways of exposure and decrease with time.

Financial crisis

According to an estimate by the Institute of Economy of the National Academy of Sciences of Belarus, the aggregate financial damage incurred by the Chernobyl catastrophe – including a 30-year mitigation period – is estimated as \$235bn US dollars. The health budget has been continuously increasing since the initial estimation to reach \$54.32bn for the period 2001-2015. The total cost for the same period is \$95bn.⁵⁷

It is too early to know the total cost of the nuclear disaster in Japan. TEPCO will have to pay an estimated 4.54 trillion yen (\$59.2bn) in damages over a two-year period, according to a government panel scrutinising the utility's financial standing in connection with compensation payments.⁵⁸ The estimates of the Study Committee on TEPCO's Management and Financial Conditions are based on the premise that the problems of at least 150,000 evacuees will continue for two years from the outbreak of the Fukushima disaster. Compensation for damage related to evacuation is estimated at 577.5bn yen (\$7.5 bn), on the assumption that evacuees have completely lost the value of their land, buildings and other properties. Damage to business operations and job losses are also included in this category, bringing its total to 1.92tn yen (\$25bn).⁵⁹ This is more than the cumulated profits from the operation of TEPCO's 17 nuclear reactors.⁶⁰

The company cannot survive without the financial support of the state. On 28 October, it asked for an estimated 900bn yen (\$11.7bn) of financial aid from the Nuclear Damage Liability Facilitation Fund, which was jointly established in September by the government and other power utilities with nuclear reactors to cover compensation payments.⁶¹

This financial burden is probably the biggest obstacle in expanding the evacuation of the population living in the contaminated territories.

The company's financial problems do not end there. The Japan Atomic Energy Insurance Pool, an institution jointly formed by 23 non-life insurers, decided last autumn not to renew its insurance contract with TEPCO for the Fukushima No. 1 plant, given the risks involved in dealing with the unprecedented disaster in Japan. The contract expired on 15 January 2012. TEPCO tried in vain to negotiate with a foreign insurance company that is not part of the institution project.

As a consequence, the company deposited 120bn yen (\$1.6bn) in compensation reserves with a government body in case further accidents hit the Fukushima No. 1 nuclear power plant. The crippled Fukushima plant will also be the first ever in Japan not covered by liability insurance.⁶²

Utilities operating nuclear reactors are not ready to cover the damage and loss resulting from a severe nuclear accident. The lack of accountability and limited capacity to cover liabilities leads to a situation where profits are privatised by an elite, but most losses and damages are shouldered by the population.

Voluntary evacuation

There is no safe limit of radiation exposure. Whatever the limit chosen for evacuation, people remaining in the contaminated territories should continuously take care in order to reduce their exposure to radioactivity. The fact that the dangers of radiation have even been denied by a number of officials, led on the one hand to a dangerous lack of caution and protective measures among part of population, and on the other to a deepened lack of trust among others who decided to evacuate voluntarily.

Many people relocated on their own during the crisis or afterwards, even if they were not requested or recommended to do so. Some families living in the contaminated territories sent their children away to the homes of relatives or friends. In rural areas, grandparents often remain in the house while the younger generations went away.

Voluntary evacuation is fully justified in many areas, but it also disrupts communities and public services: nurses, medical doctors, teachers and other vital personnel are now missing in the community. Some shops have been forced to close due to the lack of customers. It is estimated that by October 2011 about 36,000 residents voluntarily evacuated. Some 70% to 80% of the 160 households that left to Sapporo consist of a mother and children who felt insecure about their everyday lives and continue to worry about family members left behind in Fukushima Prefecture.⁶³

The discrepancy between high radiation limits for evacuation and international standards (as well as Japanese legislation before Fukushima accident itself) led to individuals having legitimate concerns about taking additional action, beyond the government's instructions. Most people who evacuated on a voluntary base are suffering financially as they are not entitled to compensation or other support.

Potentially severe food shortages

Contaminated food can lead to long-term exposure to radioactivity. Over 25 years after the Chernobyl disaster people living on the contaminated land still ingest radioactive elements daily, and some of these people are affected by on-going internal contamination. In 2003-2004, the French laboratory ACRO checked the urine of Belarusian children who came for vacation in France and found that at least two thirds of them were contaminated with caesium-137, up to 68 becquerels a litre.⁶⁴

The situation is very different in Japan. The country imports about 60% of its food but is self-sufficient for its rice. Japanese authorities fixed food contamination limits on 17 March 2011.⁶⁵ They are derived from an annual dose of 5 millisieverts if one only eats food at the limit. These limits were hastily extended on 5 April to also include seafood in response to the international concern about the contamination of the sea.⁶⁶

Generally, the transfer of radioelements through leaves is high, whereas the transfer through roots is lower. As a consequence, leafy vegetables and milk were the first contaminated food at the beginning of the crisis because the leaves were directly exposed to the fallouts⁶⁷, forcing the authorities to restrict their consumption on 23 March.⁶⁸

On 25 March, komatsuna (Japanese leaf vegetable) were found at 890 Bq/kg of radioactive caesium in suburbs of Tokyo, which is higher than the provisional limit of 500 Bq/kg fixed by authorities after the accident.⁶⁹ Radioactive iodine that has a short half-life was also problematic at the beginning of the disaster. Leaf vegetables grown later in the moderately contaminated areas had a smaller contamination level. If the Fukushima disaster had occurred in July, when crops have larger leaves, a greater proportion of the rice production of 2011 would have been too contaminated for human consumption. Similarly, if the Chernobyl disaster had happened in June, a large part of the wheat production of Europe would have been improper for consumption in 1986.

A severe nuclear accident always triggers a severe long-term food problem. The first year is worse, as it can lead to potential food shortages. For countries exporting large amounts of food, a nuclear disaster also closes the export market, challenging the economy. According to the estimates of the Agriculture, Forestry and Fisheries Ministry, 44 countries and territories either banned the import of food items produced in Japan, or demanded that they be inspected when imported, even though they are regarded safe and marketed domestically.⁷⁰

Extended food controls are necessary to protect the consumers, but it is impossible to test everything. The Fukushima prefecture produced 356,000 tonnes of rice in 2011. The prefectural authorities would need about 30 years to check all the rice bags of 30kg with their current equipment.⁷¹

Monitoring of seafood is also extremely difficult because some fish travel far. In September, a codfish with 87 Bq/kg of caesium was caught offshore of Hokkaido, several hundreds of kilometres from the Fukushima NPP.⁷² Monitoring based on the seawater is also difficult because some species can bioaccumulate radioelements: caesium can be concentrated in a fish more than 100 times than in seawater. Therefore, the detection limit of the water should be very low, but accurate measurements take time. In Japan, the detection limits⁷³ used by the authorities were too high, and were criticised by the Oceanographic Society of Japan⁷⁴.

Consumer confidence is also challenged by a nuclear disaster. Authorities who gave the go-ahead to the operation of the nuclear facility are discredited by the accident. As they falsely evaluated the safety of the plant, nobody trusts them anymore. In Japan, the fact that it took several months⁷⁵ for the Nuclear and Industrial Safety Agency (NISA) to acknowledge that three meltdowns occurred, completely eroded its credibility.

In addition, Japanese authorities have decided to allow the production of food in the contaminated areas except for those products which exhibited contamination levels above the limit. Such a policy has major weaknesses, as it is impossible to test all foods. Institutions were unable to predict and avoid many problems, such as beef contamination due to feeding cattle on contaminated rice straw⁷⁶. Nor did they expect the tea leaves to exceed the limit as far away as Shizuoka, located at about 300km from the NPP.⁷⁷

Rice is of particular importance in the Japanese diet. The harvest starting in August left plenty of time to prepare for efficient testing. Officially, everything went smoothly as expected until 16 November: Crops harvested in the Onami district of Fukushima City were found to contain 630 Bq/kg of radioactive caesium, exceeding the limit of 500 Bq/kg.⁷⁸

It turned out that 15% of the rice cultivated in this supposedly safe district has shown excessive levels of radioactive caesium.⁷⁹ Finally, bans have been imposed on rice shipments from three cities in Fukushima Prefecture.⁸⁰ As a consequence, people are reluctant to buy food produced in the vicinity of the contaminated zones. Fukushima prefecture produces about half of the peaches of Japan. During the season, peaches from Fukushima were piling up at the entrance of supermarkets at a very low price without being sold.⁸¹

Japanese authorities failed to foresee the scale of problems with contaminated food and crops, and were repeatedly caught by surprise in the following months as well as not being able to deal with them. It had a flawed programme for monitoring and screening, leading to scandals that further undermined public confidence and caused unnecessary additional economic damages to farmers and fishermen. An alternative is to prohibit all food products of an extended zone, except those that are tested and meet safety standards.

Unified management of the dose limits

Just after the disaster, the first concentration limits for food were derived from an annual radiation dose of 5 millisieverts. The external radiation limit to evacuate the population was fixed at 20 millisieverts a year. The two levels of exposure need to be added, leading to an actual and unacceptably high limit of 25 millisieverts a year in the contaminated territories.

Japanese authorities have decided to decrease the concentration limit in the food during the spring of 2012 to an annual dose lower than 1 millisievert. Such a decision is welcome, even if the transition between the two standards is problematic.⁸² As a consequence, the maximum concentration of radioactive caesium in the food will drop from 500 to 100 Bq/kg. Local authorities sometimes apply stricter standards for school lunches: the city of Fukushima has set a limit of 350 Bq/kg, whereas the Sukagawa municipal government has set a limit of 10 Bq/kg for lunch ingredients.⁸³

The central government has also decided to take charge of the cost of the decontamination for the locations where the radiation rate would induce an annual dose higher than 1 millisievert. Japan's Environment Ministry issued a decree on 14 December.⁸⁴

However, the same authorities are considering letting the population come back in the 20km exclusion zone where the contamination level is lower than 20 millisieverts a year.⁸⁵

Japanese authorities considered each way of being irradiated separately, and established separate standards, although the doses from the various ways of exposure should be added. It also wrongly disregarded potential large doses resulting from initial exposure to the radioactive plume and fallout. The lack of transparency and contradicting standards led to further confusion among the public.

The future

There is an urgent need to mitigate the exposure to the radioactive contamination in the areas where populations are still living. This requires open access to the radiation measurements and decontamination of the hotspots. The situation is more complicated for the evacuated lands: will the population be able to come back? For the highly contaminated areas there might be no other way than patiently waiting for the radioactivity to decrease.

Decontamination

The government will rezone the evacuated areas as follows:

- Zones with a radiation level of 50 millisieverts a year or higher will be off-limits for extended periods because they are likely to take years to decontaminate sufficiently for residents to return.
- Zones in which radiation levels are at least 20 millisieverts but under 50 millisieverts a year are considered as restricted zones. The authorities expect that residents may be able to return to these areas in a few years.
- Finally, zones where radiation levels are under 20 millisieverts a year will be prepared for the return of residents once living environments are restored.⁸⁶

Decontamination efforts will start in areas with annual doses of 10-20 millisieverts, where a sizable reduction can be expected and the reduction goal is 10 millisieverts or less. A stricter reduction target of 5 millisieverts a year or less will apply to schools.⁸⁷ This is in strong contradiction with international limits of 1 millisievert for any long-term exposure and a stabilised situation.⁸⁸

For all the other areas with an annual radiation exposure of 1 millisievert or more, Japan's Environment Ministry issued a decree on 14 December to clean them up. More than 100 municipalities are implicated. Local governments will measure radiation more closely, work out decontamination plans and implement them with financial support from the central government.



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No decontamination target in terms of dose is given. The decree also requires the central government to dispose of waste with radioactive caesium levels above 8,000 Bq/kg on behalf of local governments, and implement decontamination and radioactive waste disposal in both no-entry and designated evacuation zones close to the nuclear plant. The cost is evaluated to more than a trillion yen (\$13bn).⁸⁹

Decontamination is not a simple task. So far, the top soil of all playgrounds in Fukushima's schools was removed. Most of the buildings were cleaned up at the request of the anxious parents. All municipal governments reported that the soil removal had proved to be effective but the volume of soil in 19 municipalities, where data is available, amounted to some 178,000 cubic metres.⁹⁰ Cities have also decontaminated hotspots by removing sludge from side ditches and gutters.

According to the Environment Ministry, up to 28m cubic metres of soil contaminated by radioactive substances may have to be removed in the Fukushima Prefecture. This figure is based on the assumption that all the areas, where exposure is 5 millisieverts or more a year, were to be decontaminated, and in the case of forests this would be 100%. It will be even more if one includes some areas with contamination of from 1 to 5 millisieverts a year. Forests occupy about 70% of contaminated areas in the prefecture. The ministry does not believe it will be necessary to remove all contaminated soil, as long as the government restricts the entry of residents in mountainous areas and recovers cut branches and fallen leaves.⁹¹ Removing the first layer of 5cm of the cultivated soils will take off the most fertile part. In forests, it will lead to another ecological disaster.

Guidelines worked out by the Ministry of Environment to decontaminate the cultivated soils recommend only deep ploughing. The national government can extend subsidies for decontamination, on condition that large machines equipped with special agricultural devices are used, which is impossible for most of the small paddies. Some farmers are furious. In addition, the Environment Ministry is aiming primarily to reduce airborne radiation. Reducing radiation levels in agricultural products is beyond its jurisdiction.⁹² After a demonstration of decontamination in Iwaki, radiation readings in the field were 0.3 to 0.42 microsieverts/h before ploughing and 0.23 to 0.3 microsieverts/h after.⁹³

The city of Fukushima decontaminated hotspots of its Onami and Watari districts in July and August. In the week following the end of the operation, the city took fresh radiation readings at 885 points, of which seven actually registered levels exceeding those found before the decontamination. One gutter measured even showed a rise from 3.67 microsieverts an hour before the cleanup to 4.63 after the work. Radiation increased close to the mountains and in spots where water and soil washed down the slopes.⁹⁴

On 4 December, the government allowed media representatives to observe a model project to remove radioactive materials within the 20km no-entry zone. Prior to the work, the radiation level in the air stood at 20 microsieverts an hour. Afterwards, the level dropped to 6 microsieverts an hour, which is still too high.⁹⁵ Caesium is embedded in concrete and roof tiles, and is almost impossible to remove.

The Date municipal government was the first municipality to begin decontamination of houses with a budget of 150m yen (\$2m). Decontamination operations were first conducted on 26 households. However, radiation levels dropped to target levels at only four of them.⁹⁶

The financial and ecological cost of decontamination is higher than expected. Japanese authorities rushed into implementation of a large-scale decontamination that appears to be badly planned. There was no transparent discussion about the limit, i.e. what areas are actually worth expensive and difficult decontamination. This is a difficult debate that needs to be conducted democratically and openly, while putting political interests aside.

Empowerment of the population

In the case of a nuclear accident, access to the measurement of radioactivity becomes vital. Authorities have laboratories and experts to answer their questions in order to help them with the decision-making process. Citizens also need detectors, laboratories and experts to answer their own questions and help them make decisions.

Authorities have distributed individual dosimeters to all children and pregnant women of the Fukushima Prefecture.⁹⁷ This helped to find hotspots and protect the population. The Fukushima municipal government found that four children of the same family were exposed to between 1.4 and 1.6 millisieverts in September alone. Their residence was located close to a highly radioactive spot, and the family has since moved outside the Fukushima Prefecture.⁹⁸

After a relatively high radiation level of 1.62 millisieverts was recorded in a junior high school student, investigation of the apartment building in Nihonmatsu where the student had lived over a three-month period led to the discovery that highly contaminated crushed stone was used for the foundation. This crushed stone has been used in many other places and the investigation is still ongoing.⁹⁹ It would be useful to distribute individual dosimeters to the whole population of Fukushima Prefecture and in other places that are known to be contaminated.

The Fukushima prefectural government's plan for long-term health checks for its 2 million residents is also welcome. In addition, it decided to provide lifetime thyroid gland tests for some 360,000 prefectural residents aged 18 and under. Eligible residents will be tested once every two years until the age of 20, and once every five years thereafter.¹⁰⁰

Anxious members of the population rushed to buy simple dose rate detectors. Their first findings were not well accepted by the authorities who ignored this 'amateur' work. But alarmed by discoveries of radioactive hotspots far from the Fukushima Daiichi nuclear plant, Japan finally issued guidelines to help citizens and local officials to detect contaminated areas and to clean them safely. "From now on, we must offer equipment and ask people to look well beyond Fukushima to find hot spots," Masaharu Nakagawa, minister of Education, Culture, Sports, Science and Technology, said in an interview.¹⁰¹ "Citizens' groups have played a very important role in examining their neighbourhoods closely. I really appreciate their contribution."

The residents, with the help of university experts to teach them how to use radiation-measuring devices, created the most accurate map of the contamination of Haramachi Ward in the city of Minamisoma.¹⁰²

The next step in the necessary empowerment of the population is to provide them direct access to laboratories that can analyse the contamination of various kinds of samples. Many citizen initiatives to run independent laboratories have emerged in Japan since 11 March 2011. They need an official recognition and accreditation system.

Japan was previously missing a network of independent measurement stations and laboratories that would be accredited by the authorities and have the confidence of the population. In the initial stages of the accident, authorities were rejecting measurements taken by independent specialists and were even creating obstacles to those who wanted to do their own readings, despite the fact that long-term precautionary measures entail educating and empowering people in radiation monitoring.

Conclusion

A nuclear accident with massive radioactive fallout is a long-term social disaster. Emergency plans should be well prepared because every mistake can have dramatic consequences. There is no time for improvisation.

Japan, probably the best-prepared country in the world to face natural disasters, seemed unable to anticipate the events that unfolded during the nuclear disaster. This is due to a lack of preparation but also to an inadequacy of the measures taken: confinement proved to be impossible to apply in practice with massive radioactive releases lasting about ten days. Evacuation to avoid direct exposure to the plume was impossible without efficient prediction tools and workable logistics that take into consideration the lack of communication tools, difficult transportation and not enough shelters.

The most vulnerable people are the most in danger in case of a nuclear accident. Bedridden patients and handicapped people are difficult to evacuate in the case of an emergency. In the long term, children living in the contaminated territories are the most at risk.

Nuclear disasters like the ones of Chernobyl and Fukushima also trigger a food and financial crisis that hamper the recovery.

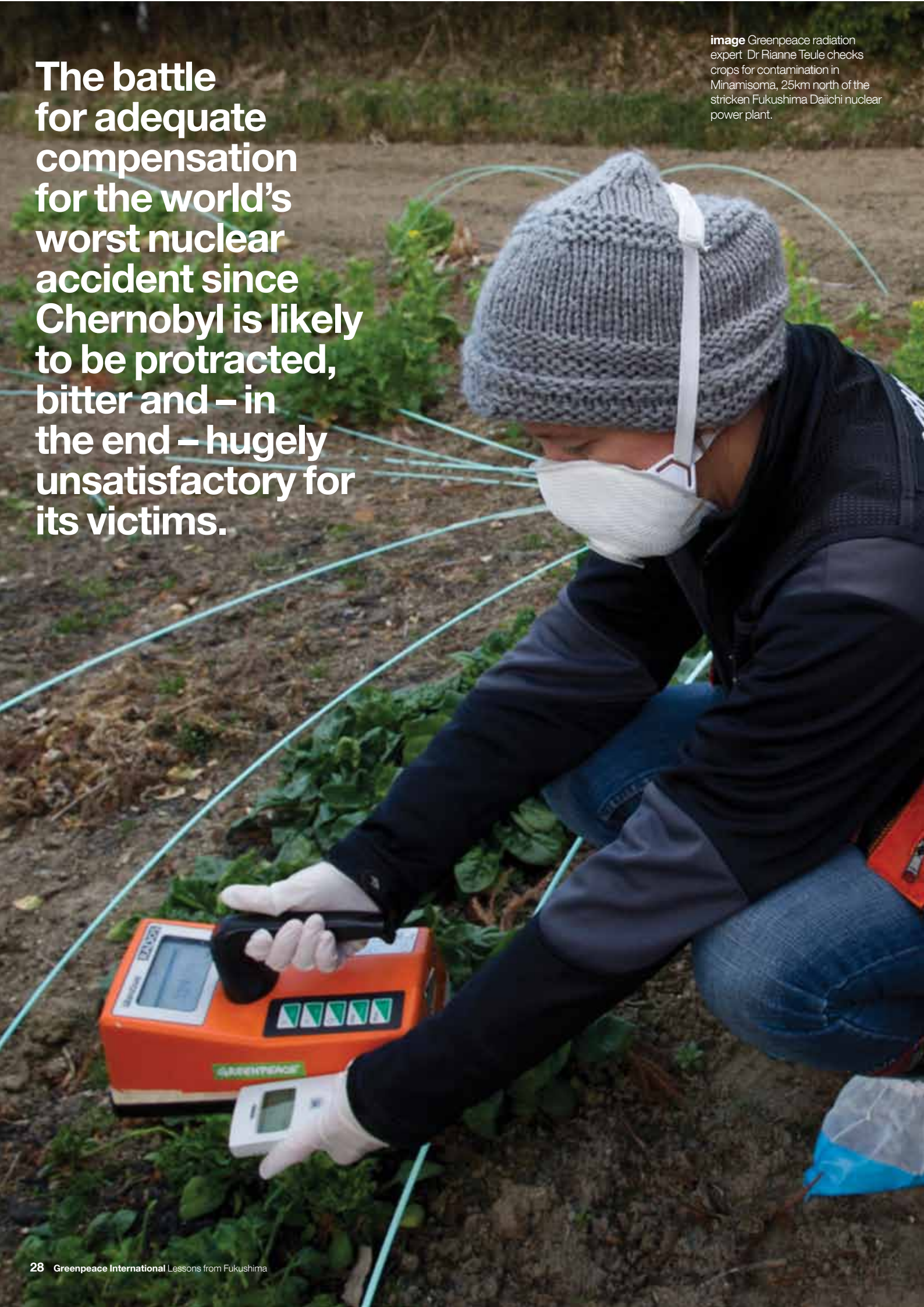
Beyond these technical difficulties, authorities and population should share the same vision of the risks. But confidence and respect is very difficult after a nuclear disaster that challenges the expertise of the authorities that failed to ensure safety.

The catastrophe has just started in Japan. Decontamination has not proven to be efficient on a large scale yet. All of this means that the population has to learn how to live in a contaminated environment for decades to come.

David Boilley is the chairman of the French Association pour le Contrôle de la Radioactivité de l'Ouest (ACRO)¹⁰³, which runs a laboratory accredited by French authorities. He has been coordinating ACRO's involvement in Japan, providing radioactivity tests on various samples, and help and advice to several new laboratories. He is Associate Professor of Physics in a French University.

The battle for adequate compensation for the world's worst nuclear accident since Chernobyl is likely to be protracted, bitter and – in the end – hugely unsatisfactory for its victims.

image Greenpeace radiation expert Dr Rianne Teule checks crops for contamination in Minamisoma, 25km north of the stricken Fukushima Daiichi nuclear power plant.



The Fight for Compensation: Tales from the Disaster Zone

Dr David McNeill

In March 2011 Katsuzo Shoji was farming rice, vegetables and rearing cows on a small plot of land in Iitate village, Fukushima Prefecture. Like many others in the area, Mr Shoji's farm was handed down from father to son; his land had been in the family since the 1880s. That history effectively ended on 11 March 2011 when cooling systems at the Fukushima Daiichi Nuclear Power plant, about 40km away, failed and nuclear fuel in three of the plant's reactors began to melt down.

After being forced to abandon their property, Mr Shoji (76) and his wife Fumi (75) live today in temporary housing, which consists of two rooms, in Date, about 60km northwest of the plant.¹⁰⁴ Initially designated outside the 20km compulsory evacuation zone, Iitate was ordered to evacuate in April after non-government observers, including Greenpeace and the International Atomic Energy Agency (IAEA)¹⁰⁵, warned that levels of caesium and other radioactive contaminants exceeded criteria for immediate evacuation.

The Shoji herd has now been slaughtered, the crops dug up and the fields abandoned to weeds. The family has joined about 7,000 other nuclear exiles from the town. Nearly 11 months since the destruction of their land, income and way of life, the Shojis have received a total of some 1.6m yen (\$20,900 US dollars), or about 150,000 yen (\$1,960) a month. "We have no expectations of being properly compensated, and have given up hope of returning to our homes," says Mr Shoji.¹⁰⁶

As I write, the family is currently waiting for its claim of roughly 2m yen (\$26,100) from Tokyo Electric Power Co (TEPCO), operator of the Fukushima plant. Six months

after the crisis erupted, TEPCO paid 1m yen (\$13,050) in 'temporary' compensation to the family, and then another 300,000 yen per person for their relocation – the same deal offered to thousands of others.

On 12 September, half a year after the accident began, the utility started sending, mostly through the post, a 58-page application form for compensation that demanded receipts (actual, not copied) for transportation and other fees incurred during the evacuation, bank or tax statements proving pre-disaster income levels, and documented evidence of worsening health since the move.¹⁰⁷ A month later, TEPCO received just 7,600 completed forms back – a small fraction from the number ordered evacuated, because the forms were widely considered too arduous and detailed.

One section of the form asked claimants to calculate (with receipts) the cost of returning to their abandoned homes to pick up belongings. Another asked if the claimant had been screened for radiation. The form was accompanied by a 158-page explanation, including 10 pages on how much in travel expenses to claim from every corner of Japan. Compensation payments applied to damages only from 11 March until 31 August, and the process requires applicants to reapply every three months. Criticism of the convoluted application process was so severe that in December 2011 TEPCO was forced to simplify it to four pages.

When the check for 2m yen arrives at the Shoji home, it is supposed to last until November 2012, when the family will have to file another claim. In the meantime, the family head says he has mentally moved on. "I've rented a small allotment and I'm growing vegetables. I don't want to think any more about the loss of my land or getting paid for it because it makes me too sad."

Mr Shoji's story illustrates the systematic weaknesses of the compensation process following the Fukushima nuclear disaster. He is one of an estimated 100,000 from the contaminated prefecture of Fukushima – people who were forced to abandon their farms, homes, schools and jobs between March and May 2011, and live elsewhere. An unknown additional number, estimated by the government as 50,000 at minimum, has moved voluntarily because

of radiation fears, ignoring official claims that life inside or around Fukushima Prefecture is safe.¹⁰⁹ Typically, mothers have taken their children out of the prefecture and started new lives as far away as Tokyo, Osaka or Kyushu, splitting up families, often against the wishes of fathers and in-laws.

“My husband didn’t agree to the move and tells us to come back home,” explains Akemi Sato, a housewife from Fukushima City (about 60km from the nuclear plant), who now lives in Tokyo with her two children aged 7 and 9.¹¹⁰

“I have to pay my bills in Tokyo and travel to Fukushima to see my husband three or four times a month. It’s very expensive and stressful but I didn’t see a choice. People say we have a chance to get compensation, but I’ve been too busy to even think about that or talk to a lawyer.”

Mrs Sato and her two children live in rent-free public housing (*toei jyutaku*) provided by Tokyo city. However, she estimates that her cost of living has increased by 100,000 – 150,000 yen (\$1,300 – \$1,960) a month as she struggles to pay extra bills for utilities, transport and her children’s education.¹¹¹ Those like Mrs Sato who have voluntarily relocated to escape radiation are not currently entitled to even the same compensation package as the Shojis.

In protest, a small number of victims have refused to play by TEPCO’s compensation rules. Fumitaka Naito paid 9.8m yen (\$128,000) for a 6,800-tsubo (2.2 hectare) plot of land in Iitate in 2009, now unworkable because of contamination.¹¹² “My view is what happened is not my fault, so I want the company to provide me with a new farm elsewhere,” he says. “I can’t wait 20 or 30 years till they compensate me for the land – I’ll be dead. But when I saw the compensation form there was no space to write my claim.” Mr Naito calculated the cost of his land, equipment and ruined produce and attached a separate sheet of paper claiming about 70m yen (\$913,000). A TEPCO official called, queried the claim, and eventually offered 150,000 yen (\$1,910). “I told them not to send it. I’m going to fight in the courts instead.”

Liability background and strategy

Japan’s Act on Compensation for Nuclear Damage (1961), enacted when the nation’s nuclear industry was in its infancy, places no cap on the operator’s nuclear liability, ‘regardless of fault, negligence or intention to harm’.¹¹³ The legislation obliges TEPCO to prepare private insurance (roughly 120bn yen / \$1.6bn) per site in the event of nuclear accidents (Fukushima Daiichi’s six reactors count as one site). The key part of this legislation reads:

“... ‘nuclear damage’ means any damage caused by the effects of the fission process of nuclear fuel, or of the radiation from nuclear fuel etc, or of the toxic nature of such materials (which means effects that give rise to toxicity or its secondary effects on the human body by ingesting or inhaling such materials); however, any damage suffered by the nuclear operator who is liable for such damage pursuant to the following Section, is excluded.”

Crucially, however, the act does not stipulate practical details and rules for applying for compensation. As lawyer Yasushi Tadano explains, it vastly underestimates the financial preparation needed for a large-scale disaster such as Fukushima. “TEPCO’s insurance of 120bn yen (\$1.6bn) wasn’t anywhere near enough to cover the number of victims. At a minimum it will cost 5 trillion yen.” (\$65bn) Moreover, Section 16 says that the government may assist in compensation claims if the claims exceed the operator’s liability – subject to Diet (parliament) approval. Section 16 is considered controversial because it makes the government in effect the indemnifier of last resort in a nuclear accident.¹¹⁴

Tadano says, “I am opposed to the idea of TEPCO being allowed to survive on public funds because I believe the shareholders and management of TEPCO should be held accountable for this accident first.”

The lack of practical details for compensation compelled the government in April 2011, a month after the Fukushima accident, to establish the Dispute Reconciliation Committee for Nuclear Damage Compensation, an organisation designed to establish guidelines – and boundaries – for compensation claims.

On 28 April, the Committee adopted preliminary guidelines for determining the nuclear damage, initially defining them as resulting from instructions by the authorities, such as orders to evacuate, stop farming or fishing.¹¹⁵ Subsequent ‘secondary’ and ‘interim’ guidelines, adopted respectively on 31 May and 5 August, include provisions for ‘permanent compensation’.¹¹⁶ At the time of writing, none of these guidelines stipulates compensation for loss of assets such as homes or farms, or for people who have left Fukushima voluntarily. There is speculation that roughly 1 million people, which is over half the population of Fukushima Prefecture, may be offered 80,000 yen (\$1,043) as a one-off compensation payment, in addition to 400,000 (\$5,218) per child (under 18) - a figure Hiroyuki

Yoshino, a leading member of the Fukushima Network for Saving Children from Radiation calls 'absolutely unacceptable'. Mr Yoshino, also a resident of Fukushima City, says his wife and four-year-old son have gone to live in Kyoto. "We have to rent an apartment there and run two separate lives. How are we supposed to live? The government doesn't seem to care."¹¹⁷

Thus, the 1961 law speaks in fairly general and even generous terms about compensation but the specific guidelines for claims have been decided since the incident itself. The Reconciliation Committee has ring-fenced claims to include only government-designated victims of the disaster, with a possible concession to residents of Fukushima Prefecture outside the evacuation zones who live in sometimes heavily irradiated areas. The Committee accepts the government's controversial recommendations that 'liveable' radiation levels may be up to 20 millisieverts a year, though as we have seen many families with children distrust that recommendation.¹¹⁸

"It's now some appointed commission that decides what's claimable, and the problem is that making guidelines after the accident is legally absolutely unacceptable," explains Julius Weitzdoerfer, a German researcher who has compiled one of the most comprehensive reports on liability and the Fukushima disaster.¹¹⁹

Moreover, a major question mark hangs over the costs of decontamination in Fukushima, an operation likely to leave a pile of nuclear waste almost 29m cubic metres – enough to fill one of the city's largest stadiums 80 times.¹²⁰ Who will pay for it? TEPCO has already argued in court that it is not responsible for the radioactivity showered across Fukushima because it doesn't 'own' it. "Radioactive materials (such as caesium) that scattered and fell from the Fukushima No. 1 nuclear plant belong to individual landowners there, not TEPCO," the utility's lawyers told Tokyo District Court, during a disposition to hear demands, by the operators of the Sunfield Nihonmatsu Golf Club 45km west of the plant that TEPCO decontaminate the property. The owners said they were 'flabbergasted' by TEPCO's argument, but the court essentially freed the utility from responsibility, according to the *Asahi Shimbun*.¹²¹ If the decision holds through legal challenges, local and central governments will be forced to foot the bill instead.

The victims of the Fukushima nuclear disaster face a choice of either waiting for a TEPCO settlement to their claims, if they are entitled under the guidelines, or going to court. As Weitzdoerfer explains, 'voluntary' settlements

are 'detrimental to the victims because they might not get as much as they can from the court'. But for social and legal reasons, very few compensation cases end up in Japanese courts. Nevertheless, some lawyers are preparing for battle. "The scale of difference between what TEPCO is offering and what these people need is so large that we're telling people not to bow down and to fight their corner, even if we can't promise that they won't lose," says lawyer Tadano.

In the meantime, lawyers and independent observers say the strategy of TEPCO and the government, during what is likely to be the most expensive liability case in Japanese history is in effect, to suppress compensation claims by making them as restricted, bureaucratic and difficult as possible for the Fukushima victims.

"It's standard practice in these cases," says Martin Schulz, Senior Economist at Fujitsu Research Institute, Tokyo. To illustrate, he points to previous mass compensation claims in Japan, including the most famous of all, the mercury poisoning of food around the town of Minamata in Kyushu island in the 1950s. "It took 40 years to settle those claims. This is how Japanese bureaucracy works."

In the most recent comparable accident to Fukushima, at the Tokaimura nuclear fuel fabrication plant in 1999, 98% of claims were settled within a year of the accident. But, as Weitzdoerfer and others have pointed out, the Fukushima disaster is of a different magnitude. "The two cases are not comparable because evacuation there was for a few hundred meters, lasted a few days, and it was over. Obviously this is completely different."¹²²

The current strategy will include keeping elderly people like the Shojis waiting until they die, and peel off all but the most determined claimants, says Yuichi Kaido, a lawyer and antinuclear activist. "They're drawing the time out, paying as little as they can and putting off settling the main most expensive claims so the victims will get fed up and quit."¹²³ Mr Kaido says the majority of enquiries to the Japanese Bar Association since the 11 March disaster are about the nuclear accident. He estimates that at least 1,000 lawyers are currently in discussion with citizens or groups from the irradiated zones scattered in over 40 different prefectures around the country. "Most people, however, are too busy struggling with new lives to even think of a lawyer or claims."

The medium-term approach is to avoid nationalising TEPCO for as long as possible, to keep the claims at arms length, says Schulz. He and other economists believe the utility is in effect a zombie company: insolvent, unprofitable for at least a decade, and facing imminent nationalisation probably sometime this year.¹²⁴ “As long as TEPCO remains a private buffer for claims against the government, it remains helpful,” says Schulz. “This is why they are focusing on these limited cases; because as long as they do, they can at least pretend to stay in business.”

TEPCO denies these charges and says it is doing its best amid an ‘unprecedented’ disaster, the line followed since March 2011 when Masataka Shimizu, then company president, said that the tsunami that struck the Fukushima Daiichi nuclear plant was ‘beyond our expectations’.¹²⁵ Spokesman Hiroki Kawamata denies making the application process deliberately difficult. “From our point of view we were merely trying to cover all bases and make sure there is nothing left out.”¹²⁶

TEPCO says that it has already paid out temporary compensation to 160,000 people. Families have been awarded an initial payment of 1m yen (\$13,045) each (except for single-person families at 750,000 yen – \$9,784), and up to another 300,000 yen (\$3,914) per person for the costs of moving out of the designated evacuation areas. Mr Kawamata adds that his company has already paid the first claims of 14,500 people, awarding up to 4m yen (\$52,183) each, but admits that the initial compensation of 1m yen (\$13,046) will be deducted from this figure.¹²⁷ He denies stalling on claims. “They are very complex and we’re moving as fast as we can.”

About 285 farmers, hundreds of fishermen and small to medium-sized businesses have also been compensated for loss of earnings. After bitter public criticism of its application procedure TEPCO says it has tripled the number of staff to explain how to apply, bringing a total of 7,000 people working in call centres, 14 local offices and company back offices. It says it has paid out a total of 291.7bn yen (\$3.81bn) so far, and estimates the total cost over two years at 1.7tn yen (\$22.2bn).

The cost, and who pays

The above figure is widely considered a gross underestimate. TEPCO’S current compensation scheme cleaves closely to the government directive on evacuation, meaning only those who have been compulsorily moved are entitled to claim. For now, the scheme also sidesteps the question of abandoned property and other assets since the government line is that evacuees from Futaba, Iitate and other heavily irradiated areas will return to their homes, farms and ports – something that few scientists believe is either possible or desirable.¹²⁸ The scheme excludes cities such as Iwaki and Minamisoma, which border the evacuation zone and whose mayor announced that he is suing TEPCO for economic damages.¹²⁹ Mayor Katsunobu Sakurai said 27,000 of the town’s 70,000 population plan to permanently leave, depriving the town of taxes and likely resulting in eventual bankruptcy.¹³⁰

Finally, the compensation scheme takes no account of the long-term impact on local populations of prolonged exposure to radiation, which is likely to eventually provoke hundreds of lawsuits.¹³¹ As Tadano explains, “The government has made no preparations to offer compensation to radiation victims, but they fear such claims. Radiation is low-level nuclear damage, so they can’t see the consequences but they undoubtedly fear that in the future, victims will emerge, and they fear that it will cost most compensation. There is a 20-year limit in the claiming period from the date of the accident. The problem will be what happens after that.”

Estimates of the total cost of the Fukushima catastrophe, including compensation, fluctuate wildly. TEPCO was told by an advisory panel in October to prepare for claims of 4.5tn yen (\$59bn) in the two years following the disaster, until March 2013.¹³² The private research institute, Japan Centre for Economic Research, put the bill over the next 10 years at 5.7tn yen (\$74bn) to 20tn yen (\$261bn) or higher.¹³³ But neither figure includes compensation to the fisheries and farming industries, though the latter does budget for the purchase of contaminated land inside the 20km evacuation zone. Some sources calculate the cost of buying up contaminated land alone at about 4tn yen (\$52bn).¹³⁴ A broader calculation, by the same research institute, puts the entire cost of the disaster, including compensation and decommissioning the Daiichi plant’s six reactors, at 40-50tn yen (\$520bn – \$650bn; a figure that approaches the bill for cleaning up the US subprime banking meltdown in 2008/9.¹³⁵

Despite being at the time of the accident the world's fourth largest power utility, TEPCO – which was established in 1951 and monopolises the supply of electricity to Tokyo (i.e., one third of Japan's total electricity) – cannot deal with this enormous financial liability by itself. The government has so far tacitly though not explicitly accepted this, the prelude say most observers to eventual nationalisation, when these claims will move into the bureaucratic realm – in other words, they will be handled by government, not private bodies.¹³⁶ Shifting the burden for the catastrophe from the private to the public has been condemned by, among others, economist Keiichi Oshima, who says the disaster proves again that the capitalist marketplace cannot make nuclear power pay. “The nuclear industry made good profits from ordinary people before the accident but now we are the ones who have to pay for the cleanup.”

Under a law rushed through parliament in August, Japan's government has set up a new public-private agency, the Nuclear Damage Liability Facilitation Fund, to keep TEPCO on life support and oversee compensation, from a mix of public cash, bank loans (underwritten by the government) government-backed bonds and money from Japan's 10 electric power companies.¹³⁷ In a careful analysis, economist Oshima concludes that although the fund has been packaged as a rapid response to the nuclear victims, it is aimed ultimately at rescuing and preventing the collapse of the nuclear industry. “It doesn't question the industry itself or make its responsibility for the accident clear.”¹³⁸

TEPCO subsequently announced plans to sell off properties and other assets to raise over 600bn yen (\$7.8bn), as well as raising electricity prices for industrial users last December. It is able to draw on 120 – 240bn yen (\$1.6 – \$3.1bn) from a government-run insurance fund provided for under the law on compensation for damage from nuclear accidents. However, Japan's biggest business lobby, the Keidanren, has been lobbying the Democrat (DPJ) government to set limits on industry liability for compensating for the disaster.¹³⁹ In the meantime, the burden of paying for it is already beginning to rain on the taxpayer.¹⁴⁰

In November 2011, the government agreed to an 890bn yen (\$11.6bn) compensation bailout fund. In late December TEPCO asked the fund for another 690bn yen (\$9bn). This probably barely scratches the surface of the total bill. In this context, the reported figure of 4tn yen (\$52bn) in final compensation costs has, in the words of lawyer Kaido, ‘absolutely no basis in reality’. The government's strategy, therefore, in the coming months

and years, will be to limit claims on the public purse. “The government will probably nationalise TEPCO and separate ‘good TEPCO’ (meaning its generating and supply functions) from ‘bad TEPCO’ (its liabilities and debts),” says Tetsunari Iida, director of the Institute for Sustainable Energy Policies in Japan. “The government will then, in a bureaucratic manner, try to limit payments.”

Conclusion

The battle for adequate compensation for the world's worst nuclear accident since Chernobyl is likely to be protracted, bitter and – in the end – hugely unsatisfactory for its victims. The lawyer Mr Kaido calls it the great legal challenge of the coming years. “How Japan handles it will define our profession for years to come.” Economist Schulz notes that as a six-decade monopoly, protected by the bureaucratic state, TEPCO is just doing what it has always done: bungling and ignoring public opinion. “But they shouldn't be allowed to. It borders on outrageous. It is government policy that resulted in this situation. Ultimately it will be the government that will pay.”

The key word here is ultimately. Hundreds of thousands of nuclear victims from Fukushima will wait, their lives in limbo, as their claims are processed. Many won't receive anything at all. In the meantime, they will pick up the pieces as best they can. Mothers will raise children hundreds of miles from their fathers. Fishermen will repair their nets and boats and wait for the sea to clear of contamination. A few will go out trawling for debris washed out by the 11 March tsunami, a job that earns them 11,000 yen a day from the government. Farmers like Katsuzo Shoji will either fight in court or abandon their legal claims to avoid being driven mad by TEPCO's Kafkaesque paperwork.

Amid the devastation, a surreal touch: unemployed farmers around the crippled nuclear plant, for 12,000 yen (\$157) a day. The local town office helped put up the public notices.

Says Mr Shoji: “We're the victims and TEPCO is the perpetrator, but I get no sense at all of the company being guilty.”

Dr David McNeill is the Japan correspondent for *The Chronicle of Higher Education* and writes for *The Independent* and *Irish Times* newspapers. He covered the nuclear disaster for all three publications and has been to Fukushima six times since 11 March 2011. He wrote this chapter based on interviews with victims and lawyers. He lives in Tokyo with his wife and son.

image Sampling soil to test for contamination, on the outskirts of Fukushima City, 60km from the stricken Fukushima Daiichi nuclear plant. Greenpeace is monitoring radioactive contamination of food and soil to estimate the health and safety risks for the local population.

Timeline:

11 March 2011 Earthquake strikes, shutting down reactors 1, 2 and 3 of the Fukushima Daiichi nuclear plant, triggering a tsunami that strikes about 41 minutes later, and detonating the start of the nuclear crisis. Prime Minister Naoto Kan will initially declare that no radioactive leaks have been detected.

12 March 2011 The government begins ordering the evacuation of residents within 10km of the plant. After an explosion at Reactor 1, the evacuation zone is widened to 20km. Residents further afield are told to stay in their homes and close windows.

11 April 2011 Iitate Village and other municipalities 30 km or more from the plant are told to evacuate after government confirms that residents are at risk of being exposed to a cumulative dose of more than 20 millisieverts of radiation a year.

15 April 2011 TEPCO announces payments of 'initial' compensation of 1m yen (\$13,045) to each evacuated household. Amount condemned as too little by families interviewed in the media. TEPCO begins distributing the money in May but some residents say they don't receive it till June or July.

28 April 2011 Dispute Reconciliation Committee for Nuclear Damage Compensation adopts preliminary guidelines for determining the nuclear damage. Subsequent meetings on 31 May and 5 August will determine guidelines or 'interim' and 'permanent' compensation.

30 August 2011 TEPCO unveils details of its compensation plan, with a pledge to begin payments by October.

12 September 2011 TEPCO begins sending out compensation forms and explanation booklets to refugees, through the post and via refugee centres.

31 October 2011 TEPCO admits it has received only 10% of completed forms after bitter criticism of complicated application procedure. Begins to simplify applications and beef up front and back-office staff around the country.

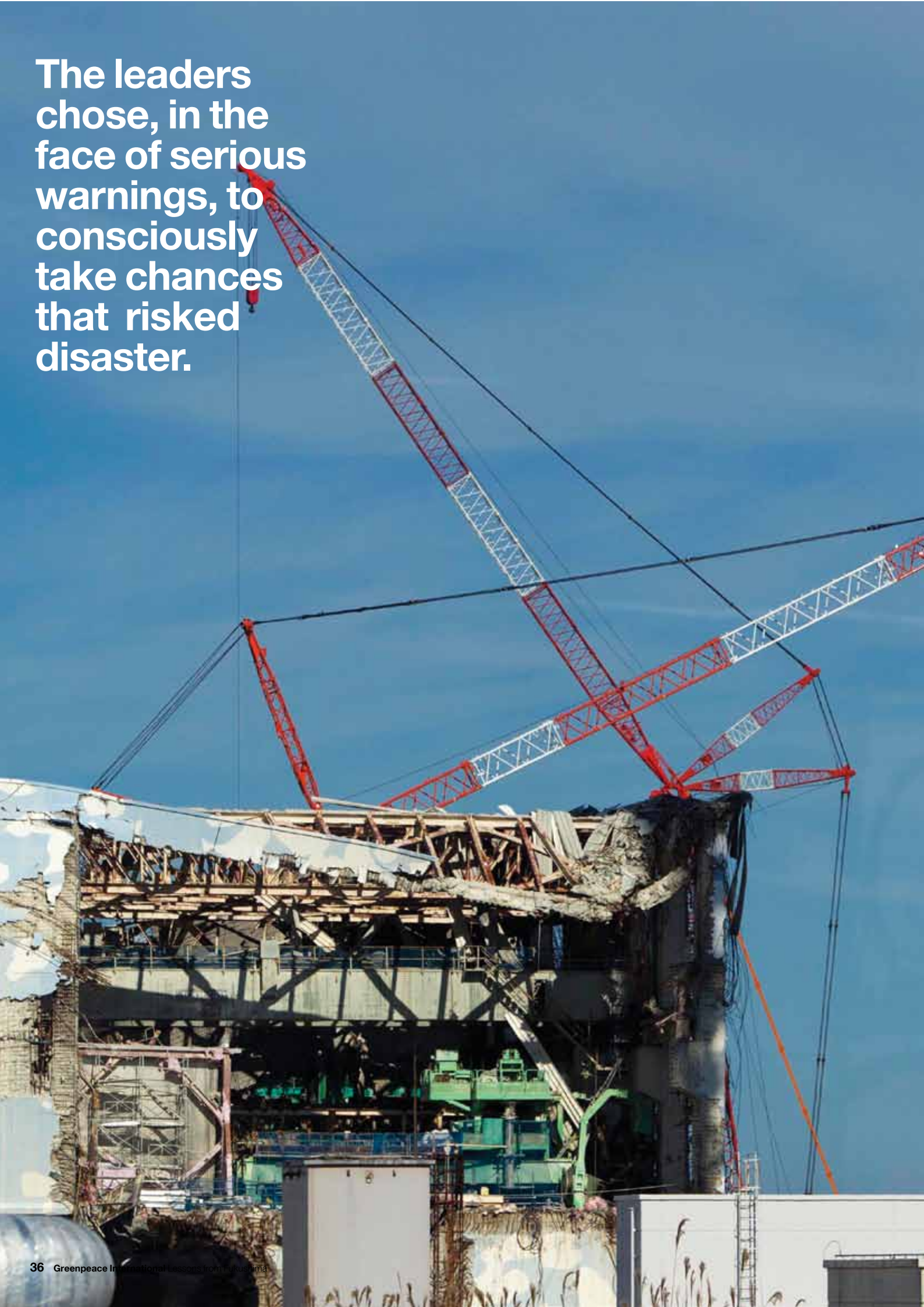
31 December 2011 NHK reports that fewer than half of compensation claimants have actually received payment.

25 January 2012 Fukushima Governor Yuhei Sato criticises government/TEPCO plans to exclude residents in the west and south of the prefecture from compensation plans and proposes a \$520m fund to assist them.





The leaders chose, in the face of serious warnings, to consciously take chances that risked disaster.



The Echo Chamber: Regulatory Capture and the Fukushima Daiichi Disaster

Arnie Gundersen,
Fairewinds Associates

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.

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 evidence¹⁶²

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 evacuation 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 reporters¹⁸⁸ 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 April¹⁹¹ – 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 Kashiwazaki-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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Endnotes

- 1** The French Institut de Radioprotection et de Sûreté Nucléaire, 26 October 2011 estimated that the amount of Cs137 released into the ocean between 26 March and 8 April 2011 to 22×10^{15} Bq, which is 20 times more than the estimation done by TEPCO in June 2011. The same amount of Cs134 should be added. Other radioelements like I131 were also released, but they have a short half life.
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The estimation of the Japanese authorities is available in the Report of Japanese Government to the IAEA Ministerial Conference on Nuclear Safety - The Accident at TEPCO's Fukushima Nuclear Power Stations, June 2011
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- 2** Ministry of Agriculture, Forestry and Fisheries, Results of the inspection on radioactive materials in fisheries products, January 2012
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http://radioactivity.mext.go.jp/en/monitoring_around_FukushimaNPP_sea_marine_soil/2012/01/1350_012514.pdf
- 4** TEPCO: 45 tons of radioactive water leaked at plant, Asahi, 5 December 2011 and Leaks sprout at 14 spots in Fukushima nuclear power plant, Asahi, 30 January 2012
- 5** The French Information note of the 22 March 2011 estimated the atmospheric release to 2×10^{16} Bq for rare gases, 2×10^{17} Bq for the iodine's and 3×10^{16} Bq for the caesium's.
http://www.irsn.fr/FR/base_de_connaissances/Installations_nucleaires/La_surete_Nucleaire/Les-accidents-nucleaires/accident-fukushima-2011/impact-japon/Documents/IRSN_NI-Evaluation-radioactivite-rejets_22032011.pdf
The Japanese NISA estimated that the total discharge amounts from the reactors of Fukushima Dai-ichi NPS were approx. 1.6×10^{17} Bq for Iodine 131 and approx. 1.5×10^{16} Bq for Caesium 137 (Report of Japanese Government to the IAEA Ministerial Conference on Nuclear Safety - The Accident at TEPCO's Fukushima Nuclear Power Stations, June 2011)
http://www.kantei.go.jp/foreign/kan/topics/201106/iaea_houkokusho_e.html
The Austrian ZAMG had results closer to 20% (Unfall im japanischen Kernkraftwerk Fukushima, press release of the 24 March 2011)
http://www.zamg.ac.at/aktuell/index.php?seite=1&artikel=ZAMG_2011-03-24GMT11:24
- 6** Stohl A, Seibert P, Wotawa G, Arnold D, Burkhardt JF, Eckhardt S, Tapia C, Vargas A, Yasunari TJ (2011). Xenon-133 and caesium-137 releases into the atmosphere from the Fukushima Dai-ichi nuclear power plant: determination of the source term, atmospheric dispersion, and deposition. Atmospheric Chemistry and Physics, doi:10.5194/acpd-11-28319-2011
<http://www.atmos-chem-phys-discuss.net/11/28319/2011/acpd-11-28319-2011.html> .
For Cs137 the estimated amount is 35.8×10^{15} Bq.
- 7** 16.7×10^{18} Bq for the Xe133; Ibid.
- 8** Ibid.
- 9** Amount of radioactive materials released from Fukushima plant up, Mainichi Japan, 24 January 2012
- 10** Ordinance of the Environment Ministry quoted in Japan to clean up areas with radiation of 1 millisievert or more, Mainichi Japan, 14 December 2011
- 11** Rough estimation done by the Asahi: Estimated 13,000 square km eligible for decontamination, 12 October 2011
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