Fukushima: five years on – FAQs

On 11 March 2011, at 2:46 p.m. local time (6.46 a.m. CET), an earthquake measuring 9 on the Richter scale hit the east coast of Japan. The quake caused a tsunami, with waves as high as 38 metres, which led to large-scale flooding and destruction of roads, the power supply and other infrastructure along Japan's eastern seaboard. The earthquake and tsunami also struck several nuclear power plants. Fukushima Daiichi sustained the worst damage, triggering a chain of events which led to core meltdown, major hydrogen explosions and massive releases of radiation.

Below, the Oeko-Institut answers the key questions about the disaster's timeline, latest assessments of the events, and the current situation in Fukushima.

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1. What happened at Fukushima Daiichi five years ago on 11 March 2011?

As a result of the earthquake and the tsunami, the Fukushima Daiichi nuclear facility was inundated and large parts of the installations were destroyed. The reactors that were operating when the earthquake struck were automatically shut down immediately. With the earthquake causing widespread disruption to the national electricity grid, the plant was cut off from its external power supply. The tsunami caused the cooling water systems at all six Fukushima Daiichi reactors to malfunction and disabled the emergency electricity supply, which had been started automatically, to five out of six reactors.

A replacement power supply could not be procured and activated in time, so a station blackout occurred. As a result, the electric pumps, which are imperative for long-term residual heat removal, failed. Without sufficient cooling, the water in the reactors steadily heated up and the volumes of water remaining in reactors 1-3 at the Fukushima Daiichi plant evaporated until finally the fuel rods were no longer covered with water. As a consequence, the temperature of the fuel assemblies rose dramatically.

The metal fuel rod claddings and the steam reacted chemically and created large quantities of hydrogen. When there was an attempt to release pressure from the reactor vessels, high pressure pushed this hydrogen into the reactor buildings, where it came into contact with oxygen, causing a series of explosions. These explosions caused various degrees of destruction in the reactors. At the same time, the fuel rods became so hot that major damage to the reactor cores, including meltdown, took place in the first, second and third reactor.

Detailed information can be found in an article by Dr Christoph Pistner from the Oeko-Institut: *Fukushima – Unfallablauf und wesentliche Ursachen* in the journal *sicher ist sicher*, 2013.

2. Who was responsible for the major incident at Fukushima?

Fukushima-Daiichi nuclear plant was not designed and had not been retrofitted to withstand an earthquake of this magnitude and its safety systems were not equipped to deal with such a massive tsunami or such high waves. As a result, no proper measures were in place to protect it from this type of earthquake-tsunami disaster. The earthquake was the direct cause of the loss of the external power supply, while the tsunami disabled all the cooling systems and much of the plant's own power supply.

Applicable reactor safety principles – such as storage of emergency diesel and batteries for the back-up power supply at physically separate locations – had not been properly implemented at the plant. Both the regulatory authorities and the plant operator lacked safety awareness and had failed to take appropriate safety measures at the site. They had ignored recent warnings about potential risks to the facility and had failed to implement international recommendations to improve safety. Instead, the operator – by his own admission – had sought to keep costs low and avoid any discussion of facility safety.

However, the Fukushima disaster has also clearly demonstrated that scenarios which are assumed to be impossible and are therefore excluded from contingency planning can nonetheless occur in reality.

3. What is the current situation at the reactor site?

To minimise releases of radiation and prevent rainwater from entering the damaged parts of the building, enclosures were installed around reactors 1 to 4 in a process that took up to March 2014. The enclosures vary in their design and construction. Reactor 1 was completely enclosed as early as 2011. Depending on the condition of the reactor building, various types of steel structure, equipped with cranes to retrieve the fuel rods from the cooling ponds, were installed in reactors 1, 2 and 3. All the fuel rods have already been removed from reactor 4 using crane equipment erected above and alongside the reactor building. Ventilation and extraction systems, with built-in filters to prevent the release of radioactive material, are an integral component of the enclosures.

In order to retrieve the fuel rods from the pond in reactor 1 – a medium-term project – the shell of the building is gradually being dismantled to give access to the upper floors. In late 2013, workers were able to clear away the wreckage of the fifth floor of reactor 3. Cranes to retrieve the fuel rods from the storage pond have been installed here, similar to the model used for reactor 4.

The exact location and condition of the partly melted cores from reactors 1, 2 and 3 have yet to be precisely determined. Initial results from scans using an external muon detection system– which can penetrate structures to different depths, depending on density – revealed that the reactor 1 core has dropped to the bottom of the building. The containment vessels in these reactors are also damaged and leaking, so radiation is still being released.

The reactors still have to be constantly cooled with water, which is injected into the reactor pressure vessels from outside. On contact with the wrecked reactor cores, the cooling water becomes contaminated. The water leaks out of the damaged reactor vessels and collects in the basements of the buildings. The contaminated water is then pumped out, most of the radioactive material is removed, and the water is reused to cool the reactors. This makeshift cooling system does not operate on a closed cycle and thus does not conform to the normal standards.

As there is still a lack of accurate information about the present condition of the reactor vessels and cores, experts are undecided about the current level of operational safety achieved at the plant, and it is impossible to say what the effects of another earthquake or natural disaster would be.

4. What else is being done to limit the damage?

Decommissioning the buildings and retrieving the fuel elements is a major project which is likely to take several decades. Experts predict that locating and safely recovering all the fuel debris from reactors 1, 2 and 3 will take 30-40 years. First, however, the reactor containment buildings will have to be cleared and decontaminated. Please also refer to Question 3.

First of all, the fuel rods must be removed from the ponds. Work on retrieving the fuel from the damaged pressure vessels can then begin. The containment vessels must be repaired and flooded with water, both types of vessel must be opened, and the fuel must be packed securely and removed. There is currently intensive debate about the right way of proceeding. Other options are also being discussed, such as allowing the melted reactor cores to remain in the wrecked reactor containment buildings for the long term. The fuel has partially melted and requires constant and intensive cooling, which poses major challenges for workers at the site. Radiation levels at the site remain very high, creating problems for repair and cleanup work. Although five years have passed since the core meltdown, the high levels of radiation in the installations mean that workers cannot enter the reactor containment buildings or can only do so for short periods. For information on the radiological situation, please refer to Question 5.

5. What radiological effects of the disaster can currently be observed at the site itself and in the surrounding area?

As before, the reactor pressure vessels, containment vessels and buildings – including, in some cases, the foundations – are wrecked and leaking, and radiation is still being released into the environment. In addition to the radiation from the reactor cores, large quantities of contaminated cooling water are still present at the site (at the start of 2016) and structures and systems are heavily contaminated and a potential hazard.

In recent years, extensive measures were taken to prevent the release of radiation into the sea and local environment. A sheetpile sea wall has been constructed to prevent further releases of radiation into seawater. Most of the uncontaminated groundwater flowing in from the landward side of the wrecked nuclear plant is pumped out and diverted away from the site.

At affected locations around the plant, various decontamination measures have been carried out since 2012 with the aim of making some areas habitable again or further reducing radiation levels in those areas which are already occupied. These measures include spraying roof surfaces, removing topsoil to a depth of several centimetres, and collecting organic material. This creates very large quantities of waste with low levels of contamination, for which temporary storage facilities have been set up in the Fukushima region. The long-term management of this waste is an issue which has yet to be resolved. Although these measures help to reduce local people's exposure to radiation, it is doubtful whether they will be successful in the long term. In addition, wind or water can carry radioactive contamination from untreated into clean areas.

6. Five years on, what is life like for the evacuees?

In 2011, around 160,000 people were evacuated, around half of them from the 20 km zone around the power plant. Since 2012, some parts of the evacuation zones have been cleared for access, albeit to varying degrees. People may enter certain areas for a limited period during the day and move around freely but may not stay overnight. Other areas can be visited at least for short periods. However, large areas around the facility are still exclusion zones, with no possibility of return to these areas even in the longer term.

More than 100,000 people are still unable to return home. Some are still housed in temporary accommodation with basic amenities. There does not appear to be a clear official strategy in place for their permanent return or for the long-term management of the contaminated areas. This lack of clarity is nurturing understandable but false hopes among evacuees that they may be able to return home one day.

7. Can any health impacts now be observed among employees who have been working at the site for five years?

Staff at the site – as many as 3,000 people during the first few months – initially had to work under great time pressure and received high doses of radiation. Around 1,400 people received doses above the normal maximum annual permissible dose for nuclear power plant workers in Japan, which is 20 millisieverts per year (mSv/yr). The increased 250 mSv dose limit for emergency works was exceeded only in a small number of cases.

The contamination and radiation intensity across the site and in the buildings have now been mapped and many of the radioactive hotspots have been cleaned up, thus ensuring that the several thousand people who are on-site every day are no longer exposed to high levels of radiation. Nonetheless, the cleanup can only be carried out with stringent safety precautions and strict restrictions on the time spent working in highly contaminated areas. As some areas are inaccessible due to their very high levels of contamination, robots have been developed to investigate the condition of the reactors.

Exposure to radiation increases the risk that workers will develop and die from cancer. The first case of cancer directly linked to the cleanup at the site was confirmed last year. However, most types of cancer take a very long time to develop. Furthermore, cancer kills around one third of the Japanese population even without the additional contamination caused by the Fukushima disaster, making it impossible, so far, to provide statistical evidence that additional radiation exposure has increased the cancer rates among workers. Additional cancer cases are expected, however.

8. Five years on, are the coastal waters off Fukushima still contaminated?

Very little caesium contamination of seawater has been detected since 2012. The caesium released has now been absorbed into sediments on the seafloor. These sediments still have worryingly high concentrations, reaching several hundred becquerels per kilogram, even in areas located far outside the evacuation zone, in some cases at a distance of 50 km from the plant. If marine fauna ingest the radionuclides stored in sediment, the radiation enters the food chain.

Caesium from Fukushima is still being detected in many samples of fish taken in a 20 km radius around the plant. In some cases, radiation levels in fish still exceed the Japanese food safety standard. In almost all cases, these fish species are at the top of the food chain, i.e. they feed on smaller, less contaminated fish or live close to the highly contaminated seafloor sediments. The sea area within 20 km of the plant will not be suitable for fishing for a long time to come.

9. How has the disaster impacted on Japan's energy policy?

After the Fukushima disaster, Japan began a temporary shutdown of all its nuclear power plants to mid 2012. Only two reactors were restarted for one year from 2012 to 2013; otherwise, all Japan's nuclear power plants were shut down from 2011/2012, and 11 of Japan's 54 nuclear plants have closed permanently. Recently – in January 2016 – Japan restarted three of its nuclear reactors despite public opinion surveys which clearly show that the Japanese people are opposed to any further use of nuclear power in its energy mix. Applications for a return to service for other nuclear power plants have been submitted to Japan's Nuclear Regulation Authority (NRA). If they are approved, more nuclear plants can be restarted.

After a sweeping formal review, the Japanese Government ordered on-site checks on safety standards at the nuclear power plants. After the 2012 elections, the present Liberal Democratic government adopted new energy policy guidelines which reinstated nuclear power as part of the country's energy mix. To what extent this will become reality remains to be seen. Although the construction of new nuclear power plants has been halted, Japan has not made an unequivocal commitment to a nuclear phase-out.

10. How safe – or unsafe – are foods in Japan today?

As radioactive contamination in the wider area around the power plant is steadily becoming more dilute and dispersed, radiation loads in foods continue to fall but are still detectable. Better surveillance has decreased the number of cases in which permitted levels of radiation in food are exceeded. Nonetheless, elevated levels continue to be detected in random sampling. Levels may start to rise again when larger areas within the exclusion zone are opened up for resettlement.

In general, short-term or occasional consumption of individual products gives no cause for concern. However, if longer periods are spent in a relevant area, it is sensible to check the origin of foods and determine to what extent they are subject to monitoring. In February 2016, the European Commission decided to ease restrictions on imports of food and animal feed from the region around the Fukushima plant. Sampling and analysis will no longer be required for foods originating in the following prefectures: vegetables, fruit (excluding persimmons), livestock products, soybeans and tea from Fukushima; all foods from Aomori and Saitama; and rice and soybeans from six prefectures: Iwate, Miyagi, Ibaraki, Tochigi, Gunma and Chiba.

Further information can be found in Commission Implementing Regulation (EU) 2016/6, published in the Official Journal (OJ) of the European Union, 6 January 2016.

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