https://www.base.bund.de/EN/ns/accidents/fukushima/fukushima.html

Federal Office
for the Safety of
Nuclear Waste Management

Fukushima ten years later: The catastrophic accident and its consequences

Source: *BASE / Michael Meier*

The Events in Brief

- A strong seaquake followed by a tsunami caused major damage to the Fukushima Daiichi nuclear power plant in Japan.
- Both the external power supply and the emergency power supply failed in reactor units 1-4. Core meltdowns and hydrogen explosions occurred.
- Significant amounts of radioactive substances were released into the atmosphere, especially in the first days after the nuclear disaster.

- Initial measures after the accident served to stabilise and secure units 1-4, and to transfer them to a controlled state.
- Further measures were taken to reduce the amount of radioactively contaminated water. From the end of 2023 onwards, the water that is contaminated mainly with tritium is to be discharged into the sea in diluted form.
- Investigations into the exact condition of the reactors are ongoing. Preparations for the removal of the fuel in unit 2 have been underway since 2022.
- By the end of 2031, the fuel elements from the fuel pools are to be completely discharged.

Ten years ago, news from Japan shocked the world: the natural disaster of a tsunami was followed by the nuclear disaster of Fukushima. BASE has published a technical report on the anniversary of the accident:

› 10 years after Fukushima. Thinking ahead about safety [https://download.gsb.bund.de/BFE/Fachdaten/base-fukushima-10-jahre-fachbericht.pdf]

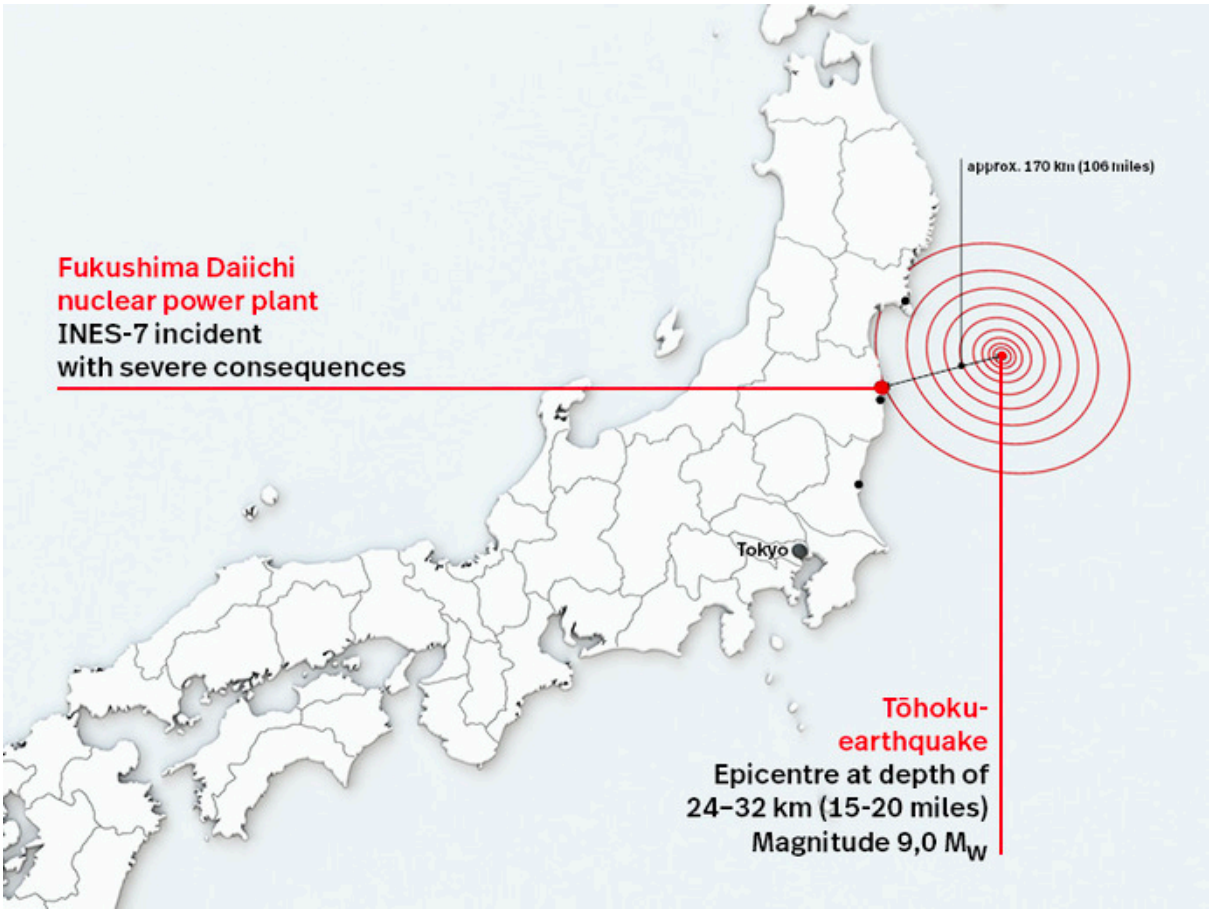
What caused the catastrophic accident? What were the consequences for Japan? And how did the events of 11 March 2011 change the world?

The technical report provides detailed answers to these questions. The most important findings and information are summarised on this page.

The accident sequence in Fukushima

On the afternoon of 11 March 2011, an earthquake in the Pacific Ocean caused a tsunami that hit the east coast of Japan. This triggered a series of accidents at the Fukushima Daiichi nuclear power plant, with nuclear meltdowns in three reactor blocks.

As a result, significant amounts of radionuclides were released into the environment. Apart from Chernobyl, the catastrophic accident in Fukushima is the only one to be classified as a level 7 accident, which is the highest level on the International Nuclear and Radiological Event Scale (INES).



Epicentre of the submarine earthquake
Source: *BASE*

There are six reactor units at the Fukushima Daiichi nuclear power plant. At the time of the earthquake, units 1-3 of the plant were in operation, and unit 4 was undergoing overhaul. The events - from the earthquake to the hydrogen explosions in the reactor units - are described below:

The report presents a chronological sequence of events:

Chronology of the accident sequence (PDF. barrier-free, in German)

Causes of the nuclear disaster

IAEA team inspects the damaged Fukushima Daiichi nuclear power plant
Source: *picture alliance / AP Photo*

Why did the earthquake and successive tsunami have such catastrophic consequences for the Fukushima Daiichi nuclear power plant? Why were precautionary measures insufficient?

In addition to technical weaknesses, human factors and shortcomings in safety culture played a major role in the in the accident and its subsequent management. Expert teams from Japan and abroad concluded that Fukushima was less a natural disaster than a "man-made" one.

Technical weaknesses of the plant

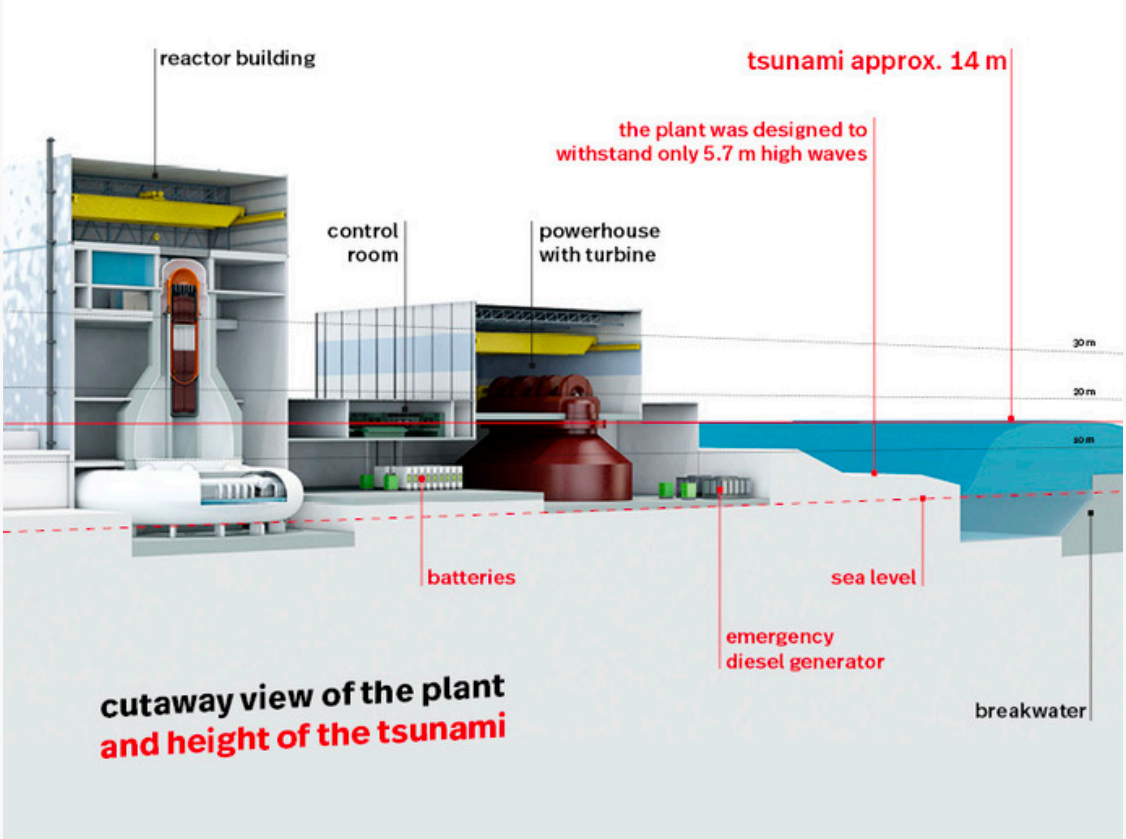
The original 1966 tsunami design had defined the maximum wave height at +3.122 metres above sea level. Until 2009, this design had been re-evaluated several times. Based on these re-evaluations, retrofitting

measures were carried out to increase the maximum wave height to 5.7 metres at the time of the accident.

Starting in 2009, the operator had carried out a series of voluntary analyses. These showed possible tsunami heights of up to 9.3 metres for units 1-4. With regard to locations near the northern and southern boundaries of the plant site, the analysis identified possible tsunami heights of up to 15 metres (cf. the tsunami height of 13.1 metres observed at the plant site on 11 March 2011).

Yet, no changes were made to the plant as a result of these analyses. IAEA investigations also showed that the emergency power supply had not been adequately designed to withstand flooding.

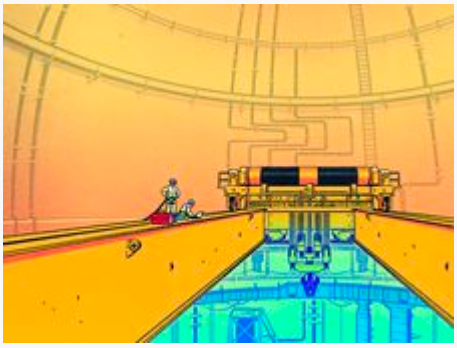
Inadequate containment pressure relief or venting following the tsunami also played a decisive role in the sequence of events. In this process, several valves are used to release the pressure in the containment vessels to the atmosphere through an exhaust stack. According to the IAEA, timely and successful venting in time would have facilitated more effective emergency measures for core cooling and could have prevented the hydrogen explosions of the reactor buildings. The explosion in Unit 4 (which was not affected by a core meltdown) - caused by the entry of hydrogen from Unit 3 - also demonstrates the inadequate venting.



Cross-section of the plant and height of the tsunami
Source: *BASE*

Human and cultural factors

Japanese and international teams of experts concluded that Fukushima could have been prevented with appropriate precautions. Human and cultural factors played a decisive role in the catastrophic accident.



Human and cultural factors

Why were there no adequate precautions? Why was the accident not prevented or at least mitigated by comprehensive risk management?

Source: *BASE/Michael Meier*

The technical weaknesses of the nuclear facilities were largely known and avoidable. Furthermore, there was no comprehensive safety culture in the cooperation between operating companies, the Japanese supervisory authority and the government. It was believed that a severe accident was not possible, and that the Japanese nuclear system was sufficiently safe and efficient. In addition, the inquiries launched after the accident claimed that the Japanese national culture, which is very much group-oriented and authority-centred, was one of the reasons for the poorly developed safety culture. The failure to learn from other serious accidents, such as those at the Three Mile Island (USA) or Chernobyl (Ukraine) nuclear power plants, was also cited.

After the catastrophic accident in Fukushima, government organisations and operators worldwide reviewed their understanding of the concept of safety culture. Topics such as the independence of oversight authorities, the monitoring of operators' safety culture, as well as the reflection on and promotion of individual safety culture concepts at the respective oversight authorities were put on the agenda.

A more detailed account of the impact and significance of human, organisational and cultural factors can be found

in the › technical report (in German) [https://download.gsb.bund.de/BFE/Fachdaten/base-fukushima-10-jahre-fachbericht.pdf].

Radioactivity in the environment

This girl returned to her old gym in Fukushima for a photo project

Source: *Carlos Ayesta - Guillaume Bression / fukushima-nogozone.com*

A significant amount of radioactive material was released into the environment as a result of the accident. This was one of the reasons why the accident at Fukushima Daiichi was rated level 7 (‘major accident’) on the International Nuclear and Radiological Event Scale.

Measures for stabilisation and decommissioning

Current aerial view of the Fukushima Daiichi plant (2020)
Source: *picture alliance / ASSOCIATED PRESS | Takehiko Suzuki*

Since the nuclear accident, the operator TEPCO has taken extensive measures to keep units 1-4 of the Fukushima Daiichi nuclear power plant in a controlled state and to minimise the release of radionuclides. At the same time, these measures serve to prepare for the decommissioning of the plant. According to current estimates, the entire decommissioning process will take 30 to 40 years.

The measures taken to stabilise and decommission the nuclear power plant are described below:

BASE's technical report on the 10th anniversary of the catastrophic accident at Fukushima nuclear power plant provides a detailed discussion of topics such as

decommissioning, remediation and waste management (only in german):

[https://download.gsb.bund.de/BFE/Fachdaten/base-fukushima-10-jahre-fachbericht.pdf]Technical report for download

Source: *BASE / Michael Meier*

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After Fukushima: Consequences for Germany

What consequences did the nuclear disaster in Fukushima have for Germany? The events in Japan triggered a socio-political debate regarding the future use of nuclear energy. In June 2011, the German Bundestag decided by a broad majority to phase out nuclear power. Extensive safety reviews were carried out for all nuclear facilities.

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Source: *BASE / Michael Meier*

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Task for the future: A safe final repository

After the catastrophic accident at Fukushima, Germany abandoned nuclear energy for good. But what about the high-level radioactive waste? It must be stored safely. The law stipulates that a site for a final repository is to be found within Germany by 2031 – in an open-ended, transparent procedure involving the public.

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