

Information on the earthquake in Japan on 11 March 2011

Compilation by GRS

as at 30 March 2011, 10:20 h (CEST)

All times local time (JST) unless otherwise indicated

(CEST (since 27-03-2011) = JST minus 7 hours)

Updated compilation of information

Changes compared with the previous state in Chapter 2 are given in Section 1. The accident sequence so far can be found in Chapter 2. A short description in tabular form of the safety-related situation and updated plant parameters can be found in Chapter 4. This also includes further specifications and supplementations of events and conditions reported over the past couple of days.

1 Changes compared with the previous state

1.1 Fukushima Daiichi

1.1.1 Unit 1

No change.

1.1.2 Unit 2

From 16:30 h until 18:25 h on 29-03-2011, freshwater was injected into the fuel pool via the pool cooling and purification system (TEPCO).

1.1.3 Unit 3

When working on the auxiliary service water system, three workers were splashed with water that had remained in an associated pipe. The water was not contaminated. (29-03-2011, 12:03 h, NISA)

1.1.4 Unit 4

No change.

1.1.5 Units 5 and 6

No change.

1.1.6 Interim storage facility at the Fukushima Daiichi site

The water temperature in the pool was 35 °C (28-03-2011, 16:10 h, NISA).

1.2 Fukushima Daini

No change.

1.3 Onagawa 1-3 and Tokai

No change.

1.4 Radiological situation

According to TEPCO, plutonium was detected in soil samples taken on 21-03-2011 and on 22-03-2011. According to TEPCO, the plutonium concentration corresponded to the concentration that is usual found in the surroundings.

Updated versions of the Figures showing the local dose rates at the Fukushima Daiichi and Fukushima Daini sites and of the survey of the local dose rates measured in the wider surroundings can be found at the end of this report.

2 Summary of the plant situation so far

On 11-03-2011 at 14:46h (6:46 CET), an earthquake struck Japan. This earthquake and the subsequent tsunami also affected the nuclear power plant sites Fukushima I (Daiichi), Fukushima II (Daini), Onagawa and Tokai.

2.1 Fukushima Daiichi

At this site, Units 1-3 were in power operation mode at the time of the onset of the accident. Units 4-6 were shut down when the event set in. At the site, the emergency diesel generators failed as a consequence of the tsunami. Mobile emergency diesel generators were taken to the plant.

Due to the high levels of radiation, the plant was evacuated completely on 16-03-2011 at 10:45 h (2:45 h CET). It is only entered to carry out important measures or record measurements (government press conference at 12:00 h (4:00 h CET)). The local dose rate at the main gate lies within a range of 2.5 – 6.5 mSv/h. In the meantime, part of the personnel has returned to the plant grounds as radiation levels have fallen.

NISA reports that TEPCO wants to establish the electricity supply from power lines in the vicinity. Power to these lines is provided by Tohoku Electric Power. A corresponding connection was to be established by the afternoon of 17-03-2011. The exact status of the re-establishment of the electricity supply is presently not known. According to TEPCO (quoted by ASAHI), however, it is not yet guaranteed that emergency cooling system will work again with the re-established electricity supply.

According to NHK it is intended to repair the auxiliary service water pumps.

According to TEPCO, cobalt, iodine and caesium were detected in discharge channel of Unit a to 4 on 21-03-2011.

According to JAIF it was derived that the flood wave at the power plant had height of 14 m, thus exceeding the design value by more than two times.

According to press releases, the switchgears of all 6 units were connected to external electricity supplies on 22-03-2011. However, no consumers have yet been connected (with the exception of Unit 5) as further tests are necessary.

Preparations continue to supply electricity to Units 1-4. In Unit 3, the main control room has been supplied with electricity again since 13:43 h (23-03-2011). In Units 1,2 and 4, electricity supply has been established up to the switchgears.

According to JAIF, temperature measurements of the RPV surface temperature have been re-established in Unit 1 to 3.

According to IAEA information of 23-03-2011 at 6:00 h CET (14:00 h local time in Japan), dose rates are available for the containments and the pressure suppression pools of Unit 1-3 of the Fukushima Daiichi plant. Up-to-date information on the dose rates in the containment and the pressure suppression pool can be found in the Table in Chapter 4.

According to IAEA information (25-03-2011, 6:00 h CET), illumination of the control rooms of Units 1 and 3 and of several items of the instrumentation of Units 1, 2 and 4 has been re-established.

The government ordered the evacuation of the inhabitants of the 20-km zone and advised the inhabitants in the area between the radiuses of 20 km and 30 km around the power plant to leave this zone voluntarily. (TEPCO on 27-03-2011 16:00 h)

2.1.1 Unit 1

Pressure inside the containment of Unit 1 rose during the course of 12-03-2011. Filtered containment venting was carried out as from 14:30 h on 12-03-2011. A hydrogen explosion occurred inside the reactor building, but outside the containment, at 15:36 h on 12-03-2011.

Borated sea water was pumped into the reactor pressure vessel (it remains unclear whether the containment was flooded as well). Injection was begun on 12-03-2011 at 20:20 h.

On 13-03-2011 at 11:13 h, the Kyodo news agency reported that the authority suspected a leak in Unit 1.

Government spokesman Edano said that there may have been a core meltdown. According to TBS (Japanese TV station), approx. 70 % of the fuel assemblies are damaged. The number of damaged fuel assemblies is said to have risen from 43% to 70% (source: German Federal Foreign Office, 16-03-2011). According to information of 16-03-2011, the fuel rods inside the reactor pressure vessel are uncovered along 1.8 metres of their length (17:00 h).

The IAEA states that electricity supply by mobile generators is ensured and that the injection of sea water is continuing.

For up-to-date information on physical values such as pressure and temperature, see the Table in Chapter 4.

According to JAIF (Japan Atomic Industrial Forum), as at 9:00 h on 17-03-2011, there is no information about the integrity of the fuel assemblies in the fuel pool of Unit 1.

The cables to the switchgear of Unit 1 and Unit 2 have been connected (report by JAIF, 22:00 h, 20-03-2011).

Sea water injection into the reactor pressure vessel is being continued. According to a press release by the operator, the sea water has been injected into the reactor via the feedwater system since 2:30 h (23-03-2011).

In a NISA press conference at 10:00 h (23-03-2011) core temperatures are said to be around 400°C. Core cooling is subsequently said to have been improved by providing further injection trains (JAIF No24 and Kyodo News).

According to recent information, the measured values of above 400 °C that were referred to as core temperatures are temperature values measured on the outside of the RPV. By 16:00 h (23-03-2011), these had gone down to approx. 305 °C.

According to NISA (24-03-2011, 5:00 h), the rate of injection into the RPV increased on 23-03-2011 from 2:33 h onwards from 2 m³/h to 18 m³/h as a result of the additional injection via the feedwater line. From 9:00 h onwards, TEPCO reduced the rate of injection to 11 m³/h since there had been a rise in containment pressure due to the increased amount of coolant injected (24-03-2011, 11:30 h, JAIF). According to JAIF (24-03-2011, 16:00 h), pressure in the RPV has risen and temperatures have fallen. Containment pressure is rising.

According to JAIF (24-03-2011, 22:00 h), pressure in the RPV is slowly rising and the RPV temperature is slowly falling. Containment pressure is slowly rising.

Electricity supply to the control room was established at around 11:30 h (24-03-2011).

According to the Kyodo news agency (25-03-2011), work on Units a and 2 had to be abandoned as highly contaminated water was found in the lower storeys of the buildings.

White smoke is continuously rising, and sea water was injected into the RPV (NISA, 25-03-2011, 6:20 h). On 25-03-2011 at 15:37 h, injection into the RPV was switched from sea water to freshwater (TEPCO).

White smoke has continuously been rising from the unit since 6:30 h 28.03.2011. (NISA)

According to the Nuclear Safety Commission of Japan (NSC), the water found in the turbine building of Unit 1 is condensate from the containment or water that was sprayed onto the buildings during the course of the accident.

Freshwater injection into the RPV is monitored by means of a provisional flow meter: (NISA)

120 l/min at 15:37 h, 25-03-2011

141 l/min at 20:00 h, 28-03-2011

133 l/min at 8:32 h, 29-03-2011

Since 8:20 h on 29-03-2011, a provisional, electrically driven pump has been in use for freshwater injection in Unit 1, as the last of the three units remaining in operation.

INES classification by the authority

Due to the release to the outside of the plant, on 12-03-2011 the authority provisionally classified the event in Unit 1 as INES 4. This INES classification was revised upwards to INES 5 on 18-03-2011.

2.1.2 Unit 2

The coolant level in the reactor pressure vessel of Unit 2 was below the normal level until 14-03-2011. Initially, it did not drop any further. Injection was by means of an emergency cooling system. It was reported by NISA that on 13-03-2011 at 11:55 local time, the electrical power supply was secured (according to the IAEA via mobile generators) and that injection into the reactor was maintained.

On 14-03-2011 at 13:25 h, cooling in Unit 2 failed. For some time, cooling was re-established with sea water. The fuel assemblies were temporarily not covered by water. On 14-03-2011 at about 20:00 h, containment pressure rose to approx. 4.15 bar (corresponds to about design pressure). At 20:37 h, containment venting was begun. According to TEPCO an opening was made in the reactor building to prevent an explosion of the hydrogen in the reactor building.

On 15-3-2011 at 06:20 h, an explosion occurred in Unit 2. According to the IAEA, up to 400 mSv/h were measured on the plant premises. JAIF reports 30 mSv/h between Units 2 and 3, 400 mSv/h next to Unit 3 and 100 mSv/h next to Unit 4. According to press reports, the assumption – based on the fact that containment pressure is falling – is that the pressure suppression pool is damaged.

According to Kyodo, TEPCO says that approx. 33% of the fuel assemblies are damaged. NISA assumes that the high levels of radiation measured since approx. 10:00 h originate from Unit 2. However, it may also be that there is a link between the high radiation levels and the vapour plume emanating from Unit 3.

The fuel rods inside the reactor pressure vessel are uncovered along approx. 1.4 metres of their length.

According to information by NISA of 18-03-2011, 6:00 h, the injection of sea water into the reactor pressure vessel via the fire extinguishing system is being continued. There is white steam rising from the reactor building.

For up-to-date information on physical values such as pressure and temperature, see the Table in Chapter 4.

According to JAIF (Japan Atomic Industrial Forum), as at 10:00 h on 19-03-2011, there is no information about the integrity of the fuel assemblies in the fuel pool of Unit 2.

Information by TEPCO on 19-03-2011, 9:00 h: an external electricity supply via a standby grid transformer has been established. At present, cables are being routed to an auxiliary switchgear system.

Sea water injection into the fuel pool was started on 20-03-2011 at 15:05 h (report by JAIF, 22:00 h, 20-03-2011).

The switchgear of Unit 2 was supplied with voltage on 20-03-2011 at 15:36 h.

At around 18:20 h on 21-03-2011, white smoke was rising from the partially destroyed roof of the reactor building. TEPCO reported that this was water vapour that did not, however, originate from the fuel pool.

According to JAIF, TEPCO reported that the smoke development was abating and that it was no longer visible at approx. 7:00 h on 22-03-2011.

From 16:07 h until 17:01 h on 22-03-2011, 18 t of sea water were injected in to the fuel pool.

As a result of the high radiation levels of more than 500 mSv/h at Unit 2, no work has been possible lately to re-establish the electricity supply of the control room. (Kyodo)

Sea water injection into the reactor pressure vessel is being continued.

According to the Kyodo news agency (25-03-2011), work on Units a and 2 had to be abandoned as highly contaminated water was found in the lower storeys of the buildings.

White smoke is continuously rising, and sea water was injected into the RPV (NISA, 25-03-2011, 6:20 h). From 10:30 h until 12:19 h on 25-03-2011, sea water was injected into the fuel pool by means of the pool cooling and purification system (TEPCO, NISA).

On 26-03-2011 at 10:10 h, injection into the RPV was switched from sea water to freshwater (with boric acid). On 27-03-2011 at 18:31 h, injection was switched from the fire-fighting pump to a provisional, electrically driven pump. (TEPCO)

Since 26-03-2011 at 16:46 h, lighting has been re-established in the unit control room. (TEPCO)

White smoke has continuously been rising from the unit since 6:30 h 28.03.2011. (NISA)

The Nuclear Safety Commission of Japan (NSC) assumes that the water in the turbine building of Unit 2 was in direct contact with molten nuclear fuel and subsequently leaked out into the turbine building via a yet unknown path.

Freshwater injection into the RPV is monitored by means of a provisional flow meter: (NISA)

270-280 l/min at 17:22 h, 26-03-2011

117 l/min at 00:12 h, 28-03-2011

From 16:30 h until 18:25 h on 29-03-2011, freshwater was injected into the fuel pool via the pool cooling and purification system (TEPCO).

INES classification by the authority

The event in Unit 2 had been provisionally classified by the authority as INES 3 on 12-03-2011. The classification was revised upwards to INES 5 on 18-03-2011.

2.1.3 Unit 3

In Unit 3, the emergency cooling system failed on 13-03-2011 at around 5:30 h. There followed a depressurisation of the reactor pressure vessel, and borated water was pumped into the reactor from 13:12 h onwards on 13-03-2011. Sea water was injected with the help of fire extinguishing pumps. Containment venting was carried out.

On 14-03-2011 at 11:00 a hydrogen explosion occurred in Unit 3. According to IAEA information, the containment was not damaged. According to TEPCO, containment pressure is stable.

According to NHK, a plume of vapour is said to have been visible above Unit 3 since 8:30 h on 16-03-2011. According to NISA, it is assumed that the containment is damaged after all. Therefore the personnel from the common main control room of Units 3 and 4 were evacuated on 16-03-2011 at 10:45 h. At 11:30 h, the operating personnel returned to resume the injection of water.

On 16-03-2011, the fuel rods inside the reactor pressure vessel are uncovered along approx. 2.30 metres of their length. According to information by NISA of 18-03-2011, 6:00 h, the injection of sea water into the reactor pressure vessel via the fire extinguishing system is being continued.

For up-to-date information on physical values such as pressure and temperature, see the Table in Chapter 4.

The water level in the fuel pool of Unit 3 is low (JAIF, 17-03-2011, 9:00 h). The water level in the fuel pool is dropping (TEPCO at 18:00 h).

It was tried on 16-03-2011 to pour water from a helicopter into the fuel pool. This measure was abandoned without success due to the high activity levels in the surroundings. The military has begun to fill water into the fuel pool by means of five water cannon. NHK reported on 17-03-2011 that according to NISA, 30 t of water had been added to the fuel pool by the military water cannon. Regarding the use of water cannon, the authority NISA states that on 18-03-2011, 6 water cannon from the army sprayed a total of approx. 50 t of water on Unit 4 at around 14:00 h. Also, a US army water cannon was used until 14:45h. It was concluded from the water vapour that became visible that the water had reached the fuel pool.

According to NISA, containment pressure increased on 20-03-2011 to 320 kPa. Measures to reduce pressure were successful. Renewed containment venting was not necessary.

According to NISA, containment pressure has fallen from 320 kPa (20-03-2011, 11:00 h) by more than 160 kPa (21-03-2011, 4:00 h) to 120 kPa (21-03-2011, 12:15 h). NISA stated that on 20-03-2011 between 21:39 h and 03:58 h (21-03-2011), water was sprayed into the fuel pool.

According to a press release, grey smoke was visibly rising from Unit 3, and workers subsequently had to evacuate from the plant area temporarily (21-03-2011, 15:55 h local time). No explosion was heard. The smoke development stopped shortly after 18:00 h, with the cause of the smoke still unclear. There were no relevant changes observed in the values of RPV pressure, containment pressure, and radiation level.

The resumption of spraying with water cannon has initially been planned for Tuesday. According to NISA it is unlikely that the smoke originates from the fuel pool as no increased local dose rates have been measured. Since the electricity supply in Unit 3 has not yet been re-established, a short-circuit can be excluded as the cause of the smoke development.

The electricity supply continues to be prepared, cables have been laid, but further preparations were postponed due to the smoke development in Unit 3.

According to information by JAIF of 22-03-2011, 16:00 h, spraying with water cannon was resumed for 1 hour at 15:50 h. The total time of spraying is thus approx. 20 hours.

According to JAIF and Kyodo, water is to be sprayed again on Unit 3 in the afternoon of Wednesday, 23-03-2011.

TEPCO announced inspections of the cooling pumps in Unit 3 to take place on 23-03-2011 in order to be able to switch from sea water injection to freshwater injection. The electricity supply of the main control room of the unit was re-established at 13:43 h (23-03-2011).

From 11:03 h until 13:20 h on 23-03-2011, 35 t of sea water were pumped into the fuel pool of Unit 3 via the pool cooling and purification system.

At 16:20 h (23-03-2011), black smoke emanated from the reactor building of Unit 3. Subsequently, the surrounding premises of Units 3 and 4 were evacuated as a precaution. However, the measured values of the reactor pressure vessel and of the containment as well as radiation measurements by the measuring probes in the direct vicinity of the plant showed no significant changes.

Following the cessation of the smoke development on 24-03-2011 at around 4:50 h, workers returned to the plant area affected.

From 5:35 h until 14:04 h, sea water (approx. 120 t) was injected into the fuel pool via the pool water and purification system.

On 24-03-2011, three workers received radiation doses of more than 170 mSv when laying cables in the turbine building of Unit 3. Two of them were confirmed to have the skin on their legs contaminated. As it appeared possible that burns had still been suffered through beta radiation despite decontamination, they were hospitalised. In total, 17 workers have so far been exposed to a radiation dose of more than 100 mSv.

According to JAIF (25-03-2011, 10:00 h), the containment is not damaged. However, TEPCO assumes that the fuel assemblies inside the reactor or in the fuel pool are damaged and that highly contaminated water has reached into the turbine building via a leak. In the meantime, draining work has been going on in the turbine building (25-03-2011, 10:25 h).

Sea water injection into the reactor pressure vessel is being continued.

On 25-03-2011, water was injected into the fuel pool by means of water cannon between 13:28 h and 16:00 h. At 18:02 h, injection into the RPV was switched from sea water to freshwater. (TEPCO)

On 27-03-2011, injection of 100 l of water was carried out with the help of a truck-mounted concrete pump from approx. 12:34 h until 14:36 h. (TEPCO)

On 28-03-2011 at 20:30 h, feeding of the RPV was switched over from the fire-fighting pump to a provisional, electrically driven pump (TEPCO).

Freshwater injection into the RPV is monitored by means of a provisional flow meter: (NISA)

220 l/min at 18:00 h, 26-03-2011

200 l/min at 20:32 h, 28-03-2011

White smoke has continuously been rising from the unit since 6:30 h 28.03.2011. (NISA)

According to the Nuclear Safety Commission of Japan (NSC), the water found in the turbine building of Unit 3 is condensate from the containment or water that was sprayed onto the buildings during the course of the accident.

On 29-03-2011 from 14:17 h until 18:18 h, Unit 3 was sprayed with freshwater by means of the truck-mounted concrete pump. So far, sea water had been used. (TEPCO)

When working on the auxiliary service water system, three workers were splashed with water that had remained in an associated pipe. The water was not contaminated. (29-03-2011, 12:03 h, NISA)

INES classification by the authority

The event in Unit 3 was classified by the authority on 18-03-2011 as INES 5.

2.1.4 Block 4

The reactor core had been completely unloaded into the fuel pool during the refuelling outage. There are thus no fuel assemblies inside the RPV.

In Unit 4, there were a fire and an explosion in the reactor building in the area of the fuel pool on 15-03-2011 at around 6:00 h. The IAEA confirmed that the fire was extinguished at about 11:14 h. The fire/explosion created two holes in the reactor building, both approx. 8 m² wide. According to TEPCO (as reported in media reports) and NISA, another fire broke out in the area of the fuel pool at about 5:45 h (16-03-2011). In this connection, the roof of the reactor building was also severely damaged. The TV station NHK reported that following attempts to extinguish the fire, no flames were visible any more. Media reports say that two workers have been missing since the fire broke out. On a photo of Unit 4 published by TEPCO, a hole in the outer wall of the reactor building is visible, measuring approx. 8 m². The outer shell of the reactor building facing Unit 3 is damaged severely, also near the ground. The roof of the reactor hall is damaged. According to JAIF (12:30 h), the reactor building is also damaged.



Photo of the Fukushima Daiichi plant, Units 1-4 (from right to left), of 16-03-2011

The fuel assemblies in the fuel pool are presumably damaged. According to media information of 16-03-11, 19:00 h CET, the water in the fuel pool is boiling. The fuel pool is to be injected with the help of fire fighting equipment (fire engine). Police water cannon has arrived at the site but cannot be used yet as rubble first has to be cleared.

Water injection was stopped on 16-03-2011 at 14:00 h (NISA). At this point in time, the IAEA gives no details about the water temperature in the fuel pool (last information had been on 15-03-2011 at 19:00 h).

According to JAIF (Japan Atomic Industrial Forum), as at 9:00 h on 17-03-2011, the water level in the fuel pool of Unit 4 is low. According to Jiji, TEPCO reports at 18:00 h that the fuel assemblies in the fuel pool are partly covered by water.

Data by IAEA on water temperature in the fuel pool (normal levels below 25 °C):

14-03-2011, 19:08 h: 84 °C

15-03-2011, 19:00 h: 84 °C

16-03-2011, 14:00 h: no data

19-03-2011, 10:00 h: no data

23-03-2011, 12:00 h: no data

According to NISA, water was sprayed by 13 water cannon into the fuel pool on 21-03-2011 between 06:37 h and 08:41 h.

The electric power supply of the unit continues to be prepared, cables have been laid (approx. 15:00 h, 21-03-2011), but further preparations were postponed due to the smoke development in Unit 3. The switchgear was connected on 22-03-2011 at 10:35 h.

According to French information, the number of fuel assemblies in the fuel pool of Unit 4 is 1500 fuel assemblies instead of the 1331 fuel assemblies counted so far. This difference may be due to approx. fresh 200 fuel assemblies that have so far not been counted.

On 22-03-2011, a truck-mounted concrete pump injected water into the fuel pool from 17:17 h onwards (capacity of the truck-mounted concrete pump: 50 t/h). After more than three hours, the injection was terminated again according to schedule at 20:30 h.

According to JAIF, injection with the truck-mounted concrete pump into the fuel pool was started again at 10:00 h on 23-03-2011.

At 22:45 h on 22-03-2011, first consumers were connected to the external electricity supply grid.

Due to black smoke above Unit 3, the surroundings premises of Units 3 and 4 were evacuated.

Injection of approx. 130 t of water with the truck-mounted concrete pump into the fuel pool took place from 10:00 h until 13:02 h on 23-03-2011.

NISA says that the water temperature in the fuel pool is 100 °C (24-03-2011, 2:40 h). This information can be put down to a wrong indication. (24-03-2011).

From 14:35 h until 17:30 h (24-03-2011), water was injected into the fuel pool by means of the truck-mounted concrete pump.

White smoke is continuously rising, and sea water is continued to be injected into the RPV (NISA, 25-03-2011, 6:20 h). From 6:05 h until 10:20 h on 25-03-2011, sea water

was injected into the fuel pool by means of the pool cooling and purification system (TEPCO, NISA).

From 19:05 h until 22:07 h on 25-03-2011, the fuel pool was injected with the help of a truck-mounted concrete pump (150 t of sea water). Water was again injected in this manner on 28-03-2011 from 16:55 h until 19:25 h (125 t of sea water). (NISA)

White smoke has continuously been rising from the unit since 6:30 h 28.03.2011. (NISA)

On 28-03-2011 from 16:55 h until 19:25 h, approx. 125 t of sea water were sprayed into the fuel pool.

On 29-03-2011 at around 11:50, lighting was re-established in the control room.

INES classification by the authority

The event in Unit 4 was classified by the authority on 18-03-2011 as INES 3.

2.1.5 Units 5 and 6

The IAEA reports about Unit 5 that on 15-03-2011 at 21:00 h (13:00 h CET), the water level in the fuel pool has dropped to 201 cm above the fuel assemblies. This was a drop of 40 cm since 16:00 h (8:00 h CET). It is planned to use an available emergency diesel generator from Unit 6 for water injection.

According to JAIF (8:00 h, 16-3-2011), the water level in the fuel pools of both units is sinking. At 14:00 h, TEPCO reports a fuel pool temperature of approx. 60 °C in both units. The fuel pool temperature is rising.

Further sources say on 16-03-2011 that venting of the reactor building is under preparation to prevent a hydrogen explosion.

On 17-03-2011, 17:30 h, NISA said that in the meantime an emergency diesel generator in Unit 5 was supplying the electricity for injecting water into the fuel pools of Units 5 and 6. Water injection is carried out by the condensate purification system. Once the

external grid connection has been re-established, injection into the RPV is to be resumed.

By 19-03-2011, three openings each were made into the roofs of the reactor buildings of Units 5 and 6 to prevent a hydrogen accumulation.

On 19-03-2011 at 04:22 h, a second emergency diesel of Unit 6 became available after repairs. This meant that it was possible to use the residual-heat removal system of Unit 5 from 19-03-2011, 5:00 h onwards and the residual-heat removal system of Unit 6 from 22:00 h onwards for cooling the fuel pools of the two plants.

"Subcritical cold" condition was reached for Unit 5 on 20-03-2011 at 14:30 h and for Unit 6 on 20-03-2011 at 19:27 h.

Fool pool temperatures on 20-03-2011 at 16:00 h were 35.1 °C in Unit 5 and 28.0 °C in Unit 6. Fool pool temperatures on 21-03-2011 at 5:00 h were 39.5 °C for Unit 5 and 32.0 °C for Unit 6.

The electricity supply of Unit 5 was switched over via transformers to external electricity supply at 11:36 h on 21-03-2011 (IAEA/JAIF).

According to TEPCO, a provisional auxiliary service water pump for Unit 5 was automatically shut down when the electricity supply was switched over to external supply (23-03-2011, 17:24 h). The pump was subsequently repaired. At around 16:14 h (24-03-2011), it was possible to start up the pump, and the reactor has been cooled with the help of this pump since 16:35 h.

On 25-03-2011 at approx. 15:40 h, the provisional electricity supply of the provisional auxiliary service water pump of Unit 6 was switched over to external electricity supply. (NISA)

Data on water temperature in the fuel pool of Unit 5 (normal levels below 25 °C):

14-03-2011, 19:08 h: 59.7 °C
 15-03-2011, 19:00 h: 60.4 °C
 16-03-2011, 14:00 h: 62.7 °C
 17-03-2011, 3:00 h: 64.2°C
 17-03-2011, 18:00 h: 65.5°C

19-03-2011, 6:00 h: 68.8 °C
20-03-2011, 16:00 h: 35,1 °C
21-03-2011, 5:00 h: 39.5 °C
22-03-2011, 5:00 h: 36.3 °C
22-03-2011, 11:00 h: 37.5 °C
23-03-2011, 12:00 h: 39.0 °C
24-03-2011, 5:00 h: 45.1 °C
24-03-2011, 17:00 h: 49.0 °C
25-03-2011, 10:00 h: 39.5 °C
27-03-2011, 14:00 h: 37.8 °C
29-03-2011, 6:00 h: 37.1 °C
29-03-2011, 14:00 h: 38.6 °C

Data by IAEA/JAIF on water temperature in the fuel pool of Unit 6 (normal levels below 25 °C):

14-03-2011, 19:08 h: 58.0 °C
15-03-2011, 19:00 h: 58.5 °C
16-03-2011, 14:00 h: 60.0 °C
17-03-2011, 3:00 h: 62.5°C
17-03-2011, 18:00 h: 62.0°C
19-03-2011, 6:00 h: 66.5 °C
20-03-2011, 16:00 h: 28,0 °C
21-03-2011, 5:00 h: 32.0 °C
22-03-2011, 5:00 h: 26.0 °C
22-03-2011, 11:00 h: 25.0 °C
23-03-2011, 12:00 h: 20.0 °C
24-03-2011, 5:00 h: 23.5 °C
24-03-2011, 17:00 h: 28.5 °C
25-03-2011, 10:00 h: 19.5 °C
27-03-2011, 14:00 h: 21.0 °C
29-03-2011, 6:00 h: 22.0 °C
29-03-2011, 14:00 h: 21.5 °C

For up-to-date information on physical values such as pressure and temperature, see the Table in Chapter 4.

2.1.6 Interim storage facility at the Fukushima Daiichi site

IRSN (Institut de Radioprotection et the Sûreté Nucléaire) estimates that there are approx. 6000 fuel assemblies in the interim storage facility pool. The radioactive material of these fuel assemblies there has been decaying for longer than that of the fuel assemblies in the fuel pools of the 6 units and therefore produces less decay heat. There is no information available about the cooling status.

As at 18-03-2011, 6:00 h CET, NISA states that the interim storage pool is completely filled with water. TEPCO confirms on 18-03-2011, 10:00 h that the water level in the interim storage pool is ensured. The interim storage pool is yet to be closely inspected.

The dry-storage facility was subjected to a visual inspection on 17-03-2011. This revealed no deviations from normal conditions. An inspection of the dry-storage facility is being prepared.

NISA reports that the water temperature in the interim storage pool is 55 °C (as at: 18-03-2011, 11:19 h). On 19-03-2011 at 09:00 h, the interim storage pool temperature reached 57 °C. Water was injected into the interim storage facility from 10:37 h until 15:30 h on 21-03-2011. At 16:30 h on 21-03-2011, the storage pool temperature was 61 °C.

At 15:37 h (24-03-2011), the electricity supply of the interim storage facility was switched over to external supplies, and cooling operation was subsequently started (24-03-2011, 18:05 h).

On 26-03-2011 at 15:30, the water temperature in the storage pool was 43 °C.

The water temperature in the pool was 35 °C (28-03-2011, 16:10 h, NISA).

2.2 Fukushima Daini

A small fire in the auxiliary building of Unit 1 was extinguished within 2 hours (source: European Clearinghouse).

Initially, residual-heat removal from the pressure suppression pools of Units 1, 2 and 4 was not possible. In Units 1, 2 and 4, the pressure suppression pool temperature of

100°C was exceeded. There is no such information about Unit 3. There are reports that Unit 3 reached a cold subcritical condition on 12-03-2011.

Coolant levels in the reactor pressure vessels of the four units did not drop. Electricity supply from an external grid is available in these units.

According to TEPCO, containment venting was being prepared for all 4 units. It was, however, not carried out.

Following repairs of the auxiliary service water pumps that had been inundated by sea water, all units reached cold subcritical conditions on 14-3-2011.

According to information by the operator, the residual-heat removal system was turned off for approx. 1 hour on 15-03-2011. It was subsequently made operational again.

INES classification by the authority

The event in Unit 1 was classified on 12-03-2011 as INES 3.

The event in Unit 2 was classified on 18-03-2011 as INES 3.

The event in Unit 4 was classified by the authority on 18-03-2011 as INES 3.

2.3 Onagawa and Tokai

According to current information, the Onagawa and Tokai sites have no acute safety-related problems. At the Onagawa plant, a fire in the turbine building was detected and extinguished. All three units at Onagawa are in shutdown condition and cold. The plant is currently being inspected.

According to media reports, two diesel generators failed at the Tokai plant, with one diesel generator remaining operable. Of two pumps provided for cooling, one was not available. TEPCO (17-03-2011, 16:00 h) reports that an external grid supply was established on 13-03-2011. Core cooling has been in operation since then.

3 Radiological situation

3.1 Radiological situation at the Daiichi and Daini sites

3.1.1 Radiological situation at the Daiichi site

On 12-03-2011 between 04:00 h and 04:40 h, the operator and the supervisory authority NISA reported an increase of the local dose rate in two locations near the plant gate of Daiichi from background values (approx. 70 nSv/h) to initially more than 10 times this level (approx. 0.9 μ Sv/h at 04:40 h) and to up to about 5 μ Sv/h at approx. 06:30 h. This increase could possibly be related to the beginning of containment venting at that point in time, although there is no corresponding confirmation.

According to further information by NISA, the local dose rate readings in the vicinity of Unit 1 of the Fukushima Daiichi plant increased during the course of containment venting until the explosion in the reactor building at 15:36 h (Japan local time) on 12-03-2011 to about 1000 μ Sv/h. Within approx. three hours after the explosion, the local dose rate readings in the vicinity of the plant dropped to \sim 70 μ Sv/h. According to the authority (quoted by the Kyodo news agency), local dose rates of more than 1200 μ Sv/h were measured again in the vicinity of Unit 1 at 11:13 h on 13-03-2011. At around 14:00 h, TEPCO recorded an increase of the measured values to up to 900 μ Sv/h. After that, the values dropped again to below 100 μ Sv/h. On 15-03-2011 at 10:20 h, local dose rates of 400000 μ Sv/h were measured in the vicinity of Unit 3, 100000 μ Sv/h in the vicinity of Unit 4, and 30000 μ Sv/h between Units 2 and 3.

Figure 1 shows the local dose rate measurements at the Fukushima I (Daiichi) site in different measuring locations for the period between 12-03-2011, 10:00 h and 30-03-2011, 9:00 h, most recently for the "west gate" and "south front central building" measuring locations.

The measured values show generally unsteady distributions with values between 60 nSv/h (background radiation) up to about 12000 μ Sv/h. Some of the maximum values can be correlated to confirmed measures at the plant (e.g. venting), especially the venting at Unit 2 on 14-03-2011 between 21:20 h and 23:00 h and the fire in the fuel pool in Unit 4 on 15-03-2011. The data relating to the fire affecting the fuel pool show an ex-

ponential decrease. This could be caused by short-lived radioactive materials deposited on the ground.

According to information by the operator, the measuring location MP 1 was shifted to the position of MP 2 on 13-03-2010 at around 20:10 h. This is near Unit 1. In this location, values between 400 and 500 $\mu\text{Sv/h}$ are measured. Since 14-03-2011, approx. 15:30 h, there have been no data from measuring locations MP3 and MP4. The local dose rates communicated by the authority (NISA) at the time of the explosion in Unit 1 are not contained in the data provided by the operator. On 15-03-2011 after approx. 6:20 h, the values measured at the measuring location at the main gate rise up to a maximum of approx. 12000 $\mu\text{Sv/h}$ at around 09:00 h. This rise is presumably linked to the fire in the fuel pool of Unit 4. The values drop again after 09:00 h. This decrease continues until 18:00 h, when a level of approx. 450 $\mu\text{Sv/h}$ is reached. The data provided by the operator for the measuring location at the main gate show renewed increases around 23:00 h to up to 8000 $\mu\text{Sv/h}$ at 23:00 h (15-03-2011) and around 11:00 h (16-03-2011), with a maximum of 10850 $\mu\text{Sv/h}$ at 12:30. The local dose rate decreases until 16-03-2011 15:50 h; further statements on the development of the local dose rate at the main gate are not possible due to the lack of data until 17-03-2011, 10:50 h. For the two communicated values on 17-03-2011 at 11:00 h and 11:10 h, the local dose rate is about 650 μSv .

Readings on 18-03-2011 at the "west gate" measuring location show constant local dose rate levels of up to about 260 $\mu\text{Sv/h}$ in the morning and in the evening between 20:10 h and 23:30 h within a range of 370 up to 450 $\mu\text{Sv/h}$. On 19-03-2011 between 08:00 h and 10:00 h, two short-term increases are noticeable to approx. 830 $\mu\text{Sv/h}$ and 660 $\mu\text{Sv/h}$. By 11:30 h, the values have gone down to about 315 $\mu\text{Sv/h}$. For the "north front central building" measuring location, the data available for the period between 13:50 h (18-03-2011) and 1:40 h (19-03-2011) show a rise from about 3400 $\mu\text{Sv/h}$ to about 5000 $\mu\text{Sv/h}$, dropping again later to 3200 $\mu\text{Sv/h}$. The available data for 19-03-2011 as from 11:40 h start with an again increased value of about 4000 $\mu\text{Sv/h}$, followed by a drop to about 2800 $\mu\text{Sv/h}$. Reasons for the temporary increases at the two measuring locations are presently not known.

On 20-03-2011 and until the afternoon of 21-03-2011, too, readings from the Daiichi site were available from the north front of the central building and individually from the west gate. Since approx. 13:00 h on 20-03-2011, a rise of the local dose rate at the north front of the central building from approx. 2600 $\mu\text{Sv/h}$ to about 3300 $\mu\text{Sv/h}$ was

recorded, with a subsequent decrease in the dose rate down to values of around 2000 $\mu\text{Sv/h}$ at 16:30 h on 20-03-2011.

Apart from a measured value of about 1300 $\mu\text{Sv/h}$ for measuring location MP 7, which was not contained in the data available so far, readings as from 16:42 h on 21-03-2011 are only available from the main gate (measured values are only available again from 23-03-2011, 20:40 h for further measuring locations, see below.). With a first measured value of 1100 $\mu\text{Sv/h}$, the local dose rate has changed by 17:40 h to about 500 $\mu\text{Sv/h}$, followed by a renewed rise, with a maximum of about 1900 $\mu\text{Sv/h}$ at 18:30 h and a subsequent drop to values around 400 $\mu\text{Sv/h}$ at 21:00 h.

The fall in the local dose rate at the main gate also continued during the course of 22-03-2011 until approx. 13:00 h to about 260 $\mu\text{Sv/h}$. Late in the afternoon and in the early evening (between 16:30 h and 20:00 h), there is an uneven distribution at the main gate, with several peaks between 325 $\mu\text{Sv/h}$ and 473 $\mu\text{Sv/h}$, interrupted by decreases to values around 250-280 $\mu\text{Sv/h}$. During the further course of time, the local dose rate at the main gate remained largely constant until 14:00 h on 23-03-2011, with values around 225 $\mu\text{Sv/h}$. At around 14:20 h, there was a renewed peak with a maximum value of 435 $\mu\text{Sv/h}$; by 23:50 h, the measured value of the local dose rate had dropped again to approx. 225 $\mu\text{Sv/h}$. Until 24-03-2011 at 21:00 h, this decrease continued to reach approx. 200 $\mu\text{Sv/h}$. On 24-03-2011 at around 14:20 h, measurements were carried out in a new measuring location (Earthquake Isolating Building), showing a maximum of 430 $\mu\text{Sv/h}$; this measuring location lies at a distance of about 0.5 km to the north-west of Unit 2.

On 25-03-2011 at around 10:30 h, an increase in the local dose rate to 540 $\mu\text{Sv/h}$ was measured at the "main gate" measuring location; this had dropped again to approx. 205 $\mu\text{Sv/h}$ by 15:30 h. At around 19:10 h, a further slight increase to values around 260 $\mu\text{Sv/h}$ was measured, which had also dropped again to 205 $\mu\text{Sv/h}$ by 21:00 h. For 26-03-2011, readings for the "main gate" measuring location are available until 11:00 h, with the last value measured being 170 $\mu\text{Sv/h}$.

Since 11:20 h on 26-03-2011, readings have again been available for the "west gate" measuring location. The local dose rate level here was 147 $\mu\text{Sv/h}$ at around midday and dropped during the further course of the day until midnight to values of 140 $\mu\text{Sv/h}$. On 27-03-2011, this trend continued, with readings of 128 $\mu\text{Sv/h}$ at 24:00 h. On 28-03-

2011, a rise to 150 $\mu\text{Sv/h}$ was recorded at around 9:00 h. During the further course of the day, the values dropped to approx. 120 $\mu\text{Sv/h}$.

On 29-03-2011, the measured local dose rate values at the "west gate" measuring location rose at around 5:00 h to 182 $\mu\text{Sv/h}$, at around 8:40 h to 184 $\mu\text{Sv/h}$ and at around 15:30 h again to 138 $\mu\text{Sv/h}$. During the further course, the local dose rate dropped to values of most recently 109 $\mu\text{Sv/h}$ on 30-03-2011 at 9:00 h.

Since 27-03-2011, the operator has been publishing readings from three further measuring locations at the Daiichi site, with the first measured data from 20:40 h on 23-03-2011. The measuring locations are at the central building, at the main gate and at the west gate.

The data measured at the central building so far that are available until 21-03-2011 were measured at the north front, whereas the new measuring location is at the south front of the central building. The newly available measured values for the "south front central building" measuring location show for the morning of 24-03-2011 a rise of the local dose rate from approx. 1700 $\mu\text{Sv/h}$ at around 6:00 h to a maximum value of 3990 $\mu\text{Sv/h}$ at 13:00 h. During the further course, the measured values dropped again to approx. 1500 $\mu\text{Sv/h}$ at around 10:00 h on 25-03-2011, followed by a renewed rise, with values up to about 2500 $\mu\text{Sv/h}$. During the further course, a drop to values of about 1170 $\mu\text{Sv/h}$ in the evening of 28-03-2011 was recorded. On 29-03-2011, there was a slight increase in the local dose rate to 1300 $\mu\text{Sv/h}$ at around 7:30 h.

The new measuring locations "at the main gate" and "at the west gate" supplement the already existing data of the "main gate" and "west gate" measuring locations. For reasons of clarity, these are not included in the overall representations of the local dose rates at the sites. The new measuring location lies "at the main gate" in north-westerly direction in proximity to the "main gate" measuring location. The times of the measurements in the new measuring locations "at the main gate" and "at the west gate" overlap the times of the existing measuring locations, differing in the absolute local dose rates, but showing similar distributions. For example, the local dose rate measured on 25-03-2011 at 00:00 h at the "main gate" measuring location is 200 $\mu\text{Sv/h}$, while at the new "at the main gate" measuring location, 252 $\mu\text{Sv/h}$ were measured. For the "west gate" measuring location, readings on 28-03-2011 at 00:00 h showed a value of 183 $\mu\text{Sv/h}$, and at the new "at the west gate" measuring location, a value of 85 $\mu\text{Sv/h}$ was measured. On 29-03-2011, the local dose rate at the "at the main gate"

measuring location rose at around 5:00 h to 236 $\mu\text{Sv/h}$ and had dropped to 180 $\mu\text{Sv/h}$ by 9:00 h. In the afternoon, the local dose rate rose here again shortly at 16:30 h to a value of 194 $\mu\text{Sv/h}$. On 30-03-2011 at 09:00 h, the local dose rate was 169 $\mu\text{Sv/h}$. At the "at the west gate" measuring location, too, a rise to 152 $\mu\text{Sv/h}$ was observed at around 5:00 h on 29-03-2011. By 12:00 h, the local dose rate there had dropped to approx. 85 $\mu\text{Sv/h}$. Most recently, the measured values on 30-03-2011 at 9:00 h was 78 $\mu\text{Sv/h}$.

NISA has confirmed that caesium-137 and iodine-131 were detected in the vicinity of Unit 1 of the Fukushima Daiichi plant. GRS assumes that radioactive materials were released into the containment and were mainly retained there. The operator, too, confirmed in a press release on 18-03-2011 that radioactive materials (e.g. iodine) had been measured within the plant premises and that the measured activity levels were exceeding natural background radiation levels with time. Furthermore, caesium-137 and iodine-131 have in the meantime been measured as surface contamination in various different prefectures.

On 17-03-2011 at approx. 10:00 h, local dose rate measurements were carried out by a helicopter flying over the plant. At a height of about 300 m above ground (240 m above the roof level of the reactor units), a local dose rate of 4.13 mSv/h was measured; at approx. 100 m height above ground (40 m above roof level), the local dose rate was 87.7 mSv/h. The readings correlate with the hypothesis that the local dose rate is caused by the direct radiation emanating from the uncovered nuclear material. According to up-to-date media information, on 17-03-2011, there were four helicopters flight over the site at a height of less than 100 m above ground. Also on 17-03-2011 at around 10:00 h, the operator said that local dose rates of 400 mSv/h were measured on the landward side of Unit 3 and 100 mSv/h on the landward side of Unit 4. More recent measured values are not available at the moment.

According to TEPCO, analyses of sea water sampled on 21-03-2011 and 22-03-2011 near the southern discharge channel at the Fukushima Daiichi site contained cobalt, iodine and caesium. For 26-03-2011, values measured by the operator are available for various sampling locations. As regards iodine-131, values up to 74 Bq/cm³ were reported in the vicinity of the southern discharge channel. Further measurements were carried out on 28-03-2011 in various sampling locations in the area of the site, showing levels for iodine-131 of up to 38 Bq/cm³.

The operator reports that on 22-03-2011, iodine, caesium and tellurium were measured in the air at the main gate to the Daiichi site. Furthermore, cobalt and cerium were detected on 23-03-2011. The readings show values of $2.2\text{E-}03 \text{ Bq/cm}^3$ (22-03-2011) and $6.7\text{E-}04 \text{ Bq/cm}^3$ (23-03-2011) for iodine-131 as well as $1.9\text{E-}05 \text{ Bq/cm}^3$ (22-03-2011) and $1.3\text{E-}05 \text{ Bq/cm}^3$ (23-03-2011) for caesium-137.

On 27-03-2011, the operator published readings from water accumulated in the turbine building sumps of Units 1 to 4. In Unit 2, a dose rate of more than 1000 mSv/h was measured on the surface of the water. The values relating to iodine-134 (half-life 52 minutes) initially published as $2.9\text{E}09$ were later revised downwards to below the detection threshold. Apart from iodine, the presence of barium, caesium, lanthanum and technetium was also confirmed for Unit 2. Renewed sampling for Unit 2 on 27-03-2011 at 20:40 h largely confirmed the results of the earlier samples of 26-03-2011 8:50 h; especially, no iodine-134 above the detection limit was observed.

According to TEPCO, plutonium was detected in soil samples taken on 21-03-2011 and on 22-03-2011. According to TEPCO, the plutonium concentration corresponded to the concentration that is usual found in the surroundings.

3.1.2 Radiological situation at the Daini site

At the Daini site, local dose rate measurements are available from 13-03-2011 in the morning until 30-03-2011, 9:00 h and are shown in Figure 2. Here, on 14-03-2011 from 22:00 h onwards, measuring location MP 4 records a rise of up to approx. $920 \mu\text{Sv/h}$ at 03:10 h and 03:50 h on 15-03-2011, with a subsequent fall to levels of around $10 \mu\text{Sv/h}$ until 18:00 h. The measured values of this peak between 03:10 h and 03:50 h were later (16-03-2011) revised downwards by the operator to approx. $92 \mu\text{Sv/h}$.

On 16-03-2011 at around 02:10 h, a renewed rise was recorded, with a maximum of $39 \mu\text{Sv/h}$ at 02:20 h, followed by a fall to $18 \mu\text{Sv/h}$ at 09:00 h and a renewed maximum of $31 \mu\text{Sv/h}$ at 11:10 h. The increased values are presumably linked to a transport of radioactive materials from Daiichi. On 20-03-2011, 19:00 h, the values lie again at around $11 \mu\text{Sv/h}$, following a short increase at 5:50 h to approx. $19 \mu\text{Sv/h}$. During the morning of 21-03-2011, the values increased again for a short while to approx. $28 \mu\text{Sv/h}$ and subsequently fell again during the further course of the day to around $12 \mu\text{Sv/h}$ by 12:00 h on 22-03-2011. At around 14:20 h, the local dose rate at the Daini site increased again for a short while to approx. $36 \mu\text{Sv/h}$, followed by a drop to about 12

$\mu\text{Sv/h}$ by 24:00 h. The data available for 23-03-2011 show almost constant levels between 11 and 13 $\mu\text{Sv/h}$. On 24-03-2011, the readings continue to show a slightly declining distribution, lying in the evening at about 9 $\mu\text{Sv/h}$. The measured values for 25-03-2011 show measured local dose rates between 9 and 14 $\mu\text{Sv/h}$ and for 26-03-2011 between 8 and 9 $\mu\text{Sv/h}$. The available data for 27-03-2011 and 28-03-2011 show values of 7 $\mu\text{Sv/h}$. On 28-03-2011 and 29-03-2011, the local dose rate showed values between 6 and 7 $\mu\text{Sv/h}$.

According to TEPCO, iodine and caesium were measured in the air at the Daini site at around 11:00 h and 18:00 h on 21-03-2011. The measured values for iodine-131 are $2.25\text{E-}04 \text{ Bq/cm}^3$ (11:00 h) and $1.58\text{E-}04 \text{ Bq/cm}^3$ (18:00 h) and those for caesium-137 are $4.71\text{E-}05 \text{ Bq/cm}^3$ (11:00 h) and $3.31\text{E-}05 \text{ Bq/cm}^3$ (18:00 h). The most recent measuring results available from 23-03-2011 in the afternoon yielded values of $2.1\text{E-}04 \text{ Bq/cm}^3$ for iodine-131 and $1.7\text{E-}05 \text{ Bq/cm}^3$ for caesium-137. Measurements of 26-03-2011 furthermore show the presence of tellurium.

3.2 Radiological situation in the vicinity

There are different measured values available in the Fukushima prefecture. According to the "Disaster Provision Main Office", the values measured in the afternoon on 22-03-2011 lie between 0.5 and 15.3 $\mu\text{Sv/h}$. The maximum values were 13.8 $\mu\text{Sv/h}$ at around 16:00 h on 23-03-2011, 12.2 $\mu\text{Sv/h}$ at around midday on 24-03-2011, 9.5 $\mu\text{Sv/h}$ in the afternoon on 27-03-2011 and 7.9 $\mu\text{Sv/h}$ in the afternoon on 30-03-2011. Three values measured in the north-west on the border of the 30-km zone showed figures of between 23 and 75 $\mu\text{Sv/h}$ in the afternoon of 22-03-2011; in these measuring locations, values of up to 170 $\mu\text{Sv/h}$ had been measured on 17-03-2011. At around midday on 23-03-2011, the maximum value of the measurements was unchanged at 75 $\mu\text{Sv/h}$. On 24-03-2011 and 25-03-2011, the measured value at this measuring location was 65 $\mu\text{Sv/h}$, 50 $\mu\text{Sv/h}$ at around midday on 27-03-2011, and 43 $\mu\text{Sv/h}$ at midday on 29-03-2011.

In the neighbouring prefecture of Ibaraki, the national local dose rate measuring network registered increased local dose rate levels, presumably caused by the radioactive materials that deposited with the emissions on 15-03-2011 and 16-03-2011. Following a decrease in the local dose rate over the past couple of days, the dose values for the monitored measuring locations (Fig. 3) lie between 0.1 $\mu\text{Sv/h}$ and 0,6 $\mu\text{Sv/h}$ on 20-03-

2011, 0:00 h. On 20-03-2011 between 11:00 h and 12:00 h, a rise in the local dose rate can be observed, followed by a renewed drop. In Horiguchi Hitachinaka City, the value was around 900 nSv/h. During the morning of 21-03-2011, the measured values increase markedly again with the arrival of an area of precipitation. Maximum levels that were reached were almost 3 μ Sv/h at the Momiyama Hokuta City station, about 140 km south of Fukushima Daiichi. At approx. 10:00 h on 21-03-2011, the values at this station were between 1100 nSv/h and 1150 nSv/h. With the continuing northerly flow and further precipitation, there was an uneven distribution at several stations in the Ibaraki prefecture during the further course of the day, with some peaks up to 1350 nSv/h. Since around the afternoon, of 23-03-2011, there has been a falling trend of the measured values. At present, the values in Momiyama Hokuta City are at around 560 nSv/h. In the Ibaraki prefecture, the maximum value, at a local dose rate of 585 nSv/h, is currently measured in Horiguchi Hitachinaka City.

The increase in the local dose rate in connection with the precipitation has been measurable as far away as in the Kanagawa prefecture to the south of Tokyo, with values around 0.20 μ Sv/h in the evening of 22-03-2011. The maximum value currently measured in this prefecture is around 0.116 μ Sv/h.

Figure 3 shows a survey of the local dose rate measurements from different prefectures of the island of Honshu. Outside the provinces already mentioned, current readings are at background level. However, GRS disposes of no data from the Miyagi prefecture, which lies to the north of Fukushima and has been particularly heavily affected by the earthquake.

3.3 Meteorological situation

According to the German Meteorological Service, a flow situation characterised by the passage of a weak low-pressure area with its centre to the southeast of the Japanese coast prevailed during the first half of the day of 15-03-2011, transporting the radioactive materials released with low winds in south-westerly direction along the coast. During the second half of the day, weather stations reported dominating weak circulating winds. During the night from 15-03-2011 to 16-03-2011, the wind freshened from north-easterly direction, so that at that time there was again a transport of the airborne materials released at the Fukushima site in easterly direction. Measuring data from the Ibaraki prefecture bordering on Fukushima in the south showed prevailing northerly to

north-westerly winds until the afternoon of 17-03-2011, with wind speeds of between 3 and 7 m/s. On 18-03-2011, the stations of this region showed either weak winds from north-easterly directions or a somewhat stronger flow from south- to south-westerly directions. These observations also confirm reports by the German Meteorological Service. With the temporary change to southerly directions, a transport of potential releases from the plant into northern parts of the country was possible.

On 19-03-2011, high pressure was predominating in the region, with a general weak westerly flow that is apparently overlaid by local circulation patterns. For example, weather stations in the Ibaraki prefecture showed predominating wind directions around east with low wind speeds during the day, which might be linked to the formation of the offshore-onshore circulation in the afternoon.

During the course of 20-03-2011, with the formation of a trough of low pressure, the wind directions predominating over Japan changed to north to north-east. Combined with an oscillating flow, a large area of precipitation passed over Honshu, reaching initially the south-westerly prefectures and in the early hours of the morning of 21-03-2011 also the Fukushima and Ibaraki prefectures. In the afternoon, precipitation in these regions already abated. Subsequently, however, with the northerly flow continuing, there was further precipitation on 22-03-2011 as the trough of low pressure moved more slowly to the east than originally predicted.

On 23-03-2011, northerly winds were still predominating in the region in the area behind the weakening trough of low pressure east of Japan; these abated during the second half of the day. On 24-03-2011, the situation was characterised by weak pressure differences above Japan. In Fukushima and the neighbouring prefectures, mainly weak southerly and south-easterly winds were reported, so that initially any potential releases from the site were transported into northern parts of the country. On Friday, an area of low pressure passed over mainland Japan and changed its path in the direction of the Pacific on Saturday. Behind the low-pressure area, near-ground flows freshened and changed to north-westerly direction so that releases were transported out onto the Pacific. On Sunday, 27-03-2011, an area of high pressure expanded from the Asian continent towards Japan. The near-ground flows kept their direction, but became weaker.

On Monday, the high-pressure situation brought low wind speeds with changing directions with it. During the further course, the centre of the high-pressure area moved to-

wards the Pacific. The region of Fukushima was thus at the north-westerly side of the high-pressure area, so that any potential releases were transported out towards the Pacific with a south-westerly to westerly flow. On Tuesday, a further area of low pressure formed to the north of Japan, so that initially potential releases were transported out towards the Pacific with south-westerly winds. During the course of Tuesday and on Wednesday, showers are expected for the island of Honshu. According to the German Meteorological Service, westerly and south-westerly winds will dominate until Wednesday evening due to the area of low pressure over the north of Japan, so that any potential releases will be transported out towards the Pacific. During the night to Thursday it is expected a small leeward area of low pressure will form over the Tokyo area, which means that owing to a short-term change of the wind in northerly direction any potential releases may be transported into the wider Tokyo area. The wind is expected to freshen and turn to north-west during Thursday, so that any potential releases should be transported out towards the Pacific again. For Friday, a temporary changing of the wind to south-westerly directions is expected due to a ridge of low pressure to the north of Japan.

3.4 Measures taken

Within the evacuation radius of Daiichi (20 km) and of Daini (10 km), a total of 210,000 people have been evacuated.

Within a radius of 30 km around the Daiichi evacuation zone, the population was recommended to stay indoors. Also, according to the IAEA, a no-fly area was established in a radius of 30 km around the plant. The IAEA states furthermore that the Japanese coast guard ordered coastal waters to be cleared within a radius of 10 km around Daiichi and 3 km around Daini. According to the latest information, the zones up to 20 km were evacuated; for the wider 30-km zone, the population was instructed to stay indoors.

As a further measure, the local authorities were recommended on 16-03-2011 to instruct people coming from the 20-km evacuation zone to take iodine tablets with stable iodine in order to block the uptake of radioactive iodine.

On 25-03-2011, the people remaining in the 30-km zone were advised to consider leaving the zone.

3.5 Foodstuffs

According to IAEA report of 19-03-2011, Japanese authorities measured radioactive iodine in foodstuffs (milk) in the Fukushima prefecture around the Daiichi plant and in vegetables in Ibaraki. The measurements were performed between 16 and 18-03-2011. Limit values were found to have been transgressed. In the raw milk dairy products up to 1510 Bq/kg were measured on 16-03-2011, which is five times the Japanese limit for putting such products into circulation. A ban on selling contaminated products was issued.

Furthermore, according to media reports of 20-03-2011 quoting the government spokesman, spinach contaminated with caesium-137 and iodine-131 above the permissible limits of 500 and 2000 Bq/kg, respectively, was found in the town of Hitachi in Ibaraki prefecture. Also, milk contaminated with iodine was found in a town 35 km to the north-west of Fukushima Daiichi. There have also been reports about contaminated drinking water in 4 towns, lying at 1- 2 % of the permissible limits.

Available data of 20-03-2011 that do, however, not consider the Miyagi and Fukushima provinces, show iodine-131 contamination in drinking water in nine provinces and caesium-137 contamination in drinking water in three provinces. For the Ibaraki province, the iodine-131 contamination is 3 - 4 % of the permissible value. In the Fukushima prefecture, media reports of 20-03-2011 say that maximum values of 10 % of the permissible value were measured. According to the Ministry of Health, one value above the permissible value was recorded on 19-03-2011.

According to media reports, the government has instructed the prefectures of Fukushima, Ibaraki, Tochigi and Gunma not to bring any raw milk, spinach and another green leaf vegetable (Kakina) from the prefectures into circulation following the detection of individual samples that were contaminated with radioactive substances at levels above the permissible limit. According to a statement by government spokesman Edano on 20-03-2011, a report on the analysis of foodstuffs is being prepared that is to be published by the Ministry of Health later on 20-03-2011, but is not yet available to GRS.

According to a report by the WHO on 21-03-2011, measurements of foodstuffs from Gunma, Fukushima, Chiba, Ibaraki, Saitama, Tochigi and Tokyo were evaluated. Here, 27 samples exceeded the provisional regulation value for iodine-131 of 300 Bq/kg for milk and of 2000 Bq/kg for vegetables. 12 samples exceeded the provisional regulation

value for caesium of 200 Bq/kg for milk and of 500 Bq/kg for vegetables. Measures were taken to stop the circulation and sale of these products. The prefecture of Fukushima has asked its inhabitants not to consume any products from within an area with a radius of 30 km. Spinach from the Ibaraki prefecture is no longer to be sold.

On 20-03-2011, 965 Bq/kg were measured in a drinking water sample from Litatemura (the limit value in Japan is 300 Bq/kg). The inhabitants were advised not to drink tap water. The Fukushima prefecture is preparing the handing-out of water bottles to the approx. 4000 inhabitants. In Kawamata, 308 Bq/kg iodine-131 were measured in tap water on 17-03-2011. This value dropped to 123 Bq/kg on 19-03-2011.

According to a press release by the Japanese health ministry of 23-03-2011, a ban was issued for the Fukushima prefecture on the sale and consumption of various vegetables from the prefecture; for the Ibaraki prefecture, the sale of fresh raw milk and herbs from the prefecture was banned.

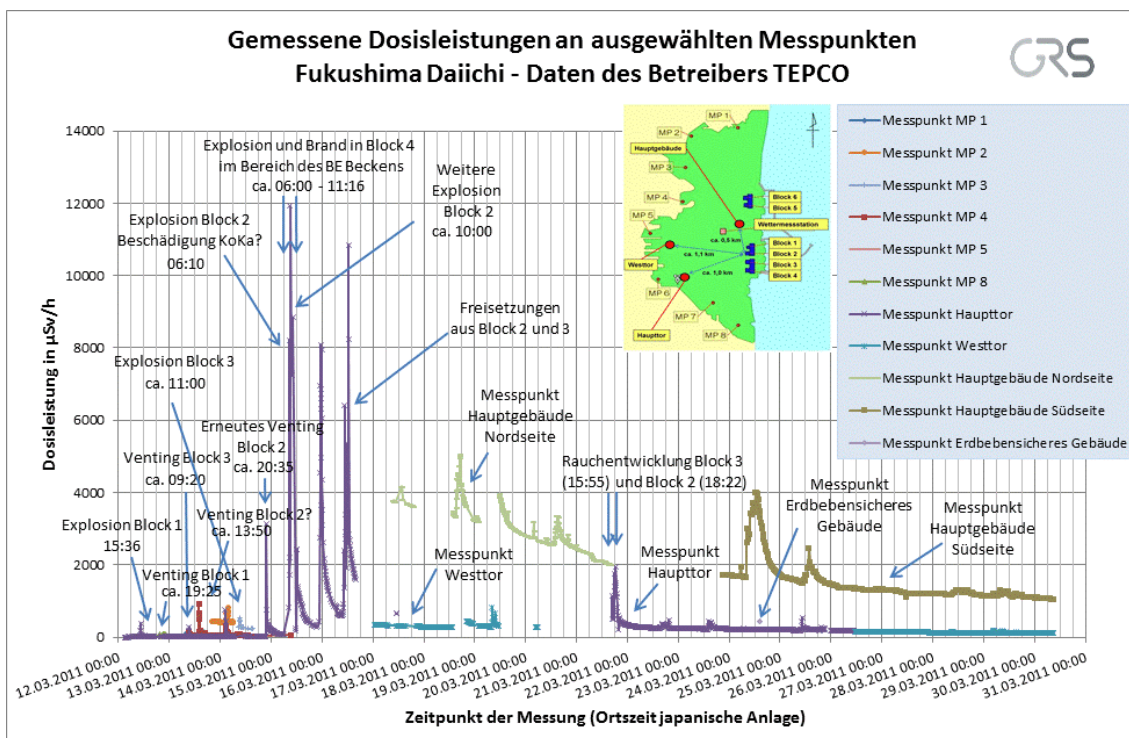


Figure 1 (all times local time)

Dose rates measured in selected measuring locations (MP) at Fukushima Daiichi – Data provided by the operator TEPCO

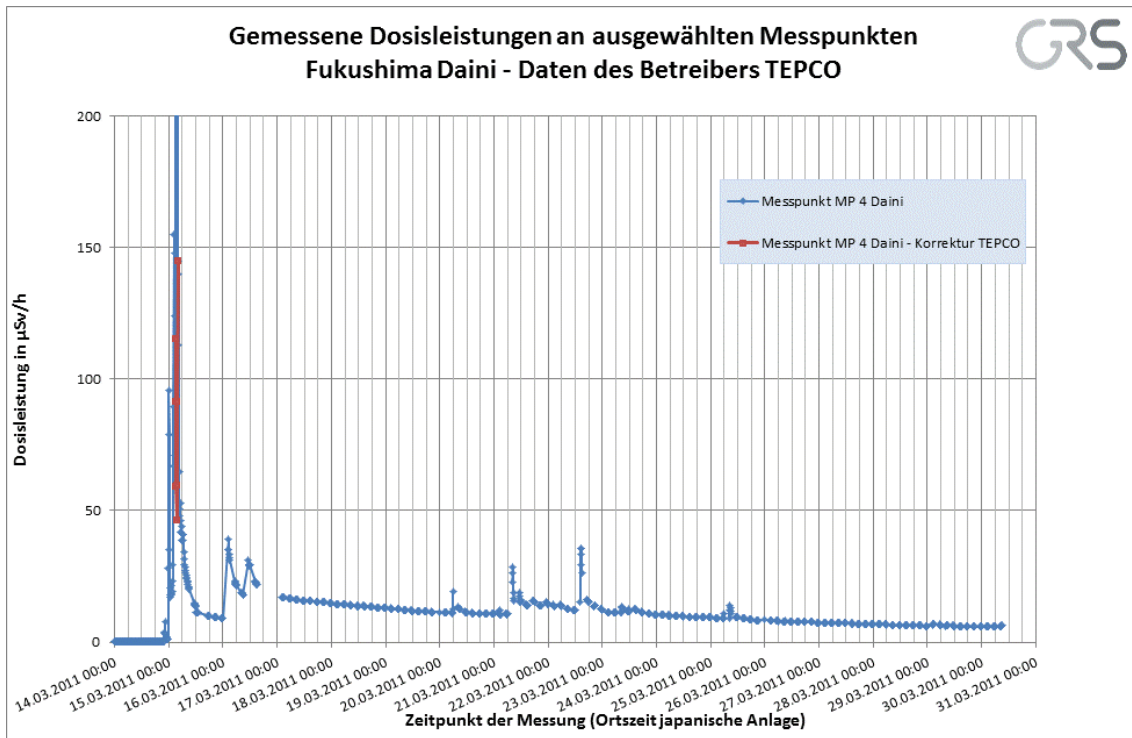


Figure 2 (all times local time)

Dose rates measured in selected measuring locations (MP) at Fukushima Daini – Data provided by the operator TEPCO

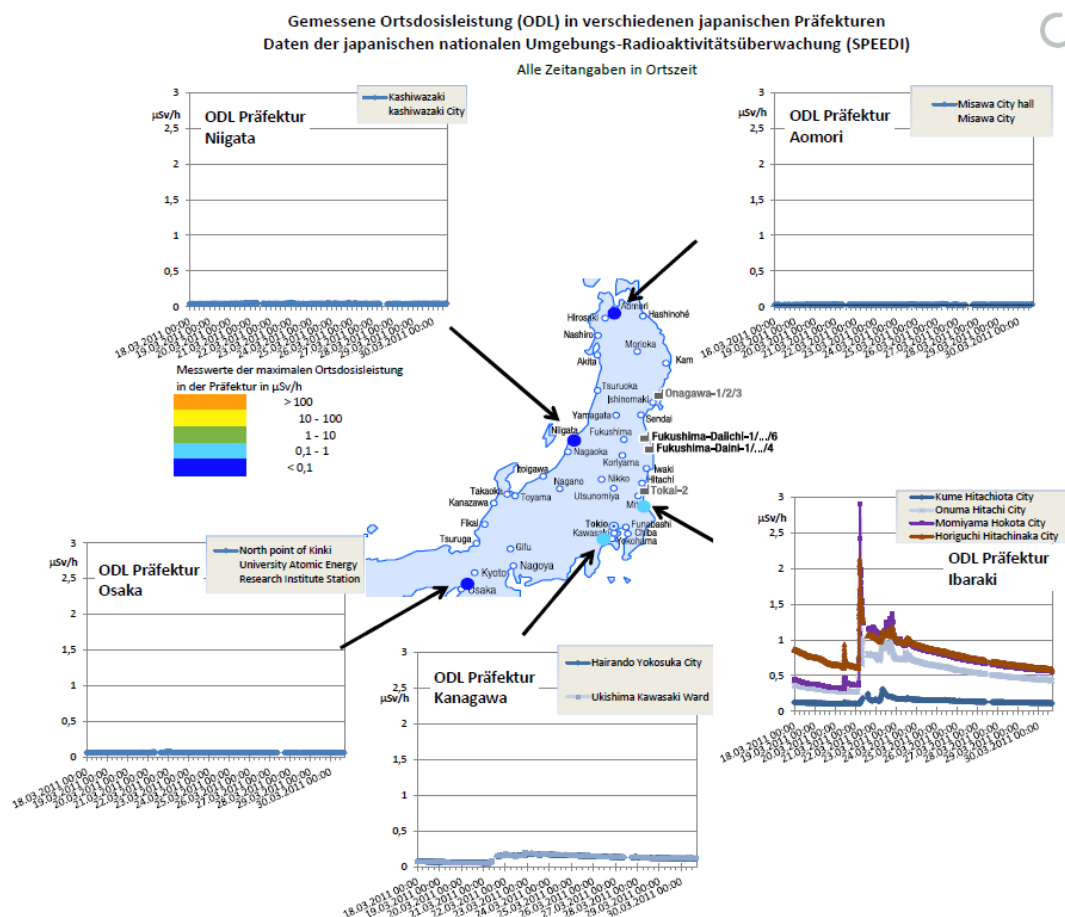


Figure 3 (all times local time)

Local dose rates measured in different Japanese prefectures – Data provided by the Japanese national environmental radioactivity monitoring system (SPEEDI)

4 Brief overview of the current safety situation

GRS is not in a position to judge on the basis of the information available to what extent the measured values indicated (pressures, temperatures, water levels) are reliable or incorrect.

Name	Power	Current status Confirmed: report by operator or NISA – unconfirmed: more detailed press report
Fukushima I (Daiichi 1)	460 MWe, 1380 MW _{therm}	<p>- Condition of core and building structures: Core damage assumed, containment intact. Depressurisation of reactor carried out. Containment venting carried out. Hydrogen explosion on 12-03-2011 at 15:36 h. Severe structural damage to reactor building. According to TBS (Japanese TV station), presumably 70% of fuel assemblies damaged.</p> <p>- Condition of feeding/injection: Electrical power supply via mobile generators. Flooding of reactor with sea water. Sea water injection into containment via pipes of fire water system since 13-03-2011, 11:55 h (temporarily interrupted on 14-03-2011 at 1:10 due to water shortage in the sea water pool). Since 23-03-2011 as from 2:33 h, the RPV has additionally been fed via the feedwater line. An external electricity supply for supplying control room lights and the illumination of several instruments has been established. Since 29-03-2011, 8:32 h, injection into the RPV, which has been switched over to freshwater, has been carried out by a provisional electrically driven pump. The injection amount is monitored by a flow meter.</p> <p>- Important plant parameters (time of measurement always 29-03-2011, 13:00 h): Amount injected into the RPV: 133 l/min (29-03-2011, 8:32 h) Reactor pressure: 0.371 MPa (measuring location A), 0.491 MPa (measuring location B) [overpressure]</p>

		<p>Water level in the reactor: 1650 mm/1600 mm below upper core edge (measuring location A and measuring location B) RPV temperature at the feedwater nozzle / at the lower plenum; 299.4 °C / 135.8 °C Containment pressure: 0.265 MPa Pressure suppression pool pressure: 0.265 MPa, water temperature unknown Dose rate in the containment / pressure suppression pool: 33.8 Sv/h / 19.7 Sv/h</p> <p>- Information on fuel pool: Asahi with reference to TEPCO: - 292 fuel assemblies (1 core consisting of 400 fuel assemblies (source: TEPCO)) - Heat output: approx. 60 kW - Volume 1020 m²</p> <p>No information available on the condition of the fuel assemblies in the fuel pool.</p>
Fukushima I (Daiichi 2)	784 MWe, 2381 MW _{therm}	<p>- Condition of core and building structures: According to information by NISA, an evaluation by TEPCO on 14-03-2011 at 22:14 h shows core damage to be "less than 5%", according to Kyodo on 15-03-2011, TEPCO reports that approx. 33% of the fuel assemblies are damaged. Containment damaged (pressure suppression pool). Depressurisation of reactor carried out. Containment venting carried out. Hydrogen explosion on 15-03-2011 at 6:20 h. Structural damage to reactor building. An external electricity supply for supplying control room lights and the illumination of several instruments has been established. Since 27-03-2011, 18:31 h, injection into the RPV, which had previously been switched over to freshwater, has been carried out by a provisional electrically driven pump. The injection amount is monitored by a flow meter.</p> <p>- Condition of feeding/injection: Electrical power supply via mobile generators. Sea water injection into containment via pipes of fire water system since 14-03-2011, 22:50 h.</p> <p>- Important plant parameters (time of measurement always 29-03-2011, 13:00 h): Amount injected into the RPV: 117 l/min (28-03-2011 00:12 h) Reactor pressure: 0.025 MPa (measuring location A), 0.025 MPa (measuring location B) [overpressure] Water level in the reactor: 1500 mm below upper core edge (measuring location A, measuring location B not available) RPV temperature at the feedwater nozzle / at the lower plenum; 160.5 °C / 143.6 °C</p>

		<p>Containment pressure: 0.100 MPa Pressure suppression pool pressure: below measuring range (under scrutiny), water temperature unknown Dose rate in the containment / pressure suppression pool: 40.5 Sv/h / 1.33 Sv/h</p> <p>Pressure suppression pool: pressure below measuring range, water temperature unknown - Information on fuel pool: Asahi with reference to TEPCO: - 587 fuel assemblies (1 core consisting of 548 fuel assemblies (source: TEPCO)) - Heat output: approx. 400 kW - Volume 1425 m³ - No information available on the condition of the fuel assemblies in the fuel pool. - Temperature 46 °C (29-03-2011, 13:00 h)</p>
Fukushima I (Daiichi 3)	784 MWe, 2381 MW _{therm}	<p>- Condition of core and building structures: Core damage assumed. Depressurisation of reactor carried out. Containment venting carried out. Hydrogen explosion on 14-03-2011 at 11:00 h. Severe structural damage to reactor building. Containment not damaged (JAIF 24-03-2011, 10:00 h). White smoke or vapour visible since 16-03-2011, 11:45 h.</p> <p>- Condition of feeding/injection: Electrical power supply via mobile generators. Flooding with sea water. Freshwater injection into the containment via pipes of fire water system since 13-03-2011, 11:55 h. Since 13:12 h on 13-03-2011, sea water has been injected (temporarily interrupted on 14-03-2011 from 1:10 h until 3:20 h due to water shortage in the sea water pool). An external electricity supply for supplying control room lights and the illumination of several instruments has been established. Intermittent injection into the fuel pool has been taking place since 27-03-2011 by means of a truck-mounted concrete pump; since 29-03-2011, freshwater has been intermittently injected. Since 28-03-2011, 20:30, injection into the RPV, which had previously been switched over to freshwater, has been carried out by a provisional electrically driven pump. The injection amount is monitored by a flow meter.</p> <p>- Important plant parameters (time of measurement always 29-03-2011, 12:00 h): Amount injected into the RPV: 200 l/min (28-03-2011 20:32 h) Reactor pressure: 0.029 MPa (measuring location A), 0.095 MPa (measuring location C) [overpressure] Water level in the reactor: 1850 mm (measuring location A) and 2250 mm (measuring location B), respectively, below upper core edge RPV temperature at the feedwater nozzle / at the lower plenum; 62.2 °C (under scrutiny) / 121.1 °C</p>

		<p>Containment pressure: 0.1075 MPa Pressure suppression pool pressure: 0.1796 MPa, water temperature unknown Dose rate in the containment / pressure suppression pool: 28.6 Sv/h / 1.16 Sv/h</p> <p>- Information on fuel pool: Asahi with reference to TEPCO: - 514 fuel assemblies (1 core consisting of 548 fuel assemblies (source: TEPCO)) - Heat output: approx. 200 kW - Volume 1425 m² - Suspected fuel assembly damage</p>
Fukushima I (Daiichi 4)	784 MWe, 2381 MW _{therm}	<p>Unit was shut down before the earthquake. Core had been fully unloaded from the reactor. Hydrogen explosion in the reactor building (fuel pool). Damage to the reactor building (15-03-2011 at 6:40 h) First fire in reactor building on 15-03-2011 at 9:38 h, ending at 11:00 h. Second fire on 15-03-2011 at 5:45 h, no longer visible from the plant premises at 6:15. According to press reports, the pool could not yet be refilled again. Attempts to do so by means of helicopter and fire engines. Intermittent injection into the fuel pool has been taking place since 22-03-2011 by means of a truck-mounted concrete pump. An external electricity supply for supplying control room lights and the illumination of several instruments has been established.</p> <p>Number of fuel assemblies in the core: 0 - Information on fuel pool: Asahi with reference to TEPCO: - 1331 fuel assemblies, 1 core consisting of 548 fuel assemblies, there are presently no fuel assemblies stored inside the reactor (source: TEPCO)) - Heat output: approx. 2000 kW - Volume 1425 m² - Suspected fuel assembly damage - Temperature: faulty indication</p>
Fukushima I (Daiichi 5)	784 MWe, 2381 MW _{therm}	<p>Unit was shut down before the earthquake, according to information by ENSI on 03-01-2011. Core in the reactor. Since 20-03-2011, 14:30 in cold shutdown condition. Residual-heat removal takes place alternately from the RPV and the fuel pool. External electricity supply is available.</p> <p>- Important plant parameters (measuring time always 29-03-2011, 14:00 h): Water level in the reactor: 2346 mm above upper core edge Reactor pressure: 0.009 MPa [overpressure]</p>

		<p>Water temperature in the reactor: 40.5 °C Containment pressure: unknown Pressure suppression pool water temperature unknown Pressure suppression pool pressure: unknown Emergency power supply from Unit 6 as of 19-03-2011, 4:22 h.</p> <p>- Information on fuel pool: Residual-heat removal system in operation again on 19-03-2011, 5:00 h. Temperature on 29-03-2011 at 6:00 h: 37.1 °C</p> <p>Asahi with reference to TEPCO: - 946 fuel assemblies (1 core consisting of 548 fuel assemblies (source: TEPCO)) - Heat output: approx. 700 kW - Volume 1425 m² - No fuel assembly damage</p>
<p>Fukushima I (Daiichi 6)</p>	<p>1100 MWe, 3293 MW_{therm}</p>	<p>Unit was shut down before the earthquake, according to information by ENSI on 12-08-2010. Core in the reactor. Since 20-03-2011, 14:30 in cold shutdown condition. Residual-heat removal takes place alternately from the RPV and the fuel pool. External electricity supply is available.</p> <p>- Important plant parameters (measuring time always 29-03-2011, 14:00 h): Water level in the reactor: 1858 mm above upper core edge Reactor pressure: 0.005 MPa [overpressure] Water temperature in the reactor: 30.3 °C Containment pressure: unknown Pressure suppression pool water temperature: unknown Pressure suppression pool pressure: unknown</p> <p>- Information on fuel pool: Temperature on 29-03-2011 at 14:00 h: 21.5 °C</p> <p>Asahi with reference to TEPCO: - 876 fuel assemblies (1 core consisting of 764 fuel assemblies (source: TEPCO)) - Heat output: approx. 600 kW - Volume 1497 m² - No fuel assembly damage</p>

Fukushima II (Daini 1)	1100 MWe, 3293 MW _{therm}	<p>No containment venting. External electricity supply, plant state subcritical cold since 14-03-2011.</p> <p>- Important plant parameters (measuring time always 29-03-2011, 12:00 h):</p> <p>Reactor pressure: 0.15 MPa [absolute pressure]</p> <p>Reactor water temperature: 27.2 °C</p> <p>Water level in the reactor: 9.296 m above upper core edge</p> <p>Pressure suppression pool water temperature: 24 °C</p> <p>Pressure suppression pool pressure: 107 kPa</p>
Fukushima II (Daini 2)	1100 MWe, 3293 MW _{therm}	<p>No containment venting. External electricity supply, plant state subcritical cold since 14-03-2011.</p> <p>- Important plant parameters (measuring time always 29-03-2011, 12:00 h):</p> <p>Reactor pressure: 0.13 MPa [absolute pressure]</p> <p>Reactor water temperature: 27.7 °C</p> <p>Water level in the reactor: 10.296 m above upper core edge</p> <p>Pressure suppression pool water temperature: 25 °C</p> <p>Pressure suppression pool pressure: 106 kPa</p>
Fukushima II (Daini 3)	1100 MWe, 3293 MW _{therm}	<p>No containment venting. External electricity supply, plant state subcritical cold since 12-03-2011.</p> <p>- Important plant parameters (measuring time always 29-03-2011, 12:00 h):</p> <p>Reactor pressure: 0.10 MPa [absolute pressure]</p> <p>Reactor water temperature: 39.2 °C</p> <p>Water level in the reactor: 7.832 m above upper core edge</p> <p>Pressure suppression pool water temperature: 26 °C</p> <p>Pressure suppression pool pressure: 103 kPa</p>
Fukushima II (Daini 4)	1100 MWe, 3293 MW _{therm}	<p>No containment venting. External electricity supply, plant state subcritical cold since 15-03-2011.</p> <p>- Important plant parameters (measuring time always 29-03-2011, 12:00 h):</p> <p>Reactor pressure: 0.11 MPa [absolute pressure]</p> <p>Reactor water temperature: 34.0 °C</p> <p>Water level in the reactor: 8.036 m above upper core edge</p> <p>Pressure suppression pool water temperature: 26 °C</p> <p>Pressure suppression pool pressure: 102 kPa</p>

Onagawa 1	524 MWe	All 3 units are in cold shutdown (below 100 °C) condition. The plant is currently being inspected.
Onagawa 2	825 MWe	
Onagawa 3	825 MWe	
Tokai 2	1100 MWe, 3293 MW _{therm}	Plant in safe cold shutdown condition.

MWe: electrical power, MW_{therm}: thermal power

GRS, stl, wez, 30-03-2011, 10:20 h