

The update of the Fukushima Daiichi Nuclear Station accident (March 11 through May 31, 2011)

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Abstract: The unprecedentedly massive earthquake and tsunami hit the Fukushima Daiichi Nuclear Power Station (the Fukushima Daiichi), operated by Tokyo Electric Power Company (TEPCO), in Fukushima Prefecture on March 11, 2011. Two months later TEPCO revealed that No.1, 2 and 3 reactors had melted at the level 7 on the rank of International Nuclear and Radiological Events (INES) scale, as par with the Chernobyl accident in 1986. Complexities of the Fukushima Daiichi's fiasco have grappled with those of question including nuclear safety standard, reactor and backup safety technology, radioactive disaster and contamination on land and at sea, spread of false rumors at home and abroad and also nuclear governance risks. The accident is a huge challenge we have to deal with immediately. A ground-breaking public awareness embraces fundamental change in nuclear world. Foremost rethinking is required to combine a smaller or zero growth of nuclear electricity with a safer world in the future.

Keyword: Fukushima Daiichi accident; earthquake; tsunami; severe accident; environmental contamination

1 Introduction

The massive earthquake hit the northeastern Japan with the magnitude of 8.8 (later adjusted at 9.0) in Richter scale at 14:46 of March 11, 2011, according to the Japan Meteorological Agency. And then high tsunami waves struck the Fukushima Daiichi Nuclear Power Stations (the Fukushima Daiichi), 170 miles north of Tokyo. While there were total eleven nuclear reactors of four nuclear power stations on stream at that time in Miyagi, Fukushima and Ibaraki prefectures, all of which were heavily affected by the quake and tsunami, and all reactors automatically halted operations.

Here below is the report on the chronological update of the Fukushima Daiichi nuclear power station accident by live-archives approach in a neutral and objective manner, with some author's remarks, as illustrated in a square circle, all of which coverage is from March 11 through May 31, 2011. All of news sources quoted herein are from the press release of the Nuclear and Industrial Safety Agency (NISA) of the Ministry of Economy Trade and Industry (METI), Tokyo Electric Power Company (TEPCO), and the NHK (Japan Broadcasting Corporation) online news service, which monitors the statements and press

conferences of Chief Cabinet Minister, and other relevant organization.

2 Initial one month after big quake

March 11, 2011 Local Time

14:46 NISA set up the Emergency Preparedness Headquarters (Tokyo) immediately after the earthquake.

15:42 and 16:36 TEPCO submitted the situation report to NISA in accordance with the Act on Special Measures Concerning Nuclear Emergency Preparedness.

19:03 Government declared the state of nuclear emergency.

20:50 Fukushima prefecture issued a directive that the residents living in the area of 2km radius from No.1 reactor must evacuate.

21:23 Residents living in the area of 3km radius from No. 1 reactor must evacuate. Residents living in the area of 10km radius must take sheltering.

Rolling blackout program in TEPCO's service area was activated, due to the Fukushima Daiichi accident,

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which accounted for total 3.8 million households who were out of power.

March 12, 2011

05:44 Residents living in the area of 10km radius from No.1 reactor had to evacuate by the Direction of Prime Minister.

The seawater injections started at both No.1 and 3 reactors of the Fukushima Daiichi, by use of seawater.

06:50 Workers who were working at No. 3 reactor temporally evacuated because of pressure increase at the containment vessel.

15:36 Hydrogen explosion occurred at No.1 reactor.

18:25 Prime Minister directed evacuation of the residents living within the 20km radius from the Fukushima Daiichi.

19:55 Directive of Prime Minister was issued regarding sea water injection to No.1 reactor.

20:05 The government ordered to inject sea water into No.1 reactor of the Fukushima Daiichi.

March 13, 2011

5:38 NISA announced that No.3 reactor was at the specific emergency stage with the loss of all coolant injection functions.

TEPCO tried to recover electric power source, coolant injection function, and vent for reducing the pressure of reactor pressure vessel (RPV).

09:08 Pressure suppression in the Containment Vessel and fresh water injection started at No.3 reactor.

09:20 Opening of Pressure vent valve of No.3 reactor.

13:12 Fresh water injection was switched to sea water injection at No.3 reactor.

March 14, 2011

TEPCO reported NISA that there was an explosion at No.3 reactor at 11:01. According to TEPCO, the containment vessel of the unit was not broken.

Residents living within the area at least 20 km radius from Fukushima Daiichi were requested to shelter in buildings or houses.

TEPCO reported to NISA that one person was injured at Fukushima Daiichi at this time.

Around 16:25 the core cooling ability was lost at No.2 reactor of the Fukushima Daiichi.

Around 16:25, the NISA announced that the reactor core had been cooled with Reactor Core Isolation Cooling System (RCIC). The RCIC was stopped after the increase of containment vessel pressure. The pressure of the reactor pressure vessel reached at 7 MPa. TEPCO then prepared for decreasing pressure inside the reactor pressure vessel by opening pressure relief valve to the containment vessel and the valve for venting the containment vessel.

20:40 TEPCO announced the status of No. 2 reactor so that seawater injection started after water level fell until the top of fuel rods. TEPCO announced that they confirmed that seawater could pour into the reactor on the basis of certain data. However, water level continued to fall. Given this situation, TEPCO prepared to open the valve for venting into the containment vessel.

20:50 TEPCO announced that they conjectured that some fuel rods were broken on the basis of the response of radiation detectors in the environment. Some news said that the reactor vessel had dried out temporarily.

March 15, 2011

The Prime Minister, Naoto Kan, appealed to the all Japanese people in media as saying that;

- Please receive my message by calm manner
- All the nuclear reactors were shut down normally but all the diesel generators to cool the reactors were not functioned because of the earthquake and Tsunami
- I ask all the people living within 20 km of the power station to evacuate

- I also would like to ask people who live in between 20 km and 30km from the power station to stay in house
- We will try our best not to release radioactive nuclides further. TEPCO will try their best to inject water, while braving the risk. I am sorry that I have caused so many worries

Tatsuo Edano, Chief Cabinet Minister, briefed at the press conference that;

- Fire broke at the No.4 reactor
- It is presumed that the suppression pool is partially damaged and small amount of radionuclide released from the flaw
- Water injection continues at the No.1, 2 and 3 reactors. The first priority is to maintain this status and handle the issue of No 4 reactor

08:00 the NISA explained the status of the No.2 reactor that sound of explosion was heard. At the same time TEPCO also announced that explosion was heard around 06:10.

22:00 the Nuclear Reactor Regulation Act has been activated, which ordered the TEPCO to start water injection as soon as possible for the spent fuel pool at No.4 reactor.

March 16, 2011

The Chief Cabinet Minister announced in a press conference that;

White fume from the No.3 reactor was observed. Radiation monitors at the site boundary of the No.3 reactor was increasing to an order of mille Sv/hr around 10:00. At the No.4, 5 and 6 reactors, water temperature in the spent fuel pool was increasing also at the No.5 and 6 reactors.

March 17, 2011

All of six fire engines began spraying water to cool the Reactor No.3 of Fukushima Daiichi.

Those fire engines were all outsourced, and provided by Japan Self Defense Force (SDF), Tokyo Fire Department and even by US Forces.

March 18, 2011

The NISA rated the Fukushima Daiichi accident as level 5 by the International Nuclear and Radiological Event Scale (INES).

March 19, 2011

At 14:00 March 19, the NISA announced that radiation monitor at the No. 3 reactor showed 3,443 micro Sieberts per hour, but later fell to 2,906 micro Sieberts.

March 20, 2011

The operation started at the No.4 reactor to fill the spent fuel pool with water. Throughout the operation 80 tons of water had been sprayed by the Japan Self-Defense Forces (SDF) with 11 fire engines.

Ministry of Defense measured the surface temperature of the No.1, 2, 3 and 4 reactors from the sky using helicopter. The SDF conducted the operation of spraying water to the spent fuel pool in the No.4 reactor two times. Total amount of sprayed water was 160 ton.

March 21, 2011

Tokyo Fire Department's task force had finished injecting water to the spent fuel pool in the No. 3 reactor after 6.5 hours operation. Then, the Self-Defense Force conducted the operation of injecting water to the spent fuel pool in the No.4 reactor.

Prime Minister Kan ordered the governors of Fukushima, Ibaraki, Tochigi and Gunma prefectures that shipment of their produced vegetables should be restricted "for the time being". The shipment of milk from Fukushima prefecture was also restricted.

The TEPCO's work to recover external AC power was in progress at the No.1 to 6 reactors.

March 22, 2011

The Tokyo Fire Department started operation of spraying water to the No.3 reactor with cooperation of the Osaka Fire Department.

Defense Minister Toshimi Kitazawa announced that operation of measuring surface temperature by the helicopter of self-defense force would be conducted every day since smoke had risen from the No.2 and 3 reactors.

The spent fuel pools lost cooling function at the No.3 and 4 reactors. The Self-Defense Force and Tokyo Fire Department cooperated to spray water to fill the spent fuel pools in the both reactors.

The TEPCO's Fukushima office announced that radioactive nuclides such as iodine and cesium were detected from the seawater samples taken several to 10 km away from the power station.

March 23, 2011

The operation to inject water to the spent fuel pool of the No.4 reactor had started with "special vehicle" which has a long arm to pour water from high to a target. Core cooling function was enhanced by increasing the number of injection lines.

The work to recover external AC power for the No.1, 2, 3 and 4 reactors was also in progress.

NISA firstly announced the projection of radioactive release calculated by the SPEEDI simulation.

March 24, 2011

All restoration works at the No.1, 2, 3 and 4 reactors were suspended because black smoke rose up from the No.3 reactor. Nuclear and Industrial Safety Agency (NISA) announced that 3 persons were exposed to radiation.

The Self Defense Force and U.S forces made decision to consolidate a system to feed freshwater from barge ships of U.S forces.

March 25, 2011

Kyushu Electric Power Company who delivers electric power in Kyushu area announced that it had decided to suspend the restart of two nuclear reactors for a while in view of the accident at the Fukushima Daiichi.

March 28, 2011

At the No.1 reactor, the roof of the reactor building had collapsed after hydrogen explosion.

NISA announced that the contaminated water with radioactive material possibly the molten nuclear fuel reached outside of the containment vessel.

The water found in the turbine building of the No.2 reactor contained radioactive material 100,000 times of the normal operation. The seawater contained radioactive iodine-131 in excess of the legal standard by 1,150 times. The TEPCO said that the 16 tons of water had been injected into the reactor every hour but TEPCO wanted to reduce the amount to 7 tons.

March 29, 2011

The TEPCO revealed that plutonium was found in soil samples from the Fukushima Daiichi.

The contaminated water was found leaking from the reactors to fill in the tunnels linking the reactor buildings to the outside of the damaged Fukushima Daiichi. Very high level of radiation was measured in the contaminated water running into a trench just outside of the turbine building for one of the reactors.

March 30, 2011

The Chairman of TEPCO, Tsunehisa Katsumata, announced at his first press conference since the March 11th reactor accident, that the company considered the decommissioning all the Nos. 1-4 reactors to be inevitable. Katsumata took over the stricken TEPCO's leadership from Masataka Shimizu, President of TEPCO, after his hospitalization amid mounting concerns over mounting hardship facing the TEPCO.

Prime Minister, Naoto Kan, got an assurance of American support by a telephone conversation with the U.S. President Barack Obama. The United States had already agreed to send several radiation-detecting robots to Japan to help explore the status of the reactor cores and spent fuel pools in the damaged nuclear plant.

NISA announced that radioactive air might be leaking from the No 2 and No 3 reactors, and also that radioactive iodine and cesium had been found in sea water.

The AREVA's CEO, Anne Lauvergeon, arrived in Tokyo, together with five experts to provide technical assistance to the operator of the Fukushima nuclear power station.

March 31, 2011

The International Atomic Energy Agency (IAEA) reported that they detected the radiation level twice as high as its criterion for evacuation in a village 40 kilometers apart from the troubled Fukushima Daiichi.

TEPCO began to transfer about 150 tons of contaminated water from the tunnel of No.1 reactor to a storage tank.

April 1, 2011

Prime Minister Naoto Kan and French President Nicolas Sarkozy, agreed in Tokyo that they will cooperate in crafting new international nuclear safety standards by the end of this year.

Sarkozy said that the problem with nuclear energy is "there are no global common rules", at the joint press conference after their fifty minutes talks. Sarkozy visited Japan, as the president of France and chair of both G-8 and G-20.

Anne Lauvergeon, CEO of AREVA, visited to Economy, Trade and Industry Minister, Banri Kaieda. Kaieda thanked Lauvergeon for AREVA's donation of radiation protective suits and masks.

Lauvergeon said that the AREVA delegation heading for Japan includes specialists on the disposal of radioactive water and spent nuclear fuel.

Describing the current crisis as "the complicated problem human never experienced," the CEO said the situation is "very serious" and that it will take time for the contingency to be under control. The CEO's visit coincided with French President Nicolas Sarkozy's trip to Tokyo.

Singapore also announced that it had banned imports of vegetables and fruits from central Japan due to radioactive contamination.

Contaminated radioactivity exceeding the safety standards had been detected in beef from Fukushima and vegetables from Ibaraki, Tochigi and Chiba prefectures.

The US Energy Secretary Steven Chu told reporters in Washington, that about seventy percent of the core

of a reactor had been damaged, and that another reactor had undergone a 33 percent meltdown, which came from forensic modeling.

April 2, 2011

TEPCO told that it had identified for the first time a place where high-level radioactive water was leaking into the ocean from the No. 2 reactor.

The International Atomic Energy Agency announced that radiation levels in Iitate village 40 kilometers from the Fukushima Daiichi, had dropped below the criterion for evacuation.

A barge provided by the US Navy was preparing to pump large volumes of fresh water by hose to a water tank near the No.1 reactor.

April 3, 2011

Highly radioactive water continued to leak into the sea through a crack in a pit at the troubled Fukushima Daiichi.

April 4, 2011

The chief executive of General Electric (GE), Jeffrey Immelt, met with METI Minister Banri Kaieda, in Tokyo, to be attended by Hitachi President Hiroaki Nakanishi.

TEPCO poured a polymer absorbent into a duct leading to the pit in the hope of blocking the leak.

Chief Cabinet Secretary Yukio Edano indicated that an independent body should be set up to investigate the accident at the Fukushima Daiichi.

Yukio Edano also announced that recent checkups had found no problems in the thyroid of children in the area near the troubled Fukushima Daiichi.

The government of Fukushima Prefecture began free monitoring of local industrial products for radiation following the leaks from the Fukushima Daiichi.

April 5, 2011

Republic of Korea or South Korea has expressed concern over Japan's release of contaminated water into the sea from the troubled Fukushima Daiichi.

The Japanese government held the joint seminar with the International Atomic Energy Agency on the sidelines of the 10-day safety review in Vienna.

April 6, 2011

TEPCO began dumping thousands of tons of relatively low level radioactive water into the sea, to make more storage space for increasing amounts of far more contaminated water.

Yukio Edano told at the news conference that it was an "inevitable step", and added that this decision was "very regrettable and we are very sorry"

A French nuclear safety institute called IRSN called for long-term monitoring of the Pacific Ocean off northeastern Japan following leaks of radioactive material from the Fukushima Daiichi.

Japanese fishermen demanded fair compensation from TEPCO, for damage to fish stocks caused by the company's release of radioactive wastewater into the sea.

April 7, 2011

The South Korean government protested that release of contaminated wastewater could violate the international law. There was a growing criticism in the country that Japan did not notify the neighboring countries in advance about the release of contaminated water.

Foreign Minister Takeaki Matsumoto spoke to reporters, in response to the South Korean expression of concern on Monday. Matsumoto announced radioactive wastewater was released as an emergency measure in accordance with Japanese domestic law, and did not pose any significant health threat.

The largest after-quake of M7.1 since March 11, hit the northern coast of Honshu in Japan.

Power operations had been all knocked out at coastal nuclear power plants from Aomori to Ibaraki prefectures, while electricity was still crucial to keep their cooling systems operating. The plants switched to emergency diesel power generators.

The quake had shut down three lines of the total four external power lines at Onagawa nuclear power station in Miyagi Prefecture, where only one external line remained in place.

The quake disabled all external power lines at a nuclear fuel reprocessing plant in Aomori Prefecture. The cooling systems here are still running by emergency diesel power.

TEPCO continued to inject nitrogen gas into the containment vessel of the No.1 reactor without any problems. TEPCO said the injection was aimed at preventing hydrogen from exploding inside the containment vessel at the No. 1 reactor. TEPCO again detected a very small volume of plutonium in soil samples.

TEPCO said that at least 50,000 tons of wastewater contaminated with highly radioactive material had stored in reactor turbine buildings and outdoor trenches.

April 8, 2011

All of nuclear power plants and the related facilities in the coastal areas of northeastern Japan were forced to rely on emergency power after their electricity was cut off in Thursday by the earthquake in night of April 7.

All of external power lines at Higashidori nuclear power station in Aomori Prefecture were knocked out in Thursday's quake. TOHOKU said that the strong earthquake caused water to overflow from the spent fuel storage pools in one of its nuclear power plants.

April 9, 2011

The seawater radiation levels continued to rise in areas north of the plant. TEPCO detected 110 becquerels of radioactive iodine-131 per cubic centimeter in seawater samples collected 30 meters from the water outlets of their plants.

April 10, 2011

Nuclear and Industrial Safety Agency (NISA) disclosed that it put the upgrading of the Fukushima March 11 accident from the original level 5 to the level 7 that is the highest one of the International Nuclear and Radiological Event Scale (INES) . The

level 7 is the same level as that for Chernobyl accident.

TEPCO told that the tsunami of March 11 reached as high as 15 meters which was much higher than the TEPCO's originally estimated height of 5.7 meters.

Agriculture Minister Michihiko Kano said that the government would fully compensate farmers who could not afford to plant crops due to radioactive contamination of their rice paddies.

China government source said that it would expand its ban on agricultural imports from Japan due to public concerns about radioactive contamination in food following the problems by the Fukushima Daiichi.

April 12, 2011

TEPCO received a combined 2 trillion yen as the emergency loan provision from major banks.

April 13, 2011

Chinese Premier Wen Jiabao urged Japan's leader to disclose all necessary information on the crisis at the Fukushima Daiichi.

Korea government expressed deep concern about Japan's raising the severity level of the nuclear disaster to the highest INES level.

Author's Comments:

Although the amount of radioactive release is a lot less than ten percent of Chernobyl, the situation at Fukushima is still very serious. Things have not got worse at the station since March 11th, and conditions appear to be markedly more stable nowadays, although it was not completely under control.

Moreover other IAEA member countries had different opinions from Japanese parlous adherence of a previous level 5 accident, of which stern concern might be a pressure for Japanese authority to change, during the latest IAEA seminar at Vienna.

April 14, 2011

The government had detected radioactivity above the legal limit of the fish caught in the sea off Fukushima

Prefecture and of the 11 kinds of vegetables grown in the prefecture.

Because of radiation contamination, the Japanese government banned the shipment of some shiitake mushrooms grown outdoors in eastern Fukushima Prefecture.

April 15, 2011

The United States lifted its previous recommendation of voluntary evacuation for families of government employees living in Tokyo and other Japanese cities. The US State Department had earlier recommended that US citizens should avoid travel within 80 kilometer radius of the damaged power station.

April 16, 2011

The European Commission advised European ports to check radiation levels on ships and cargoes arriving from Japan to see whether or not they exceed a new limit.

3 One month later: the roadmap was issued

April 17, 2011

Urged by Government, TEPCO Chairman Tsunehisa Katsumata announced what is called Roadmap, i.e., a master plan to get the TEPCO's still unstable nuclear power stations under safely control in 6 to 9 months.

Concretely, the schedule plan of two-stage process was set in the roadmap. In the first stage of the next 3 months, TEPCO aimed to cool down the No.1 and 3 reactors in a stable manner to cover fuel rods with water by injecting water into the reactor vessels. The TEPCO also planned to establish the water recirculation system which could purify the contaminated water from the reactor vessel, remove the residual heat of reactor core by heat exchanger and return thus processed water back to the reactor vessel. Tsunehisa Katsumata also mentioned that TEPCO would contain the leakage of high radioactive water in the No. 2 reactor by finding and patching the damaged parts in the both vessels of reactor and containment.

In the second stage, TEPCO planned to stabilize the plant by cold standby condition, that is, to lower the

water temperature in the reactors below 100 degrees Celsius. Concerning radioactive release to the environment, TEPCO intended to set up water purification facilities to treat highly contaminated water. TEPCO also planned to wrap the whole reactor buildings by giant sheet covers in order to prevent the radioactive particles in the reactor building from diffusing into the air.

On the day, U.S. Secretary of State Hillary Rodham Clinton flew to Japan, met Prime Minister Naoto Kan and had tea with Emperor Akihito at the Imperial Palace.

April 18, 2011

TEPCO introduced the US-made remote-controlled robots in the 1st floor of the No. 1 and 3 reactors building to measure radiation levels, temperatures and oxygen densities.

April 19, 2011

The U.S made remote-controlled robots detected high radiation level inside the reactor buildings. This was the first publicized report on the condition of inside the reactor buildings since March 11.

The Japan Iron and Steel Federation decided to urge its member companies to measure radiation levels of their products during manufacturing to prove and guarantee that the products are free from radioactive contamination.

Russia lifted its guideline for travelers to Japan. A Japanese business representative in China called for a measured approach to the imported foods from Japan amid rising fears in China.

April 20, 2011

Anne Lauvergeon, CEO of AREVA, told reporters in Tokyo that AREVA will help TEPCO to build the facility to remove radioactivity from the contaminated water.

April 21, 2011

Prime Minister Kan and Prime Minister Gillard of Australia met in Tokyo and expressed the need to enhance their cooperation in the framework of the International Atomic Energy Agency (IAEA) to globally strengthen the safety standards of nuclear power generation.

April 22, 2011

The U.S. Nuclear Regulatory Commission mentioned that the conditions at the Fukushima Daiichi were "static but fragile" in the latest assessment of the nuclear emergency report.

TEPCO announced that the radioactive substances that leaked into the sea for over six days from April 1st were estimated as 4,700 terabecquerels.

April 23, 2011

Tens of thousands of farm animals had been abandoned in the evacuation zone surrounding the Fukushima Daiichi although many of them reportedly had already died.

April 24, 2011

The government banned people from entering the zone within a 20-kilometer radius from the Fukushima Dai-Ichi for reason of public health.

The prefectural government of Fukushima placed a limit within one hour a day on the use of 5 public parks in the prefecture due to high levels of radiation.

April 25, 2011

All of total six reactors in the Fukushima Daiichi were inter-connected with external power transmission lines. TEPCO began connecting the cables for the No.1 and No.2 reactors with the grid for the No.5 and No.6 reactors.

On the day, Japanese-made robots were announced to be introduced for inspecting the damaged Fukushima Daiichi. The robots were developed by research groups at Chiba Institute of Technology, Tohoku University and other institutions.

April 26, 2011

The city of Koriyama in Fukushima Prefecture planned to remove the contaminated topsoil from school grounds to allow children to resume outdoor activities.

April 27, 2011

TEPCO announced to revise that the estimated fuel damage ratio in the No.1 reactor was from 70 percent to 55 percent, while those in the No.2 and No.3 reactors by 5 percentage points each to 35 percent and 30 percent, respectively.

The education board of Fukushima Prefecture decided to distribute radiation monitors to local schools and kindergartens.

TEPCO announced that water may be leaking from the spent fuel pool of the No. 4 reactor. More than 1,500 spent fuel rods, the largest number at the site were stored in the pool. TEPCO began spraying chemical hardening agent over the Fukushima Daiichi site to prevent the spreading of radioactive dust.

April 28, 2011

TEPCO disclosed a plan of discharging safely highly radioactive water of nearly 70,000 tons from a storage and processing facility, to be conducted in collaboration with U.S. and French firms.

April 29, 2011

The U.S. Nuclear Regulatory Commission announced that the situation at the Fukushima Daiichi had "definitely improved" but should still require close monitoring.

April 30, 2011

The environment ministers of Japan, China, and South Korea met in Pusan, South Korea and agreed to step up their sharing of information to minimize the environmental impact of disasters.

The first group of foreign tourists arrived in the Tokyo Metropolitan area since the March 11th accident.

May 1, 2 and 3, 2011

Japan's Foreign Minister Takeaki Matsumoto urged the European Union to review its controls on imports from Japan.

May 4, 2011

TEPCO announced that they would utilize metal containers to store a lot of contaminated water with zeolite, a mineral product to absorb radioactive materials effectively.

Radiation levels 100 to 1,000 times above the normal level were detected in the seabed near the damaged Fukushima Daiichi.

May 6, 2011

The agriculture ministry announced that they would plant sunflowers on trial base by the end of May in the farms in Fukushima Prefecture where rice planting had been halted due to radioactive contamination.

Prime Minister Naoto Kan has requested to the Chubu Electric Power Company (CHUBU) in central Japan to suspend power operations of all the four reactors at the Hamaoka nuclear power station, due to the high risk of big earthquakes in 30 years.

Author's Comments:

Sunflower is said to have a capability of collecting radioactive cesium from the ground.

CHUBU, the owner of the Hamaoka nuclear station, operates No.4 and No.5 reactors, other than the No.3 reactor which is now offline for regular inspection. There were originally five nuclear reactors in total at Hamaoka, but No.1 and 2 reactors already stopped operation for decommissioning.

Prime Minister Naoto Kan's request to stop all nuclear power stations at Hamaoka for the moment is based on the projection by a science ministry panel on earthquake research that an 87-percent occurrence probability of a magnitude-8-class earthquake would hit the Hamaoka region within 30 years.

May 8, 2011

Chubu Electric Power Company's chairman Toshio Mita left for Qatar for negotiations to procure additional liquefied natural gas to be used for power generation.

May 10, 2011

TEPCO announced its additional 1 trillion yen expenditure program to procure fossil fuels for fossil power generators as well as for the commercial bonds and debt payment.

May 11, 2011

Chubu Electric Power Company announced that it would temporarily shut down the Hamaoka nuclear station, to respond to the request by Prime Minister Naoto Kan.

May 12, 2011

Prime Minister Naoto Kan thanked Chubu Electric Power Company for its quick decision to accept his request that power operations be suspended at the Hamaoka nuclear station. He also mentioned that all the rest nuclear power stations in Japan could continue operation after confirming their safety.

The prime minister stressed that Japan should change from nuclear and fossil fuels to natural energy such as solar and wind power and biomass fuels. He also pledged efforts to create a more energy-efficient society.

May 13, 2011

TEPCO admitted for the first time that the No. 1 reactor at the Fukushima Daiichi was in a state of "meltdown" that most of the fuel rods were likely to have melted down and fallen to the bottom of the reactor vessel to cause water leakage into the containment vessel.

A radioactive substance exceeding the state limit was detected in pasture grass and vegetables in Tochigi and Ibaraki prefectures.

The US Nuclear Regulatory Commission's executive director, Bill Borchardt announced in Washington that Fukushima Daiichi was not entirely stable.

The government decided the scheme of subsidizing for TEPCO to the compensation for nuclear disaster in Fukushima.

Radioactive substances above the legal limits were detected in tea leaves harvested in Kanagawa Prefecture.

Author's Comments:

About one third of 54 reactors in Japan will be shut down by late May due to the March 11 accident, which led to the suspension of 14 reactors, including the Fukushima Daiichi, and also the determent of operation resumption of 19 reactors that are currently offline under inspection.

Chubu Electric Power Company shut down 2 reactors among its 4 reactors at the Hamaoka. Naoto

Kan had requested to do so to avert another imminent earthquake. All of 35, or about two-thirds of Japan's commercial reactors will have been shut down by the end of upcoming May. Thus Japan will have about 75 percent of its reactors shutdown by this summer.

May 14, 2011

TEPCO announced an operation plan to transfer high radioactive water which had been pooled in the turbine building of the No.3 reactor in order to avoid contamination of the sea if spilled over from there.

Radioactive elements were detected in grass and vegetables in Tochigi and Ibaraki prefectures.

The last operating reactor at the Hamaoka nuclear power station stopped generating electricity as the last part of the process to suspend plant operation.

May 15, 2011

A massive hollow floating platform (barge) what is called "Mega-float" to transport and hold radioactive water from a troubled nuclear power station, started from Yokohama to Fukushima.

TEPCO discovered an estimated 3,000 tons of contaminated water in the basement of the damaged No.1 reactor building.

4 Two months later: the revised roadmap

May 17, 2011

Despite the latest finding of a meltdown in one of the three reactors, both the government and TEPCO pledge to stick to the initial timetable to bring the current nuclear crisis under control by January at the latest.

Prime Minister Naoto Kan told at a session of Budget Committee, House of Representatives that "There may be some changes to the methods (to stabilize the crisis) but I believe we can move forward with the plan without changing the timeline,".

Goshi Hosono, an adviser to Prime Minister Naoto Kan announced that the nuclear fuel in the reactor vessels might have largely melted "in the worst-case

scenario" presumably for both the No.2 and 3 reactors, not to mention the No.1 reactor.

The giant storage barge that is to be used to hold radioactive water arrived at a port near the Fukushima Daiichi. The steel mega-float, 136 meters long and 46 meters wide, can store up to 10,000 tons of water.

May 18, 2011

Workers entered the No.2 and 3 reactor building at the Fukushima Daiichi for the first time since March 11.

Farmers in Fukushima Prefecture demanded about 5.5 million dollars in compensation to the damages given by TEPCO's radioactive contamination.

May 19, 2011

Prime Minister Naoto Kan commented that the country's nuclear regulatory agency (NISA) must be independent from the industry ministry (METI).

May 20, 2011

Workers at the No.2 reactor found peak radiation levels of 50 milli-Sieverts per hour. Workers also experienced high humidity and intense heat, which would limit the work there only to 15 minutes. At the No.3 building the worker's team detected 160 to 170 milli-Sieverts of radiation per hour near a pipe connected to the reactor.

More than 90 percent of elementary and junior high schools in Fukushima City obliged to limit school children's outdoor activities in their athletic fields due to radiation-contaminated topsoil.

May 21, 2011

The Osaka Institute of Public Health announced that tiny amounts of cesium-134 and cesium-137 were found in samples collected at the rooftop of the institute.

May 22, 2011

Japanese Prime Minister Naoto Kan, Chinese Premier Wen Jiabao, and Republic of Korea President Lee Myung Bak met in Tokyo and announced the joint statement that the three countries reconfirm the utmost importance of strengthening the safety of nuclear plants and should continue to operate nuclear facilities safely with transparency.

The Japan, China and South Korean leaders decided to enhance information sharing on nuclear safety. The leaders agreed to work together to build a framework for early notification of emergencies, and to discuss how to promote information exchanges among experts.

The joint statement also stressed the importance of taking necessary measures based on scientific evidence in assessing the safety of trading products following nuclear accidents.

May 23, 2011

TEPCO admitted that fuel melted at the No.2 and No.3 reactors, in addition to the No.1. Reactor, which had been already admitted to fuel melt.

TEPCO continued the transfer of high radioactive water from the two reactor buildings to several storage facilities within the Fukushima Daiichi, but those facilities would be expected to be full within 3 or 4 days. About 47,000 tons of contaminated water had accumulated in the turbine buildings and utility tunnels.

May 24, 2011

The fields survey mission of the IAEA, headed by Mike Weightman arrived in Japan. The mission team comprising of eighteen members including U.S., France, Russia, UK, China, Korea and so on, had stayed for ten days to make research and interview in Fukushima and Tokyo.

The government decided to set up two state panels on the Fukushima Daiichi accident: the one is to investigate the accident, and the other to study the damage compensation issues including unfounded loss by spread of false rumors.

May 25, 2011

Chief Cabinet Secretary Yukio Edano told that the power usage restrictions would be in place from July 1 through September 22 for service areas of TEPCO, and to September 9 for the area of Tohoku Electric Power Company. The government had already called for a power-saving target of 15 percent.

The Japanese government had decided to set up a panel to investigate the accident of the Fukushima

Daiichi headed by Yotaro Hatamura, Professor Emeritus at the University of Tokyo.

May 26, 2011

Prime Minister Naoto Kan pledged at the G8 summit in Deauville in France that the highest-possible levels of safety for nuclear power, by sharing the lessons of the Fukushima accident in the international community, and to do so by joining hands with the International Atomic Energy Agency would be the top priority issue. The prime minister also declared that a policy of raising the ratio of solar and other renewable energies in Japan as a percentage of power generation from 9 percent to 20 percent by the next decade.

May 27, 2011

The eighteen nuclear experts from the IAEA, headed by Mike Weightman of UK, first visited nuclear facilities at the Fukushima Daiichi station followed by the Fukushima Daiichi including No.6 reactor.

The G8 leaders announced a declaration focusing on nuclear safety before wrapping up their 2-day summit in the French city of Deauville on Friday.

In the joint declaration, the leaders urge the IAEA to create new international standards for the construction and operation of nuclear power plants in areas of high risk, including threats posed by terrorism and earthquakes.

They also call on member countries to base trade and travel restrictions on scientific grounds, addressing import ban lift imposed by some countries on Japanese products after the nuclear accident.

May 28, 2011

TEPCO announced that Fukushima Daiichi had successfully restored cooling systems of the spent fuel pools in No.1, 2, 3 and 4 reactors.

May 29, 2011

Dairy farmers had begun moving cows out of a village in the evacuation zone.

TEPCO announced that the radioactivity level and humidity became the highest in the No.2 reactor building, and because of which the recovery

operation to enter the internal of the reactor building difficult to do.

May 30, 2011

TEPCO reported high levels of radioactive water had accumulated in the basement of No.1 reactor.

The science ministry warned that the accumulative radiation exposure level had exceeded the government limit for evacuation at the two locations more than 20 kilometers apart from the Fukushima Daiichi.

May 31, 2011

The government panel reviewing compensation for the Fukushima Daiichi had set up the guidelines for compensation payments for so-called rumor-induced damages and mental suffering of evacuees.

5 Closing remarks

5.1 Enormous magnitude of quake and tsunami

A nuclear safety engineer told that the earthquake magnitude of 9.0 was far beyond the assumed safety standard ever since Fukushima Daiichi nuclear power station had started forty years ago. The quake and tsunami damaged most of the generators and backup systems, harming the ability to cool down the reactors of the Fukushima Daiichi.

The tsunami walls either should have been built higher, or the generators should have been placed on higher ground to withstand the potential flooding, according to the U.S. experts. The actual plant exhibited complete weakness to withstand the violence of tsunami force, although the plant design met the safety standards both for the earthquake and tsunami set by the national regulation.

5.2 Reactors meltdown

In the mid-May two months later, TEPCO disclosed for the first time that most of the fuel rods in the No.1 reactor at the Fukushima Daiichi had dropped to the bottom of the pressure vessel 16 hours after the March 11 earthquake. Nine days later TEPCO admitted that both No.2 and 3 reactors had also melted.

The No. 1 reactor has lost its cooling system at the same time when the tsunami hit, and then the water

level in the pressure vessel fell down below the top of fuel rods. The temperature of the fuel rods is believed to have reached 2,800 degrees Celsius at this stage, and the meltdown advanced rapidly. Almost all the fuel rods might have been melted and have dropped to the bottom of the pressure vessel by 6:50 am on March 12.

Until March 14 after the Fukushima Daiichi accident, according to the New York Times, some U.S. nuclear experts had analyzed that the Fukushima Daiichi was presumably spinning out of control, and got worsened to the level 5 (as was Three Mile Island accident in 1979), and even might reach the level 7 (as was the Chernobyl disaster in 1986) by the rank of International Nuclear and Radiological Events scale (INES), due to the explosion at the No. 2, and 3 reactors and the fire twice at No.4 reactor in the spent fuel pool.

The government panel on the investigation of the Fukushima Daiichi accident, headed by Professor Yotaro Hatamura was set up in early June. He urged that his panel needs to answer convincingly to the public's questions. But he stressed the panel will not aim to clarify who are responsible for the accident. The panel's 4 teams will discuss the technical problems of the accident, background social issues, the national regulation system of nuclear safety and other issues.

5.3 Decision to use seawater

In wake of the Fukushima Daiichi accident, to avert melt-down, seawater flood in a last-ditch effort came after an explosion caused by hydrogen although the steel containment of the reactor remained in place. The decision to flood the reactor core with corrosive seawater, experts said, was an indication that TEPCO and Japanese authorities had probably decided to scrap the plant. That last attempt was called a "Hail Mary pass" as the New York Times Online reported March 14.

5.4 Roadmap to stabilize the Fukushima Daiichi

In mid-April one month after the quake, TEPCO publicized the first near-term roadmap of stabilizing timetable within 6-9 nine months, to ensure the evacuated inhabitants to return home safely. However,

two month later in mid-May the contents of the initial roadmap has been revised because of the difficulty of establishing even the makeshift cooling system of the damaged reactors as well as the management of abundant volumes of contaminated waters from the damaged containment vessels.

5.5 Evacuation of local residents and foreigners

The government ordered the evacuation of about 100 thousand residents who live within twenty km from the Fukushima Daiichi. Also, people living within the circle of twenty to thirty km from the Fukushima Daiichi were ordered to stay indoors. However, a village called Iitate which is 40 kilometers away from the Fukushima Daiichi, suffered from high level radioactivity, although it is located outside the evacuation zone.

At the early stage of the Fukushima Daiichi accident, due to the shortage of reliable information, foreign residents, visitors and tourists have felt in panic for fear of radioactivity. The U.S. embassy in Tokyo has advised to the U.S. citizen to leave outside fifty miles off the Fukushima Daiichi, until its ban lifted on April 20. A lot of foreign embassy staffs and families, including their nationals and tourists were encouraged to leave the metropolitan area, although it locates outside evacuation zones set forth by Japanese authorities.

5.6 Land and water contamination

Fallouts of radioactive substances diffused from the Fukushima Daiichi have contaminated the nearby land and sea, and even as far as Osaka, where tiny amounts of cesium-134 and cesium-137 were found in samples.

Ministry of Education and Science disclosed geographical air radiation maps on the day by day basis. For example, it was found 2.98 micro-Sieberts per hour at Iitate village in Fukushima Prefecture as of May 24. Most of schools in Fukushima City limit outdoor activities due to radiation-contaminated topsoil.

5.7 False rumors, claims and compensation

By the restriction of government, sales of vegetables, fruits and fishes subjected to radioactive exposure in

water and on land have been prohibited in Fukushima and nearby prefectures,

To compensate for the damages of fisherman, farmers and livestock due to the radioactive contamination by Fukushima Daiichi accident, a tentative finance scheme has been set forth by the TEPCO's account, which numerates huge amount of money, although a lot of claims are said to be unfounded claims caused by false rumors which are caused by fear against radioactive hazard.

More than twenty foreign countries has banned Japanese farm and fishery products import, and even machines and general merchandises with additional customs restriction to prevent from radioactive exposure and contamination.

In many inland cities of China, panic of buying salts occurred among local residents to mitigate radioactive contamination. In Gangwon of South Korea, schools were closed due to the fallouts of radioactive substances diluted out of the Fukushima Daiichi, South Korean news media reported.

In the joint statement in Tokyo on May 23, the leaders of Japan, China and South Korea has stressed the importance of taking necessary measures based on scientific evidence in assessing the safety of products.

5.8 Outsourced equipments

At the early stage of the Fukushima Daiichi accident, the Japan Self-Defense Force and the Tokyo Fire Department had cooperated in conducting operation of spraying water to cool the damaged reactors, fill in the spent fuel pools, store the abundant contaminated waters, *etc.* Fire-trucks, pumps, water barges and tanks, unmanned robots and other key hardware facilities and equipment have been outsourced from international firms of U.S, Russia, China, UK, including French AREVA with decontamination process equipment.

5.9 Inevitable switch to fossil fuels for electric power

According to the IEEJ, additional LNG and oil procurement as of the end of May 2011, account for 9.4-12.2 million ton and 140-160 k b/d, respectively

against those of last year level. This fact of switch to fossil fuels should meet the requirement of the electricity loss, due to the suspension of Hamaoka nuclear power station and the closure of Hirono coal-fired power station.

The head of CHUBU flew to Qatar to procure additional LNG shipment. The Russian Premier, Vladimir Putin swiftly proposed more Sakhalin LNG cargo as the relief for TEPCO's need of gas for electric power generation. Malaysia, Indonesia and Australia also pledge to supply more LNG cargoes. Kuwait proposed five million barrels per day supply of crude oil for Japan as the disaster relief with free charge. Saudi Arabia also intends to deliver crude oil to Japan for relief.

5.10 Regional cooperation for disaster prevention

The case of the Fukushima Daiichi accident raises a new scheme of regional cooperation in case of nuclear disaster, especially in East Asian regional partners of Japan, China, South Korea and Taiwan. The regional cooperation will be necessary for the joint training for disaster prevention and sharing of equipment and information.

5.11 International cooperation for nuclear safety

The Fukushima Daiichi accident has been recognized as a critical issue in the world today. Prime Minister Naoto Kan pledged at the G8 summit in Deauville in France in late May that nuclear safety is the highest priority issue so that the necessity of sharing the lessons learned from the Fukushima Daiichi accident among the international community.

5.12 The IAEA investigation team

The eighteen experts from the IAEA investigation team headed by Mike Weightman of UK, and other delegates from France, Russia, US, China, South Korea and other countries visited Tokyo since May 24 through early June. The IAEA team held hearings and interviews with METI/NISA officials. On May 27, they visited the Fukushima Daiichi as well as the Daini and interviewed with TEPCO officials. The final report was submitted at the IAEA ministerial meeting to be held in June 20 in Vienna.

5.13 Looming severe electricity shortage

The rolling black-out program by TEPCO in Kanto area including Tokyo had been activated at the first

stage of the accident in March 11, but after then it was suspended due to warm temperature and slumping economy.

However, in hot summer season with surging electricity demand outlook, TEPCO, TOHOKU and CHUBU should overcome the looming severe electricity shortage especially in late July through mid-August not only in Kanto and Tohoku Districts, but also in Chubu district and even as far as Kansai district.

Therefore in all demand sides, overall electricity saving and sharing, peak shift, and other nation-wide countermeasures are required to reduce electricity consumption in households, commercial shops, manufacturers, and public organization to avert the massive black-out.

Nomenclature

CEO	Chief Executive Officer
CHUBU	Chubu Electric Power Company
G8	The Group of Eight industrial countries
IAEA	International Atomic Energy Agency
IEEJ	Institute of Energy Economics of Japan
INES	International Nuclear and Radiological Event Scale
JAI	Japan Atomic Industry Forum
METI	Ministry of Economy, Trade and Industry
NISA	The Nuclear and Industrial Safety Agency
NHK	Nippon Hoso Kyokai (Japan Broadcasting Corporation)
SPEEDI	Systems for Prediction of Environmental Emergency Dose Information
TEPCO	Tokyo Electric Power Company
TOHOKU	Tohoku Electric Power Company