(Fukushima Prefecture)," in the meantime, stipulated as its decontamination policy that not only full-body decontamination (shower) but also decontamination by undressing, wipe-offs, hair washing, etc., be implemented depending on the specific body sites indicating high dose rates. Therefore, deliberations to raise the screening level had been based on a wrong understanding. However, at the time, it was more important to formulate policies for detailed decontamination methods (removal of clothes, wiping off, etc.) corresponding to doses (examination of the background of the Manual provisions stipulating the policy), rather than raising the screening level for whole-body decontamination (shower). Furthermore, it is conceivable that the NSC advice, which allowed for the 100,000 cpm screening level, as well as the order issued by the Director-General of the Local NERHQ based on that advice, might have been unnecessary. Rather, to the contrary, the advice and order posed problems. By simply raising the screening level to 100,000 cpm, no decontamination procedures were specified for those detected to have radiation levels of 13,000 cpm or higher but below 100,000 cpm, and left room for an interpretation that decontamination was not required for such people.

Regarding Problem (ii) the lack of communication, the cause of the incident is considered to be as; the low consciousness to the importance of relevant persons involved in communicating information (the person sending the order to the prefecture and the recipient), and lack of communication within the Local-NERHQ, or ERC Medical Treatment Squad, or among each other. This problem happened when the Local-NERHQ and the prefecture experienced a first-time large scale nuclear disaster that made them fall into disorder. In emergency situations such as this, it is vital to acknowledge the importance of sharing important information among the personnel in charge, to nominate a person, who is adept in coordinating the relevant administrative organizations, at the top of the emergency response department (team), and to take response measures in a unified manner among the related national and local administrative organizations. From this aspect, another problem was that a staff of the Ministry of Health, Labour and Welfare, who had been expected to take main roles as a person in charge at the Local NERHQ and coordinate discussions/arrangements between the ERC and prefectural staff, did not gather until March 21, 2011, at the Local-NERHQ.

(e) Standards for the use of school buildings and schoolyards

In the Interim Report three problems concerning use criteria of school buildings and schoolyards were pointed out as remaining (Interim Report Chapter VII. 5. (6) b.). Investigation results of these problems are as follows:

The first problem was a question: "In setting a criterion for the use of schoolyards as the children's activity base, was it adequate to refer to the same value (20 mSv every year) in the criteria for designating the Deliberate Evacuation Area?"

As noted earlier in Chapter IV. 5. (2) a., MEXT announced its stance on April 19, 2011, with respect to criteria for the use of school buildings and schoolyards ("Provisional criteria for the judgment of the use of schoolyards and educational facilities ("Provisional Criteria")): restricting activities on schoolyards to about one hour per day at schools that have an air dose rate measuring 3.8 μSv/h (annually, this corresponds to the 20 mSv[13] that ICRP has established as the upper limit of the reference level for "existing exposure situations"[14]) or above; and permissible to continue using school buildings and schoolyards as usual at schools that have an air dose rate measuring below 3.8 μSv/h. This announcement raised criticisms and concerns about the lack of consideration for children by obviously allowing radiation exposure up to 20 mSv/year, or about the lack of sufficient prior explanations and publicity to the people in Fukushima Prefecture.

The Provisional Criteria were indeed problematic as: (i) the assumption of eight hours a day for schoolyard activities should be practically much shorter; (ii) the assumption of wood buildings (assumes the radiation dose rates are estimated as 0.4 times that of outdoors) for indoor activities but actually the school building structures are of concrete constructed with radiation dose rates inside estimated as 0.1 time that of outdoors; and (iii) radiation exposure on weekends should be lower unless one stays in high level radiation dose rate areas like schoolyards. Even if the air dose rate was 3.8 μSv/h in schoolyards, the actual exposure dose would be significantly lower. The problem was that there was no sufficient explanation for such background.

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[13] This value is based on an assumption that children spend eight hours of a day outdoors and 16 hours indoors (See Interim Report Chapter V. 5. (2) a.).

[14] See Interim Report Chapter V. 4 (1) b.

This 20 mSv/year was really a guidance value for formulating specific criteria of school buildings and schoolyards. But, certainly the MEXT explanations at the time might have been comprehended as if establishing the 20 mSv/year as a reference value for the use of school buildings and schoolyards. It is difficult to say that such an explanation could allay the strong sense of anxiety and unease toward radiation, and it was not appropriate from the point of view of risk communication, either. Furthermore, there is still room for debate as to whether it was appropriate to apply the upper limit of the value, that is used under "existing exposure situations," to school buildings and schoolyards that were used by children, who are generally considered to be more susceptible to the influence of radiation than adults (ICRP Pub60). Later on May 12, 2011, MEXT re-estimated an exposure dose that corresponded more closely to realistic living conditions, and set a figure of 10 mSv/year[15] or lower. This was set based on a condition, with safety margin, that children spent in outdoors six hours (including two hours in the schoolyards) on school days, and eight hours on weekends.

The second problem was a question: "There were areas where schools measuring 3.8 μSv/h (or 20 mSv a year) or more were concentrated. From the very beginning, should not those areas have been designated as a Deliberate Evacuation Area?"

According to the monitoring survey conducted in the beginning of April, there was a tendency that schools measuring 3.8 μSv/h or higher were concentrated in specific areas of Fukushima City, Nihonmatsu City and Koriyama City, etc.. MEXT conducted another monitoring survey to all the relevant schools on April 14. The result showed that still 16 schools had dose rate of 3.8 μSv/h or higher (dose rate at 50 cm above ground) in their schoolyards but in those schools' premises all the part covered by concrete showed the dose rates lower than 3.8μ Sv/h. According to the monitoring survey conducted outside the school premises at about the same time, there were only a few spots measuring the dose rates over 3.8 μSv/h, indicating that even schoolyard spots measuring high dose rates were localized without area-wise

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15 The calculation is based on the following assumptions: On each of 200 school days of a year, children spend one (1) hour to/from school, two (2) hours in the schoolyards, five (5) hours in the school building, three (3) hours outdoors after school and thirteen (13) hours; on each of the off-school days (131 days), they spend eight (8) hours outdoors, and sixteen (16) hours at home; the accumulated dose for 34 days from the day of accident to April 14 was 2.56 mSv; and the radioactive materials gradually deplete after April 14 onward (See Chapter IV. 5. (2) a.).

contamination, thus did not have the element (area-wise high dose rate contamination) to be designated as a Deliberate Evacuation Area.

The third problem was a question: "Schools measuring the dose rates lower than 3.8 μSv/h were allowed to use without any restrictions, but the level of 20 mSv a year is the maximum dose rate of 'existing exposure situations' recommended by the International Commission on Radiological Protection (ICRP), which leaves a question whether the new criteria were appropriate from a perspective of minimizing the radiation exposure to the extent possible."

In this country, the radiation exposure due to just natural radiation alone reaches around 2.1 mSv a year[16]. In a "planned exposure situations" without an accident like the latest one at the nuclear power station, the additional planned exposure to be acceptable is another 1 mSv a year (the public exposure dose limit during in the planned exposure situations, see the Interim Report Chapter V. 4. (1) b.). This means the 10 mSv a year is not a small number. It is said that the correlation between radiation dose rates and the probability of developing cancer is unknown under a low dose rate environment (Interim Report Chapter V. 4. (1) b.), and that, even if they have correlation, it is too small to observe significant increases. However, even so, the government should not feel satisfied in a figure of 10 mSv/year, but should have put in place policies to reduce the exposure dose to the extent possible[17], in consideration of the fact that a greater impact of radiation is anticipated on children than on adults (ICRP Pub60)[18], and the ICRP recommendation seeks a reduction, as much as possible (optimization of protection, See Chapter V. 4. (1) b. in the Interim Report), of the exposure dose under reference level of 1 to 20 mSv/year set out in the "existing exposure situations." Even for schools that have an air dose rate measuring below 3.8 μSv/h, it would have been appropriate to make further attempts to reduce exposure dose by, for instance, setting criteria for activities within the schoolyards.

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[16] Nuclear Safety Research Association, Radiation in human life environment (calculation of the national dose, new version), December 2011

[17] As a matter of fact, many schools in Fukushima Prefecture took measures to keep the exposure dose as low as possible by independently setting the restriction guidelines for children to use schoolyards, regardless of the aforementioned MEXT Provisional Criteria.

[18] Some data show a significant difference in the high dose range of 1,000 to 4,000 mSv.

(f) Radiation emergency medical care institutions

Six hospitals had been designated as initial radiation emergency medical care institutions for response to accidents such as that which occurred at the Fukushima Dai-ichi NPS, as described earlier in Chapter IV. 4. (6). But four of these six hospitals were unable to fulfill their function as radiation emergency medical institutions because they were included in the evacuation area. Such a situation would have been brought up by the fact that this kind of severe accident had not been postulated in which initial radiation emergency medical care institutions could be covered by the evacuation areas. Therefore, **a considerable number of medical facilities for radiation emergency medical treatment should be located in the area which is not likely to be included in an evacuation designated area, so that radiation emergency medical care could be provided even in a severe accident like the accident at the Fukushima Dai-ichi NPS. Those medical facilities should not be concentrated in the area close to the nuclear power station. At the same time, such medical care systems in a nuclear emergency would need to be coordinated for collaborating over a wide area across the prefectural borders.**

(g) Public understanding of radiation effects

Radiation effect to human body was reviewed in the Interim Report Chapter V. 4. (1), but cannot be regarded easy to understand since it requires knowledge to understand the concept of such as stochastic effect. Furthermore, it is also hard to accept that the general public had sufficient opportunities to learn about scientific characteristics of radiation or its effect to human body at schools or in a community[19]. It is reported that a considerable number of the public get fears against radiation effect regarding the accident at the Fukushima Dai-ichi NPS, and there are victims of fraudulent businesses taking advantage of such people's fears. The facts stated

[19] The Investigation Committee investigated the status of how the topic of radiation had been taken up in the school curricula in the compulsory school education history in Japan. The topic was deleted in the Curriculum Guidelines for Junior High Schools announced in 1977 (enforced since JFY1981). The topic was recovered back in its 2008 version (to be enforced since JFY2012. But the education of that topic started in JFY2011 pursuant to the special arrangement effectuated in 2008). The new Curriculum Guidelines announced in 2008 stipulates that the radiation properties and their utilization should be referred to in the subject of "Energy." In the meantime at Senior High Schools the topic of radiation was educated in the subject of "Science I" to every pupil from JFY1982 to JFY1993. But before and after that period, the topic was educated to limited pupils who took the selected subject of physics, for instance (same as now).

above are likely the cause of these happenings.

This accident has served as a reminder of the need not only to take all possible precautions in order to protect ourselves against radiation, but also to "fear radiation properly." Knowledge such as the following will be useful in order to "fear radiation properly" (Interim Report Chapter V. 4. (1) b.):

(i) Radioactive materials are not contagious like a virus;

(ii) The average annual radiation exposure from natural radiation (including internal radiation exposure from foods etc.) without accidents at nuclear power stations etc. is about 2.1 mSv a year in the county[20] (international average is about 2.4 mSv a year[21])[22];

(iii) Iodine-131 absorbed in human body accumulates in thyroid gland, but since its half-life is short, only about eight days, the residual iodine-131 originating from the accident at the Fukushima Dai-ichi NPS remains only little;

(iv) The physical half-life of cesium-134 is two years and that of cesium-137 is 30 years. A large amount of them still remain in the environment, but unlike the iodine, they do not accumulate in particular parts of human body upon absorption. They are distributed uniformly to muscular tissues of the whole human body, and half of them will be removed from the adult's body in 90 days[23];

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[20] Nuclear Safety Research Association, Radiation in human life environment (calculation of the national dose, new version), p155 onward, December 2011: This national average used to be about 1.5 mSv till December 2011. The reason of this big increase of the value is explained (p157) as the underestimated exposure dose due to radioactive polonium 210 because of lack of sufficient data till then.

[21] Nuclear Safety Research Association, Radiation in human life environment (calculation of the national dose, new version), p159, December 2011, and UN Scientific Committee on the Effects of Atomic Radiation, SOURCES AND EFFECTS OF IONIZING RADIATION (UNSCEAR 2008 Report to the General Assembly with Scientific Annexes), p.4

[22] These figures are annual dose rate humans receive from natural world, regardless of nuclear accidents etc. (includes external exposures such as from ground and space, and from internal exposures such as inhalation and food ingestion. Average domestic external exposure alone is around 0.6 mSv a year and that of world average is around 0.9 mSv a year). Therefore, when radiation exposure (both external and internal exposures) up to 1 mSv a year that ICRP suggests as the individual dose limit (public exposure dose limit under "planned exposure situations") is received in Japan, the average total individual exposure dose rate (external dose rate and internal dose rate) becomes around 3.1 mSv/year.

[23] The biological half-lives (the time needed for radiation in the body to deplete by 50% due to metabolism and other mechanisms) of cesium-134 and cesium-137 are said to be nine days for those up to one year old, 38 days for those up to nine years old, 70 days for those up to 30 years old, and 90 days for those up to 50 years old, respectively (Food Safety Commission, "Provisional Guidance Regarding Radiation," March 29, 2011, and Ministry of Agriculture, Forestry and Fisheries, "Basic Knowledge of Radioactive Materials," February 2012)

(v) Human bodies originally contain about 120 Bq/kg of radiation materials including potassium-40 and carbon-14[24];

(vi) There are foods in our daily life consumption that contain 100 Bq/kg or more of radioactive potassium; and

(vii) Correlation between exposure dose and cancer initiation is not apparent in an environment of less than 100 mSv, but the radiation protection principle assumes a direct proportion between them.

There is, of course, a need to put utmost effort into preventing unnecessary exposure in the future, and at the same time, **as many opportunities as possible should be institutionalized for the public to get knowledge and deepen their understanding of radiation. By doing so, the individuals would be able to judge the radiation risks based on correct information; in other words, they would be freed from unnecessary fears about, or from underestimating, the radiation risks because of the lack of information.**

f. Analysis concerning the provision of information to the public

(a) Prior consent from the Prime Minister's Office

On March 12, 2011, NISA Deputy Director-General, Koichiro Nakamura (hereafter, "NISA Deputy Director-General Nakamura"), announced the possibility of a "core meltdown" at Unit 1 of the Fukushima Dai-ichi. The relevant parties who had been gathered at the Prime Minister's Office had not received any prior report of a possible "core meltdown." Knowing the announcement of NISA, they saw as problem that NISA had announced a fact unknown to the Prime Minister's Office without informing the Prime Minister's Office of it in advance, and requested a prior report on the contents before the announcement. Consequently, based on a decision made by NISA Director-General Terasaka, NISA decided to obtain prior consent on the contents of press announcements from the Prime Minister's Office.

Starting on March 13, TEPCO also decided to obtain consent from the Prime Minister's Office prior to its press announcements, as noted in Chapter IV. 8. (4), thereby leading to delays

[24] An average Japanese of 65.3 kg (an average man of 20 years old or higher in 2008) is said to have 7,856 Bq (Working Group for an assessment of the effect of radioactive nuclides in food or health, Food Safety Commission, Provisional Estimation of Radionuclides in the Human Body, July 13, 2011)

in these press announcements.

It is natural for the Prime Minister's Office, which should serve as the center of the government for decision-making and announcements, to seek prompt provision of information and certainly other administrative organizations and nuclear operators including TEPCO should try to provide relevant information and materials as early as possible. But, as noted above, requiring a prior consent of administrative organizations or higher government bodies before making press announcements could create a situation where public announcements can be delayed and urgent information cannot be released immediately. In other words, strict accuracy and centralization of announcements occasionally sacrifices promptness of announcements. For example, TEPCO attempted to obtain consent to an announcement from the Prime Minister's Office regarding the condition of the pressure increase of the Unit 3 primary containment vessel in the early morning of March 14, but lost timing of the announcement in time while the nuclear reactor building exploded at 11:00 on the same day.

It is not necessarily appropriate to seek prior consent from the Prime Minister's Office for the release of all information, as there are cases where each public relations organization needs to make announcements by its own decision, regarding urgent information.

(b) NISA publicity that actively negated a core meltdown

NISA started seeking prior approval from the Prime Minister's Office for the content of its press announcements as noted in (a) above, after the occasion of an announcement on "core meltdown" by NISA Deputy Director-General Nakamura. Evidences show that some of the spokespersons of NISA began to make awkward statements thereafter in efforts to avoid a reference to a core meltdown, as described in detail earlier in Chapter IV. (2). For instance, at a press conference by NISA on March 14, 2011, when Assistant to NISA Hidehiko Nishiyama ("NISA Spokesperson Nishiyama") affirmed the possibility of a core meltdown or made comments to the effect of not denying the possibility of a core meltdown, another NISA staff who was also at the press conference stated immediately after the announcement "I think the situation has not reached the stage of such as a meltdown" – as if to dismiss the statement by NISA Spokesperson Nishiyama and negate actively the possibility of a core meltdown. However within NISA back then, core melt had been acknowledged as quite affirmative or at

least a fact difficult to negate. Therefore it is hard to understand the remark of this NISA staff.

It might be acceptable to refer to an uncertain matter as uncertain. But it is definitely wrong to make an announcement negating an undeniable fact. Regardless of the subjective knowledge underlying the remarks made by the abovementioned NISA staff, the remarks actively denied the possibility of a core meltdown, which was a fact hard to deny. As such, these remarks were extremely inappropriate in the sense that they had misguided local residents and emergency response staff at the central government and on site, who were desperately in need of information.

(c) Publicity about the impact of radiation

When conducting publicity activities concerning radiation exposure or concerns for radiation exposure to residents during the accident at the Fukushima Dai-ichi NPS, the government often used the expression "immediate (no immediate effect on the human body") (See Chapter IV. 8. (8) above). Chief Cabinet Secretary Edano, taking a responsible role of government announcements, used often this kind of wording. He mentioned at the beginning as, regarding low level radiation dose exposure of residents, for example, "it does not harm human health much" (at around 08:30 on March 13), "the situation will not develop to harm health in our view" (at around 15:30 on the same day), or " a quantity not to worry about" (at around 21:00 on March 14). At the subsequent press conferences he began to use the expression as "immediate (no immediate effect on the human body);" for example: "in broad strokes, no immediate effect on human body," at around 18:00 on March 16, regarding monitoring figures of the same day at around 20 km from the Fukushima Dai-ichi NPS; or "Your thorough understanding and response with coolness are cordially requested, since the figures are not at a level that immediately affects your health (even if you take tentatively the food which contained radioactive materials exceeding the provisional regulation values)" at the press conference at around 16:00 on March 19, regarding radioactive materials detected from milk etc. exceeding provisionally regulated values. Later in the hearing by the Investigation Committee, Chief Cabinet Secretary Edano explained as "(We) Used (the expression) for implying that the effect of accumulated low level radiation exposure was not obvious, but at least the value was in a level not to cause acute symptoms," referring to the expression "immediate…"

Besides, the expression "immediate (no immediate effect on health)" was also used on the Consumer Affairs Agency's home page and in the NSC bulletin as mentioned previously in Chapter IV. 8. (8).

In the background of such expression of "immediate," there is scientific knowledge regarding low level radiation exposure that correlation between radiation exposure and development of cancer etc. is not obvious, and it will take considerably long time to become cancerous even if correlation exists (See Interim Report Chapter V. 4. (1) b.). Chief Cabinet Secretary Edano's explanations mentioned above are likely to be based on this scientific knowledge. However, this expression "no immediate effect on the human body" could refer to "there is no need to worry about the effect on the human body" or conversely, "while there is no immediate effect on the human body, there are long-term effects to the human body." It was not necessarily clear which meaning the expression had been used in reference to. Expressions such as this, which could be comprehended in more than one way, should be avoided in the use of publicity in times of emergency, and is an important issue to be reviewed in the future from the perspective of risk communication.

(d) Problem with non-publicity of the "sketch of a contingency scenario"

On March 22, 2011, Prime Minister Kan made a request to the Chairman of the Japan Atomic Energy Commission, Shunsuke Kondo ("Dr. Kondo"), as noted earlier in Chapter IV. 8. (9), to provide a hypothesis of the worst-case scenario for the accident at the Fukushima Dai-ichi NPS, and the measures to be taken in the event of such a scenario. The request was made with an intention to predict what situation would result from the accident if the accident further developed, and to be prepared therefor. In response to this request, Dr. Kondo drew up a "Sketch of a Contingency Scenario for the Fukushima Dai-ichi Nuclear Power Station" (hereafter, the "Sketch"). On March 25, Dr. Kondo submitted his personal Sketch to the Special Advisor to the Prime Minister, Goshi Hosono ("Special Advisor Hosono"). Special Advisor Hosono reviewed the measures laid out in the Sketch, but did not release the Sketch publicly.

Announcing the occurred fact in prompt and accurate manner is one of the important roles of the government. Simulating the worst case scenario also is one of the important roles of the government. The Sketch was based only on the virtual facts, not on the real facts, and therefore,

there was concern of being misperceived that the entire picture in the Sketch was happening in the real world, if released without sufficient explanation. Simulation results based on the virtual facts are not necessarily required always to be announced promptly, because they are based simply only on the virtual facts. Sufficient explanation is required for a report of this nature to avoid misunderstandings when to disclose, if it is to be disclosed as a matter of importance. As the Sketch had been a simulation based on a hypothetical scenario very because they are based only on the virtual facts with a low probability of taking place in real life, it cannot be flatly said that the action of Special Advisor Hosono not releasing the text of the document publicly was inappropriate. However, generally speaking, there can be also an option of releasing it, even for a simulation based on a hypothetical scenario. This can be carried out with a thorough explanation of the preconditions behind the simulation, and with consideration given to factors such as the need for publication, the presence or absence of measures in response to the simulated results of the scenario, and the timing of the publication.

g. Distribution of information overseas and coordination with international community

(a) Sharing of information with international community

The problem of releasing contaminated water to the ocean without prior explanation to neighboring countries was reviewed in the Interim Report Chapter VII. 5. (5). Followings are the problems that became clear in details after the Interim Report, concerning the relationship with international community.

After the onset of the accident, Japan did not necessarily provide information pertaining to the accident to other countries in a satisfactory manner, as mentioned in Chapter IV. 9. (2) above. Following causes can be pointed out in this regard: (i) The government itself did not have sufficient information regarding the conditions at the Fukushima Dai-ichi NPS until the Integrated Headquarters was established early in the morning on March 15; (ii) The experts that were capable of elaborating on the reactor conditions were deeply occupied with accident responses, thus did not have available time to sufficiently explain to the international community; or (iii) Being not notified that the United States of America (hereinafter referred to as “USA”) had been collecting information for its own evacuation advices, the government did not set up active information provision measures at the beginning.

Provision of information to overseas countries is equally important as to the Japanese public, especially to neighboring countries or those countries which have many of their nationals residing in Japan. Active and careful responses should be in place for prompt and accurate provision of relevant information with due consideration to language barriers.

(b) Receiving support from other countries

Japan was initially not able to receive provisions of relief supplies immediately, as noted earlier in Chapter IV. 10. (2) b., because there were flaws in the system to receive relief supplies from other countries, and in addition there were no storage space for the supplies that were received.

Neither METI's Nuclear Disaster Management Operation Manual nor TEPCO's Nuclear Operator Emergency Management Operation Plan had descriptions on the response procedures to receive relief supplies from overseas in the occurrence of a nuclear disaster. NISA, the competent agency, had even no full-time staff to administer receiving tasks of relief supplies. There was only one person who was engaged in handling this task for receiving while he was covering another post in parallel. Therefore, a big confusion resulted in receiving the relief supplies until the beginning of April.

NISA could not receive the relief supplies at the beginning, since NISA could not reserve a space for storing the supplies offered from overseas. NISA first took a process to identify the bodies that needed these supplies, and then to inform the will of acceptance to the countries offering the supplies and asked for shipment. As a result complaints arose from the international community about the late reply to accept supplies. Later NISA rented a warehouse near the Narita International Airport, which improved the situation by replying earlier for receiving the supplies from the aid-providing countries.

International support in a nuclear emergency should be accepted and received as early as possible, when offered, for international comity and for urgently meeting national needs. To avoid confusion and inappropriateness experienced in the early stages at the time of the accident, operation manuals of competent ministries, nuclear operator emergency management operation plans and other relevant materials should prescribe

how to respond to such international support.

(4) Accident preventive measures and emergency preparedness

a. Need for comprehensive risk analysis and severe accident measures

(a) The background of why accident management, targeting external events, not introduced

In Japan, too, deliberations started since 1992 on the accident management ("AM") as a measure for a severe accident, and nuclear operators completed their development by around 2002 as part of their voluntary safety initiatives. The evaluation of their effectiveness was conducted in 2004 by the relevant regulatory bodies. The regulatory authorities had an intention to expand the AM scope from internal events such as mechanical failure and human errors to external events such as earthquakes/tsunamis, but only measures for incidents arising as a result of internal events have been drawn up as accident management programs. External events such as earthquakes and tsunamis were not viewed as targets for specific consideration.

A couple of reasons can be provided as a background to the abovementioned situation, including:

(i) The Probabilistic Safety Assessment ("PSA") that is regarded as a useful means of reviewing severe accident measures by assessing the safety of nuclear facilities in a comprehensive and quantitative manner was gradually being established but still limited as a means, because the PSA for external events established prior to the Fukushima nuclear accident was only the seismic PSA;

(ii) The regulators checked the PSA results for internal events and severe accident measures thereupon on the occasion of nuclear safety inspections related to the Periodic Safety Review ("PSR"), but did not go as far as to offer opportunities for improving severe accident measures, in consideration of technological advancements of PSA for external events;

(iii) When the NSC reviewed the implementation plan of AM measures at Unit 3 of Hokkaido Electric Power Company, too, the early introduction of the PSA was not deliberated due to factors such as work pressure on seismic back checks, despite the suggestions by some that the implementation of external event PSA and of reasonable additional measures, if there had been any, should be encouraged; and

(iv) Verification of safety at nuclear reactor facilities concerning natural phenomena was gradually in progress starting from earthquakes. The experience at the Kashiwazaki-Kariwa NPS when the Niigata-Chuetsu-oki Earthquake occurred, the seismic back check results upon revision of the Regulatory Guide for Reviewing Seismic Design of Nuclear Power Reactor Facilities (NSC RG L-DS-I.02) (hereinafter referred to as "Seismic Design Regulatory Guide), etc. contributed to this progress, but at the point of the Fukushima NPS accident, only a partial deterministic seismic assessment had been completed; and in addition

(v) At TEPCO, the AM for internal events reported to the government for review received its evaluation as "acceptable," but it did not go further to specific consideration of AM that involved external events such as earthquakes beyond design basis events.

Consequently, comprehensive risk analysis for external events was not conducted, encompassing analysis through seismic PSA and safety analysis for tsunami, and fires, volcanoes, and slope collapses, etc. which could cause a disaster.

(b) Need for comprehensive risk analysis

In the verification of safety at nuclear power reactor facilities concerning natural phenomena, it would be unavoidable to place priorities on safety verification of relatively frequent earthquakes and their accompanying tsunamis or slope collapsing, due to budgetary and personnel constraints of nuclear operators and regulating authorities. However, **nuclear facilities are installed in a natural environment, which is really diversified. Nuclear operators should conduct comprehensive risk analysis encompassing the characteristics of the natural environment including the external events, not only earthquakes and their accompanying events but also other events such as flooding, volcanic activities or fires, even if their probabilities of occurrence are not high, as well as the internal events having been considered in the existing analysis. Nuclear regulators should check the operators' analysis.**

In doing so, nuclear operators should actively utilize currently available methods in their analyses of such external events, even if the PSA approach is not firmly established for them. The government should consider support to promote relevant research

programs for such initiatives.

It is needless to say that measures to minimize the damage should be ensured, even when an event occurs exceeding the measures determined by such risk assessment (the so-called "assumptions").

(c) Formulation of severe accident measures in consideration of comprehensive risk analysis

As described in (a) above, the problem of measures for ensuring safety at nuclear reactor facilities in our country was that the measures actually implemented did not sufficiently reflect the suggestions of taking external event risk into consideration, such as those of earthquakes and tsunamis, even though the suggestions had been made as important. AM as severe accident measures was limited only to those for internal events which began to be developed in 1992 and completed in 2002. The regulatory authorities also did not review them with consideration of external events. Furthermore, there were no appropriate understandings at the regulatory authorities that the facilities and procedures developed by nuclear operators as an AM, including that in the TEPCO's accident management development report, had not been necessarily effective in severe accidents initiated by an external event such as earthquakes and tsunamis.

In order to ensure maintaining nuclear safety at nuclear power stations, vulnerability of individual facilities for a wide range of characteristics of various internal and external events should be identified by comprehensive safety analysis encompassing external events also, and appropriate measures (severe accident management) against such vulnerability should be examined and placed in shape, assuming a situation in which the core may have serious damage by an accident far exceeding the design basis. The effectiveness of such severe accident management should be evaluated through the PSA or other means.

Under such circumstances, there can be no justification to dispense with examining and implementing severe accident measures on the ground of immaturity in PSA techniques. Even though there are restrictions in risk analysis methods, nuclear operators should review and assess severe accident measures in order to ensure the safety of their own facilities, in consideration of the characteristics and limitations of the risk analysis method employed. In

conducting this review, there is a need to take sufficient reference from other sources, too, such as situations in other countries. When implementing severe accident measures in urgent need, the regulating authorities should also verify and review, using risk analysis methods or other means, the effectiveness of those measures in the event of a natural disaster, even if they urge deliberating and implementing the legitimization of safety measures or request to nuclear operators.

b. Revision of nuclear emergency preparedness

With regard to the development of a nuclear emergency preparedness system, the NSC commenced work in 2006 on revising the "Regulatory Guide: Emergency Preparedness for Nuclear Facilities" (NSCRG: T-EP-II.01) (hereafter, "Emergency Preparedness Regulatory Guide"), in tandem with the establishment of safety standards for nuclear or radiation emergency situations under the International Atomic Energy Agency ("IAEA"). In the process the introduction of the Preventive Action Zone ("PAZ") to Japan was discussed, but the concept and scope of PAZ were never directly included in this regulatory guide after all, as a result of coordination between NISA and the NSC. The reason was that prerequisites for effective PAZ operation had not been sufficiently developed, and the NSC and NISA had not been ready to review the prerequisite events for examining the setting of evacuation zones, etc.

In the meantime, NISA commenced its review on complex disasters, which saw the simultaneous occurrence of a nuclear accident and large-scale natural disaster. A review was requested, under the initiative of NISA, to the Central Disaster Prevention Council, which deliberated managing natural disasters and nuclear disasters. But it was only three days prior to the Tohoku District - off the Pacific Ocean Earthquake, when the request was made. It should be assessed as too late that relevant in-depth discussion had not been made at the Central Disaster Prevention Council and other bodies prior to the earthquake.

The existing Emergency Planning Zone ("EPZ") had been set before the accident on the basic assumption of 8 to 10 km from a nuclear power station, so that the situation could be well dealt with even in an incident far exceeding a hypothetical accident. However, the accident has shown the need to reconsider what accidents to assume and how to designate evacuation areas.

Furthermore, the roles of the government in a nuclear emergency are so large that the government responses should not be limited to those outside nuclear site boundaries such as the residents' evacuation. It should also be considered what the government should do to cooperate or support the nuclear operator in a nuclear emergency, in consultation with the operator.

Moreover, natural disasters and nuclear disasters involve their respective characteristics in emergency responses and recovery actions suitable to respective incidents, and the priority should be put first to envision the responses to respective incidents, and examine and develop their emergency responses and recovery plans. As mentioned in the Interim Report VI. 6. (2), there is a possibility that a nuclear disaster and a natural disaster, or more than one natural disaster, occur simultaneously, or during the time of recovery operation, thus the emergency preparedness not only to the individual events but also to simultaneous events should be examined.

(5) Nuclear safety regulatory bodies

NISA is an organization to regulate safety of nuclear power reactor facilities, and is expected to take a responsible role of accident responses in front as the Secretariat for the NERHQ in a nuclear disaster at commercial reactors. However, in the latest accident responses, it is difficult to say that NISA has sufficiently fulfilled its role as the organization responsible for taking preventive measures against accidents as well as for responses to the accident. Examples are: (i) it could not collect information from the nuclear operator etc. regarding the nuclear disaster and failed to sufficiently function to provide relevant information as required from the Prime Minister's Office and relevant ministries in a timely and sufficient manner; (ii) It could not dispatch experts with sufficient expertise at the beginning who could explain to the Prime Minister's Office how the nuclear disaster situation would develop and what responses by the government would be needed; (iii) It could not make effective use of SPEEDI information despite its acquiring the information, in an understanding that without emission source information, it could not be utilized for evacuation programs; and (iv) It failed to request the operators to implement appropriate severe accident measures, regarding preventive measures of nuclear accidents, since it was busy responding to specific issues and could not sufficiently

respond to mid-to-long term issues including domestic regulation issues such as sever accident measures.

In consideration of problems such as those posed by NISA, the Investigation Committee raised following five points in Chapter VII. 8. (2) of the Interim Report with respect to the operations of nuclear safety regulatory bodies: (i) The need for independence and transparency; (ii) Organizational preparedness for swift and effective emergency response; (iii) Recognition of its own role as a provider of disaster-related information to Japan and the world; (iv) Development of competent human resources and specialized expertise; and (v) Efforts to collect information and acquire scientific knowledge. The Investigation Committee also recommended taking consideration to these points in the planning to establish the new nuclear safety regulatory body. The following two points have been added in the Final Report in consideration of investigations and verifications conducted after the Interim Report. The two points included here are items that are also applicable to the NSC.

(i) Active relationship with international organizations and regulatory bodies of other countries

Dispatching staff to international organizations or international conferences with constant attendance should build up human network with staff of international organizations and foreign regulatory authorities, and will enable to smoothly exchange information and knowledge such as regulatory trends, and furthermore will facilitate smooth office processing works such as a notification and other matters in cases like the latest nuclear disaster. However, under existing staff capacity conditions at NISA, relationships with international community are limited to a small number of personnel exchanges with the IAEA and the Nuclear Regulatory Commission ("NRC") of the United States. Furthermore, as priority must be given to the processing of domestic administrative affairs, there are limitation to the presence that can be sufficiently shown at international conferences and other such events. These efforts do not contribute sufficiently to the enhancement of organizational competence of the regulatory authorities and to coordination with the international community with respect to nuclear safety.

The limited number of personnel at a government administrative organization is a collective issue of the all administrative organizations, and not limited to an issue of NISA

etc. But that of the new regulatory body should be duly considered, because of the importance of nuclear safety. The new regulatory body should secure its personnel, should establish an organizational system competent for international contribution, and develop human resources who can take a role in personnel interaction with international organizations or regulatory bodies of other countries.

(ii) Strengthening of the regulatory body

Organizational structure of NISA and the NSC originates from the reorganization of central government ministries in 2001. Both organizations, however, are difficult to evaluate that they deserved the position they administered, regarding their activities to prevent the nuclear accidents and the latest accident responses. They were not able to sufficiently administer the mid-to-long term challenges, although recognizing the importance of issues such as the conforming of domestic regulations to the international standards at IAEA. They were caught up in the specific problems on a case-by-case basis such as the so-called TEPCO's record falsification case (2002) and the concerns at the Kashiwazaki-Kariwa NPS resulting from the Niigata-Chuetsu-oki Earthquake (2007); occasionally they were not able either to provide sufficient advice and guidance, based on specialized expertise to operators and relevant agencies for responding to an emergency.

In order to ensure nuclear power safety, responses to individual problems encountered are not sufficient. Continuous efforts are needed to keep national regulatory guides updated at their newest and best qualities, with consideration to international trends of safety regulations and nuclear security, not only to the latest scientific knowledge in the country and overseas. Nuclear operators bear the prime responsibility on nuclear power generation and necessary responses should be of course voluntarily implemented on their own responsibility. Regulatory authorities also should carry out swift and appropriate planning concerning nuclear safety regulation in response to the mid-to-long term issues. While monitoring the latest trend of relevant research on comprehensive risk assessment and severe accident measures covering external events such as those mentioned previously in (4) a. above, the regulatory authorities should urge operators to implement measures, and pursue effective nuclear safety regulation by verifying those measures. It is, of course, important to take

preventive measures against accidents such as the accident this time. But in addition, **considering that the impact of a nuclear disaster on society can be sizable, responses in an emergency should be fully established during normal times by formulating the emergency preparedness or by conducting nuclear emergency response drills so that effective and prompt responses could be taken in an emergency. The regulatory organization should foster the specialized skills to provide individuals and organizations responsible for emergency response with expert advice and guidance and should also foster the management potential to utilize organizational resources effectively and efficiently. Appropriate size of budget and human resources should be duly examined.**

(6) TEPCO competence

a. Vulnerabilities in emergency response capability

TEPCO has been conducting legally required education and drill to relevant personnel of nuclear power generation prior to the accident. As a matter of fact, in the hearings of the Investigation Committee to TEPCO personnel, every staff in the nuclear sector showed abundant knowledge in the isolation condenser ("IC"), fail-safe functions, reactor water level indicators, and the CAMS. They were on the level with that of the plant manufacturer personnel.

However, upon investigation of the response measures taken by TEPCO staff toward this severe accident, effective use of such knowledge was occasionally questionable. A typical example was the misunderstanding of the IC functioning conditions, the detail of which was discussed in the Interim Report Chapter IV. 3. (1), but the same observation is also applicable to the case of reactor water level indicators. Referring to the reactor water level indicating no movement for a long time, nobody at the TEPCO Head Office or Fukushima Dai-ichi NPS pointed out the possibility at the time of the accident that the reactor water level might have been below the reactor inlet nozzle (further below the bottom of active fuel ("BAF")). According to the records including those from the in-house television-conference system, somebody mentioned the risk of improper reactor water level indicated higher than the actual level when the reference water head lowered, but there is no indication that further discussion with assessment and study was made with a concern of the possibility that the reactor water

level was below the reactor inlet nozzle.

Despite the abundant knowledge of the CAMS mechanism and the AM assessment referring to the indicated results of CAMS, no effort was taken at the time of the accident and even thereafter in order to grasp the plant conditions correctly by assessing the integrity of the pressure vessel or containment vessel using the indicated results of CAMS. They merely reported to NISA the calculated values of core damage fraction on a manual basis.

It is certain that in continued environment of extremely stressful accident responses, the thinking ability might have slowed, but when examining the response at the beginning of the accident (the misunderstanding of IC operating conditions, for example), or the response far later after the accident (the interpretation of the CAMS measurement records, for example), it cannot be denied that the ability to think about and confront the situation independently was poor, and that there was a lack in flexible and proactive thinking, which is necessary in responding to a crisis. These are not the problems of individuals, but rather should be addressed as TEPCO's corporate failure to provide staff education and training focused on the enhancement of such qualities and capabilities. Further probing into this issue reveals a fundamental problem of the inability to capture such crises as a reality that could happen in our lives; this, in turn, is the result of a myth of safety that existed among nuclear operators including TEPCO as well as the government, that serious severe accidents could never occur in nuclear power plants in Japan.

The Investigation Committee described in the Interim Report Chapter VII. 4. (1) that among TEPCO's nuclear power relevant personnel, fundamental understanding such as that of the IC had been lacking. The meaning intended was to point out that at TEPCO, fostering qualities and abilities to respond to a critical and serious accident had not been practiced. Of course, these qualities and abilities cannot be acquired overnight, and cannot be acquired from mere tabletop exercises. The qualities and abilities required for accident responses are the capabilities to sort relevant information collected by weighing all possibilities, then make decisions how to respond, and implement, beyond the knowledge from textbooks. The Investigation Committee strongly expects TEPCO, as a nuclear operator that bears the primary responsibility for nuclear safety, to sincerely revise its existing education and training contents, as well as to implement practical education and training programs aiming at the enhancement of qualities and

capabilities that are required in accident response, for each individual that deals with nuclear power.

b. Problems of a vertical organization based on specialized official capacities

TEPCO has structured its organization with an Emergency Response Center and other relevant departments in its Disaster Management Operation Plan and Accident Management Guide, under which functional teams are formed, including power generation teams, recovery teams, and engineering teams, etc. with the aim of providing an organizational, unified response in the event of a nuclear disaster. However, these functional teams certainly made efforts to fulfill their respective scopes given, but did not perform sufficiently well in capturing the situation from a comprehensive point of view, positioning the roles of their own teams within the overall picture, and carrying out the necessary support operations based on such perspectives.

TEPCO personnel, just like as those of other nuclear operators, categorize themselves by their specialty areas from normal times such as an "operating guy," a "safety guy," an "electric guy" or a "machine guy," and their roles are segmentalized. While some personnel take an official career path by experiencing various fields widely and shallowly, some remain in one specialty for long periods. Such personnel might have abundant knowledge of his/her own specialty, but in contrast it is hard to say that he/she has sufficient knowledge of other areas, even closely related matters. If an organization is structured with these kinds of personnel, the individuals might have a narrow view of things, and, even if the organization seems to function without any problems under normal conditions, it results in exposing weaknesses of the organization in an emergency like the latest accident. Superintendent Yoshida was instructing from the early stage on March 11 to examine the water injection by fire engines, which had not been the scheme formulated beforehand in the manual. As a result, none of the functional teams or groups realized it was a task under its jurisdiction, thus no substantial review was done until early morning of March 12. This should be a typical case in which the aforementioned weakness became exposed.

When opening the SRV, it can be done on the control panel in the main control room by the shift team on duty, if electric power is available. But during the station black out, the recovery

team had to connect a total of 120V batteries to the connecting terminal on the back of the control panel. As a result, an issue arose when implementing the opening operation of Unit 2 SRV in the evening of March 14 onward, it was not clear who should implement the operation: the shift team or the recovery team. This should be another case in which the weaknesses of a vertical division of administration became exposed.

c. Lack of education and training with a view to extreme situations

The ability of each individual in functional teams in the Emergency Response Centers established at the Fukushima Dai-ichi NPS ("Fukushima Dai-ichi NPS ERC") and at the TEPCO Head Office ("TEPCO ERC") was insufficient, as mentioned in b. above, to make decisions and judgments in a timely manner, and to fulfill his or her function as a member of the functional team. This can be considered to stem from a consequence of inadequate education and training that gives a view to an extreme situation such as the complete and simultaneous loss of AC power at multiple nuclear reactor units. According to the abnormal operating procedures (event-base) and emergency operating procedures (symptom-base) of TEPCO, neither of the procedures assumes loss of all AC power at multiple units that lasts for days after scram. These procedures assume the AC powers will recover in couple of hours or one day. But the procedure does not stipulate the process how the AC power recovers. It appears that the procedures are written in detail, but there is always a way out somewhere, and the ground why there is a way out is unsourced.

The accident management development report which TEPCO compiled in 2002 specifically stipulates that "at events that all AC powers are lost, the events progress slowly, with sufficient time margin," but the reason why the events progress slowly is left unsourced. Preparing these kinds of insufficient procedures, even if being informed to all relevant personnel, will just enable the response to the cases of very localized power outages.

Referring to drills, at the Fukushima Dai-ichi NPS for example, a drill was carried out around the end of February in 2011, simulating a series of events of an external power loss at one of the units due to an earthquake, with a transformer broken, followed by emergency diesel generators (DG) failing to start, thus losing the AC powers, leading to a notification pursuant to Article 10 of the Nuclear Emergency Preparedness Act. But the drill assumed the recovery of DGs after a

certain amount of time, which meant the drill just simulated the situation on how to manage until the DG power was recovered. It was not designed to assume an extremely serious situation like this accident.

TEPCO insists that it was an event beyond assumptions that the Fukushima Dai-ichi NPS lost almost all power sources due to the earthquakes and tsunami. However, it should be regarded as having been beyond assumptions simply because such events had been excluded from assumptions based on the myth of safety as a prerequisite without any basis, and the scope of assumptions was very limited. It should be concluded that, whatever education or drills are conducted based on this kind of limited assumptions, it will not contribute to the improvement of emergency management capabilities.

d. Lack of enthusiasm in uncovering the causes behind the accident

Even as of the present point in time more than one year after the accident, TEPCO has not demonstrated sufficient enthusiasm in thoroughly clarifying the causes behind the accident and thereby contributing to the prevention of the recurrence of a similar accident. For Example, in the MAAP analysis reported by TEPCO in March 2012, the conditions assumed therein were apparently wrong, if judged from the measured results by CAMS and the indicated values of reactor water level indicators. Nevertheless, TEPCO, without correcting these assumptions, has drawn the analysis results, by simply correcting the calculated values closer to the actually measured facts only for the first half of the event progress, and by ignoring part of the unfavorable data that was actually measured, but insisted that there were limitations at this moment in the existing analysis code and input data of assumed conditions. Even though there are limitations regarding the analysis model or radiation dose rate measurements, a further realistic analysis should be possible by using data that are already available or can be gained easily. Actually when the Investigation Committee raised a range of questions in its hearing, concerning the analysis, TEPCO defended by replying as: (i) no consideration was made to CAMS results; (ii) the false indications derived from the reactor water level indicator's mechanism were not adjusted in the analysis; or (iii) among the data from the shift operators' logbook of Unit 3, the reason was unknown why the reactor water level indicator's reading one hour after the HPCI had stopped had not been considered in the analysis. Thus, TEPCO

admitted the insufficiency of their analysis, but shows no intention to conduct a further analysis.

TEPCO bears the prime responsibility to actively contribute with its utmost effort to the prevention of similar accidents. TEPCO should have the enthusiasm in obtaining new knowledge from a range of event progress and use of the knowledge to prevent similar accidents and improve the safety of nuclear power generation, but their attitude towards clarifying the causes does not show such enthusiasm. The Investigation Committee calls strongly for a proactive stance from TEPCO in proceeding with clarification of the causes behind the accident.

e. Need for the creation of a safety culture of an even higher level

TEPCO bears critical responsibilities to society as a nuclear operator primarily responsible for nuclear power plant safety. Nevertheless, TEPCO was not sufficiently prepared for such an accident, that natural disasters including tsunami may lead to large-scale core damage. Furthermore, TEPCO had not taken adequate preparedness for tsunami risks beyond design basis at the Fukushima Dai-ichi NPS. The accident showed quite a number of problems with TEPCO such as insufficient capability in organizational crisis management; hierarchical organization structure being problematic in emergency responses; insufficient education and training assuming severe accident situations; and apparently no great enthusiasm for identifying accident causes. TEPCO should receive with sincerity the problems which the Investigation Committee raised and should make further efforts for solving these problems and building higher level safety culture on a corporate-wide basis.

At the eighth meeting of the Investigation Committee (February 24 and 25, 2012) with participation of overseas experts, Dr. Richard A. Meserve, Former Chairman of the US NRC pointed out that “the responsibility of individuals is also important in safety management. It is important that every individual involved in this area should have awareness of his/her own responsibility and always keeps a questioning attitude.” This mindset is also one of the important elements of a safety culture to be built.

(7) Harmonization with international practices such as the IAEA safety standards

Looking back about the 10 years since NISA was established in 2001, regulatory authorities including NISA could not actively contribute to the activities of developing international safety standards, while being occupied with other projects including the seismic back checks. The NSC also did not pursue, despite its awareness of the necessity, the updating of the domestic standards conforming to the IAEA safety standards, particularly in the issues of the defense in depth and severe accident responses. Consequently, Japan's involvement in the international safety standard development activities has been limited only to checking the negatives. Thus the criticism is reasonable that Japan was inactive in the human contribution to such international activities or in harmonizing the domestic standards with the international standards. On the other hand, Japan has made a certain level contribution concerning the development of IAEA safety standards in the earthquake and tsunami area.

As mentioned previously, regulatory authorities such as NISA had been aware of the need to review and formulate national guides and standards with reference to IAEA safety standards. But, they mostly failed to implement these measures. **It is necessary to keep the national regulation qualities constantly updated in line with the nuclear knowledge accumulation and technological development in the international and national community. To this end, continuous efforts are needed to keep the national regulatory guides newest and best while monitoring international standards, such as those at the IAEA.**

Japan has contributed to activities related to the formulation of IAEA standards in the area of earthquakes and tsunami. Further on, **lessons on nuclear safety should be extracted from the accident, and those lessons and relevant knowledge should be provided to the international community so that they could contribute to the prevention of similar accidents, not only in our country but also in other countries. In the process of revising national regulatory guides, international contribution should be pursued by making efforts to propose them to incorporate into the IAEA standards etc., if they turn out to be effective and useful as international standards.**

2. Recapitulation of Major Issues

(1) Building of fundamental and effective disaster preventive measures

The Investigation Committee conducted investigations and verifications into the damage due to, and actual responses to, the accident at the Fukushima Dai-ichi NPS, as well as prior measures having been taken by the government and TEPCO toward the prevention of nuclear accidents. In the Interim Report and the Final Report, the Investigation Committee pointed out that there had been many problems in these areas. These problems are listed below once more. Firstly, the following problems were pointed out regarding the accident responses at the Fukushima Dai-ichi NPS:

(i) Functions and operation procedures of the IC set of Unit 1 were not comprehended well enough not only by the shift teams but also by the NPS ERC and TEPCO- ERC. As the result, the IC condition was not properly grasped from the information intermittently obtained;

(ii) The risk of battery depletion at Unit 3 was underestimated. As the result, the shift team manually stopped the HPCI, before confirming the preparedness for sufficient depressurization and availability of alternative means of water injection. The inappropriate procedure caused failure to depressurize the reactor for the alternative means of water injection. Moreover, these operations were implemented by the decision of limited staff in the shift team etc. without asking for the manager's instruction, that revealed the inadequate information sharing procedures at the NPS;

(iii) At Unit 3, alternative means of water injection using fire engines should have been examined and prepared before the batteries for the RCIC and HPCI were likely to deplete. But the NPS ERC started examining and preparing the means only after learning that the HPCI had stopped; and

(iv) At Unit 2, the RCIC water source was switched over to the S/C, while the RCIC was out of control and unable to cool the S/C by RHR. In this circumstance, the RCIC could stop functioning in any minute, causing the S/C pressure and temperature to rise, and a difficulty in depressurizing the reactor by SRV, and there was a possibility that the alternative means of water injection became impossible. Therefore, the S/C pressure and temperature should have been continuously monitored while completing the preparation of the alternative means of water injection by fire engines and, without waiting for the RCIC to stop, the alternative means

of water injection should have been implemented by SRV depressurization before the S/C lost its pressure suppression capability. In actuality, however, the S/C pressure and temperature remained unmonitored until around 04:30 on March 14.

On the other hand, the following points were pointed out referring to the prior measures by the government and TEPCO toward the prevention of nuclear accidents:

(i) Nuclear operators requested, as its voluntary efforts, the Tsunami Evaluation Subcommittee, the Nuclear Civil Engineering Committee of the Japan Society of Civil Engineers, Inc. (now Public Interest Incorporated Association) (hereafter referred to as "JSCE") to compile the "Tsunami Assessment Method for Nuclear Power Plants in Japan" (hereafter, "Tsunami Assessment Method"), based on which the nuclear operators estimated the anticipated tsunami height. This Tsunami Assessment Method had a limitation of using only the "tsunamis with recorded trace heights, which were judged to be fairly reliable" as its base reference, and having a high possibility to exclude the tsunamis with insufficient literature or reference materials from the assessment;

(ii) Concerning the tsunami to anticipate in the design phase, the Seismic Design Regulatory Guide was revised in September of 2006, in which tsunami response measures were stipulated. But during the deliberation of the revision process of the Guide at the NSC, sufficient discussion regarding tsunami was not made. No criteria for the effectiveness of the tsunami assessment method or tsunami response measures were presented from NISA etc., either;

(iii) At TEPCO, a tsunami wave height exceeding the design basis height was calculated at the Fukushima Dai-ichi NPS, by referring to the point mentioned in the report (*), indicating a possibility of inter plate earthquake (tsunami earthquake) anywhere in the area from north-off shore Sanriku to off-shore Boso towards the trench, and by test calculations based on the research paper "Wave Source Model" of Jogan tsunami. However, no affirmative tsunami response measures were taken;

(*) "Long-term evaluation of seismic activities in the region from Sanriku-Oki to Boso-Oki" ("Long-term Assessment") compiled by the Headquarters for Earthquake Research Promotion ("Promotion Center") of MEXT

(iv) Also in Japan, severe accident response measures were being developed by the regulatory authorities and nuclear operators, but the events reviewed were limited to internal

events such as mechanical failure and human errors. The scope of events for review was not actively expanded and promoted to external events including earthquakes and tsunami etc.;

(v) TEPCO was not examining and preparing AM measures for tsunami. TEPCO understood that they could respond to natural disasters including tsunamis within design, thus was extremely insufficient in developing measures to respond to natural disasters beyond design basis that caused serious damage to reactor cores;

(vi) TEPCO did not assume a simultaneous breakdown and damage at multiple units, concerning power sources. No measures had been ever taken for ensuring independence of Emergency DGs and power distribution panels by multiplexing and diversification of their locations. There was no preparedness to a situation of the loss of DC power as well. Moreover, the operating procedures were not developed and staff education was not conducted for responding to such a situation. No equipment or materials were sufficiently stocked for responding to such situations;

(vii) Water injection using fire engines had been recognized as effective by some TEPCO personnel, but was not authorized as part of AM measures, and seawater injection was not examined as part of AM measures. It was not clear which function team should implement water injection by fire engines;

(viii) At TEPCO, a smooth communication method within the power station had not been developed, assuming the loss of all power sources for a long time. The routinely used PHS ran out of battery power. Radio communication which was used after the PHS power depletion had constraints in locations able to communicate; and

(ix) No specific rules were in order concerning operational personnel of equipment and materials in case of emergencies. As a result, the operational personnel in need failed to deploy, giving an impact on the prompt development of the initial response activities to the accident.

The Investigation Committee strongly seeks the sincere acceptance of these criticisms by practically all stakeholders in nuclear power generation, including the government, nuclear power operators, nuclear power plant manufacturers, research institutes, and nuclear academic societies, as well as the implementation of specific initiatives to eliminate and improve upon these problem areas.

As it is described previously, **quite a number of problems exist, which need highly**

specialized nuclear knowledge over a wide range for solving technical and nuclear engineering problems. These problems should be reviewed and resolved, results being shaped into concrete actions, through competent knowledge by stakeholders in nuclear power generation. In doing so, they should sincerely take into consideration the recommendations the Investigation Committee has made and they should do so with accountability to society for its process and results.

Referring to the items that should be reflected to the future safety measures based on the latest accident, the government has presented directions of measures of as many as 30 items, including, external power, on-site electrical facilities, cooling/water injecting systems, containment vessel damage and hydrogen explosion, and accident response system/instrumentation facilities. Some of these measures would be further specified closer to reality. The Investigation Committee strongly urges that relevant individuals and organizations make continued and integrated efforts to develop the truly effective measures including these.

(2) Lack of complex disaster point of view

The accident at the Fukushima Dai-ichi NPS resulted from the Tohoku District - off the Pacific Ocean Earthquake accompanied by a major tsunami. The earthquake and tsunami, of course, not only hit the Fukushima Dai-ichi NPS but also caused serious human and physical damage to the Pacific Coast area in Tohoku district.

The Tohoku District - off the Pacific Ocean Earthquake caused a large-scale, wide-area, and complex disaster that included the elements of an earthquake, tsunami, and nuclear accident. When such a complex disaster occurs, a lot of difficulties different from individual accidents or disasters are resulted simultaneously. The national government and local municipal governments encountered had to respond to more than one unprecedented disaster simultaneously. Amidst a situation in which the earthquake and loss of power cut off communication lines, they fell into a state of confusion at various stages and consequently failed to respond to problems timely or adequately. As reviewed in the Interim Report and this Final Report, the Off-site Center, which should have taken a primary role in accident responses, could not function fully due to failure of communication means and other reasons. The monitoring equipment was also damaged, resulting in difficulty in monitoring radiation dose

rates. The essential infrastructures to respond to an accident at the nuclear power station were seriously damaged to function.

In particular, the incapability of the Off-site Center to function demonstrated the lack of complex disaster point of view in emergency preparedness at the government and local municipalities. In other words, the Off-site Center was a facility located and developed without sufficient consideration of the risks of access road damage or communication system breakdown due to an earthquake. Consequently, the complex disaster revealed its limitations, and it immediately lost its functionality.

In this accident, the accident occurred simultaneously at multiple reactor units, and the accident progress at one unit affected the emergency response at the adjacent unit. In the existing severe accident measures in our country, a simultaneous occurrence of serious accidents at multiple units was not considered possible.

Until the accident at the Fukushima Dai-ichi NPS, the national government and the majority of local governments did not imagine the occurrence of a nuclear accident in the form of a complex disaster highlighting the inadequacies in Japan's crisis management attitude, in both aspects of the safety of nuclear power plants as well as safety of the surrounding local communities. **When reviewing the existing safety measures at nuclear power stations, risks of a large scale complex disaster should be sufficiently considered in emergency preparedness.**

(3) Change needed in an attitude to face risks

In establishing safety measures for accidents or disasters, whether the causes are internal (flaws/failure, human errors, etc.), or external (earthquakes, tsunami, volcanoes, tornadoes, destructive storms, landslides, mudslides, power outages, aircraft crashes, terrorist attacks, etc.), it is naturally necessary to predict the probability of occurrence and mode of damage in each event. In particular in Japan, earthquakes, tsunami and volcanoes are important risk elements in the safety of nuclear power stations as well as in regional disaster prevention.

As elaborated in the Interim and Final Reports, attention in recent seismological research based on the plate tectonics theory has been shifting to the regional characteristics of seismic source areas, the characteristics of submarine faults concerning tsunami earthquakes causing

major tsunamis, and probabilistic assessment on the frequency and probability of occurrence of such earthquakes. The application of such new forms of knowledge in identifying specific priority regions for emergency preparedness could be deemed reasonable to a certain extent.

However, despite advances in academic knowledge, a gap was also growing between such advanced knowledge and emergency preparedness (Pitfalls in Safety Barriers by the Swiss cheese model of J. Reason), as seen in the following cases: (i) the probabilistic assessment of earthquakes and tsunami, which predicts a possibility of occurrence of earthquakes in terms of scale and frequency in each region divided by the characteristics of initiation, is based on limited case studies for which detailed records remain. They are mostly in Edo Period between 200 and 400 years ago even at the oldest, although depending on the region. On the other hand, earthquakes and tsunami occurring in long intervals of 500 to 1,000 years with insufficient records such as those mentioned in historical documentation, which are difficult to estimate their source model and scale, are left out from the database; (ii) research institutes and the relevant administrative agencies have attempted to improve precision in computing the probability of occurrence of natural disasters such as earthquakes and tsunami, in order to provide clear justification for the establishment of certain emergency preparedness. On the other hand, however, there were growing tendencies to forget the traditional concept of emergency preparedness that mandated the consideration and preparation at the same time for those rare natural phenomena lying beyond the boundaries of existing academic knowledge; or (iii) in assuming earthquakes and tsunami for design, extremely rare cases have been raised as issues to be reviewed under the expressions “residual risk” and “remaining challenges,” but, in actual fact, they were simply so written down in documents and have continued to be left behind without further and deeper discussions.

In order to avoid such pitfalls, it is necessary to make the following significant changes in the perception of risks, based on the premises of safety measures and emergency preparedness.

(i) It is necessary to humbly face the reality of natural threats, diastrophism and other natural disasters, which are sizable in scale and time, keeping in mind that Japan has often had them in its long history.

(ii) Risk reduction should be tackled in a drastically different approach. In the past risk concept used as the basis for safety measures and emergency preparedness, the probability of

occurrence of an event has been placed at the center of judging criteria, and events with a low probability of occurrence have been removed from the scope of safety measures. There was a certain level of reasonableness in such an approach when designing general machinery or buildings. However, what the Tohoku District - off the Pacific Ocean Earthquake demonstrated was the importance of shifting awareness of risk so that "even if an event is predicted in a probabilistic approach to have a low probability of occurrence, appropriate measures need to be taken in cases where the consequence of damage is extremely large once an accident or disaster occurs."

In that instance, when it deals with designing general machinery or buildings, the conventional approach of estimating the risk as "Risk = Probability of occurrence x Consequence of damage" will be applicable. However, **in the government as well as in private entities, a new approach to safety measures and emergency preparedness should be established for a disaster which potentially brings about serious damage in broad areas like a gigantic tsunami or the severe accident at the Fukushima Nuclear Power Station, regardless of its probability of occurrence.**

(iii) An institutional framework is needed to ensure continued in-depth examination of "residual risks" or "remaining issues" without leaving them behind beyond the predetermined safety measures and emergency preparedness.

After the Tohoku District - off the Pacific Ocean Earthquake, experts in safety theory or risk management came to emphasize, in a variety of occasions, the importance of focusing attention on the aforementioned way of considering risk and on "residual risk." Among those, particularly important is the concluding remark in the "Report" (September 28, 2011) compiled by the "Committee for Technical Investigation on Countermeasures for Earthquakes and Tsunamis Based on the Lessons Learned from the '2011 off the Pacific Coast of Tohoku Earthquake'" (Chairman Yoshiaki Kawata; Professor, Kansai University) of the Central Disaster Management Council. In the Report, while reflecting on the fact that the Jogan tsunami (in 869) and similar events had been placed outside of considerations, the concluding remark says that "Despite the probability of their occurrence being low, historic earthquakes in which earthquake and tsunami damage is considered to have been on an overwhelming scale must be adequately examined."

It is hoped that the way risks are perceived, which forms the premise for future emergency preparedness of Japan, will come to be thought of, based on this sort of approach in regards to various external causes, in addition to earthquakes and tsunami.

(4) Importance of "Deficiency analysis from the disaster victims' standpoint"

Why was the evacuation of people from surrounding regions fraught with chaos on the occasion of the accident at the Fukushima Dai-ichi NPS ? This question is of equal importance to the question of why the severe accident had occurred at the Fukushima Dai-ichi NPS.

In designing and establishing a nuclear power station, which is a massive system, nuclear operators first formulate multiple safety measures for the various facilities that could be called the "system core domain," such as those inside of the reactor building and turbine building. This involves reactor safety measures themselves as well as other measures such as establishing two emergency generators to respond to situations in which external power is lost, or preparing multiple emergency cooling water systems.

Taken into account next are the various facilities that could be called the "system support domain." In other words, the preparation of truck-mounted emergency generators for use during accidents, fire engines, heavy machinery, support equipment and extension electrical cables, etc., equipment for measuring radiation dose rates at sources of radioactive material emissions and in neighboring regions (emissions detectors and monitoring posts), the development of communication infrastructures and transportation infrastructures, etc.

Additionally, the administrative institutions concerned – the government and regional municipalities – have to formulate nuclear disaster prevention plans to prepare for the unlikely event of an accident in which radioactive materials disperse over neighboring regions, in order to protect the people in those regions from radiation exposure. However, in addition to frameworks for evacuating people in the region and information systems planning, these disaster prevention plans should include measures for providing medical support, measures for schools and childcare centers accompanying environmental contamination, and measures for the agricultural and fisheries industries, etc. The domain where these kinds of measures are required will be provisionally referred to as the "regional safety domain."

The purpose of dividing the domains relating to nuclear power stations into the three

categories of "system core domain," "system support domain" and "regional safety domain" is not to impose strict divisions like those for determining the domains covered under design standards, but rather to make it easier to determine within what sort of overall framework the safety of the system itself and the safety of the people in the surrounding regions should be ensured. It should be noted that in some cases a facility will have a common role in two domains. For example, the monitoring post and communication infrastructure, etc. cited under the "system support domain" are also key facilities in the "regional safety domain."

In verifying the safety of a nuclear power system, what is observed will differ greatly depending on the position of the person doing the verifying. When examining the safety of the system from the nuclear operator's standpoint, naturally, the area where an all-out effort is initially made is in ensuring the safety of the "system core domain." As a result of implementing multiple safety measures, nuclear power is recognized as being "safe." If, however, that recognition ends up becoming certitude, then a certain laxity tends to develop in the stance of engaging in tasks and undertaking checks with a sense of vigilance when ensuring safety in the domains other than the core domain.

Whether talking about the "system core domain" or the "system support domain," when safety is said to be ensured this only means the safety within the boundaries of the preconditions of the design: In a case where an event occurs that is outside of those preconditions, safety can no longer be assured. In fact, not only were nuclear operators and regulatory-related institutions overly confident that an event outside design conditions would not occur, until they were faced with an event that exceeded those conditions in the way this massive tsunami did. They did not notice that even in the "system core domain," the measures for preventing a worst-case scenario were actually riddled with "holes," to say nothing of the deficiencies in the safety measures that they had overlooked in the "system support domain" and the "regional safety domain." This is representatively expressed by the fact that at the NSC and NISA also, when deciding nuclear disaster-prevention plans there was a false sense of confidence that a situation involving a large-volume dispersal of radioactive material as a result of damage to the containment vessel of the reactor would not occur. Consequently they did not prepare the system support for responding to such a predicament, or formulate measures for evacuating citizens.

The following two points should be cited as important lessons demonstrated by the above

facts:

(i) If nuclear operators and regulatory bodies overestimate the safety of the "system core domain" within only those assumptions, for which it was designed, safety measures will fail.

(ii) Safety measures in the "system support domain" and "regional safety domain" need to be able to function independently in the case of an emergency, regardless of the level of safety of the "system core domain." Should this principle be neglected, it would increase risks to create many "pitfalls" (deficiencies) in the safety barrier, which should protect the lives of regional people.

So, what has to be done to detect those kinds of deficiencies, and to ensure that the barriers for preserving safety in each of the domains are sound?

As a means for achieving this, the Investigation Committee proposes an approach which can be called a "deficiency analysis from the disaster victims' standpoint." This is a method of analysis conducted from the standpoint of a person who has fallen victim to the disaster. Through this method, personnel in charge of emergency preparedness at regulatory bodies and local governments, working in collaboration with specialists in the field of disaster issues, put themselves and their families in the shoes of residents of the affected areas and analyze thoroughly the events that might befall themselves in the worst case.

Put more specifically, what scale of nuclear accident is to assume, as a premise for evacuation planning? Should the envisaged event occur, are communication routes in place for conveying information speedily and accurately? What area will radioactive materials disperse across, and how? In one's own area, what radiation dose could there potentially be for it to actually be safe? How will the areas to evacuate be decided? Are the direction of evacuation, the means of travel and the evacuation destination completely reliable? Will it be possible to evacuate hospital patients, elderly people living at home and disabled people? How long with the evacuation take? As a result of environmental contamination from radioactive materials, what sort of impact will there be on residential conditions and lifestyles, the farming, livestock, fisheries, forestry and various commercial industries, and children's childcare services and education, etc.? Are these measures in place, in advance? Thoroughly investigating a raft of issues such as this serves to highlight flaws and deficiencies in safety measures.

Between April and July 2006, the NSC set up a working group and explored revising the

Emergency Preparedness Regulatory Guide (NSCRG: T-EP-II.01) with the goal of strengthening the emergency preparedness framework, including the establishment of evacuation zones for residents living in the vicinity of nuclear power stations, in line with new IAEA policies. At that point, however, NISA voiced strong objections, arguing that an adequate response was possible under the then-existing emergency preparedness framework, and so the revision plan was frozen after all. When this issue too is examined from the perspective of "deficiency analysis from a victim's standpoint," it provides a vivid insight into the true nature of the problem. Japan's nuclear emergency preparedness framework made no allowance whatsoever for the occurrence of a major event in which large quantities of radioactive materials would be dispersed as a result of damage to or venting of a reactor containment vessel; only a small-scale leak of volatile materials etc. had been assumed. By comparison, based on the lessons of the Chernobyl accident and other events, in the IAEA's new policies severe accidents had come to be an assumption of emergency preparedness. More specifically, as areas that would be needed to evacuate quickly when an emergency event occurred, the area within a 3-5 km radius of a nuclear power station was designated as a PAZ. With an emphasis on preventing deterministic effects as a result of radiation exposure, residents living within the PAZ were to immediately evacuate from the zone from the point at which there was a danger of a release of radioactive materials. It was these new policies that the NSC had sought to introduce in Japan.

Meanwhile, however, NISA was convinced that a situation such as damage to a reactor containment vessel would not occur in Japan, and it argued that the existing emergency preparedness framework, which designates the area within an 8-10 km radius of a nuclear power station as an Emergency Preparedness Zone ("EPZ"), was enough. NISA also asserted that, because up to then it had been persuading residents living in the vicinity of nuclear power stations that a major accident would not occur, it would be extremely difficult to now turn around and say that there was a need for emergency preparedness that assume a severe accident could occur. It also said that it was difficult to endorse changes to emergency preparedness that might cause confusion locally at a point when emergency preparedness had sunk in and emergency response drills were being properly implemented, and for this and other reasons it objected vehemently to adopting the new policies. In some respects also, the NSC had not

properly compared the details of the IAEA's new policies against Japan's system, and nor had it adequately assessed areas of difficulty on the implementation front, for example, and so ultimately the adoption of the IAEA's new policies was put off.

If this issue is assessed from the perspective of "deficiency analysis from a victim's standpoint," the following kinds of problem points surface:

(i) Even though the nuclear emergency preparedness framework is something decided in the interests of protecting regional citizens' safety, it ended up becoming nothing more than a token debate, when it came to the envisaged events to form the most important preconditions for the framework that a serious accident in the form of a damage to a reactor containment vessel would not happen, as a result of overconfidence on the part of the regulatory-related institutions.

(ii) Emergency preparedness is a key item in the "regional safety domain," and as previously mentioned they must be measures to prepare for a worst-case scenario, irrespective of the level of safety of the "system core domain." Nevertheless, the reality was that no such systems planning took place.

(iii) If regulatory-related institutions persuade regional citizens by simply insisting that nuclear power plants are absolutely safe, it becomes difficult to subsequently alter the emergency preparedness framework to make it safer.

(iv) To construct a genuinely safe social system there is a need for factual information concerning risks to be shared among regulatory-related institutions and citizens. However, in preparing the nuclear emergency preparedness framework, not enough information was supplied to citizens on the one hand, while aspects such as "nuclear power is safe" and "the disaster responses are infallible" were being overemphasized on the other. In connection with the above-mentioned opinion exchanges that occurred over the consideration that was given to revising that Emergency Preparedness Regulatory Guide, NISA Director-General Kenkichi Hirose reportedly made a comment, during a luncheon that was held with an aim of exchanging views with the NSC, along the lines of: "Citizens have at last calmed down over the issue of emergency preparedness. Let sleeping dogs lie." This can be cited as one example of just how lacking in the above-mentioned perspective ("deficiency analysis from a victim's standpoint") the regulatory-related institutions have been up to now.

(v) NISA argued that emergency response drills were being properly implemented, and cited

this as one reason why there was no necessity to change emergency preparedness again. However, the true state of emergency response drills was that at a single municipality on a week day, a few hundred citizens at most would participate, and consequently the drills were not substantial enough to enable a response in the event of a fully-fledged nuclear accident.

When the system's problem areas are studied and brought to the surface in this way, from the standpoint of the victims, it highlights just how many critical "holes" there are.

Similarly, when the "system support domain" also is verified from the perspective of "deficiency analysis from a victim's standpoint," various problem points surface: Will the facilities for measuring sources of radioactive material emissions and the monitoring facilities in neighboring regions be capable of functioning and properly communicating information even in an earthquake, a tsunami and power outage? Will SPEEDI information be able to be used effectively? Will Off-site Centers be able to function even while radioactive materials disperse? Has nothing been left to chance regarding the communications infrastructure and transportation infrastructure vital for the emergency response? Is the various support equipment infallible? This type of "deficiency analysis from a victim's standpoint" takes on considerable significance when it comes time to examine and analyze safety that empathizes with the seriousness and urgency citizens (the victims) feel.

The government and nuclear operators should take the improvement steps for flaws and defects in the safety measures that are identified through this analysis. It would probably be difficult to block up all the "pitfalls" immediately. Under such circumstances, it is important that information on the remaining measures and the related issues be released, and for regulatory bodies and local government bodies to discuss with residents the future measures to take, and, in cooperation, to come up with the next best solution. Only by capturing disasters from the perspective of the residents in the affected areas, and establishing safety systems accordingly, a truly safe and secure society will be created in Japan.

A lesson that can be drawn from the above analysis is this: **An accident at a nuclear power station has risks to bring about damage in vast areas. Nuclear operators on one hand, nuclear regulators on the other, should establish a systematic activity to identify all risk potentials from the "disaster victims' standpoint," when designing, constructing and operating such nuclear systems, for ensuring credible nuclear safety including evacuation**

planning in the local society. Such an approach should be practiced.

Moreover, as was also pointed out in the Interim Report, **with regard to the residents' evacuation plans and evacuation drills** that were mentioned here, we once again point out that **radioactive materials may disperse over vast areas due to an accident at a nuclear power station. The prefecture and local municipalities involved should closely collaborate in building up an effective system through evacuation planning and its drills for minimizing confusion.**

(5) The issue of "beyond assumptions" and lack of the sense of crisis at the administrative bodies and TEPCO

Government officials and TEPCO executives frequently used the expression "beyond the scope of assumptions" to describe the occurrence of a massive earthquake and massive tsunami that had caused huge damage to the Pacific coast of eastern Japan and triggered a nuclear accident. In the sense that not even earthquake specialists were predicting that several hypocenters would move almost simultaneously and a massive earthquake with a JMA seismic intensity of M9.0 would strike, there were certainly aspects to the events that transpired that were "beyond the scope of assumptions."

Nevertheless, this only means that an earthquake occurred that was "beyond the scope of assumptions" if the scale and mechanism of the hypocenters were assessed in strictly scholastic terms. If the question asked is was there no forecast whatsoever in general terms of an earthquake likely to trigger a massive tsunami on the Sendai plain or the Fukushima Prefectural coast, then that is not necessarily the case.

To begin with, the word "beyond assumptions," broadly speaking, can refer to two meanings. One means that an incident, which could not be predicted even with possession of the most advanced academic knowledge, occurred. The other one means that, in light of financial limitations and other limitations to the ability to respond to all predictable events in institutionalizing a system or constructing a building, or in predicting an occurrence of natural disasters, a line was drawn to exclude incidents that were realistically assessed to have a low probability of occurrence, and an incident of a scale far beyond that line occurred. Based on the study of the seismological progression and emergency preparedness administration over the

past ten or so years, it is recognized that the latter meaning held true in the case of the latest major tsunami.

Plate tectonics theory, which says that major earthquakes will occur as a result of the ocean floor (plates) sinking, appeared at the end of the 1960s, and since then understanding of the mechanisms that trigger major earthquakes has deepened. Additionally, thanks to the development of the GPS continuous observation network on the Japanese archipelago from the 1990s, observational evidence has shown that strain was building up as a result of plate subsidence in the Pacific Ocean off the coast of the Tohoku region. As a result, more researchers were realizing that a major earthquake occurring in the vicinity of the Japan Trench offshore of the Tohoku region was a possibility, or to put it another way, more researchers were realizing that it was dangerous to assume that just because it was a location where a major earthquake had not occurred within a history of several hundred years one would not occur there in the future. In the midst of that, in a long-term evaluation by the Promotion Center in July 2002, it was pointed out that there was a possibility of a tsunami earthquake occurring anywhere in the vicinity of the Japan Trench between offshore of Sanriku and offshore of Boso. This indicated that there was a possibility of a tsunami earthquake occurring even off the coast of Fukushima Prefecture, which had been positioned as a seismic gap. However, based on a strong request from the bureau in charge of emergency preparedness at the Cabinet Office, a proviso was added to this long-term evaluation (prediction), which cautioned that due to data limitations, the figures for the occurrence probability and earthquake magnitudes contained errors.

The decision to exclude seismic gaps from national disaster prevention measures was made determinably by the Central Disaster Prevention Council, which decided the country's overall disaster-prevention plan. As described in detail previously in Chapter V. 2. (2), at the second meeting of the "Committee for Technical Investigation on Counter-Measures for the Trench-type Earthquakes in the Vicinity of the Japan and Chishima Trenches" ("Trench Expert Committee") of the Central Disaster Prevention Council, the secretariat presented a proposal to compromise with the earthquakes to be covered in the review of disaster-prevention measures. This involved having disaster-response measures cover: (i) areas where large earthquakes had repeatedly taken place in the past; and (ii) areas where large earthquakes rarely occurred; but excluding from coverage (iii) areas where there was no record of a major earthquake occurring.

The reasoning behind this was that "no sufficient knowledge is yet available on the probabilities of occurrence (meaning scientific research was underdeveloped)."

In response to this, the earthquake and tsunami specialists among the members of this Trench Expert Committee argued that the seismic gap in the area running along the Japan Trench off the Fukushima Prefecture and Ibaraki Prefecture coasts should be covered under disaster-response measures for tsunami earthquakes, and that consideration should also be given to a Jogan-type tsunami, for which a true picture was beginning to emerge. However, the secretariat did not change its policy, pointing out that the disaster-response plan was legally-binding and because budget constraints and the ability of the municipalities concerned to respond are also involved, a fairly persuasive basis was needed when deciding to include an area in the plan's coverage. Subsequently, this Trench Expert Committee compiled a report in 2006 that essentially complied with the secretariat's above-mentioned policy, in which along with removing a tsunami earthquake in the area running along the Japan Trench off the Fukushima Prefecture and Ibaraki Prefecture coasts from its review coverage, it stated only that a Jogan-type tsunami "needs to be kept in mind." Meanwhile, the area off the shore from Nemuro to Tokachi, an area with a "500-year earthquake recurrence interval," was designated to be covered under the disaster-response measures, since owing to steady and cumulative studies research on the occurrence cycle and fault model had progressed to a point where the case that could be made for this review was persuasive.

It cannot be denied that the process of the government's decision-making on emergency preparation that is outlined above was reasonable to a certain extent when the logical framework of government administration is taken into account. However, faced with the reality that close to 20,000 lives were lost as a result of a massive tsunami, and that well over 100,000 people were forced to evacuate after a massive tsunami over 14 m high struck and triggered a nuclear accident, can the government walk away simply by saying that it made no mistakes and that there was nothing they could have done more because this major earthquake and tsunami were "beyond assumptions"? If so, no lesson useful to create a safe society can be learned.

In order to look for solutions to this question, it becomes necessary to undertake analysis through approaches to accident research that are not bound by the administration's logic. Approaches to accident research mean initiatives for carrying out cause analysis that ask

questions, regardless of the government's logic and whether the government held responsibility, such as: were there no other options or approaches available that would have even marginally reduced the damage and was there no means of reforming the administration's decision-making framework? When analyzed from this standpoint, the following problem points surface:

(i) Up to now there were considerable interest in the Nankai Trough among earthquake researchers, and research on a massive earthquake occurring in the Japan Trench and Chishima Trench was not sufficient. This has been influenced by the fact that clear historical records remain (in Nankai), and that social interest in an earthquake occurring in central Japan where a large number of people live was high. After pioneering research regarding a massive earthquake occurring in the Japan Trench and Chishima Trench, starting with the Jogan Earthquake, undertaken around 1990, only scant research was carried out in the 10-plus years subsequent to that. Japan is a "disaster-prone country" that has experienced historically a large number of earthquake and tsunami disasters. However, in publicly-funded research projects within the scientific research budget etc., the growing prevalence of a style of research that emphasizes narrow research targets has in some respects given rise to "places where the sun shines" and "places where the sun does not shine" in the field of earthquake research. It needs to be noted that relying on knowledge based on research of this type when assigning priorities in disaster-prevention measures may have increased the "beyond the scope of assumptions" risk. (This issue is similar in nature to the problem discussed above in (3), regarding the pitfalls that can develop as a result of concentrating solely on improving the accuracy of risk probability calculations). **Scientific knowledge of earthquakes is not sufficient yet. The latest research results should be continually incorporated in emergency preparedness. In other words, a policy/rule concluded at a certain point based on the then-available knowledge should be reviewed with flexibility and revised, without groundless procrastination, when new knowledge of earthquakes and tsunami become available.**

(ii) If an area is excluded, due to limited financial resources or other reasons, from the areas for strengthening emergency preparedness because of low or unknown probabilities of occurrence, the damage would be extremely serious once a massive earthquake and tsunami hit the area. Administrative bodies should take initiatives of, for instance, launching research projects on earthquake evaluation in specific areas for which some

seismologists warn of risks, even if few in number, or which show traces of massive earthquakes and gigantic tsunami (tsunami deposits, for instance) from the remote past; or formulating an innovative disaster prevention plan in full cooperation of public administration, residents and experts through disclosing relevant information.

(iii) Up to now, emergency preparedness plans decided on by the Central Disaster Prevention Council have moved forward without paying a particular attention to the regions where nuclear power plants are located. However, **disaster risks in nuclear power plant siting regions should be noted. It was the role of NISA to prepare for nuclear emergencies at nuclear power stations. However, the policy of the Central Disaster Management Council has strong relevance to the emergency preparedness at nuclear power stations. The Central Disaster Management Council should duly consider the nuclear power stations, too, in its policy making.**

On the other hand, how were TEPCO's tsunami responses?

TEPCO calculated the maximum wave height for tsunami to anticipate that could strike the Fukushima Dai-ichi NPS and Fukushima Dai-ni NPS using the Tsunami Assessment Method compiled by the JSCE in 2002. It obtained a figure of 5.4-5.7 m above the Onahama Peril for the Fukushima Dai-ichi NPS and 5.1-5.2 m for the Fukushima Dai-ni NPS, and took measures accordingly. Later, within the "Long-term Assessment" by the "Promotion Center," the observation was made that the possibility of a tsunami earthquake occurring offshore from Fukushima Prefecture could not be ruled out, and so from May to June 2008 TEPCO calculated the wave height of a tsunami envisaged to take place as the result of an earthquake in the class of the Meiji Sanriku earthquake (in 1896) occurring off the coast of Fukushima Prefecture, whereupon it obtained an extremely high figure for the Fukushima Dai-ichi NPS site, of 9.3-15.7 m. Additionally, around October of that year, TEPCO referred to a Jogan-type tsunami simulation conducted by another expert to estimate the tsunami wave height and similarly obtained high figures of 8.6-9.2 m for the Fukushima Dai-ichi NPS and 7.7-8.0 m for the Fukushima Dai-ni NPS.

However, TEPCO executives concluded that the earthquake predictions for the vicinity of the Japan Trench including the earthquake offshore from Fukushima Prefecture mentioned in the "Long-term Assessment" in 2002 and the new simulation research on a Jogan-type tsunami

simply pointed out possibilities, and that in fact no such tsunami would likely occur. And rather than embark on new tsunami measures immediately, they decided only on a plan to ask the JSCE for investigation, and to perform a tsunami deposit survey for the Fukushima Prefecture coast.

In the meantime, in response to requests from NISA, TEPCO reported the results of the above-mentioned tsunami calculations on three occasions – in September 2009, May 2010 and on March 7, 2011 (four days before the Tohoku District - off the Pacific Ocean Earthquake struck on March 11) – but because neither NISA nor TEPCO had a sense of urgency, this did not lead on to any action being taken to promptly implement proactive tsunami countermeasures, and the measures that had been based on the 2002 tsunami assumptions were left as they were.

Around this time the Earthquake Research Committee at the "Promotion Center" was compiling a new "Long-term Assessment" report, being scheduled to publish in October 2011, based on progress in research on Jogan-type tsunami and other developments. Getting aware of this, TEPCO made requests on March 3, 2011, to the Secretariat of MEXT's "Promotion Center" that included stating that it "wants (the report) to describe the Jogan Sanriku-Oki Earthquake as can be interpreted that its seismic source has not been identified yet, and to think of modifying wording to describe the Jogan Sanriku-Oki Earthquake in the revised version since the text in the draft revision sounds as if the earthquakes frequently occurred." This action cannot help but raise the suspicion that rather than taking sincerely the outcome of a government institution's earthquake and tsunami forecasts, TEPCO was instead attempting to prevent being pressured to undertake measures to counter a massive, Jogan-type tsunami, or was attempting to avoid having questions raised about deficiencies in its tsunami defense measures.

When TEPCO's responses, such as the ones outlined above, are examined in hindsight, it is to be mentioned that TEPCO lacked a sense of urgency and imagination toward major tsunami, which could threaten to deal a fatal blow to its nuclear power plants. Consequently, this could be considered as one of significant background factors that led to a serious nuclear accident and inadequate measures against the expansion of damage.

(6) Issues of the government crisis management systems

Following a criticality accident in 1999 at the JCO nuclear fuel fabrication facility (hereinafter referred to as "the JCO criticality accident"), the Nuclear Emergency Preparedness Act was enacted the same year with the goal of protecting people's lives, personal safety and property from a nuclear disaster by strengthening measures to counter such a disaster. Based on the lessons of the JCO criticality accident, the Act stipulated that in the event of a nuclear disaster, a Local NERHQ would be set up near the accident site. It also stipulated that the Director-General of the Local NERHQ would be delegated with authority by the Prime Minister and would lead the response to the situation. The Nuclear Emergency Response Manual that was formulated based on the Act also assumed that the response to the situation would center on the Local NERHQ.

In fact, in the latest case also, in accordance with the Nuclear Emergency Response Manual, when disaster struck, core members of the Local NERHQ assembled on-site in order to perform the Local NERHQ's functions, beginning with Motohisa Ikeda, Senior Vice-Minister of METI, who served as Director-General of the Local NERHQ, as well as TEPCO Vice-President Sakae Muto and others. However, at the Off-site Center that was to serve as the base for the headquarters, the communications equipment had been rendered all but unusable due to the earthquake, and so the Local NERHQ was not able to fully perform its function as a command center.

As a result, the NERHQ (the Director-General is the Prime Minister) set up in Tokyo had no choice but to stand at the forefront of the disaster response, including carrying out duties that should have been performed by the Local NERHQ. In the process, the capacities of the Crisis Management Center located belowground in the Prime Minister's Office were not utilized, where officials from the relevant ministries and agencies had assembled, and decisions on key matters took place mainly on the fifth floor of the Prime Minister's Office, centering on Prime Minister Kan. Moreover, the initial response to the nuclear accident took the form of Prime Minister Kan himself playing the lead role, including actively gathering information himself, and traveling to inspect the accident site.

In a hearing with this Investigation Committee, Prime Minister Kan commented on the fact that the fifth floor of the Prime Minister's Office became a kind of command center, saying that

"Systems that had been envisaged during normal times did not work, and the Prime Minister's Office had to seize the initiative, but effectively it was not a problem, because NSC Chairman Madarame and officials from NISA were on the fifth floor, and in each case I was deciding responses after listening to their opinions." As a technology graduate Prime Minister Kan prided himself on "being familiar with" nuclear power (an expression he used during a hearing with this Investigation Committee). When it came to responding to the earthquake and tsunami disaster, Prime Minister Kan was deciding responses to the situation based on reports he was receiving on an as-needed basis from Crisis Management Deputy Chief Ito and other members of the Emergency Operations Team in the basement of the Prime Minister's Office. In contrast, however, when responding to the nuclear disaster, he did not attempt to utilize the capacities of the Crisis Management Center located belowground at the Prime Minister's Office for systematic responses in a coordinated manner. One of the adverse effects of this is that because, for example, officials from MEXT, which oversees SPEEDI, were not included among the decision-making members on the fifth floor of the Prime Minister's Office, the opportunity was lost to learn of the existence of SPEEDI and consider the possibility of utilizing it.

This time, a command center was set up on the fifth floor of the Prime Minister's Office, which had not been stipulated in the Nuclear Emergency Response Manual, and Prime Minister Kan came to the forefront to deal with the accident. The background to these circumstances can be attributed to the inability of the Local NERHQ to fulfill its original roles, as well as to inadequacies in the information consolidation scheme in the Prime Minister's Office, and in the advisory function of the NSC. However, the Prime Minister's original role is to give appropriate, final decisions on the most important matters brought up by specialized divisions along with suggested options and leave information gathering and response measures to each organization, department and agency of the government. Intervening in the site of the disaster as a commander may create confusion on-site, and lead to a loss in the opportunity of making important decisions or lead to making wrong judgment. As such, such an action should be viewed more as a possible cause of a greater harm than that of good.

Learning from the experience as a result of the accident at the Fukushima Dai-ichi NPS, the crisis management system for a nuclear emergency should be urgently reformed, in which the nuclear emergency response manual should be revised assuming an occurrence

of a complex disaster combining an earthquake/tsunami disaster and a nuclear accident. In its reforming process, the strengthening of response capabilities of off-site centers is needed. In addition, it is also required to build a crisis management system by examining how to respond to a situation which a local nuclear emergency response headquarters cannot handle by convening personnel from relevant emergency response bodies.

(7) Issues of the provision of information and risk communication

When a nuclear disaster that has a serious impact on a wide area occurs and additionally where the circumstances change from one moment to the next, the approach taken to disclosing information domestically and internationally by the institutions concerned is extremely important. There are many means of conveying information, including press conferences and websites, but unilaterally conveying a decision by the government or an expert is known as a risk message. However, when conveying information in the case of a nuclear disaster, unilateral risk messages will conversely pose a danger of fueling confusion and mistrust among the people, because it will involve communicating information on sophisticated scientific and technical matters and information on radiation and radioactivity that bears little connection to the everyday lives of the general public. It is desirable to communicate disaster-related information while getting feedback on things such as what kinds of information citizens need, particularly citizens in the vicinity of the accident site, and how these citizens are perceiving (interpreting) the information that has been communicated.

As already stated, the ways in which information was provided from the government to the public in the aftermath of this accident raised many questions and doubts as to whether the information had been communicated in a prompt and accurate manner, from the perspective of the residents in the surrounding areas who had had to evacuate, and the people at large. Examples are: the way of providing information on the situation and predictions of dispersion of radioactive substances, which is important in the evacuation of residents in the vicinity; way of providing information on the core conditions (in particular, core meltdown) and the critical conditions at Unit 3 of the Fukushima Dai-ichi NPS; and repeated explanations of "there is no immediate effect on the human body," that were difficult to understand, when providing information on the impact of radiation on the human body.

In this way, irrespective of the circumstances, as a result of cumulative problems such as delays in the transmission and release of urgent information, the holding back of press releases and the lack of easy-to-understand explanations, citizens in the vicinity were prevented from making appropriate autonomous decisions. Additionally, these problems fueled doubts and mistrusts among citizens, including that "the government and TEPCO are probably covering something up." As a risk communication approach at a time of an emergency disaster, it was inappropriate.

A fundamental principle of public relations is to convey facts promptly, accurately and in an easy-to-understand manner. Even in an emergency disaster, adhering to this principle is crucial because it serves eventually to help people in the vicinity to make appropriate autonomous decisions and prevents unnecessary uncertainty and confusion taking hold among citizens. At the same time "promptness" and "accuracy" are sometimes in conflict with one another. In that situation it should be kept in mind that if sacrificing "promptness" in order to ensure "accuracy," there is conversely a danger of inviting citizen's mistrust and concern. When a situation develops in which information cannot be obtained and accurate public relations are not possible, it is both necessary and important to communicate that situation as it stands.

Additionally, looked at from the standpoint of being "easy to understand," the communication on evaluative facts requires particular consideration. As facts to be included in publicity, in addition to already-released and already-known simple facts (for example, an explosion occurred at the reactor building or contaminated water flowed into the sea, etc.), there are also evaluative facts that can be inferred from various already-known facts (for example, a core meltdown, or the impact of radiation on the human body, etc.). Unless these types of evaluative facts are explained with a great deal of care, more than occasionally it will be difficult to gain citizens' understanding. Where evaluative facts are concerned, it may be believed that in some cases it is probably not possible to say anything conclusive due to insufficient information or the uncertainty of the situation, but even in those circumstances it would be desirable to provide an explanation to that effect and then disclose information as promptly as possible.

The following can be said for all emergency situations, not just for nuclear disasters, but **it is necessary to build mutual trust between the public and the government and to provide**

relevant information in an emergency while avoiding societal confusion and mistrust. To this end, a risk communication approach on risks and opinion exchanges thereupon should be adopted for a consensus building among all stakeholders based on mutual trust. This time, amid the state of confusion arising from the outbreak of a complex disaster, as previously noted a large number of problem areas could be detected in the government's public relations activities, including those of NISA, from a risk communication perspective. **The government should examine, by institutionalizing an appropriate body, how to provide relevant information in an emergency to the public, promptly, accurately, and in an easily understandable as well as clear-cut (not misleading) manner. Inappropriate provision of information can lead to unnecessary fear among the nation. Therefore, an expert on crisis communication may be assigned for providing appropriate suggestions to the cabinet secretary responsible for information provision to the public in an emergency.**

(8) Importance of a safety culture vital to the lives of the public

Safety culture of the nuclear power sector refers to "assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance." This concept was first advocated by the IAEA's International Nuclear Safety Group ("INSAG") in the "Summary Report on the Post-Accident Review Meeting on the Chernobyl Accident" (1986). In its subsequent reports, INSAG adopted the concept as one of the fundamental principles for ensuring the safety of facilities. The essence of the concept is "the integration of temperament and awareness, and attitude, which organizations and individuals should possess in order to ensure that as an overriding priority, nuclear safety issues receive the attention warranted by their significance."

Generally speaking, it is extremely rare for an accident to occur as the result of a single error or failure alone – it will normally take the form of a large number of overlapping elements. Furthermore, those unsafe factors tend to have been embedded in the organizations or systems before the accident, and in some cases an accident is the work of those temporally and spatially removed from the accident itself – the decision-makers at an operation (the management team or administrators) or the people who set the rules or created the manuals. J. Reason, who had a

major theoretical impact on the world's accident investigation systems, refers to these kinds of accidents as "organizational accidents."

Factors contributing to a lack of safety that gives rise to organizational accidents do not involve just the operators – in some cases they are created by the administrative organizations that are the regulatory authorities. Whether or not factors contributing to a lack of safety are likely to be generated is connected to the level of safety culture at that organization.

Safety culture such as this exists in the form of ingrained behaviors (or in the form of making behaviors second nature), approaches to decision-making and mindsets among the management team or administrators (in the case of operators) and leaders and officials (in the case of regulatory authorities). Specific check points for determining this level of safety culture, with reference to J. Reason's theories and other ideas, would be illustrated as outlined below:

(a) The safety culture level at the operator

(i) Is safety officially expressed as a mission?

(ii) Is the management team able to make firm decisions on safety?

(iii) Is a policy in place to ensure safety independently, irrespective of the financial circumstances or sales results?

(iv) When unsafe factors or risks exist, are decisions on dealing with those issues not lenient, or are they not being made simply for the sake of appearances?

(v) Are there not thick vertically-segmented barriers that are hindering horizontal cooperation within the organization or the sharing of risk information?

(vi) Are there not frequent interruptions in communication between the headquarters and sites of the organization?

(vii) In managing a complex system and coping with problems that emerge, are there people in competent positions able to understand the system overall and deal with it?

(viii) If an accident occurs, is the organization not at risk of becoming dysfunctional?

(ix) Will no inconsistencies develop between the management team's decisions and instructions and the decisions and actions of those on-site?

(x) Is the management team undertaking frank disclosure of information with regard to safety efforts and evacuation measures for citizens in the vicinity?

(b) The safety culture level at regulatory authorities

(i) Is the promotion of nuclear power policies separated from regulatory duties?

(ii) Is there an unfaltering will to make ensuring safety the mission, irrespective of the material and human resources situation?

(iii) When safety measures to perfection cannot be adopted due to political or administrative limitations, is there an established stance of disclosing information to citizens and the general public regarding those circumstances and alternative plans?

(iv) Does the authority concerned have staff possessing the specialized knowledge and ability, the level being equal to those of the staff at operators, to comprehend a complex technological system?

(v) Are the inspectors equipped with adequate ability to understand technical issues and adequate ability to carry out inspections, and are they fulfilling their duties on-site?

(vi) Is the approach to duties losing sight of a whole picture of safety importance, being pressed by not a hurried, summary examination of safety that pursues checks on technologically-insignificant details?

Additionally, in order to ensure safety, as well as organizational perspectives such as those above, the roles and duties of every individual attached to the organization are also important. It is essential that each individual develop a finely-tuned ability to sense risk, which each can express perceived risks or problems they have become aware of freely within the organization, and that this information is shared up to the organization's upper levels and appropriate responses are made.

The results of the investigation and inquiries undertaken by this Investigation Committee suggest that there are examples both on TEPCO and NISA which would be difficult to assert to have satisfied the conditions set out in some of the checkpoints mentioned above. For example, at TEPCO: In hindsight the company had not taken adequate measures with regard to the risk of the Fukushima Dai-ichi NPS being struck by a tsunami that exceeded assumptions; its workforce was vertically-segmented, and even in dealing with this accident a perspective of carrying out the necessary tasks based on a comprehensive overview of the situation was lacking; and the organizational information sharing system was not in place as can be seen in important steps relating to the handling of the accident being carried out without seeking direction from senior staff. Meanwhile, at NISA, the regulatory authority, failed to satisfy the

conditions set out in many of checkpoints above: There were problems with its information disclosure stance, including no thought whatsoever being given to releasing monitoring results and SPEEDI information in order to help with the evacuation, along with inadequacies in the release of information concerning the core meltdown also; in dealing with the accident, in some cases it lacked the capacity to properly grasp the conditions on-site and accurately explain them to the Prime Minister's Office etc.; its safety inspectors cannot be said to have performed their roles proactively at the Fukushima Dai-ichi NPS; and in the pursuit of short-term duties, adequate engagement in medium- to long-term issues was not taking place, in part due to insufficient organizational system. In this way, it is difficult to assess both the nuclear operator and the regulatory authority as having sufficiently established a safety culture.

Well established safety culture is vitally important to people's lives in the nuclear power industry, which may cause serious situations once an accident occurs. In view of the reality that safety culture was not necessarily established in our country, the Investigation Committee would strongly require rebuilding safety culture of practically every stakeholder in nuclear power generation such as nuclear operators, regulators, relevant institutions, and government advisory bodies.

(9) Necessity of continued investigation of the whole picture of accident causes and damage

a. Need to continue uncovering the causes of the accident

Although the responsibilities of the Investigation Committee are concluded with the submission of the Final Report, there are still many points that remain to be clarified, as raised in 1. (1) b. above of this Chapter, which were left due to the impossible on-site investigations in the reactor buildings as well as time limitations. These include: the details of the overall damage incurred, beginning with the damaged areas in the main facility of the Fukushima Dai-ichi NPS, their degree of damage, and the development of events over time; the background to the leakage of radioactive substances; and the cause of the explosion in the reactor buildings.

Meanwhile, the impact on residents' health, and contamination of air, soil, water and items such as the agricultural, farming, and fishery products, are issues that require continued investigation and verification going forward. The Investigation Committee has no choice but to conclude its investigations and verifications at this point in time. Furthermore, there are also

problems in repairing the damage that has been caused, and expected to require long-term response into the future, including decontamination and methods of compensation for damages caused. As such, items that were not subjected to investigation and verification by the Investigation Committee remain of great importance to the victims and affected areas, and are issues that are of great concern to the society.

The government, nuclear operators, nuclear plant manufacturers, research institutions, academies, all such stakeholders (relevant organizations) involved in nuclear power generation should take active roles in investigating the accident and in fact analyses, and continue, in their respective capacities, their comprehensive and thorough investigations of the remaining unresolved problems. The government, in particular, should not conclude its investigations of the Fukushima nuclear accident at the time when this Investigation Committee or the Fukushima Nuclear Accident Independent Investigation Commission ("NAIIC") of the National Diet conclude their activities. It should continue its initiatives to investigate the causes of the accident. On-the-spot investigations of reactor buildings should certainly be conducted in detail, including the impacts of earthquakes, as soon as the radiation level lowers.

b. Need to conduct investigations in order to clarify the full scope of damage

This nuclear accident brought various forms of serious damage to regions covering a wide area. Citizens in areas contaminated with high concentrations of radioactive material were compelled to live as evacuees for long periods or to relocate (move to a new address), forcing circumstances upon them that included disaster-related deaths, suicide, break-ups of families, the inability to carry on operating farms (including orchards), livestock businesses, commercial pursuits, distribution services, food-processing businesses and small factories, etc., and losses of places of employment. The stress that was created by unstable living conditions such as this caused the health of more than a few middle-aged and elderly peoples to deteriorate and resulted in a string of people falling victim to what should be called disaster-related deaths.

Additionally, the damages suffered by the health and welfare sector include a significant decline in the number of medical institutions and medical practitioners in areas in the vicinity of the nuclear power station. This made it difficult for citizens to obtain medical treatment and

meant more than a few welfare facilities became unusable. The tragedies explained in detail in this Final Report are also included, such as the string of fatalities that occurred after long strenuous journeys on evacuation buses from Okuma Town's Futaba Hospital, where a large number of seriously ill elderly patients had been being treated.

In the farming sector, as a result of farmers losing their farmland and the cessation of livestock businesses etc., people were faced with the difficult task of having to change occupations. Also serious is the discarding of contaminated farm produce and the plunge in prices for produce due to harmful rumors and misinformation. The lifestyle prospects for self-employed people in various trades who have closed their stores or small factories are also bleak.

In areas contaminated by radioactive materials, the schools, kindergartens and day-care centers have been forced to close for long periods, making it necessary for them to utilize other schools and facilities long distances away for classes. Children faced a long continuous period of being unable to play outdoors, and conditions likely to put stress on both their mental and physical development continued.

Decontamination measures pose a large number of difficult problems in terms of cost as well as in terms of the decontamination efficacy, and the confused situation continues. It is not expected to be possible to decontaminate highly-contaminated areas, and there is no telling how those citizens who are unable to return home and who have "lost their hometowns" should go about rehabilitating their communities or go about living from here on.

In analyzing the damages of the nuclear accident, what is important is not to simply grasp the general situation in terms of total numbers, but rather to secure a specific grasp of the entire picture and details of the human suffering wherever possible – how were the lives and dignity of individual people threatened, and to what degree were lifestyles and lives distorted or disrupted? How were areas wrecked as a result of contamination by radioactive materials, and what areas were not able to be rehabilitated? Studies aimed at recording the entire picture and details of suffering such as this are not being underway at present. Additionally, administrative institutions have studied and are dealing with the damage situation to the extent necessary in terms of their jurisdictions, but they are not carrying out studies for the purposes of taking a straight look at the realities of the suffering and recording them.

Japan as a country which experienced an unprecedented nuclear disaster should transfer as lessons to future generations the whole picture of "Human suffering" including the facts in detail. This can be done by: recording the results of a comprehensive investigation of academic study in respective specialized fields and collection of testimonies of an enormous number of stakeholders and victims; investigating the adequacy of relief, support and reconstruction programs for the victims; or transferring the facts showing how extensive and serious the damage by a nuclear disaster could be. Comprehensive investigative records exist in Japan that are full of insights into the reality of the "human suffering" brought on by massive disasters in the past[25]. **The Investigation Committee believes that it is the national responsibility of Japan to transfer the whole picture of "Human suffering" to future generations based on the recorded results of comprehensive investigation of the Fukushima nuclear disaster. The investigation of the "Human suffering" may need the participation of a wide area of academic fields, vast costs and time. The Investigation Committee requests the government to actively build the investigation system, in cooperation with local municipalities, research institutions, private organizations and other relevant bodies, and provide necessary support to such investigation initiatives.**

[25] Examples of detailed recording of the whole picture of human suffering by natural disasters are: Kaizosha, Taisho Daishinsai Kasaishi (Record of the Fire Disaster in Taisho Great Earthquake) (105,000 deaths or missing), 1924, concerning the Great Kanto Earthquake in 1923; and City of Nagoya, Isewan Taihoo Saigaishi (Record of the Isewan Typhoon Disaster) (5,098 deaths or missing), 1951, concerning the 1959 Ise Bay Typhoon. There are also very good model of a comprehensive investigation approach or recording the facts, although they are not caused by natural disasters: City of Hiroshima, Hiroshima Genbaku Sensaishi (Records of the Hiroshima A-bomb War Disaster) (5 Volumes), 1971; and City of Nagasaki, Nagasaki Genbaku Sensaishi (Records of the Nagasaki Atomic Bombing and Wartime Damage) (5 Volumes), 1977-1983, both of which dealt with the A-Bomb victims in 1945 (about 210,000 deaths or missing in total).

3. Recommendations for Preventing Recurrences of Nuclear Disasters and for Mitigating Damages

This Final Report presented the necessary recommendations of the Investigation Committee, as previously stated, based on the facts identified as a result of its investigation and inquiries into the causes of the accident. Additionally, the Interim Report also presented a number of recommendations of the Investigation Committee based on the investigation and inquiries as of that point. The Investigation Committee believes implementing those recommendations will be effective and important in preventing recurrences of nuclear disasters and mitigating damages, and it strongly requests that the government, the municipalities concerned, nuclear operators and other related institutions reflect these recommendations and execute them in their future safety measures and emergency preparedness.

The rationale of the Investigation Committee making these recommendations is the Cabinet decision taken on May 24, 2011 that formed the basis for the establishment of the Investigation Committee, requesting that policy recommendations be made with regard to preventing damages caused by the accident at the Fukushima Dai-ichi NPS from spreading, and to preventing similar types of accidents from recurrence. As stated in Chapter I. 5. of the Interim Report, issues concerning nuclear power generation, such as whether or not nuclear power stations should be retained and whether or not they should be restarted, are not within the scope of this Investigation Committee's investigation. Furthermore, this Investigation Committee's proposals are not based on the premise that nuclear power stations should continue to exist and be utilized in the future also. Issues concerning the pros and cons of nuclear power generation should ultimately be decided based on the choices of the people, and this Investigation Committee does not possess any point of view whatsoever in regards to those issues. However, the reality is that Japan has a large number of nuclear power stations, and we would like to point out that irrespective of what is done with them in the future, safety measures and emergency preparedness are required.

It will be important to strive to implement these recommendations of the Investigation Committee promptly and reliably in all cases. Therefore, along with asking that the government instructs the agencies/ministries concerned and the departments/bureaus concerned to ensure the recommendations are substantiated by reflecting and implementing them, the Investigation

Committee also urges that conclusive follow-ups be conducted, including securing a grasp of the progress in the efforts being made by the agencies/ministries concerned and the departments/bureaus concerned, and then assembling and publishing those findings. Additionally, at the concerned municipalities, and at TEPCO and other concerned institutions also, the Investigation Committee urges that along with similarly reflecting and implementing the recommendations, follow-ups are undertaken regarding the progress of those efforts.

Here we categorize the recommendations made in the Interim Report and the Final Report into seven areas, and restate them:

(1) Recommendations for a basic stance for safety measures and emergency preparedness

(2) Recommendations for safety measures regarding nuclear power generation

(3) Recommendations for nuclear emergency response systems

(4) Recommendations for damage prevention and mitigation

(5) Recommendations for harmonization with international practices

(6) Recommendations for relevant organizations

(7) Recommendations for continued investigation of accident causes and damage

Within each area, fundamental and general items are recorded first, followed by specific and detailed items.

(1) Recommendations for a basic stance for safety measures and emergency preparedness

- **Recommendations for emergency preparedness in light of complex disasters in mind** (Final Report VI. 2. (2))

When reviewing the existing safety measures at nuclear power stations, risks of a large scale complex disaster should be sufficiently considered in emergency preparedness.

- **Recommendations for changing an attitude to face risks** (Final Report VI. 2. (3))

(i) It is necessary to humbly face the reality of natural threats, diastrophism and other natural disasters, which are sizable in scale and time, keeping in mind that Japan has often had them in its long history.

(ii) Risk reduction should be tackled in a drastically different approach. In the government as well as in private entities, a new approach to safety measures and emergency preparedness

should be established for a disaster which potentially brings about serious damage in broad areas like a gigantic tsunami or the severe accident at the Fukushima Nuclear Power Station, regardless of its probability of occurrence.

(iii) An institutional framework is needed to ensure continued in-depth examination of "residual risks" or "remaining issues" without leaving them behind beyond the predetermined safety measures and emergency preparedness.

- **Recommendations for "deficiency analysis from the disaster victims' standpoint"** (Final Report VI. 2. (4))

An accident at a nuclear power station has risks to bring about damage in vast areas. Nuclear operators on one hand, nuclear regulators on the other, should establish a systematic activity to identify all risk potentials from the "disaster victims' standpoint," when designing, constructing and operating such nuclear systems, for ensuring credible nuclear safety including evacuation planning in the local society. Such an approach should be practiced.

Radioactive materials may disperse over vast areas due to an accident at a nuclear power station. The prefecture and local municipalities involved should closely collaborate in building up an effective system for minimizing confusion.

- **Recommendations for incorporating the latest knowledge in the emergency preparedness** (Final Report VI. 2. (5))

(i) Scientific knowledge of earthquakes is not sufficient yet. The latest research results should be continually incorporated in emergency preparedness. In other words, a policy/rule concluded at a certain point based on the then-available knowledge should be reviewed with flexibility and revised, without groundless procrastination, when new knowledge of earthquakes and tsunami become available.

(ii) If an area is excluded, due to limited financial resources or other reasons, from the areas for strengthening emergency preparedness because of low or unknown probabilities of occurrence, the damage would be extremely serious once a massive earthquake and tsunami hit the area. In such specific areas for which some seismologists warn of risks, even if few in number, or which show traces of massive earthquakes and gigantic tsunami and massive tsunami (tsunami deposits, for instance) from the remote past, administrative bodies should take initiatives of formulating an innovative disaster prevention plan in full cooperation of public

administration, residents and experts through, for instance, launching research projects on earthquake evaluation or disclosing relevant information.

(iii) Disaster risks in nuclear power plant siting regions should be noted. It was the role of NISA to prepare for nuclear disasters at nuclear power stations. However, the policy of the Central Disaster Management Council has strong relevance to the emergency preparedness at nuclear power stations as well. The Central Disaster Management Council should duly consider the nuclear power stations, too, in its policy making.

(2) Recommendations for safety measures regarding nuclear power generation

- **Recommendations for building disaster preventive measures** (Final Report VI. 2. (1))

Quite a number of issues exist in specifying concrete actions required, which need highly specialized nuclear knowledge over a wide range, for solving technical and nuclear engineering problems concerning the responses to the accident at the Fukushima Dai-ichi NPS, and the then-available emergency preparedness by the government, TEPCO and other organizations. These issues should be reviewed and shaped into concrete actions, through competent knowledge by stakeholders in nuclear power generation. In doing so, they should sincerely take into consideration the recommendations the Investigation Committee has made and they should do so with accountability to society for its process and results.

- **Recommendations for the necessity of comprehensive risk analysis** (Final Report VI. 1. (4) a.(b))

Nuclear facilities are constructed in a natural environment, which is really diversified. Nuclear operators should conduct comprehensive risk analysis encompassing the characteristics of the natural environment. In the analysis, they should include the external events, not only earthquakes and their accompanying events but also other events such as flooding, volcanic activities or fires, even if their probabilities of occurrence are not high, as well as the internal events having been considered in the existing analysis. Nuclear regulators should check the operators' analysis. Nuclear operators should actively utilize currently available methods in their analyses of such external events, even if the PSA approach is not firmly established for them. The government should consider support to promote relevant research programs for such initiatives.

- **Recommendations for severe accident management** (Final Report VI. 1. (4) a. (c))

  In order to ensure maintaining nuclear safety at nuclear power stations, vulnerability of individual facilities for a wide range of characteristics of various internal and external events should be identified by comprehensive safety analysis. And appropriate measures (severe accident management) against such vulnerability should be examined and placed in shape accordingly, assuming a situation in which the core may have serious damage by an accident far exceeding the design basis. The effectiveness of such severe accident management should be evaluated through the PSA or other means.

(3) Recommendations for nuclear emergency response systems

- **Recommendations for reforming the crisis management system for a nuclear emergency** (Final Report VI. 2. (6))

  Learning from the experience as a result of the accident at the Fukushima Dai-ichi NPS, the crisis management system for a nuclear emergency should be urgently reformed, in which the nuclear emergency response manual should be revised assuming an occurrence of a complex disaster combining an earthquake/tsunami disaster and a nuclear accident. In its reforming process, not only the strengthening of response capabilities of off-site centers is needed, but it is also required to build a crisis management system by examining concretely how to respond to a situation which a Local NERHQ cannot handle by convening personnel from relevant emergency response bodies.

- **Recommendations for the nuclear emergency response headquarters** (Final Report VI. 2. b. (a))

  The emergency response headquarters should, in general, be located close to the accident site where the relevant information is easy to obtain in a nuclear emergency, and the activities at the accident site are easy to grasp. To promptly collect accurate information is, needless to say, the fundamental principle in the nuclear emergency response. The government emergency response headquarters should be set up in a way which enables the government people access to the necessary information while staying in government facilities like the Prime Minister's Office, without moving to the nuclear operator's head office.

- **Recommendations for off-site centers** (Interim Report VII. 3. (1) a.)

The Government should take prompt actions to ensure that off-site centers are able to maintain their functions even during a major disaster, learning from the fact that the Off-site Center (in Fukushima) became unusable because the risks of radioactive contamination had not been adequately considered beforehand.

- **Recommendations for the roles of the prefectural government in nuclear emergency responses** (Final Report VI. 1. (2) c.)

In a nuclear emergency, the prefectural government should take a responsible role in front, because the damage can extend to a regional size. The nuclear disaster prevention plan should take this point into account.

(4) Recommendations for damage prevention and mitigation

- **Recommendations for the provision of information and risk communication** (Final Report VI. 2. (7))

It is necessary to build mutual trust between the public and the government and to provide relevant information in an emergency while avoiding societal confusion and mistrust. To this end, a risk communication approach on risks and opinion exchanges thereupon should be adopted for a consensus building among all stakeholders based on mutual trust. The government should examine, by institutionalizing an appropriate body, how to provide relevant information in an emergency to the public, promptly, accurately, and in an easily understandable as well as clear-cut (not misleading) manner. Inappropriate provision of information can lead to unnecessary fear among the nation. Therefore, an expert on crisis communication may be assigned for providing appropriate suggestions to the cabinet secretary responsible for information provision to the public in an emergency.

- **Recommendations for improving radiation monitoring operations** (Interim Report VII. 5. (2) d.)

(i) To ensure that the monitoring system does not fail at critical moments, and to ensure the collection of data and other functions, the system should be designed against various possible events, including not only an earthquake but also a tsunami, storm surge, flood, sediment disasters, volcanic eruptions and gale force winds. Measures should be taken to prevent the system from functional failures even in a complex disaster simultaneously involving two or

more such events. Furthermore, measures should be developed to facilitate the relocation of monitoring vehicles and their patrols even in a situation where an earthquake has damaged roads.

(ii) Training sessions and other learning opportunities should be enhanced to raise awareness of the functions and importance of the monitoring system among competent authorities and personnel.

- **Recommendations for the SPEEDI system** (Interim Report VII. 5. (3) c.)

In order to protect the lives and dignity of residents caught up in a disaster, and to prevent the spread of harm from the disaster, measures should be developed to improve operational guidelines of the SPEEDI system so that crucial information on radiation dose rates is provided promptly in a manner acceptable to the people. Measures, including hardware and infrastructure-related measures should be developed and implemented to ensure that SPEEDI functions remain operable even during a complex disaster.

- **Recommendations for evacuation procedures of residents** (Items (i) to (iv) in the Interim Report VII. 5. (4) c. and item (v) in the Final Report VI. 1. (4) b.)

(i) Activities to raise public awareness in daily lives are needed to provide residents with basic, practical knowledge of: how radioactive substances are released during a major nuclear accident; how they are dispersed by wind and other agents; how they fall back to the ground; and how the exposure to radiation can affect human health.

(ii) Local government bodies need to prepare evacuation readiness plans that take into account the exceptionally unusual nature of a nuclear accident, periodically conduct evacuation drills in a realistic circumstance, and take steps to promote the earnest participation of residents in those drills.

(iii) It is necessary to complete, during normal times, readiness preparations, such as drafting detailed plans for ensuring means of transportation, traffic control, securing evacuation sites in outlying areas, and securing water and food supplies at the evacuation site, taking into consideration the situation that the evacuees may number in the thousands to over a hundred thousand[26]. It is especially important to develop measures that support the evacuation of the

[26] The Interim Report quoted "thousands to tens of thousands" as the number of evacuees. The number is hereby

disadvantaged, such as seriously ill or disabled people in medical institutions, homes for the aged, social welfare facilities, or in their own homes.

(iv) The above types of measures should not be left up to the local municipal governments, but need in addition to involve the active participation of the prefectural and national governments in designing and operating an evacuation plan and a disaster prevention plan, in consideration of the situation that a nuclear emergency would affect a large area.

(v) The existing Emergency Planning Zone (EPZ) had been set before the accident on the basic assumption of 8-10 km from a nuclear power station, so that the situation could be well dealt with even in an incident far exceeding a hypothetical accident. However, the accident has shown the need to reconsider what accidents to assume and how to designate evacuation areas. Furthermore, the roles of the government in a nuclear emergency are so large that the government responses should not be limited to those areas outside nuclear site boundaries such as the residents' evacuation. It should also be considered what the government should do to cooperate or support the nuclear operator in a nuclear emergency, in consultation with the operator.

- **Recommendations for the intake of stable iodine tablets** (Final Report VI. 1. (3) e. (c))

  In the existing emergency preparedness, administration of stable iodine tablets is, in principle, subject to the judgment of the government NERHQ. A system which allows local municipalities to independently administer the tablets should be reconsidered, and so is the appropriateness to distribute them in advance to the residents as a precaution.

- **Recommendations for radiation emergency medical care institutions** (Final Report VI. 1. (3) e. (f))

  A considerable number of medical facilities for initial radiation emergency medical treatment should be located in the area which is not likely to be included in an evacuation designated area, so that radiation emergency medical care could be provided even in a severe accident like the accident at the Fukushima Dai-ichi NPS. Those medical facilities should not be concentrated in the area close to the nuclear power station. At the same time, such medical care systems in a

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revised in consideration of the real number of evacuees. The number of evacuees may further increase, depending on the scale of an actual accident.

nuclear emergency would need to be coordinated for collaborating over a wide area across the prefectural borders.

- **Recommendations for public understanding of radiation effects** (Final Report VI. 1. (3) e. (g))

As many opportunities as possible should be institutionalized for the public to get knowledge and deepen their understanding of radiation. By doing so, the individuals should be able to judge the radiation risks based on correct information; in other words, they would be freed from unnecessary fears about, or from underestimating, the radiation risks because of the lack of information.

- **Recommendations for information sharing with, and receiving support from, overseas** (Final Report VI. 1. (3) g. (a) and (b))

Provision of information to overseas countries is equally important as to the Japanese public, especially to neighboring countries or those countries which have many of their nationals residing in Japan. Active and polite responses should be in place for prompt and accurate provision of relevant information with due consideration to language barriers.

International support in a nuclear emergency should be accepted and received as early as possible, when offered, for international comity and for urgently meeting national needs. To avoid confusion and inappropriateness experienced in the early stages at the time of the accident in Fukushima, operation manuals of competent ministries, nuclear operator emergency management operation plans and other relevant materials should prescribe how to respond to such international support.

(5) Recommendations for harmonization with international practices

- **Recommendations for harmonization with international practices such as the IAEA safety standards** (Final Report VI. 1. (7))

It is necessary to keep the national regulation qualities constantly updated in line with the nuclear knowledge accumulation and technological development in the international and national community in order to ensure nuclear power safety. To this end, continuous efforts are needed to keep the national regulatory guides newest and best while monitoring international standards, such as those at the IAEA. Lessons on nuclear safety should be extracted from the

accident, and those lessons and relevant knowledge should be provided to the international community so that they could contribute to the prevention of similar accidents, not only in our country but also in other countries. In the process of reviewing national regulatory guides, international contribution should be pursued by making efforts to propose them to incorporate into the IAEA standards etc., if they turn out to be effective and useful as international standards.

(6) Recommendations for relevant organizations

- **Recommendations for the nuclear safety regulatory body**

(i) The need for independence and transparency (Interim Report VII. 8. (2) a.)

An organization with regulatory oversight over nuclear safety must be able to make decisions effectively and independently, and must be able to function separately from any organization that could unduly influence its decision-making process. The new nuclear safety regulatory organization should therefore be granted independence and should maintain transparency.

The new nuclear safety regulatory organization must be granted the authority, financial resources and personnel it needs to function autonomously as an entity concerned with nuclear safety and should also be given the responsibility of explaining nuclear safety issues to the Japanese people.

(ii) Organizational preparedness for swift and effective emergency response (Interim Report VII. 8. (2) b.)

In light of the serious impact of a nuclear emergency on the nation, the nuclear safety regulatory organization, which would play a key role in emergency response, should, during normal times, work out an emergency prevention plan and implement emergency response drills to facilitate rapid response if an emergency occurs. Furthermore it should foster the specialized skills to provide individuals and organizations responsible for emergency response with expert advice and guidance, and should foster as well the management potential to utilize organizational resources effectively and efficiently.

In addition, the nuclear safety regulatory organization must be well aware that its role is to respond responsibly to crises. It should beforehand prepare systems that can deal with a major emergency if it occurs, and develop partnerships with relevant government ministries and

agencies and with relevant local governing bodies to create mechanisms for cross-organizational response, with the role of the nuclear safety regulatory organization clearly demarcated.

(iii) Recognition of its role as a provider of emergency-related information to Japan and the world (Interim Report VII. 8. (2) c.)

The new nuclear safety regulatory organization must be fully conscious that the way it provides information is a matter of great importance, and must also, during normal times, establish an organizational framework that enables it to provide information in a timely and appropriate manner during an emergency.

(iv) Development of competent human resources and specialized expertise (Interim Report VII. 8. (2) d.)

The new nuclear safety regulatory organization should consider establishing a personnel management and planning regime that encourages personnel to develop lifetime careers. For example, it should offer improved working conditions to attract competent human resources with excellent specialized expertise, expand opportunities for personnel to undergo long-term and practical training, and promote personnel interaction with other administrative bodies and with research institutions, including those involved in nuclear energy and radiation.

(v) Efforts to accumulate scientific knowledge and to collect information (Interim Report VII. 8. (2) e.)

The new nuclear safety regulatory organization to be established should keep abreast of trends embraced by academic bodies and journals in the field (including those in foreign countries) and by regulatory bodies in other countries, in order to continue acquiring knowledge that will contribute to its regulatory activities. It must also understand the implications of that knowledge, systematically share and sufficiently utilize such knowledge, and resulting outcomes should be archived and continually utilized as an organization.

(vi) Active relationship with international organizations and regulatory bodies of other countries (Final Report VI. 1. (5))

The limited number of personnel at a government administrative organization is a collective issue of the all administrative organizations, and not limited to an issue of NISA, etc. But that of the new regulatory body should be duly considered, because of the importance of nuclear safety.

The new regulatory body should secure its personnel, should establish an organizational system competent for international contribution, and develop human resources who can take a role in personnel interaction with international organizations or regulatory bodies of other countries.

(vii) Strengthening of the regulatory body (Final Report VI. 1. (5))

In order to ensure nuclear power safety, responses to individual problems encountered are not sufficient. Continuous efforts are needed to keep national regulatory guides updated at their newest and best qualities, with consideration to international trends of safety regulations and nuclear security, not only to the latest scientific knowledge in the country and overseas. Considering that the impact of a nuclear emergency on society can be sizable, emergency preparedness should be fully established during normal times by formulating an emergency prevention plan or by conducting nuclear emergency response drills so that effective and prompt responses could be taken in an emergency. The regulatory organization should foster the specialized skills to provide individuals and organizations responsible for emergency response with expert advice and guidance and should also foster the management potential to utilize organizational resources effectively and efficiently. Appropriate size of budget and human resources should be duly examined.

- **Recommendations for TEPCO** (Final Report VI. 6. e.)

TEPCO bears critical responsibilities to society as a nuclear operator primarily responsible for nuclear power plant safety. Nevertheless, TEPCO was not sufficiently prepared for such an accident, that natural disasters including tsunami may lead to large-scale core damage. Furthermore, TEPCO had not taken adequate preparedness for tsunami risks beyond design basis at the Fukushima Dai-ichi NPS. The accident showed quite a number of problems with TEPCO such as insufficient capability in organizational crisis management; hierarchical organization structure being problematic in emergency responses; insufficient education and training assuming severe accident situations; and apparently no great enthusiasm for identifying accident causes. TEPCO should receive with sincerity the problems which the Investigation Committee raised and should make further efforts for solving these problems and building higher level safety culture on a corporate-wide basis.

- **Recommendations for rebuilding a safety culture** (Final Report VI. 2. (8))

Well established safety culture is vitally important to people's lives in the nuclear power

industry, which may cause serious situations once an accident occurs. In view of the reality that safety culture was not necessarily established in our country, the Investigation Committee would strongly require rebuilding safety culture of practically every stakeholder in nuclear power generation such as nuclear operators, regulators, relevant institutions, and government advisory bodies.

(7) Recommendations for continued investigation of accident causes and damage

- **Recommendations for continued investigation of accident cause** (Final Report VI. 2. (9) a.)

  Participants (organizations concerned) that are involved in some way in the generation of nuclear power, such as the government, power utilities, nuclear power plant manufacturers, research institutions and academic societies concerned, should actively contribute to verifying this accident and clarifying the facts, and should continue to comprehensively and thoroughly examine and verify these types of as-yet unexplained matters from their respective standpoints. In particular, the government should not consider that the accident investigations and inquiries surrounding the Fukushima NPS disaster have ended accompanying the winding up of the activities of this Committee and the National Diet of Japan Nuclear Accident Independent Commission. It should continue to spearhead efforts to investigate the causes of the accident. Above all, a detailed on-site investigation (including verifying the impact of earthquake ground motion) within the reactor buildings is a task that should be undertaken without fail. once radiation levels have declined

- **Recommendations for extended investigation of the whole picture of accident damage** (Final Report VI. 2. (9) b.)

  Japan as a country which experienced an unprecedented nuclear disaster should transfer as lessons to future generations the whole picture of “Human suffering” including the facts in detail. This can be done by: recording the results of a comprehensive investigation of academic investigation in respective specialized fields and collection of testimonies of an enormous number of stakeholders and victims; investigating the adequacy of relief, support and reconstruction programs for the victims; or transferring the facts showing how extensive and serious the damage by a nuclear disaster could be. The Investigation Committee believes that it is the national responsibility of Japan to transfer the whole picture of “Human suffering” to

future generations based on the recorded results of comprehensive investigation of the Fukushima nuclear disaster. The investigation of the "Human suffering" may need the participation of a wide area of academic fields, vast costs and time. The Investigation Committee requests the government to actively build the investigation system, in cooperation with local municipalities, research institutions, private organizations and other relevant bodies, and provide necessary support to such investigation initiatives.

Chairperson's Remarks

The results of this Committee's investigation and inquiries, which were carried out over a period of one year and one month, are as described in the Interim Report and the Final Report. Through this investigation the Committee has succeeded to confirm various facts. With regard to the problems that surfaced from those facts, the Investigation Committee has discussed in Chapter VII of the Interim Report and Chapter VI of this Final Report, and made a large number of recommendations based on them with regard to preventing nuclear disasters from recurring, and approaches to specific policies and efforts to prevent damages from occurring and expanding.

This Committee's investigation and inquiries were unable to clarify some points regarding the event itself of the accident that had occurred, due to factors such as time restraints as well as the difficulties posed by on-site inspections – entering areas near the reactors was impossible because the radiation levels still remained high, for example. In addition to the seismic adequacy of Units 1 to 3, a great deal of attention is also focusing on the seismic adequacy of Unit 4, where large quantities of spent fuel are stored, but due to the time restraints it was not possible to investigate this point either.

Neither was the Investigation Committee able to carry out "reproduction experiments" as I had intended it would when I had been appointed as Chairman. Areas that can be assumed to be in particular need of reproduction experiments are the mistaken readings given by water-level indicators, as well as the hydrogen outbreaks and the leakage paths the gas followed. Incidentally, for some people the term "reproduction experiments" brings to mind large-scale experiments using the actual objects in question, but the reproduction experiments I refer to here are small-scale tests that straightforwardly reproduce phenomena with the equivalent conditions of the actual event using testable materials. Reproduction experiments are not only helpful in confirming the events that occurred – in some cases new facts and new perspectives can be discovered in the course of carrying them out, and consequently they can also prove extremely useful for deepening understanding and searching for effective countermeasures to utilize in the future. It is our strong hope that the various organizations and institutions connected to nuclear power will continue to clarify the full extent of the accident and investigate its causes with reference to the findings of this Committee's investigation and to strive to obtain the knowledge needed to construct comprehensive and genuinely effective measures and policies for preventing accidents. And in doing that, I hope that reproduction

experiments are also carried out.

This accident and the damages resulting from it still lasting and conceivably responses will become necessary on various fronts in the future also. One of those major challenges is the issue of decommissioning reactors. It has been decided that the four reactor units of the Fukushima Dai-ichi NPS where the accident occurred will be decommissioned, but the decommissioning work will conceivably take several decades at least. The decommissioning will require new, hitherto unseen technologies, as well as continued development and supply of capable engineers for years for the work. Other major challenges will include ensuring the safety of the personnel undertaking the decommissioning work, and regional issues. The institutions concerned, beginning with the government, must continuously monitor the decommissioning work until it becomes possible to say that the accident cleanup has ended and the accident is completely over.

It can be assumed that radiation will continue to have an impact for many years to come. The government must make an all-out effort to help victims and support the recovery, in line with the damage conditions. It is difficult to confirm how damages from radiation will actually present themselves until a considerable period of observation has passed. This Committee included in the coverage of its investigation and inquiries the situation of the damages resulting from the accident and measures to deal with them, but due to time constraints there were more than a few items that it could not pursue. The Investigation Committee hopes strongly that the institutions concerned, beginning with the government, continue to investigate damages such as these and respond to them, and do not assume the matter to have ended along with the investigation and inquiries of this Committee.

Despite the limits mentioned above, this Investigation Committee was able to shed a considerable amount of light on the background to the accident and the resulting damages during its more than one year of activities, I believe. A variety of knowledge has been gained in this accident, and that knowledge will undoubtedly also prove useful in preventing accidents and damages arising from the use of various technologies – not just nuclear power – in society.

The knowledge gained as a result of this accident is also applicable to other sectors, and in order to ensure that it stands up to evaluation in 100 years' time, it will be necessary to see that this does not end as simply knowledge about specific sectors, but rather that it is elevated to the level of being generally and universally known. Knowledge of that type will serve as a powerful reference when

our future society seeks to coexist with new technologies. From here on I would like to show what types of knowledge were obtained as a result of this accident and to present the main items, in order to conclude the investigation of the unprecedented disaster namely the Accident at the Fukushima NPS.

(1) Things that are possible happen. Things that are thought not possible also happen.

The direct cause of this accident can be traced back to the fact that everything was built and operated based on the premise that "an extended station blackout will not happen." However, by rights the mindset should be "things that are possible happen." In February 2012, after this Investigation Committee had compiled its Interim Report, an international meeting with participation of the foreign experts was held. At that meeting, experts from France and other countries pointed out that in the nuclear power sector "you have to think that the improbable may also happen (improbable est possible)." In considering what sorts of things should be thought about, the most important point is to think based on experience and logic. This involves learning about incidents and experiences that have taken place in the past both at home and abroad and considering all the elements involved, to discover the things that could logically occur. Something has a low probability of occurrence does not mean it will not occur. It is a mistake to believe that events with a low probability of occurrence or events that are not established as knowledge do not need to be considered and that responses to them do not have to be made.

Furthermore, there is a need to be aware at the same time that phenomena that are not even adequately recognized – in the sense that "we consider it impossible" – can happen as well. To put it another way: "Phenomena that have never even been thought about can also happen."

(2) You cannot see things you do not wish to see. You can see what you wish to see.

When people see and think about things they tend to view only what they themselves consider agreeable and only the course they are trying to take; they cannot see things they do not want to see or things that are inconvenient*. The impact of this kind of human psychology can be glimpsed in TEPCO's natural disaster preparedness, which were not outfitted with AM measures for tsunami, and did not provide for a situation involving a simultaneous and complete loss of power at several reactor facilities. To prevent situations like this, there is a need to be constantly self-aware that one's

views are biased not only by his/her own interests but by the various influences of the organization, society and the times that surround himself/herself, and to be conscious that something is always overlooked.

This is even applicable to this Investigation Committee's reports. This Committee has not shed light on the complete picture of the Fukushima NPS accident – it is simply one milestone on the road to clarifying the facts of the accident. I do urge that as a result of people striving to clarify the causes of the Fukushima NPS accident from here on, follow-up checks be made to see if there were omissions or errors, and that based on those findings ongoing efforts are made toward further clarifying the facts and preventing accidents.

* In Volume III, Chapter 18 of the "The Gallic Wars," Julius Caesar's account of the successful ploy waged by his legate Sabinus against the Veneti, Caesar wrote that "fere libenter homines id quod volunt credunt" ("Men readily believe what they want to believe"). This phrase has been liberally translated as "people only see what they themselves want to see" or "people only see what they desire and want to see" and has come to be known as one of Caesar's maxims.

(3) Assume to the extent possible and make full preparations.

It is important to assume to the extent possible and to prepare fully. It is also necessary to acknowledge the possibility that things may happen that have not even been thought of and make provisions so that they do not reach the point of becoming worst-case scenarios. In the Fukushima NPS accident, the result of investigations show that substantial provisions had been made against earthquakes and it was not possible to confirm that key facilities had stopped functioning as a result of the earthquake itself, but it is conceivable that because preparations were not in place for a scenario in which the site was struck by a tsunami that exceeded assumptions, disabling responses to the situation and this resulted in the major accident. If new knowledge – even if not fully confirmed – had been taken on board, with tsunami assumptions revised and adequate preparations made accordingly, or if adequate preparations had been made for the advent of unforeseen circumstances, there is a possibility the situation would not have escalated into a major accident of this level.

It is easy to say things like this in hindsight, but extremely difficult to adopt this mindset at a time when nothing is actually happening. Nonetheless, it is vital to take preventative measures for accidents and disasters by constantly reviewing what is possibly assumable, without adhering

tenaciously to assumptions made at a previous point in time, such as at the design stage. It is likewise essential to make adequate preparations based on the mindset that circumstances that have not even been thought of up to now can occur.

(4) Creating a framework alone does not mean it will function. Frameworks can be constructed but goals not collectively shared.

Operators, regulatory-related institutions and regional municipalities had each created frameworks to respond to nuclear accidents in a formal sense, but when an accident ultimately occurred those responses were found to be flawed in places. Conceivably, that was because the members of those organizations were not fully conscious of what those frameworks' goals were, and what was entrusted them with by society. Without creating an environment in which each member is conscious of what they have to do as a personal issue, even if a framework is created it will not function as one whole. That is because its goals are not collectively shared. The fact that SPEEDI's system, constructed for times of emergency, was not used for the evacuation strategy is most certainly an example of this.

In order to ensure sharing goals by all members of an organization, it is necessary to create an atmosphere in which each member is constantly thinking about what they have been entrusted with by society, what position they occupy in the organization overall, and how their job affects the organization overall. Furthermore, education and training is needed in order to maintain that atmosphere. Social management must be undertaken to ensure that each member is precisely aware of the matters that society has entrusted them with.

(5) Everything changes, respond flexibly to changes.

When given conditions are considered to be fixed, then detailed and (superficially at least) commendable responses are possible. However, given conditions are constantly changing, and unless responses that meet those changes are constantly sought out, they become inconsistent with the actual circumstances. For example, as a result of progress that had been made in investigative research on earthquakes and tsunami, a theory had emerged that it was possible an earthquake and tsunami on a larger scale than had previously been considered could occur off the coast of Fukushima Prefecture. Those concerned were aware of this new theory, and had taken measures of

sorts, but from the standpoint of preventing the disaster, ultimately those measures came up short. From here on, the only way to stop situations such as this from happening is to consider that all matters will change, pay scrupulous attention to observation, show humility in being open to external ideas, and continue to respond appropriately.

(6) Acknowledge that risks exist, and create a culture able to debate the risks directly.

Refusing to permit the existence of risks and reasoning that they should be completely excluded seems at a glance a sincere way of thinking, but on occasions this does not match reality. Asserting that risks should be completely excluded despite the fact that no-one is capable of foreseeing completely what type of situations may arise, has risks creating "a safety myth" in which the existence of unlikely risks is ruled out. Nuclear power has an extremely high energy density, and is essentially dangerous, yet it cannot be denied that in spite of that, attempts have been made to promote the use of nuclear power as an energy source with no risks in order to dispel society's unease. Nuclear emergency response manuals were not equipped to deal with a large-scale disaster such as this one, and emergency response drills prior to the event were also insufficient, and in this and other ways the nuclear emergency preparedness was inadequate. There is no denying that the misguided perception that a major accident in which large quantities of radioactive material would be released could not happen at Japan's nuclear power stations formed a backdrop to that inadequacy.

Denying the existence of risks will not only lead to a rigid mindset that becomes out of sync with the actual situation, it also makes it impossible to take the disaster-prevention and disaster-mitigation measures truly necessary. Trying to exclude risks completely generates unnecessary costs, and it also becomes impossible to discuss and carry out disaster-management measures in order to prevent damages from growing and alleviate their impact once risks end up becoming actualized. Without creating a culture in which risks are acknowledged as risks, and in which it is possible to debate those risks head on, major risks end up being shrouded in a veil of safety and left unresolved, and this is a pattern not limited to nuclear power.

That being the case, when examining one matter it becomes necessary to look directly and simultaneously at the benefits and risks it brings, and to make a judgment while undertaking a balanced consideration of those factors. At that point, if opposing ideas are negated and the matter in question is dealt with based on one side's ideas alone without genuine debate taking place, the worst

path will be followed. This severe accident demands that we Japanese change our mindset.

(7) It is vital to be conscious of the importance of seeing with your own eyes, thinking with your own head, making decisions and taking action, and vital to cultivate such faculties.

In dealing with an accident or disaster that is beyond the scope of assumption and for which there is no manual to rely upon, the people concerned must consider the various possibilities based on the information each has at-hand, decide how they should deal with those possibilities, and take action. In this accident there were many cases in which inappropriate action was taken, but at the same time there were also a large number of cases in which people strove to overcome the situation using ingenuity and judgment, such as gathering together the batteries of cars in the vicinity and using them as an emergency source of power for operating measuring instruments in order to collect the minimum data in need. Responses such as this were made possible as a result of the people concerned thinking themselves about the outcomes they wanted to achieve, making judgments and taking action. To make the optimum actions possible in a situation in which there is nothing to rely on, it is necessary to have an attitude of thinking for yourself in order to face up to a situation, and a flexible and active way of thinking. It will be important to undertake organizational management to boost qualities and faculties such as these during ordinary (non-emergency) times, along with carrying out training and drills.

The accident at the Fukushima NPS was a major accident that is prominent during the whole history of humankind. The events that occurred within the nuclear power station after it was flooded as a result of the tsunami were a series of incidents that people involved with nuclear power generation in Japan had never encountered before, and without the actions of those involved in dealing with the accident at the facilities, who risked their lives, the accident would have worsened further and radioactive materials might well have dispersed over a clearly much wider area than at present. As stated in the Interim Report and this Final Report, it cannot be denied that some pieces of responses to individual incidents were not appropriate; but on the other hand, I by all means wish to record here that those undertaking tasks on-site have made an all-out effort.

With a nuclear power station accident an extremely long time is required between the accident outbreak and the point where the decommissioning work and other necessary measures end and it

becomes possible to say that the accident is genuinely over. Not only that, however, they are also dreadful events in which the lifestyles and social activities of people in a wide-ranging area are destroyed, since people living in the vicinity are torn from the area completely and unreasonably due to the released radioactive materials. The fact is large numbers of people continue to be harmed by this accident even now – in Fukushima Prefecture more than 100,000 people are still forced to evacuate, for example. The accident continues to exert a significant impact on the lifestyles of the nation's citizens also. People around the world also suffered a deep sense of shock and unease as a result of this accident. Everybody of us must put the matters learned from this accident to use in social management from here on. Everybody of us must treat this accident as a lesson from nature that human concepts can be found lacking, and continue to learn from this accident without ever forgetting it.

July 23, 2012

Chairperson of the Investigation Committee on the Accident at the Fukushima Nuclear Power Stations of Tokyo Electric Power Company
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