Report

Working Group on Risk Management of Low-dose Radiation Exposure

December 22, 2011

Office of the Deputy Chief Cabinet Secretary

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1. Purport of the holding of the working group

Residents who evacuated from the area due to effects of the Tokyo Electric Power Co. (TEPCO)'s Fukushima Daiichi nuclear power plant accident have conflicting desires of wanting to return to their homes and not wanting to return to areas that could cause ill health effects from radiation. Those who were not evacuated also feel uneasy about health and other effects from radioactive substances. Given this situation, our working group held discussions with a focus on effects of low-dose radiation exposure, in particular regarding risks associated with annual exposure dose of 20 millisieverts (mSv), the current level in Japan for issuance of evacuation orders, and about specific matters requiring special consideration such as the handling of children and pregnant women. We took particular note in our discussions of both domestic and international scientific findings related to low-dose radiation exposure, including results obtained to date from epidemiological research on the A-bomb survivors of Hiroshima and Nagasaki and the residents living around the site of the Chernobyl nuclear accident, among others. Moreover, the group engaged in debate regarding the proper way in which such risk should be communicated to the public.

A wide disparity of opinion exists among even experts in the field of low-dose radiation effects. With the objective of gaining understanding of the Japanese people regarding this working group's decision-making process, we decided to publicize the proceedings of our meetings, which were marked by discussions based on the participation of leading experts from both Japan and abroad with wide-ranging, even contradictory, views and opinions.

1.1. Purport of meetings

Carrying out of more appropriate risk management in the future regarding low-dose radiation exposure is necessary as a measure to counter the radioactive substances emitted due to TEPCO's Fukushima Daiichi nuclear power plant accident. Toward that end, full reference must be made to the latest scientific findings submitted by international and other related organizations and assessment of countermeasures made to the present. Moreover, the issues facing the accident survivors at the scene must be identified and handled appropriately. From this perspective and based on the request of Goshi Hosono, Minister for the Restoration from and Prevention of Nuclear Accident of Japan, this working group relating to risk management of low-dose radiation exposure was established, after which it committed to deliberations, under the Radiation Contamination Countermeasure Advisory Council, as a venue for the scrutiny of scientific findings and assessments from both inside and outside Japan, identification and selection of issues facing the regions affected by the accident, and review of the future direction to take for handling of the situation.

1.2. Fundamental issues

'Cold shutdown' and other targets have been achieved with regard to the Fukushima Daiichi nuclear plant, representing completion of 'Step 2' of the decommissioning process. The interest of the Japanese people, in particular those from Fukushima prefecture, is now shifting to the question of when residents will be able to return to their homes. However, the evacuees and those still residing in Fukushima prefecture feel uncertain about the assessments made of the risk from low-dose radiation exposure for individuals, in particular risks to the health of children and pregnant women. Moreover, fundamental concerns remain in terms of daily life, including the question of whether local communities can continue to exist even if residents are able to return home. Development of appropriate risk communication for such residents is the fundamental prerequisite for efforts aimed at recovery and reconstruction of Fukushima. Amid such circumstances, this working group was entrusted with development of scientific views and opinions regarding the following three items.

1) First, the proper way to consider health effects from low-dose radiation exposure of 20 mSv annually, the current level used for issuance of evacuation orders:

   The national government judged whether to issue evacuation orders on the basis of this annual dose of 20 mSv as one of its determination references. How exactly this standard of 20 mSv should be assessed from the perspective of health effects is a major issue for consideration.

2) Second, communication of views and opinions regarding the nature of consideration necessary for children and pregnant women, who are considered to be highly sensitive to radiation's effects, to serve as source material for the government's various management efforts to respond to the situation:

   Even as the emergency situation following the accident has abated somewhat, residents face low-dose radiation exposure for the foreseeable future and perhaps over the long term. Amid such circumstances, expression of views and opinions related to the handling of children and pregnant women in particular is necessary, including identification of needed measures that perhaps differ from those used in the emergency phase of the accident.

3) Third, since the start of the Fukushima nuclear accident, severe criticism of the government's disaster risk communication efforts:

   In the future, when the evacuees return to their homes, views and opinions will need to be conveyed regarding appropriate distribution of information on radioactive substances and radiation doses in relation to health risks from low-dose radiation exposure.

Furthermore, the assessments made by the working group are based on scientific perspectives at the present time and organized to include limitations of science in the current age, asking the question regarding what of relevant opinions are scientifically consistent and also what of the relevant issues have not been based on science.

1.3. Process in investigation

The working group has made available to the public the inner workings of its discussions and deliberations with the aim of gaining the understanding of the Japanese people regarding how the aforementioned three points were determined, including the decision-making process itself. The group also has posted live and prerecorded broadcasts of its proceedings online on the internet.

The working group was able to garner the participation of overseas experts as well as various leading specialists from Japan. We determined to carry out debate based on the participation of experts able to recommend methodologies and approaches that perhaps differ from the government's efforts. All working group meetings benefited from the participation of government officials who engaged in active debate, including Minister Hosono.

2. Scientific findings and international consensus

Scientific findings regarding radiation's health effects, in particular health effects from low-dose radiation exposure, are the result of humanity's historical experience. Directly showing concrete association between radiation exposure dose and effects on human health using animal experiments, in vitro experiments, or gene studies is a challenging task. However, such research can be utilized to complement scientific findings from studies in the past of radiation's effects on human health and mechanisms behind the cause of such effects.

Such scientific findings represent the foundation underlying our consideration of radiation effects from the recent Fukushima Daiichi nuclear accident and countermeasures developed to deal with its aftermath. Disparate findings involving radiation's effects have been reported, and clear understanding of international consensus regarding these scientific issues is thus necessary. The international consensus should conform to reports put out by such international organizations as the United Nations Scientific Committee on the Effects of Atomic Radiation (hereinafter referred to as "UNSCEAR," an organization that reports its scientific findings to the United Nations), the World Health Organization (WHO), the International Atomic Energy Agency (IAEA), and other such bodies.

Studies on human health effects from the atomic bombings of Hiroshima and Nagasaki serve as the foundation for worldwide epidemiological research into radiation for both their scope and precision in this particular research field, with UNSCEAR also consistently publishing related reports. The Chernobyl nuclear accident serves as an example of many individuals suffering internal exposure. When also taking into consideration low-dose exposures, at least 5.0

million residents of the areas surrounding Chernobyl, including children, were exposed. Results of studies related to the Chernobyl accident have been reported in detail by such international organizations as UNSCEAR, WHO, and IAEA.

2.1. Health effects as understood using current scientific methods

(1) Risks from low-dose[1] radiation

1. Current scientific findings related to health effects from low-dose radiation exposure are based mainly on detailed data obtained over more than a half-century from the survivors of the atomic bombings of Hiroshima and Nagasaki. These data enjoy great credibility internationally and serve as the foundation for UNSCEAR reports.
   - A) Reports from epidemiological studies of A-bomb survivors from Hiroshima and Nagasaki have shown a dose-dependent increase in cancer risk starting at dose levels slightly more than 100 mSv [1].
   - B) Risk of cancer development from radiation at levels of 100 mSv or lower is considered so slight according to international consensus that risk is concealed by carcinogenic effects from other causes. At such low levels, clear increased risk of cancer development from radiation is difficult to prove. Scientific methods other than epidemiological studies also are being utilized to elucidate cancer risk, but at present, such methods have not yielded unequivocal risk information for humans.

2. On the other hand, an extended duration is sometimes required before cancer develops after radiation exposure. With low-dose exposure to 100 mSv or less, cancer risk might become apparent only with an even longer passage of time in the case of persistent exposure. In any case, wide-ranging preventative countermeasures are necessary, including exhaustive efforts to decontaminate affected areas.

(2) Health effects from long-term radiation exposure

The 100 mSv figure under 1. of (1) above involves assessment in the case of short-term radiation exposure. For a cumulative dose of 100 mSv from continuous exposure over the long term in a low-dose environment, health effects are assumed to be less severe than those from short-term, or instantaneous, exposure (known as the ‘dose rate effect’). This phenomenon has been verified scientifically in animal experiments.

- A) In epidemiological studies of residents of the state of Kerala in India, a region with some of the highest levels of background radiation in the world, no increase in cancer risk was observed even for cohorts with cumulative doses exceeding 500 mSv [2]. On the other hand, however, in epidemiological studies of Techya River watershed residents, who were exposed to radiation through a series of radiation disasters at nuclear weapons facilities in the southern Ural mountains of the former Soviet Union, risk increases have been reported for a cumulative dose range of around 500 mSv [3]. Dose estimation and confounding factors should be further analyzed in these reports, but in either studies no increase in cancer risk was observed for dose levels of around 100 mSv.

B) Health effects from exposure to radioactive substances emitted into the environment due to the Fukushima Daiichi nuclear accident represent a situation of long-term low-dose exposure, with cancer risk thought to be lower than that in instantaneous exposure, even in the case of identical doses.

(3) Differences between external and internal radiation exposures

1. One argument holds that internal radiation exposure has greater effects on human health than does external exposure. However, in the case of radioactive substances present either externally or internally, the resulting radioactivity damages DNA, and that compromised DNA might, during the process of DNA repair, cause mutations that can in turn lead to cancer development. For that reason, if equivalent doses[2] affecting organs are the same in external and internal radiation exposures, the risk is considered to be equivalent [4].

   A) Among types of radiation, gamma rays are the most penetrating, which means that absorption of energy from such rays is not limited to the sites at which the substances emitting the radiation are deposited and piled up.

   B) Issues that have been investigated in detail by international organizations regarding when radioactive substances are inhaled or taken in through the diet include to what organs the substances concentrate, how much radiation dose each organ absorbs, and radiosensitivity of each of the organs, which is one of the factors involved in cancer development. According to such investigations, model calculations[3] can be made depending on differences in length of time in the body and organ to which the radiation concentrates for each of many hundreds of radioactive nuclides and isotopes, as well as depending on size and other characteristics of the absorbed radioactive particles. For example, if 1 becquerel of radioactive substance is inhaled or ingested orally these models can be used to calculate what organs have received approximately what exposure (equivalent dose and effective dose expressed in siebert,[4] effective dose being arrived at by addition of risks of all organs). Therefore, even with different nuclides, effects on human health are considered to be equivalent as long as radiation doses measured in units of sievert are the same after differences in the radiation quality and organ radiosensitivity are taken into account.

C) In clinical and epidemiological research, excess relative risk[5] of thyroid cancer in subjects exposed in childhood has been shown to be nearly equivalent between external and internal exposures [5].

D) Among the nuclides released in the Fukushima nuclear accident, plutonium, which emits mainly alpha waves, and strontium, which gives off mostly beta waves, have large effective doses per unit amount of radioactivity (1 becquerel) in the case of internal exposure.[6] Nevertheless, compared with cesium, the quantity of these radioactive particles emitted into the environment was extremely small in the case of Fukushima,[7] with amounts taken up internally into the body also considered limited. For that reason, exposure doses from these compounds are estimated to be smaller than the radioactive cesium doses.

E) In the Chernobyl accident, the cause of increased thyroid cancer among children is considered to be selective internal exposure of the thyroid that was due to consumption of milk contaminated by radioactive iodine during a period of up to several months after the disaster.

F) Average exposure doses for residents living around the Chernobyl nuclear accident site were assessed in a 2008 UNSCEAR report to have been 33 mSv for 116,000 evacuees, more than 50 mSv for 270,000 residents of areas with the highest contamination levels, and 10-20 mSv for 5.0 million residents of areas with low contamination levels. Observing such residents of these surrounding areas, there are some physicians and other healthcare workers who have pointed out increases in various other types of disease. However, the consensus understanding among such international organizations as UNSCEAR, WHO and the IAEA is that no increases in leukemia or other illnesses have been scientifically confirmed among the general population including children.

2. One report indicated increased bladder cancer incidence from internal exposure to low levels of radioactive cesium among residents of the Ukraine [6].[8] However, the analytical methodology has been questioned and its findings are in contradiction to other epidemiological study results. For example, no findings of increased bladder cancer incidence were obtained from epidemiological studies conducted continuously starting in the 1960s of the Sami people of Scandinavia, who were exposed to high levels of radiation internally through the consumption of reindeer meat contaminated by radioactive cesium emitted into the environment from atmospheric nuclear testing and the Chernobyl nuclear accident [7]. Based also on results from other international epidemiological studies, causal association between internal exposure of low levels of

radioactive cesium and bladder cancer has not been confirmed.

(4) Effects on fetuses and infants/children

Generally speaking, relative risk of cancer development tends to be higher with younger age at exposure. Among those in childhood/puberty, cancer risk from high-dose radiation exposure is greater than the risk among adults. In low-dose exposures, however, such disparity in cancer risk profiles due to age-group differences is unclear. On the other hand, research into in-utero survivors of the atomic bombings has suggested that risk of developing cancer in adulthood among those exposed in utero is equivalent to, or perhaps slightly lower than, the risk of those exposed in early childhood [8].

Moreover, at present no genetic effects from radiation have been detected in several tens of thousands of offspring of the A-bomb survivors, based on long-term follow-up studies [9, 10]. In cancer radiotherapy, depending on the site of the cancer, testicular and ovarian organs are exposed to higher radiation doses than those experienced by the A-bomb survivors, and yet no genetic effects have been observed in large-scale epidemiological studies of the children of such patients (the parents) [11].

A) Studies following the Chernobyl nuclear accident showed that risk of thyroid cancer development was lower in those exposed in utero than among those exposed in childhood.

B) Compared with the thyroid exposure from the Chernobyl accident, thyroid exposure for children from the recent Fukushima Daiichi nuclear accident is thought to be limited, with exposure doses small and cancer risk extremely low. According to results from numerous tests on childhood thyroid exposure, environmental radiation contamination levels, food contamination levels, and so on, it appears highly unlikely that large amounts of radioactive iodine were ingested due to the environmental effects from the Fukushima nuclear disaster, in stark contrast with the Chernobyl accident.

(5) Biological defense mechanisms

1. When radiation damages DNA, mutations arise, added to which are multi-stage transmutations, together forming one of the mechanisms behind malignant transformation of normal cells. On the other hand, biological organisms are equipped with biological defense capabilities[9] that form a protective system by which the process of carcinogenesis is suppressed.
2. Even low-dose radiation exposure is known to damage DNA, leading to abnormalities in the repair process, characterizing another mechanism behind cancer's development. However, also noted is that for low doses, the extent of DNA damage is limited, making it

apparent that both the repair-process accuracy and biological defense are functioning sufficiently, with no increase in cancer risk resulting from such doses [12].

2.2. Conceptualizing health risks from radiation

(1) Definition of risk

Radiation risk is a yardstick used to indicate the potential for manifestation of harm. Risk is not the antonym of "safety" nor does it mean simply "danger."

(2) Concept of models assuming linear increase in risk without threshold values

The concept that risk increases in linear fashion with radiation dose,[10] even in cases of low-dose exposure, is employed in the areas of radiation protection and management.

A) This does not mean, however, that the concept is accepted as scientifically proven fact, but that it is employed as a determination to compensate for scientific uncertainty standing firmly on the side of public health safety.

B) The idea of risk increasing in linear fashion with dose is merely a means with which to limit exposure to radiation. In other words, the concept is meaningful when comparisons are made between such different risks as those from estimated radiation exposure and other health risks from, for example, measures used to protect a population from radiation.

C) In accordance with this concept, however, application of the low-dose exposure risk from radiation of 100 mSv or much less to a population (collective) dose for a large number of people (unit: person-sievert) to predict number of deaths would lead to inordinately large uncertainty and render the information unsuitable. The ICRP has pointed out the same problem involving use of this concept [13].

(3) Understanding risk levels

1. Japan's national government and TEPCO together share responsibility for the Fukushima Daiichi nuclear accident, and therefore both parties must reflect deeply on their involvement in causing societal uncertainty and anxiety due to low-dose radiation exposure.
2. Simple comparisons between risks from radiation exposure due to such accidents as the recent one and risks from other factors such as medical exposure of patients that is oftentimes voluntary are not necessarily appropriate. Comparisons with other factors, however, can effectively assist in the understanding of risk levels.

   A) According to mortality data from 2009, about 30% of Japanese people die from cancers. If a dose rate reduction effectiveness factor (DDREF) of 2 is applied to the results of studies of the A-bomb survivors in Hiroshima and Nagasaki, estimates show a lifetime increase of about 0.5% in cancer risk mortality over the long term for exposures of 100 mSv. In contrast, however, disparity of at least 10% exists among prefectures in Japan with respect to cancer mortality rates.

B) In order to understand the radiation health risk, it might be compared with risks associated with other cancer causing factors. For example, smoking is considered to be equivalent to risk from between 1,000 and 2,000 mSv of radiation exposure, obesity[11] between 200 and 500 mSv, and a lack of vegetables in the diet[12] and passive smoking[13] [14] between 100 and 200 mSv.

C) From the perspective of radiation dose, a single CT scan, for example, leads to exposure of several mSv of radiation. For a seriously ill patient to undergo multiple CT scans during hospitalization is not at all rare.

D) Moreover, one round-trip air flight between Tokyo and New York exposes passengers to roughly 0.2 mSv of radiation, due to increased cosmic rays from flying at high altitudes.

E) The worldwide average for exposures due to natural sources of radiation is considered to be 2.4 mSv annually, compared with the Japanese annual average of about 1.5 mSv.[14] The worldwide average for radon exposure[15] is 1.2 mSv annually, according to an UNSCEAR report, with the range estimated to be vary between 0.2 and 10 mSv annually, depending on geographic location. Japan's figure for radon, by comparison, is 0.59 mSv annually.

F) Chloroform, a representative trihalomethane compound considered to have carcinogenic effects, is commonly found in drinking water. Even in cases of continuous consumption of two liters of tap water on average per day, however, cancer risk is less than 0.01%, a level considered not high enough to warrant concern. Cancer risk from radiation of 100 mSv (for example, about a 0.5% increase in lifetime probability of dying from cancer in the case of exposure over the long term to 100 mSv) is greater than this risk from chloroform intake.

3. Based on the situation presented in the above 2., from the radio-protection perspective, the concept of cancer risk increasing in linear fashion with radiation exposure is extremely important, even in cases of low-dose exposure to 100 mSv or less. When risk is compared in accordance with this principle, health risks[16] based on an assumed annual dose of 20 mSv are considered to be lower than risks from other carcinogenic factors (such as smoking, obesity, diet lacking in vegetable intake, and so on), and roughly comparable with risks associated with radiation protection measures (such as stress from

evacuation, lack of exercise due to avoidance of outdoor activity, and other such factors).

2.3. ICRP “reference levels”

1. The International Commission on Radiological Protection (hereinafter referred to as the “ICRP”)[17] classifies radiation exposure situations into three different types: “emergency,” “existing,” and “planned.” As targets for the designing and carrying out of measures for protection from radiation during the emergency exposure and the existing exposure situations, the ICRP has recommended a radiation dose range (band) for each of the situations, establishing “reference levels” within these ranges appropriate for the particular situation and recommending application of such values for ensuring the safety of residents in affected areas [13, 15, 16].

A) These reference levels take into account economic and societal factors and serve as targets for the formulation of measures based on the principle of “optimization,”[18] whereby exposure levels are reduced to levels as low as reasonably achievable.

B) The reference levels are used for the carrying out of protective measures preferentially for those thought to have been exposed to radiation exceeding those levels over a fixed period of time, with the aim of achieving exposures lower than the reference values. The levels also serve as indices for assessment regarding whether or not the protective measures in place have been effective.

This does not mean, however, that exposure doses for all residents must immediately fall below these reference levels; rather, the reference values are to be used as the basis for devising measures aimed at the decrease of exposures below those values and reduction of radiation doses progressively over time.

C) The reference levels do not represent “limits” for radiation exposure. Neither should they be interpreted as indicating a boundary between “safe” and “dangerous.”

2. Respective reference levels for each situation are as indicated below:

A) The reference level for emergency situations[19] is selected from within the range of an annual 20 to 100 mSv.

B) The reference level for existing exposure[20] situations is selected from within the range of an annual 1 to 20 mSv for the general public.

C) As indices for efforts to gradually improve the situation in existing exposure, interim reference levels can be established, with efforts made toward improvement based on a long-term annual target of 1 mSv.

D) For planned exposure situations, establishment of “dose constraints,”[21] rather than use of reference levels, within the range of an annual 1 mSv or less, is recommended, depending on the situation regarding the exposure status of the general public.

2.4. Application of radiation protection

(1) Management based on the principle of optimization

When government policy for radiation protection with respect to low-dose exposure is implemented, efforts must be undertaken to reduce radiation exposure to levels as low as reasonably achievable on the basis of scientific fact.

A) Various radiation-protection measures can be considered, depending on the sources of radiation and pathways of exposure in question. Specifically, such measures include decontamination limits on entrance into the areas with high levels of radiation, and controls on intake of food and drink suspected of having high levels of radiation contamination, among others.

B) When such radiation-protection measures to be used are selected, both the benefits associated with decreased radiation doses (in terms of health and psychological security, etc.) and the deleterious effects associated with avoidance of radiation (in terms of economic harm caused by evacuation and relocation, destruction of community, disadvantage from lost work, and mental and psychological effects from changes to lifestyle, etc.) should be taken into consideration, consistent with ICRP's philosophy.

C) When carrying out government radiation-protection policy, special attention should be paid to children and pregnant women.

D) Radiation-protection measures with respect to decontamination, health management, and food safety are considered most effective when devised to indicate in intelligible terms effectiveness of the measures and to notify the public of the target ranges, timeframe of implementation of the measures, and targeted values.

(2) Managing the situations following Chernobyl

With respect to the response to the post-Chernobyl accident situation, some were of the opinion that the former Soviet Union's government measures for relocation of individuals from affected areas, among others, were worthy of emulation. Other opinions from such international organizations as the IAEA, however, have deemed the measures employed at that time as excessive.

A) In terms of the response in the aftermath of the Chernobyl accident, if local radiation levels in such countries as the Ukraine were found to exceed 5 mSv annually starting around five years after the accident, in the 1990s, government measures were implemented to relocate to other regions those residents living continuously in contaminated areas, with those efforts continuing today.

B) Nevertheless, some residents continue to live even now in such areas, with it difficult to say that the measures have been either consistent or exhaustive. Moreover, the levels for relocation of residents in the event of a new accident are now set at higher doses than this annual figure of 5 mSv.[22]

C) The response in the aftermath of the Chernobyl nuclear accident included provisional dose limits for the one year immediately after the accident set at an annual 100 mSv, with those limits reduced progressively over time, and the level of an annual 5 mSv adopted starting in the fifth year and thereafter following the accident.

D) On the other hand, within one month following the Fukushima Daiichi nuclear accident, evacuation (exclusion) zones were established, based on a level of an annual 20 mSv of radiation exposure. The handling of evacuation with regard to the Fukushima Daiichi accident is clearly stricter at present than the response following the Chernobyl accident, based on the concept of reference levels used to reduce exposures progressively over time.

<u>(3) Residents' participation and communication of risk</u>

1. While the Fukushima nuclear power plant has achieved 'cold-shutdown' status, the first priority in securing the safety and security of residents in a situation in which the environment is already contaminated is the restoration of lost confidence between the residents and the government and other officials involved and the rebuilding of a relationship of trust.
2. The fact that expert opinions varied with regard to safety and the danger and health effects from radiation when expressed by the mass media and others led to feelings of uncertainty and unease on the part of the local area residents and thereby invited chaos. With reflection on this situation, factors now considered to be of crucial importance are review of the scientific findings obtained to date and provision of such information to local residents in a format that ensures ready understanding of risk assessment consistent with the ongoing situation in Fukushima. Based on these efforts, it is necessary to ensure that residents are able to handle such situations on their own if necessary, based on accurate understanding of radiation and radioactivity.
3. It is crucially important to explain to the public whether the numerical values used in the area of risk communication indicate scientifically verified health effects or are targets set by government policy for radiation protection (values involving ICRP reference levels) in order to obtain their understanding and avoid causing chaos.
4. Based on the experience of the Chernobyl nuclear accident, active participation by area residents amid existing radiation exposure toward long-term solutions to the situation are

indispensable.

In contrast to the emergency response that governments must immediately adopt in cases of emergency exposure situations, an existing exposure situation requires consideration of the varied and numerous values and beliefs held by citizens, whose participation is absolutely critical.

5. To convey scientific facts of such a situation to citizens in as intelligible manner as possible, administrative personnel/bureaucrats such as government officials as well as experts from various fields, including the social sciences and psychology, must communicate information about risk founded on the development of a relationship of trust with residents/citizens.
   A) Through communication with residents and with cooperation from government and experts, all involved can understand the risks and thereby devise appropriate measures for dealing with the situation.
   B) In particular, the roles of experts such as local medical and local school officials who share the specific values of the residents and can explain the situation's health risks are of utmost importance.
   C) A most important role of the government in such a scenario is the provision of intelligible information about efforts at monitoring radiation levels and accurate information about the risks involved.

3. Assessment of the current situation in Fukushima / direction of future management

To this point in time in Fukushima, the government has employed levels that call for evacuation at an annual exposure level of 20 mSv, but actual exposure doses on average have been assessed far below that level.

Even in zones in which doses are no more than 20 mSv, the government must make efforts to reduce exposure as a matter of policy. The top priority for such policy is protection from radiation for children, who are highly sensitive to radiation's effects, and in particular infants, whose parents are greatly concerned about radiation's health effects, making it necessary to carry out deliberate protective measures.

3.1. Assessment of the current situation in Fukushima

(1) Fukushima's current situation

1. The accident at the Fukushima Daiichi nuclear power plant was categorized as a level '7' according to the International Nuclear and Radiological Event Scale (INES), a nuclear accident the equivalent of which had never before been experienced in Japan, with the

government adopting a myriad of protective measures since the time of the accident. The Chernobyl accident also measured a 7 on the same scale, but the Fukushima accident by comparison resulted in only around one-seventh the amount of Chernobyl's radioactivity released into the environment, indicating that the two accidents can be considered vastly different, even from the perspective of health effects on local residents.

2. When devising its protective measures for the evacuation zones, the government adopted, from the standpoint of ensuring safety, the most conservative level of 20 mSv annually among the reference levels suggested by the ICRP for evacuation in emergency exposure situations (20-100 mSv on an annual basis). However, precisely because the government adopted this model with its priority on safety when assessing radiation exposure dose among humans, the actual doses for the one-year period since the accident to which most residents were exposed are expected to be significantly lower than this 20 mSv level.

   A) In more detail, with respect to external exposure, the results from measurements using personal dosimeter devices for 36,478 children and pregnant women in the city of Fukushima indicated that about 80% of this population had been exposed to additional doses of up to 0.1 mSv over the one-month period of September 2011, according to information released by the Fukushima City Disaster Countermeasure Headquarters on November 1, 2011. On the other hand, the air dose rate[23] in the city of Fukushima was measured at 0.92 microsieverts per hour, and estimates of doses with the method[24] used for establishment of the evacuation zones based on these values led to estimates of an annual dose of around 4.8 mSv and a monthly dose of about 0.4 mSv. A simple comparison of the two results thus indicates that the actual exposure doses measured with dosimeters in Fukushima were about one-quarter of the estimated values.

   B) Moreover, measurements with personal dosimeters by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) that took place of educational staff members as representatives of the children in their charge resulted in observed measurement values of 0.8 times[25] on average the estimated exposure doses resulting from multiplication of each of air dose rates both inside and outside buildings by length of time spent in each of the respective locations (source: Outline of "Results of monitoring using simplified integrating dosimeter (4)," June 23, 2011, Ministry of Education, Culture, Sports, Science and Technology).

   C) For the 1,589 residents (except for radiation workers) in the regions (Kawamata-machi [Yamakiya district], Namie-machi, Iitate-mura) targeted in the priority review conducted by the Fukushima prefectural government's "Prefectural resident health management survey," estimates of cumulative exposure doses over the four months after the accident were made based on actual activity records of that period. Among that total, 998 (62.8%) were thought to be exposed to less than 1 mSv, 1,547 (97.4%) to less than 5 mSv, and 1,585 (99.7%) to less than 10 mSv, with the remaining four individuals exposed to levels exceeding 10 mSv, and one person exposed to 14.5 mSv, the largest dose of all.

D) As for internal exposure, measurements of 6,608 individuals using whole body counters carried out by the Fukushima prefectural government yielded the following figures: Those exposed to committed effective doses[26] of 1 mSv or less of cesium-134 or cesium-137 comprised 99.7% of the total, and those exposed to greater than 1 mSv totaled 0.3%, with the maximum dose measuring less than 3.5 mSv (as of the end of October 2011), according to materials released by the Regional Medical Department of the Health and Welfare Office of the Fukushima prefectural government. As reference, the average annual amount of natural radiation taken in by the Japanese through intake of foodstuffs is considered to be roughly 0.41 mSv.

E) Regarding exposure associated with food intake, which is considered likely to comprise the major source of internal exposure in the future, the Pharmaceutical Affairs and Food Sanitation Council estimated actual doses using measurement data of radioactive concentrations in food and drink products collected by the Ministry of Health, Labour and Welfare. The Council's assessment was that such exposure only amounted to low levels (about 0.1 mSv annually as a median value; as an assumption made on the side of safety, even foodstuffs in the 90th percentile[27] of radiation concentration would yield internal exposure of only 0.244 mSv annually even with continuous intake over that period[28]), according to material No. 4 of the Food Sanitation Subcommittee of the Pharmaceutical Affairs and Food Sanitation Council, dated October 31, 2011. These estimates, while not limited to the residents of Fukushima prefecture, are valuable for such assessments, given that generally speaking the residents consume foodstuffs produced in various locales.

F) Internal exposure associated with inhalation of deposited radioactive materials re-suspended in the air has been assessed at the relatively small amount of only several percent of the total of both internal and external exposures (1.9%, according to the report "Assessment of internal exposure associated with use of school playgrounds," Material No. 3-1, 31st Nuclear Energy Safety Council, Ministry of Education, Culture, Sports, Science and Technology, May 12, 2011).

3. Assessment methodologies of radiation exposure doses at the time of formulation of relevant regulations made to date placed priority on safety in emergency situations. In the future, it will be necessary to deliberate on methodologies that are more precise from

the perspective of dose-assessment experts through careful examination of disparities between the radiation doses assessed with the current assessment methodologies and individual dose assessments based on estimates from activities carried out by individuals and the air dose rates of the locations at which those activities took place or actual measured exposure doses.

(2) Risk avoidance for residents of the Fukushima Daiichi nuclear power plant accident

Japan's national government has set its evacuation standard at the level of 20 mSv annually, adopting the strictest value from the perspective of safety from among the reference levels for radiation exposure in emergency exposure situations. At establishment of the current evacuation zones, doses were estimated on the high side for safety's sake, without any factoring in of natural decay of radioactivity or other such factors, one of the reasons why it is now possible to assess actual average annual exposure doses as far less than this limit of 20 mSv.

Orders to evacuate as a measure for handling the emergency exposure situation were accompanied by significant burden on the daily lives of residents. In a situation of existing exposure, however, a more varied complement of measures than used in the case of emergency exposure must be considered, while taking into account the burden placed on the region and its residents. Moreover, measures must be adopted based on the idea of approaching a lifestyle close to that lived prior to the accident, based on the devising of comprehensive measures aimed at reduction of risk, such as decontamination centered on daily life environment and securing of food safety.

3.2. Direction toward protection from radiation (with priority on steps for protection of children)

(1) Efforts including decontamination aimed at reduction of exposure doses

Radiation protection levels adopted by Japan at the current time are set at an annual exposure of 20 mSv. In the future, however, it will be necessary to further reduce exposure doses as much as possible.

A) When carried out, this process must be adopted in step-by-step fashion, with progressive improvement taking place starting in those regions assumed to have high exposure for residents. Steps aiming at a long-term target of 1 mSv per year (the ICRP estimates a period of several decades) should be devised from the perspective of aiming at complete recovery.

B) At the same time, to effectively utilize resources invested when carrying out such steps related to decontamination of areas of daily life and to health management, and so on, appropriate and reasonable prioritization of efforts and clarification of intermediate reference exposure levels are measures considered to be effective.

For example, the government's policy regarding its announced measures for decontamination aims at a situation in which additional radiation doses[29] on an annualized basis for the general public are reduced around 50% by the end of August 2013, compared with the figures at the end of August 2011, including physical decay of radioactive substances, setting the long-term target for additional exposure doses at a level of no more than 1 mSv per year. For residents in areas estimated to have exposure levels at 20 mSv per year, this policy would mean reduction in radiation exposure to an annual 10 mSv in two-year period, which could be considered an intermediate reference level. Moreover, even after such targets are attained, it would be necessary to continue making stepwise progress in decontamination efforts, leading to possible targets of the further halving of exposure doses, for example (at that point, 5 mSv per year for areas with annual exposure to residents of 10 mSv).

<u>(2) Carefully thought out steps with priority on children</u>

When implementing steps to reduce radiation exposure, it is necessary to carry out carefully thought out protective measures with priority placed on children, who are considered highly sensitive to effects from radiation, and infants, whose parents naturally have great concerns about radiation's effects.

A) First, importance should be placed on the understanding of assumed radiation doses, with studies conducted on the pathway by which major exposures are taking place, including both internal and external exposures. Moreover, accurate investigation and grasping of actual radiation exposure levels is also necessary.

B) External radiation, which is thought to be the major exposure pathway for the present, is the result of radiation emitted from radioactive substances in soil and other sources, making decontamination a high priority for the environments in which children are present and active.

The national government has determined guidelines, for example, regarding measures related to decontamination and so on, aiming at realization of about 60% reduction in additional annual radiation dose levels for children, including physical decay of radioactive substances, by the end of August 2013, compared with the levels at the end of August 2011, through priority decontamination of the environments in which children are present and active. It is recommended that the same policy regarding exhaustive and comprehensive decontamination of activity zones for children, such as pathways used for travel to and from schools and as well as public parks where children play, among other areas, is also adopted in evacuation zones following the lifting of the evacuation orders.

C) Outside the evacuation zones, the government has provided economic support for decontamination of soils for schools measured to have air dose rates of more than 1 microsievert per hour in schoolyards and kindergarten grounds. As a result, the air dose rates in nearly all such schoolyards and kindergarten grounds now fall below that level of 1 microsievert per hour.

In the future, when evacuation orders are lifted, protective measures aiming at exposure doses for the evacuation zones that are equivalent to those used for schools outside the evacuation zones must be adopted. Specifically, prior to the reopening of schools in the evacuation zones with air dose rates in schoolyards and kindergarten grounds and so on of more than 1 microsievert per hour, exhaustive decontamination efforts including of the surrounding areas must be undertaken with an eye to reducing levels beneath that cutoff.

In addition, comprehensive decontamination of areas in which children are present and active, such as pathways for travel to and from school and public parks, and so on, not only the schools themselves, should be undertaken, aiming at additional annual exposure doses of less than 1 mSv over the long term for the areas in which children are present and active.

Also necessary is work aimed at reduction of external exposure from extracurricular school activities by carrying them out in areas with relatively low dose levels, as well as efforts to maintain the physical and mental health of children.

D) Appropriate management is also required for prevention and reduction of internal exposure. Toward this end, the setting of appropriate and reasonable standards regarding radiation concentration in foodstuffs and strict observance of such standards are considered crucial, through efforts to measure radioactive concentration in foodstuffs, for example, that are suited with the local conditions and needs in the region concerned. Upon implementation, introduction of radiation contamination testing of school lunches should be seriously considered, from the perspective of employing stricter measures with respect to children. Moreover, to assess internal exposure from food intake, continuous screening for internal exposure should also be considered.

E) When radiation doses are measured in individual children, some with high measurement values are bound to appear. For such children, a kind, attentive, and compassionate response on an individual basis is called for by physicians, radiation technicians, public health nurses, radiation experts, and school staff and educators, among other related personnel. Such efforts should be designed to identify the source of the high radiation levels, provide assistance in terms of lifestyle issues when required, and offer psychological support, as a complement to further decontamination efforts adopted in the problem areas in question.

(3) Risk communication from the viewpoint of residents intimately tied to the region

When conducting countermeasures to reduce radiation doses, risk communication based on scientifically identified facts, and that from the viewpoints of the residents of the affected areas are essential. Such a task is one of the keys for restoration of confidence in government.

A) Local government officials engaged in active risk communication with residents in the affected regions have pointed out that continuous activities aiming at improvement of the environment conducted by the residents themselves, such as decontamination work, are the best risk communication methods, as they lead to elimination of anxiety and restoration of vitality in daily lives. Expansion of such active participatory citizen efforts to endeavors besides decontamination work is an important subject for investigation.

B) Moreover, it is important for the government to provide the means whereby individuals can obtain information on their own, thereby enabling them to understand and assess their own particular circumstances, as well as to foster the environment in which continuous voluntary efforts are possible toward recovery and restoration.

C) Not only understanding of the emotional state of residents by government officials and experts but also direct communication between the government, experts and such residents can lead to all parties working together on measures to reduce radiation exposure from the same viewpoint based on mutual understanding.

(4) Health countermeasures to reduce cancer risk

At present, Fukushima prefecture residents and evacuees face anxiety about radiation's health risks, in addition to numerous psychological and social burdens because of limits on lifestyle associated with measures used for radiation protection.

That such continued protective measures have led to increased psychological and mental burdens for such residents is another issue requiring consideration. However, the handling of radiation's health effects represents an opportunity to make more progress than ever before with respect to cancer-prevention measures. Enhanced efforts at reduction of cancer risk, the issue of utmost concern for residents, by improving lifestyle habits, such as smoking, diet and exercise, other than radiation, and achievement of early cancer detection through improvement of the cancer screening participation rate, which is currently low, are essential. Finally, the national government should be actively involved in the support of such efforts.

4. Conclusions

1. In the TEPCO Fukushima Daiichi nuclear accident, Step 2 of the decommissioning process has concluded with attainment of ‘cold shutdown’ of the power plant itself, among other actions. However, due to radioactive substances emitted from the plant until this point in time, residents now face the issue of low-dose radiation exposure over the long term.

   The simple return of residents to the areas previously categorized as evacuation zones would not indicate resolution of the problems inherent in the situation. The national government and TEPCO share responsibility for the Fukushima Daiichi accident, and both must therefore engage in the earnest handling of societal fear and anxiety spawned by the consequent low-dose radiation exposure. Until those affected by the disaster can return to their homes and rebuild their communities of natural beauty and human warmth, the national government must expend considerable energy. To achieve this goal, national, prefectural, city/town/village governments and area residents need to cooperatively engage in persistent efforts over the long term. Continuous cooperation from experts and specialists in the relevant fields also is a must.

2. The following views represent the results of debate to the present with respect to the three issues that this working group has been charged to investigate:

   1) According to scientific findings based on international consensus, increased risk of cancer from low-dose radiation exposures at 100 mSv or less is so small as to be concealed by carcinogenic effects from other factors, making verification of any clear cancer risk from radiation exceedingly challenging.

      Nevertheless, from the perspective of radiation protection, special measures should be adopted to reduce risk from exposure by making determinations on the side of safety, based on the concept that risk increases in linear fashion with radiation dose, even in such cases of low-dose exposures of 100 mSv or less.

      Health risks from annual radiation exposure of 20 mSv, the current level for issuance of orders to evacuate an affected area, are quite small particularly when compared against the risks from other carcinogenic factors. From the perspective of protection from radiation, protective measures such as decontamination of mainly areas of daily life and management of food safety should be continued, and through such efforts, this level should be sufficient to allow avoidance of risk. Furthermore, when carrying out such radiation protection measures, the issue of what measures to adopt should be deliberated upon from a policy perspective, based on comparison of the risks associated with adoption of such measures (stress associated with evacuation, cessation/insufficiency of exercise due to avoidance of outdoor activity, and so on).

With this in mind, the level of an annual dose of 20 mSv is believed to be an appropriate starting point toward further reduction of dose exposures in the future.

At the time the current evacuation zones were established, radiation exposure dose estimates were made on the side of safety, without any consideration paid to the natural decay of radioactivity, or other factors, meaning that actual average exposure doses are, thus, estimated to be far below the annual level of 20 mSv.

2) Cancer risk from low-dose radiation exposure of 100 mSv or less for children and fetus is so small as to be concealed by carcinogenic effects from other factors, the same as in the case with adults, making verification of any clear increase in cancer risk extremely challenging. On the other hand, however, in cases of high-dose exposure exceeding 100 mSv, children through puberty are at higher cancer risk from radiation than are adults.

With this in mind, even in low-dose exposures of no more than 100 mSv, adoption of measures for radiation protection with a priority placed on children is appropriate, given the significant unease experienced by residents of the affected area. However, because children are thought to be highly sensitive to the effects of stress and so on associated with attempts to avoid radiation exposure, deliberate measures for caring children are considered to be of paramount importance.

3) Clear communication to people and affording a better understanding regarding whether the values used with the aim of radiation protection are scientifically verified or are the result of government policy is an important point. Based on the Chernobyl experience, having residents actively participate in both long-term and effective radiation protection efforts is crucial. For that reason, government and specialists must take on risk communication from the viewpoint of residents that provides intelligible and transparent information based on widely accepted scientific facts.

Based on the above opinions, our working group hereby offers the following five suggestions:

1. For decontamination efforts, an appropriate order of priority should be set in progressive fashion, by establishing reference levels, for example, of an annual 10 mSv in the two-year period. And after that goal is met, the exposure level would be reduced to an annual 5 mSv as the next step. Moreover, these reference levels must be used as targets and as markers for attainment of such targets when carrying out radiation protection measures, backed by clear and simple explanations about the concepts, not as values for expression of radiation exposure “limits.” Moreover, the

national government should take responsibility for decontamination efforts in partnership with local cities, towns and villages, creating an effective and comprehensive system for such efforts.

2. Priority should be placed on decontamination of environments in which children are present and active. In the future, when decontamination is conducted for the evacuation zones, protective measures should be adopted that aim at achieving radiation doses equivalent to those of schools outside the evacuation zones, with the policy for exhaustive decontamination of children's activity zones, such as pathways to and from schools and public parks, and the like, to be the same in these evacuation zones after the lifting of evacuation orders. More specifically, for schoolyards and kindergarten grounds and other such areas measured with air dose rates of 1 microsievert or more per hour, that figure must be reduced to less than 1 microsievert before the schools in the evacuation zones are reopened. Moreover, exhaustive decontamination efforts for zones in which children are present and active, such as pathways to and from schools and public parks, and so on, must be carried out with the aim of long-term additional exposure of no more than 1 mSv on an annual basis.
3. Special consideration is necessary regarding foodstuffs provided to children, with establishment and observance of appropriate and reasonable standards regarding radiation concentration therein. Along with health management and exposure dose measurement for children, distribution of radiation detectors for measurement of radiation in foods should be distributed quickly to affected areas to allow residents to understand their own radiation exposure situation, with the aim of attaining transparency of such information and active citizen participation. Exhaustive efforts must be made to educate residents regarding methods for measurement of radiation using such devices.
4. To achieve proper understanding of the situation and carry out countermeasures, government officials and specialists with a wide range of expertise need to take part in continuous conversation with residents at the level of the local community with respect to health and other issues, starting first with effects from radiation exposure. Also necessary is the training of experts intimately familiar with the region.
5. The age-adjusted mortality rates from cancer in Fukushima prefecture in 2005 per 100,000 population were 193.3 for men and 95.1 for women, ranking that prefecture 24th and 26th from the highest, respectively, with respect to cancer mortality among all prefectures in Japan.[30,31] After the report was released, the Fukushima prefectural government announced its aim to reduce age-adjusted cancer deaths (among those under the age of 75 years)[32] by 20% over the following ten-year period, in accordance

with the Cancer Prevention Promotion Plan that the prefectural government formulated in March 2008.[33] It is now imperative for this prefecture's government to establish new targets upon verification of the status of progress in its efforts regarding the current plan, with the aim of making Fukushima Japan's lowest prefecture in terms of mortality from cancer in about 20 years for example, while for the present putting into practice the various measures for steady attainment of the original target of 20% reduction. Toward that end, reduction of other carcinogenic risks is called for through improvement of lifestyle and other habits such as smoking, diet and exercise, and so on, along with packaging of such improvements in a government policy that includes increasing the numbers of people electing to undergo health examinations. In this way, Fukushima should strive to become in the future a region heralded throughout the world for its cancer-prevention measures, paving the way toward realization of its residents' wishes in the future.

Footnotes

1. There is no clear definition of 'low-dose exposure' based on international consensus, but most recent information refers to a level of 200 mSv or less.
2. Level of biological effects differs depending on type of radiation. Even in cases of exposure to the same energy, the extent of biological effects can vary. Equivalent dose is defined as doses that cause roughly equivalent biological effects and is derived by multiplication of absorbed dose (absorbed energy per unit mass) by "radiation weighting factor," which reflects differences in extent of biological effects from different types of radiation. Equivalent dose is a measure used for purposes of radiation protection, with sievert (Sv) the unit of measurement.
3. When stipulating radiation sensitivity, this method is based on average values for gender and age. For that reason, actual risk values may include such fluctuations as children's higher sensitivity to radiation.
4. Addition of "tissue weighted factor," which reflects extent of risk of cancer in organs and tissues, to the equivalent dose results in whole organ dose information, with sievert (Sv) the unit of measurement.
5. For certain health effects, "relative risk" is used to express how many times greater the risks are for an exposed group compared with a control group. Relative risk of 1 means that radiation exposure has not affected risk in that particular instance. Excess relative risk is the result when 1 is subtracted from the relative risk for the risk factor targeted for study (in this case, radiation exposure).
6. For example, according to ICRP Pub. 71, these doses in an infant at three months of age for strontium-90 would be 2.3 x 10^{-4} mSv per 1 becquerel; for cesium-134: 2.6 x 10^{-5} mSv per 1 becquerel; and for cesium-137: 2.1 x 10^{-5} mSv per 1 becquerel.
7. According to the Japanese government report titled "Report of Japanese Government to the IAEA Ministerial Conference on Nuclear Safety - The Accident at TEPCO's Fukushima Nuclear Power Stations" (Nuclear Emergency Response Headquarters, June 2011), the (total) amounts of radioactive emissions into the atmosphere were considered to be roughly the following: cesium-134 at a level of 1.8 x 10^{16} becquerel and cesium-137 at 1.5 x 10^{16} becquerel, with strontium-90 at 1.4 x 10^{14} becquerel or roughly 1/100th the levels of cesium. Plutonium-239 and plutonium-240 were considered to be 3.2 x 10^{9} becquerel, or about 1/10,000,000th the levels of cesium.
8. Pointed out in research about the Chernobyl nuclear accident by Dr. Fukushima, the director of the Japan Bioassay Research Center
9. Such as anti-oxidation substances, repair of DNA damage, elimination of mutant cells, elimination of cancer cells
10. Called the Linear Non-Threshold Model (LNT)

11. Risk for the group with BMI (index for measurement of obesity calculated on the basis of height and body weight) of 30 or greater compared to the group with BMI of 23.0-24.9
12. Risk for the group consuming 110g per day (median value) compared with the group consuming 420g per day
13. Risk for the group of women whose husbands were non-smokers compared with the group of women whose husbands were smokers
14. According to “Lifestyle environmental radiation” (1992), Nuclear Safety Research Association
15. Reference to radon typically refers to radon-222, which is generated at the time of decay of radium-226, the daughter nuclide of uranium-238. This radon is a noble gas element with a half-life of 3.8 days, and it exists everywhere in our daily environment. The world indoor radon concentration average is 40 becquerel per cubic meter, and great variety is observed among countries with regard to this average, from 10 becquerel per cubic meter to the Czech Republic’s 140 becquerel, with northern Europe having generally high levels. Japan’s average is 21 becquerel per cubic meter, about half of the world average.
16. Assuming residents of areas considered to have an annual exposure of 20 mSv calculated on the basis of the air dose rate as of August 2011 were to continuously reside in the locations for the next ten years, the radiation exposure dose would be estimated at about 95 mSv over that period, even without decontamination effects (trial calculation from materials of the Nuclear Emergency Response Headquarters, dated August 26, 2011). Actual exposure doses, however, are thought to be below that value.
17. An international scientific organization that provides recommendations about arrangements for radiation protection for people and the environment from the perspective of experts and specialists
18. Indicates the principle known as ‘As Low As Reasonably Achievable’ (ALARA)
19. A situation in which emergency actions are necessary to avoid or reduce undesirable effects from such situations as a nuclear power accident or radiation emergency
20. When management decisions are required in a situation of existing exposure, including long-term exposure in the recovery stage following a state of emergency
21. With respect to planned exposure situations, limits on individual exposure can be applied in planned stages, with predictability of such doses to ensure without fail that the upper limits are not exceeded, as differentiated from reference levels.
22. For example, based on the experience of the Chernobyl nuclear accident, new standards were adopted in Russia as a long-term measure in 1996 that do not require relocation from the affected area if the first-year exposure level is 50 mSv.
23. The average monthly value measured over a period of one month (September 2011) at a fixed number of sites (25 sites) by the Ministry of Education, Culture, Science, Sports and Technology,

and other ministries, and the governments of Fukushima prefecture and Fukushima city

24. Estimated on the basis of duration of time spent outdoors per day (8 hours) and radiation shielding effect (0.4) for duration spent indoors (16 hours) in a wooden shelter
25. Comparison between estimates of exposure doses derived from multiplication of the measured air dose rate values in mainly school buildings and grounds of 55 schools and kindergartens in Fukushima prefecture by the actual duration of time spent in said locations, and the measurement results from personal dosimeters used during the period from June 6 to June 19
26. This is the effective dose of internal exposure after the intake of radioactive substances into the body. In the case of adults, the committed time is 50 years after intake, whereas in children it is until the age of 70, with the committed effective dose considered to be equivalent to the dose of the year of intake. For a definition of effective dose refer to footnote #5. The conversion factor for the standard person is calculated using anatomical models and computational physiological models.
27. This refers to the value at the level of the 90th percent when radiation concentration data is organized in the order of smallest value to highest
28. Estimate results using a method (deterministic dose estimate) for estimation of exposure doses based on the assumption of continuous intake of an average Japanese dietary intake with a certain concentration of radioactive substances (representative values)
29. Radiation dose exposure from which has been subtracted natural radiation dose and therapeutic/medical radiation dose
30. Demographic statistics from the Statistics and Information Department, Minister's Secretariat, Ministry of Health, Labour and Welfare. The crude mortality rate (ordinary mortality rate derived by dividing number of deaths by population) due to cancer as of 2010 is now 305.7 for men and women combined per 100,000 population.
31. The crude mortality rates by prefecture are affected by the age demographics in each of the prefectures. For example, even if the mortality rates by age group are the same, the crude mortality rates would be higher in prefectures with a higher number of aged people and lower in prefectures with a higher number of young people. Therefore, age-adjusted mortality rate (per 100,000 population) is the mortality rate adjusted for age demographics in order to allow comparison of mortality situations among prefectures with different age demographics. Using this age-adjusted mortality rate makes possible more accurate comparisons of mortality in groups with different age demographics.
32. The national government's Cancer Prevention Promotion Basic Plan (June 2007) calls for a reduction in age-adjusted mortality rate (for those under the age of 75) from cancer, because these target values are considered appropriate as highly precise indices that eliminate aging effects to the extent possible.

33. In materials submitted by the members of the Ministry of Health, Labour and Welfare's Cancer Control Office (May 2007), precise calculations based on certain sets of assumptions were carried out, establishing throughout Japan the goal of "20% reduction in cancer mortality over the ten years starting in 2005 (under 75 years of age, age-adjusted)." The government announced as concrete means toward this goal (1) reduction of smoking rates through anti-smoking efforts; (2) diffusion and precision management of health examinations with established effectiveness; and (3) similar levels of cancer treatment available to all members of society, as the basis for the aforementioned rate of reduction in reflection of the contribution of each of these efforts. Using such information as reference, the national government formulated its Cancer Prevention Promotion Basic Plan, and the government of Fukushima prefecture then established its own Cancer Prevention Promotion Plan in line with the national government's framework.

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[15] ICRP Publication 109 Application of the Commission’s Recommendations for the Protection of People in Emergency Exposure Situations, Annals of the ICRP 2009; 39(1): 11-60.

[16] ICRP Publication 111 Application of the Commission’s Recommendations to the Protection of People Living in Long-term Contaminated Areas after a Nuclear Accident or a Radiation

Emergency, Annals of the ICRP 2009; 39(3): 9-46.

Reference (1) – Members of the Working Group on Risk Management of Low-dose Radiation Exposure

- ENDO, Keigo: President, Kyoto College of Medical Science; Vice Chairman, Japan Radiological Society
- KAMIYA, Kenji: Vice President, Fukushima Medical University; Director, Hiroshima University Research Institute for Radiation Biology and Medicine
- KONDO, Shunsuke: Chairman, Japan Atomic Energy Commission, Emeritus Professor, The University of Tokyo
- MAEKAWA, Kazuhiko: (Co-chair of the working group), Emeritus Professor, The University of Tokyo; Chairman, Radiation Emergency Medicine Network Meeting, National Institute of Radiological Sciences
- NAGATAKI, Shigenobu: (Co-chair of the working group) Emeritus Professor, Nagasaki University; Former Director, Radiation Effects Research Foundation
- NIWA, Ohtsura: Emeritus Professor, Kyoto University
- SAKAI, Kazuo: Director, Research Center for Radiation Protection, National Institute of Radiological Sciences; Visiting Professor, Department of Nuclear Engineering and Management, The University of Tokyo Graduate School
- SASAKI, Yasuhito: Permanent Director, Japan Radioisotope Association; Former Director, National Institute of Radiological Sciences
- TAKAHASHI, Tomoyuki: Member, Radioactive Substances Countermeasure Section meeting, Food Sanitation Subcommittee, Pharmaceutical Affairs and Food Sanitation Council; Associate Professor, Kyoto University

(Names indicated in alphabetical order, with last names in capital letters appearing first)

[Government agency participants]

- HOSONO, Goshi: Minister of the Environment, Minister for the Restoration from and Prevention of Nuclear Accident of Japan
- NAKATSUKA, Ikko: Senior Vice-Minister of the Cabinet Office
- SONODA, Yasuhiro: Parliamentary Secretary of the Cabinet Office
- TAKAYAMA, Satoshi: Parliamentary Secretary of the Environment

Reference (2) – Background of Deliberations by the Working Group on Risk Management of Low-dose Radiation Exposure

(1) 1st Working Group Meeting (November 9)

Expert members – KODAMA, Kazunori: Chief Scientist, Radiation Effects Research Foundation

SAKAI, Kazuo: Director, Research Center for Radiation Protection, National Institute of Radiological Sciences

After explanations were provided regarding health effects from radiation, the meeting engaged in deliberations on effects of low-dose radiation exposure over the long term, differences in effects depending on radionuclide, biological defense capabilities, and other topics.

(2) 2nd Working Group Meeting (November 15)

Expert members – SHIBATA, Yoshisada: Professor, Nagasaki University Graduate School of Biomedical Sciences

KIMURA, Shinzo: Director, Fukushima Office, International Epidemiology Research Laboratory, Associate Professor, Radiation Hygiene, Dokkyo Medical University

After explanations were provided regarding health effects from the Chernobyl nuclear disaster, the meeting engaged in deliberations on the idea that no increases in cancers will be observed, besides thyroid cancer, from radiation exposure among children (Professor Shibata), and the basis for creation of the standard of 5 mSv per year by the Ukrainian government (Associate Professor Kimura), among other issues.

(3) 3rd Working Group Meeting (November 18)

Expert members – NIWA, Ohtsura: Emeritus Professor, Kyoto University

SHIMADA, Yoshiya: Group Leader, Experimental Radiobiology for Children's Health Research Group, Research Center for Radiation Protection, National Institute of Radiological Sciences

After explanations were provided regarding risks to children and pregnant women from low-dose exposure, the meeting engaged in deliberations on other effects besides health effects such as severe psychological and societal effects, greater cancer risks from smoking and obesity than from radiation exposure at a level of 100 mSv, and necessity of explanations of correct information with a scientific basis, and so on.

(4) 4th Working Group Meeting (November 25)

Expert members – KODAMA, Tatsuhiko: Professor, Research Center for Advanced Science and Technology, The University of Tokyo

KAI, Michiaki: Professor, Oita University of Nursing and Health Sciences

After explanations were provided regarding the thinking about risk management for low-dose radiation exposures, the meeting engaged in deliberations on such issues as behaviors and different effects of each kind of radionuclide in the human body, research into possible health effects from the perspective of genomics, differences in effects from internal exposure depending on radionuclide, and comparisons of risks between radiation and other risk factors, among other topics.

(5) 5th Working Group Meeting (November 28)

Expert members – CLEMENT, Christopher H.: Scientific Secretary, ICRP

LOCHARD, Jacques: Member (Chair of Committee 4), ICRP Main Commission

After explanations were provided regarding ideas from an international perspective related to low-dose radiation exposure, the meeting engaged in deliberations on such issues as the prioritization of measures with regard to the government's reference levels and ideas about the relocation of residents in the Chernobyl situation.

(6) 6th Working Group Meeting (December 1)

Expert members – NAKAYACHI, Kazuya: Professor, Faculty of Psychology, Doshisha University

KAMIYA, Kenji: Vice-president, Fukushima Medical University

After explanations were provided regarding the manner in which risk should be communicated to the public, the meeting engaged in deliberations on such issues as methods for quantitative risk understanding and elimination of related anxiety and stress, methods for obtaining trust of the public, and activities related to risk communication employed in the affected local areas, among other topics.

(7) 7th Working Group Meeting (December 12)

Expert members – TANAKA, Shun-ichi: Contamination Advisor, Fukushima Prefecture; Chairman, Research Organization for Information Science and Technology

NISHIDA, Shoji: Mayor, Date City, Fukushima Prefecture

After explanations were provided regarding issues arising at the local level and the direction necessary for future countermeasures with regard to the situation, the meeting engaged in deliberations on such issues as methods of conveying relevant information from the government and experts, necessity of residents' participation, and importance of measuring exposure doses and amount of radiation present in the immediate environment, among other issues.

Following the above, a draft compilation was discussed.

(8) 8th Working Group Meeting (December 15)

The draft compilation was discussed.

*Each meeting's expert members submitted CVs (summaries of publications), which will be added in Attachment 1.

Messages from the following experts attending the working group meetings will be added in Attachment 2.

- BALONOV, Mikhail: Member, ICRP Main Commission
  Consultant, World Health Organization (WHO)
  Consultant, United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)
- BURKART, Werner: Former Deputy Director General, IAEA
- CLARKE, Roger: Emeritus Member, ICRP Main Commission
- BOICE, John D. Jr.: Member, ICRP Main Commission
  Professor, Medicine at Vanderbilt University School of Medicine
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Reference (3) – Handling to date by the government with respect to low-dose exposures

(1) The fundamental process involves the government taking into consideration ICRP recommendations and adopting measures for handling of the situation after obtaining opinions based on expert viewpoints from such committees as the Nuclear Safety Commission.

(2) As measures for handling of the emergency exposure situation, the government established initial evacuation and refuge zones March 11-12, 2011, expanded the zones, and ultimately established an evacuation zone covering an area with a radius of up to 20 km from the nuclear power plant. On March 15, the government established an indoor-evacuation zone covering a range of 20-30 km from the plant site. In addition, in consultation of the ICRP reference levels, the government adopted the strictest level of annual dose exposure of 20 mSv from within the emergency exposure levels from the perspective of safety, then established its planned evacuation zones and issued its evacuation orders. For locations with a continued air dose rate estimated to exceed 20 mSv of cumulative dose over the one-year period since the accident in some of the areas in which the spread of radiation regionally did not warrant establishment of planned evacuation zones (with respect to “Planned Evacuation Zones” and “Emergency Evacuation Preparedness Zones,” by Atomic Energy Safety Commission, April 10, 2011), the government created “Designated Locations for Recommended Evacuation,” after consultation with the relevant local governments, and started its support for evacuation and initiated calls for precautions to take in daily life, among other measures. In such circumstances (“Handling for designated locations estimated to have cumulative doses in the one-year period following the accident exceeding 20 mSv,” Nuclear Emergency Response Headquarters, June 16, 2011), the government relied on conservative calculations, by considering annual exposure of 20 mSv to be the effective dose rate for measurement values of air dose rate, with outdoor exposure of 8 hours and indoor of 16 hours, a shielding coefficient of 0.4 for indoor exposure, and no attenuation thereafter.

(3) For handling of the existing exposure situation, the government determined guidelines for decontamination measures, making certain based on ICRP standards that annual additional exposure was at or below 1 mSv as a long-term goal, and by the end of August 2013, that about a 50% reduction, including physical decay of radioactive substances, could be achieved compared with the annual additional exposure for the public at large as of the end of August 2011 (“Regarding basic ideas related to radiation protection toward future lifting of evacuation, restoration,” Atomic Energy Safety Commission decision, July 19, 2011; “Basic ideas toward decontamination promotion” and “Basic policy for decontamination in

emergencies," Nuclear Emergency Response Headquarters, August 26, 2011; "Basic policy for special measures related to dealing with environmental contamination caused by radioactive substances emitted due to the nuclear power accident accompanying the Great East Japan Earthquake of March 11, 2011," by Cabinet decision, November 11, 2011).

(4) With special consideration paid to children and pregnant women, the government is currently carrying out a program of lending dosimeters to individuals and conducting ultrasonic thyroid screening (alongside Fukushima prefecture's efforts). Even with regard to decontamination and other measures, the government has made the determination to reduce annual additional radiation dose by roughly 60%, including physical decay of radioactive substances, by the end of August 2013 compared with the levels measured at the end of August 2011, through the process of decontamination of environments in which children are present and active in priority fashion. In addition, the government determined its own policy of measures related to decontamination, and so on ("Basic ideas toward decontamination promotion" and "Basic policy for decontamination in emergencies," Nuclear Emergency Response Headquarters, August 26, 2011; "Basic policy for special measures related to dealing with environmental contamination caused by radioactive substances emitted due to the nuclear power accident accompanying the Great East Japan Earthquake of March 11, 2011," by Cabinet decision, November 11, 2011).

(5) The government also is engaged in distribution of information to the public and residents, such as by the monitoring of environmental radiation (emergency monitoring conducted by the Ministry of Education, Culture, Sports, Science and Technology, among others), measurement of food products for radiation contamination levels (screening by local and regional governments), and establishment of consultation services regarding concerns about radiation (Health Consultation Hotline by the Ministry of Education, Culture, Sports, Science and Technology, among others), to list some of the efforts.