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# IRRS follow-up mission Germany 2011

## Supplement on the Advance Reference Material (ARM)

Regulatory implications of the Fukushima Dai-ichi NPP accident

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# 1 Introduction

On 11.03.2011 at 14:46 h (6:46 h CET) a 9.0 magnitude earthquake occurred off the coast northwest of the Japanese main island. In this coastal area, there are three nuclear power plant sites (Onagawa, Fukushima, Tokai) with several boiling water reactors each. The earthquake caused severe destruction and also led to the loss of power supply in the adjacent coastal regions. As per design, the earthquake triggered an immediate shutdown of the reactors affected. The loss of external power supply caused the automatic start of the emergency diesel generators. The severe earthquake was followed by a tsunami which reached the coastal area of nuclear power plant site Fukushima with an estimated height of about 14 to 15 metres. Particularly at the Fukushima I site, the tsunami caused flooding of large areas of the power plant site and severe damage to the infrastructure. The resulting failure of the emergency diesel generators and the auxiliary service water systems led to a complete loss of residual heat removal. The reactor cores in the three units at the Fukushima I site then heated up; core damage occurred with hydrogen releases into the reactor buildings, causing hydrogen explosions in several units. This led to radioactive releases into the environment, and evacuation zones were established around the power plant site. It is to be assumed that parts of the cores in the Units 1 - 3 are severely damaged. For Unit 1, a penetration of the melt through the reactor pressure vessel is assumed.

The loss of residual heat removal also led to insufficient cooling of the fuel assemblies in the fuel pools, which probably also led to damage of the fuel assemblies there.

With the help of emergency measures, water, to some extend also sea water, was injected into the pressure vessels and fuel pools in different ways to ensure sufficient cooling.

# 2 Political decisions with impact on the regulatory framework

## 2.1 Talks between Chancellor Merkel and Minister Röttgen and the minister-presidents of the Länder

On 14 March 2011, Chancellor Angela Merkel announced a 3-month moratorium on the recently decided extension of the operating lives of German nuclear power plants. On 15 March 2011, the first meeting of the Federal Government represented by Chancellor Angela Merkel and the five minister-presidents of the Länder with nuclear power plants took place.

The result was that all German nuclear power plants are to be subjected to a safety review in the next three months. (see “Order to temporarily cease operation”)

For the safety reviews, the operators have to shut down the nuclear power plants commissioned prior to 1980. These are the nuclear power plants Biblis A and B (Hesse), Neckarwestheim I and Philippsburg (Baden-Württemberg), Brunsbüttel (Schleswig-Holstein), Isar I (Bavaria), Unterweser (Lower Saxony). It was also decided not to restart the Krümmel NPP that was out of operation at that time.

All others will be reviewed during normal operation.

At European and international level too, Germany wants to have current safety standards reviewed. The Chancellor announced that she would be pushing for uniform and rigorous standards within both the EU and the G20.

The legal basis for the shutdown of the older nuclear power plants is provided by the Atomic Energy Act, §19 (3), which reads as follows:

*“The supervisory authority may order that a situation be discontinued which is contrary to the provisions hereof or of the statutory ordinances issued hereunder, or to the terms and conditions of the notice granting the licence or general approval, or to any subsequently imposed obligation, or which may constitute a hazard to life, health or property because of the effects of ionizing radiation. In particular, the supervisory authority may order that*

1. *certain protective measures shall be taken,*

2. *radioactive material shall be stored or kept in custody at a place designated by it,*

3. *the handling of radioactive material, the erection and operation of installations of the kind referred to in § 7 and § 11, para. (1), subpara. 2, as well as the handling of installations, equipment and devices of the kind referred to in § 11, para. (1), subpara. 3, shall be suspended or, if a requisite licence is not granted or is definitely revoked, discontinued."*

On 22 March, a second meeting of the Federal Government and the five minister-presidents of the Länder with nuclear power plants took place. It was decided that the review of all nuclear power plants should be performed by the RSK and the respective procedure for the involvement of additional experts was agreed upon (see Chapter 3.2.1).

## 2.2 13th amendment to the Atomic Energy Act

On 6 June 2011, the Federal Cabinet adopted the draft of a 13th act to amend the Atomic Energy Act (in German).

This draft accounts for the results of the safety reviews of all nuclear power plants in Germany and the re-assessment of the risks associated with the use of nuclear energy within a cross-social dialogue under the participation of the Ethics Commission "Secure Energy Supply" and aims at ending the use of nuclear energy for commercial electricity production in Germany as soon as feasible.

The amended act was passed by the German Federal Parliament (Bundestag) on 30.06.2011, approved by the German Federal Council (Bundesrat) on 08.07.2011 and entered into force on 06.08.2011. (see Federal Law Gazette 2011 Part I no 43, Bonn 5 August 2011 - in German)

On this basis, the following main modifications of the Atomic Energy Act are to be introduced:

- The granting of further electricity production rights according to the 11th amendment of the Atomic Energy Act will be cancelled.
- The licences for power operation of the seven oldest nuclear power plants and the Krümmel nuclear power plant will terminate with the entry into force of the amended Atomic Energy Act.
- For the three youngest plants, the licences for power operation will expire in 2022 at the latest; for the other plants on a step-by-step basis until 2015/2017/2019/2021 at the latest.
- The transfer of electricity volumes will still be possible, provided that the respective end times are adhered to.

# 3 Actions taken by the regulatory body in the aftermath of the Fukushima Dai-ichi NPP accident

All national and international activities to improve safety in the aftermath of the events in Fukushima since 11 March are listed in the "Timetable of actions", Annex 1.

## 3.1 Immediate actions taken by the regulatory body

### 3.1.1 Reactions of Federation/Länder/GRS immediately after the event

In the case of Fukushima there was no need to activate for national events foreseen "emergency organisation (crisis centres)". Due to the public interest and the severity of the accident, both, the BMU and the GRS activated the "foreseen organisational framework". To prevent misunderstandings, for both the term "situation centre" will be used.

Immediately after the event, the Federation, the Länder and their expert organisations activated their situation centres. The situation centres of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and GRS established contact with each other at short notice and agreed on the further exchange of information. To provide appropriate information to the public, it was agreed that all findings of the GRS situation centre, regularly communicated to the BMU several times a day, were also to be disseminated through the GRS website to keep the public informed.

### 3.1.2 BMU/GRS/UM BW situation centres

**Activities of the BMU situation centre**

Due to its national and international obligations a complex system of mechanism, procedures and organisational precautions have been taken for adequate response for emergency response to events of national and international origin. Details about the organisational arrangements and procedures have been reported under Article 16 in the German CNS report for the fifth review meeting of the contracting parties to the Nuclear Safety Convention.

Information necessary for BMU activities in such a case are presented and available for the different actors in the RS Intranet Portal (RS Intranet Portal).

Tasks and structure of the BMU crisis management organisation and their way of working is outlined in the document “RS national crisis respond organisation“.

All information provided by GRS, the European clearing houses, the IAEA, the Tepco press releases, international supervisory authorities and expert organisations were systematically evaluated by the BMU situation centre for a situation assessment and prepared for the Länder and the public (see “BMU actions within the first four weeks of the Fukushima crisis”).

Immediately after the accident, information had been systematically provided through the **Federal Electronic Situation Display ELAN** (**E**lektronische **La**gedarstellung für den **N**otfallschutz), a portal operated by the Federal Office for Radiation Protection (BfS) for the BMU on which the BMU and BfS provide information. The data and information are available to the situation centres of the Federation and the Länder. They relate both to radiation protection and plant conditions and comprise, in particular, reports, plant information, meteorological data, forecasts taking into account radiation protection aspects and measurement results.

In the days following, the BMU situation centre monitored the developments in the Japanese plants, made evaluations and kept the Länder informed.

- Setting up of a hotline

Already on Friday, 11.03.2011, a dedicated hotline was set up. Experts of the responsible Directorate-General RS were at the disposal of the citizens to answer questions and to inform about the events in Japan. The information to the citizens was later replaced by a constantly updated recorded message.

- BMU website

Updated reports on the situation in Fukushima were published on the BMU website to three times a day. In addition, the BMU website provided answers to frequently asked questions. All the data and information were published both on the BMU website and the GRS website has been consistent.

- Measures for the control of persons, goods and aircrafts

Due to the experience of Chernobyl, the BMU had already prepared a draft for a "fast-track ordinance" (in German) in accordance with § 6 of the Precautionary Radiation Protection Act for the control of persons and goods, which entered into force on 23.03.2011. This fast-track ordinance also includes limits for control measurements on aircrafts.

**Activities of the GRS situation centre**

The GRS situation centre is activated in cases of relevant events in Germany and abroad.

After the first press releases on the Fukushima accident in the morning of 11 March 2011 BMU asked the INES officer who is a GRS senior expert for further information on the impacts of the earthquake on affected NPPs in the region. A first assessment of the threat to the nuclear power plants located in this region was performed by GRS experts in the morning on 11.03.2011. The shutdown of all NPPs in the affected region as designed reported in the press was in agreement with the experiences from previous earthquakes. In the course of the morning, further press releases on various plants were received that reported on the failure of the cooling systems, fires and the alarm "abnormal condition", which suggested a deterioration of the plant conditions at the Japanese NPP sites. In response, GRS activated an emergency team and increased the number of staff involved during the first few days from initially 10 to 20 persons. The emergency team consists of experts from various disciplines who were assisted by staff trained for public relations. A 24-hour shift, including weekends, was established which could later be gradually reduced with increasing stabilisation of the situation in Fukushima.

Until the end of March, around 50 persons were involved in the GRS emergency organisation with a total of about 3,700 man-hours (scientific experts and technical assistants).

The main task of the situation centre was to continuously keep track of incoming information and to conduct safety assessments, initially also on the basis of documents of similar American plants. There was continuous contact between the GRS and BMU situation centres. On behalf of the BMU, initially six, later two to three situation reports were prepared per day and made available to the BMU and to the public. In addition, staff of the ministries was systematically informed in detail. The situation reports were also submitted to the Technical Inspection Agencies.

On a specially dedicated website, the GRS Fukushima information portal, information on current developments and technical backgrounds were continuously provided to the public with the aim of making the discussion more objective. By mid-May, there had been about 3.5 million visits to the GRS web pages.

**Activities of the UM BW situation centre**

As specification for a Land, the following describes the approach of the supervisory authority in Baden-Württemberg.

The criteria for the establishment of emergency task forces have not been reached by the Fukushima event. Due to the significance of the events, however, situation centres were set up, as described in the following.

- Establishment of a situation centre at the UM BW

Immediately after the event became public on Friday, 11.03.2011, the information available (sources: information from the Gesellschaft für Anlagen- und Reaktorsicherheit - GRS, information from the BMU, press releases of Tepco - the Japanese nuclear power plant operator - and the IAEA - International Atomic Energy Agency) were systematically evaluated and the development of events continuously monitored. The same day, the UM BW established a situation centre headed by the Director General. In the following days, the centre staff kept track of the developments in the Japanese plants and was in constant contact with the BMU, Baden-Württemberg Ministry of the Interior and other expert institutions (e.g. the Institute for Environment, Measurements and Nature Conservation Baden-Württemberg (LUBW)).

- Establishment of a situation centre of the Baden-Württemberg Land Government

Additionally, on 12.03.2011, a situation centre of the Land Government was established at the management level, involving the Interior Minister, the Minister in the State Ministry and the chairpersons of all parliamentary groups represented in the federal state parliament (Landtag) of Baden-Württemberg. At the first meeting on 13.03.2011 in the UM BW, the centre staff received information about the situation in the Japanese plants,

the possible implications for Baden-Württemberg, and about first measures carried out and planned.

- Setting up of a hotline

Already on Sunday, 13.03.2011, a dedicated hotline was set up. Experts of the responsible department of the UM BW were at the disposal of the citizens from 8:00 am to 8:00 pm, including weekends, to answer questions and to inform about the events in Japan. This service was well accepted by the public and heavily used. Frequently asked questions related to the impact on Baden-Wuerttemberg, travel restrictions, radiation protection measurements for air passengers, as well as for imported foods and consumer goods.

- Internet Portal of the UM BW

Updated values of radioactivity measurements (local dose rate and air activity concentration) and their temporal variations of about 150 measurement points of the remote monitoring system for nuclear power plants (KFÜ) are permanently available on the Internet.

- Measures for the control of persons, goods and aircrafts

Already in the first days following the nuclear disaster, in Germany, some cases of contamination of persons, aircrafts and goods coming from Japan were detected. In response, the following measures were taken:

Persons:
Since there are no scheduled direct flights from Japan to Baden-Württemberg, the following was specified for the Stuttgart airport: passengers who changed aircraft and feared to be contaminated with radioactive substances due to their stay in Japan had the possibility to be screened for contamination at the airport free of charge by the airport fire brigade. The airport fire brigade was also available for contamination measurements at any time in special cases (for example, diverted aircrafts).

In case of suspected incorporation of radioactive substances, the incorporation measurement stations already published in a press release of the UM BW were available for examinations.

Goods:
Goods coming from Japan to Germany have been spot-checked for radioactivity by the customs

Aircrafts:
The BMU had prepared a draft for a "fast-track ordinance" (in German) in accordance with § 6 of the Precautionary Radiation Protection Act, which entered into force on 23.03.2011 and included limits for control measurements on aircrafts..

### 3.1.3 International contacts

As soon as it became clear that the events in the Fukushima plants were severe reactor accidents, the BMU contacted the EU Clearinghouse in Petten, the IAEA and several European regulatory bodies concerning technical information relating to Fukushima. In addition, on 12 March, an employee of the BMU was sent to Japan upon request of the Federal Foreign Office in Berlin to provide on-site advice and support to the German embassy in Tokyo regarding the analysis of the nuclear accidents. In the early phase of the accident, the situation in the NPPs was rather unclear which made it difficult to give appropriate protection action recommendations to the embassy staff in Tokyo and the Germans in the Japanese areas devastated by the earthquake.

During the acute phase of the nuclear disaster, the activities of the BMU employee concentrated on the provision of advice in Tokyo on nuclear disaster response, the preparation of precautionary relocation of the embassy staff on Friday, 18 March, from Tokyo to Osaka, and, in the period from 19 March, on the provision of advice rather oriented to precautionary radiation protection in Osaka.

Not only due to the hazards from several aftershocks, some of them very strong, the working conditions in the embassy in Tokyo were exceptional during the first accident

phase: Despite many power failures and poor communication means in the regions, German citizens in the earthquake region of north-eastern Japan had to be contacted, consular tasks had to be fulfilled and support and assistance provided to those offered having difficulties to leave the crisis area.

There was also considerable need for information and advice of different parties affected. One example is the provision of analyses as the only direct source for German institutions and enterprises in Japan and their staff, for German citizens residing in Japan and the embassy staff and their relatives. The embassy needed expert support to make statements at any time on the potential consequences of the complex and threatening accident sequences in the Fukushima I NPP, the health hazards of radioactivity, and appropriate measures to protect against radiation.

In retrospect, the Federal Ministry for the Environment has fulfilled the high expectations of the Federal Government regarding the support of the German embassy in Tokyo and Osaka, where on-site implementation took place successively by several persons from the area of operations of the Federal Ministry for the Environment: by consultants from the BMU (12 to 28 March and 25 March to 5 April) and from the BfS (3 to April 14 and April 17 to 28).

In addition to information transmitted by the BMU situation centre and information processed by GRS, on 25 March, website "International Emergency Information" of the BfS was established for the German embassy in Tokyo, where relevant current data, dispersion forecasts under consideration of daily updated weather data, and information for Germans in the host country Japan have been provided.

Immediately after accident occurrence, GRS started information exchange with the situation centre of its French partner organisation IRSN. The situation reports were translated into English and made available to the members of the European TSO network ETSON and other foreign authorities with whom GRS co-operates.

## 3.2 Follow-up actions

### 3.2.1 Plant-specific safety review (RSK-SÜ) of German nuclear power plants in the light of the events in Fukushima-1

Due to the Fukushima-I nuclear accidents that occurred after the 9.0 magnitude earthquake and the subsequent tsunami on Friday, 11 March 2011, the BMU called upon the Reactor Safety Commission (RSK) at its 433rd meeting to draft a catalogue of requirements for a safety review of the German nuclear power plants and to assess the results of the review carried out on this basis. The insights gained from the accident sequence in Japan are to be considered in particular with respect to whether the current design limits have been defined correctly and how robust the German nuclear power plants are regarding beyond-design-basis events.

At its 433rd meeting on 17.03.2011, the RSK derived provisional insights from the accident in Japan for operating plants as well as for plants in refuelling and overall maintenance inspection outage and prepared a first draft of requirements for the safety review.

On 30.03.2011, the RSK discussed and finally endorsed the Catalogue of requirements for plant-specific reviews of German nuclear power plants in the light of the events in Fukushima-I - Japan (see “RSK Catalogue of Requirements – Preface” and “RSK Catalogue of Requirements“).

On 05.04.2011, a questionnaire approved by the RSK regarding the safety review was sent to the utilities (see “Questionnaire concerning information for NPP” – in German). The operator reports were due on 21.04.2011.

At its 435th and 436th meeting on 21.04.2011 and 28.04.2011, the assessment criteria for the evaluation of the operator reports were discussed and completed by the RSK.

At its 437th meeting from 11.05.2011 to 14.052011, the RSK prepared a statement on the findings of the safety review which was presented to the public on 17.05.2011 (see “RSK - Summarising assessment and recommendations”).

In this statement, the RSK draws the following conclusions:

*"It follows from the insights gained from Fukushima with respect to the design of these plants that regarding the electricity supply and the consideration of external flooding events, a higher level of precaution can be ascertained for German plants.*

*The RSK has furthermore reviewed the robustness of German plants with respect to other important assessment topics.*

*The assessment of the nuclear power plants regarding the selected impacts shows that for the topic areas considered, there is no general result for all plants in dependence of type, age of the plant, and generation.*

*The existing plant-specific design differences according to the current state of licensing were only partially considered by the RSK. Plants that originally had a less robust design were backfitted with partly autonomous emergency systems to ensure vital functions. In the robustness assessment performed here, this selectively leads to evidentially high degrees of robustness.*

*The RSK has derived first recommendations for further analyses and measures from the results of the plant-specific review."*

### 3.2.2 Commission of Experts of the Baden-Württemberg Land Government

In response to the events in the Japanese nuclear power plants, the Baden-Württemberg Land Government appointed an independent Commission of Experts to review the nuclear power plants in Neckarwestheim and Philippsburg. The appointment of this commission was publicly announced by Minister-President Mappus and Environment Minister Tanja Gönner on 14.03.2011.

The task of the Baden-Württemberg Commission of Experts was to perform a step-by-step analysis of the events in Japan, to examine the applicability to the facilities in Baden-Württemberg and, finally, to consider and assess the scope of risk prevention in the design of nuclear facilities in Baden-Württemberg,

The members of this independent body are recognised experts in their fields and familiar with the field of reactor safety.

The members of the Baden-Württemberg Commission of Experts are:

- Dipl.-Ing. Klaus-Dieter Bandholz (Managing Director of the ESN Sicherheit und Zertifizierung GmbH),
- Prof. Dr. Hans Dieter Fischer (Ruhr-Universität Bochum – chair of telecommunications),
- Dr. Gottfried Grünthal (Head of the Seismic Hazard and Stress Field Section at the GFZ German Research Centre for Geosciences in Potsdam),
- Dr. Erwin Lindauer (former Chief Executive Officer of the GfS Gesellschaft für Simulatorschulung mbH), and
- Dipl.-Ing. Michael Sailer (CEO of the Öko-Institut, Chairman of the Nuclear Waste Management Commission).

A first co-ordination of the tasks of the Commission of Experts to investigate the applicability of the events in Japan to the nuclear power plants in Baden-Württemberg took place on Wednesday, 16.03.2011, in a telephone conference.

Against the background of the few reliable information about the events in Japan that were available at the time of the appointment of the Commission of Experts, the following five topics that have played a decisive role for the events in Japan, were selected for further investigation:

- Earthquake
- Loss of auxiliary service water supply / ensuring residual heat removal
- Grid connection / electrical energy supply
- Infrastructure / autarchy
- Accident management measures

The first meeting of the Baden-Württemberg Commission of Experts took place on 22.03.2011 at the UM BW in Stuttgart. At this meeting, the next steps were specified,

the scope of the five work packages for further investigation was defined based on the known and applicable insights gained from the events in Japan.

The work packages were assigned according to the respective fields of competence of the experts.

The focus was on site-specific aspects (such as impacts in case of twin-unit plants and the respective geographical site factors) and on the maintenance of cooling of the fuel assemblies in the reactor core and in the fuel pool.

During the following weeks, the documents were made available to the experts from the UM BW that were required for their activities (mainly documents of the last safety review). In addition, there were plant visits to the two sites Philippsburg (Friday, 15.04.2011) and Neckarwestheim (Monday, 18.04.2011). The respective plans for these on-site inspections were prepared in accordance with the specifications made by the members of the Commission of Experts.

The schedule for the nationwide review by the Reactor Safety Commission, that had meanwhile been adopted, required a further adjustment of the approach of the Commission of Experts, as it was necessary to prepare the contributions to the consultations by 28.04.2011.

Thus, contents of the second meeting of the Commission of Experts on 20.04.2011 at the UM BW in Stuttgart were the presentation of the results acquired so far and the consultations on how to proceed until publication of the report on the results, which represents the completion of work of the Commission of Experts.

When considering the five topics, the experts identified safety margins in all plants to differing degrees.

From the findings for the respective topics, the members of the Commission of Experts have derived suggestions for optimising opportunities for further increasing the safety level of the plants during beyond design basis events (see excerpts of the “Results of the Review by the Commission of Experts of BW”, the full text of the report is available in German). The UM BW will follow up these suggestions.

After announcement of the 3-month moratorium by the Federal Government, a nationwide very comprehensive review process was initiated which should be completed by an evaluation by the Reactor Safety Commission (RSK). The catalogue of requirements for the safety review of all German nuclear power plants was publicly presented on 31.03.2011 by Federal Environment Minister Röttgen and the RSK Chairman.

Major tasks of the review that were to be carried out by the Commission of Experts, are now performed by the RSK for all German plants. To avoid an overlap of the two bodies, the findings of the Commission of Experts should now be taken into account in the consultations of the Reactor Safety Commission and supplement them.

The initially planned third stage of the investigations of the Commission of Experts (review of the scope of risk prevention) was therefore mainly considered within the framework of the RSK investigations.

### 3.2.3 Meeting of the Reactor Safety Technical Committee

At its 56th meeting on 24 May 2011, the Reactor Safety Technical Committee (Fachausschuss Reaktorsicherheit – FA RS) of the Länder Committee for Nuclear Energy (LAA) discussed the results of the RSK Safety Review and concluded (see presentation of the RSK statement concerning the safety reviews of German NPPs – in German) the following (see "Conclusions of the 56th meeting of the FA RS" – in German):

*"The Reactor Safety Technical Committee takes note of the report of the RSK. The Reactor Safety Technical Committee asks the BMU to evaluate the RSK statement, in particular also with regard to the current regulatory issues and with regard to possible new design requirements, and to bring appropriate proposals into the discussions between the Federation and the Länder. The Reactor Safety Technical Committee asks the BMU to commission the RSK with the continuation of the consultations with the aim of clarifying unclear issues and open questions. The Länder, in turn, will evaluate the RSK statement with regard to the plants under their supervision."*

In addition to the plant-specific allocation to the different levels and degrees of protection, the RSK formulates recommendations that have to be considered in the context of supervision. Moreover, it identified unresolved issues on which it will continue its consultations. The RSK included these issues in its work programme. (see letter from BMU to the Länder authorities – in German.)

A compilation of all documents and results of the RSK in the light of the events in Fukushima, is presented in a report that was made by GRS upon request by the BMU (see GRS report "English translation of excerpts of RSK documents").

### 3.2.4 Convention on Nuclear Safety

The fifth Review Meeting of the Contracting Parties to the Nuclear Safety Convention took place from 4 to 14 April 2011 in Vienna, Austria. Before the meeting, the Contracting Parties were asked by the President of the Conference, Mr. Li (see letter from Mr. Li), to respond to nine Fukushima related questions. BMU and the Länder Baden-Württemberg, Lower-Saxony and Schleswig-Holstein reviewed the current status and the actions taken already in the light of conclusions to be drawn from the Fukushima accident. The findings were presented by Germany during the session of its Country Group (see Presentation of Germany).

# 4 Plans for up-coming actions to further address the regulatory implications of the Fukushima Dai-ichi NPP accident

## 4.1 Experts of the Federation

In order to be able to gather and use all the insights obtainable from the Fukushima nuclear accidents, GRS received an approval by the BMU for the performance of in-depth analyses and assessments over the next three years.

One objective of the project is to reconstruct what happened in the affected power plant units as far as possible. This includes both the external hazards at the beginning of the accident and the gradual loss of safety functions, and the processes after heating of the reactor cores and containment venting up to the hydrogen explosion and the release of radionuclides. The countermeasures taken in the course of the accident are also to be analysed and verified.

For an integrated event analysis, it is important to consider as far as possible the degree of destruction of the nuclear power plant building and its infrastructure, in particular of the fuel pools, caused by earthquake and tsunami. In addition, knowledge has to be gathered as to the degree of destruction of infrastructure outside the power plant site.

The experiences from other severe incidents and accidents show that it takes  years until all facts are made public. This year, GRS will try to contact the Japanese TSO JNES in order to clarify the most important questions about the accident sequence. Moreover, it is planned to attend all conferences that deal with the accident to share information and technical and scientific knowledge. At the beginning of the project, it will also be explored what information and knowledge are available at other authorities or TSOs, in particular at the U.S. NRC. This knowledge is a prerequisite for the involvement and active participation in scientific and technical analyses of the accident sequences at the international level and for recommendations on precautionary measures and accident control, as well as the establishment of stable plant conditions.

Another objective of the project is research and provision of findings on plant-specific measures to prevent such accident sequences, to limit and reduce releases, and to restore effective retention functions sustainably in case of beyond design basis events. The sequences are to be analysed, using German power plants under beyond design basis accident conditions since in-depth knowledge and information about the plants is available here. This will make it possible to give recommendations for the improvement of measures to control or to mitigate the consequences of beyond design basis events also for other European plants, based on the results of this project.

Besides the work on the optimisation of accident management measures and crisis management measures and their preparation, the assessment methods for safety reviews are in the process of further development so that beyond design basis events can be better assessed. Further, efforts are to be made to develop methods for the performance of so-called stress tests on the basis of scientifically substantiated findings with the aim of enabling the performance of deterministic assessments of the robustness towards beyond design basis events. Basically, such methods would also be suitable for reviews that are performed, for example, by international bodies. For this work, the existing networks, such as ETSON, OECD working groups of the OECD/NEA or the European Commission (EC), are used. In future, it will also be possible to perform joint activities for the review of foreign plants in co-operation with the networks, if required.

## 4.2 BMU request for a GRS Information Notice

GRS has been commissioned by the BMU to prepare a detailed technical report on the events in Fukushima. In addition to this report, GRS was commissioned to analyse events in Fukushima for potential applicability of individual aspects to German plants, and to prepare and Information Notice (WLN) in accordance with the practice agreed with the Länder.

## 4.3 Topics derived by the RSK from consultations on Fukushima

Based on the results of the Plant-specific safety review (RSK-SÜ) of German nuclear power plants in the light of the events in Fukushima-1 (Japan), at its 438th meeting on 08.07.2011, the RSK agreed on the topics to be further dealt with in detail in the aftermath of the Fukushima NPP accidents (see conclusions of the 438th RSK meeting – in German). The topics are as follows:

**Earthquake**

- Consideration of all conditions of low-power and shutdown operation (e.g. flooded reactor cavity during refuelling).
- New curves for the determination of the probabilities of seismic acceleration loads at concrete sites that might lead to a higher level of design earthquakes.

**Flood**

- Protection of canals and buildings regarding the intrusion of water and the floating resistance in the case of a higher level flood. Assumed postulate: flooding of the plant site.
- Accessibility of the plant buildings in the case of longer-term flooding.

**Station blackout**

Specific examination of low-power and shutdown operation and storage of the fuel assemblies in the fuel pool. Battery capacities, safety margins of the plants, demand for 10 hours of availability.

**Loss of offsite power**

Long-lasting loss of offsite power, superimposition of an aftershock with operation of the emergency diesels.

**Loss of service water supply**

Robustness of the existing service water supply requirements under consideration of account current operating experience, also taking into account the cooling of the fuel assemblies both in the fuel pool and in the reactor core during low power and shutdown operation.

**Precautionary measures**

- In-depth examination of precautionary measures to prevent load crashes in the area of the primary system and the fuel pool.
- Generic aspects of “flooding of the annulus in PWR plants“.

**Accident management measures**

- Further development of the accident management concept under external hazard conditions (re-establishment of the supply of three-phase alternating current, injection possibilities for the cooling of fuel assemblies, identification of available safety margins, consideration of wet storage of fuel assemblies, etc.).
- Supplementation of the requirements on accident management (SAMG).
- Optimisation of available measures.

**Aircraft crash**

- Consequential mechanical effects due to an aircraft crash that lead to a limited loss of coolant.
- Protection of the fuel pool of decommissioned plants.

**Release of explosive and toxic gases in the vicinity of plants**

Verification of adherence to safety margins in the case of blast waves and site-specific consideration of toxic gases.

**Effects of an accident in one power plant unit on the neighbouring unit**

Based on the damage states of a power plant unit, the consequences for the maintenance of the vital functions of the unaffected unit are to be examined.

**Generic issues**

- Superimposition of events with system operating conditions of short duration (e.g. superimposition of earthquakes with loaded fuel assembly transport casks attached to a crane).
- Long-term operation and post-operational phase of the fuel pools.
- Impact on grid stability.

The RSK has requested their expert committees to resume consultations on the respective topics.

## 4.4 Crisis organisation

Although in Germany the emergency response centres are mainly designed and tested for national events, these structures have worked well at the level of the Federation and the Länder. Through the use of the information system ELAN, all documents and information were quickly forwarded to those in charge. The co-operation of the Federation and the Länder as well as the information of the public by the Federation and the Länder was good. Possible future improvements of the organisation of fast response to international events are currently being examined. For this purpose, a discussion within the Federation-Länder committees is being prepared.

# 5 International measures at EU level

## 5.1 Initiatives by the Energy Commissioner Oettinger (European Commission)

In order to be able to directly start with the formulation of the EU response to the events in the Fukushima Dai-ichi nuclear power plant, EU Commissioner Oettinger convened a high-level conference on 15 March on behalf of the European Commission with the participation of energy ministers, national nuclear safety authorities and nuclear power plant vendors and operators from all EU Member States. The result was a broad agreement on supporting the principle of a European approach for a comprehensive safety and risk assessment of nuclear installations.

At an European Council meeting on 25 March, the Heads of States and Governments of the EU Member States concluded that the safety of all EU nuclear plants should be reviewed on the basis of comprehensive risk and safety assessments (“stress tests”'). Against this background, the Council requested the European Commission and ENSREG to develop and agree upon the scope and modalities of these tests.

## 5.2 Development of EU-wide specifications for NPP stress tests (ENSREG consultations)

On 24.05.2011, ENSREG, the European Nuclear Safety Regulators Group, a high level advisory body comprising representatives of all 27 EU Member States and the European Commission, reached a consensus on the scope and modalities of a comprehensive and transparent risk and safety assessment ("stress tests") of European nuclear power plants, as requested by the European Council (24/25 March 2011).

As requested by the European Council also, ENSREG made full use of available expertise, notably from the Western European Nuclear Regulators Association (WENRA), which had started working on the scope and methodology already at its spring meeting, March 22/23, 2011.

The WENRA proposal, the final version of which was submitted to ENSREG May 7, 2011, was subject to a public consultation to allow for stakeholder engagement.

This consensus comprises a Declaration and an initial independent regulatory technical definition of a “stress test” and how it should be applied to nuclear facilities across Europe (see “Declaration of ENSREG - EU Stress tests specifications”). ENSREG also proposed to establish a process in order to address risks due to security threats which are not part of ENSREG's mandate accompanied by its intention to remain associated with this process (see EU-Stress Tests – timetable). Both strains should contribute to a comprehensive risk and safety assessment.

ENSREG agreed that the assessment according to the declaration will cover extraordinary triggering events like earthquakes and floods and the consequences of any other initiating events (e.g. transport accidents, such as airplane crashes) potentially leading to multiple loss of safety functions requiring severe accident management.

Starting with June 1, 2011, all the operators of nuclear power plants in the EU will have to review the response of their nuclear plants to extreme situations, in particular operators will have to check and improve mitigation measures available after a potential loss of safety functions, caused by any reason. That includes the loss of electrical power or loss of ultimate heat sink for heat removal from the reactor, the management of loss of core cooling functions in their reactors as well as in spent fuel pools and the maintenance of containment integrity.

The operators’ reports will be first reviewed by the national nuclear regulators. They will then prepare summary national report, which will be reviewed by Review Teams, set up by ENSREG. A two-phase approach allows for an interim report to the European Council, 12.12.2011, and a final report to the European Council in June 2012.

## 5.3 Activities initiated by the BMU for the European stress test

The BMU invited (in German) representatives of the Länder and the plant operators to meet on 30.06.2011 to discuss the modalities of the European stress tests. At this meeting, it was agreed that the BMU will provide the structure of the operators' reports and a concept for the German national report (see "structure of the operators´ reports and for the national report" – in German). Furthermore, the proposal of the WENRA Chairperson for the operator reports and the national report was distributed. The plant operators were given the opportunity to comment on it. It was agreed that the operators´ reports should be suitable for publication. Specific detailed information, that is to be treated as confidential, should be documented separately.

Currently there is an ongoing exchange and cooperation of the regulating authorities, expert organisations and licensees to perform the agreed working programme in times.

# Annex 1 - Timetable of actions concerning the Fukushima accident

| Date 2011 | Organisation | Initiative/Activity | Notes |
|---|---|---|---|
| 11 Mar | | Tohoku earthquake | Tsunami hit Fukushima I |
| 11 Mar | BMU/UM BW/GRS | Activation of the situation centres | |
| 11 Mar | BMU/Länder | Information of the Länder | ELAN, an ongoing task |
| 14 Mar | Government of the Land of Baden-Württemberg | Appointment of the Baden-Württemberg Commission of Experts | Analysis of the events in Japan, examination of the applicability to the plants in BW and, finally, consideration and assessment of the scope of risk prevention in the design of nuclear facilities in Baden-Württemberg. |
| 15 Mar | Federal Government | First meeting of Federal Government + 5 minister-presidents of the Länder with nuclear power plants | – safety review of German NPPs<br>– 3-month moratorium<br>– shut down of the 7 oldest NPPs during this moratorium |
| 15 Mar | BMU/Länder | Meeting of Minister Röttgen with ministers in charge of the Länder | |
| 15 Mar | EC | EC response Japan, Oettinger;<br>Extraordinary meeting with commissioner Oettinger regarding the appraisal of the nuclear hazards in Japan | |
| 16 Mar | EC | EC Working Party on Atomic Questions (WPAQ):<br>– developments in Japan<br>– Follow-up to the HL meeting on 15 March | |
| 17 Mar | BMU | Called upon the Reactor Safety Commission (RSK) to draft requirements for a safety review at 433rd meeting | Requirement on RSK |
| 21 Mar | IAEA | Extraordinary meeting of IAEA Board of Governors<br>here: Nuclear Safety in JPN | |

| Date 2011 | Organisation | Initiative/Activity | Notes |
|---|---|---|---|
| 22 Mar | Federal Government | Second meeting of Federal Government + 5 minister-presidents of the Länder with nuclear power plants | – request to Reactor Safety Commission RSK to prepare a catalogue of requirements for plant specific safety reviews<br>– taking a request from the German Federal Parliament dated March 17 into account<br>– establishment of a new Ethics Commission, founded to reassess risks from nuclear energy<br>Advice on political decisions after completion of the safety review May 15 |
| 22-23 Mar | WENRA | Discussion of the Fukushima NPP accident and possible WENRA measures | First proposal on European “stress tests” on nuclear power plants, published 23 Mar |
| 24-25 Mar | G 8 NSSG | First meeting (Presidency France) | Presentation Gillet, F |
| 24-25 Mar | EC | European Commission, conclusions | Request to ENSREG to develop and agree upon the scope and modalities of stress tests |
| 30 Mar | RSK | Discussion on requirements for plant specific reviews at its 433rd meeting | RSK has published catalogue of requirements for plant-specific safety reviews on April 30 decides on a list of requirements<br>– Concept for stress test<br>– addressing natural and man-made hazards<br>– including Cyber security |
| 4 Apr | Ethics Commission | Ethics Commission meeting | |
| 5 Apr | G20 | Extraordinary meeting of G20 energy ministers, Abu Dhabi | |
| 5-6 Apr | WENRA TF | First meeting of WENRA task force | |
| 12 Apr | WENRA | The WENRA task force sends its proposal to WENRA Chair<br>WENRA Chair distributes the proposal to WENRA members, asking for approval within one week. It is assumed that the document is not significantly modified | |
| 15 Apr | Federal Government | 3rd meeting Federal Chancellor + all minister-presidents of the Länder Issue: accelerated development of renewables and energy efficiency | |
| 20 Apr | WENRA | WENRA issues its proposal on its website, asking stakeholders for comments within 2 weeks (before the 4th of May) | |

| Date 2011 | Organisation | Initiative/Activity | Notes |
|---|---|---|---|
| 06 May | UM BW | Results of the review by the Commission of Experts of BW | |
| 15 May | RSK | Results RSK-SÜ | |
| 24 May | ENSREG | ENSREG reached a consensus on the scope and modalities of a comprehensive and transparent risk and safety assessment ("stress tests") | |
| 30 May | Ethics Com | Results of the Commission on Secure Energy Supply | |
| 1 Jun | EU Members | Starting of the EU Stress tests | All the operators of nuclear power plants in the EU will have to review the response of their nuclear plants to extreme situations.<br>National interim reports to the European Council until 12.12.2011.<br>Final report to the European Council in June 2012. |
| 6 Jun | Federal Government | The Federal Cabinet adopted the draft of a 13th act to amend the Atomic Energy Act | |
| 15 Jun | RSK<br>Ethics Commission | End of verification phase | – Results RSK + Ethics Commission<br>– Decision Federal Government |
| 30 Jun | Federal Parliament | The amended act was passed by the German Federal Parliament (Bundestag) on 30.06.2011 | |
| 20-24 Jun | IAEA | Safety Conference | |
| 30 Jun | BMU/Länder | The BMU invited representatives of the Länder and the plant operators to discuss the modalities of the European stress tests | |
| 08 Jul | Federal Council | Approval of the amended Atomic Energy Act by the German Federal Council (Bundesrat) | |
| 12 Jul | UM BW | UM BW submitted a proposal on the "essential elements of the review reports of the Länder and the National Report" to the authorities | |
| 06. Aug | | Entry into force of the 13th amendment of the AtG | |

## Reference documents

- Order to temporarily cease operation
- Atomic Energy Act
- Draft of a 13th act to amend the Atomic Energy Act
- Federal Law Gazette 2011 Part I no 43, Bonn 5 August 2011
- German CNS report 2011
- RS national crisis response organisation
- BMU actions within the first four weeks of the Fukushima crisis
- Fast-track ordinance - limits for control measurements - aircrafts
- RSK Catalogue of Requirements – Preface
- RSK Catalogue of Requirements
- Questionnaire concerning information for NPP
- RSK - Summarising assessment and recommendations
- Excerpts of the “Report of the Review by the Commission of Experts of the Land Baden-Württemberg”
- Report of the Review by the Commission of experts of BW (full text in German)
- Presentation of the RSK statement concerning the safety reviews of German NPPs
- Conclusions of the 56th meeting of the FA RS
- Information letter from BMU to the Länder authorities on 56th Meeting of FA RS
- Letter from Mr. Li
- CNS Presentation of Germany
- Conclusions of the 438th RSK meeting

- Declaration of ENSREG - EU Stress tests specifications
- EU-Stress tests – timetable
- BMU invitation to the Länder to discuss the modalities of the European stress tests
- Structure of the operators´ reports and for the national report
- Proposal of the WENRA Chairperson Jukka Laaksonen

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