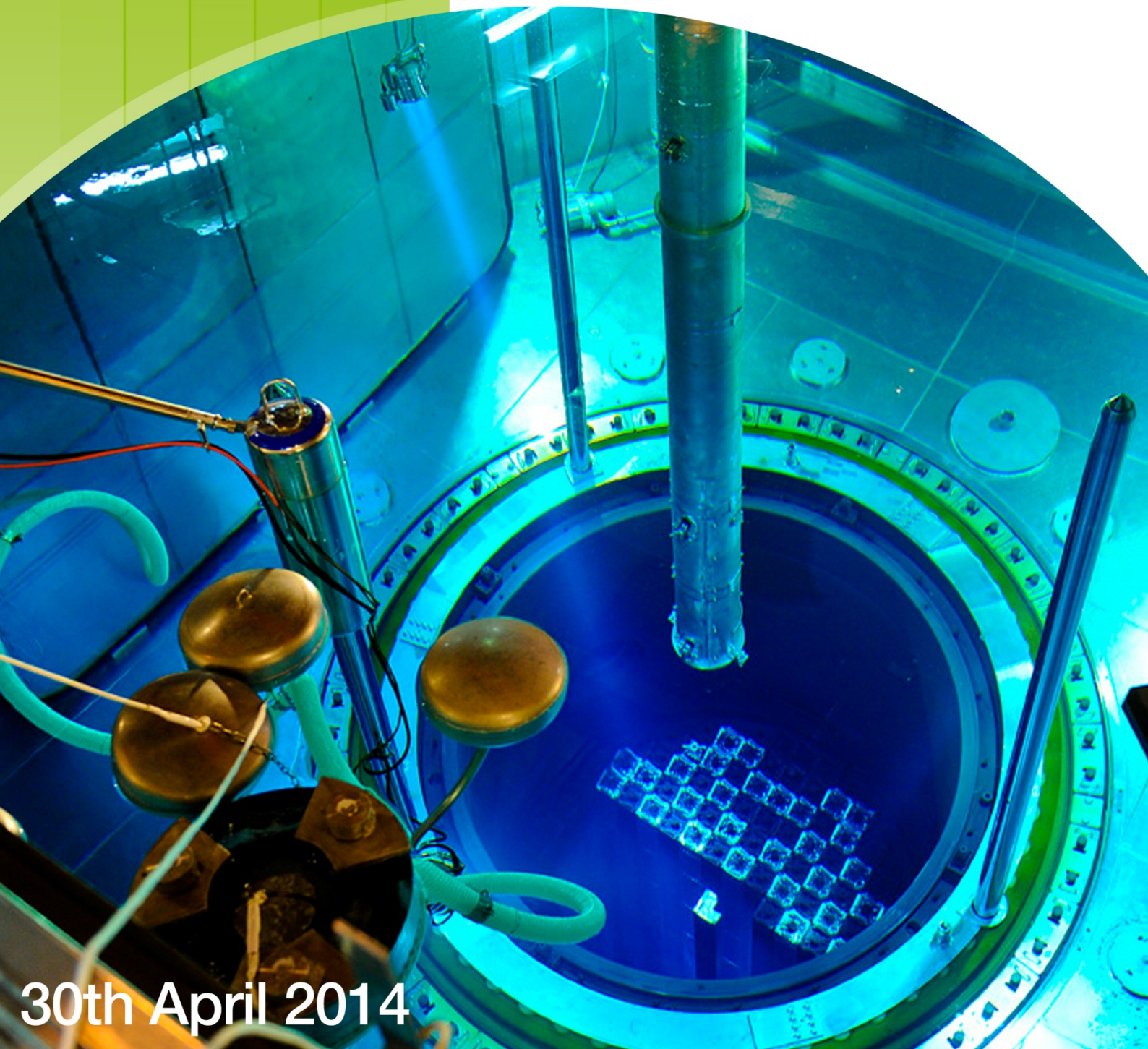
BELGIAN STRESS TESTS

FANC

federal agency for nuclear control

National progress report on the stress tests of nuclear power plants



30th April 2014

This report presents the progress and the monitoring of the action plan undertaken by the licensee and followed-up by the regulatory body to enhance the protection of the Belgian nuclear power plants following the Belgian stress tests.

1. Introduction

Belgium is endowed with seven pressurized water reactors currently in operation on two distinct sites:

- The Doel site, located on the Scheldt river close to Antwerp (Flanders), home of four reactors:
  - Doel 1/2: twin units of 433 MWe each, commissioned in 1975,
  - Doel 3: single unit of 1 006 MWe, commissioned in 1982,
  - Doel 4: single unit of 1 039 MWe, commissioned in 1985.

- The Tihange site, located on the Meuse river close to Liège (Wallonia), home of three reactors:
  - Tihange 1: single unit of 962 MWe, commissioned in 1975,
  - Tihange 2: single unit of 1 008 MWe, commissioned in 1983,
  - Tihange 3: single unit of 1 054 MWe, commissioned in 1985.

Both sites are operated by the same licensee, namely Electrabel, a company of the GDF-SUEZ energy and services Group.

For all nuclear safety related matters, the licensee's activities are under the control of the Belgian regulatory body[1], which is composed of:

- the Federal Agency for Nuclear Control (FANC),
- and Bel V, its technical subsidiary.

As a consequence of the accident that occurred on 11 March 2011 at the Japanese Fukushima-Daiichi nuclear power plant, a wide-scale targeted safety reassessment program was set up among the member states of the European Union operating nuclear power plants.

This "stress tests" program is designed to re-evaluate the safety margins of the European nuclear power plants when faced with extreme natural events (earthquake, flooding and extreme weather conditions) and their potential consequences (loss of electrical power and loss of ultimate heat sink), and to take relevant action wherever needed. The approach is meant to be essentially deterministic, looking only to the preventive aspects but also on the mitigative measures (severe accident management).

The scope of the Belgian stress tests for NPP's covers all seven reactor units including the associated spent fuel pools, and the dedicated spent fuel storage and waste management facilities at both sites, namely:

[1] Additional information about the Belgian regulatory body and nuclear facilities is available on the FANC website (http://www.fanc.fgov.be), specifically in the 2014 report for the Convention on Nuclear Safety

- "SCG" building at Doel (dry cask spent fuel storage facility),
- "DE" building at Tihange (wet spent fuel storage facility),
- "WAB" building at Doel (Water and Waste treatment building).

Similar Belgian stress tests have been conducted for the non-NPP nuclear facilities and are presented in another report from the regulatory body available here. The building for the Water and Waste treatment building (WAB) at Doel, which includes equipment for the processing, storage and handling of liquid effluents and solid radioactive waste is included in this report, even though it was part of the stress test for the other Belgian nuclear facilities. Indeed, Electrabel as the operator and license holder of the WAB, has included the action plan for WAB in the global action plan for nuclear power plants. Therefore, the regulatory body has chosen to include the WAB building in this report.

In accordance with the European methodology, the stress tests of the nuclear power plants are performed in three phases:

1. The licensee carries out the stress tests in its facilities and communicates a final report to the Belgian regulatory body (in the present case, one final report per site). In these reports, the licensee describes the reaction of the facilities when facing the different extreme scenarios, and indicates, where appropriate, the improvements that could be implemented to reinforce safety. This phase was achieved by the licensee on 31 October 2011.

2. The regulatory body reviews the licensee's final reports and evaluates the approach and the results. Based on these data, the regulatory body writes its own national report and communicates it to the European Commission. This phase was achieved by the regulatory body on 30 December 2011.

3. The report of all national regulatory bodies participating in the stress tests program is subject to an international peer review. The national reports are reviewed by other regulatory bodies representing 27 European independent national Authorities responsible for the nuclear safety in their country. This phase was achieved by ENSREG on 26 April 2012.

The resulting national action plan synthetizes all of the licensee actions undertaken as a result of the stress tests program. Until full implementation, this action plan is updated regularly.

Some of these actions have been amended or cancelled when their relevance have been questioned by the remaining operating lifetime of the units. This is the case for the actions intended for the Doel 1/2 units which will cease operation in 2015 as a result of a decision of the Belgian Federal Government in December 2013.

Likewise, the target dates mentioned in the action plan must be considered as "indicative", given that some actions might face time constraints due to interaction with other projects, and depend on internal or external resources for supply and implementation on the sites.

Upon demand of the Belgian Federal Government, terrorist attacks (aircraft crash) and other man-made events (cyber-attack, toxic and explosive gases, blast waves) were also included as possible triggering events in the stress tests program for the nuclear power plants. The assessment of these man-made events were however not in the scope of the European stress tests programs. For security reasons, the progress on specific actions related to man-made events is not included in this report.

2. Stress tests national action plan

2.1. National action plan

The national action plan was set up and updated progressively all along the stress tests program, and is still liable to modifications depending on the possible aleas.

Indeed, the licensee's action plan was amended several times to take account of the subsequent requirements and recommendations derived from the on-going stress tests process and implying several interested parties at the national and international levels.

a) Licensee's initial action plan

The needs for safety improvement were first identified by the licensee as a result of the stress tests self-assessment, which led to a series of proposals presented in the licensee's final reports released in October 2011. The proposed actions were pursuing the following main objectives:

- Topic 1 (extreme natural events):
    - enhanced protection against external hazards (earthquake, flooding, extreme weather conditions).
- Topic 2 (loss of electrical power and loss of ultimate heat sink):
    - enhanced power supply,
    - enhanced water supply,
    - enhanced operation management (procedures),
    - enhanced emergency management (on-site),
    - non-conventional means (NCM).
- Topic 3 (severe accident management) :
    - enhanced protection against severe accidents (SAM).

Overall, the indicative deadlines proposed by the licensee for the implementation of the corresponding actions were in line with the importance of the issues. They also took account of the constraints related to the complexity of the actions, the dependence on internal or external resources for supply and implementation on the sites, and the potential interactions with other projects (especially the "LTO" project aimed at the earliest units).

A number of short-term actions were already implemented by the end of year 2011, and the majority of the remaining actions were to be implemented during years 2013 and 2014.

b) Regulatory body review

The regulatory body reviewed the licensee's final reports and acknowledged the set of propositions formulated by the licensee. However, the regulatory body identified additional improvement

opportunities that were detailed in the national report released in December 2011, and for which relevant actions were expected.

Furthermore, the regulatory body asked the licensee to anticipate earlier completion of a few specific actions due to their importance for the improvement process.

The licensee's action plan was updated accordingly.

On 15 March 2012, the licensee submitted a detailed consolidated stress tests action plan, including the additional requirements of the regulatory body mentioned in the national stress tests report. In total, 350 individual actions were identified.

c) International peer review

The subsequent international peer review of the national stress tests reports, supervised by ENSREG, allowed identifying further lessons not only at the national level but also at the European scale. The aim of the peer review was, among others, to share relevant findings and to benefit from the best practices and insights in order to further improve safety on the field. In this respect, a number of propositions were successively issued by ENSREG in a peer review report and a peer review country report released in April 2012, followed by a compilation of recommendations and suggestions released in July 2012.

The analysis of these documents led to the inclusion of additional actions in the licensee's action plan wherever applicable. Most of the recommendations derived from other countries were already in force in the Belgian units or scheduled in the action plan and thus did not imply further amendments.

After taking into account the additional actions as a result of the ENSREG peer review, the FANC formally approved on 25 June 2012 the consolidated version of the licensee's action plan.

d) Current national action plan

The content of the current national action plan (Updated in November 2013) results from the successive input sources described above.

2.2. Follow-up review process

The national action plan is updated regularly to perform a close follow-up of the status of the different on-going actions. The licensee is directly involved in the process to provide the relevant data.

Within the regulatory body, Bel V plays a key role in the monitoring of the licensee's action plan status and progress. The FANC is obviously involved but on a higher level.

The review process consists of three types of periodic meetings:

- technical meetings,
- progress meetings,
- steering committee meetings.

The technical meetings are convened on a monthly basis. These meetings deal specifically with technical matters. The licensee and Bel V are the main attendees to these meetings. The FANC may also participate from time to time, depending on the importance of the issues that will be discussed.

The progress meetings are convened every three or four months. These meetings deal with the status of the licensee's action plan and general topics with cross-cutting issues. In addition to the licensee and Bel V, the FANC also attends these meetings systematically.

The steering committee meetings are convened twice a year. These meetings deal with high-level strategies and issues, such as internal resources, major postponements, etc. The senior management of the licensee, Bel V and the FANC, attend these meetings.

These different types of meetings allow a close follow-up of the licensee's action plan by the regulatory body, with appropriate periodicities according to the level of detail and technicality.

If an action has to be delayed or modified, the regulatory body assesses the acceptability of the modification based on different criteria:

- the reasons for the need for a change or delay,
- the compensatory measures available or already implemented,
- the suitability of the modified approach.

2.3. Implementation and compliance monitoring

The licensee is responsible for the full and proper implementation of its own actions.

On the field, Bel V is in charge of the supervision of the licensee's action plan progress, on behalf of the regulatory body. This responsibility implies close monitoring of the implementation process of the licensee's action plan, and checks to confirm the compliance of the actions implemented in the facilities. These data are used to validate the licensee's action plan status.

The items to be closed in the licensee's action plan are proposed by the licensee, with reference to any related document or piece of evidence showing that the action has effectively been implemented. Once prior checks and confirmations have been performed, Bel V can ratify that these actions are indeed considered to be closed and the licensee's action plan is then updated.

3. Status of stress test actions

The status of the complete action plan is not presented here for readability. Only the major actions are highlighted in the followings paragraphs.

3.1 Enhancement of the protection against external hazards

As a part of the Belgian stress tests of the nuclear power plants, the protection of the nuclear reactors against seismic and external-flooding hazards, as well as extreme meteorological conditions has been extensively reassessed. In its final stress tests report, ENSREG recommends that the return frequencies of the dimensioning hazards be decreased to 10E-4 per annum. The nuclear reactor protections must then be improved in order to resist a 10,000-year beyond-design flood or a 10,000-year seismic hazard.

The analysis of the stress tests have highlighted several actions to enhance the protection against external hazards

Earthquake

Concerning the **adequacy of the design basis earthquake** (DBE), a first seismic risk assessment was performed by the Royal Observatory of Belgium.

For the NPP Doel 3 and Doel 4, the results obtained are still in conformity with the values used in the design basis. As a consequence of their upcoming definitive shut down, Doel 1 and Doel 2 are not considered in this section.

For the Tihange NPP, the assessment resulted in an increase of the peak ground acceleration ("PGA") in comparison with the value considered when designing the facilities. The assessment is currently being completed and consolidated. Therefore no definitive conclusion on the adequacy of the DBE can be drawn. Nevertheless, the safety margin assessment performed during the stress tests has demonstrated that the equipment have much more robustness than required by the DBE.

Due to the stringent timeframe of the European stress tests, the PSHA study of the ROB had to be conducted in quite a short time. As suggested by the ROB, the Regulatory Body requested the licensee to carry out a more elaborated study with due consideration of (1) other elements such as the use of a more recent ground-motion prediction equation or such as a cumulative absolute velocity ("CAV") filtering, (2) external reviews by international experts and (3) results arising from other international studies. This revaluation of the seismic hazard is currently in progress and planned for early 2015.

The **safety margin assessment** for the Doel and Tihange units was performed on the basis of a review level earthquake ("RLE") being as high as 1.7 time the peak ground acceleration (PGA) of the current design basis earthquake. It showed that systems, structures and components ("SSC") required for achieving and maintaining safe shutdown state are robust enough, except for a few mechanical and electrical elements that have a low probability to resist a RLE. Further justifications or improvements through easy-to-implement modifications are currently in progress.

Several actions are ongoing to enhance the protection of the NPP's against seismic hazards:

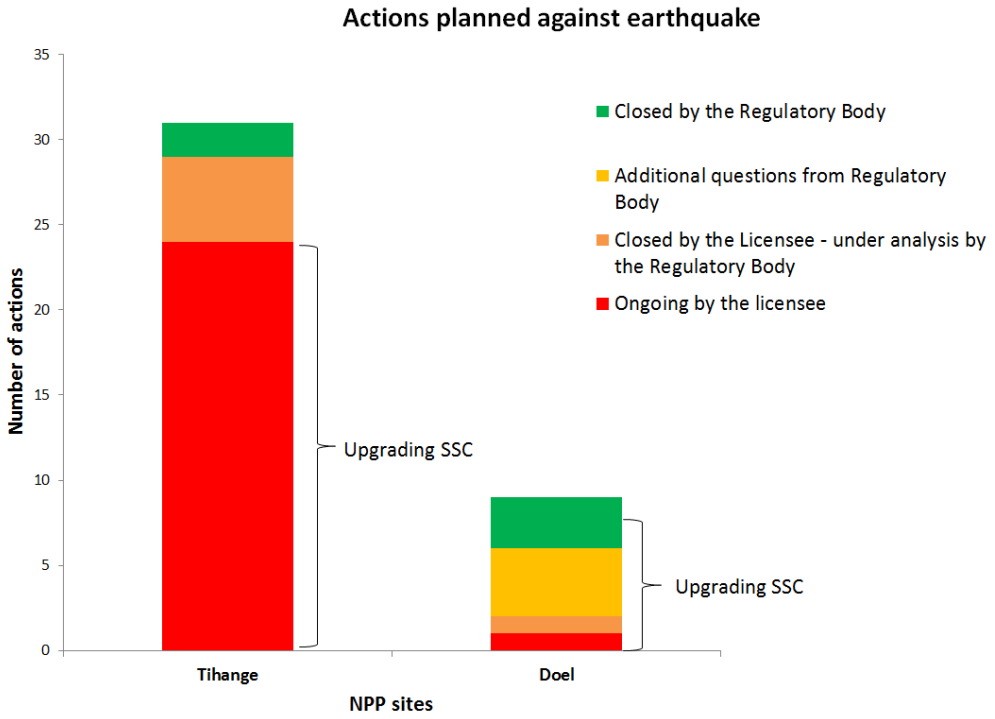
- The stress tests have highlighted that several **Structure, Systems and Components** (SSC) of Doel and Tihange have a low probability of resisting an earthquake exceeding the "Review Level Earthquake" (RLE). 22 SSC's have been identified at Tihange 1, 3 at Tihange 2, 1 at Doel 1/2, 1 at Doel 3 and 1 at Doel 4. Following the stress tests, the licensee has committed to raise these SSC's to a high probability to resist RLE by corrective actions or to confirm that sufficient margin exists by more precise calculations. Most modifications have been physically realized in 2013 by the licensee. The regulatory body has recently begun their review process of the action reports which are expected in early 2014.

  At Tihange 1, the licensee had classified the **Electrical Auxiliary Building** (BAE) as having a medium probability to resist a RLE. Although a medium probability is acceptable in the stress tests context, the licensee has committed to evaluate the feasibility to increase this classification to a high probability of resistance. The feasibility study on reinforcement of the BAE at Tihange 1 has shown that the actions necessary to raise this probability level to high are technically difficult or impossible. However some specific and feasible improvements remain considered.

- In Doel, the licensee planned to check the seismic qualification of the Refueling Water Storage Tank (RWST) of Doel 1/2 and their piping to establish whether they comply with the RLE level. However, the Belgian government decided in 2013 to definitively stop these two nuclear reactors in 2015. As a consequence, this action has been judged unreasonable and will not be implemented.

- Similarly, most actions to achieve at Doel 1 and Doel 2 in the framework of the stress test action plans to enhance the reactor protection were originally planned to be included in the Long Term Operation of these reactors. This is the case of the increase of the reliability of the water supply to the steam generators. Due to the governmental decision to stop these two reactors, these actions do not have to be undertaken by the licensee.

The following graph summarizes the ongoing action plan by the licensee at Doel and Tihange concerning the enhancement of the site protection against the seismic hazards. At Tihange, most actions concern the upgrading of the SSC's to a high probability to resist to a RLE and are close to finalization by the licensee. The remaining actions are almost finalized by the licensee and are under analysis by the regulatory body.



Flooding

Tihange

- During the previous Periodic Safety Review (PSR) in Tihange, a probabilistic methodology has been used to determine the flood level of the Meuse as a function of return frequency. One of the conclusions arose shortly before the Fukushima event, and is that the Tihange site is currently protected by its design against a Reference Flood with a statistical return frequency between 10E-2 and 10E-3 per annum. Nevertheless, so as to comply with the international standards, it was decided to use a more conservative flood corresponding to a 10,000-year flood as the new design basis for the Tihange site. Consequently, the Tihange site was not fully protected against this new Reference Flood. Several actions have therefore been proposed in the National Report in December 2011 to enhance the protection against flooding by additional provisions:

    i. A peripheral protection of the site,
    ii. Some local volumetric protections,
    iii. The mobilization of non-conventional means on site.

    However, a further analysis has shown that the implementation of the second level (local volumetric protections) would not provide an infallible protection and would decrease the reliability of the protection strategy against flooding due to complexity of the interactions with the other levels of protection. The licensee has proposed to abandon this second level.

Nowadays, the licensee has finalized the study phase of the **peripheral protection** of the site. A wall, together with isolation devices of water intakes and solutions for discharging cooling and sewer water to the Meuse river, is currently in construction to surround the lower areas of the site. A safety margin to the wall height in order to adequately cover uncertainties associated with the new design basis flood has been considered as requested by the regulatory body. The construction began in October 2013 and should be finalized in June 2015. The final reception of the peripheral protection is expected by the licensee in September 2015 (initially planned in the beginning of 2015).

The last additional provision is planned to protect the site either in case of a flood beyond-design, or in case where the peripheral protection would fail in protecting the site of Tihange against a flood below or equal to its design value. The deployment of **non-conventional means** will be done during the flooding alert period. These non-conventional means are situated at least 1 m above the level corresponding to the design flood and consist, among other things, of:

- Additional diesel generators in bunkered buildings,
- Fixed pipes (with a few exceptions of flexible elements),
- Pumps for make-up of water from water tables to the primary circuit, the steam generators and the spent fuel pools.

The licensee has reinforced the third level of protection, the non-conventional means (redundant pumps for instance), to compensate for the delay needed for building the peripheral protection of the site. All the corresponding actions have been finalized by the licensee in 2013 and the provisions are operational. The regulatory body is currently carrying out an assessment of the modifications.

- At Tihange, the robustness of the **emergency preparedness** strategy and organization has to be improved. The flooding alert system is based on a direct communication between the SETHY (the regional authority in charge of the protection against flooding) and the NPP. As a conclusion of the stress test analysis, the regulatory body has recommended to further improve the robustness and the efficiency of this communication. A convention has been signed in 2013 between the licensee and the SETHY to define a collaborative environment, including the access to more flow measurements and water levels over the Meuse and the increase of the available instrumentation during a flooding period. Moreover, means for on-site transport of personnel and equipment while the site is flooded (amphibious vehicles) are available since June 2012 at Tihange. In 2013 the licensee has finalized the implementation of the associated procedures and the organization of the training of the personnel.

- Finally at Tihange, the internal hazards potentially induced by the flooding have been examined as requested by the regulatory body. Potential internal fires and internal explosions have been considered. Protective actions are proposed and considered acceptable by the regulatory body.

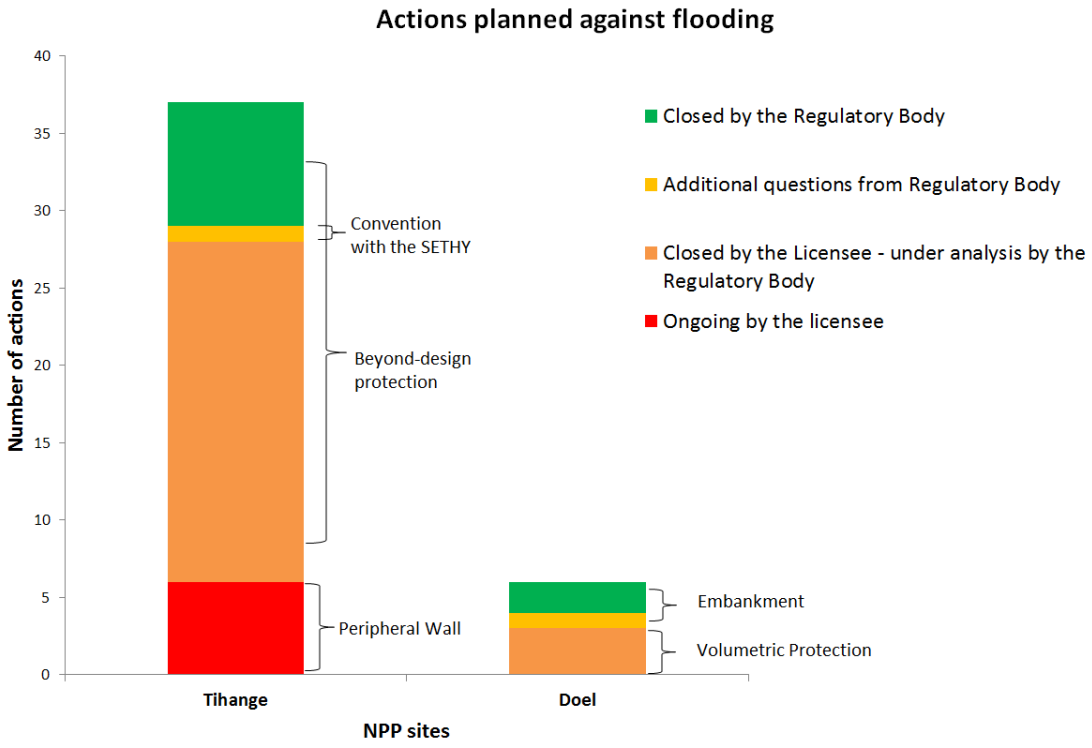
Doel

- The Doel site was already well protected against flooding; only in few circumstances water can intrude onto the site. As a preventive measure, sandbags are available to protect the critical entrances. In the framework of the Belgian stress tests, these sandbags were planned to be replaced by permanent volumetric protections. These barriers (cofferdams, …) against the flooding have been installed at Doel in 2013. The regulatory body is carrying out an assessment of these actions.

- In addition, to enhance the protection of the Doel site against flooding, some actions have been carried out on the embankment. To prevent any possible weakening, the licensee has reinforced the embankment with concrete tiles in 2013. Moreover the licensee has modified the internal procedures to perform embankment inspections more regularly. These actions are presently assessed by the regulatory body.

The following graph summarizes the ongoing action plan against the flooding hazard followed by the licensee at Doel and Tihange. These graphs have an indicative value as every action is considered to have similar relevance.

At Tihange, many actions are directly related to the construction of the peripheral wall (wall construction, PIU (Internal Emergency Plan) procedures, …). The rest mainly corresponds to the implementation of the non-conventional means for the beyond-design protection. At Doel, most actions are related to the volumetric protection and the embankment reinforcement.



Extreme weather conditions

In addition to the earthquake and flooding hazards, the resistance of the sites against extreme weather conditions has been evaluated in the framework of the stress tests. Additional hazards like tornadoes, heavy raining, lightning, snowfall, … have been considered. The stress tests have highlighted actions to undertake in order to enhance the site protections.

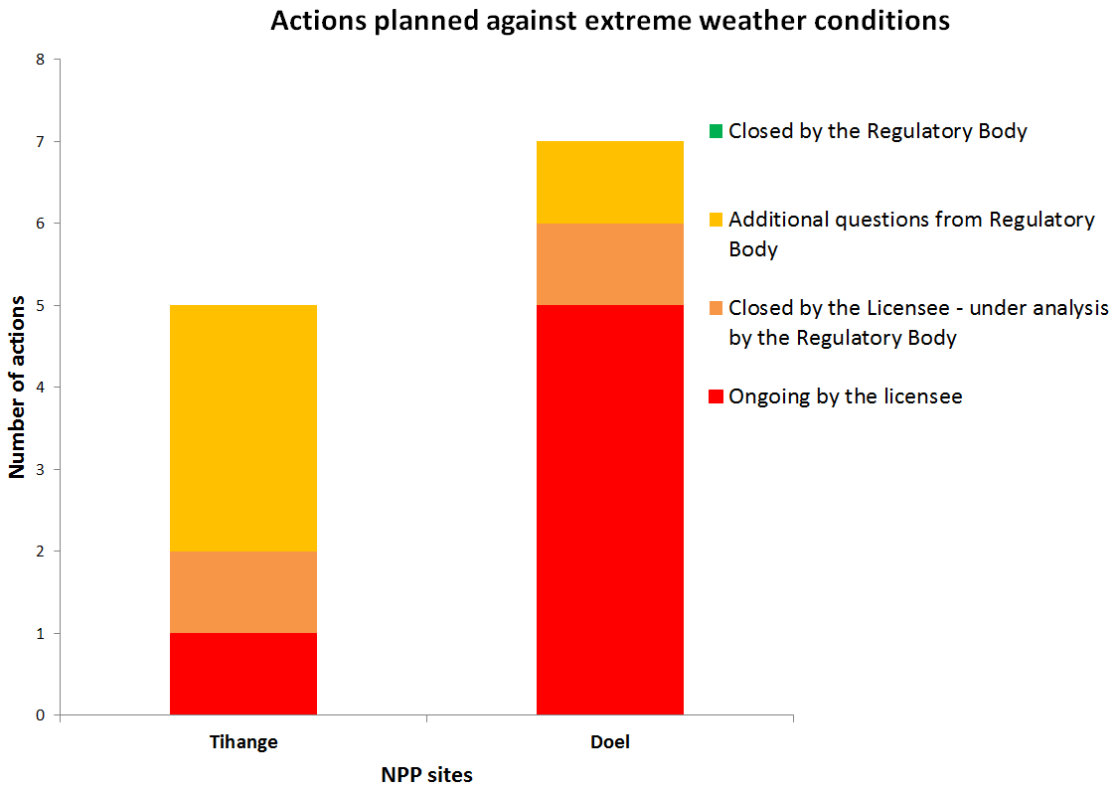
- The regulatory body has recommended the reassessment of the capacity of the **drainage systems** (five separate networks at Doel, separate networks per unit at Tihange), using a detailed hydrodynamic model in order to cover both short-duration heavy rains and long-lasting rains. This revaluation of the impact of heavy rains is still ongoing by the licensee. Potential improvements could be envisaged depending on the results of this action.

- The robustness of the second-level system of Tihange 1 and Doel 1/2 against a beyond-design **tornado** have to be confirmed by the licensee, given the fact that high intensity tornadoes have been observed in the past years in neighboring countries. This action is expected to be finalized in 2014.

- At Doel, the assessment of the protection against **lightning** is currently being carried out. Based on this analysis, an action plan will be determined to adapt the existing installation. This study is in progress and should be finalized by the end of 2015.

- Intervention procedures have been improved by the licensee in case of **heavy snowfall** to remove snow layers over 30 cm thick on “non-bunkered” buildings.

The following graph summarizes the ongoing action plan by the licensee at Doel and Tihange.



3.2 Enhancement of the power and the water supply

Tihange NPP

Considering the numerous and redundant power supply sources and heat sinks available, every reactor unit in Tihange has a high level of robustness in this respect. Indeed, every unit disposes of:

- three external power supply sources;
- two independent ultimate heat sinks (river water and alluvial groundwater), and additional access to limestone water that is independent of the alluvial groundwater;
- at least two levels of technically and geographically independent internal sources of power supply (in total, 16 diesel generators and a turbine-driven alternator), with a fuel autonomy of several weeks;
- a turbine-driven safety feedwater pump for each unit;
- and various cooling water capacities.

Furthermore, mobile devices (power generators, flexible hoses, pumps, valves, etc. - some of which are preinstalled) can also ensure power supply of the essential equipment and water supply of the steam generators and the primary system. Their capacity and deployment time have been designed according to the dynamics of the situations that were assessed.

Consequently, the cooling of reactor core and of the spent fuel pools are secured with a high degree of certainty even in very unlikely cases such as the loss of power supply sources or heat sinks. As a result, the risk of significant activity release should these extreme scenarios occur is negligible. In conclusion, the NPP has emergency equipment and sufficient autonomy to manage this kind of hazards for a long time. This time period is sufficient to restore off-site power supply or to bring in off-site resources.

Doel NPP

The Doel 1/2 units can make use of three independent heat sinks, which are all capable of independently keeping the units cooled:

- the Scheldt river;
- the atmospheric forced draught cooling towers;
- the heat exchangers cooled by the ambient air.

Likewise, the Doel 3 and Doel 4 units can make use of independent heat sinks which are all capable of independently keeping the units cooled:

- the atmospheric forced draught cooling towers, with supply from the Scheldt river and from cooling ponds;
- 3 cooling ponds of 30 000 m^3 each.

In every unit there are 2 internal electrical power supply levels. These 2 levels function independently from one another and are physically separated. For the power supply of the safety equipment, there are 19 diesel generators with – in total – a few weeks fuel supply. Moreover, most diesel generators are air-cooled, thus making them independent from an external heat sink.
Finally, every unit disposes of a pump, powered by a steam turbine, in order to be able to continue supplying cooling water to the steam generators. This cooling water is available in various tanks and in the cooling ponds.

On both sites
Nonetheless, some measures are considered to still enhance the robustness of the facilities. More than one hundred actions have been identified in the action plan for the enhancement of the power and the water supply in the Belgian NPP's. The licensee has currently finalized 40% of these actions. The following paragraphs summarize the progress of the major actions undertaken at Doel and Tihange:

Power Supply

- **Complete Station Black Out (CSBO)**
  CSBO consists in loss of off-site power supply and first-level and second-level internal power supplies. Compared to the design basis scenario of Station Black-out, this scenario adds the loss of the second-level internal power supplies. As this scenario is a beyond design basis scenario for all the Belgian units, the licensee has proposed a set of additional measures to avoid the cliff edge effects.
  The licensee commits to use non-conventional means:
    - to refill the steam generators and the spent-fuel pols,
    - to ensure make-up for the primary circuit in open configuration,
    - to avoid the overpressure in the reactor building,
    - to restore the electrical power supply to instrumentation and control panels, and
    - to make operable the emergency compressed air circuit.

  Therefore, in the action plan, an alternative power supply for non-conventional means or safety equipment has to be implemented on both sites.

  At **Tihange**, the finalization of the installation of this emergency electrical grid is planned for 2016. Several actions related to the CSBO project have been delayed in order to primarily focus the licensee attention on the flooding project at Tihange.
  At this moment, the strategy and the design for the alternative power supply are ongoing. Nevertheless, priority actions will be executed as soon as possible in function of plant outages.
  Among these priority actions, the feasibility study to provide a technical solution for water make-up to the primary system of Tihange 2 and Tihange 3 units in "CRP open" configuration has been finalized in 2013. The regulatory body is reviewing the conclusions of this action.
  Most actions related to the CSBO topic in Tihange has been delayed to 2016 for the same reasons such as the implementation of an alternative power supply (380V) for rectifiers or the assessment that all containment penetrations can be closed in due time and whether the relevant containment isolation systems remain functional.

  At **Doel**, the requested mobile means (pumps and diesels) will be available in the future years. Nevertheless, some other mobile equipments are temporarily available to assume the needed safety functions.

- A procedure to manage the autonomy of the electrical diesel generators has been finalized in 2013 by the licensee. This procedure indicates the equipment and facilities that can be stopped to reduce the diesel and oil consumption of the electrical diesel generators to increase their autonomy. Depending of the situation, 33 to 36 equipments can be stopped (mainly fans and pumps). The regulatory body is currently assessing these actions.

- At Doel, the licensee has provided a fuel tanker truck in 2013 for the on-site transport of diesel fuel as required in the stress test action plan. The regulatory body is currently analyzing the procedures concerning this new equipment.

- Some actions specific to Tihange 1 unit are included in the Long Term Operation (LTO) of this reactor (2015-2025). These actions are already ongoing and will be finalized within the further years. This is specifically the case of enhancing of the autonomy of the EAS auxiliary feedwater reservoir and for adding an auxiliary feedwater pump.

- At Tihange the licensee had to study the feasibility to ensure a better geographical separation of the high voltage lines to further improve the reliability of the external power supply to the NPP's, in collaboration with ELIA. This action has been realized in 2013 by the licensee. A request has been send to ELIA (the manager of the high voltage network) to add a new high voltage lines from the other side of the Meuse. This solution is not currently implementable according to ELIA.

  In addition, the licensee had to ensure in agreement with ELIA that in case of loss of off-site power, the NPP's have the highest priority for reconstruction of the external power supply to the NPP's. This agreement has been discussed in 2013 by the licensee and ELIA.

Water supply

- At Doel 3 and Doel 4, in the framework of the **CSBO**, the installation of nozzles on the intake and discharge of the spray pumps (SP), and of connections to the emergency cooling (LU) and to the emergency feedwater (EF) systems, was planned in the stress test action plan. These actions include the purchase of mobile pumps in order to achieve alternative water make-ups. Initially planned for the end of 2014, these actions have been delayed to the end of 2015 due to delays in the equipment delivery. This automatically delayed the actions for about one year since these actions concern the installation of connections that can be executed only during the plant outages.

Loss of primary and alternate ultimate heat sink (UHS)

"Loss of primary ultimate heat sink" has been studied in the original design basis of all the Belgian units when one unit is affected by this accident. "Loss of primary and alternate ultimate heat sink" is a beyond design basis accident. To avoid cliff edge effects, several measures have been proposed by the licensee. Some of them are similar to the CSBO measures like the use of non-conventional means to refill the steam generators and the spent fuel pools, to ensure make-up for the primary circuit in open configuration or to avoid the overpressure in the reactor building.

- In the framework of the UHS scenario, the regulatory body has requested for Tihange 2 and 3 to carry out alignment and operating tests of the emergency deep water intakes from the Meuse river and to justify the availability of the emergency intakes in accordance with the requirements of US NRC RG 1.27. The relative actions have been finalized in 2013 by the licensee and are currently under analysis by the regulatory body.

- In addition, the regulatory body has requested the licensee to justify that the water capacity of the second level of protection is sufficient when all the units of the site are affected by the loss of primary UHS. This action has been finalized by the licensee in 2013 for both sites and is currently under analysis by the regulatory body.

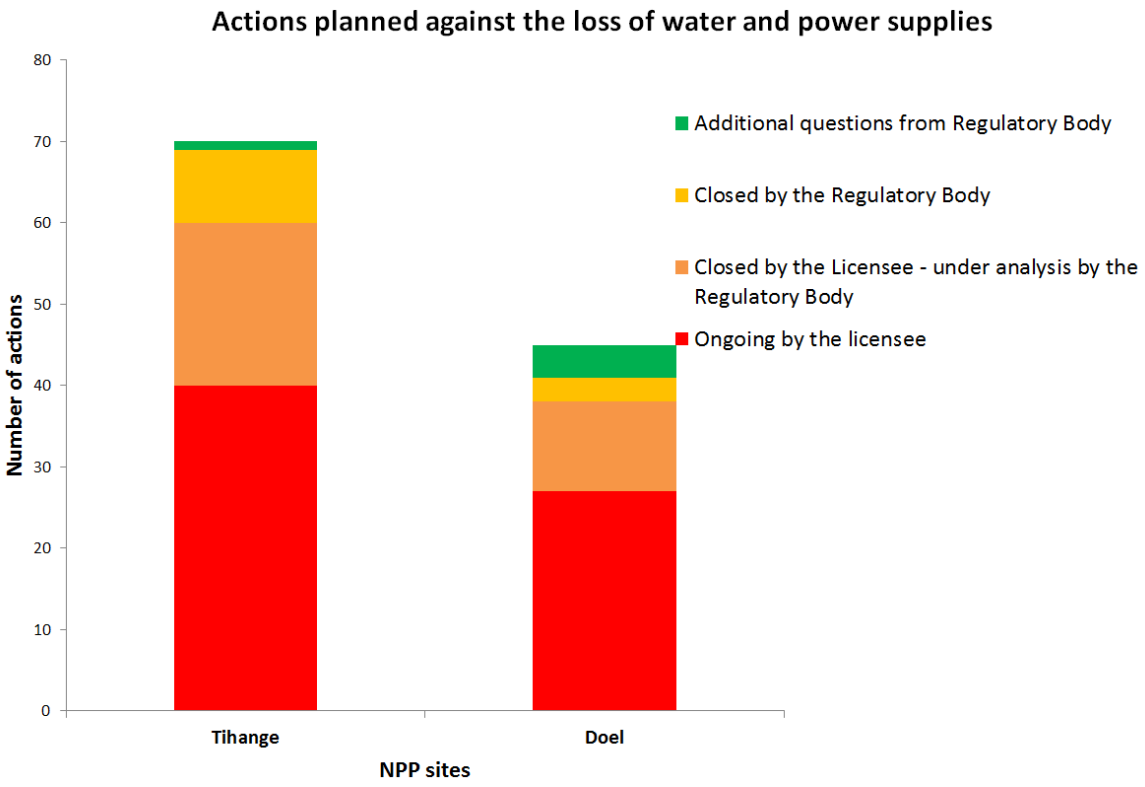
Spent Fuel Pools

- At Doel, the study of alternative water supply for the spent fuel pools (PL) using supplementary nozzles has been achieved by the licensee in 2013. The regulatory body is currently reviewing the action report.

- For the spent fuel pools of Tihange, additional level measurements have been implemented in 2013 by the licensee.

Moreover, the regulatory body has requested the evaluation of two configurations for the spent fuel pools: the configuration with a fuel assembly handled in the reactor pool during a CSBO and the configuration with the loss of water inventory in the spent fuel pools. The first evaluation will be finalized in 2015 while the second one has been finalized in early 2014.

The following figure summarizes the action planned in Doel and Tihange to protect the nuclear power plants in case of loss of power supply and loss of water supply. The inclusion of beyond-design scenario for UHS and CSBO involves a lot of actions in the BEST action plan, as this topic includes one third of the total number of actions.


Actions planned against the loss of water and power supplies
80
70
60
50
40
30
20
10
0
Number of actions
Tihange
Doel
NPP sites
Additional questions from Regulatory Body
Closed by the Regulatory Body
Closed by the Licensee - under analysis by the Regulatory Body
Ongoing by the licensee

3.3 Severe Accident Management

Enhancement of the operation management

As a result of the Fukushima accident, the licensee reassessed its organization so that it could face situations that are far beyond the design basis, which could affect simultaneously several units and could lead to the unavailability of some parts of the emergency management infrastructure or affect the access conditions and the environment.

The Belgian stress tests have highlighted that the operation management could be improved on the nuclear sites. In this respect, several actions have been decided to enhance procedures.

- At Tihange and Doel, the "earthquake procedures" have been modified in 2013 by the licensee to speed up the detection and mitigation of induced flooding on the site.

- The actions resulting from the periodic safety review concerning the flooding hazards at Tihange are described in section 3.1. The licensee is increasing the implementation of the related procedures. The procedures for the beyond-design protection are operational. The procedures related to the peripheral wall will be finalized after the construction of the wall is completed by the end of 2015.

- On both sites, the licensee will introduce procedures describing the actions to take in case of a total loss of heat sinks and in case of a total loss of internal or external power supplies. As these actions are directly linked to the CSBO project, described in section 3.2, their finalization is not planned before 2016.

- The introduction and the completion of the procedures for the connections and the commissioning of alternative power and water supplies have also been delayed pending finalization of the CSBO project.

Enhancement of the emergency management (PIU)

So far, the licensee's organization in emergency situations has been designed to overcome events affecting a single unit of the NPP and to manage design basis external events. This organization is periodically tested and improved through exercises.

As a result of the Belgian stress tests, the licensee reassessed this organization in order to be able to face far beyond design situations that could affect simultaneously several units.

In this respect, several actions have been decided in the framework of the stress tests:

- At Tihange, the site operation center "COS" was planned to move to an underground room in the new entrance building. However, this building has appeared to not be conveniently located to resist to a beyond-design flood and to not be ideally protected against earthquakes. Consequently, the COS will be moved in term to a new building to be constructed and put into service in 2017. Considering the given commissioning

schedule of the new COS, several actions have been undertaken in the present COS and other emergency rooms to improve their capacities (additional communication means, additional radioprotection equipment, an additional power generator - available in 2014, …).
The licensee has defined the specifications of the new COS. Those specifications are presently under assessment by the regulatory body.

- A study on modifying and strengthening the emergency management organization has been launched to include "multi-unit" events at Doel and Tihange. The licensee has finalized the implementation of the new organization of the emergency plan and of the adapted logistics in 2013. The description of the new organization of the emergency plan has already been analyzed and questioned by the regulatory body. Its implementation is still in an analysis process by the regulatory body.

- Several additional actions have been or are carried out by the licensee in order to enhance the emergency management. These actions include the harmonization of site training programs, the construction of on-site resistant storage for mobile means, the setting-up of fallback bases, the improvement and diversification of communication means, additional means for managing work on a contaminated site, and so on. Some of these additional actions were finalized in 2013 by the licensee.

Enhancement of the protection against severe accidents (SAM)

The scenarios involving severe accidents have been reassessed from a "defence-in-depth" perspective during the Belgian stress tests. Some actions that could further reduce the risk of potential releases into the environment resulting from an extreme situation were identified in the action plan.

The following actions have been continued in 2013:

- The feasibility study for installing a filtered vent system on the containments of each unit was started in 2012 and is now finalized. The related assessment activity by the regulatory body is ongoing. Filtered vent systems will be installed on every NPP's, except Doel 1 and Doel 2 (they will be closed before an eventual installation). The licensee has chosen a 'scrubber' design that does not require important work in the reactor building. The licensee is currently studying the various responses to its request for proposals. The licensee plans a final design for 2014-2015 and a progressive installation from end of 2016 depending on the NPP outages, up to end of 2017 for the latest unit.

- The assessment of the residual risk of hydrogen production and accumulation in spent fuel buildings have been carried out in 2013. The study, presently under assessment by the regulatory body, shows that there is no explosion risk due to the accumulation of hydrogen in the SFP buildings of the NPP's.

- The follow-up of R&D activities related to the corium-concrete interaction issue is planned to be continuously carried out.

- A study aims at optimizing mobile means and their storing infrastructure, taking into account the analysis of the Extensive Damage Mitigating Guidelines (EMDG). This study was finalized in early 2014 and is presently assessed by the regulatory body.

- The feasibility study for the implementation of additional water injection in the reactor pit will be finalized in 2014.

3.4 Water and waste treatment building - Doel (WAB)

In the National Report on the Belgian Stress Tests, the WAB at Doel was classified in the non-NPP facilities. However, as the WAB building will be affected by the events occurring in the Doel NPP and as the licensee Electrabel has included the WAB in its global action plan, the action plan for the WAB is included in this report.

Several actions were proposed by the licensee or requested by the regulatory body in order to enhance the protection of the WAB building. Finally, 15 actions have been listed by the licensee to be undertaken in the WAB. Most of them are already implemented by the licensee and under analysis by the regulatory body. The actions in the WAB should be completely completed in 2014.

- Concerning **Earthquake**, the licensee proposed to develop procedures in order to detect possible leaks in the WAB after earthquakes and to isolate them.

  The regulatory body requested moreover to upgrade the four SSC graded at a low probability to resist a RLE to a high probability. These two actions have been finalized by the licensee.
- No actions had to be undertaken concerning the **flooding** hazards. However, the licensee had to enhance the protection against **heavy rains** for the WAB building. Indeed, the regulatory body has requested to limit the accumulation of water on the WAB roofs either by periodic inspections or periodic maintenance of the necessary overflows. The licensee has also to evaluate the impact of rainfall of 10E-3 return frequency on the sewer system network. These two actions are planned by the licensee in 2014.

  Finally, the regulatory body has requested to evaluate the possibility of entry of water in the WAB building and to define its potential impact on the safety functions. This action has been finalized by the licensee in 2013.

Enhancement of power and water supply

The regulatory body has formulated several requests to enhance the protection of the WAB building against the loss of power and water supply.

- In the framework of the CSBO and the UHS, several actions have been requested by the regulatory body. These actions are still ongoing in 2014.

Enhancement of emergency management

- The licensee had to conduct a limited study in order to define the necessary arrangements to pump to an intermediate storage place the water contents of the basement after extreme accidents. This action has been finalized in 2013 by the licensee.
- The regulatory body requested to make available in the WAB and on the PC network on a permanent basis an inventory of the radioactive waste in various locations in the WAB. The licensee has presented its conclusions concerning this action in 2013.

4 Conclusions

This report presents the progress at the end of 2013 of the action plan defined by Electrabel following the stress tests on the Belgian nuclear power plants. Based on the progress of the action plan, the regulatory body considers as satisfactory the current progress of the licensee. Most actions follow the scheduled planning of the original action plan while delays have been duly justified by Electrabel.

The regulatory body will continue to carefully follow the progress of the stress test actions implemented by the licensee in the future years. The general organization between the licensee and the regulatory body appears to be successful and will be continued until the finalization of the stress test action plan.

The follow-up of this report, describing the situation of the action plan in the end of 2014, will be presented by AFCN in the beginning of 2015.