NUCLEAR REGULATORY AGENCY

European "Stress tests"
Kozloduy NPP

Updated National Action Plan of Bulgaria

Contents

Structure of the Updated NAcP

- **Introduction**
- **Part I – Actions at NPP Site level (Topics 1-3)**

External Initiating Events; Loss of Safety Systems; Severe Accident Management

- **Part II – Actions at Institutional level (Topics 4-6)**

National Organizations; Emergency Preparedness and Response; International Cooperation

- **Part III – Additional measures and actions**

ENSREG Peer Review Report for Bulgaria, WANO Program

- **Part IV – Update of the National Action Plan (2014)**

Attachments 1 to 4

1. Responses/clarifications on issues identified in the rapporteur's report from the 2013 workshop

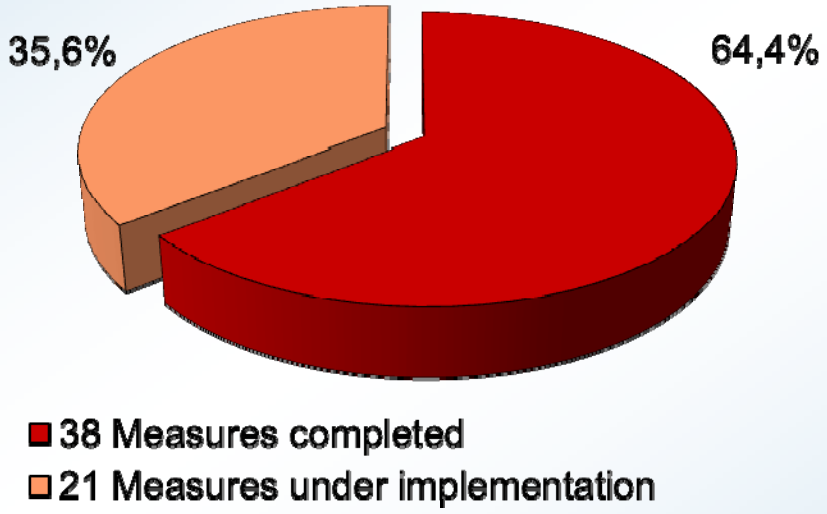
- ***Some of the measures and activities identified in the NAcP are quite comprehensive***
- ***Internal deadlines are not identified in the NAcP***
- ***Retention of WWER-1000 melted core is analysed within the international cooperation framework and the issue can be resolved upon the completion of those analyses***

2. Progress on implementation of the NAcP

Implementation status of the Updated NAcP measures

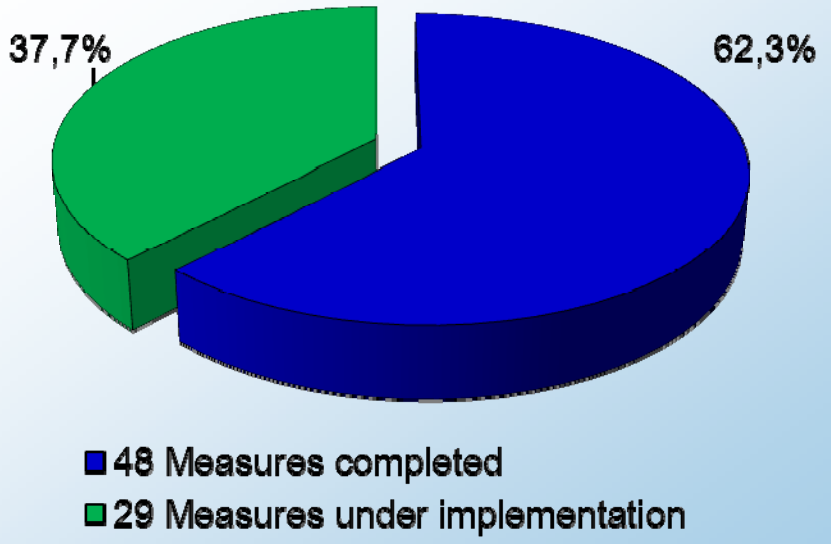
NPP Site level

Total of 59 Measures



The whole NAcP

Total of 77 Measures



2. Progress on implementation of the NAcP

- **Implementation schedules of seven Site level measures have been changed**

  The reasons for change in the implementation schedules of respective measures and/or proposal of new measures are as follows:

- Extension of the scope
- Planning of new measures as a result of completed analyses and studies
- Breaking up the complex measures into several separate activities with their own implementation deadlines
- Administrative issues arising from procurement procedures

3. Main changes and technical basis

- **NAcP first revision in January 2014**
  - Progress report (sent to ENSREG)
  - 10 additional measures defined in a new Attachment IV resulting from:
    - studies and analysis;
    - extension of scope;
    - breaking up the complex measures
- **NAcP second revision in December 2014 – Updated National Action Plan (UNAcP)**
  - Status update
  - 4 new measures added to Attachment IV as outcomes of studies and analysis
  - Deadline changes due to incorrect planning and procurement procedures

3. Main changes and technical basis

➢ Extension of scope

The concept for **alternative power supply** initially covered:

- Procurement of two MDGs 0.4kV for each of units 5&6 (A-1-1) in addition to the available one MDG 6kV
- Provisions for recharging of one battery per unit (C-1-1)

Consequently **the concept was expanded** to include additional provisions for diversification and interchangeability of 6kV and 0.4kV MDGs (possibility to use each one of MDGs)

3. Main changes and technical basis

➢ Extension of scope (cont.)

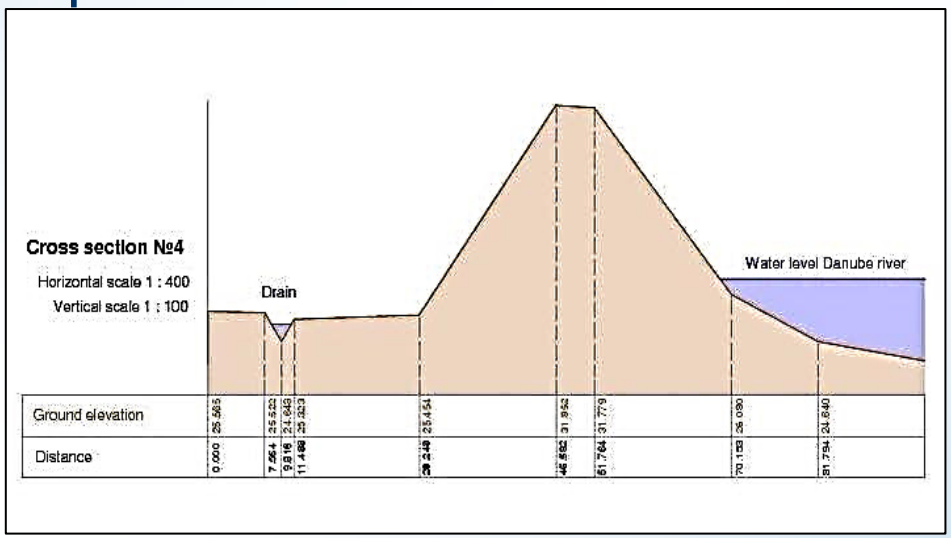
In this respect the following new measures for **alternative power supply** were added:

- FA-1-1-1: ***Provisions for powering the reliable supply cabinets by MDG 0,4 kV and MDG 6 kV and expanding the consumers, including the cabinets at the Auxiliary Building*** – deadline: November 2016;
- FA-1-1-2: ***Provisions for recharging one battery per unit by MDG 0.4kV (in addition to MDG 6kV)*** – deadline: November 2016;
- FA-1-1-3: ***Seismic upgrade of the overhead corridors connecting Auxiliary Building to Units 5&6 reactor buildings*** – deadline: November 2016;
- FA-1-1-4: ***Construction of buildings for sheltering of the MDGs*** – deadline: October 2015

3. Main changes and technical basis

➢ Extension of scope (cont.)

B-3-1: ***Improvement of the protective functions of the dike in the region of the Kozloduy valley*** – deadline for implementation was extended from 2012 to December 2014 as the dike area for review and improvement was expanded



3. Main changes and technical basis

➢ Changes in the schedule

- B-2-3: ***Modernisation of the sewage network and drain pump system*** **-** scheduled for October 2013. Due to problems connected with the equipment supply and revision of the technical specification the deadline was extended to November 2015
- D-1-2: ***Construction of KNPP off-site Emergency Response Centre (ERC)*** **-** initial deadline: December 2016. The ERC is of bunker type, with specific complex underground part, situated in the town of Kozloduy; the project requires coordination with a large number of external organizations and solving legal and administrative issues, related to the transfer of land ownership; the completion deadline was extended to December 2017

3. Main changes and technical basis

➢ Changes in the schedule (cont.)

- D-2-6: ***Extension of the scope of SAMGs for the spent fuel pools and specific reactor shutdown states, not covered by the current SAMGs*** - initially scheduled for December 2014. Currently verification and validation undergoing; the deadline is extended to July 2015
- D-3-2: ***Installation of measuring channels to monitor and evaluate the concentration of steam and oxygen in the containment*** - initially scheduled for June 2014, the time period is insufficient for development of a conceptual design, detailed design, equipment manufacturing and installation during outages; deadline extended to December 2016

3. Main changes and technical basis

➢ Changes in the schedule (cont.)

- FD-2-4-1: ***Installation of additional pipeline to the spent fuel pool cooling system for back up from an external source*** - initially scheduled for November 2014; due to delay in the equipment supply, the deadline was extended to November 2015

3. Main changes and technical basis

➢ Breaking up the complex measures

- D-1-1: ***Review of KNPP on-site and off-site emergency plans to consider the possible effects on physical isolation due to external hazards*** - The KNPP On-site Emergency Plan was reviewed taking into account the external hazards and possible effects on physical isolation, as well as the interfaces with other actions. No further changes in the on-site plan were considered necessary as a result of a full-scale national exercise conducted in November 2014.

  The review of the Off-site Emergency Plan is being implemented under Measure EP-1-1 *(Topic 4 - National organizations)*, deadline: until the end of 2015

3. Main changes and technical basis

➢ Breaking up the complex measures (Cont.)

- D-2-4: ***Develop technical means to provide direct injection of water to the reactor core, SGs, spent fuel pool and the containment by mobile fire protection equipment in extreme conditions***. In January 2014, the measure was split into three separate measures:

  FD-2-4-1: *Additional backup pipeline to the SFP cooling system*, deadline: November 2015;

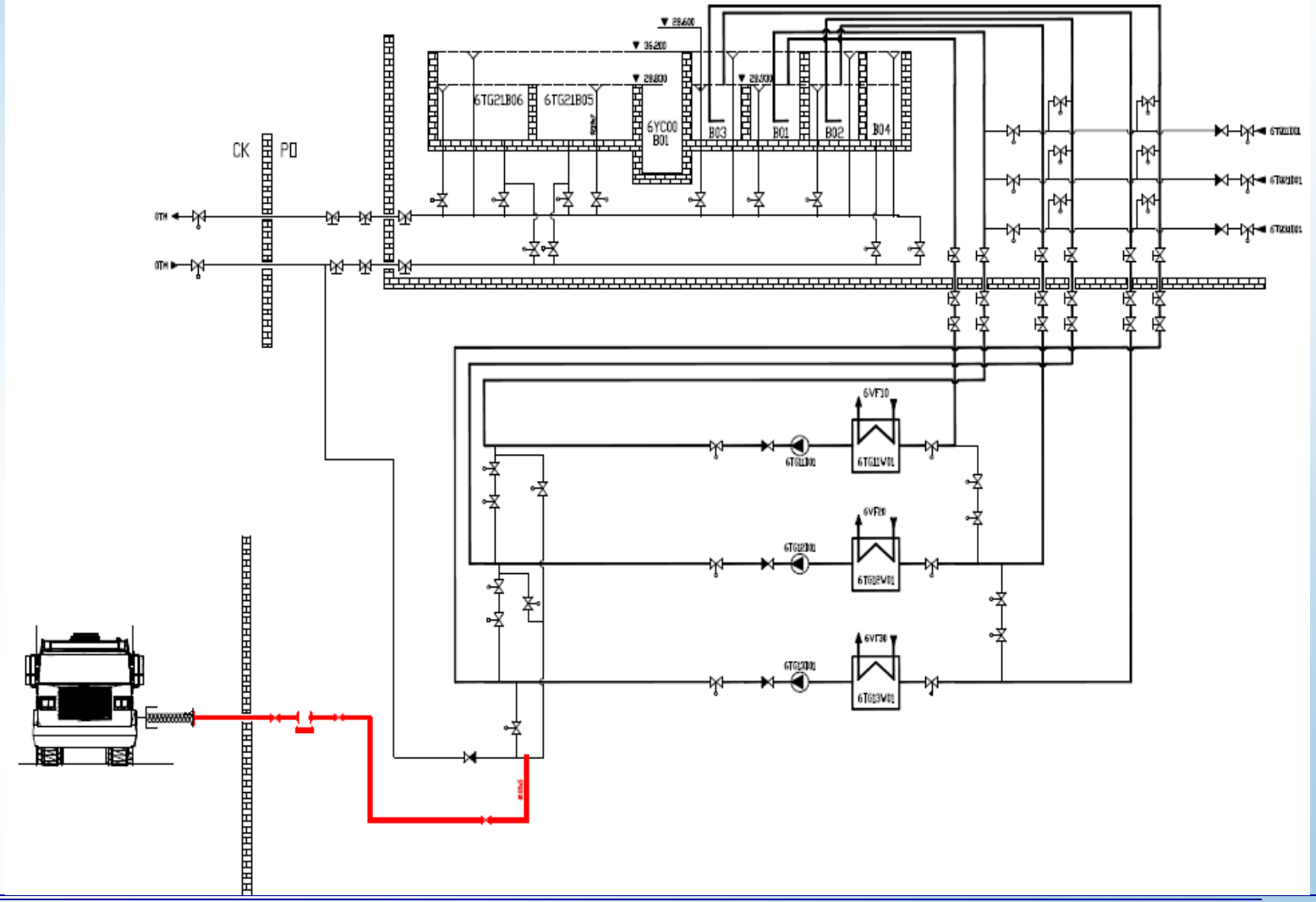
  FD-2-4-2: *Direct water injection to the reactor core*, deadline: December 2016;

  FD-2-4-3: *Direct water supply to SGs,* deadline: June 2015
- *Part of measure D-2-4* associated with the containment studies, was moved to *D-3-5: Study the possibilities for molten core retention in case of severe accidents*, deadline: December 2017

3. Main changes and technical basis

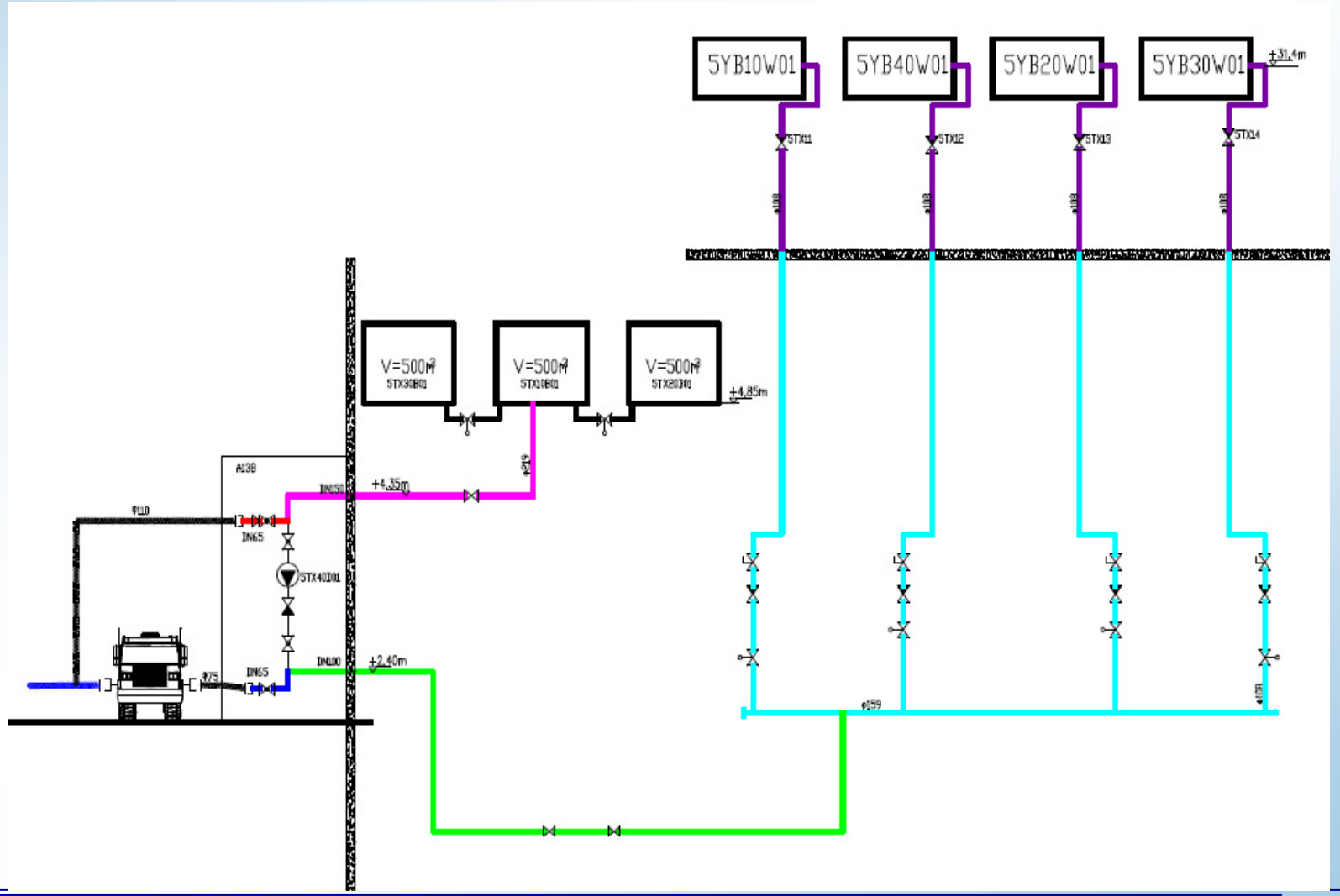
FD-2-4-1:

New water injection line to Spent Fuel Pool using mobile equipment



3. Main changes and technical basis

FD-2-4-3: Direct water injection to SGs from external source



3. Main changes and technical basis

➢ New measures

As a result of the completed studies and analyses since the 2013 Workshop, 14 new measures have been identified and added to the NAcP, arranged in the following groups:

- ***Group FA*** – Additional alternatives for residual heat removal;
- ***Group FB*** – Prevention of flooding and mitigation of the consequences;
- ***Group FC*** – Alternative provisions for ultimate heat sink;
- ***Group FD*** – Capabilities for severe accident management

All 14 new measures are contained in Attachment IV

4. Relevant outcomes of studies and analyses

- C-2-3: ***Feasibility study of the power supply of hydro-accumulator valves to provide make-up in cold shutdown conditions and failure of the emergency DGs***

- The outcome of the study demonstrates the need for supplying power to the hydro-accumulator connecting valves from the batteries
- The reliability analysis of electrical boards confirms the availability and reliability of the consumers
- The design solution enables the operators to control the hydro-accumulator valves in case of emergency conditions with loss of all AC power sources.

4. Relevant outcomes of studies and analyses

- D-2-8: ***Analysis of the impact of severe accident conditions on the habitability of the MCR and ECR***
- Severe accident phenomena are analyzed and the radiological consequences for the premises of the Containment and the Reactor building are assessed
- The airborne distribution pathways are identified and the radiation levels in the MCRs, ECRs and other premises in the Reactor buildings of units 5 and 6 are assessed
- The results of the study show that in a certain moment the criterion for the MCR habitability will be reached and the operators will have to move to the ECR
- As a result of the study, 4 new measures FD-2-8-n are planned to prevent airborne distribution to the MCR/ECR

4. Relevant outcomes of studies and analyses

- A-3-1: ***Assessment of possible damage on the regional road infrastructure around the plant following extreme weather conditions***

- Road conditions assessment and identification of access routes for mobile equipment, supplies and personnel are performed
- As a result, the main road to the plant and the on-site roads have been repaired
- An alternative access road was selected which will be used in case of damage on the regional road infrastructure around the plant

5. Good practices and challenges

➢ Good practices

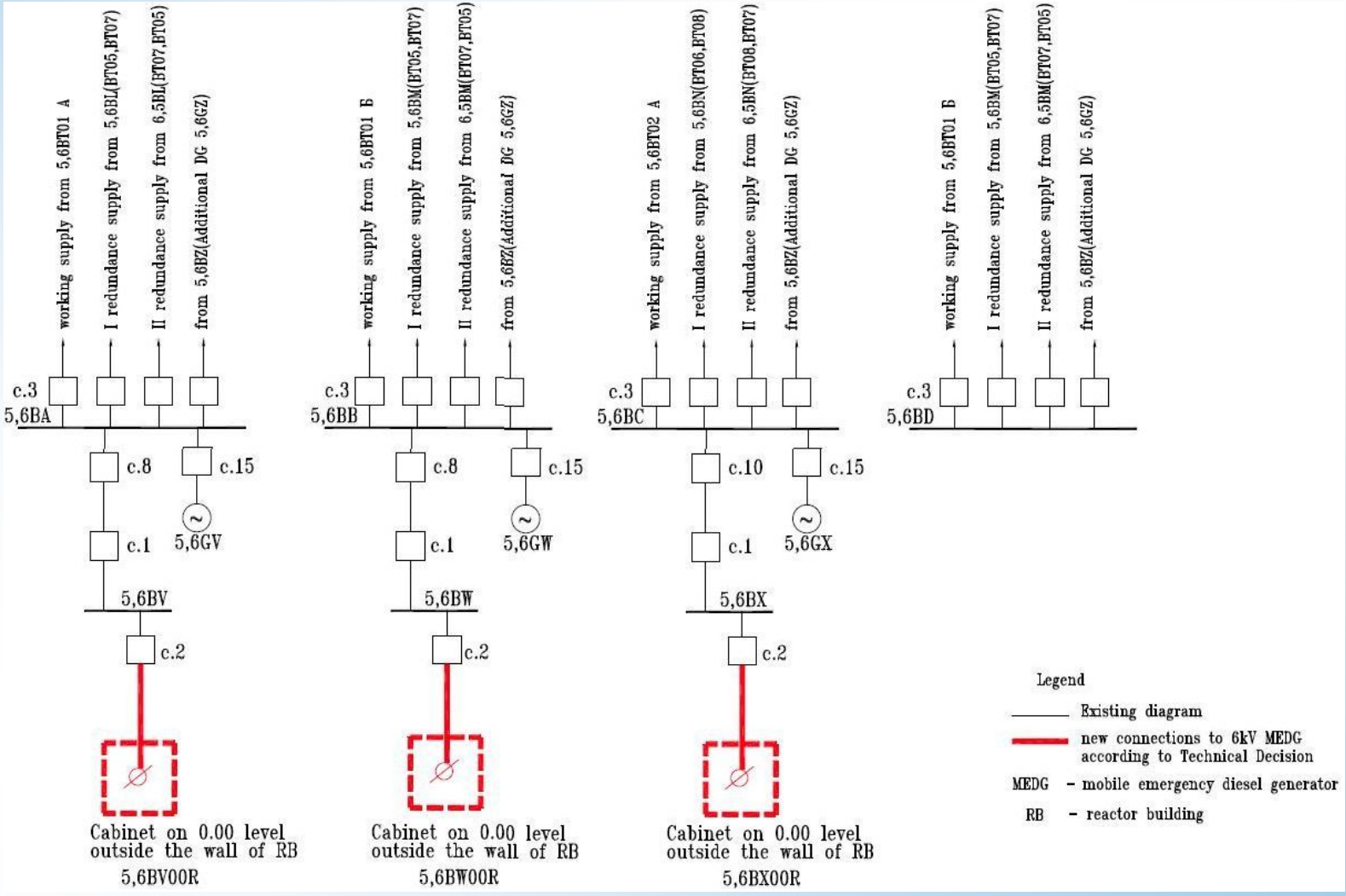
1. Increasing the reliability and efficiency of the alternative power supply (A-1-1): To provide more effective and diverse use of the three MDGs, available on site (one MDG 6 kV and two new MDGs 0.4 kV) in case of SBO, the concept for alternative power supply was expanded. Four new measures in the field FA are planned, which will provide:

- direct connections to the 6 kV reliable power supply cabinets of units 5& 6 safety systems and the Auxiliary Building;
- construction of a new reliable power supply cabinet 0.4 kV in order to increase the capacity of the existing one under accident conditions;
- recharging one battery by MDG 0.4 kV in addition to the recharging provided by MDG 6kV;
- ensuring alternative access routes to the connection points and construction of bunker type shelters for MDGs

5. Good practices and challenges

Example

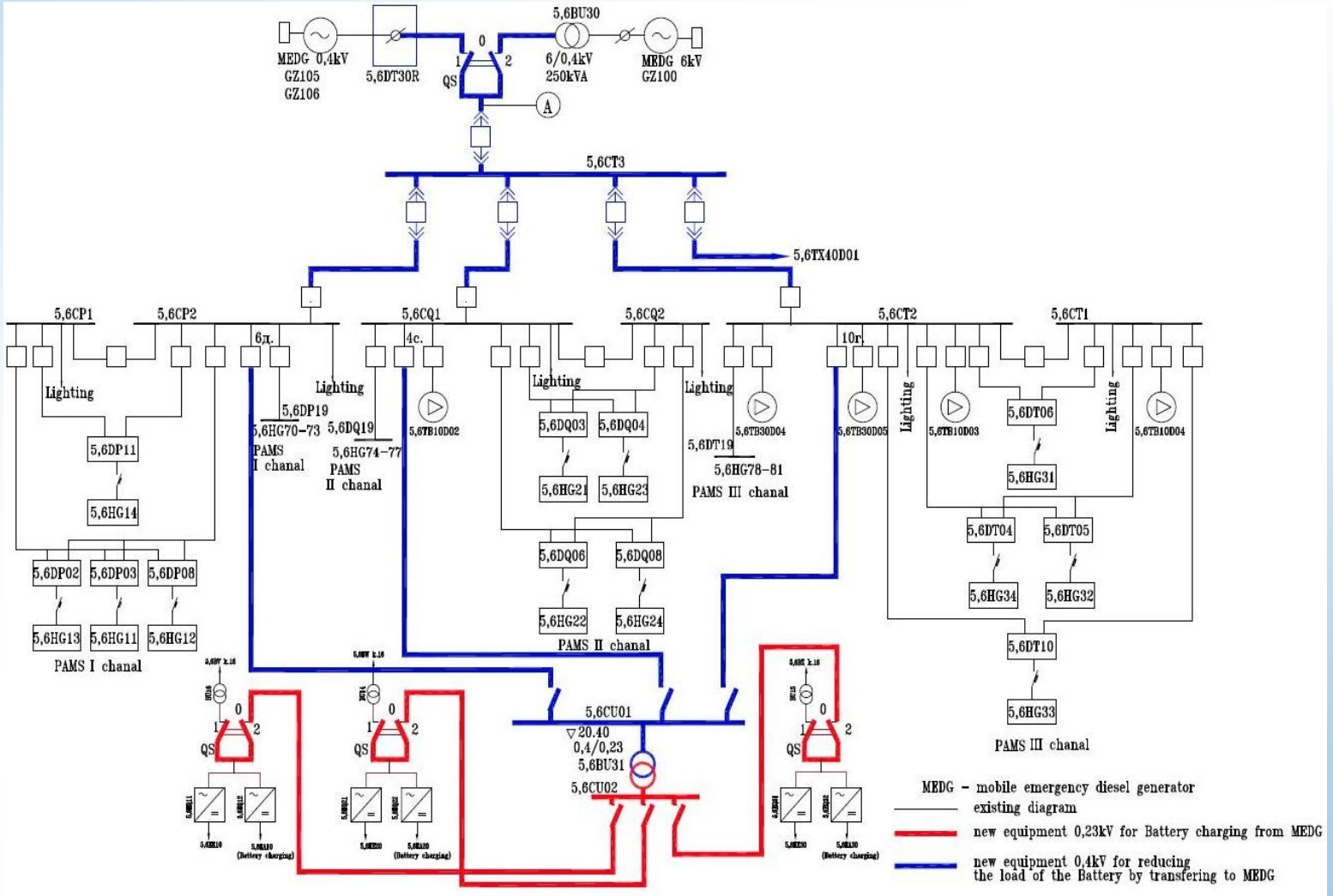
FA-1-1-1
Powering the reliable supply cabinets of safety systems by MDG 6kV during SBO



5. Good practices and challenges

Example

FA-1-1-2
Recharging one battery by MDG 0.4 kV in addition to the provided by MDG 6kV



5. Good practices and challenges

➢ Good practices (cont.)

2. Severe accident management provisions:

- **Before Fukushima accident:** Installation of Containment Venting System (scrubber type); Installation of hydrogen recombiners; Development of PSA- level 2 and SAMGs; Alternative SG FW supply powered by MDG; RCP sealing for 24 h
- **Following the stress tests:** Plugging of the ionization chamber channels in the walls of reactor vessel cavity to prevent basemat melt-through and early containment by-pass; Installation of wide-range temperature sensors to monitor the reactor vessel temperature; Installation of additional PARs; Extension of the scope of the EOPs to cover reactor shutdown states and SFP accidents; Development of SAMGs for Technical Support Team and for MCR/ECR personnel; Installation of instrumentation channels to monitor and evaluate the concentration of steam and oxygen in the containment

5. Good practices and challenges

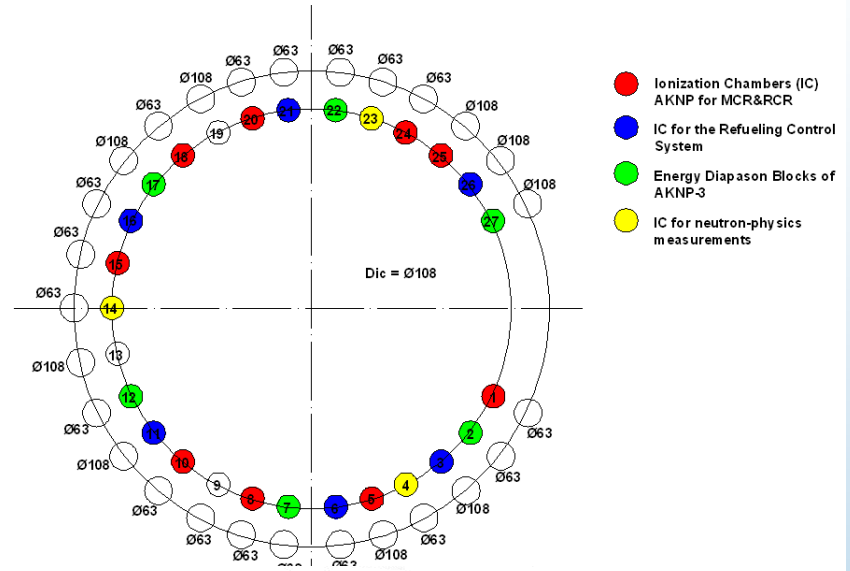
Example: Plugging the ionization chamber (IC) channels

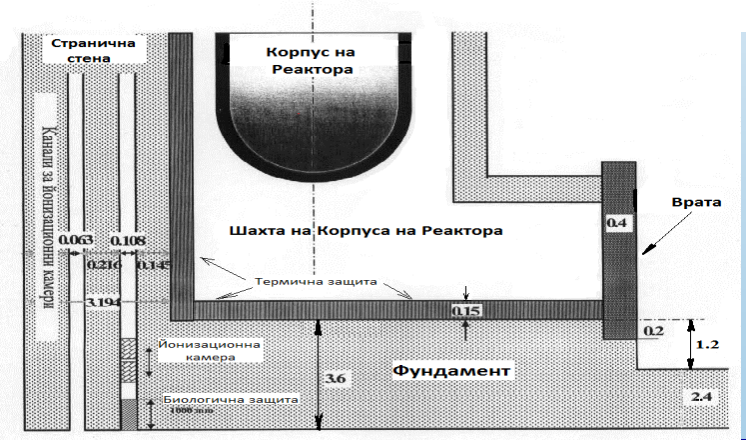
Problem identification:

At the beginning of an ex-vessel phase of a severe accident, a vulnerability of the design was identified leading to early (up to one hour) basemat melt-through via ionization chambers channels situated around the reactor pit, and after penetration of melt into the premise below the containment – bypass of the containment

Solution of the problem:

To plug the bottom of IC channels by high-temperature-resistant plugging devices for prevention of early containment melt-through during severe accident



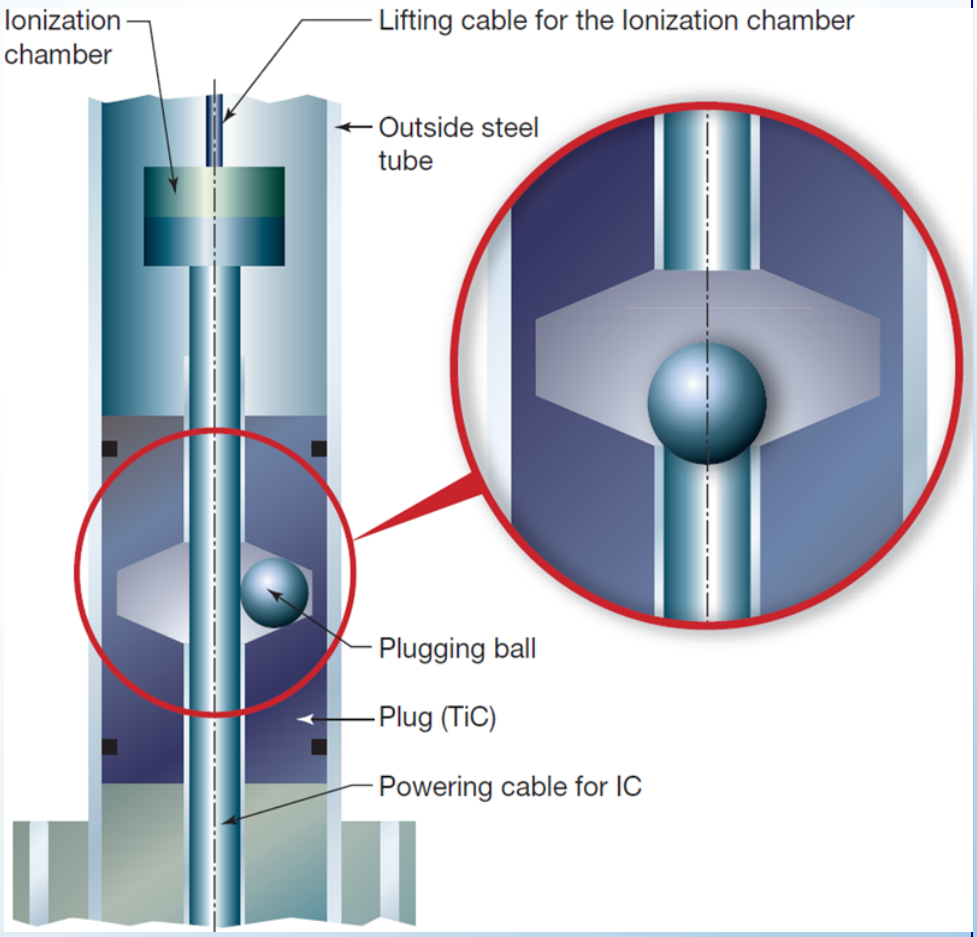


5. Good practices and challenges

***Example*: Plugging the ionization chamber (IC) channels**

Plugging devices for IC channels

- ***Illustration of more important parts:***
  - Lifting cable for the IC, – present
  - Ionization Chamber (IC), – present
  - Powering cable for IC, – present
  - Hard melting ceramic saddle/plug made of Titanium Carbide (TiC);T_M=3170^{o}C, - installed
  - Plugging ball, hard melting sphere made of Tungsten Carbide, T_M=2870^{o}C, - installed
- ***Principle of operation:***
  - melt ablates the concrete wall and falls down into the IC channels
  - the melt temperature is high enough to burn up the cable and release the ball
  - ball falls over the central orifice (designed for the power cable of IC) and plugs it



5. Good practices and challenges

➢ Good practices (cont.)

3. Bunkered Facilities

- **Second off-site Emergency Response Centre of bunker type** will be constructed in the town of Kozloduy and will be connected with the on-site emergency centre using reliable communication channels. The building will be fully protected from extreme weather conditions. The Centre will receive information about the plant status and the radiological conditions on the NPP site and around it. The off-site centre could accommodate the standby Technical Support Team and standby Emergency Response Teams
- **Three bunker type buildings to shelter each MDG** will be constructed on Kozloduy NPP site. The buildings are designed to withstand an earthquake 50% stronger than the Design Basis Earthquake, as well as the impact of extreme weather conditions - wind, snow, temperatures, floods, tornado, etc.

5. Good practices and challenges

➢ Challenges

1. **Selection of core retention strategy:** Implementation of this measure implies performing of wide scope analytical and research activities, specific to the reactor design, and exchange of knowledge among the interested countries. Kozloduy NPP initiated and conducted 3 national and international workshops to discuss the various options and existing practices in the WWER operating countries. It was concluded that the selection of a core retention strategy (in-vessel or ex-vessel) could be performed within the framework of the international cooperation projects, with the joint efforts of the WWER-1000 operating countries and the involvement of the reactor Chief Designer. Some measures associated with the implementation of ex-vessel core retention concept are implemented in parallel.

5. Good practices and challenges

➢ Challenges (Cont.)

2. Management of large quantities liquid RAW: This measure envisages study of conceptual solutions for potential treatment of large quantities contaminated water in various scenarios of severe accidents recovery activities. The study is in close interface with other technical solutions – direct water supply from external source to the containment (Measure D-3-5, December 2017), direct water supply from external source to the reactor core (Measure FD-2-4-2, December 2016), and accordingly estimating the boron and/or water solutions generated for a specified time period, assessment of the available volumes in tanks, analysis for transferring liquids, availability of water treatment facilities, assessment of the adequacy of existing measures for prevention of releases to the environment.

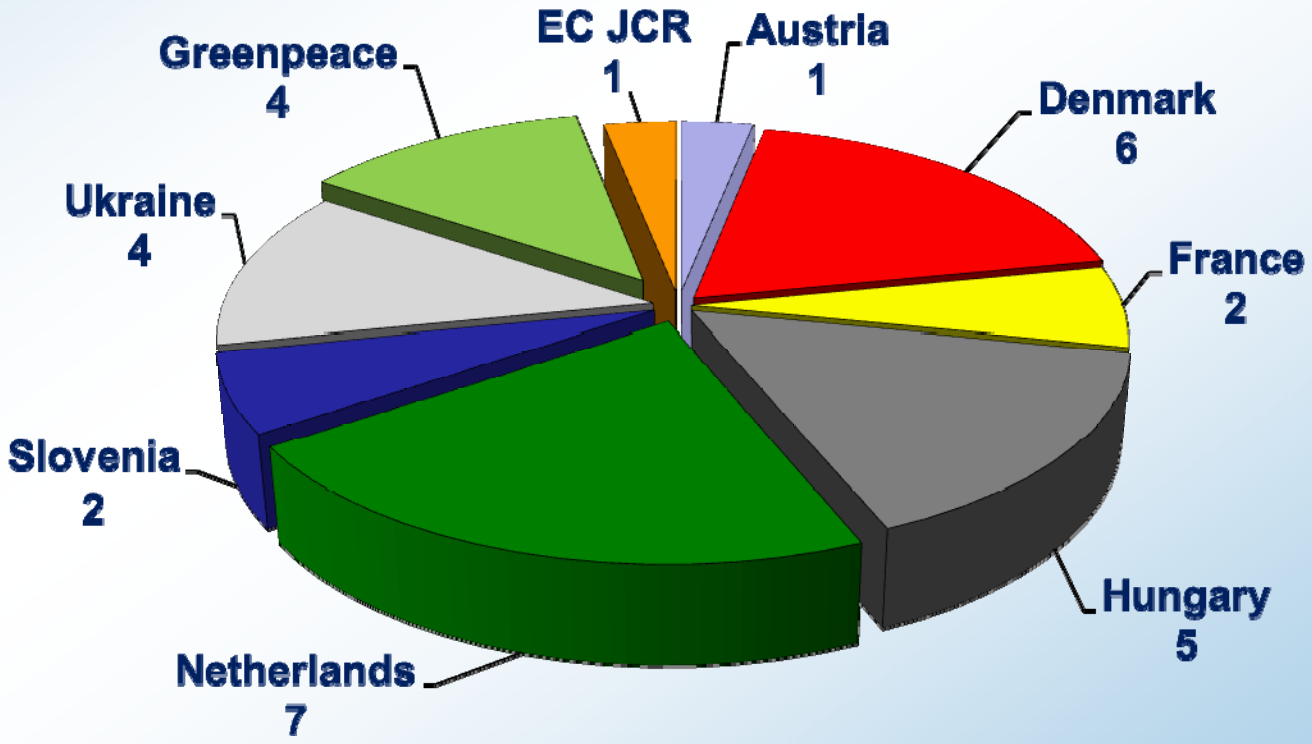
European "Stress tests"
Kozloduy NPP

PART II

Answers to the Questions raised on the Bulgarian UNAcP

Questions raised on the Updated NAcP

Number of Countries	EC-JCR	Green peace	Mr. Renneberg	Total Number of Questions	Topic 1	Topic 2	Topic 3	Topic 2&3	General
7	1	4	2	34	9	3	13	1	8



Summary

- Totally 34 questions asked to the Bulgarian UNAcP (including the generic questions to all countries)
- Majority of the questions are related to one of the following summarised issues:

1. Re-evaluation of the site specific natural hazards
2. Implementation of the Revised WENRA RLs in the national regulations
3. MDG concept and use of bunkered approach
4. Conceptual design of the Off-site ERC
5. Reactor Coolant Pump sealing for 24 h

1. Re-evaluation of the site specific natural hazards

Re-evaluation of natural hazards - carried out in the frame of the site selection for new build at Kozloduy (2012-2014). The re-evaluated mean values of the hazards are defined with 10^{-4} exceedance probability, as follows:

- **Seismic hazard**
  - PGA based on random horizontal component = 0.193 g
  - PGA based on maximum horizontal component = 0.22 g
- **Flooding hazard (site elevation +35.00)**
  - max water level of Danube river (natural flow): +32.46 m
  - max water level (natural flow) combined with high wave: 32.76 m
  - MWL (deterministic assessment): failure of Hydro Facilities "Iron Gate-1,2" combined with extreme precipitation and max water flow

1. Re-evaluation of the site specific natural hazards

- **Extreme weather conditions**
  - max. air temperature: 54°C
  - min. air temperature: minus 34°C
  - snow load: 4,37 kN/m^2
  - icing (thickness): 66 mm
  - strong winds: 53 m/sec
  - max. 24h precipitation: 130 mm
  - tornado: complex probability of occurrence 10^{-7} (approx. EF4)
- **Drought hazard** (probability of exceedance 10^{-3})
  - min water level of Danube river: +20.54 m
  - min water flow: 1375 m^3/sec

The revised design basis external events for units 5 and 6 will be defined as a result of the PSR (2015-2016).

2. Implementation of the revised WENRA RLs in the national regulations

- According to the WENRA Statement on the revised RLs for existing reactors taking into account the lessons learned from the Fukushima accident (Oct. 2014):
  - the regulators commit to harmonize their national regulatory systems by implementing the new RLs until 2017 as a target date
- The process of review and revision of the Bulgarian national requirements is being implemented under actions N-1-1 and N-1-2
- A new Regulation on the Safety of NPPs was drafted in 2014 taking into account:
  - the revised WENRA RLs (including Issue T – Natural Hazards), and
  - the WENRA Safety Objectives for new NPPs
- The Regulation is currently undergoing a consultation process and is expected to be published in 2015/ 2016

3. MDG concept and use of bunkered approach

- As a result of Action A-1-1, the Kozloduy site is equipped with 2 new MDGs 0.4 kV in addition to the existing one MDG 6 kV
- The implementation of Action C-1-1 provides recharging of safety system batteries by the 6 kV MDG
- To diversify the recharging option, provisions for recharging also by the 0.4 kV MDGs are additionally planned (new Action FA-1-1-2)
- Bunker type shelters are considered to store MDGs (new Action FA-1-1-4). They are designed to withstand the following impacts:
  - Seismic impact – DBE of 10^{-4} probability of exceedance, increased by a safety factor of 1.5;
  - Extreme weather conditions (wind, snow, maximum and minimum temperature) with 10^{-4} probability of exceedance;
  - Combined impact of weather conditions, each of 10^{-2} probability of exceedance;
  - Tornado loads of 10^{-7} complex probability of exceedance.

3. MDG concept and use of bunkered approach

The implementation of the new FA actions will ensure the following:

- **Robustness to external hazards** – bunkered storage approach (for each MDG), providing capability to withstand the specified impacts of external hazards
- **Diversity** - two different types of MDGs - 6kV and 0.4 kV are supplied at the site, each of them capable to recharge the safety system batteries
- **Independency**
  - Each type of MDG uses its own connecting points;
  - Each MDG is capable of recharging each of the three redundant batteries of safety systems;
  - Each MDG has its own support equipment (fuel tank, control panel, cables) installed at a truck

4. Conceptual design of the Off-site ERC

- The selected site and the conceptual design of the Off-site Emergency Response Centre take account of all IAEA requirements for availability, technical and informational support and protection
- The selected site is in the town of Kozloduy (at a distance of 6 km of the plant) and has an appropriate infrastructure to provide timely access for the emergency response team
- The ERC will be situated in the underground part of the building, air-tight designed to provide protection of the emergency response team
- The ERC design considers the same protection concept against extreme external hazards, as the MDG bunkers;
- The seismic design of the new ERC includes a substantial margin over the PGA for a 10^{-4} recurrent period

5. Reactor Coolant Pump (RCP) sealing for 24 h

The issue connected to the RCP sealing was addressed before the Fukushima accident and resolved as follows:

- Pump sealing tests, performed by the suppliers in 1999, confirm the tightness of the seals for at least 24 h;
- The power supply of make-up pumps and the boron injection pumps are backed up by an additional SBO DG, installed at each of units 5&6, to ensure cooling of the seals in cases of loss of off-site power or confinement isolation;
- The potential for boron dilution is excluded by an interlock, closing the suction lines of make-up pumps when they lose power supply. To restart the pumps (by DG) they will be connected manually to the deaerator, containing concentrated boron solution.

5. Reactor Coolant Pump sealing for 24 h

- The resolution of this issue was subject of several international reviews - IAEA Safety Review Missions (1995 and 2000), and IAEA Follow-up Mission in 2008, when the issue was finally closed for Kozloduy NPP
- The stress-test did not indicate the need for further investigations on this issue.


NUCLEAR REGULATORY AGENCY
Thank you for your attention!
ENSREG 2nd National Action Plan Workshop, Brussels, 20-24 April 2015