МІНІСТЕРСТВО ПАЛИВА, ЕНЕРГЕТИКИ ТА ВУГІЛЬНОЇ ПРОМИСЛОВОСТІ УКРАЇНИ
ЕНЕРГОАТОМ
ENERGOATOM
НАЦІОНАЛЬНА АТОМНА ЕНЕРГОГЕНЕРУЮЧА КОМПАНІЯ

UKRAINE NUCLEAR POWER SAFETY AND ECONOMICS: POST-FUKUSHIMA

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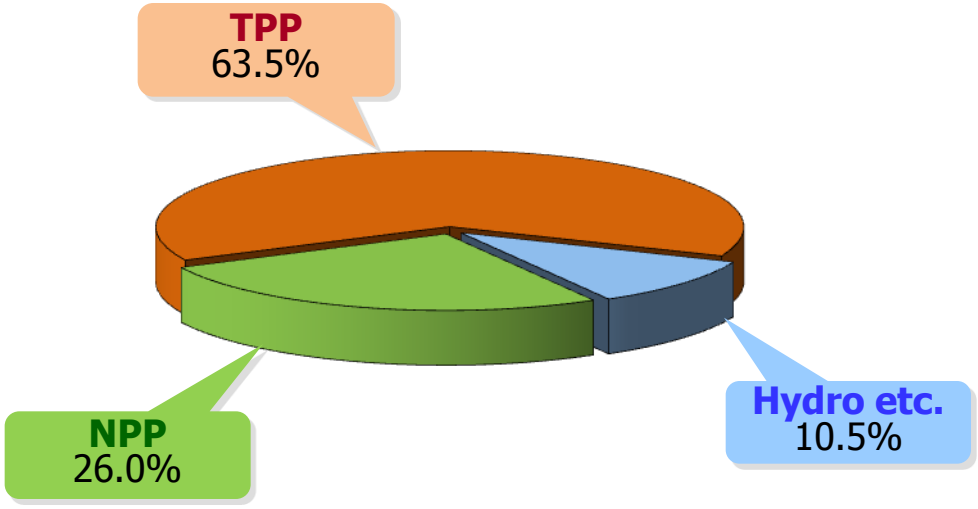
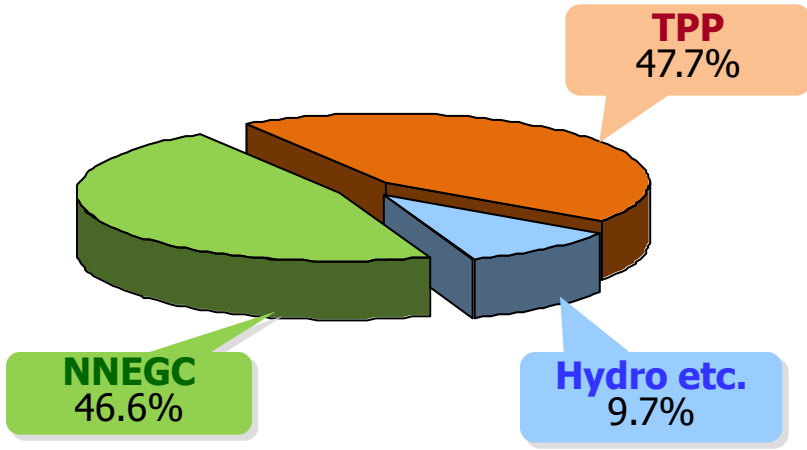
SAFETY
OF
UKRAINE's
NUCLEAR POWER PLANTS

NNEGC ENERGOATOM IN UKRAINE ENERGY MIX (2011)

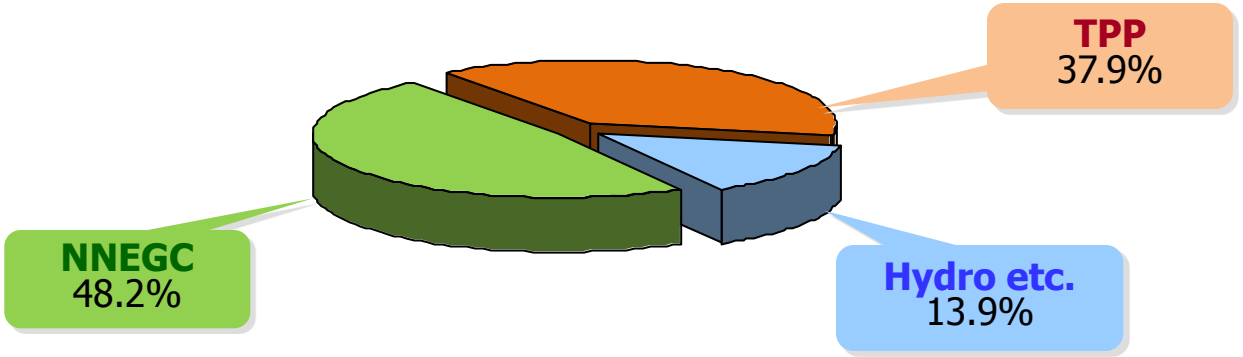
Power generating capacities



Electricity generation in Ukraine

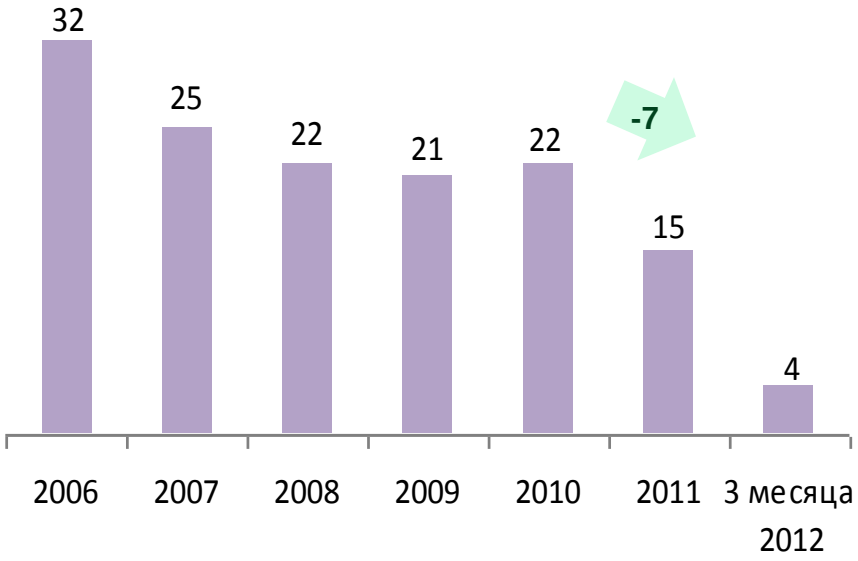


Electricity release to Ukraine power market

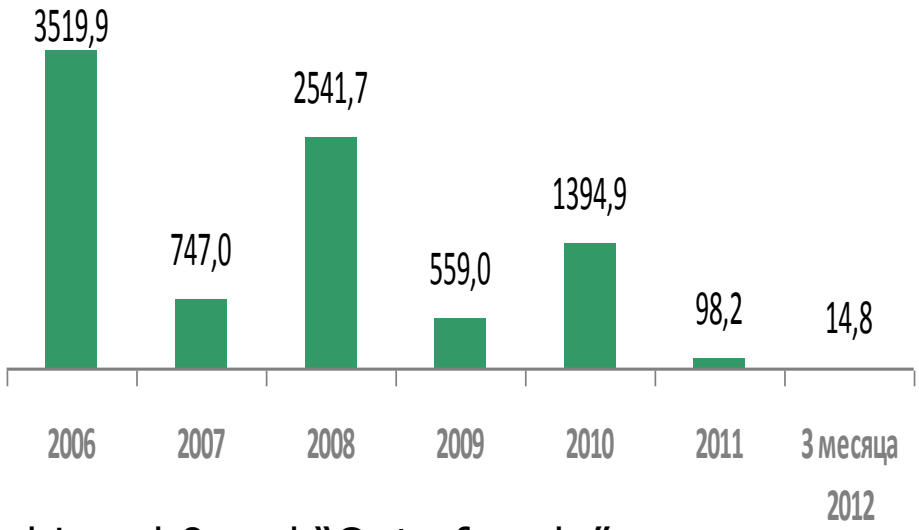


NPP OPERATIONAL EVENTS

Nuclear reactor operational events



Electricity underproduction due to operational events, mln kWh



As per INES, all operational events are rated Level 0 and "Out of scale".

The utility carried out investigations into all NPP operational events and took corrective measures.

NUCLEAR AND FIRE SAFETY

(2011 and 3 months of 2012)

No recorded cases of exceedance of:

- permissible, reference and regulated process levels of gas-aerosol releases;
- water discharges of radioactive substances in the environment;
- reference level of the personnel individual exposure dose.

In 2011 and over 3 months of 2012 **there were no** fires at facilities of NNEGC Energoatom

INTEGRATED (CONSOLIDATED) SAFETY ENHANCEMENT PROGRAM FOR UKRAINE's NUCLEAR REACTORS

Safety enhancement of NPP power units is carried out in accordance with the current industry-wide program – "Integrated (Consolidated) Safety Enhancement Program for Nuclear Power Units of Ukraine" that was put in effect by a joint order of the Ministry of Fuel and Energy and the State Nuclear Regulatory Committee of Ukraine No. 517/172 of 07.12.2010 and approved by the Cabinet's resolution No. 1270 of 07.12.2011.

The "Integrated Program…" included measures that were not implemented in frames of previous programs but were still topical. All measures are priority-rated by their safety significance and considering ends of operating lives of the power units. According to this program, the "Consolidated Measures…" were developed and added with extra measures produced basing on results of in-depth reassessment of nuclear safety of the Ukrainian NPP (stress tests).

INTEGRATED (CONSOLIDATED) SAFETY ENHANCEMENT PROGRAM FOR UKRAINE's NUCLEAR REACTORS

An estimated implementation cost of the "Integrated Program…" is UAH13.8bn (*€1.18bn*). To implement the program at one power unit it is necessary UAH1.1bn (€100m) on average.

In 2011 the "Integrated Program…" was financed 75.8% of the yearly plan and 109.2% of the yearly plan's capital investments were effectively spent.

Currently, the "Integrated Program…" is financed exclusively out of own funds of the utility. The company works on getting loans from EBRD/Euratom.

To get the loans, a large work has been done regarding the European and Ukrainian procedures, approvals have been obtained from the corresponding Ukrainian ministries and agencies, a report on the project environmental assessment has been produced and public consultations have been carried out.

Advantages of Ukraine’s nuclear reactors over that of Fukushima-Daiichi

Advantages of VVER design over BWR(1)

1

- VVER has a possibility of removing heat through the secondary circuit. This advantage allows removing residual heat even through one steam generator. When boiler water is in the steam generator and there is natural circulation transients with the loss of heat removal through the primary circuit (leaks etc.) are substantially mitigated.

2

- Emergency protection of VVER reactors is ensured by control rods insertion by gravity from the top, while in BWRs the control rods are inserted hydraulically from the core bottom.

3

- VVER feature two systems to ensure subcriticality. In BWRs the boron control is not provided; the boron solution is injected only to stop the reactor. An additional subcriticality due to the presence of boron is not envisaged in BWRs.

Advantages of VVER design over BWR(2)

4

- VVER reactors have larger critical power ratio as compared to BWRs.

5

- VVER containment is of larger volume than that of BWR, and this gives more possibilities and margins to limit pressure build-up in case of an accident.

The main advantage of VVER in comparison with BWR in terms of residual heat removal in conditions of full loss of power is the possibility to remove heat through the secondary circuit that increases time before heavy damage of the reactor core and allows implementing additional strategies of the severe accident management.

MAIN OUTCOMES OF TARGET SAFETY REASSESSMENT AT UKRAINE's NPPs

STRESS TESTS

After the tragic events at the Japanese Fukushima-Daiichi NPP and statements adopted by the world community Ukraine joined the European Union's countries in additional reassessment of NPP safety based on the comprehensive and transparent assessment of risks in frames of so-called stress tests.

In furtherance of the Decree issued by the President of Ukraine No. 585/2011 of May 12, 2011 and para. 2 of the resolution adopted by the Collegium of the State Nuclear Regulatory Committee of May 19, 2011, the Company **carried out an off-schedule targeted assessment of safety of operating NPPs in Ukraine**, including their seismic resistance checks.

REASSESSMENT RESULTS

Extreme external impacts

Emergency preparedness and response system

Safe design

- Earthquake
- Fire
- Flood
- Tornado
- Hurricane
- Temperature
- Snow
- Icing

ЕНЕРГОАТОМ ENERGOATOM

AMOUNT OF WORK DONE

Stress tests carried out:

- For all operating NPPs in Ukraine
- For all initial states of power units considering all possible extreme impacts on NPPs typical of their host regions
- For the following initiating events:
  - Long-term NPP blackout
  - Loss of heat removal to ultimate heat sink
  - Overlapping of the above events
- In regard of nuclear fuel location:
  - In the reactor cores
  - Spent fuel pools and reloading pools
  - Fresh fuel sections
  - Dry storage facility for spent nuclear fuel (for Zaporozhe NPP)

STRESS TESTS

Reports on the off-schedule reassessment of safety of the Ukrainian nuclear power units and SNF dry storage facility at Zaporozhe NPP were subjected to nuclear and radiation safety review by the State Nuclear Regulatory Committee of Ukraine.

Basing on results of the off-schedule reassessment of safety of the Ukrainian nuclear power units the Collegium of the State Nuclear Regulatory Committee of Ukraine in November 2011 noted that the sequence of events occurred at Fukushima-Daiichi NPP **was nearly impossible at Ukraine's NPPs**; basing on the stress tests results new critical external natural impacts or combinations of impacts in addition to those considered during design of NPPs and analyzed in detail in frames of the NPP safety justification were not identified.

STRESS TESTS *(continued)*

In frames of the cooperation with EU, the National Report was submitted for review (peer review) to the EC and ENSREG. Besides, corresponding national reports of ENSREG Member States and Switzerland were submitted for review to Ukraine's experts who came up with a broad range of comments. Also, during the peer review the Ukraine's experts answered questions of the European experts regarding the National Report of Ukraine.

On February 4-9, 2012, in Luxemburg a meeting of the EU Secretariat was held and devoted to stress tests where **Ukraine successfully presented its National Report and results of independent check of the stress tests**, and also took part in a discussion of answers and comments to national reports of Member States.

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STRESS TESTS *(continued)*

In March 2012 a group of independent experts of the European Nuclear Safety Regulators Group (ENSREG) carried out a Peer Review Mission in Ukraine to coordinate outstanding issues and generate the final report on the topical peer review of stress tests results of Ukraine's NPPs.

After an ENSREG's Peer Review Mission at South Ukrainian NPP the experts generated and submitted for review to the Ukrainian Regulatory Authority a draft report on results of the peer review of stress tests results at Ukraine's NPPs.

In May 2012 the agreed upon final revision of the report was sent to Ukraine.

STRESS TESTS *(peer review results)*

Basing on results of the ENSREG Mission, the EU experts noted the following problem issues:

- Incomplete meeting of requirements of the IAEA's NS-R-1 as regards qualification of the equipment, severe accidents, seismisity, completeness of probabilistic and deterministic safety analyses.
- The works to analyze severe accidents have not been completed yet in Ukraine. These works should have the highest priority rating.
- It is necessary to strengthen the work on the national safety enhancement program.

STRESS TESTS *(peer review results)*

Basing on the results of the ENSREG's peer review mission, the following recommendations were given to the State Nuclear Regulatory Committee for review:

1. It is necessary to demonstrate at a high level of confidence that the key functions required for severe accident management are achieved.
2. The strategy and program of equipment qualification in conditions of severe accidents must be fulfilled.
3. Risk produced by both the reactor and spent fuel pool in conditions of severe accidents should be assessed.
4. It is necessary to carry out analyses of accidents in SFP in different configurations to supplement SOEP and develop SAMG.

STRESS TESTS *(peer review results)*

4. Stability of means of cooling in SFP in case of the core damage should be enhanced in case of damage to the internal pipelines of the containment due to a hydrogen explosion.
5. It is necessary to study the livability of MCR and LSP in case of severe accidents.
6. To review issues of protection of the personnel and the public under a severe accident.
7. For multi-reactor NPPs a possibility of immediate actions required to prevent the core melting, large release and prevention of the public evacuation should be verified in detail.
8. Sufficiency of seismic stability of building which house the crisis center should be assessed.

Strong features of NPP VVER noted by EU experts

1

- The high level of redundancy of systems, structures and components and power sources (diesel generators) at Ukraine's VVER reactors provides additional possibilities and flexibility for accident management. The VVER-440 design (Rovno NPP) has already been supplemented with additional safety enhancements to prevent severe accidents (additional emergency feedwater system, inter-unit and systemic electric interconnections, emergency measures)

2

- The large water inventory at NPPs with VVERs increases time available for severe accident management. Calculations have shown that for VVER-1000 there is sufficient time margin (7-10 hours) to restore the reactor cooling function. (For VVER-440 this time is substantially longer owing to a large water inventory in the reactor).

3

- Thus, the problem of risk of a common cause failure for both types of reactors is solved through the use of mobile units to restore the core cooling function, which should ensure fast connection and be stored in a safe place.

Main conclusions made basing on stress test results

1

- Designs of Ukraine's NPPs take account of all possible external extreme natural impacts. The NPP safety at the design impact values is justified in the Safety Analysis Reports and additionally tested in frames of the stress test reports. Vulnerability of power units under severe accidents is assessed for all types of power units in operation in Ukraine.

2

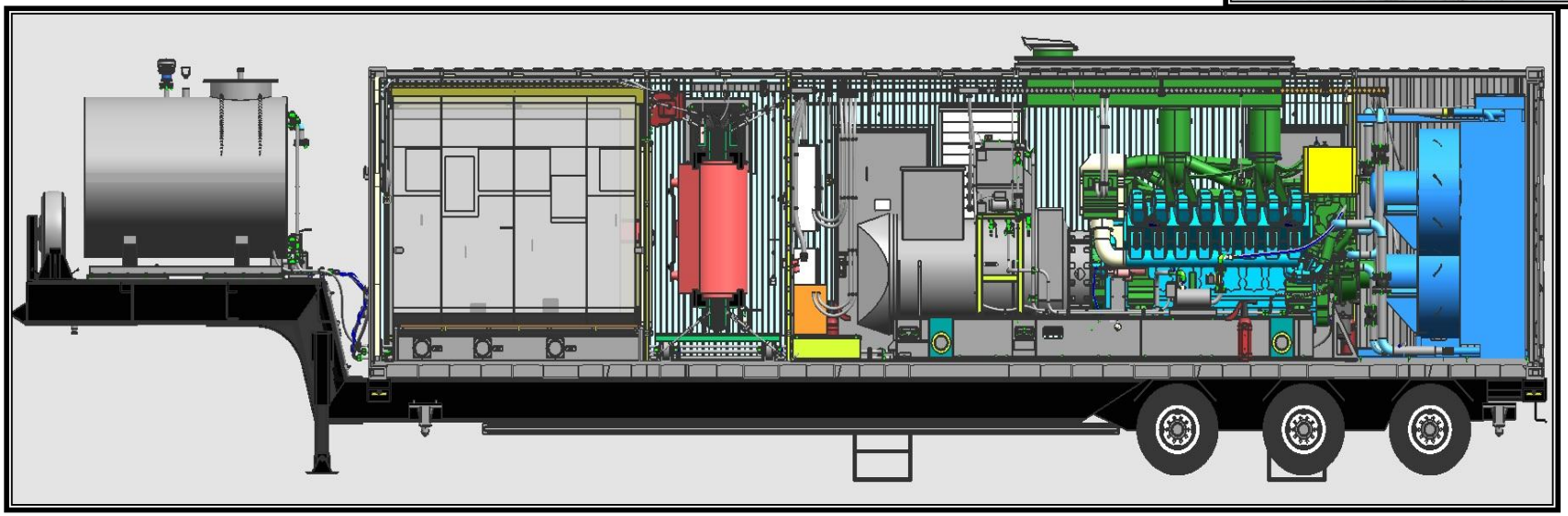
- NPP designs have safety margins as regards external extreme natural impacts, which parameters exceed design values. However, these margins are acknowledged insufficient for an accident similar to that happened at Fukushima-Daiichi.
- The restoration of the core cooling function in case of such accident is through the use of mobile pumping and generator units, as well as the implementation of SAMGs for Ris and SFPs covering all operational conditions of power units.

3

- The implementation of SAMG strategies will require additional reconstruction measures such as qualification of the equipment, installation of hydrogen recombiners in the containment, containment emergency pressure relief system, PARPM etc.
- All problem issues identified basing on the stress test results are included in the national safety enhancement program.

Main safety enhancement measures planned in Ukraine

MOBILE DIESEL GENERATORS AND MONOBLOCK PUMPS



Measures to accelerate and refine previously planned safety enhancement

1. Development and implementation of severe accident management guides
2. Bimplementation of measures to monitor and reduce hydrogen concentration in the containment under beyond design basis accidents
3. Retaining integrity of the containment in case of interaction with a melt of fuel-containing materials after destruction of the reactor pressure vessel in a severe accident
4. Development and implementation of the emergency diagnostics in conditions of a severe accident

Additional measures put on the program basing on stress test results

1.Implementation of the system for filtered releases from the containment in conditions of severe accidents (№16205);

2. SG make-up in conditions of prolonged blackout of NPP (№13307)

3. Emergency power supply in conditions of prolonged blackout of NPP (№15103)

4. Ensuring performance of Category A service water consumers in case of spray pools dewatering (№13511)

5. Make-up and cooling of the spent fuel pool in conditions of prolonged blackout of NPP (№11305)

6. Instrumentation available during and after the accident (№14101)

Fukushima-Daiichi lessons learned and economics

- The Fukushima-Daiichi lessons gave a new impetus to the nuclear power development, which should bring to a new qualitative level of NPP safety.
- This process will require additional expenditures; however, these expenditures is the necessary price to be paid for NPP safety, which much less than consequences brought about by Fukushima-Daiichi and Chernobyl accidents.
- In conclusion it may be sid that in spite of the negative consequences brought about by Fukushima-Daiichi accident, the nuclear power today doesn’t have alternatives and remains attractive in terms of the use of energy resources and is still the basis of energy independence of many nations of the world.

THANK YOU FOR ATTENTION!