INPRO Dialogue Forum on Global Nuclear Energy Sustainability:
Long-term Prospects for Nuclear Energy in the Post-Fukushima Era

27-31 August 2012
Seoul, Republic of Korea

Nuclear Energy Prospects for UKRAINE

Leonid Benkovskyi,
National Nuclear Energy Generating Company/UKRAINE

1.1 Concept of sustainable nuclear energy system:

*Sustainable energy system means a system that meets the current demands in energy taking into account that future generations will also be able to meet their demands.*

Priorities of Ukraine related to the sustainability of nuclear energy system

• SAFETY
• ECONOMICAL ISSUES
• ENVIRONMENT
• INFRASTRUCTURE
• RADIOACTIVE WASTE MANAGEMENT

1.2. Driving forces for expanding nuclear power program in Ukraine:

• demand in significant base-load generating capacities for industrial development;

• availability of domestic uranium deposits;

• availability of infrastructure to support NPP operation, human resources, personnel training system, as well as NPP operation experience;

• keeping CO₂ emissions at low level.

1.3 Long-term policy for nuclear energy and main aspects of nuclear power programme in Ukraine for the next decades:

To date Ukraine operates 15 nuclear power units located at four sites with total installed capacity of 13 835 MW.

For the past 5 years NPP share in total electricity generation in Ukraine has made up 47-48%.

Up to 2050 the nuclear share in electricity generation is to be maintained at the current level – about half of the total electricity generation in Ukraine. The nuclear share in energy mix is to be revised considering macroeconomic indicators of the Ukrainian economy, situation at the global markets of energy sources, as well as development level and introduction of advanced technologies in energy sector.
The operational lifetime was extended for 20 years (December 10, 2010) based on the results of periodic safety review.

<table>
<thead>
<tr>
<th>NPP, Unit No.</th>
<th>Electric power, MW</th>
<th>Reactor type</th>
<th>Connection to the grid</th>
<th>Design lifetime expiry date</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZNPP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1000</td>
<td>V-320</td>
<td>22.07.1985</td>
<td>22.07.2015</td>
</tr>
<tr>
<td>5</td>
<td>1000</td>
<td>V-320</td>
<td>14.08.1989</td>
<td>14.08.2019</td>
</tr>
<tr>
<td>6</td>
<td>1000</td>
<td>V-320</td>
<td>19.10.1995</td>
<td>19.10.2025</td>
</tr>
<tr>
<td>SUNPP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1000</td>
<td>V-338</td>
<td>09.01.1985</td>
<td>09.01.2015</td>
</tr>
<tr>
<td>RNPP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>420</td>
<td>V-213</td>
<td>22.12.1980</td>
<td>22.12.2010*</td>
</tr>
<tr>
<td>4</td>
<td>1000</td>
<td>V-320</td>
<td>10.10.2004</td>
<td>10.10.2034</td>
</tr>
<tr>
<td>KhNPP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1000</td>
<td>V-320</td>
<td>08.08.2004</td>
<td>08.08.2034</td>
</tr>
</tbody>
</table>
The State Enterprise “National Nuclear Energy Generating Company ‘Energoatom’” was established in 1996. NNEGC “Energoatom” comprises all Ukrainian NPPs in operation. NNEGC “Energoatom” is entrusted with functions of an Operating Organization responsible for safety of all operating NPPs of Ukraine.

1.3 Long-term policy for nuclear energy and main aspects of nuclear power programme in Ukraine for the next decades (cont’d):

• The key elements of Ukraine’s nuclear energy programme in the near-term (before 2030) are:
  - safety upgrades to ensure operation in compliance with the highest international safety standards, taking into account the lessons learnt from the Fukushima Daiichi nuclear accident in Japan;
  - provide for long-term operation of existing reactors beyond their original design lifetime and construct new capacities to address anticipated electricity needs;
  - the construction of a new centralized dry spent nuclear fuel storage facility;
  - construction and put into operation in 2016 of fuel fabrication plant;
  - decommissioning of the Chernobyl Units 1, 2 and 3 with RBMK reactors (graphite-moderated light water-cooled reactors) and construction of the New Safe Confinement to replace the existing sarcophagus over Chernobyl Unit 4.

1.3 Long-term policy for nuclear energy and main aspects of nuclear power programme in Ukraine for the next decades (cont’d):

Some conclusions (cont’d):

- Lifetime extension of nuclear power units in operation and construction of new nuclear capacities alongside with preparation of power units reaching the end of their lifetime for decommissioning (after 2030) will be the main task (challenges) for nuclear power development in Ukraine for the next decades. Thus, the government should accumulate all necessary funds to finance decommissioning of old NPPs and construction of new ones by means of investments secured in the tariff for electricity generated by NPPs.

- To secure nuclear power supply in Ukraine government should promote extension of the existing nuclear fuel fabrication capacities, as well as develop and implement relevant cooperation in fuel fabrication, reprocessing and recycling with other countries.
2. Main lessons learned after Fukushima in UKRAINE

- Straight after the Fukushima accident Ukraine started implementing all necessary measures related to organization and implementation of in-depth extraordinary safety assessment of NPP units (stress-tests),
- In Ukraine was developed an Action Plan on implementation of the dedicated extraordinary safety assessment and strengthening of nuclear power units in Ukraine considering the events at Fukushima NPP.
- The Action Plan included **near-term and long-term activities**. Near-term activities consisted of dedicated extraordinary safety assessment of nuclear power units in Ukraine (stress-tests), review of emergency preparedness procedures and revision/amendment of “Integrated Safety Improvement Program for Ukrainian NPPs” and schedule of activities to be implemented in 2011. Long-term activities include NPP safety enhancement measures determined based on the results of the dedicated extraordinary safety reassessment of NPPs in Ukraine with detailed analyses of:
2. Main lessons learned after Fukushima in UKRAINE

• external natural hazards (earthquake, flooding, fire, tornado, extreme high/low temperatures precipitations, strong winds);
• loss of external power supply and/or ultimate heat sink;
• severe accident management.

Based on the results of the dedicated extraordinary safety reassessment of operating NPPs in Ukraine SNRIU specified that:

1. Sequence of events that occurred at Fukushima NPP is practically impossible for NPPs in Ukraine;
2. No new external natural hazards or combination of these hazards were revealed in addition to those considered during NPP design phase and analyzed in details during NPP safety justification;
3. Compulsory condition for long-term operation of nuclear power units beyond their 30-year design lifetime will be the implementation of activities aimed at enhancing safety of NPPs by the operator taking into account the lessons learnt from the Fukushima Daiichi nuclear accident.
Moreover, based on the results of the safety reassessment of NPP units the acting regulatory documents on nuclear and radiation safety will be analyzed and proposals on their refinement will be developed in order to strengthen safety requirements for operating and new NPPs.

**SNRIU confirms the following requirements to the operator:**

- to implement planned activities on safety strengthening envisaged in the “Concept for Safety Enhancement of Operating NPPs” and “Integrated Safety Improvement Program for Ukrainian NPPs”;

- to update seismic safety analyses and external hazards analysis for operating NPP units;

- to complete severe accident analyses and SAMG development.
SNRIU intends to issue licensees only for reference reactor designs to be built in Ukraine. Besides, these reactor designs should be in compliance with the updated safety requirements including at least:

- passive safety systems that do not require personnel involvement and have independent power supply sources;
- redundancy of protective passive and active safety systems that secure reliable stop of chain reaction and long-term residual heat removal from the reactor;
- functional, special and design diversity of the systems responsible for passive long-term isolation and retention of radioactive substances within the containment boundaries of the reactor in case of emergency situations.

UKRAINE confirms its firm commitment to constant improvement of nuclear and radiation safety.
3.1 National anticipation in the next decades of XXI Century

**Nuclear energy system of Ukraine in 2030:**

1. Lifetime extension of the operating NPPs of Ukraine for 20 years. Lifetime of 11 units (the installed capacity of each unit is 1 GW) is supposed to be extended.

2. Construction and commissioning of Units №3 & №4 of Khmelnitsky NPP (accordingly in 2018 and 2020 with minimum capacity – 2GW)

3. Commissioning of new additional units with total capacity of 5 GW by 2030 (according to the basic scenario).

4. Commencement of construction of new units to replace those to be decommissioned after 2030 (it is necessary to start construction of 12 GW of installed capacity by 2022).
3. Expectations of Ukraine for global Nuclear Power development in the 21st century

Nuclear energy system of Ukraine in 2030 (cont’d):

4. Provision of Ukrainian NPPs with domestically mined uranium in the amount of 3000 t per year by 2030 that will allow to cover the demand of about 19 GW of the installed capacity of LWR.

5. Operation of fuel fabrication plant.

6. Preparation for decommissioning of 10,88 GW of installed capacity in 2031-2039.

7. Operation of the dry spent nuclear fuel storage facility (DSNFSF) at Zaporizhzhya NPP and centralized spent nuclear fuel storage facility (CSNFSF). All SNF from running Ukrainian NPPs will be stored.

*Total installed capacity of NPPs in 2030 may be about 19 GW, nuclear share in total energy mix – 47-48%*
3. Expectations of Ukraine for global Nuclear Power development in the 21\textsuperscript{st} century

Nuclear energy system of Ukraine in 2050:

1. Operation follow-up of the NPP units that were built before 2030. Total installed capacity – 8 GW (Zap NPP-6, KhNPP-2,3,4, RNPP-4, units at new sites – 3 GW).

2. Construction and commissioning of new units from 2030 to 2040 to replace those ones under decommissioning with total capacity of 11 GW (RNPP-1-3, SUNPP-1-3, Zap NPP-1-5, KhNPP-1).

3. Construction and commissioning of new units with installed capacity of 3 GW after 2030 to meet the growing demand for electricity (criterion – about 50\% of electricity output in energy mix).

4. Decommissioning of 12 units (10,88 GW) in 2031-2039
   - 2031-2032 – decommissioning of units RNPP-1 and RNPP-2 (total capacity 880 MW);
   - 2033-2039 – decommissioning of 10 units with VVER-1000 (total capacity 10 GW).
3. Expectations of Ukraine for global Nuclear Power development in the 21st century

Nuclear energy system of Ukraine in 2050 (cont’d):

5. Provision of Ukrainian NPPs with domestically mined uranium in the amount of 5000 t per year by 2050 that will allow to cover the demand of about 22 GW of the installed capacity of LWR.

6. Operation of fuel fabrication plant.

7. Operation of CSNFSF and DSNFSF at Zap NPP.

Total installed capacity of NPPs in 2050 may be about 22 GW, nuclear share in total energy mix – 46-49%
Types of the reactors to be built in Ukraine and their capacity:

- In the near-term (before 2030) Gen-III+ LWR are more likely to be selected for construction in Ukraine. Heavy water reactors are also considered to be built.
  Possible LWR types: AES-2006, AP-1000, APR-1400.
  Possible HWR types: CANDU EC6.

- The following LWR and HWR designs may be selected for construction in 2030-2050: AES-2006, AP-1000, APR-1400, EPR-1600, CANDU EC6.

- Construction of fast reactors before 2050 may also be considered.
Expected nuclear fuel cycle (e.g., open or closed):
• Open NFC will be used until SNF reprocessing issues are solved.

Local NFC services and foreign suppliers:
• Local NFC services will include: uranium mining and U3O8 production, pellets sintering, nuclear fuel fabrication, spent nuclear fuel storage, HLW disposal;
• Foreign suppliers of NFC services will include: conversion services, uranium enrichment, design and manufacturing of reactors, spent nuclear fuel reprocessing.
3. Expectations of Ukraine for global Nuclear Power development in the 21st century

• Major policy implications and challenges

Impediments that may impact expanding nuclear power program in Ukraine are listed below:

• economical issues (unavailability of proven financing sources for new NPP construction);
• public acceptance taking into account Chernobyl accident;
• foreign suppliers dependency in reactor technologies, nuclear fuel fabrication and SF reprocessing technologies (holders of the reactor technologies may be “overloaded” with commercial orders);
• potential influence of political and economical considerations on the application of technologies of other countries
3. Expectations of Ukraine for global Nuclear Power development in the 21st century

CONCLUSION

Even after the Fukushima accident, nuclear power is enjoying the world recognition as a reliable and clean energy source supporting innovative development of countries, economic growth of regions, securing well-paid jobs and improving the environment.

Ukraine has a well developed nuclear power industry and keeps its commitment to continue its further long-term development.
Thank you for your attention!