



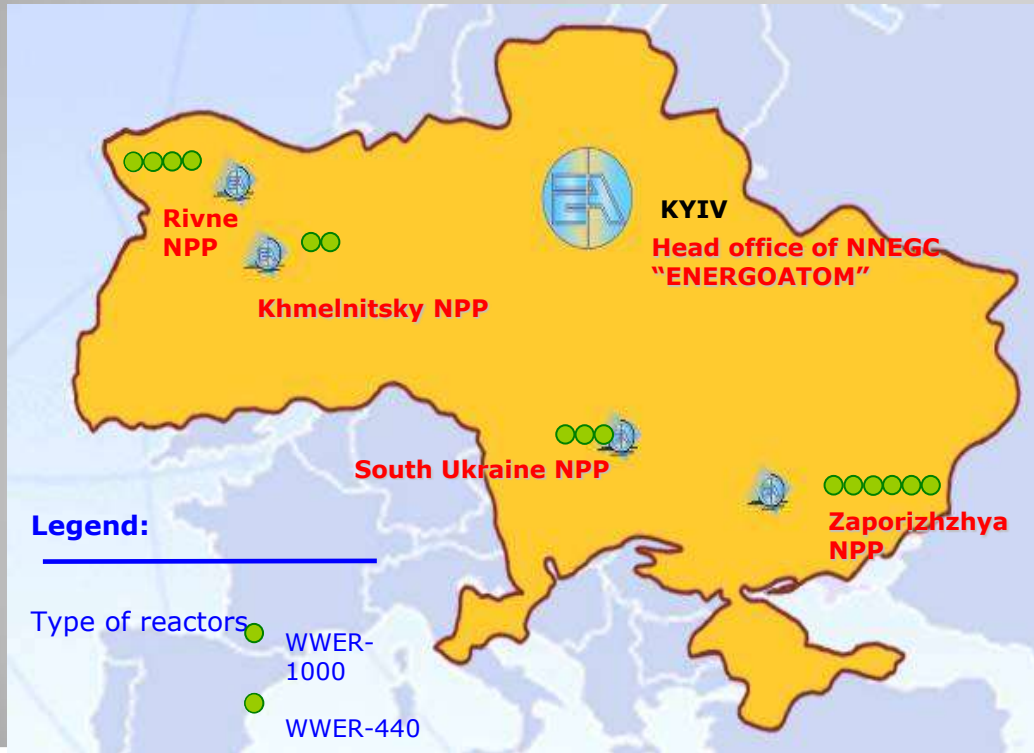
Assessment of Ukrainian Nuclear Energy System by INPRO methodology - Infrastructure

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Current status of nuclear power branch in Ukraine

Nuclear power plants



There are 4 NPPs in operation in Ukraine. These nuclear power plants include 15 units with total capacity 13,835 GW.

- Zaporizhzhya NPP – 6 units with VVER-1000, total capacity 6 GW;
- Rivne NPP – 4 units with 2 VVER-440 and 2 VVER-1000, total capacity 2,835 GW;
- Khmelnitska NPP – 2 units with VVER-1000, total capacity 2 GW;
- South-Ukraine NPP – 3 units with VVER-1000, total capacity 3 GW.

Current status of nuclear power branch in Ukraine

Front end

- There are uranium deposits and mining capacities in Ukraine. The extracted uranium is used for fabrication of fuel for the Ukrainian NPPs. The local uranium covers about 30% of nuclear fuel demand for Ukrainian NPPs (about 800 t per year).

Current status of nuclear power branch in Ukraine

Back end

- Spent nuclear fuel (SNF) of Rivne NPP, South-Ukraine NPP and Khmel'nitska NPP is sent for reprocessing to Russian Federation. Reprocessing waste will be sent back to Ukraine.
- Spent nuclear fuel of Zaporizhzhya NPP is being stored in dry storage facility at the site of Zaporizhzhya NPP.
- A centralized storage facility for spent nuclear fuel of VVER type reactors is under construction in the Chernobyl exclusion zone.
- Waste reprocessing is being performed at the NPP's sites. In the future it is planned to transport radioactive waste and reprocessing waste to the Complex "Vector" (Chernobyl exclusion zone) for long-term storage/disposal

IAEA Project on Strategic Nuclear Energy Planning

At the moment the IAEA Project on Strategic Nuclear Energy Planning in the Framework of INPRO **is realized in Ukraine.**

Project was initiated by Ukraine and supported by IAEA, start of the project – 2011.

Project objective:

- To develop different scenarios within the frames of strategic energy planning of Ukraine energy system including Nuclear Energy System (NES), which could be integrated into national decision making process.

In the project:

- On the base of macroeconomic forecast and role of nuclear power in electricity generation the scenarios of energy system development up to 2100 are assessed;
- Modeling of different types of nuclear fuel cycles is performed.

Assessment of Nuclear Energy System

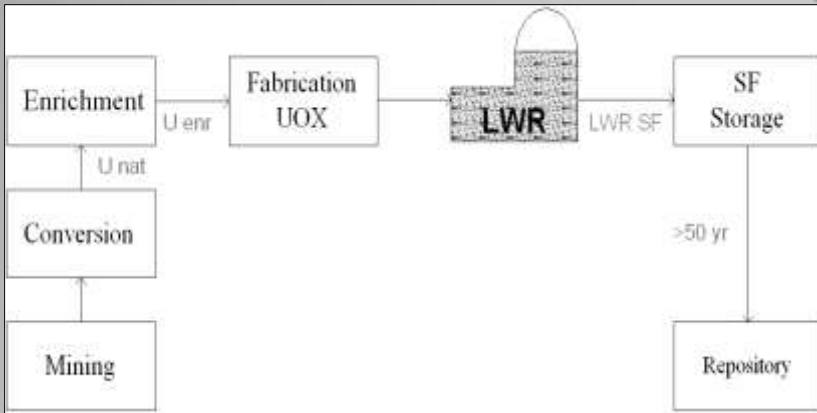
At the moment an assessment of Nuclear Energy System is carried out in the following areas:

**Waste management,
Infrastructure,
Economics.**

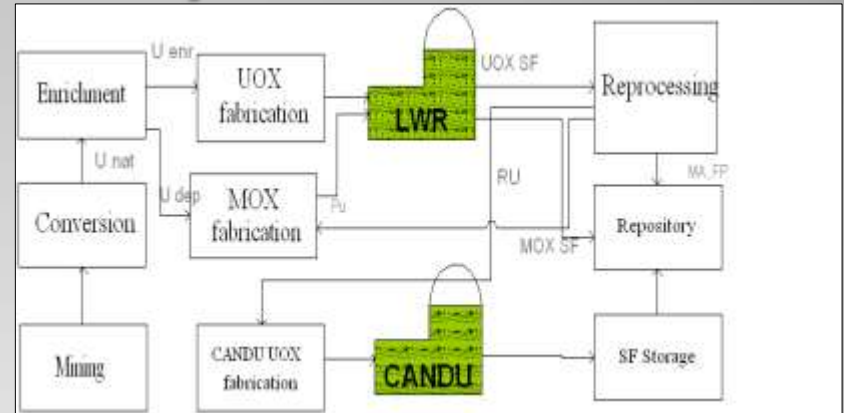
For assessment of “Infrastructure” the IAEA-TECDOC-1575 “Guidance for the Application of an Assessment Methodology for Innovative Nuclear Energy System. INPRO Manual – Infrastructure” is used.

Assessment of Nuclear Energy System

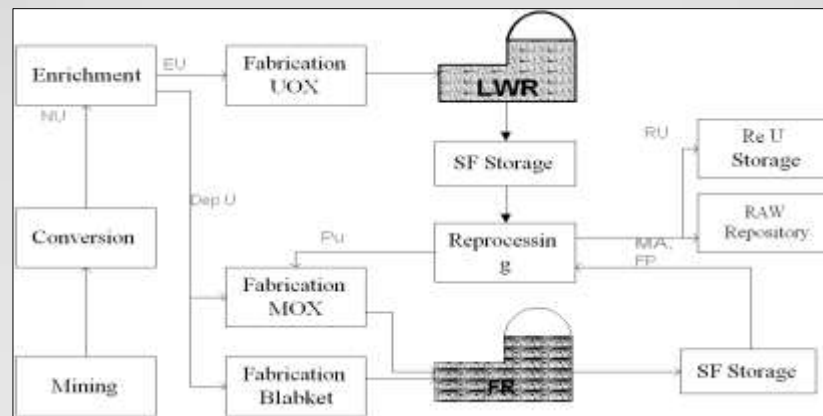
is carried out for following scenarios (**NFC configuration**)



Open fuel cycle with LWR



Partially closed fuel cycle with HWR and LWR



Closed fuel cycle with LWR and FR

Infrastructure Assessment (1)

Preliminary results of assessment of Infrastructure on example of Open NFC are presented below

Infrastructure basic principle:

Regional and international arrangements shall provide options that enable any country that so wishes to adopt, maintain or enlarge an INS for the supply of energy and related products without making an excessive investment in national infrastructure

Infrastructure Assessment (2)

According to methodology Infrastructure is estimated by 4 User Requirements:

- **UR1 Legal and institutional infrastructure:** *Prior to deployment of an INS installation, the legal framework should be established to cover the issues of nuclear liability, safety and radiation protection, environmental protection, control of operation, waste management and decommissioning, security, and nonproliferation*
- **UR2 Industrial and economic infrastructure:** *The industrial and economic infrastructure of a country planning to install an INS installation should be adequate to support the project throughout the complete lifetime of the nuclear power program, including planning, construction, operation, decommissioning and related waste management activities*
- **UR3 Political support and public acceptance:** *Adequate measures should be taken to achieve public acceptance of a planned INS installation to enable a government policy commitment to support the deployment of INS to be made and then sustained*
- **UR4 Human resources:** *The necessary human resources should be available to enable all responsible parties involved in a nuclear power program to achieve safe, secure and economical operation of the INS installations during their lifetime. The owners/operators should have enough knowledge of the INS to be intelligent customers and should keep a stable cadre of competent and trained staff.*

Infrastructure Assessment Results (1)

| User requirement | Criterion | Evaluation parameter | Evaluation |
|--|-------------------------------|---|------------------------|
| UR.1 (Legal and institutional infrastructure) | CR. 1.1 Legal aspects. | 1.1.1 Scope of the nuclear legislation | Fulfilled |
| | | 1.1.2 Adequacy of nuclear law | Fulfilled |
| | | 1.1.3 international legal arrangements. | Fulfilled |
| | | 1.1.4 Completeness and adequacy of regulations and guidelines | incomplete fulfillment |
| | CR. 1.2 Institutions | 1.2.1 Independence of regulatory body. | Fulfilled |
| | | 1.2.2 General functions of regulatory body. | Fulfilled |
| | | 1.2.3 Review of safety regime. | Partial fulfillment |
| | | 1.2.4 Review of emergency preparedness regime | Fulfilled |
| | | 1.2.5 Review of physical protection regime | Fulfilled |
| | | 1.2.6 Review of proliferation resistance | Fulfilled |

Infrastructure Assessment Results (2)

| User requirement | Criterion | Evaluation parameter | Evaluation |
|--|--|--|---|
| UR.2 (Industrial and economic infrastructure): The industrial and economic infrastructure of a country planning to install an INS installation should be adequate to support the project throughout the complete lifetime of the nuclear power program, including planning, construction, operation, decommissioning and related waste management activities. | 2.1 Availability of credit lines sufficient to cover investments into the nuclear program infrastructure. | 2.1.1 Financing of infrastructure provided by industry. | Fulfilled |
| | | 2.1.2 Financing of infrastructure provided by government. | Fulfilled |
| | 2.2 Demand for and price of energy products in a country enable a satisfactory financial return. | 2.2.1 Electricity price is adequate to enable a satisfactory return on capital invested. | Partially fulfilled |
| | | 2.3 Size of installation matches local (national) needs. | 2.3.1 The results of energy system planning demonstrate the sufficient space available for nuclear power. |
| | 2.3.2 The size of planned facilities has been determined by means of adequate studies. | | Fulfilled |
| | 2.4 Internal or external industrial infrastructure can support owner/operator of nuclear installations. | 2.4.1 Survey of the existing capabilities of the national industry. | Fulfilled |
| | | 2.4.2 Plans for national participation. | Fulfilled |
| | 2.5 Added value of proposed nuclear installation covers the cost of investments necessary to support nuclear installation. | 2.5.1 Cost benefits study performed. | Fulfilled |
| | | 2.5.2. Study to define benefits of nuclear program to society | Not fulfilled |

Infrastructure Assessment Results (3)

| User requirement | Criterion | Evaluation parameter | Evaluation |
|---|---|---|---------------|
| UR.3 (Social-political infrastructure): The relevant steps should be taken to achieve public acceptance of planned INS installation. | 3.1 Information provided to public. | 3.1.1 Existence of a national energy policy. | Fulfilled |
| | | 3.1.2 Communication of benefits of nuclear power to the public. | Not fulfilled |
| | | 3.1.3 Information on the operation of nuclear facilities. | Fulfilled |
| | | 3.1.4 Evidence that the public communication program adequately addresses issues of risk. | Not fulfilled |
| | | 3.1.5 Use of experts during public communications. | Fulfilled |
| | 3.2 Participation of the public in the decision making process (to foster public acceptance). | 3.2.1 Sufficient participation of the public. | Fulfilled |
| | | 3.2.2 Participation of the public in the decision making process is available. | Fulfilled |
| | 3.3. Public acceptance of nuclear power is sufficient to ensure there is negligible political risk to policy support for nuclear power. | 3.3.1 Public polling (survey) is performed on a regular basis. | Not fulfilled |
| | | 3.3.2 The public surveys are carried out by professional organizations using recognized practices and techniques. | Fulfilled |
| | | 3.3.3 The result of a survey show that a majority of the public either support, or at least do not oppose, a planned (or established) nuclear power program and that there is a positive (at least stable) trend. | Not fulfilled |
| 3.4 Government policy is supportive of nuclear power. | 3.4.1 To describe steps taken by the government to support nuclear power. | Fulfilled | |

Infrastructure Assessment Results (4)

| User requirement | Criterion | Evaluation parameter | Evaluation |
|--|--|---|------------------------------------|
| <p>UR.4. (human resources): The necessary human resources should be available to enable the operating organization to maintain safety culture and ensure safe operation of the INS installation.</p> <p>The operator should have enough knowledge of the NPP to be intelligent customer and should keep a stable cadre of competent and trained staff.</p> | 4.1 Availability of human resources | 4.1.1 Educational and training system for manpower needed in NP projects. Evidence that an adequate educational system is available/planned. | Fulfilled |
| | | 4.1.2 Attractiveness of the nuclear power sector. | not sufficient data for assessment |
| | | 4.1.3 Capacity to accept the additional load of nuclear power program. Evidence that human resources needed to deploy the nuclear program are available without unduly interfering with other domestic industrial activities of comparable value to the country. | not sufficient data for assessment |
| | 4.2 Attitude to safety and security culture. | 4.2.1 Availability of mechanism for periodic safety review, including technical infrastructure and control. | Fulfilled |

Infrastructure Assessment Results (5)

Results of assessment for all User Requirements:

- **UR1 Legal and institutional infrastructure:**
Evaluation parameters – 10, nonfulfillment – 2.
Criteria – 2, nonfulfillment – 2
- **UR2 Industrial and economic infrastructure:**
Evaluation parameters – 9, nonfulfillment – 2. Criteria
– 5, nonfulfillment – 2
- **UR3 Political support and public acceptance:**
Evaluation parameters – 11, nonfulfillment – 4.
Criteria – 4, nonfulfillment – 2
- **UR4 Human resources**
Evaluation parameters – 4, nonfulfillment – 2. Criteria
– 2, nonfulfillment – 1

Infrastructure Assessment – examples (1)

For example preliminary results of assessment by some criteria and evaluation parameters of requirement UR1 “Legal and institutional infrastructure”

The requirement is stated as follows:

- **UR1 Legal and institutional infrastructure:** *An adequate legal framework should be established to cover the issues of nuclear liability, safety and radiation protection, environmental protection, control of operation, waste management and decommissioning, security, and non-proliferation.*

Infrastructure Assessment – examples (2)

| User requirement | Criterion | Evaluation parameter | Evaluation |
|---|-----------------------------------|---|------------------------|
| UR.1.1 (Legal and institutional infrastructure) | CR. 1.1 Legal aspects. | 1.1.1 Scope of the nuclear legislation | Fulfilled |
| | | 1.1.2 Adequacy of nuclear law | Fulfilled |
| | | 1.1.3 international legal arrangements. | Fulfilled |
| | | 1.1.4 Completeness and adequacy of regulations and guidelines | incomplete fulfillment |
| | CR. 1.2 Institutions | 1.2.1 Independence of regulatory body. | Fulfilled |
| | | 1.2.2 General functions of regulatory body. | Fulfilled |
| | | 1.2.3 Review of safety regime. | Partial fulfillment |
| | | 1.2.4 Review of emergency preparedness regime | Fulfilled |
| | | 1.2.5 Review of physical protection regime | Fulfilled |
| | | 1.2.6 Review of proliferation resistance | Fulfilled |

Infrastructure Assessment – example -1(1)

Criterion CR1.1. Legal aspects.

- **Indicator IN 1.1.** *Status of legal (nuclear) framework*
- **Acceptance limit AL1.1:** *Legal framework has been established in accordance with international standards.*

Evaluation parameters:

- EP. 1.1.1 Scope of the nuclear legislation. – ***Fulfillment***
- EP. 1.1.2 Adequacy of nuclear law – ***Fulfillment***
- EP. 1.1.3. International legal arrangements – ***Fulfillment***
- EP. 1.1.4. Completeness and adequacy of regulations and guidelines – ***incomplete fulfillment***

Infrastructure Assessment – example 1(2)

By the *evaluation parameter EP1.1.4 "Completeness and adequacy of regulations and guidelines"* we draw a conclusion about ***incomplete fulfillment***.

Why:

in Ukraine the regulatory base is created, process of improving is going on. For example, the total amount of regulation documents concerning nuclear installations - 71. But still part of them – documents of the former USSR. These documents are require review. In this direction Regulator conducts a scheduled work.

Also the areas of RW and SNF management, decommissioning are insufficiently covered by norms

Infrastructure Assessment – example 2(1)

Criterion CR. 1.2. Institutions

- **Indicator IN 1.2.** *Status of State organizations with responsibilities for safety and radiation protection, environmental protection, control of operation, waste management and decommissioning, security and non-proliferation*
- **Acceptance limit AL1.2** *State organizations have been established, in accordance with international standards*

Evaluation parameters:

- EP 1.2.1 Independence of regulatory body – **Fulfillment**
- EP. 1.2.2. General functions of regulatory body – **Fulfillment**
- EP. 1.2.3. Review of safety regime – **Partial fulfillment** (for generation stage).
- EP. 1.2.4. Review of emergency preparedness regime – **Fulfillment**
- EP. 1.2.5. Review of physical protection regime – **Fulfillment**
- EP. 1.2.6. Review of proliferation resistance – **Fulfillment**

Infrastructure Assessment – example 2(2)

By the *evaluation parameter EP1.2.1 "Independence of regulatory body"* we draw a conclusion about **fulfillment**.

- It is confirmed by conclusions of IAEA in the report on assessment of Regulatory Body of Ukraine (IAEA NS IRRS 2010. Integrated Regulatory Review Service. Report to The Government of Ukraine):
- «The team confirmed SNRCU's strengths, as identified during the IRRS 2008 mission and in particular: SNRCU is effectively regulating nuclear and radiation safety; **is de facto an independent regulatory body and has taken effective action towards achieving transparency and communication with the public and Parliament.** »

Infrastructure Assessment **conclusions**

Thus, on the basis of preliminary results of an assessment of the Infrastructure it is possible to draw the following basic conclusions:

- The configuration of open fuel cycle of Ukraine fulfills the most part of evaluation parameters - 24 of 34,
- 10 evaluation parameters - not fulfills: 3 of them - partial fulfillment of conditions, 2 of them - not sufficient data for assessment
- improvements of Infrastructure of open fuel cycle are required in the area of SNF and RW management (including RW management on decommissioning stage)
- Also improvements are required in the area of public acceptance and human resources

Thank you for your attention