Summary

Independent review of the proposed lifetime extension of Unit 1 at the South Ukraine nuclear power plant and its compliance with relevant nuclear safety standards (ПНАЕ Г-7-002-86)

National Ecological Centre of Ukraine (NECU)

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A recent independent expert analysis concluded that the conditions of Unit 1 at the South Ukraine nuclear power plant raise serious concerns about the safety of its operations. The report shows that observed wear in a number of elements in the reactor vessel already exceeds allowed levels **warning that appearance of small (micro) cracks is highly probable if the reactor continues to operate beyond its designed lifetime**. Keeping this unit in operation could cause an accident that would result in the release of radiation and irradiation of the plant's workers, and the people and the environment surrounding the reactor.

The State Nuclear Regulatory Inspectorate of Ukraine (the 'Inspectorate'), the government authority in charge of nuclear and radiation safety, approved a prolonged lifetime of the South Ukraine Unit 1, even though some compulsory measures to improve safety of Unit 1 had not been completed. 54 upgrades were in fact still pending. In addition the national energy company Energoatom had not completed the structural assessment and prognosis of the technical condition of reactor vessel at the required level and to the full extent. The conclusions of a state expert review of nuclear and radiation safety for the safe operation of the reactor beyond its designed period are not in line with chapter 4 of the Law of Ukraine "On the use of nuclear energy and radiation safety" in the part regarding independence and conservative approach. This expert review requires double-checking[1].

In spite of this, on 2 December 2013 the Inspectorate issued a license for Unit 1 to continue its operations for ten more years until 2 December 2023. This decision put doubts on the Inspectorate's ability to guarantee nuclear power safety and the impartiality of its decisions. The license was issued after a resolution by the board of the Inspectorate from 28 November 2013. The resolution is based on findings from the expert review mentioned above.

National Ecological Centre of Ukraine (NECU) also evaluated the expert review and found that as of 14 October 2013, 54 compulsory measures from the Complex (Consolidated) Safety Upgrade Program for Ukrainian NPPs (the 'safety upgrade programme') were not completed. 30 other measures to address defects or to implement the recommendations for improving safety at Unit 1 of the South Ukraine plant remain incomplete.

The expert review states that the assessment of the actual number of load cycles at the reactor for the overall period of its operation recorded an excessive number of cycles of 'planned cooling down to 'cold' conditions at the rate of 30°C/hour' mode. Moreover, an excessive number of actual (as opposed to expected) cycles were recorded as having 'Separate hydro-testing for strength in terms of primary coolant circuit (180 kg/cm2)". This shows that the

[1] Звіт про виконання державної експертизи ядерної та радіаційної безпеки матеріалів «Рішення про продовження терміну експлуатації корпусу і верхнього блоку реактора енергоблоку №1 ВП ЮУ АЕС в понадпроектний термін по ТР виконання оцінки технічного стану ТР.1.3812.2894 від 20.03.2013 р.». - http://necu.org.ua/wp-content/uploads/0002ZvitDNTC_YaRB_proPTE_YUUAES1.pdf

core component of the unit, the reactor pressure vessel´s integrity might be seriously compromised by this additional stress.

As requested by Energoatom, the evaluation of static and cyclic strength of the reactor vessel elements in an over-design period was performed to assess whether further operations at Unit 1 would be possible and whether evidence could substantiate these claims[2].

The reactor vessel is the only component of the nuclear plant that cannot be replaced. Its condition is vital for determining the lifetime of a unit. Therefore, when carrying out the expert review to substantiate the lifetime extension of a unit, it is necessary to evaluate the condition of the reactor vessel in the worst-case scenario i.e. a conservative approach is needed.

In order to conduct such an independent assessment of the reactor at Unit 1 for the extended life time and to check its compliance with strength standards, NECU together with expert support analysed elements of reactor vessel design[3] to establish whether they are compliant with the strength calculation standards for the equipment and pipelines used at nuclear power plants ПНАЕ Г-7-002-86 (the 'independent assessment'). Those elements of the reactor vessel at Unit 1, where cyclic vulnerability exceeds tolerable levels according to the Energoatom report, were selected as the focus of the independent assessment.

Based on the assessment, the following conclusions were made:

- The accumulated fatigue damage exceeds overwhelmingly the accepted limits for the metal of the flange joints of the protection management system, the neutron measurement and thermal control channels, the cover of the protection management system connections, reactor seal assembly, zone of the welding joint of the case of fitting pipe of emergency cooling system, the reactor vessel building-up zone, the separation ring and the welded connections 3 and 4 of the reactor vessel.

This means that **cracks might appear in listed elements of the reactor vessel at any time now and during operations beyond Unit's designed lifetime**.

- According to state regulations, the strength of the reactor vessel elements with cyclic vulnerability exceeding 0,8 should be assessed with due regard for extra earthquake load - 50 additional cycles. Energoatom's report lacks information and calculations in this regard, therefore the document needs further refining.

In other words the condition of cyclic strength is not met for a reactor vessel elements listed above and additional earthquake load is not considered. The remaining lifetime of the reactor vessel and elements thereof remains unknown for the time being.

The report has been developed with gross violations of strength standards and needs further improvement.

The state expert review for the resolution to extend the lifetime of Unit 1 does not comply with any of the state Strength standards which is not acceptable. Ukrainian law requires that decisions involving safety considerations use a conservative approach, i.e. one based on the worst-case scenario. However the conclusions of the expert review are quite vague and over-optimistic, and a number of critical safety issues are glossed over. For instance, the expert review does not state

[2] Report 'Evaluation of static and cyclic strength of the reactor vessels elements in over-design period for unit 1' of the SUNPP is available at: http://www.nirs.org/international/cee/sunpprzhezh714.pdf

[3] (see report 'Analysis of documents regarding the lifetime extension for unit 1 of the South Ukrainian nuclear power plant')

directly that the resolution on the extension of the lifetime is in conflict with Ukrainian regulations. Note that the assumption of the expert review when assessing a threatening trend of potential fluence accumulation at the area of weld joint 3 of the reactor vessel: 'the reactor vessel elements can accumulate neutron fluence more slowly than expected'. Such an approach appears to be far from conservative.

- The expert review neglects the displacement of critical brittle temperature as a result of cyclic loads for the welded connections 3 which is also against the conservative approach principles.

The findings of the independent assessment show that if the displacement of critical brittle temperature is taken into account, the lifetime of the reactor would probably be less than that approved by the Inspectorate. This means that extending the reactor lifetime until the 38th fuel campaign (or the 40th year) of the unit operation is overestimated and has to be revised..

Moreover, one critical regime (mode of operation) was omitted from the assessment of the condition of reactor pressure vessel at Unit 1. This mode could impact the state of the reactor and its remaining lifetime. According to the article by the state nuclear safety inspector for the Soviet State Nuclear and Radiation Safety Authority [4],on 22 October 1985 at South Ukraine NPP Unit 1 an emergency mode took place with "the rate of cool down of the reactor plant constituted 1800°C/hour. It exceeds the emergency cool down rate by 30 times.

The above mentioned mode of operation was not taken into account when assessing the static and cyclic strengths of the reactor vessel elements. Moreover, it was not taken into account in the expert review. Energoatom has confirmed[5] that a regime with the stopping of four main circulating pumps at the SouthUkraine Unit 1 has taken place on 22 October 1985 but the company does not call it an emergency mode.

NGO demands and recommendations:

Based on the above, the decision on the extension of lifetime of South Ukraine unit 1 was premature and unjustified and the safe unit's operation beyond designed lifetime is questionable.

Ukraine is in a critical state, so nuclear safety is critical because of the potentially disastrous effects. Ukraine, like other 'nuclear' states, cannot open itself to possible risk when it comes to nuclear and radiation safety - any emergency operation at nuclear power plants may result in serious consequences for people, the environment, the economy and national security.

NECU demands that Energoatom and the State Nuclear Regulatory Inspectorate of Ukraine **carry out an independent assessment and expert review of nuclear and radiation safety at Unit 1 of the South Ukraine nuclear power plant,** with the involvement of European specialists, IAEA representatives, European Nuclear Safety Regulators Group (ENSREG) members. Special attention should be paid to the assessment of the cyclic strength of elements of the reactor vessel, resistance to brittle crushing and the forecasted remaining lifetime of the reactor.

[4] http://atom.org.ua/?p=273

[5] Energoatom's letter dated 12.01.2015 № 176/32. - http://necu.org.ua/zapyt-netsu-do-naek-enerhoatom-schodo-nadannya-informatsiyi-pro-robotu-yuzhno-ukrayinskoyi-aes/

In case of negative results of the independent expert assessment and expert examination are obtained, the Inspectorate should **cancel license** No. EO 001019 for the right to conduct activities at the lifecycle stage "operation of the nuclear unit 1 of South Ukrainian NPP", and **Energoatom should stop operating the unit** and take steps to ensure safe working condition for personell and protection of the environment.

In addition, the Inspectorate should **carry out a thorough verification** of the fact that both South Ukraine NPP and Energoatom ignore the "22.10.85" mode which took place in 1985 and could materially affect the lifetime of the reactor vessel.

International donors funding the upgrade measures necessary to extend the lifetime extension for Ukrainian power generating units including the EBRD and the European Commission should **assume their share of responsibility for the safe operation of old nuclear reactors in Ukraine**. NECU calls international donors to:

- assist actively in the independent reassessment of the technical condition of unit 1 of South Ukraine NPP;
- carry out an assessment of the operational independence and professionalism of the Inspectorate in terms of Ukraine's compliance with its obligations under guarantee agreements[6], in particular with respect to the proper and transparent decision-making procedure for the lifetime extension for nuclear units;
- issue recommendations for the Inspectorate to achieve independence, impartiality and justification in its decision-making and place the compliance with these recommendations among the conditions for extending tranches under the approved loans;
- assist in bringing the decision-making procedure for beyond-design lifetime extensions in line with the requirements of national and international laws, in particular in the areas of nuclear safety and environmental protection.

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[6] Loan agreements for **Ukraine nuclear power plant safety upgrade programme** between the EBRD and Energoatom and between the EURATOM and Energoatom.