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Briefing on the Current Status of the K2R4 Completion Project

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Report for the Austrian Federal Ministry
of Agriculture and Forestry, Environment and Water Management

Risk Research Report No. 45

Vienna, November 2000

Summary:

In the K2R4 modernisation and upgrade program, a number of important safety issues is not adequately addressed. Therefore, the reactors must be regarded as particularly hazardous.

The claim that K2R4 reaches a Western safety standard is not substantiated. On the contrary, the safety issues not dealt with adequately clearly indicate that K2R4 would not be licensable in the West.

The new RISKAUDIT report shows that there have been no improvements of the modernisation program in the last years. On the contrary, the schedule for five important issues appears to be slipping. Furthermore, there are several issues where serious complications could arise which call into question the concept of the modernisation program.

A re-evaluation of the seismic hazards at Rivne and Khmelnitsky is urgently required. It is to be expected that the assumptions on seismic loads will have to be significantly increased. According to Russian or French standards, a maximum regional intensity of 7 as known from historical records would correspond to a maximum horizontal peak ground acceleration of 0.19 g or 0.25 g, respectively, as opposed to 0.05 g as previously assumed. Another problem not sufficiently considered is the possible activation of karst processes by the construction of the plants which can lead to the weakening of foundations.

The economic situation in the energy sector in the Ukraine is alarming. Means are lacking for repair, maintenance and upgrading. It is not plausible to assume that K2R4 could be isolated from the general deplorable state of affairs. Furthermore, it is highly unlikely that Ukraine will be able to implement a costly modernisation program for all nuclear power plants, as required by EBRD.

Finally, the financial volume in the order of 500 million US-$ per unit, as envisaged for K2R4, is lower by a factor of 5 to 6 than the budgets for comparable projects in the Czech Republic and Germany, which were, however, still not sufficient to reach Western safety standards.

The arguments presented here are not meant to imply that the Ukrainian energy sector should not be supported by loans from Western banks. But other, possibly more modest investments in operating installations will help the Ukrainian economy much more effectively – without new nuclear power plants. It would be highly appropriate if they were supported by the EBRD.

Shortcomings of the K2R4 Modernisation and Upgrade Program:

The Institute of Risk Research of the University of Vienna has identified, in a report of October 1998[i], a large number of safety issues which are not or not adequately addressed in the K2R4 modernisation and upgrade program.

Among those, there are many issues of high safety significance, for example:

- Safety of steam generator collectors and tubes
- Fire prevention/fire protection
- Seismicity
- Reactor pressure vessel embrittlement
- Containment structure and containment bypass hazards
- Spectrum of design base accidents (DBAs) and beyond design base accidents (BDBAs) to be analysed
- Influence of extreme whether conditions

All in all, 29 safety issues which are not dealt with adequately were identified. If the modernisation and upgrade program is implemented as planned, the operation of the K2R4 reactors must be regarded as particularly hazardous because of those shortcomings of the program.

K2R4 and the Western Safety Standard:

In the above-mentioned report[i], it was made clear that claims K2R4 reaching an *'internationally acceptable safety level'* or *'a safety level similar to that of similarly aged but recently re-licensed Western plants'* , as forwarded by Energoatom, are in no way substantiated.

It has been claimed that K2R4 will at least conform to the IAEA NUSS series of standards, which have to be regarded as a bare minimum. However, no point-by-point comparison of the K2R4 designs with the NUSS standards has been submitted so far.

An important indicator for the general safety level of a nuclear power plant is provided by a probabilistic safety analysis (PSA). A PSA, however, is not scheduled to be performed for K2 and R4 until after start-up.

Furthermore, many of the safety issues not dealt with adequately in the modernisation and upgrade program are clearly indicative of severe design deficiencies which would not permit licensing of the reactors in Western countries – for example, inadequate seismic design, proneness of reactor pressure vessel to embrittlement, containment design (single-shell containment).

The Revised RISKAUDIT Report of November 2000 and the Time Schedule of the Modernisation Program:

Recently, RISKAUDIT has submitted a revised final safety assessment report for the EBRD loan procedure[ii]. In this report, the current status of the modernisation program is reviewed.

From the report, it becomes clear that no improvements of the program have been implemented since the previous report of RISKAUDIT was compiled in December 1997[iii]. It is stated explicitly that *"[n]o major changes in the measures foreseen in the Modernisation Programme have been noted."*[iv]

The report also shows, however, that the time schedule of the modernisation program is deteriorating. In particular, there are five important measures the timing of which seems to have been clear in 1997, but is today emphasised as requiring clarification by RISKAUDIT[v]:

- Development of materials on equipment qualification
- Implementation of devices to measure Boron-10 concentration
- Hydrogen removal from reactor plant primary circuit, analysis of hydrogen safety
- Analysis of air conditions inside rooms of safety system at lower ambient temperatures
- Elaboration of accident procedures

The authors of the RISKAUDIT report obviously are concerned about the slippage of the schedule; hence the report contains statements like, for example, *"it has to be pointed out that the implementation of former RISKAUDIT recommendations is still actual"*[vi] and *"[t]he lack of progress which has been noticed can impact the schedule of the safety substantiation of the units before start-up"*[vii].

Apart from the five points listed above, there appear to be only minor shifts in schedule between 1997 and 2000. The fact remains that a significant portion of the measures will be implemented after start-up of the reactors. In many cases, that means implementation at the first time when the reactors are shut down for refueling. For VVER 1000s, this most likely takes place about one year after the first start-up. Hence, the units at K2R4 will operate for this period of time even without many of the planned improvements; perhaps even longer, if measures are implemented at later refueling stoppages.

In the 1997 RISKAUDIT report, seven measures were identified *"which may lead to problems difficult to be solved during implementation"* or *"to further requirements"*[viii] – in other words, those are issues where complications can arise which seriously call into question the concept of the modernisation program.

Those measures are still identified in the same way in the report of November 2000; hence, no progress has been made in the clarification of those crucial issues[ix]:

- New control strategy (Xenon oscillation and power distribution)
- Development and implementation of measures to control leakage primary/secondary circuit
- Providing 'rigid embedding' of steam and feedwater pipelines at 28.8 m level
- Analysis to determine the extent of pipeline breaks impact inside the reactor building
- Rigid support of steam and feedwater lines
- Assessment of the risk of 'average minimal temperature' and 'extreme cold condition'
- Develop materials on equipment qualification

It is noteworthy that these issues overlap to some extent with the issues with an increasingly unclear schedule as listed above.

Since there have been no improvements in the modernisation program at all, combined with a deterioration of the schedule, the assessment of the Institute of Risk Research of Vienna University of October 1998 is still fully valid today; if anything, the overall situation at K2R4 has become worse.

Re-evaluation of Seismic and Geologic Problems:

New results concerning the seismic threat to K2R4 and other geologic problems have not been taken into account in the modernisation program at all and, as far as can be seen, were not considered by RISKAUDIT. Those problems alone require comprehensive new studies and very likely will have far-reaching consequences for the K2R4 project.

Until recently, the Eastern European Platform was considered to be an aseismic area. A re-evaluation of earthquake hazards in the South Ukrainian region, however, resulted in the cancellation of the Crimean nuclear power plant project, after ten years of construction[x].

A seismic upgrade of Khmelnitksy nuclear power plant was suggested in a hazard study by Van Gelder and Varpassuo[xi]. Their analysis shows a peak ground acceleration of 0.18 g at a return frequency of 1:10.000 years – considerably higher than the value of 0.05 g for the same frequency in the Mouchel study[xii].

Rokityansky[xiii] also raises the question of the effects of strong earthquakes in Romania on large areas of the Ukraine. Other authors[xiv] report on neotectonic activity and a renewed seismic activity in the Carpathians and the Eastern European Platform. In a recent publication, a neotectonic uplift of up to 300m is reported in the Ukraine south of the Pripyat depression[xv]

A re-evaluation of the seismic hazards at Rivne and Khmelnitsky is therefore urgently required. Even without application of newly developed, paleoseismic methods, it is to be expected that the assumptions on seismic loads will have to be significantly increased. According to Russian or French standards[xvi], a maximum regional intensity of 7 as known from historical records would correspond to a maximum horizontal peak ground acceleration of 0.19 g or 0.25 g, respectively.

Another problem recognised only recently concerns karst phenomena. The presence of such phenomena is among the exclusion criteria for siting of nuclear power plants in several countries.

The construction of the plants at the K2R4 sites can result in an activation of karst processes which would not have occurred naturally, because of additional technogenic infiltration, recharge of groundwater and a change of the underground environmental processes. First studies by Ukrainian scientists[xvii] provide evidence of high risks due to changes in the geological environment. A development of karst processes on a regional scale can lead to a weakening of the strength and stability of rocks and foundations, hydro- and geomechanical impacts on external facilities like open pit mines and to greater effects of local seismicity.

Economic Factors Influencing Safety:

The financial situation in the energy sector in the Ukraine gives reason for concern. In the first eight months of the year 2000, the cash collection rate of Energoatom was about 20 %[xviii]; it was still lower in the years before.

The consequence is that required measures of upgrading, repair and maintenance cannot be performed for lack of funds. For example, it is generally recognised that the steam generators of the VVER 1000/320 series have a high failure rate. Yet, steam generator replacements cannot be performed as planned in Ukrainian nuclear power plants because the new components have to be imported from Russia and the Czech Republic and there is not sufficient hard currency available.

A report by an Ukrainian press agency emphasises this point:

“In December [1999], when the energy crisis hat the Ukraine and initiated fan-pattern blackouts, it became clear that not stingy Europe or intrigues from Moscow caused

the crisis. One third of the Ukrainian nuclear power reactors were out of operation because of lack of money for the repair and maintenance ...“[xix]

This is the economic context in which K2R4 is to be completed and to go into operation. It is not plausible to assume that those two reactors can be isolated from the deplorable state of affairs generally existing in the energy sector.

Furthermore, this situation renders it highly unlikely that Ukraine will be able to implement a costly modernisation program for all nuclear power plants in the country, as required by EBRD[xx]. The repayment of K2R4 loans would further aggravate the lack of funds for repair, maintenance and upgrades of nuclear power plants.

Comparison to other VVER 1000 Modernisation Programs:

A brief comparison of the volume of the K2R4 modernisation program with other projects planned or implemented clearly shows the inadequacy of K2R4 modernisation.

The completion and upgrade of Temelin unit 1 required a budget of about 3 billion US-$[xxi] and included measures far more comprehensive than the K2R4 program. Even so, Temelin 1 could not achieve a Western safety standard – shortcomings remained, for example regarding seismic design, containment design, pipe whip restraints and reactor pressure vessel embrittlement.

A similar estimate was given in the early 90s for the completion of the Stendal unit A VVER 1000 (2.3 – 2.9 billion US-$[xxii]). In the case of Stendal, too, open safety issues remained. This project was given up both for economic and safety reasons.

Thus, a financial volume in the order of 500 million US-$ per unit, as envisaged for K2R4, is lower by a factor of 5 to 6 than the budgets for comparable projects in the Czech Republic and Germany, which were, however, still not sufficient to reach Western safety standards.

Concluding Remark:

The arguments presented here are not meant to imply that the Ukrainian energy sector should not be supported by loans from Western banks.

But other, possibly more modest investments in operating installations will help the Ukrainian economy much more effectively – without new nuclear power plants. It would be highly appropriate if they were supported by the EBRD.

Footnotes:

[i] P. Hofer et al.: Comments on the Safety of Khmelnitsky Unit 2 and Rivne Unit 4 in the Frame of the Public Participation Procedure of EBRD

[ii] Final Safety Assessment Report for the Loan Approval Procedure; RISKAUDIT Report N° 120-Rev.1, November 2000

[iii] Final Assessment Report for the Loan Approval Procedure; RISKAUDIT Report N° 120, December 1997

[iv] RISKAUDIT November 2000, sec. 1.6

[v] RISKAUDIT November 2000, Appendix I

[vi] RISKAUDIT November 2000, sec. 3.6

[vii] RISKAUDIT November 2000, sec. 3.8

[viii] RISKAUDIT December 1997, Appendix 1

[ix] RISKAUDIT November 2000, Appendix 1

[x] I.I. Rokityansky: Vulnerability to earthquakes in the Ukraine; 2nd EuroConference on Global Change and Catastrophe Risk Management, Earthquakes Risks in Europe, IIASA, Laxenburg, Austria, 2000

[xi] P. van Gelder, P. Varpasuo: Bayesian seismic hazard assessment for a nuclear power plant; in: S. Lydersen (ed.), Proc. Europ. Conf. on Safety and Reliability, Trondheim, 1998 (Vol. 2, 1437-1443)

[xii] Environmental Impact Assessment for Completion of Khmelnitsky Unit 2 Nuclear Power Station; Mouchel Consulting Ltd., Contract No. 97/06/21.00, MCL 482 16-R1/Version 3.1, June 1998

[xiii] Rokityansky 2000

[xiv] I.I. Chebanenko et al.: The net of global fracturing of the Carpathian-Balkanian-Dinarian orogenic system; National Academy of Sciences of Ukraine, Kyiv, Geol. Journal No. 1-2, 9-13, 1998 & V.P. Palienko: The structure geomorphical features for the neotectonic rejuvenation zones in the Eastern Carpatians; Geol. Journal No. 1-2, 14-20, 1998 & L.S. Galetskiy, T.P. Shevchenko: Planetarium geodynamic system of throughout ore concentrating zones of activation; Geol. Journal No. 1-2, 54-65, 1998

[xv] A.K. Karabanov et al.: The recent vertical movements in the Pripyat depression; Pancardi 2000, Dubrovnik, Vjesti Hrvatskoga geoloskog drustva 37/3, Zagreb, 2000

[xvi] Russian standard PNAE G7-002-86 and French SCSIN standard

[xvii] V.M. Shestopalov et al.: Materials for Analyses of the State of Geological Environment within the Territory of the Rivne NPP; Site Report prepared for Insitute of Risk Research, Vienne, 1998

[xviii] Completion and Safety Upgrade of Khmelnitksy Unit 2 and Rivne Unit 4; European Bank for Reconstruction and Development (EBRD), BDS00-154, 15 November 2000, sec. 1.3.1

[xix] Ukrainian press agency “Versia”, Bulletin from May 1, 2000

[xx] EBRD 15 November 2000, President’s Recommendation

[xxi] Nucleonics Week, June 25, 1992 & Nucleonics Week, January 14, 1999

[xxii] Sicherheitstechnische Bewertung des Kernkraftwerkes Stendal, Block A, vom Typ WWER-1000/W-320; Gesellschaft für Reaktorsicherheit, GRS-99 & Supplementary Facts to the Press Conference, 20 March, 1991, of NPP Stendal management, 27 March, 1991