ENERGIE
VERWERTUNGSAGENTUR

EXECUTIVE SUMMARY

Economic Assessment of the Khmelnitsky 2 and Rovno 4 („K2/R4“) Nuclear Plants in Ukraine

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2 LEAST COST STUDY – EXECUTIVE SUMMARY

E.V.A has been commissioned with an Economic Assessment as part of comprehensive comments for the Austrain Government on the project of completing the Khmelnitksy 2 and Ronvno 4 („K2/R4“) Nuclear Plants in Ukraine, in particular on the project documentation released by ENERGOATOM as part of the consultation with the public as requested by the EBRD. E.V.A in turn passed on part of the work to Sussex University's Science and Technology Policy Research (SPRU), the Institute of Risk Research (IRR) Vienna and the Vienna Institute for Comparative Economic Studies (WIIW). Accordingly this Executive Summary is mainly based on 3 detailed reports (see annex 1-3):

- The Case for Completing the K2/R4 Nuclear Plants in Ukraine: A critique of the Stone and Webster Report of May 1998, report to the E.V.A. by P. Bradford, G. MacKerron, J. Surrey & S. Thomas, SPRU (Science and Technology Policy Research), University of Sussex, Falmer, Brighton, UK, October 1998 (96 p.);
- Cost Estimation of Implementing the Safety Upgrading Measures for K2 and R4, Draft Report, report to the E.V.A. by Institute of Risk Research (IRR) Vienna, October 1998 (22 p. excl. tables);
- The K2/R4 Completion Decision in light of Ukraine's Recent History of and Prospects for Economic Transition, Final Report by the Vienna Institute for Comparative Economic Studies (WIIW) to the E.V.A., October 1998 (32 p. excl. tables).

The report by Stone & Webster (S&W)[1], made available by the project sponsor EnergoAtom in the Project Documentation, concluded that K2/R4 is the best use of the available capital, or 'least cost', and, not least on that basis, the EBRD has given provisional approval for the project to go forward.

However, a comprehensive analysis of S&W shows that completing these reactors would not represent the most productive use of US$1bn or more of Western funds.

A fundamental problem with the S&W report is the methodology used, a computer-based least cost planning model, which is inappropriate in a situation as uncertain as Ukraine faces. A frequent flaw running through many of the arguments of S&W is the tendency to state the unknowable with certainty. When an economy is so dislocated and abnormal (as Ukraine's), and hyper-inflation has wiped out savings, where the international value of the currency is low and many bills remain unpaid, prediction is very difficult. All the key parameters involved in a 'least cost' assessment for Ukraine are surrounded with great uncertainty. **The type of model used by S&W can be highly sensitive to even small changes in input assumptions and the uncertainty surrounding the key variables means that there is a high risk that the results produced by such a model will be wrong.**

S&W's conclusions stem directly from the assumptions fed into the model. The conclusion of this report, that the completion of K2/R4 is not least-cost, is based on an assessment of the assumptions chosen for the following variables:

[1] Stone & Webster Management Consultants, Inc., Least-Cost Electric Power System Development Analysis, UKRAINE, Completion of Khmelnitsky 2 and Rovno 4 Nuclear Power Generators, Economic Due Diligence, Report to for European Bank for Reconstruction and Development, May 1998

2.1 Electricity demand

Forecasts of power demand turn on estimates of when sustained economic growth will return, and of the pattern that industrial restructuring will take then. The IMF's economic forecast for Ukraine was revised downward in early September to reflect the Russian contagion, from 3 % to 1 % growth for 1999, 3 % in 2000 and 4 % in 2001. WIIW is currently forecasting essentially zero growth in 1998, 1 % in 1999 and 2.5 % in 2000-2004. Growth will remain low for the foreseeable future, with the consequence that demand for energy overall, and electricity in particular, will likely fall further and then recover only slowly; even 5 % economic growth after 2003 does not necessarily imply energy consumption in 2010 above 1995 levels.

Furthermore, power demand will stagnate both if reforms falter and if they go ahead vigorously. It is only under the illogical scenario of rapid growth with slow structural change that power demand would grow rapidly in the period up to 2010.

Sustained economic growth will probably involve significant reduction and modernisation of Ukraine's traditional heavy industries, and the growth of new industries and services. Both factors should strongly encourage more economical use of electricity, and they should also favour energy efficiency schemes of the type now being promoted by the World Bank and the EBRD, but not reflected in the S&W report.

Consequently, there is still a considerable surplus of installed generating capacity (nearly 100 per cent), and the need for additional base load plant such as K2/R4 is a long way off, beyond 2010.

2.2 Expected completion costs

There have been a number of successively higher cost estimates for completion, modernization, and commissioning of K2/R4. These estimates are:

- EBRD Study of Economic Aspects of Nuclear Generation and Safety Improvements in Eastern and Central Europe, June 1993, US$0.92bn
- USDOE/Minatom Study, July 1994, US$0.98bn
- Energoatom Project Presentation, August 1988, US$1.25bn
- EBRD, September 1998, estimated the cost of completing both units and providing support to the Ukraine Nuclear Regulatory Authority at US$1.725bn.

There can still be little confidence in any of the various elements of the estimated costs of completing and operating K2/R4. This basic lack of confidence in the cost estimates makes K2/R4 a high risk investment – especially as we have no reason to think that the avoidable cost of generation from the fossil fuel plants that K2/R4 would replace would be higher than the generating cost of K2/R4 (including the investment cost and return on capital).

Experience with the Temelin and Mochovce nuclear plants, in the Czech and Slovak Republics respectively, illustrates the severe problems in completing nuclear plants of Soviet design. Temelin suggests that the financial risk is greater, the larger the amount of re-design, retrofitting, and modifications which are undertaken. Technical and organisational problems in the Temelin completion project caused considerable cost over-runs and delays in this project. The need for a major modernisation programme at K2/R4 suggests a similar development could be expected there.

S&W argue that some of the uncertainties attaching to the completion costs have been resolved since the Panel reviewed these costs in February 1997[2]. In particular the modernisation (safety upgrade) programme (MP) is now said to have been finalised and therefore more confidence can be placed in one of the more uncertain areas of costing the completions. **However, it is not clear that the modernisation programme is as final as argued (see detailed report by IRR). There has, for example, been no survey of the condition of the dormant plants, and without such a survey, cost estimates are particularly speculative.**

There is significant evidence based on probabilistic safety analysis (PSA) results from other WWER-1000/320 units and the lack of treatment of relevant issues, identified by IRR, in the K2/R4 Modernization Programme (MP) to conclude that a minimum of internationally required safety level (INSAG-3[3] , IAEA) is not reached by the project.

Further costs than quoted in the present MP for implementing more comprehensive measures to solve these issues have to be expected.

2.3 Expected lead-time of K2/R4

Any delays beyond the completion dates, based on the expected completion time of 30 months, at the time of loan disbursements will have further financial consequences.

Interest during construction will directly increase. In addition, there is the possibility that EnergoAtom will have to start repaying the loans before there is any sales revenue from the new plant, a problem that has affected Temelin in the Czech Republic.

2.4 The Operating Costs and Performance of K2/R4

The S&W report significantly over-estimates the reliability of K2/R4 and seriously underestimates the running costs. It assumes the load factor for K2/R4 will be 75 per cent, well above the level any of the WWER-1000 plants in the FSU and Eastern Europe has achieved. Such a level of performance may be a useful target but is entirely inappropriate for investment appraisal which should be based on the most likely outcome. The lack of any sensitivity tests of operating performance for K2/R4 suggests an assumption that performance levels are highly predictable. This is far from the case: nuclear operating performance varies widely from plant to plant even for apparently similar plants.

The S&W report assumes a production cost for K2/R4 (operations and maintenance [O&M] costs and fuel costs) of about US$13/MWh. Official US data for American plants suggests that an assumption of double that, US$26/MWh, would be more appropriate. The likely savings from building K2/R4 are highly sensitive to the running costs of the nuclear power plant. For example, using S&W data, K2/R4 will operate at half the cost of a cheap, efficient Ukrainian fossil-fired plant, while basing the costs on US experience, the savings disappear. The lack of any sensitivity testing on the O&M costs is a serious omission. In the USA, O&M costs vary by a factor of three with no obvious explanatory factors.

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[2] International Panel of Experts chaired by Professor John Surrey, Economic Assessment of the Khmelnitsky 2 and Rovno 4 Nuclear Reactors in Ukraine: Report to the European Bank for Reconstruction and Development, the European Commission and the US Agency for International Development, SPRU, University of Sussex, England from 4th February 1997

[3] International Nuclear Safety Advisory Group of the IAEA, Report No. 3

2.5 Assumptions on Existing Fossil Fuel Plant and New Capacity Options

The assumption that a significant capacity of existing fossil fuel plant is retired by 2004 is crucial in creating an apparent need for new capacity from 2007 onwards, which is met by K2/R4. However, imposing a pre-determined retirement date for existing fossil fuel plant is not appropriate. The correct way to deal with it would be to estimate the costs that would be incurred in keeping this plant in service and then allow the model to calculate whether it is economic for it to be retired and replaced by new plant. If this plant is not arbitrarily retired, on all except the S&W high demand growth scenario, there is no need for K2/R4 until after 2010, when the need may be for load-following, not base-load plant.

More realistic cost data for combined cycle gas turbines (CCGTs) suggest that this option is likely to be a much cheaper way of meeting any need for base-load generating plant. Moreover, provided they have suitably flexible gas contracts, CCGTs are much better suited to non-base load operation than nuclear plants.

Combined cycle gas turbines (CCGTs) are likely to have far fewer economic risks because much stronger guarantees on performance and costs are available from the equipment suppliers.

2.6 Fossil fuel prices

The future price assumed for fossil fuels, coal, oil and gas has an important bearing on the case for K2/R4. The output of K2/R4 will substitute for power generated using fossil fuels. Therefore the higher the assumed price of fossil fuels, the bigger the savings there will be in running K2/R4 instead of existing fossil fuel plants.

There is no strong case for assuming that the price of fossil fuels will either fall or rise over the period relevant for K2/R4. As a result, the Panel and S&W assumed that the international price of fossil fuels would be unchanged in real terms (in US dollars) throughout the period to 2010, the period over which K2/R4 were assessed.

The S&W report implicitly assumes that the Ukraine coal industry rationalisation plan will fail and that the privatised utilities will continue to choose to buy low quality Ukrainian coal. If the coal industry rationalisation plan is reasonably successful, the cost of Ukrainian coal should stabilise or even fall and its quality improve. If it is not successful, there are many low-cost coal producers from which coal could be imported, and it is likely that privatised generators in Ukraine's competitive wholesale power market would take this opportunity to reduce the main element in the cost of coal-fired generation. Use of higher quality coal would avoid the need to waste imported natural gas using it as a supplementary fuel to poor quality Ukrainian coal.

Sensitivity tests are included in the S&W report which envisage higher and lower than forecast fossil fuel prices. **The procedure of allocating a probability to the future price level for fossil fuels in the S&W report is highly dubious and these sensitivity tests have little validity – it is not possible to estimate the probability for a variable which is essentially unpredictable. However, the S&W report does show that the case for K2/R4 is highly sensitive to the price of gas. Using more realistic assumptions on the construction cost and performance of CCGTs, it is likely the model would show that any fall in the price of gas would make K2/R4 very bad investments compared to CCGTs even if S&W's assumptions on K2/R4 were accepted**

2.7 Least cost alternatives

There is no shortage of economically attractive projects in the Ukrainian energy sector on which US$1bn or more could be spent more productively than on completing K2/R4. These include:

- nuclear plant safety upgrades including measures for improvement of performance;
- restoring non-nuclear plant to efficient working order;
- rehabilitation of municipal district heating plants (including conversions to combined heat and power);
- reinforcing the electricity grid where needed;
- a wide range of energy efficiency projects, especially in infrastructure and publicly owned buildings such as hospitals, schools and pumping plants.

The need for safety upgrades at the 11 existing WWER-1000 stations is pressing. If the safety upgrades increase reliability, the extra output of the existing nuclear stations would make K2/R4 even more uneconomic. However, if the safety upgrades did not increase output, K2/R4 would be no more reliable than the existing WWERs.

Also an extensive fossil fuel power plant rehabilitation programme to complement the government's plan to concentrate coal production on the lower-cost mines and put the coal industry on a commercial footing is essential.

CCGTs, which are largely factory-built and which have a long record of international experience with comparable plants, appear to be a much lower risk option for new capacity than K2/R4, which will mainly require site work.

It is difficult to quantify the effects of improved electricity efficiency in a least cost model, but to ignore the potential, as S&W do, further strains the credibility of the conclusion that K2/R4 is least cost**.**

The commitment of the World Bank and EBRD to the Energy Efficiency Plan suggests that efficiency improvements are likely to be least cost. A low risk least cost strategy would be to direct capital investment to a large number of less expensive projects.

2.8 Conclusion

In the light of a comprehensive analysis of the assumptions of S&W and the economic developments in Ukraine, completing K2/R4 is likely to prove a costly and risky diversion away from addressing the urgent problems that the Ukrainian electricity sector is facing. **Whether or not Chernobyl is closed, there is unlikely to be any need for K2/R4, especially if the reliability and efficiency of the existing nuclear and fossil-fired plants can be improved.**

The 1995 Memorandum of Understanding (MOU) between G7 and Ukraine seemed to offer a sure way to close Chernobyl by offering grants to cover the direct costs of cleaning up the site and guaranteeing US$1.8bn of much-needed Western loans for investment in projects in the Ukraine electric power sector. The MOU was right in addressing Ukraine's urgent need for capital, but unfortunate in appearing to tie most of the capital to K2/R4. Abandoning K2/R4 now would clear the way for the flow of investments to more profitable and less risky projects, of which there are plenty.