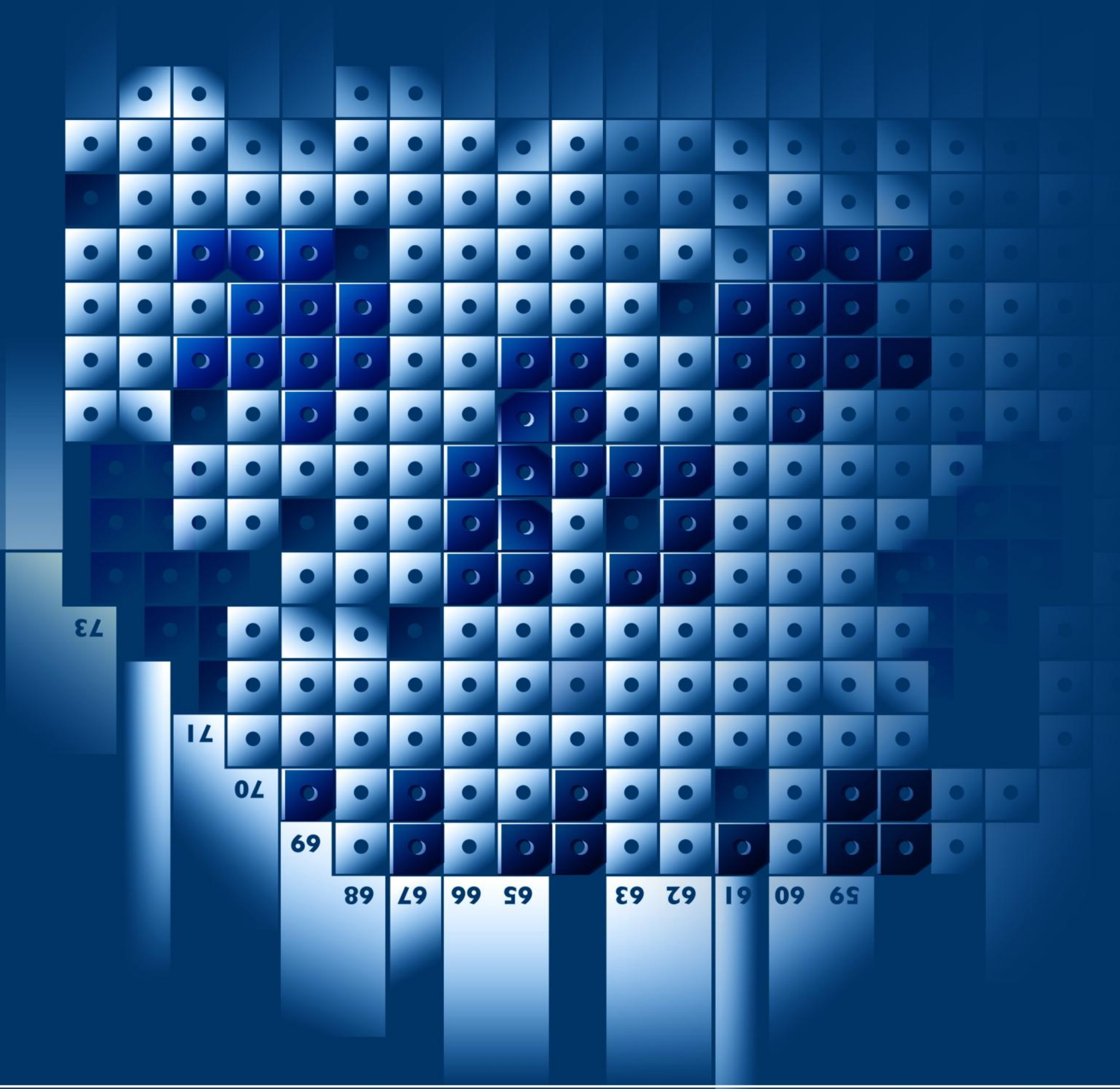
Khmelnytska Nuclear Power Plant Units 3 and 4 Completion Project



ISSUE PAPER

PROJECT OF COMPLETION OF UNITS 3 AND 4 OF THE KHMELNITSKY NUCLEAR POWER PLANT

PLANS, OPPORTUNITIES AND PROBLEMS

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Abbreviations

PWR – Pressurized water reactor

SNF – Spent nuclear fuel

PSP – Pumped storage plant

HPP – Hydroelectric power plant

SNRC – State Nuclear Regulation Committee

SFTC – State Foreign Trade Company

ZNPP – Zaporizhya Nuclear Power Plant

ICUF – Installed Capacity Utilization Factor

IAEA – International Atomic Energy Agency

IEA– International Energy Agency

NNEC – National Nuclear Energy Company

NTRES – Non-traditional renewable energy sources

NERC – National Electricity Regulatory Commission of Ukraine

IPS – Integrated power system

WEM – Wholesale electricity market

WMP – Wholesale market price

FEC – Fuel and energy complex

RAW – Radioactive waste

RNPP – Rivne Nuclear Power Plant

IFS – Investment feasibility study

TPP – Thermal power plant

CHPP – Combined heat and power plant

KNPP – Khmelnitsky Nuclear Power Plant

CNPP – Chernobyl Nuclear Power Plant

Introduction

The aim of this issue paper is a research and in-depth analysis of the project of completion of units 3 and 4 of the Khmelnitsky Nuclear Power Plant which has already been approved by the Government. The issue paper covers potential benefits for Ukraine and possible related adverse impact on the country's economic, political, social and environmental areas.

A deeper evaluation may be done upon the availability of all the IFS materials. However, it is already very clear that the project in its current form bears significant technical and environmental risks. A more detailed and specific analysis will be conducted after the publication of the full IFS materials which will include the information about how the new nuclear units will fit with the country’s existing energy structure, description of the necessary resources (project economics), detailed decommissioning scheme etc.

The first section of this issue paper contains a general overview of Ukraine's energy sector and covers the dynamics of changes in the energy production structure during the recent 20 years, energy exports etc.

Section two provides a direct analysis of the project of construction of units 3 and 4 at the Khmelnitsky Nuclear Power Plant. The arguments given in this section make the public extremely concerned over the construction plans.

Section three describes general problems observed in the energy sector.

Summary

The Energy Strategy of Ukraine to 2030 (hereinafter referred to as the Energy Strategy) was approved by decree of the Cabinet of Ministers of Ukraine No. 145-p dated March 15, 2006. The document outlines key goals, objectives and priorities of the country in its fuel and energy complex (FEC).

The Energy Strategy offers significant increase of nuclear power production. It is expected that the share of energy production by nuclear power plants (NPPs) will remain at a level reached in 2005 (nearly 50%). The plans for construction of new NPP facilities until 2030 are defined by the number of existing units which may be in operation during this period as their term of operation is extended by 15 years. 9 of 15 currently operating nuclear power units will be in operation in 2030. Therefore, to reach the goals of the Energy Strategy in terms of energy production it is necessary to put into operation 20-21 GW of substituting and additional facilities at the NPPs by 2030. The Energy Strategy sets plans to construct and put into operation units 3 and 4 of the Khmelnitsky Nuclear Power Plant by 2016.

The first unit of the Khmelnitsky Nuclear Power Plant was put into operation in 1987, and the second unit was added in 2004. The plant is designed to have 4 units, and for the time being it has units 3 and 4 that are in different state of availability and the construction of which began in the 1980s.

On April 21, 2010 Ukrainian Government signed an agreement with Russian Federation to receive a loan to complete the construction of two units of the KNPP.

However, the possibility and - more importantly – the necessity to complete the construction of two units at the KNPP raise a number of technical, economical and environmental questions. The key questions are:

- **Lack of economical and strategic reasons** to expand nuclear power facilities, as Ukraine already has the excess of installed power facilities and a significant potential for energy saving and upgrade of the existing facilities;

- **Choice of risky and insecure reactor.** In the 1980s power units were designed for the VVER-1000 (V-320) series of nuclear reactors, and now there are plans to install the VVER-1000 (V-392B) series of reactors which have not been installed at any plant for the time being and it is not clear if such reactors are suitable for half-constructed facilities of the KNPP;

- **Clear threat of the increased project timeline and budget.** As of March 2010, Rosatom State Corporation (the main equipment supplier) was constructing 15 power units in Russia and abroad[1]. Most projects (especially export contracts) have shown significant increase of construction times and costs[2]. Correspondingly, reasons exist to doubt in the claimed terms and costs of completion of the power units at the KNPP;

[1] http://www.rosatom.ru/ru/about/press_centre/details/index.php?id4=17583

[2] http://www.proatom.ru/modules.php?name=News&file=article&sid=2252

- **Water resources.** The issue of water resources for the NPP is of particular importance. One VVER-1000 series reactor needs 60,000 litres of water per hour[3]. According to international classification, Ukraine is among the countries that have poor water resources (1,000 m^3 per person). In most regions of Ukraine this index is very or extremely low (0.11 to 1.95 thousand m^3). However, Ukrainian NPPs are located exactly in such regions which lack water resources. The Khmelnitsky NPP is situated in the upper course of the Goryn River; its flow volume is not sufficient to cool down the four power units of the KNPP without damage to the ecosystem of the Goryn River. The Rivne NPP is located in the middle course of the Styr River. In the low-flow period, this river shows deficiency of water, so the available water resources are not sufficient for the further construction of the Rivne NPP. The mode of operation of the projected power-generating plant on the Southern Buh River suggests the water level fluctuations of over 2 meters during the day, which will fully destroy the river's natural conditions in an area of over 100 km.

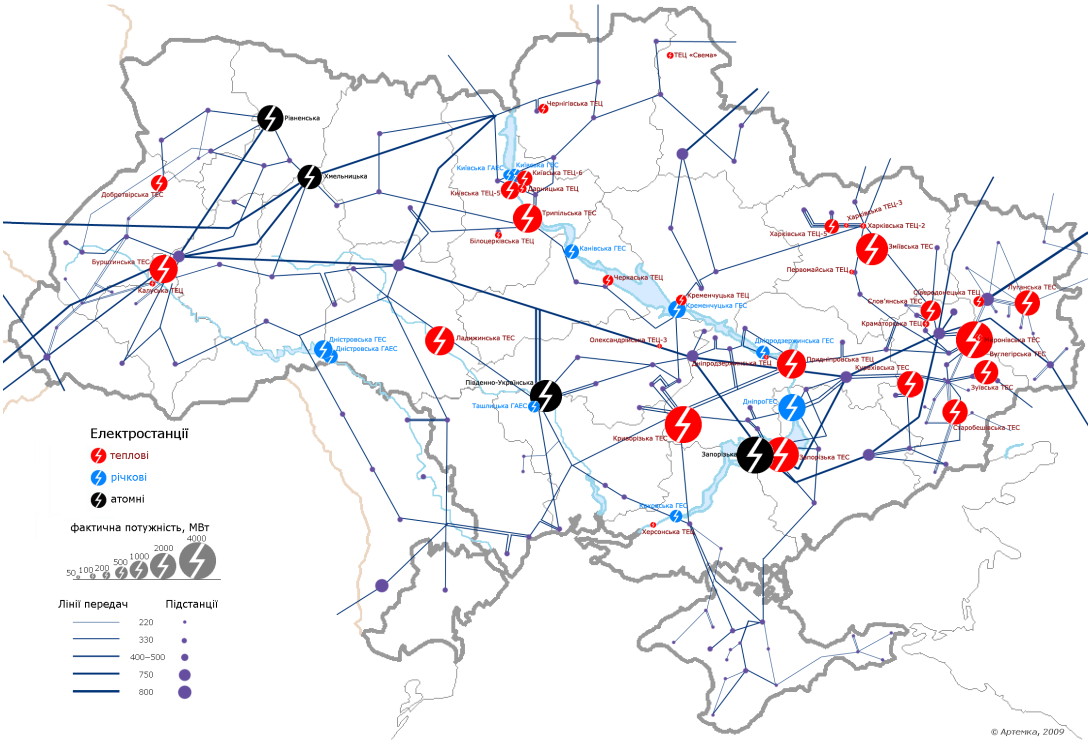
- **Waste management.** Traditionally, radioactive waste (RAW) management is one of the most pressing problems of the nuclear industry. estimates show that reactors of the VVER-1000 type generate from 40,000 to 135,000 m^3 of liquid radioactive waste (Bulatov, 1999). Operation of NPPs leads to the accumulation of solid RAW (polluted clothes, building materials, instruments etc) which are stored to be buried in future. As a result, literally all Ukrainian NPPs accumulate radioactive waste, though the operator (National Nuclear Company Energoatom) has not taken any feasible steps to create proper conditions for the waste burial.

Therefore, even the brief overview of the plans to complete the construction of units 3 and 4 at the KNPP shows technical risk, insecurity and economic inexpediency of the project, which, additionally, will have a severe adverse impact on the region's environment and local ecosystems.

[3] http://www.rnpp.rv.ua/virobnictvo/tekhnologichna-skhema-kharakteristiki-obladnannja/

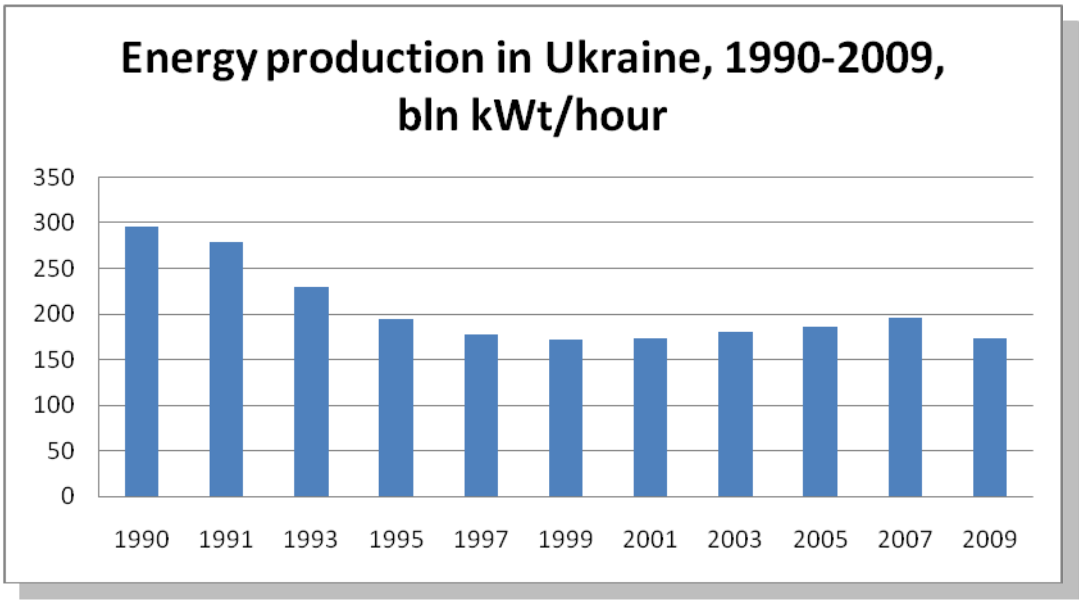
1 Electricity Generation Market Overview

1.1 Energy needs and energy generation



Ukrainian energy production and consumption sector has seen major changes during the recent twenty years. Collapse of the USSR and industrial decline led to the dramatic decrease of energy production. In 1990, Ukrainian energy plans generated 295 bn kW/hour, and the consumption levels in the same year peaked at 41 GW. The total installed capacity in 1990 was approximately 53GW. In 1990 the demand for energy was stably dropping reaching the minimum in 2000[4]. Stabilization of the country's macro economy and the growth of domestic demand caused the revival of Ukrainian economy and, consequently, the growth of energy consumption. From 2000 to 2007 the country's economy was growing with the average GDP growth rate of 7.5% annually. Such growth rates have brought Ukraine to the leading positions in terms of economic development. For almost 8 years, between 2000 and 2008, energy production and consumption levels were steadily growing.

[4] State Statistics Committee of Ukraine



The peak of consumption in this period was 196 bn kW/hour in 2007, which is 66% of the 1990 levels. Ukraine is among the countries which were least exposed to the global financial and economic recession. According to the Ministry of Fuel and Energy, in 2009 the levels of energy production in Ukraine were 172,907 mn kW/hour[5], which is the same as in 1999-2000.

Significant decrease in energy consumption caused the pause in operation of significant excessive facilities, mostly the TPPs. This resulted in the considerable changes in the structure of energy production by fuel type. In 1990 TPPs produced 68% of energy, while 25.7% of energy was produced by NPPs, 3.6% by HPPs, and 2.7% by public CHPPs. In 2009 these figures were, correspondingly, 41.1%, 48%, 6.8%, and 4.1%[6].

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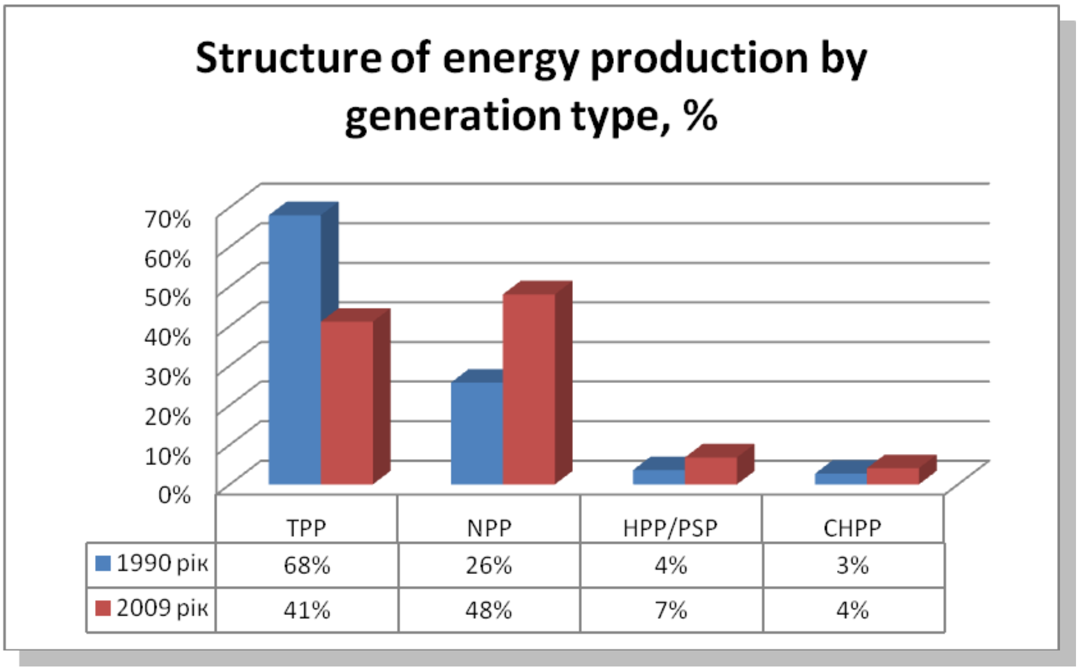
[5] Statement of key indicators of Ukrainian fuel and energy complex development for December 2009 and 12 months of 2009

[6] See above



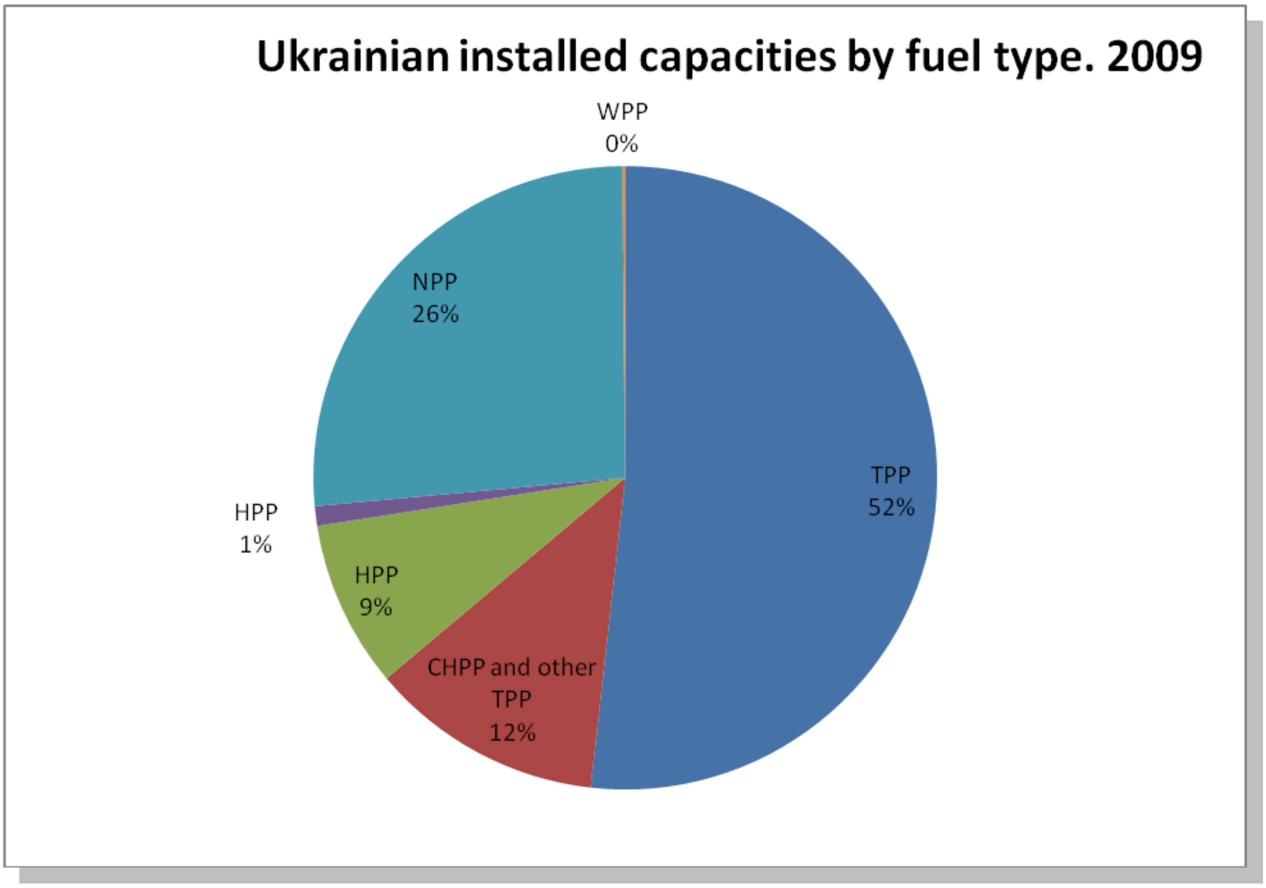
The Energy Strategy of Ukraine to 2030 describes key goals and principles of development of the country's fuel and energy complex. The document was approved by the Cabinet of Ministers of Ukraine in 2006, but was heavily criticized by Ukrainian and international experts and did not get the approval of Ukraine's Parliament. Most experts criticized the overestimated levels of GDP growth and energy consumption in Ukraine, prioritization of nuclear energy and coal industry, and the focus on the energy consumption rather than energy efficiency and energy saving initiatives.

Ukraine has to import fuel from other countries because it does not have the sufficient quantity of its own fuel and energy resources. Although the country's energy dependence is dropping (54.8% in 2005 vs. 60.7% in 2004), most of its oil, gas and nuclear power is supplied from one source. Attempts to increase the share on electricity production by nuclear power plants to compensate the gas supplies from Russia are a 'trade bad for worse' scenario. If we can buy the Turkmen gas, build condensed gas terminals and have our own gas production facilities, which create opportunities for diversification and maneuvers, in nuclear sector the dependence on fresh nuclear fuel supplies from Russia is almost 100%.

1.2 Condition of energy generating facilities

Ukraine's integrated power system (IPS) comprises of 4 NPPs, 14 TPPs, 7 HPPs, 2 PSPs, 97 CHPPs, small HPPs and other sources. The total installed capacity is 52.6 GW[7], where heat power 30.5 GW, nuclear power is 13.8 GW, HPP/PSP is 5.1 GW, isolated generating plants etc – 3.3 GW.

[7] http://www.ukrenergo.energy.gov.ua/ukrenergo/control/uk/publish/article?art_id=63551&cat_id=35061



As mentioned above, the structure of energy generating facilities has changed little since Ukraine became independent. But the energy production balance did change. In 1990 nuclear power plants which still account for 26% of Ukraine's total installed capacity generated nearly 26% of the total energy volume; in 2009 the share of nuclear power plant energy production has reached almost 50%. This is a result of increased preference for nuclear energy which misbalanced the whole energy system of the country. Prioritization of NPPs is preconditioned by the significant administrative reduction of charges for energy produced by NPPs compared to the charges for TPPs. The artificially created conditions where almost 50% of the energy is produced by 26% of the installed capacity have caused sharp drop of economic and technical performance of thermal power plants. The inefficient use of the available TPP facilities has led to high fuel over-consumption, machinery tear and wear, and environmental overload.

In the recent 15-20 years the construction of new nuclear units (unit 6 of the ZNPP, unit 2 of the KNPP, unit 4 of the RNPP) has increased the share of nuclear power and decreased the share of thermal power in the energy balance of Ukraine. As a consequence, within the recent decade nearly 15-20 GW of the installed TPP capacities were not used during season peak loads and therefore must be written off according to the existing procedure.

As a result, Ukrainian NPPs had to carry out the tasks out of their scope of competence. Below is an abstract from the report of Ukrainian Ministry of Environmental Protection on nuclear and radiation safety of Ukraine in 1996: "Another negative trend in nuclear power sector is seen from the sector's operational analysis for 1996. Energy production losses due to central dispatch limitations amount to 616 mn kW/hour, which is a record and characteristic for the misbalances observed in Ukraine's energy system. *Ukrainian nuclear plants were designed for operation in basic mode and are not intended for adjusting mode. NPP expansion (adding unit 6 at the Zaporizhya NPP) with reduced energy production at* *thermal plants and pumped storage plants <...> caused the exhaustion of adjusting capacities in the energy system, as a result of which the dispatching office started using nuclear units to adjust the frequency in the electric grid* (italics by NECU). From the safety point of view, state authorities cannot approve such mode of operation of nuclear power plants. Putting into operation new units at the Rivne NPP and Khmelnitsky NPP even worsens the existing energy misbalance, and the situation may get out of control which will cause the necessity not to use the full capacity the nuclear power stations have. Adjusting capacities in Ukrainian energy system become essential for safe operation of nuclear power plants".

According to the IAEA as of May 2010, by nuclear power installed capacity Ukraine is the 7th country in the world and the 4th country in Europe. At the time when the whole world is improving the output and efficiency of the available units, Ukraine increases the number of its units. This is why Ukrainian NPPs are idle for longer period during repairs, refueling and technical limitations. The installed capacity utilization factor (ICUF) is constantly dropping. The ICUF is the key technical and economic indicator of operation of energy facilities. It growth increases the amount of generated energy and reduces fuel costs. From 2000 the ICUF of the Ukrainian NPPs was growing and reached its peak of 79.4% in 2004. In 2009 the rate of utilization of nuclear power stations in Ukraine was 68.4% which is a kind of 'record' for Ukrainian nuclear industry as in the developed countries this index reaches 90 to 100%. Some estimates show that a higher ICUF of nuclear power plants would allow producing the same amount of power as produced by two new high-capacity units[8]. It is therefore obvious that instead of building new facilities it is more reasonable from the economic point of view to increase the efficiency of the already existing plants.

TPPs

Company	**Owner**	**Total power, MW**	**Generation**
Zahidenergo, OJSC	national Nuclear Energy Generating Company of Ukraine	4700	Burshtynska, Dobrotvorska, Ladyzhynska TPPs
Centrenergo, OJSC		7575	Trypilska, Zmiyivska, Vuglegirska TPPs
Dniproenergo, OJSC		8185	Prydniprovska, Zaporizka, Kryvoriska TPPs
Donbasenergo, OJSC		2655	Slovyanska and Starobeshivska TPPs
Shidenergo, LLC	DTEK	4085	Zuyevska, Kurahovska, Luganska TPPs

Thermal power plants are facing significant difficulties due to low consumer prices (especially for public consumption), cross subsidizing, prioritization of nuclear sector and market regulation by the government. Due to poor financing and impossibility to raise investment the facilities are now in catastrophically bad condition.

[8] http://www.day.kiev.ua/7270/

During the recent 10-15 years most thermal power plants, especially large condensing plants, have become totally outdated. As of 2009, 92.1% TPP units completed their estimated operational life (100,000 hours) and 63.8% units exceeded the acceptable limit of maximum life and physical depreciation (170,000 and 200,000 hours, correspondingly) and require urgent upgrade or replacement[9]. Obsolescence and physical depreciation of the units increase the number of equipment failures.

At the same time, the Energy Strategy contains plans for functional changes in the operation of TPPs. The increase of share of energy production by NPPs and insufficiency of flexible HPP facilities will lead to the TPP utilization for covering the peak loads in the network.

Shunting operation of TPP and use of non-project fuel make the operation of thermal facilities yet more complicated, deteriorate technical and economic performance of thermal power generating companies and increase the inefficiency of utilization of oil fuel, gas and coal.

Ukrainian thermal power plants (TPPs) are united under 5 companies, where 4 companies are state-owned and are a part of the National Nuclear Energy Company, and 1 company (Shidenergo LLC) is a private company owned by Donbass Fuel and Energy Company.

Experts believe that only major reforms can rescue the sector from collapse. Transition to the market of bilateral agreements, gradual introduction of reasonable prices, and sector liberalization will help raise investments to heat generation industry. This will allow updating machinery and distribution networks and improving market relations between the players.

Prior estimates show that the costs of upgrade of TPP units are about $1.5 per 1 W of the unit's power[10]. The TPP upgrade is hence an efficient and more economically sound alternative to the construction of new nuclear facilities.

1.3 Export potential

State Foreign Trade Company (SFTC) Ukrinterenergo is currently the exclusive energy exporter from Ukraine. The company supplies energy to Hungary, Slovakia, Romania, Poland, Moldova, Belarus and other countries.

Ukrinterenergo operates on the wholesale electricity market (WEM) of Ukraine where it buys energy at lower prices than in the domestic market (the difference between the export and domestic price is covered by Ukrainian consumers).

From 2006, energy exports from Ukraine have dropped significantly. The drop in exports is related to the drop in prices for energy at the European level on the one hand, and the increase of Ukrainian prices on the other hand. Therefore, poor efficiency and condition of Ukrainian power sector do not allow it to

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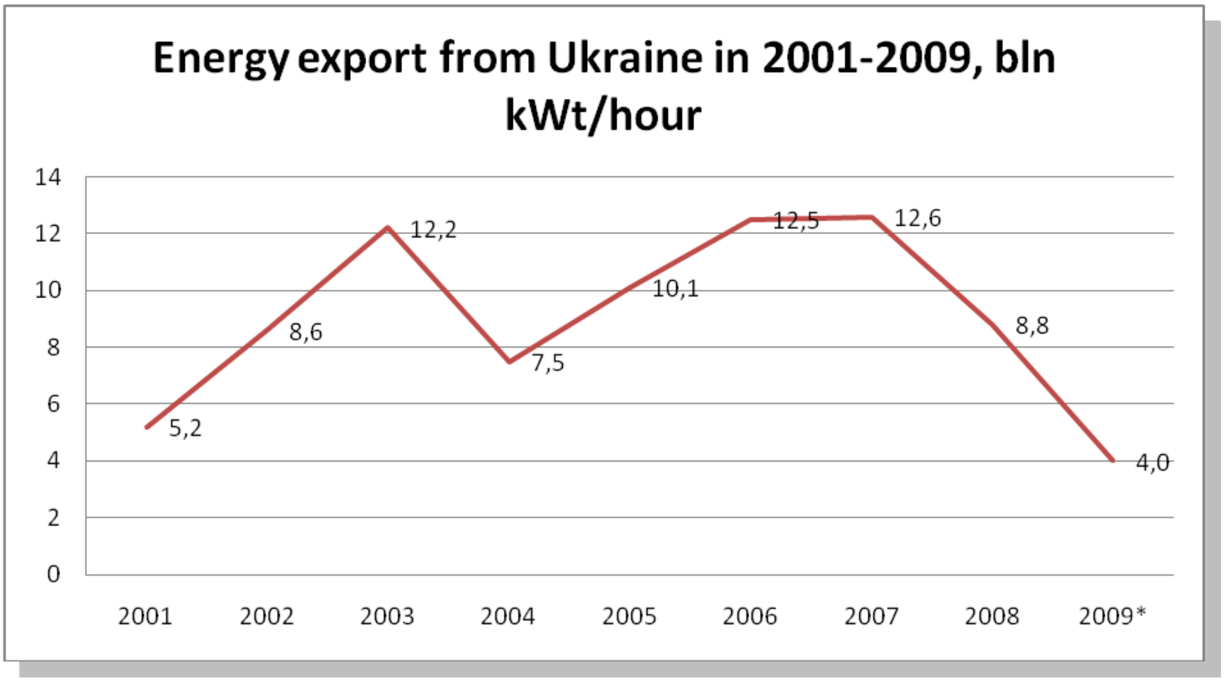
[9] First-priority steps for integration of the united energy systems of Ukraine into the united energy systems of the EU

[10] Energy and Energy Saving. Bulletin of the Kremenchuk Mykhaylo Ostrohradsky National University. Issue 3/2009 (56). Part 1

compete with the European power sector. In view of this any statements about the export potential of the energy to be produced by units 3 and 4 of the KNPP look extremely inappropriate.



Source: State Statistics Committee of Ukraine

Export potential of the Ukrainian energy looks even more pessimistic in view of the existing plans to build 5 new NPPs in Eastern Europe: in Belarus, Lithuania, Kaliningrad Region (Russia) and 2 units in Poland[11].

1.4 Conclusions about the necessity of new facilities

The current condition of Ukrainian generating facilities and financial and economic situation in Ukraine and in the world require a review of the country's development plans, particularly in the energy sector.

As mentioned above, the Energy Strategy of Ukraine to 2030 is the key document that regulated the development of FEC. The document contains plans for construction of 22 new power-generating units (9 replacement units and 13 new units). The strategy estimates that from 2005 to 2010 energy consumption in Ukraine will grow from 185 bn rW/hour to 210 bn kW/hour. However, the economic recession amended the ambitious plans of the energy sector management. During 2009 alone Ukraine's economy fell by 15%. Energy production not only did not increase by 25 bn rW/hour as expected by the Strategy, but dropped almost to 173 bn kW/hour. The same figures were recorded in 2001 and 2002. This is the most dramatic fall since the collapse of the USSR. Citigroup and the EBRD estimated that Ukrainian GDP will increase by 3-4% in 2010. The World Bank is more skeptic with its estimate of 1% GDP growth. According to the IMF, the economy will be able to reach its pre-crisis level (2008) only in

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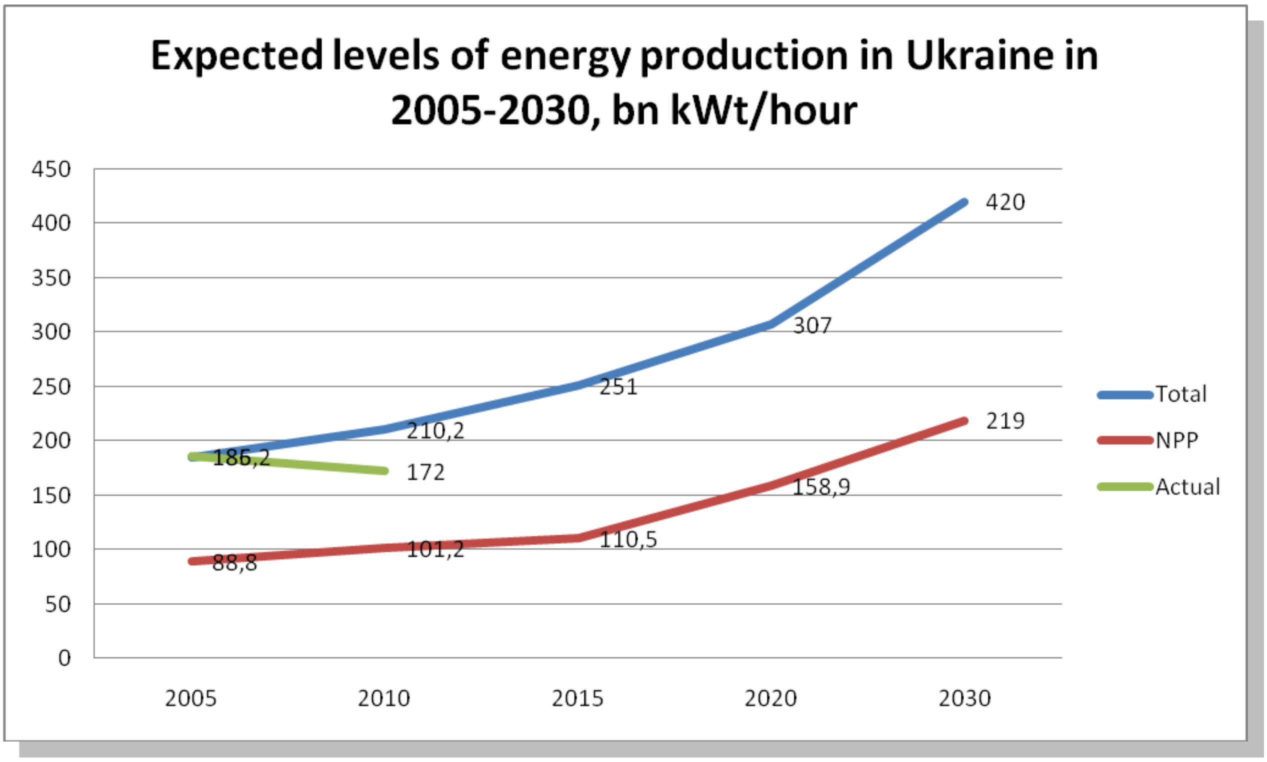
[11] http://www.dw-world.de/dw/article/0,,5790336,00.html

2014[12]. Obviously, even the sharp growth of economy (which is not expected anyway) will not create the real need of additional basic facilities in the nearest 5 years.



Source: [Energoatom]

Chances that volumes of energy export from Ukraine to Western countries will become the same or increase are also quite low. The big difference between the prime cost and energy prices for people is a precondition for high wholesale market price (WMP). Prices for exported energy are defined by the NERC. Rules require that export price may not be lower than the WMP on the domestic Ukrainian market. In this situation the WMP in Ukraine is higher than in Hungary which has the highest energy prices[13].

The expansion of energy generating facilities in the absence of domestic demand and poor export opportunities cause long downtimes of power plants. Consequences include high tear and wear of machinery, increased fuel consumption, deterioration of the company's financial standing, and drop of the installed capacity utilization factor.

Nuclear power plants are base-load facilities. It is the first level of energy system of any country, which covers the country’s basic demands of energy throughout the year. So called adjusting or shunting facilities represented by hydropower plants and pumped storage plants are used to cover seasonal or daily peak loads. Due to the increase of share of NPPs in the country’s energy system without increasing

[12] Mirror Weekly. No. 6 (786), February 20-28, 2010. Anatoly Galchinsky: “Only liberal treatment can cure the economy”.

[13] Kommersant-Ukraine No. 118 dated 14.07.2010. Ukraine has run out of energy

the share of shunting facilities nuclear power plants are operated in shunting mode for which they are not intended and designed at all.

In the existing conditions Ukraine can improve the energy security of its economy and people. It does not require building new nuclear power units. The necessary step is to utilize the existing facilities in a more efficient way, and cut energy transportation and consumption costs through systematic energy-saving measures. The upgrade of TPPs and restoration of small HPPs have a potential which is sufficient for many years. This would be must more efficient and useful for the whole energy system of Ukraine and, more importantly, profitable from the point of view of economy. This will also allow to avoid the increase of the spent nuclear fuel and radioactive waste which is particularly important because for the time being there are no good approaches for the management of such type of waste in the world.

Technologies of use of alternative energy sources are developing so dynamically that investments in this sphere are growing every year despite the financial crisis and overall reduction of the state allocations. This is not strange, as many experts believe that the development of renewable energy source technologies will soon make an innovative breakthrough in science and technology. The countries that invest in the innovative technologies today contribute to their energy security and technological leadership in future. Wind power engineering is very demonstrative. The installed capacity of wind-power stations doubles every three years. 38 GW of wind-power facilities were put into operation in 2009 (and only 1 GW of nuclear power facilities). Investments in new turbines in 2009 were much higher than investments in the previous years. The turnover of the global wind-power sector reached EUR 50 billion (EUR 40 billion in 2008)[14]. And this is about wind power alone.

Instead of completing construction of two outdated reactors that feature a range of problems (see below), Ukraine should opt for investing in innovative and novel technologies. Construction of two unnecessary nuclear steam boilers (which NPPs are in fact), instead of innovative research, may keep Ukraine away from novel global technologies and trends for a long period of time.

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[14] World wind energy report 2009

2 The Project of Completion of Units 3 and 4 of the KNPP

The construction of unit 3 of the Khmelnitsky Nuclear Power Plant started in 1985. In 1990, in view of the accident at the Chornobyl NPP, the USSR declared a moratorium on the construction of new power-generating units, and already erected facilities were not conserved. In 2005 the Cabinet of Ministers of Ukraine approved the decision to continue the construction.

2.1 Technical problems

In 2006, Ukrainian Ministry of Fuel and Energy in synergy with NNEC Energoatom inspected building structures for units 3 and 4 of the KNPP. The inspection analysis was provided to the State Nuclear Regulation Committee of Ukraine (SNRC) for state investigation of nuclear and radiation safety. The results of the state investigation showed the following:

1. "The Reports do not contain analysis of the possibility to use the existing building structures of unit 3 of the KNPP during its construction with the VVER-1000/V-3095 series of nuclear reactors.
2. The scope of inspection is not full, namely:
   - the inspection did not cover many premises located below the zero level because they were flooded;
   - the inspection did not cover the embedded parts of fixture wires and channel-forming components, most of which were damaged by fire in 1989.
3. Absence of a significant part of documents on reinforced concrete and metal building structures of unit 3 of the KNPP: 30% of documents of reinforced concrete structures, and 12% of documents on metal building structures.
4. Operating life of the existing building structures of unit 3 of the KNPP was defined without taking the above comments into account, and their durability is not sufficiently reasoned even for construction of this unit with the VVER-1000/V-320 type of reactor"[15].

Therefore, the reliability of the existing structures which were not conserved and were standing open for over 20 years, is very doubtful. To ensure the safe operation, the reliability of all structures in such highly dangerous devices as nuclear reactors must be absolute. Attempts of Energoatom to use the structures "most of which were damaged by fire”, taking into account that “the inspection did not cover many premises located below the zero level because they were flooded” look as speculation in terms of safety and a Russian roulette.

Another open issue is whether it will be possible to host the VVER-1000/V-392 reactor in the existing structures. The type of reactor was approved in 2008 through a contest. The key selection criterion was the possibility to host the reactor in the existing structures. Originally, it was planned to use the VVER-1000/V-320 type of reactors which are the most popular type of reactors used in Ukraine. Conclusions of the SNRC make it clear that the type of reactor was selected without considering a possibility to host it in the existing structures.

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[15] http://www.snrc.gov.ua/nuclear/uk/publish/article/115523

Very demonstrative in this area is the experience of Bulgaria, which also had units at the Belene NPP the construction of which was not completed since the USSR times. After the structures (which were previously decommissioned, unlike in Ukraine) were inspected, it was decided to fully remove the existing infrastructure to build new units. Removal costs amounted to EUR 112 million, which was cheaper than adjusting the structures to the reactors[16]. This decision was also reasoned by the changes in construction regulations.

The designers (Hydropress Design Bureau, Russian Federation) describe the VVER-1000/V-392B type of reactors as the upgraded and improved version of the ‘big series’ reactor, VVER-1000/V-320. The project of installation of the V-392 reactors at NPP was developed for the stage two (units 5 and 6) of the Balakovsk Nuclear Power Plant. The project was licensed and received approval to start construction operations, but construction operations are suspended at the moment. Hence, currently there is no operating nuclear reactor with the V-392 model in the world. Energoatom’s plans to install experimental units (which are not installed anywhere in the world) on the structures which are not intended for this purpose jeopardize the safe operation of the plant and the national safety of Ukraine in general.

2.2 Water resources

According to classification of the UN Economic Commission for Europe, Ukraine is one of the European countries with the lowest level of water resources (1,000 m^3 per person). Under the international classification, only the Zakarpattya Region has the average level of water resources (6,190 m^3 per person). In the Chernigiv, Zhytomyr, Volyn and Ivano-Frankovsk Regions this index is low (2,000 to 2,600 m^3). In most Ukrainian regions this index is very and extremely low (110 to 1,950 m^3). According to the State Committee of Ukraine for Water Resources, the total water intake in Ukraine is over 15 billion m^3. If we add sanitary operations and evaporation (29.8 billion m^3), we get 44.8 billion m^3. This is equal to river flow in a very low-water year. Nearly 65% of the river flow in Ukraine is already regulated, and further regulation without damaging river ecosystems is almost impossible. However, such regulation is clearly planned.

For no apparent reason, the USSR authorities selected locations for nuclear power plants, which are major consumers of water resources, mostly in the regions of Ukraine that have the lowest levels of water resources: the Rivne, Khmelnitsky, and Mykolaiv Regions. It has always raised a range of pressing problems for the energy sector, water management system, and local people.

The Khmelnytsk NPP is located in the upper reaches of the Goryn River, where at the outlet on the border with the Rivne Region the estimated annual river flow is 282 million m^3, of which 196 million m^3 of water must remain in the river for water consumers downstream. For purposes of cooling the four units of the Khmelnitsky NPP is was decided to build a cooling pond with a volume of 86 million m^3, which must be filled in spring only. As cooling 4 units requires 120 million m^3 of water annually, filling the pond in a low-water year at the expense of flood is impossible. It is therefore clear that construction of new units at the KNPP will inevitably damage the ecosystems of the Goryn River.[17]

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[16] UA Energy. Demolishing or building? 19.11.2009

[17] “Environmental safety in the aspect of development of Ukrainian energy sector". Digest, page 122

This conclusion was confirmed back in October 1985 by the Scientific Board of the Academy of Sciences of the USSR on technical, environmental and economic aspects of location, construction and safe operation of large energy facilities, which on instruction of the state authorities inspected conditions for construction of new nuclear power plants in Ukraine. Even at that time the Board made the following conclusion: "The Republic has almost no potential to increase its water resource with flow regulation. Water is in deficit, and is polluted by waste water. The amount of pollution is significantly higher than the self-purification capacity of the water sources". We put emphasis on the fact that this statement was made in the social and political conditions of the Soviet times.

2.3 Project financing

The case of nuclear reactors construction in Belene (Bulgaria) shows that raising finance for such projects is very difficult, as leading international financial institutions do not want to fund such type of construction due to high (mostly, financial) risks. Today Ukraine does not have its own funds to finance the construction of units 3 and 4 at the KNPP. Statements that the Russian Federation will provide a loan for the project are also doubtful, as the same statements were made regarding the construction of reactors in Bulgaria, but the project is still on hold.

Even if Russia provides a loan for construction, the money will likely be used only to buy the Russian-made equipment. In other words, Russia will invest into its own industry at the expense of Ukraine. Rosatom estimates the construction costs will be $5-6 billion while Ukrainian Ministry of Fuel and Energy originally produced the figure of UAH 15 billion and later announced the estimated project costs of UAH 30 billion. Uncertainty is even increased by statements that Russian state banks will provide a $2 billion loan for construction of the KNPP. Although the press office of Energoatom denied this statement, it did not add transparency or public trust to the project. Such significant controversies and mismatches create a high risk of money laundering and financial fraud. This risk is even higher in view of the long construction term (5 years).

It is planned that the repayment of the principal amount of the loan will start 6 months after the beginning of commercial operation of the units. "Construction" of units at the Temelin NPP in Czech Republic gives sufficient evidence that Energoatom will likely have to start repaying the loan even before it starts selling the energy generated by the new units. Hence any delays in the construction of units 3 and 4 of the KNPP will inevitably bring financial consequences. However, delays and significant project budget increases are traditional in the construction of large nuclear plants all over the world (Temelin NPP in Czech Republic, Belene NPP in Bulgaria, Olkiluoto NPP in Finland). In the light of poor project and financial control in Ukraine the process of implementation of a national-scale project looks very dubious.

The leading international financial institutions do not think that new nuclear power plants in Ukraine have anything common with the efficient use of huge amounts of money. In 1995, Ukraine addressed so called development banks with a request to finance the construction of two reactors, unit 2 of the Khmelnitsky NPP and unit 4 of the Rivne NPP. Construction of the above reactors started in 1985-1986 and stopped after the Verkhovna Rada announced a moratorium in 1990. The state of the units at the beginning of construction operations was almost the same as the current state of units 3 and 4 of the KNPP. The estimated construction costs were $ 1.725 billion. The project was submitted to the EBRD for analysis. The EBRD's lending rules require the project's compliance with normal banking principles. Additionally, the project must meet the EBRD's lending conditions for nuclear power sector, and the bank's Energy Operations Policy stipulated that the project must:

- be financially viable;
- meet environmental requirements and requirements to public consultation process;
- meet Western principles of nuclear safety;
- meet Western principles of lowest costs.

In 1996, on request of the EBRD an international group of experts conducted economic assessment of the construction project. The assessment report was submitted to the EBRD, the European Commission and the United States Agency for International Development (USAID) on January 2, 1997. All group members, except one, agreed that the project was not economically viable as it did not met the lowest cost requirement, and completing the construction of the reactors by 2000 was not the most efficient way to use the funds of the EBRD and the European Union intended for support of development of the Ukrainian energy sector. This example clearly demonstrates the international investment unattractiveness of nuclear power project. Ukraine did not receive a loan from the banks to complete the construction of unit 2 of the KNPP and unit 4 of the RNPP, but the banks provided finance to improve the safety of these units. The program for safety improvement of these new units was started after they were put into operation. This proves that the level of safety of the new reactors does not meet international standards.

In December 2005 Ukrainian Government approved the Conception of Safety Improvement at the Operating Nuclear Power Plant Units to 2010, applicable to all nuclear power units of Ukraine except unit 2 of the KNPP and unit 4 of the RNPP. The part which is not finished by the established deadline (end of 2010) will be included into the new Consolidated Program of Safety Improvement at NPP Units to 2017. It is expected that the Program will be financed from the EUR 1.45 billion loan provided by the EBRD and Euroatom[18]. It is planned to borrow these funds against the state's security. Nuclear power sector is unprofitable and cannot exist without the state support. It would be much more efficient to use the resources consumed by the nuclear power sector for the development of alternative energy sources and energy efficiency, as all developed countries do.

[18] A billion-worth vaccination against explosion, Economic News, No. 99 (1332) dated 18.06.2010

For the time being there is no official document to specify the cost of completion of units 3 and 4 of the KNPP. All authorities and organizations involved in the project deliver different - sometimes completely contradicting - information regarding the financial side of the project.

On April 30, 2010, the meeting of Prime Ministers of Russia and Ukraine in Sochi approved a decision about cooperation of the two countries for construction of the KNPP. Press reported that on June 8 after the meeting of the Ukrainian President V. Yanukovych and Russian Prime Minister V. Putin Russia provided Ukraine a $2 billion loan. On June 9 the Ukrainian Fuel and Energy Minister Yuriy Boyko and Rosatom's Director General Sergiy kiriyenko signed the cooperation decision in Kyiv. It was announced that the loan agreement would be signed as soon as the parties discuss all issues. Rosatom estimated the cost of construction of the units in $5-6 billion. At the same time, Ukrainian nuclear power experts estimate the cost of construction of one unit in UAH 30 billion. So far there is no information about the purpose of Russia's first loan, $2 billion. It is also not clear whether the construction of the units will be completed in parallel or sequentially.

Anyway, Energoatom's attempts to complete construction of units 3 and 4 of the KNPP in the existing structures the durability and reliability of which is very questionable, means saving on safety.

Completion of units 3 and 4 of the KNPP means further extensive development of the nuclear energy sector the expediency of which is quite dubious and should be reviewed with the participation of the public.

2.4 Human resources

Stalin said: "Human resources are decisive". In Ukraine the problem of human resources in nuclear power industry is crucial. The two key reasons are migration of highly qualified experts to more financially attractive projects abroad and destructive HR policy of the state in general.

Today nuclear industry experts talk about the 'nuclear power Renaissance'. However, the reality suggests the opposite. A 'nuclear power boom' as in the 1980s is possible on paper only. Sharp drop of orders of new nuclear power generating units after a range of major accidents caused the drop of demand for the experts in the field. For example, the USA had 65 university programs on nuclear power in 1980, and has just 29 now. Finding experienced experts, including constructors, technical specialists, engineers and scientists, for NPP construction and operation is one of the essential problems. The data below illustrate the situation with human resources in the nuclear power industry[19]:

- USA: 40% of people currently working at NPPs can retire within the nearest five years. Fore the time being, only 8% of NPP employees in the USA are under 32.
- France: almost 40% of the current stuff of the national power-generating company EDF, involved in the operation and maintenance of reactors, will retire by 2015.
- UK: no courses on nuclear engineering were given to senior students. The absence of market for graduates of technical departments/heating engineers in nuclear engineering proves that nuclear energy sector is not attractive for new students and is a very rare choice of the best students.
- Germany: the situation is dramatic and is getting even worse. The number of institutions that train qualified nuclear power specialists has dropped from 22 in 2000 to 10 in 2005 and will be 5 in 2010. In 1993 46 students got diplomas in the field, and 0 students in 1998.

In Ukraine, the situation is not any better. Since Ukraine became independence, it put into operation 3 nuclear power-generating units: unit 6 of the Zaporizhya NPP, unit 4 of the Rivne NPP, and unit 2 of the KNPP. However, the construction of these units started back in the 1980s, and at the time when construction was re-started their most part of work was already done. 6 years passed since the last Ukrainian reactors were put into service. For 6 years Ukraine was not involved in the construction of nuclear power-generating facilities which requires highly qualified and skilled human resources. During this period of time the country has lost valuable experience and, more importantly, human resources, as specialists had to change the job or go abroad for NPP construction projects. It is unlikely that Ukraine can quickly recover such potential.

There is a common delusion that nuclear power sector creates many jobs. On average, one operating unit needs no more than 1,300 people. Therefore, one job will be worth nearly UAH 4 million.

2.5 Public opinion and public dialogue

Ukrainian nuclear power sector is made of highly dangerous facilities that may adversely impact the significant part of the country's people. Public participation in decision-making process in the area of nuclear power sector development is a necessary precondition in the political practice of developed countries.

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[19] Report on the global nuclear power industry for 2007. M. Schneider, E. Froggatta. Brussels, London, Paris, January 2008.

A range of major accidents at NPPs in the late 1970s-1980s greatly shifted the standing of nuclear power sector which had been energy leader in public opinion. A wave of protests and resistance of the people living in the vicinity of NPPs set new requirements to the safety of NPPs, led to decommissioning of new facilities in Europe and significantly limited the future of nuclear power industry in many European countries including Italy, Germany, Sweden etc.

Today public opinion about NPPs has seen major changes. Social polls show that most people in Sweden support the idea of operating nuclear reactor until the end of their operating life and construction of new facilities if necessary[20]. Such change of public thinking is the result of active, ongoing and transparent dialogue of nuclear power departments and state authorities and civil society organizations.

Ukrainian laws require informing people about the operation of nuclear power facilities and public participation in making decisions on construction of new nuclear power plants. However, as a rule, state department related to fuel and energy complex still feature the lack of transparency typical for the nuclear power sector in the USSR. Most often, legal requirements are observed on paper only. Accidents at Ukrainian nuclear power plants (e.g. at unit 3 of the RNPP on September 22, 2009) show that Energoatom and Fuel and Energy Ministry are not very concerned over timely public disclosure.

Unwillingness of state authorities responsible for nuclear power plants to ensure open, timely and expansive public information and participation shapes the relevant attitude of Ukrainian people to nuclear power sector. From April to June 2005, Razumkov Centre conducted public poll on nuclear power sector. The results showed that 55% of the respondents did not support the construction of new nuclear power facilities and extension of operating life of the existing facilities, and 39% of the respondents thought that nuclear power sector was capable of securing Ukraine's energy independence. Nearly 65% of the respondents believed that the nuclear reactors that were being operated in Ukraine were not safe. 84% of the respondents confirmed that they did not receive sufficient information about plans to increase the number of nuclear power-generating units. Public opinion polls conducted on request of the State Nuclear Regulation Committee (SNRC) have shown that today the public opinion about nuclear power sector has not changed much. The SNRC is the only state authority that demonstrates openness and is ready for dialogue with public organizations. However, public opinion polls give evidence that most people are not aware of the independent state regulatory authority and its functions.

Even the adherents of nuclear energy admit that only the extensive anti-nuclear movement in the 1980s in the former FRG made it possible to invest huge amounts of money in safety improvements at nuclear power plants and make them extremely accident-protected[21]. The other side of the medal is that the absence or fall of public awareness and criticism leads to the weaker control and hence weaker safety of nuclear power sector.

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[20] Razumkov Centre. National Safety and defense, No. 6, 2005

[21] Nuclear energy: myths and reality. Thematic research in nuclear energy. Published by the Heinrich Böll Foundation. Berlin, February 2006.

2.6 Dependence on Russia

Ukraine is 100% dependent on Russia in terms of fresh nuclear power supplies and 60% dependent in terms of equipment supplies. Although fuel supplies are partially compensated by supplies and processing of Ukrainian uranium concentrate, the dependence on one partner in this area is almost absolute. Westinghouse's fuel is currently being tested for licensing at unit 3 of the South Ukraine Nuclear Power Plant. In view of changes in Ukraine's foreign policy, new government and aggressive policy of the Russian partners, there is small chance that the process of diversification of strategic raw material supplies will be continued.

Atomstroyexport is a Russian company that won the contest for construction of units 3 and 4 of the KNPP and the key designer of nuclear reactors abroad, but it has some production limitations. Moreover, the available facilities in Russia hardly cover domestic orders and already signed international contracts. Therefore plans to complete construction of units 3 and 4 of the KNPP by 2016 (and 20 reactors more, as defined in the Energy Strategy) appear quite dubious.

Russian company TVEL won the contest for nuclear power plant construction in Ukraine, but this only reinforces Russia's monopoly in Ukrainian nuclear power industry.

3 Miscellaneous

3.1 Spent nuclear fuel management

Ukrainian NPPs annually produce nearly 150 tons of spent nuclear fuel (SNF). Nuclear industry experts claim that SNF is a potential fuel for the new generation reactors and see SNF as a raw material rather than waste. In fact, this opinion has been existing just as long as nuclear energy sector, but construction of the new type of reactors that would combust SNF has not started anywhere in the world so far. The reality is a bit different than the theory, and today SNG is highly radioactive waste.

In Ukraine SNF produced by the VVER-440 type of nuclear power units (units 1 and 2 of the Rivne NPP) is transported to Mayak, a company located in the Chelyabinsk Region of Russia. SNF produced by all other NPPs, as stipulated by contracts with Russian partners, must be transferred to Mining and Chemical Plant in Zheleznogorsk, Russia, for reprocessing. But construction of fuel reprocessing plant has not even started! This is why fuel discharged from the VVER-1000 type of reactors from all ex-USSR is brought to the special storage owned by this company. 15 years ago the storage was already almost full. In view of this, in 1993 Russia refused to take fuel from Zaporizhya NPP, the largest NPP in Europe. As a result Ukraine had to start express construction of it own SNF storage new the Zaporizhya NPP which was put into service in 2001.

Spent fuel discharged from the VVER-1000 reactors at the Rivne, Khmelnitsky and South Ukraine NPPs is still brought to the Mining and Chemical Plant in Zheleznogorsk, but Russian partners can refuse to continue accepting it at any time. In connection with this the Government decided to build a centralized storage for SNF from the three Ukrainian nuclear power plants.

New units at the Khmelnitsky NPP will only intensify the problem of spent nuclear fuel transportation and management. Plans to use SNF as fuel for next-generation NPPs are not viable today. Firstly, no commercial application of such technologies is planned in the nearest fifty years; secondly, SNF reprocessing produced highly radioactive waste anyway; thirdly, SNF reprocessing and storage have nothing common with clean and safe environment.

3.2 Radioactive waste

Radioactive waste (RAW) is the most dangerous type of waste. Radioactive radiation is dangerous for all living organisms. The worst thing is that humans cannot see or feel the radiation. We can be near a dangerous facility without feeling irreversible processes taking place in our bodies that can do us irremediable harm.

Of all nuclear industry sectors nuclear energy sector is responsible for the highest quantity of dangerous waste. Every stage of nuclear energy cycle – uranium mining, nuclear fuel production, operation of nuclear power plants, solving problems with spent nuclear fuel (SNF), and transportation at every stage of the cycle – produces radioactive waste. Additionally, Ukraine has got enormous nuclear legacy of the biggest manmade accident in the history, the disaster at the Chornobyl Nuclear Power Plant (CNPP).

85-90% of Ukrainian RAW are low- and medium-active waste. Highly-active RAW are mostly accumulated at industrial sites of nuclear power plants in special-purpose storages.

Taking into account that 'disposal' of 1 dm^3 of low- and medium-active RAW costs nearly $50, it is clear that nuclear power sector – Ukraine's key radioactive pollutant - will never make enough money for disposal of its own waste. And every unnecessary year of NPP operation increases the amounts of money necessary for the future waste disposal.

3.3 Decommissioning

Nuclear decommissioning is the last yet extremely important stage of the plant's operation which requires significant time and financial resources. Unlike conventional industrial plants, nuclear power plants may not be just shut down and dismantled after the end of its operating life and additional operating life. After the energy delivery from the NPP to the electric grid stops, decommissioning and plant dismantling takes significant power, financial, human and time resources.

Ukrainian nuclear power experts say that Energoatom timely transfers money to the State Foundation for Nuclear Decommissioning, however these funds are repeatedly used for other purposes like covering the gaps in the state budget. Hence for the time being finance for nuclear decommissioning is not accumulated which creates risks for the future.

As reported by the Guardian, the UK's Secretary of State for Energy and Climate Change Chris Huhne disclosed that Britain was facing a £4bn black hole in unavoidable nuclear decommissioning and waste costs[22]. The article's author points out that such costs raise many questions about the economic viability of nuclear power and set additional requirements to nuclear power technologies in terms of waste management and disposal. In fact, Ukraine's NPP installed capacity is 3GW higher than in the UK, so such costs might be impossible for the country.

Real nuclear economy with nuclear power plant construction, operation, SNF and RAW management, and decommissioning might be too expensive without offering any benefits to Ukraine.

3.4 Transmission lines

Development of centralized electricity production, mainly through nuclear power plant construction, has caused the need to build many powerful transmission lines (TLs) connecting the electricity producers with consumers. However, no significant growth of electricity consumption is observed in the country, so Ukrainian energy experts are also working on the construction of TLs for energy exports to other countries. Construction of high-voltage transmission lines requires significant land allocations, which causes social protests in the relevant regions. An illustrative example here is the Adjalyk-Usatove transmission project where state company Ukrenergo is constructing high-voltage line above the houses and gardens of people who live in the village of Usatove. When local people tried to defend their rights, over 400 security guards took the side of the project owner. Security guards with dogs took the construction site in three rings, and the operations went on.

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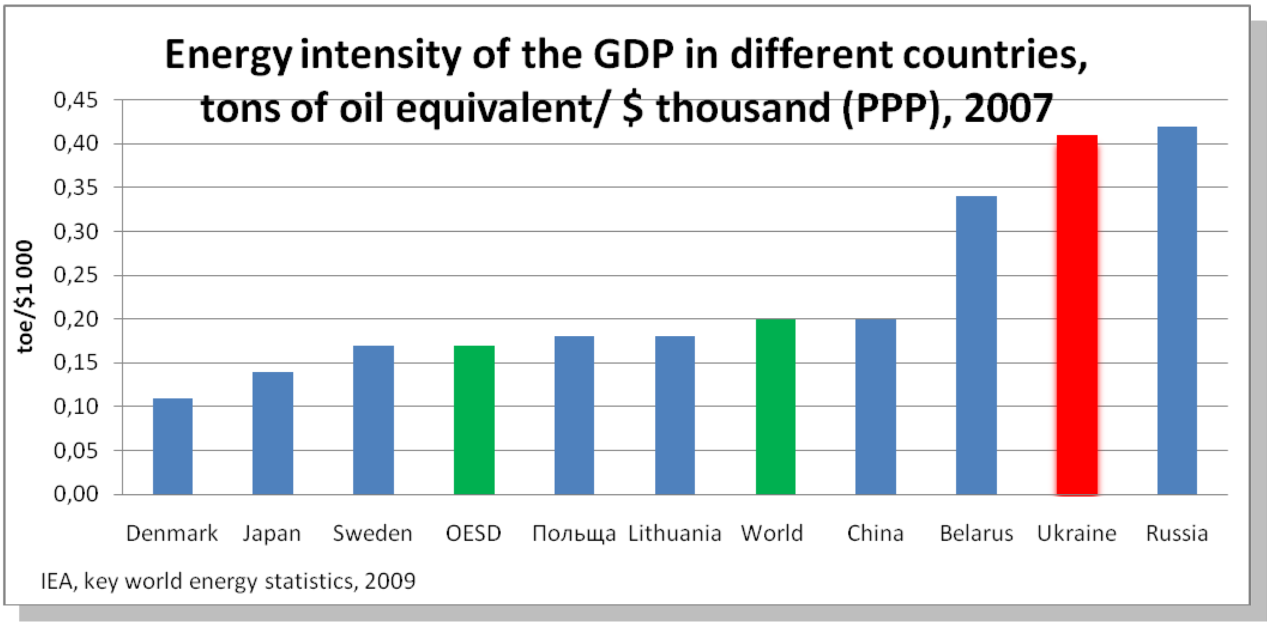
[22] http://www.guardian.co.uk/politics/2010/jun/01/chris-huhne-black-hole-nuclear-power-budget

Another negative example is the project of construction of 750 kV transmission line from the Zaporizhya nuclear power plant (NPP) to the Kakhovsk substation, where the transmission line is planned to cross the unique nature reserves including the Bilozersk Tract, Vodyanski and Ivaniski Kuchugury, Kairsk Gully, Lower Dnieper National Park, Botanical Dendropark etc. Construction of transmission line pylons and installation of cables will cause significant adverse impact on the local ecosystems and bird migration.

Costs for the construction of units 3 and 4 of the KNPP do not include costs of transmission line construction for powering the new units and the relevant infrastructure. One 750 kW TL may cost at least $200 mn, so completing construction of the KNPP will bring additional financial burden. These are additional costs (which will likely be covered by loans of development banks) that will eventually have to be covered from the country's budget and by its taxpayers.

Conclusions

Nuclear power plants are basic-load power plants. Ukraine already has the excess of installed basic loads but lacks shunting facilities. Construction of units 3 and 4 of the KNPP will cause even greater misbalance in the country's energy system and reduce the efficiency of the existing facilities. Instead of investing $4-5 billion into other country's economy, a much more efficient option would be to invest in energy saving initiatives, upgrade of thermal power plants, and renewable energy sources. Despite Ukraine has a specialized state agency (NERC), it still is a leading country in terms of inefficient resource management. Ukrainian economy is more energy-intensive than Belarusian and 2-3 times more intensive than in the developed European countries. Although within the recent years Ukraine's energy efficiency has been growing and reached 0.5 kg of equivalent fuel per $1 of GDP (PPP)[23], this index corresponds to the level of Poland in the early 1990s. The high energy intensity is the key source of Ukraine's greenhouse gas emissions.



Countries are facing financial crisis and are trying to cut deficits of state budgets, costs and state debts. Instead, Ukrainian Government is only increasing the country's debts through this economically unnecessary project. Ukraine has excessive installed capacities. Even if the country fights the crisis in the nearest time (which is not very likely), the excessive capacities are sufficient to cover its own needs and for export (the recovery of which is also not expected in the nearest time). Transition of the energy market to bilateral agreements and gradual growth of energy prices will reduce energy consumption even more. The expansion of nuclear power facilities without the available energy market will cause the long downtimes of NPPs, operational limitations and drop of the ICUF.

Instead of building 2 GW of new basic facilities, it would be much more expedient to decommission the existing facilities and use the money to recover and upgrade 3-4 GW of the existing heat power units the catastrophic condition of which causes great concerns. Another alternative option is investing in energy

[23] http://www.rbc.ua/rus/newsline/show/energoemkost_vvp_za_2008_g_snizilas_na_0_13_kg_uslovnogo_topliva _ na_1_grn_vvp_ekspert_270320090

efficiency measures, energy consumption reduction and use of local energy sources. Importantly, these initiatives do not require borrowing enormous amounts of money the repayment of which would involve political loyalty and stability.

Yet more concerns arise over the technical side of the project. Expansion of nuclear facilities and decrease of the share of thermal energy will lead to the NPPs operation in shunting mode which bears potential threat for the whole energy system of the country. The selected reactor type is also quite dubious, as this type of reactor is not currently in operation anywhere in the world. Such types of reactors were planned to be installed at the Balakovsk NPP, but the project is currently on hold. According to developers, the VVER-1000/V-392 type of reactor is an interim stage between the big series reactors (V-320) and the newest AES-2006. Prior research has shown that safety improvement of the V-320 reactors requires significant investment, and this is why Ukraine had to borrow money for this purpose. At the moment there is no evidence that the proposed units (V-392) are any safer than the V-320.

Risks are associated not only with the units, but also with plans to install these units in the existing structures of the KNPP. The structures in which units 3 and 4 of the KNPP are planned to be installed, have been standing under the open air for 20 years without decommissioning, which has significantly impacted their durability and reliability. Construction requirements for nuclear power-generating units have changed significantly and are now tougher than in the 1980s when the nuclear unit construction started. Even the State Nuclear Regulation Committee of Ukraine is very skeptical about the plans to install the unit in the structures that suffered from time, metal corrosion and damage of concrete parts. Energoatom puts emphasis that using the existing structures will save a lot of money, but this is a safety speculation.

Plans to complete construction of units 3 and 4 have nothing common with the current situation in Ukraine and in the world, are not economically viable, are technically complicated and highly dangerous. The country does not need any new basic facilities.

In its overview of Ukraine’s energy policy for 2009 the group of experts of the International Energy Agency (IEA) defined three priority directions for Ukraine in this area: energy efficiency, prices (which should cover the real energy cost) and transparency. These recommendations are still worth following today.

Nuclear power Renaissance is still at the level of rhetoric talks.

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