THE *NUCLEAR RENAISSANCE*: RUSSIA IN GLOBAL CONTEXT

The world has been demonstrating particular interest in the development of nuclear energy sector in the recent years. Today it seems that the growing energy demands of mankind can hardly be met without resorting to peaceful nuclear energy uses. However, reliance on this sector raises a number of significant issues.

Nuclear renaissance is topical for Russia as well – the country plans to increase the share of nuclear energy by 30 percent of general energy balance by 2020, and this is quite an ambitious task. At the same time, if Russia focuses only on domestic matters, it may miss the global train and lose the thriving international market. What is the proper balance? Which role should Russia play in *nuclear renaissance*? What are the difficulties and how to overcome them?

All these problems were discussed by renowned experts – Valentin Ivanov, academician of the Russian Academy of Natural Sciences, chair of the Board of Directors and Scientific-Technical Council, *ZAO Energomontazh International*; Vladimir Kagramanyan, assistant to director general on innovative nuclear energy technologies, the Leipunsky Institute of Physics and Power Engineering (IPPE); Alexander Polushkin, deputy director general on development, *Rosenergoatom*; Nikolay Ponomarev-Stepnoi, vice president, the Kurchatov Institute; Alexey Ubeev, deputy head of the department of external relations, *ZAO Atomstroyexport*; and Alexander Chebeskov, head of the section of nuclear energy systemic analysis, IPPE.

SECURITY INDEX: What is the realistic forecast of the global nuclear energy development by 2020–2030? What will its share in global energy balance be? What are the prerequisites for the implementation of such plans? Can nuclear energy in Russia really account for 30 percent of energy balance by 2020? How to ensure sufficient fuel supplies to newly built reactors?

VALENTIN IVANOV (RUSSIAN ACADEMY OF NATURAL SCIENCES): First of all, one has to mention the major reasons for rapid development of nuclear energy sector. They go beyond the fact that organic fuel reserves are exhausting. We have enough of them, let's say, for the next one hundred years, including tar sands, Arctic shelf and the Antarctic. Another important factor is the potential expansion of the *golden billion*. It has advanced energy- and resource-saving technologies, but also high specific consumption of energy resources per capita. Now that this community may be joined by China, India and Latin America (over two billion people representing booming economies), it will be necessary to produce and deliver to consumers the enormous amount of organic energy resources (oil, gas, and coal) every minute, every hour, every day. This is a real mission impossible for any kind of transport, let alone political issues that prevent shipments (look at Ukraine, Belarus, or *Nord Stream* construction in the Baltic Sea) and *force majeure* (man-made disasters, earthquakes, sabotage, etc.). Hence, energy sectors in the future should be regional by nature, so that delivery (both fuel shipments and energy transfers to consumers) may not affect energy security. Beside energy systems relying on local resources (mostly renewable), only nuclear energy meets these criteria.

Moreover, the latter has available resources for several thousand years, taking into account breeders of plutonium and thorium.

Nonetheless, by 2020–2030 not much will change, as far as the amount of nuclear energy production is concerned. These years will be marked with massive decommissioning of reactors with expired service lives. So the industry of all nations that use nuclear power plants (NPPs) will hardly cope with the task of developing sufficient capabilities and equipment to replace them in electrical generation or surpass the current levels.

Russia is not an exception. On the contrary, it will feel even stronger impact of this process. In the 1990s our infrastructure required for NPP construction was ruined, there is a qualitative and quantitative shortage of human resources (from builders to applied science and safety monitoring). My estimate would be 20 percent of Russia's energy balance by 2030 – this is much more realistic than the astonishing figure of 30 percent.

If this 20-percent level is achieved and Russia does not take extra commitments on supplying uranium to Russia-designed foreign reactors, our domestic reserves (including the Elkon field) with some indispensable import of raw materials (e.g. from Kazakhstan) will be enough to ensure the operations of light water reactors, such as *VVER-1000*, to be constructed, in accordance with the aforementioned *Rosatom*'s plans.

By 2030, if the current strategy is implemented, a few commercial NPPs with fast breeder reactors (FBRs) should emerge. They will have closed fuel cycle with 1.2–1.3 breeding ratio. This will enable us to use accumulated spent nuclear fuel from *VVER-1000* reactors (and partly from *RBMK-1000*) for the second time after regeneration. Besides, the production of excessive plutonium in FBRs means the appearance of a new resource, with new balance of fissile materials – and this will determine the quantity and characteristics of new NPPs after 2040–2050.

ALEXEY UBEEV (*ATOMSTROYEXPORT*): Possible mid-term nuclear energy development scenarios differ even within the IAEA, which is a highly respected and the traditionally prudent in its assessments. According to the optimistic scenario, total capacity of NPPs in the world may amount from 360 GWe now to 510 GW by 2020. In other words, within the next 10 years it will be necessary to build and commission 10–12 reactors per year – and today it seems nearly impossible. A more realistic figure is six-seven new NPPs per annum, so by 2020 the world may obtain 420–430 GW from the nuclear sector. Taking into account the expected intense process of decommissioning, the share of nuclear energy will not change much and should fluctuate between 16 and 20 percent of global energy balance. Obviously, in some states and regions that are active in developing peaceful nuclear energy uses, this balance may be different.

Such playing with the figures may last forever, since it is always easier to make long-term forecasts than to answer a specific question. For instance, how many NPPs will become operational next year? In fact, the next one-two years will be quite indicative for Russia and the global nuclear industry – will the plans of NPP construction and building of appropriate infrastructure succeed or will they remain on paper? According to the IAEA, the construction of infrastructure required for normal functioning of nuclear energy sector should take 10–12 years. May it happen that the countries currently zealous to build NPPs will abandon their plans after facing inevitable structural, administrative, financial, legal, personnel and other problems?

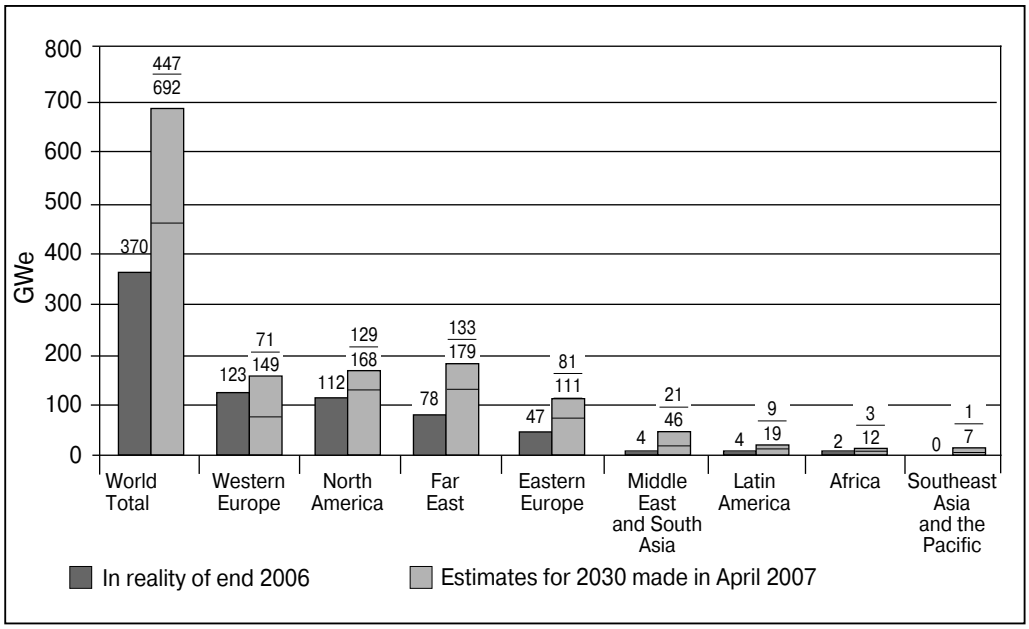
All aforementioned difficulties in construction of NPPs together with the limited capabilities of nuclear power machine-building (especially for the equipment that has long production cycle) can be overcome. Such situations occurred in the history of global nuclear energy development. The statistics says that in the 1970s mankind built 162 reactors with the total capacity of 120 GW; in the next decade, another 176 reactors with 190-GW capacity were constructed. Meanwhile, since the early 1990s until now the international community has commissioned only 19 power plants (implications of Chernobyl and the Three Mile Island tragedy). This means 20, or even 30 (like in the United States) years of reluctance! Hence, there is no continuity in the industry and in personnel training.

Another factor that may impede the ambitious plans is the lengthy process of licensing (two-three years) and construction (7–10 years). These are real terms, not declared ones. For instance, the building of the European Pressurized Water Reactor (EPR) in Olkiluoto (Finland) lags two years behind the schedule. In parallel, the licensing goes on. The Japanese argue that theoretically it takes three years to build power plants – but there is no practical evidence yet. Our endless construction process has been criticized since the Soviet times.

There is slow progress in solving legal and financial issues related to harmonization of domestic and international legislation on such urgent matters, as civil liability for nuclear damage, intellectual property rights, or risk insurance. They are topical now that Russia sets up joint ventures, strategic alliances, establishes international centers, and builds nuclear facilities abroad.

ALEXANDER CHEBESKOV (IPPE): Among many short-term forecasts of nuclear energy development, the most reliable seem to be the assessments of the IAEA consultancy on nuclear capacity projections. This task force was established about 30 years ago and provides annual estimates of nuclear energy development in different countries based on the bottom-up approach. With the help of the special software, such national forecasts are extrapolated at the regional level and finally at the global level. The reports have only low and high levels, which are published in updates and annual reports. Figure 1 indicates the results of the latest meeting at the IAEA in April 2007.

Figure 1. **Estimates of Nuclear Capacity Development by Region by 2030**



It is clear from the chart that in all regions there is an expectation of capacity growth. The only exception is Western Europe, the minimal scenario for which implies substantial reduction in nuclear capacity by 2030.

In general, the expected growth rate varies from 20 percent to 90 percent, if one compares 2006 and 2030. However, despite such optimistic forecasts the share of nuclear energy in the global balance will decrease to 5.7–5.9 percent by 2020 and 4.9–6.1 percent by 2030. In fact, in late 2005 it was 6 percent. The same process will happen in electrical generation – going down to 14–15 percent in 2020 and 12–13 percent in 2030 (in comparison with 15.5 percent in global electrical generation in 2005).

In February 2008, the Russian government approved the general scheme of deployment of power generation facilities. The basic scenario implies the commissioning of new facilities with

the capacity of 137 GW by 2020, out of which 25 percent should belong to the nuclear industry (37 new reactors). The optimistic option maintains that the share of nuclear energy may reach 30 percent (42 new reactors).

At present, the new Strategy of Nuclear Energy Development is being elaborated in Russia. Among its goals is the growth of total capacity of NPPs – 100 GW in 2030 and 300 GW in 2050. If such output is achieved, the share of nuclear energy in electrical generation in Russia will exceed 30 percent.

According to different estimates, Russia has enough uranium to develop nuclear energy until 2030. After that the country needs a radical shift – massive commissioning of FBRs and closed nuclear fuel cycle in the energy sector.

ALEXANDER POLUSHKIN (*ROSENERGOATOM*): I would like to say a few words about the investment program of *Rosenergoatom*. Its large scale can be understood in comparison with the activities of the corporation in the last 10 years.

Until 1998 there were practically no investments in the nuclear energy sector of Russia. Some money was allocated to develop new projects, such as *NPP-91, NPP-92, BN-800, KLT-40S,* and maintain the facilities under construction, the building of which was suspended in 1991–1992.

Everything was against further progress of nuclear energy – post-Chernobyl syndrome of the general public, opinions of the leading politicians (who made their careers on two slogans – «*A bas* the Communists!» and «*A bas* the NPPs!»), the lack of money (only 10 percent of produced electricity were paid for), stagnation of industry and collapse of construction companies. It seemed that our industry would never revive...

In summer 1998 the first post-Chernobyl federal program of nuclear energy development was approved. Some hopes emerged. The program did not provide for new large-scale construction, it ran out of money, it was not perceived well in the regions, but anyway it was a breakthrough – the government clarified its position.

Since then and until 2005 the situation began to change to the better and this was quite a dynamic process. The construction of two reactors was finished and they became operational (Rostovskaya No.1 and Kalininskaya No.3). Russia started to upgrade and extend the service lives of existing NPPs – Novovoronezhskaya No.3 and No.4; Kolskaya No.1 and No.2; Leningradskaya No.1 and No.2; Kurskaya No.1 and No.2; Bilibinskaya No.1, No.2, No.3, and No.4. The construction of reprocessing facilities for radioactive waste was launched. The annual amount of investments grew from 3 billion rubles in promissory notes in 1998 to 20–24 billion rubles in hard cash in 2005. Projects abroad – Iran, India, and China – helped to maintain the production plants that manufactured equipment for NPPs.

Since 2006 the revolutionary changes in nuclear energy development and investments have begun. The new management team headed by Sergey Kiriyenko elaborated and passed through the government the federal program of nuclear energy sector development in 2007–2010 with the prospects of its extension to 2015. This document implied the commissioning of two reactors per year starting from 2012.

The new project – *NPP-2006* – was developed. The construction of *BN-800* at the Beloyarskaya NPP commenced; the building of Rostovskaya No.2 and Kalininskaya No.4 was resumed; new engineering companies were set up on the basis of existing design bureaus. New construction sites were opened for Novovoronezhskaya No.2 and Leningradskaya No.2; the service lives of Leningradskaya No.3, Kurskaya No.3, Novovoronezhskaya No.5, Kolskaya No.3 and No.4, Beloyarskaya No.3 were extended. New program of raising the capacity of existing NPPs was launched. The amount of investments in 2006 achieved 35 billion rubles, in 2007 – 60 billion rubles (out of which 18 billion were appropriated in the federal budget). The plan for 2008 is 120 billion rubles (with 50-billion support from the federal budget)!

Particular attention is paid to the extension of service lives of the first and second generation reactors. The investments here will amount to 15–17 billion rubles in 2008.

A few years before the service life (it is about 30 years) is expired, the detailed examination of equipment, buildings and facilities takes place. The list of equipment and technical systems to be replaced or fully repaired is formed. Besides, the list of deviations is created and the decision to eliminate them is taken (if the technology does not allow – the compensation measures are elaborated). After thorough analysis the project of service life extension is prepared, reviewed by the experts and approved for implementation by Rosatom.

This area is one of the today's priorities. First of all, by spending $300–400 million we can extend the service life of a megawatt reactor for another 15 years – this is beneficial for the economy. Secondly, such extension helps to maintain the serial construction of new NPPs without losing the general capacity level of the nuclear energy sector.

Another important issue is the handling of spent nuclear fuel and radioactive waste. The amount of investment in waste management will be 10–13 billion rubles in 2008 – each NPP is constructing facilities for reprocessing and storage of liquid and solid waste accumulated during the years of operations.

However, our primary task is to develop new facilities. Here we speak about finishing the construction of some reactors (with high degree of readiness, the building of which was suspended), new NPPs (under the *NPP-2006* project with the capacity of 1,150 MW), conservation of sites where the construction has to be put off, and elaboration of new designs for the future. It is planned to invest 75–80 billion rubles in 2008 in such activities. Before that we had to comply with the goals set in the federal program of nuclear energy development until 2015. Starting from this year we have a new orientation point – the aforementioned general scheme of power facilities deployment until 2020.

In accordance with the general scheme, we should commission one reactor per year until 2012, two reactors per annum in 2012–2014 and, at least, three blocks starting from 2015. The total capacity of the facilities that will become operational in 2009–2020 should amount to 32,000 MW. Meanwhile, we will decommission 3,700 MW of old plants, so nuclear energy production in Russia by 2020 should exceed 51,000 MW. Average annual power generation at an NPP should increase from 150 billion kWh now to 380 billion kWh.

During the first years of program implementation, the federal budget and *Rosenergoatom* will pay the costs nearly 50/50. Later on, the corporation will increase its contribution into the investment program and by 2015 there will be no federal investments.

It is noteworthy that beside serial construction of NPPs with *VVER* reactors (1,150 MWe), there are plans to make operational an FBR at the Beloyarskaya NPP No.4 by 2012. This reactor should have the capacity of 800 MWe (*BN-800*). Experts believe that this technology will make the future of nuclear energy sector. Russia is a leader in this area and after commissioning of *BN-800* and closed nuclear fuel cycle (spent fuel is returned to the reactor after regeneration), its leading positions will only strengthen. The lessons learned at the Beloyarskaya NPP could be used to devise the plans of global nuclear energy development in the second half of the 21st century.

Another curious project that we have is the floating NPP with the 70-MWe capacity. The pilot version should become operational in Severodvinsk by 2010. There are reasons to believe that this project is quite promising – and not only for intense use in the Russian northern regions, but also abroad. Beside electricity, the floating NPP produces heat and can also be used for desalination.

One has to note that funding is no longer a decisive factor in the program implementation. Nowadays, the key issue is the supply of resources, above all human resources, materials and equipment.

SECURITY INDEX: What are the major problems and challenges related to large-scale development of nuclear energy sector in the world, especially when it comes to some countries that lack the experience of operating high-capacity NPPs?

VALENTIN IVANOV: As a rule, politicians and experts fear the proliferation of fissile materials (enriched uranium and plutonium extracted from spent nuclear fuel or targets) that may facil-

itate the development of nuclear weapons and expansion of the *nuclear club*. The existing fuel cycle technologies for reactors do provide for the production of enriched uranium and plutonium at some stage. There are different proposals on how to reduce the risk of proliferation in this case (leasing of fuel, leasing of NPPs, work with highly radioactive fuel to prevent the use of fissile materials without strong biological protection, etc.).

In my opinion, a more significant problem is the lack of clear and coherent policy of spent fuel management. If there is no decision on centralized (a few centers in the world) long-term supervised storage of spent nuclear fuel, the nations that have limited nuclear energy uses and are freshmen in this area immediately face a serious challenge. The existence of many storage facilities that are scattered around the world in different geographical conditions without clear vision of what should be done with them next, only exacerbates the risk of incidents and accidents.

ALEXEY UBEEV: Let me touch upon the nonproliferation issues connected with the *nuclear renaissance*. Obviously, as nuclear materials and technologies proliferate, there is a growing risk of their diverted use, above all when it comes to sensitive technologies of nuclear fuel cycle – uranium enrichment, storage and management of spent nuclear fuel and radioactive waste. The multilateral solutions towards nuclear fuel cycle, the tightening of export controls may help to reduce the risks, if the nations abandon in good faith their legitimate right (under the NPT) to develop peaceful nuclear energy technologies. The task of the near future is to make international initiatives attractive from political and commercial point of view. The acceptance of new technological barriers (nuclear energy systems with inherent security) requires rejection of attractive, but hazardous technical solutions. It is suggested to supply certain proliferation-sensitive equipment and compact nuclear *batteries* in the form of a *black box*, which prevents unauthorized use. In fact, floating NPPs and low-capacity nuclear reactors are the prototypes of such *batteries*.

It is evident that the phenomenon of *nuclear renaissance* has many aspects and is quite a mosaic, so it is difficult to forecast whether it will make a comprehensive picture, or only some elements of it will survive. And God save us from new Chernobyl!

SECURITY INDEX: How can Russia help to solve these problems? What are the major competitive advantages of Russia in comparison with other suppliers of nuclear equipment and services? What will the share of Russia on global nuclear market (NPPs, fuel, enrichment services) be in the foreseeable future?

VALENTIN IVANOV: Russia has appropriate legislation that enables us to return to our territory radioactive waste and fissile materials from spent nuclear fuel of Russian origin. This is a good offer for the countries that start peaceful uses of nuclear energy, but not all of them prefer the Russian fuel. There is a need to elaborate further international laws and national legislation, so that this problem gets a global solution.

My opinion is that one of the primary advantages of the Russian fuel supplies is their ability to take away spent nuclear fuel without returning radioactive waste. This advantage is the second in the list headed by Russia-designed reactors. After implementation of the pilot project on floating NPP (*KLT-40S*) Russia will be able to lease NPPs and solve the problems of spent nuclear fuel and complete decommissioning (there is no need for dismantlement, deactivation, collection and disposal of radioactive waste). Such benefits are quite attractive for potential customers from Indonesia, India, and even China. Russia has designed (at the level of concepts) low-capacity NPPs (3–10 MW) with integral construction and high safety and security level. They are easily transported, provide for more than 10 years of operations without reloading, and can do practically without permanent staff. This is also an attractive offer for many countries.

As far as regular equipment for serial NPPs is concerned (*VVER-1000*), I can hardly see any potential benefits for Russian suppliers and Russian projects here. This market witnesses tough competition.

ALEXEY UBEEV: A few words about economic component of nuclear energy. The construction of any NPP is a multibillion euro project and it will take long to pay back the investments.

Experts assume that the average cost of one kWh exceeds 2,000 euros and it is rapidly increasing. The development of innovative reactors and nuclear fuel cycle technologies (*INPRO, GIF-IV, GNEP* international programs) will take even longer to implement, have higher risks and unpredictable practical output.

Now the companies are not only interested in construction, but also in management of NPPs, in electricity sales. However, even these earnings will not be enough to maintain the nuclear fuel cycle enterprises, including safe management of spent nuclear fuel and disposal of radioactive waste. Without organizational and financial support of the state, the development of nuclear energy sector, at least, at the initial stage, is hardly possible. The government should provide loans for construction, tax breaks, higher tariffs for electricity generated at the NPPs, assurances on compensation of possible nuclear damage, etc. A good example of effective state support is France, where the president works as a personal lobbyist of the national nuclear energy sector. After all this sector account for only two mass products – electricity and heat, so to raise the profits of NPPs one should develop this second component as well.

I would like to unveil some myths concerning the successes of Russian nuclear industry. There is a false impression that our success in getting contracts for construction of NPPs is accounted for by low price of domestic technology, or even dumping. But believe me, no one will take up unprofitable projects – in the past we did feel the affect of politics, but nowadays only technologies and economic factors compete.

So, one should not have a gloomy picture. Fundamental reforms in the industry, substantially increased funding, including budgetary expenditure, promising research (including some ideas and technologies which were not realized earlier for different reasons) – all this makes a good starting point for the development of Russian nuclear complex. We have products, services and technologies to offer to the world market. For instance, take our unique experience of industrial operation of FBRs (*BN-350, BN-600*), power plants of ships, etc. It is important to offer the potential clients a full set of services – from infrastructure development and personnel training to construction of NPPs, nuclear fuel leasing, its removal and withdrawal and decommissioning.

VLADIMIR KAGRAMANYAN (IPPE): The initiative of Vladimir Putin to establish the global nuclear power infrastructure (GNPI) is aimed at solving the problems that you mention. It was set forth on January 25, 2006 in St. Petersburg in the course of the Eurasian Economic Community summit. Such global infrastructure should enable all concerned parties to have equal access to nuclear energy and comply with the nonproliferation commitments. The key element of such infrastructure should be the system of international centers that will provide nuclear fuel cycle services, including uranium enrichment under the IAEA control and on the principles of non-discriminatory access. Russia is ready to set up such center on its territory – with innovative technologies, new generation of reactors and fuel cycles – on the basis of broad international cooperation. Such centers, as it was mentioned at the press conference in the Kremlin on February 1, 2006, could also provide for disposal of spent nuclear fuel.

Nowadays Russia builds more NPPs abroad than any other country. China got two blocks with *VVER-1000* reactors at the Tianwan NPP, there is an agreement to build additional blocks at this site. The work at the Kudankulam NPP in India has reached its final stage – it means the commissioning of another two blocks with *VVER-1000* reactors; and the parties negotiate the construction of additional blocks there. The work at the Bushehr NPP in Iran is coming to an end. At the same time, the construction of the Belene NPP in Bulgaria starts. Russia gets ready for tenders on NPP construction in Belarus, Egypt, Turkey, etc.

At present, *TVEL* supplies nuclear fuel to 14 states for 74 NPPs. The corporation intends to expand its share on the world market with the fuel for pressurized water reactors and conquer up to 30 percent of global market by 2010. *TVEL*'s production is reliable and has a good image abroad. One has to note that Finland and the Czech Republic have decided to replace their fuel supplier – *Westinghouse* – with *TVEL* for the NPPs in Loviisa and Temelin.

As far as uranium enrichment technology is concerned, Russia has an indisputable leadership in the world. At present, Russian enterprises are replacing their equipment with the eighth-

generation centrifuges, which have higher production capacity. New ninth- and tenth-generation equipment is being designed. According to Deputy Director General of the Urals Electrochemical Combine Gennady Soloviev, at one of the recent meetings of Rosatom's Scientific-Technical Council U.S. and Russian devices were compared,

> «Americans followed the path of developing very large, supercritical 15-meter machines. Russia decided to develop small ones – about half a meter – which are assembled by 20 into a single unit. If one takes industrial output of a U.S. centrifuge at the experimental plant and by Russian centrifuges assembled into a unit, it will turn out that Americans produce 325 SWU a year, while our centrifuges provide for two and half time higher result. The difference may be smaller in comparison with *Urenco*, but still our equipment is 150 percent more efficient.»

SECURITY INDEX: How deep should Russia's cooperation with foreign companies be when it enters the global market? What would the benefits of such cooperation be?

VALENTIN IVANOV: To my mind, Russia should make maximum use of interaction with foreign companies. Technologies that are used to build reactors, to dispose of radioactive waste, to create nuclear fuel cycle, to manage spent nuclear fuel are too complicated and should not confine to national limits. Deep cooperation in the development of global nuclear energy sector means geographical expansion of the market, exchange of experience and higher efficiency of all activities in this sector. For instance, Russia has not yet carried out (even at the experimental level) a large-scale disposal of high level waste, while some countries already operate such facilities. Many other examples can be made.

It is also clear that the notion of cooperation nowadays implies the effective use of economic, market mechanisms.

ALEXEY UBEEV: International cooperation in the industry is inevitable, if we want to remain competitive. We have things to borrow from our partners, as far as some bulky equipment and instrumentation and control systems are concerned. For example, during the construction of the Tianwan NPP, *Atomstroyexport* maintained close cooperation with the French-German *Areva NP-Siemens*. The interaction will continue in building the NPP in Bulgaria. Today the world has four-five large transnational holdings that divide the world nuclear technology market. Besides, the demand for NPP construction is so high now (so far mostly at the level of declarations) that all actors will obtain enough contracts. The alliances can be established to implement specific projects, but it does not mean that *ad hoc* coalitions should prevent the companies from competing with each other in other tenders.

VLADIMIR KAGRAMANYAN: Russia should obviously cooperate with foreign companies to promote its production on the world market. This is especially true for the areas, in which Russia has not yet achieved the required potential after the collapse of the Soviet Union. Cooperation with foreign companies will enable Russia to reach the appropriate level of manufacture of equipment and various systems for nuclear energy sector.

As far as nuclear technologies are concerned, Russia has an evident priority here – I mean uranium enrichment and FBRs; and they should be further advanced.

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NIKOLAY PONOMAREV-STEPNOI (THE KURCHATOV INSTITUTE): The *Security Index* journal posed a number of important questions concerning *nuclear renaissance* to the round-table participants.

The analysis of energy problems in the short-term and long-term perspectives enables us to argue that the tensions on the world energy market continue to heighten.

Developing countries have new production facilities and, hence, their demand for energy grows. The gap in per capita energy consumption between the developed and developing nations is narrowing and in the next decades it will be necessary to double or even triple global energy production. The process is inevitable and to solve the issue, mankind should discover and use new energy resources. If people do not want to lose the world, they should *switch on* all possible sources of energy to meet this growing demand.

Under these circumstances, the maintenance of energy security becomes the highest priority in the world. One of the solutions would be to ensure large-scale progress of nuclear energy sector. Year by year new states declare their intention to develop nuclear energy – most of them are developing countries, even those whose *energy well-being* seems to be out of question. So, the *nuclear renaissance* is not a whim of transnational corporations planning to gain new profits, it is an imperative of our era determined by the desire to ease tensions on the energy market and, hence, to ensure energy security.

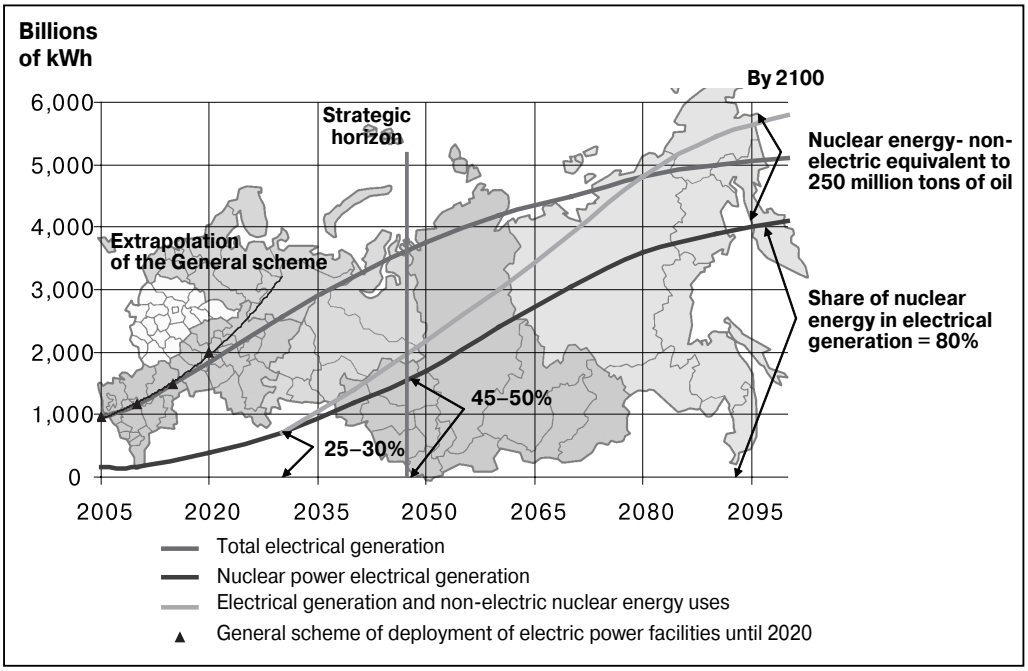
To mitigate the tensions, there is a need for dramatic change in the amount of nuclear energy uses. This will imply new role of nuclear energy sector in the energy balance of many countries. According to our estimates,

- By mid-century the total amount of operating nuclear facilities in the world should increase five times.
- The range of countries and regions practicing peaceful nuclear energy uses will significantly expand, including those nations that do not have previous experience of nuclear technology uses and, hence, do not possess specialized nuclear safety procedures and nonproliferation skills.
- Nuclear energy development will be based on the experience of the past. However, new challenges (the scale of use, the growing number of users, new areas of application) would require innovative solutions. The nuclear energy sector will witness changes – the use of FBRs that will supply fuel to the nuclear energy sector, the nuclear fuel cycle will include spent fuel reprocessing and recycling of fuel materials, i.e. it will be the closed nuclear fuel cycle. Nuclear reactors will be used not only for electrical generation at NPPs, but will get new applications, such as energy support for industrial technologies (e.g. hydrogen production). Beside high-capacity reactors connected to unified electricity grids, regional NPPs of low and medium capacity will be developed – they will supply local customers with heat and electricity.
- Mankind should agree that nuclear energy development is a vital need, but it should also demand for maintenance of nuclear, radiation and environmental safety and other nonproliferation safeguards. Hence, new approaches towards nonproliferation are prerequisites for *nuclear renaissance*. Additional measures should be taken to reduce the proliferation risks, or at least, to keep them at the current level. Such steps should be taken in all spheres – political, institutional, technological – and this may be a matter of special debate in the *Security Index* journal.

Why should Russia participate in this *renaissance*, if it has immense organic fuel reserves? The country faces serious energy problems, as its economy is booming. Most of electricity is produced in Russia by burning natural gas (over 75 percent in the fuel balance of thermal power plants). Taking into account the export significance of gas, one of the key tasks for the Russian energy sector is to ensure its diversification in the coming decades, e.g. by using coal, developing nuclear energy and hydropower plants. However, there is one particularity in this sector of economy – most of traditional sources of energy are situated behind the Urals, while most of consumers are concentrated in the European part of the country. So it is quite difficult to provide for large-scale increase in electrical generation at thermal and hydropower plants, since coal and electricity require long-distance transportation. Therefore, it is important to develop nuclear energy capabilities in the European part of Russia. Figure 2 demonstrates our estimates of electricity production and nuclear energy development until 2100 (taking into account the current update of the Strategy of Russia's Energy Development until 2030). Such long-term forecast is accounted for by the need for huge capital investments in nuclear technologies and long service life of nuclear power plants.

Even large-scale development of nuclear energy cannot solve the problem of growing demand for engine fuel and heat for industry and housing. The use of nuclear energy capabilities in the hydrogen production, in energy-consuming industries and in public utilities is also inevitable. So in the future this part of nuclear energy sector may become comparable to traditional electricity production at NPPs.

Figure 2. **Development of Electrical Generation in Russia until 2100 and the Role of Nuclear Energy Sector**



Source: The Kurchatov Institute

Successful implementation of the tasks set in Russia's nuclear energy development programs should ensure good competitive position of our technologies on the global market. A target would be to conquer 20 percent of the world nuclear market.

The roundtable participants shared their views on the development of nuclear energy sector. As expected, their positions did not always coincide. However, I assume that there is a common feature in all statements – the willingness to find the optimal scenario of nuclear energy development in the conditions of growing global energy shortage. Let us hope that the alarming notes concerning unrealistic scale of the plans and pace of nuclear energy development will disappear thanks to the decisive actions of the international community aimed at confronting the growing threat of the energy crisis.