Iranian industrial complex, including defense industry, supplies the Armed Forces with practically all kinds of conventional arms and materiel. Despite significant advancement, Iran is highly dependent on foreign states as far as complicated modern equipment is concerned, including aircraft, missiles, armor, radio electronics, etc. Chemical industry and some other key sectors remain dependent on imported components. The weakest point of Iranian industry is low capabilities to manufacture means of production.

Development programs elaborated for defense industry provide for keeping reliance on import of technologies and replication of foreign analogues. Although Iran has succeeded in maintaining indigenous military R&D, development programs still envisage application of foreign technological achievements.

In the early 1990s, some experts predicted that Iran would develop nuclear weapons in the next few years. Nonetheless, these assessments proved to be ill-grounded. Iran is in the process of shaping its scientific and technological potential and it will take him long time to reach required level for WMD production.

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[1] *Iran Statistical Yearbook 1998.* Tehran, winter 2000, table 21.1.
[2] Ibid., table 22.18.
[3] *Nezavisimoye voennoye obozreniye*, 2000, October 20-26.
[4] *SIPRI Yearbook 1999* (in Russian). M., 2000, p. 307.
[5] *Iran Statistical Yearbook 1998,* table 7.4, 7.11, 7.12.
[6] *Military and Arms Transfer News*, 1995, No. 95/13, November 1.
[7] *Nezavisimoye voennoye obozreniye*, 1997, December 19-25.
[8] S. Bagdasarov, D. Chavushyan, *Military and Military-Economic Potential of Middle East Nations*. M., 1998, p. 23.
[9] *Izvestiya*, 2000, July 18.
[10] *SIPRI Yearbook 1999,* p. 317.
[11] *Islamic Revolution in Iran: Past, Present, and Future*. M., 1999, p. 79.
[12] *Iran Statistical Yearbook 1998,* table 18.9.
[13] *SIPRI Yearbook 1999,* p. 379.
[14] Ibid., p. 398.
[15] *Vremya Novostei*, 2000, May 16
[16] G. Gerardi, M. Aharinejad, "An Assesment of Iran's Nuclear Facilities". *The Nonproliferation Review,* 1995, Spring–Summer.
[17] *New York Times*, 2000, September 19.

Commentary

FEASIBILITY OF PUTIN'S INITIATIVE: WAYS TO ENSURE SUSTAINABLE ENERGY SUPPLY[1]

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[This article was originally published in Russian in *Yaderny Kontrol*, No. 2, Vol. 7, March-April, 2001]

At the UN Millennium Summit President Putin set forth an initiative to ensure energy supply for the sustainable development of mankind, to resolve in radical way the problems of proliferation of nuclear weapons, and to provide for environmental recovery of the planet. He proposed to launch an international project aimed at pursuing these goals with the help of nuclear energetics. There is no doubt that such initiative is topical and timely as a new century begins.

Putin's initiative is based on critical analysis of the state of global energy sector. There is an obvious shortage of cheap organic fuel, especially gas and oil, and high pollution of environment by waste of energy plants. At the same time, in the process of promoting energy supply for mankind one should bear in mind high population growth rate and increasing economic gap between developed and developing nations. Evidently, different regions will have different growth rate and structure of energy sector. The aforementioned factors will affect development of regional and global energy policy. Without concerted efforts and common concept of energy development, it will be difficult to ensure sustainable energy supplies.

Assessment of the problem of developing energy and protecting environment in the conditions of continuing population growth and predicted increase in energy consumption suggests advisability of large-scale nuclear energy development, at least, for some regions, including Russia. Large-

scale nuclear energy development will mitigate greenhouse effect and provide for optimal (economically and environmentally) growth of global energy consumption. Oil and gas will be preserved for non-energy uses and for power plants that will use them most efficiently.

If we want to solve energy problems of humanity by developing nuclear energy, we should think about improving and upgrading nuclear fuel cycle technologies, introduce close fuel cycles, extended reproduction of nuclear fuel, involvement of new types of nuclear fuel, development of nuclear power plants with different capacity armed with reactors with fast and thermal neutrons. All these activities will be necessary to meet various demands of consumers and to accomplish structural tasks of nuclear energetics. Large-scale nuclear energy sector requires closed fuel cycles, so that it may not only use fissionable uranium isotopes existing in nature, but provide for expanded production and application of artificial fissionable isotopes of plutonium and uranium-233.

Many elements of future structure of nuclear energy sector have already been developed, but much has to be done to create a coherent structure of nuclear energetics capable of long-term and large-scale development. Above all, this relates to development of technologies, components and systems of nuclear fuel cycle and solution of radioactive waste management problem. Developed states should think about the future and assist developing countries in implementation of existing and new projects, adapting them to specific conditions and requirements of the Third World. To invent advanced nuclear energy technologies that will take into account more than 50-year experience and will meet demands of global energetics, there is a need for concerted efforts of all states interested in nuclear energy and possessing scientific and technological potential and knowledge.

Large-scale development of nuclear energy sector will have to enhance efficiency of nuclear nonproliferation regime. Anyway nuclear power plants and related technologies, nuclear fuel enterprises and fuel itself should be designed in a manner to secure nuclear nonproliferation, though it is understood that nuclear energy sector is not the only and the major way of nuclear arms proliferation. Modern technologies of natural uranium enrichment and separation of plutonium from natural uranium (not in energy reactors) give a chance to acquire nuclear material required for weapons. Meanwhile, the so-called current nonproliferation regime was established more than 30 years ago and does not take into consideration developments that have occurred so far, proliferation of new nuclear technologies, and changes in global political and economic situation. This is why, to ensure effective nonproliferation, mankind should take political, organizational and technical measures at national and international levels both in the spheres of nuclear fuel cycle and nuclear material management.

Format of Putin's initiative at the UN Millennium summit did not require any technical details of implementation. However, the presidential speech contained some technical ideas, 'We should reliably block the ways for spreading nuclear weapons. We can achieve this in several ways, among them, excluding the usage of enriched uranium and pure plutonium in world atomic energy production.' This concept seems to be unclear for the public, has caused equivocal interpretations and has not been accepted by many experts.

Enriched uranium. There are two categories of enriched uranium – highly-enriched uranium and low-enriched uranium. To develop nuclear weapons, one needs HEU, whereas peaceful nuclear power plants use LEU (and it is not recommended to apply HEU in nuclear energetics). Proposal to exclude the usage of enriched uranium will face negative response of entire world nuclear community, since existing peaceful nuclear energy sector based on boiling and pressurized-water reactors employs low-enriched uranium.

Excluding the usage of enriched uranium and pure plutonium in nuclear energy production. This is supposed to be one of the ways to enhance efficiency of nuclear

nonproliferation regime. Nonetheless, there are some examples that refute this theory. Nuclear weapons were developed when there was no civilian nuclear energy production. India has no enrichment industry and does not use pure plutonium in its peaceful nuclear energy production. New Delhi has heavy-water reactors with natural uranium fuel. Fabricated plutonium does not return to the fuel cycle. It may seem that all aforementioned nonproliferation requirements are in place, but India still possesses nuclear weapons. The same is true as far as Pakistan is concerned.

Returning plutonium to nuclear fuel cycle. Some nations (Germany, France, Belgium) have learned to reprocess irradiated nuclear fuel of energy reactors, to separate pure plutonium and use it afterwards to produce energy. Thus, proposal to refrain from stockpiling plutonium separated in the course of reprocessing irradiated fuel and to return it to nuclear fuel cycle is already being implemented in modern nuclear energy sector.

Final solution to radioactive waste problem. It is too early to say that Russian fundamental research in the area of incineration of plutonium and other radioactive substances creates prerequisites for final solution to the problem of radioactive waste. The aforesaid research is at its initial stage.

We presume that key technical ideas mentioned in the initiative are the result of the BREST project. It is understandable why Russian nuclear industry leadership is so much concerned about this project and strives to use supreme authorities to introduce these innovations. BREST is allegedly capable of solving all problems of large-scale nuclear energetics: unlimited fuel supplies, cardinal solution to the problem of nuclear arms proliferation, natural safety, incineration of radioactive elements and no more problems with radioactive waste. These allegations have not yet been proved in the course of research and technical activities and they are quite controversial.

According to authors of the BREST project, combination of reactor and reprocessing in single complex will ensure nonproliferation. It is true that mixture of plutonium and actinides used to close fuel cycle cannot be applied to develop nuclear weapons, but it is easy to separate pure plutonium from such mixture and to employ it in A-bomb instead of reactor. Such decision will limit commercial use of such reactors: they will be built by *nuclear club* members only, since transfer of spent fuel reprocessing technology to non-nuclear weapon states will increase proliferation risks. Besides, this technological solution will amplify radiation danger, taking into account the final process of decommissioning and shutting down the reactor.

Spreading of the BREST reactors and scale of nuclear energy development will depend on the amount of plutonium produced after reprocessing spent nuclear fuel of existing thermic reactors. It will inevitably lead to creating productive capacity for fuel reprocessing and separation of pure plutonium, though this contradicts with ideas of radical solution to the problems of nuclear proliferation and natural safety of radioactive waste disposal. Output of reprocessing plants will have to grow; uranium mining and enrichment industry will have to be expanded. Authors of the BREST project do not take these considerations into account and argue that they have resolved the issue of nuclear arms proliferation.

To tackle future fuel shortage, one needs cycles with extended reproduction of nuclear fuel. The BREST project deliberately avoids extended reproduction and this will impede large-scale development of nuclear energy sector. The problem of disposal of excessive neutrons has not yet been studied.

BREST is at its initial stage. Technology of lead coolant is under development today. BREST does not provide for even maintenance of oxygen potential in narrow permitted range (if it succeeds). To secure work of fuel rods, it is necessary to find optimal amount of oxygen in coolant suitable for certain temperatures and to maintain it at this level during all the time reactor is operated. There has been no evidence of normal functioning of construction materials and their normal coexistence with lead in

certain temperature conditions and under high neutron irradiation. The authors of the BREST have failed to study impact of irradiation on behavior of fuel rods and other elements placed in lead coolant: there have been no tests in real-time mode in reactors. The problem of mixed nitride fuel requires considerable efforts and time to be resolved. Technical solutions concerning fuel reprocessing are *in the bud*.

Long-term strategy of nuclear energy development in Russia and appropriate governmental decisions contain specific tasks for near and distant future as far as existing reactors, new generation reactors and fuel cycles are concerned. Nowadays the worst thing would be to take an arbitrary decision and to adopt any technological solution as the only remedy, call it the best way out and abandon all other directions of research. According to feasibility studies, the BREST is not ready for the stage of technical design and cannot be named the only component of long-term strategy of Russian nuclear energy development. This project can hardly become a basis for consolidation of international efforts (since key and the most valuable concept of Putin's initiative is to ensure joint endeavors).

It is necessary to study, develop and test new technologies, assess their efficiency in accordance with technical and economic criteria, as well as from the point of reducing proliferation risks. Nations of the world (the USA, France, Japan, South Korea and others) seek ways and technological solutions for new generation nuclear energy production. Under these circumstances, Putin's initiative about international project may have a consolidating effect, facilitate comparative analysis of several ways of nuclear energy development, which can be evaluated according to unified technical, economic, environmental and nonproliferation criteria. The international project should, in fact, focus on elaboration of such criteria. Broad interpretation of Putin's initiative is required: standards for nuclear energy of the future, optimal structure, key elements and new projects of nuclear energy sector, diminished proliferation risks. If the presidential proposals are regarded only in conjunction with implementation of the BREST project they may cause harsh criticism of international community.

International project should concentrate on comparing programs and concepts of various states and promote international cooperation in development and implementation of these projects. Such activities should be based on consensus and approved and unified requirements and should cover only specific power plants and nuclear fuel cycle systems. The project implies that all countries concerned will unite their efforts in securing energy supply for the sustainable development of mankind.

In the course of debate on Putin's initiative held at the Scientific Council meeting of the *Kurchatov* Institute, we have suggested to include several components in international project, each of which can be later incorporated into a number of projects.

Requirements to nuclear energy of the future. Nuclear energy sector should provide for cost-efficient, safe and reliable energy production in all regions of the world, where energy development on the basis of organic fuel is impeded because of economic, environmental and resource limitations, hence, hampering development of these regions. At the first stage, it is reasonable to formulate a broad range of requirements to nuclear energy and its long-term and large-scale development. One of the major tasks during transition to sustainable development is to find economic and political mechanisms facilitating such development.

Optimal structure and major elements of future nuclear energetics. It is necessary to choose structure and components of nuclear energetics that will meet different requirements and will contain closed fuel cycles with optimal neutron and nuclide balance. This structure should also provide for required production of nuclear fuel and multiple recycling of fuel, should minimize amount of radioactive waste and ensure that useful products are rationally consumed.

Solution to the problem of nuclear proliferation. Increasing use of nuclear energy, disposal of weapons-usable materials, expanding areas of uses and the growing number of countries dealing with nuclear energy, reproduction of nuclear fuel, closed fuel cycle and progress of nuclear technologies (not only in the fuel cycle of

nuclear energetics) pose the threat of nuclear arms proliferation. To mitigate this danger, the world community should:

- regulate proliferation-sensitive technologies, including those beyond fuel cycle of nuclear energetics;
- take strategic decisions and select technical means at all stages of nuclear fuel cycle to decrease stockpiling of weapons-usable materials, reduce their total amount and curb trafficking;
- perform disposal of excessive weapons-usable nuclear materials;
- develop and introduce technologies of nuclear material management that are based on inherent security of nuclear materials, i.e. use technological barriers impeding unauthorized withdrawal of nuclear materials from the cycle;
- improve organization and technical means of MPC&A.

International recommendations on large-scale development of nuclear energy sector should provide for optimal direction of development starting from today and up to distant future. This may result in the need to develop jointly and demonstrate in the near future some nuclear technologies that may become a basis for further large-scale development. These technologies should be aimed at:

- unlimited fuel resources due to the efficient use of natural uranium and, subsequently, thorium;
- the elimination of severe accidents, resulting from equipment failures, human errors, and external conditions, which release radiation and require the evacuation of the population which could be achieved primarily due to the natural properties and behavior inherent in nuclear reactors and their components (natural safety);
- the environmentally safe energy production and waste management in a closed fuel cycle involving in-pile burning of long-lived actinides and fission products and radiation-equivalent radioactive waste disposal without disturbing the natural radiation balance;
- the barring of the nuclear weapons proliferation pathway associated with nuclear power by phasing out the technologies of plutonium separation from spent fuel and uranium enrichment and by physically protecting nuclear fuel against theft;
- the economic competitiveness due to low costs, fuel breeding, high efficiency of the thermodynamic cycle, and the resolution of the NPP safety problems without adding to the complexity of plant design or imposing extreme requirements upon equipment and personnel.

Implementation of the international project will also require recommendations on funding and project management (establishment of working groups, decision-making procedures, etc.). Development of nuclear technologies has long become an international process, so it would be only natural if concerted efforts of countries concerned are promoted. Invention of new nuclear technologies meets long-term interests of the world community and, above all, developed states and should be endorsed by their governments if such technologies do not pose proliferation threats.

The international project is planned to be carried out under IAEA auspices, since it complies with the Agency's major objective to promote peaceful nuclear energy development. However, the IAEA cannot make its own scientific and technological contribution to project development. Its mission is to organize work of international experts to assess achieved results and to work out recommendations. The Agency cannot make any substantial financial contribution to the project.

Development of new nuclear technologies is a costly process and only states with sound research and industrial infrastructure in this area, including Russia, may cope with this task. We presume that Russia and other developed nations will benefit from concerted efforts in this sphere. Such cooperation may take bilateral and multilateral forms. In this connection, it would be reasonable to discuss the international project at the G-8 summit and to set common principles of management and funding.

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[1] The author expresses his gratitude to experts of the *Kurchatov* Institute – P. Alexeyev, N. Kukharkin, V. Sidorenko, S. Subbotin, and V. Sukhoruchkin – with whom he discussed and prepared major theses of this article.