GENERATION "NEXT" AND NUCLEAR POWER

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My generation was labeled by Russian mass media as generation "Next." My technical education is above average. My current position is as a mechanical engineer in the leading research and development institute for Russian nuclear engineering for peaceful applications. It is noteworthy to point out that many of our developments were really first-of-a-kind in the history of engineering.

However, it is difficult to grasp the importance of these accomplishments, especially since the progress of nuclear technologies is at a standstill. Can generation "Next" be independent in their attitude towards nuclear power or shall we rely on the opinions of elder colleagues in our industry?

Humanists and philosophers claim that the main purpose of a human is to reveal his capabilities as fully as possible, to satisfy emotional and spiritual demands, and to succeed in areas which best create a prosperous environment. The world community has invented a measure that indicates if living conditions meet these requirements. This measure of human development covers:

- average life expectancy;
- level of literacy or accessibility of higher education;
- level of prosperity which is supposed to be in proportion to power consumption in a given country and is measured, for example, in kW·h per capita per year.

Nuclear power is an area of human activity where the measure of human development is brought to a much higher level than in many other industries meant for sustenance of human population. The high-density source of energy stimulate the capability for learning and replacement of traditional sources of energy such as oil, coal, and gas with nuclear fission and fusion energy. Combustion of fossil fuels involves a serious risk of global warming due to air pollution with NO_x and SO_2 particles. Continued use of fossil fuels in the future will increase a greenhouse effect that can be countered by tightening of gas release monitoring and medical standards, no matter how expensive these measures will be.

Nuclear power technologies may prevent the environmental risk caused by fossil fuel, as stated by many nuclear power experts.

Speaking about the environmental risk, many people insist the global warming is a real problem in the world today. During combustion of fossil fuel for electricity production huge amounts of CO_2 and other greenhouse gases are released into the atmosphere. The contents of typical air pollutants in large cities and industrial areas exceed to a large extent the background levels which are considered natural. As a result, the number of reported cases of chronic lung diseases, cancer, heart troubles, etc. was significantly increased that lead to a higher rate of premature fatalities.

On the other hand, the former president of US National Academy of Science F. Zeits in his 1988 petition suggested to denounce the agreement on limitation of greenhouse gas release. He claimed that ÑÎ$_2$ produced positive effects on diversity of biological species and, on the whole, ÑÎ$_2$ can be viewed as a wonderful and unforeseen present given by the industrial revolution.

Can generation "Next" trust predictions of the scientists? It seems that my generation has got into the virtual reality which is full of different opinions expressed by the specialists from many scientific areas. How can we make a decision which is correct specifically for us? What opinion we need to support or how can we choose our own way?

To be able to answer all these questions, we shall be actively involved in the development of nuclear projects which are under way in our Institute.

Two of these projects will be discussed in detail below. They are reactor facility NIKA-70 and nuclear power plant UNITHERM.

The regions of extreme North and other areas similar in terms of their climatic conditions occupy about half of the Russian territory. These regions are characterized by severe climatic conditions, large distances from water transportation routes which are accessible all year round and railroads. The investigated natural resources are plentiful, though on average these vast territories are not well-developed in industrial and economic sense. Electrical and thermal loads are typically low, and the large distances between the electricity users prevent generation of a common power grid, even the small one. In most cases local fuel and energy resources are not available on site of electricity users. Consequently, transportation of fuel and accumulation of emergency stock of fuel supplies in the conditions of extreme North imply increased expenses for long-distance delivery.

The investigations performed at the Institute of Physical and Technical Problems of Northern Territories

(Yakutsk) demonstrate that in extreme North alone and other territories similar in climatic conditions there are about 90 settlements that already demand or may require in nearest future electricity supply to be provided by small- and medium-size power plants. Under these circumstances nuclear energy sources can be regarded as the reasonable alternatives to fossil fuel power plants.

I work at the Research and Development Institute of Power Engineering (RDIPE) which has recently undertaken an active effort to design advanced reactor facilities, of the "Next" generation with PWR reactors having enhanced safety features. These developments will have the benefit of RDIPE's long-time experience in design of propulsion nuclear steam supply systems. Two of these projects will be discussed in detail below. They are reactor facility NIKA-70 and nuclear power plant UNITHERM.

NIKA-70 is a RDIPE-developed reactor facility of the next generation and is intended for use in a floating cogeneration nuclear power plant. Due to specific design features of the facility, all manufacturing activities and acceptance tests can be performed on the manufacturer's premises. The facility can be delivered to the operating site as fully functional.

Space-saving characteristics of the facility and, consequently, shallow draught of the barge carrying the cogeneration plant (estimated as about 3 m) will allow to transport the plant by waterways to the distant areas.

NIKA-70 is a two-circuit reactor facility with water-water integral reactor. The characteristics of the facility are summarized in Table 1.

All primary circuit components (the reactor core and control rods, steam generator, circulation electric pumps, pressurizer) are placed in a single reactor vessel (see Figure 1). This arrangement of the reactor facility provides the ability to:

- place almost all primary circuit pipelines outside the reactor facility, thereby minimizing the risk of loss of integrity;
- ensure high flow rate of natural circulation of the primary coolant;
- enlarge coolant inventory above the reactor core and improve the core cooling conditions in case of beyond design-basis accident with leak in the primary circuit and no possibility for water supply inside the reactor.

All primary circuit components do not require in-service maintenance on power operation of the plant. The components are placed in a strong leaktight safeguard vessel which is capable to confine the release of radionuclides from the primary circuit under all design-basis accident.

TABLE 1. Characteristics of the reactor facility NIKA-70

Parameter	Value
Thermal power of the reactor core, MW	70
Electrical power of turbogenerator unit, MWe	**15**
Steam output, kg/s	25
Pressure of superheated steam, MPa	3.0
Temperature of superheated steam, min., °C	275
Feedwater temperature, °C	60
Nominal pressure in the primary circuit, MPa	14
Primary coolant temperature at nominal power operation, °C:	
at core inlet	260
at core outlet	300
Operational power range, % $N_{nom.}$	20...100
Core effective life, years	5
Fuel:	
enrichment by U^{235}, %	19.7
loading of U^{235}, kg	251
Specific power of the reactor core, kW/l	40
Assigned service life of the reactor facility, years	30

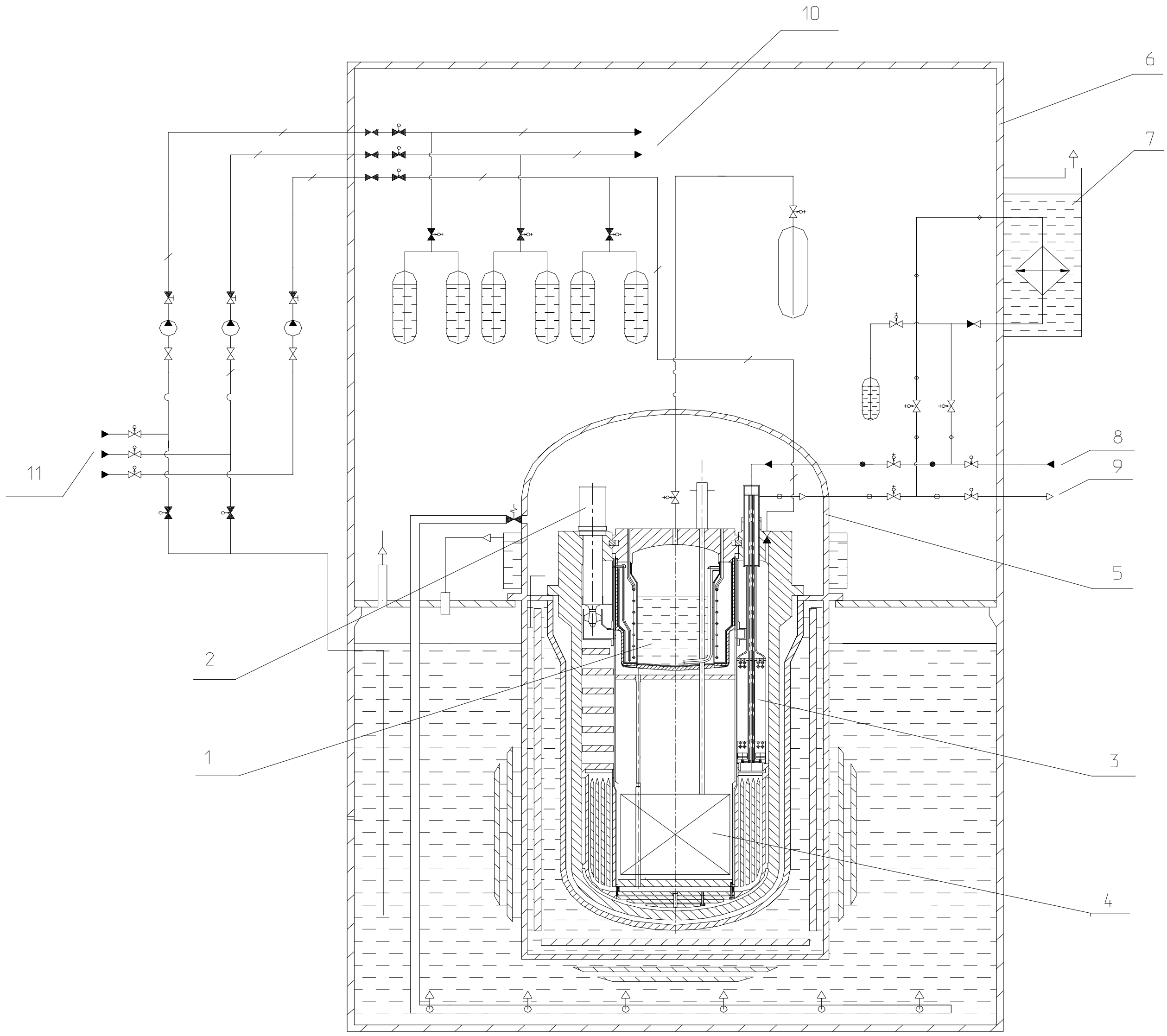

FIGURE 1. Reactor facility NIKA-70

1- pressurizer, 2 – MCP, 3 – steam generator (SG), 4 – reactor core, 5 – safeguard vessel, 6 – containment, 7 – ECCS, 8 – water to SG section, 9 – steam from SG sections, 10 – makeup water for the primary circuit, 11 – from water accumulators

The remaining components of the reactor facility are placed in strong leaktight containment which acts as an additional barrier for prevention of radionuclide transfer to the environment.

Another advanced nuclear installation designed by RDIPE was given the name UNITHERM. This is a self-sustained small-size cogeneration nuclear plant intended for electricity and heat supply to small towns and industrial enterprises located in the regions that are poorly accessible for transportation of traditional fossil fuels, or laying pipelines for gas supply and construction of centralized power supply lines. Cogeneration NPP UNITHERM was specially designed for operation in remote regions where there is no developed infrastructure and a lack of qualified personnel required for operation of the power systems traditionally based on large-size thermal and nuclear power plants.

Cogeneration NPP UNITHERM is characterized by the following advantages:

- the use of well-proven technology of water-cooled reactors and experience in designing and operation of such reactors;
- maximum achievable level of the plant safety can be assured thanks to the safety features inherent for water-moderated nuclear reactors;
- minimum damage to natural landscape and wildlife due to NPP transportation to the construction site and subsequent dismantling in

the form of large, pre-fabricated modules; this approach is helpful to minimize the scope of mounting/dismantling activities and excess impact on the environment.

Cogeneration nuclear plant UNITHERM has been designed in the frame of the conversion program with the aim to take benefits of propulsion nuclear power systems with reliability and self-sustaining capability proven by more than 30 years of operation. UNITHERM design incorporates current trends in developing nuclear cogeneration power plants in various countries, as several similar projects have been proposed worldwide, for instance, SDR-2, SES-10 (Canada), SHR, GEYSER (Switzerland), ÑÀRÅÌ (Argentina), DHR (China), US-developed military purpose facilities, etc.

Cogeneration nuclear plant UNITHERM can be used for generation of heat and electricity. The plant can operate in such climatic zones where the atmospheric temperature varies from minus 55 °Ñ to plus 35 °Ñ. Local sources of cooling water are not required, since turbogenerator condenser and heat exchangers of the safety system are cooled by atmospheric air. Seismic resistance of UNITHERM design is adequate to withstand maximum seismic loads equivalent to magnitude 8 by MSK-64 scale. Confining of the radioactive release can be guaranteed in case of maximum earthquake up to magnitude 9.

UNITHERM cogeneration plant has modular design that allows its transportation to/from the construction site by sea and river ships as well as by motor vehicles and railroad carriages. After decommissioning the site will meet "green field" conditions. Nuclear fuel loading is adequate for the plant operation during the whole assigned life time without refueling of the reactor core.

The plant can work in the periods of continuous operation equal to one year. During this period the service personnel shall only supervise the plant operation without the need for any maintenance activities. On the plant site the personnel will work outside the area of contamination both under normal operating conditions and in case of ultimate design-basis accident. The shift staff includes 2 persons. Total number of personnel required for routine supervision of the plant operation is not more than 12-15 people working in 5 shifts. One of these shifts is needed for replacement of vacational staff or those in the sick list, etc. Qualification requirements to the personnel are job-related functional requirements. During the plant operation the staff shall fulfil rather simple duties relating to monitoring of component operation and keeping on-line communication with the regional service center. All required repair and preventive maintenance activities shall be performed by highly qualified specialists grouped in a maintenance crew (5-10 people) that work on site once a year during 1 or 2 weeks.

The main characteristics of UNITHERM cogeneration nuclear plant are shown in Table 2. Schematic diagram of the reactor facility is given in Figure 2.

My personal contribution in designing of these facilities is moderate. But I am committed to the idea of developing safe, extremely reliable, and easy for operation and maintenance power systems that are capable of generating cost-efficient electricity for many years. I fully realize that implementation of the design is very dependent on the opinion of the nuclear community, so is the capability of nuclear power to affect economic conditions in Russia and abroad. I am hoping that common sense will finally prevail and that technical progress will not be blocked. That is why I spend a lot of

TABLE 2. Characteristics of the nuclear plant UNITHERM

Parameter	**Value**
Thermal power, MW	15
Electrical power for the users, MW	**1.3**
Electrical power for in-house needs, MW	0.21
Thermal power for the users, Gcal/h	4
Number of steam generators	1
Parameters of electricity provided for the off-site users:	
current type	three-phase
frequency, Hz	50
voltage, kV	0.4/10
Parameters of provided thermal energy:	
steam: pressure, MPa	max 1.2
temperature, °C	max 210
water: pressure, MPa	max 1.2
temperature, °C	90-150
Assigned service life, years	20

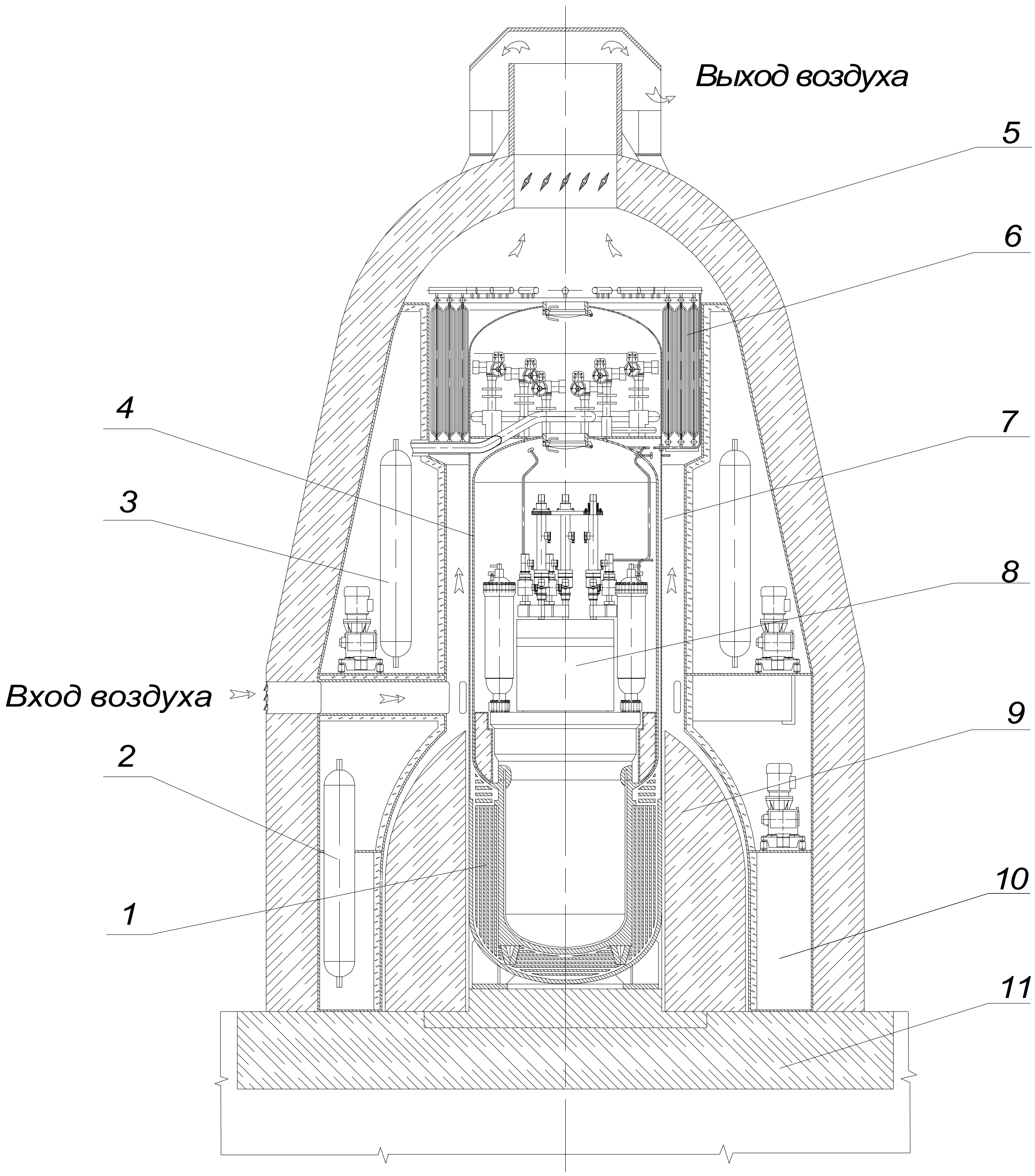

FIGURE 2. Reactor facility UNITHERM

1 – iron-water shielding tank, 2 – cisterns for gaseous radwaste storage, 3 – liquid poison supply system, 4 – safeguard vessel, 5 – confinement, 6 – heat exchanger of cooldown system, 7 – containment, 8 – reactor, 9 – units of biological shielding, 10 – storage for liquid and solid radwaste, 11 – basement

effort to overcome the technical problems that are included in the scope of my responsibilities. I spare no effort to learn from my older colleagues who possess a huge engineering and research experience they can share. My work is like climbing up a ladder to the future. I hope that my contribution will become more important with time.

I have to be fair about my future career. Probably, a correct choice of my way of life and my prosperity as a component of generation "Next" well-being can be proved by the growing prestige and importance of nuclear power among other power technologies of the new century. In that case reactor facilities NIKA-70 and UNITHERM will be needed to support the economic progress of Russia in the future. To make it true, it is the obligation of the young nuclear engineers, including myself, as the people of generation “Next” to work intensively.

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