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N. S. Simanov, student of group s-AES-61 (SSTU)
N. A. Propisnov, student of group s-AES-61 (SSTU)
N. A. Propisnova, student of group s-AES-61 (SSTU)
g. Saratov

MARKET POTENTIAL FOR SMALL MODULAR REACTORS (SMRs)

I. Introduction

According to the IAEA classification, low-power nuclear power plants include power units with an electrical capacity of less than 300 MW. [1] Recently, the market of low-power nuclear power plants (NPPs) has been wildly developed, although most of the work in small nuclear power is at the stage of scientific research and development of conceptual projects.

Because of the smaller size and modularity of the SMRs, a set of innovations is introduced into the design and processes, which can not only shorten the construction time but also expand the value proposition of nuclear energy. SMRs have lower capital costs per unit of production, but their economic competitiveness has yet to be proven in practice when their operation begins.

According to a study conducted in 2016 by a group of international experts of the Nuclear Energy Agency (NEA) concerning the potential SMRs market in the near future (until 2035), two scenarios were developed. Two scenarios are considered: an optimistic scenario with a high level of risk (which assumes successful licensing of SMRs and the establishment of their factory production and the corresponding supply chain) and a conservative scenario with a low level of risk, in which SMRs are expensive to build and operate, and therefore only a limited number of projects have been completed, including prototypes and factories in remote/isolated areas. [2]

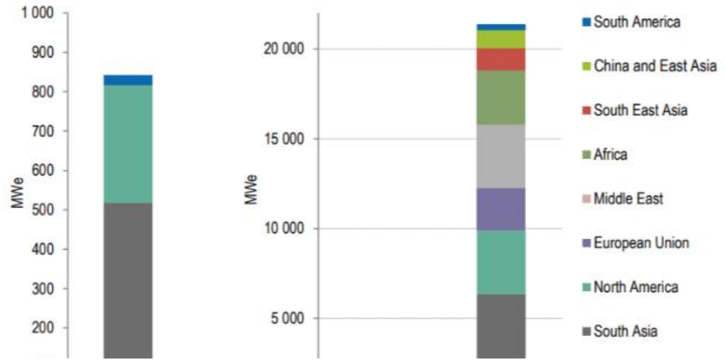

Figure 1: Estimated SMR capacity by region in 2035. [2]

According to the scenario, which provides for a high level of deployment, by 2035 up to 21 gigawatt electric (GWe) of

SMR will be implemented in several regions of the world, which will amount to about 3% of the total installed nuclear capacity on a global scale. Thus, the share of SMRs in the total volume of new nuclear facilities under construction in 2020-2035 may approach 9%. The scenario involving a low level of deployment involves the introduction of less than 1 GWe, represented mainly by prototypes in countries where government programs related to SMRs are being implemented.

We can expect that the primary drivers of the further development of the small modular reactors market will be three main directions:

- decarbonization of energy systems;
- joint deployment with variable renewable energy (VRE);
- use of nuclear energy in remote and hard-to-reach areas.

II. Decarbonization of energy systems

To achieve complete decarbonization of energy by the middle of the century, world leaders concluded the Paris Agreement. We can only implement the goals in a cost-effective way that does not jeopardize the ability of modern energy systems to supply consumers and industry.

A report published by the New Nuclear Watch Institute (NNWI) concludes that the construction of a new nuclear power plant is the most effective way to decarbonize the energy system. The annual change in the share of a total generation because of nuclear power has the greatest (negative) impact on the carbon intensity of the system - compared to other low-carbon technologies, such as hydropower and variable renewable energy sources. Per megawatt of installed capacity, nuclear energy is associated with a reduction in the carbon intensity of the energy system by 34% more than renewable energy sources. [3].

Decarbonization policies can help increase the number. For example, in the electric power sector, low-power nuclear power plants can be considered as a convenient option, considering the dimensions of the reactor, to replace several decommissioned coal-fired power plants.

In addition, low-power nuclear power plants can also decarbonize other sectors of the economy. For example, there are proposals to use low-power nuclear power plants to generate heat in district heating systems, where the outlet temperature is between 80-200 °C.

Areas of the potential application of low-power nuclear power plants with higher steam parameters include, first, oil refining, steam reforming of natural gas, and thermochemical production of hydrogen.

We can expect that the further development of the low-powered NPPs market will occur under the decarbonization goals, which will stimulate the need for low-carbon sources of electricity. [4]

III.Joint deployment with variable renewable energy (VRE)

Wind or photovoltaic solar generation can act as energy sources in conditions of sustainable development requirements. However, in difficult natural and geographical conditions, renewable energy production is not able to meet the needs. To fully meet the needs, we propose to use systems integrated with low-power nuclear power plants, making such energy systems suitable for flexible operation.

These types of integrated systems can increase the overall reliability and sustainability of the energy system, making them an economically attractive option.

Understanding the various market opportunities of SMRs is important for assessing their long-term potential in this area.

IV. Use of nuclear energy in remote and hard-to-reach areas

To date, it mainly involved nuclear power plants in the production of electricity in the baseload mode within centralized power systems.

Low-power nuclear power plants are designed for remote areas with undeveloped network infrastructure, in which it is impractical to build more powerful nuclear power plants.

Low-power nuclear power plants have several obvious advantages directly related to the energy component: ensuring the energy independence of hard-to-reach territories, as well as environmentally friendly energy production. Also, a low-power nuclear power plant can produce thermal energy, which is important for areas with a cold climate.

For example, the roadmap for the development of Canadian SMRs in 2018 identifies several hard-to-reach settlements and mining enterprises where SMRs - and in particular, micro module reactors - can be economically competitive as a replacement for diesel generators. [5]

Considering all these factors, low-power nuclear power plants have a significant potential for power supply to isolated territories.

V. Russian developments of SMRs

The interest shown by many developing countries shows a real possibility of developing a potential market in the future for this category of reactors.

As an example, we can consider the already built Russian Floating Nuclear Power Plant (FNPP) of low power. The floating nuclear thermal power plant “Akademik Lomonosov” has a maximum electrical capacity of over 70 MW and includes two-reactor installations KLT-40S. The maneuverability of this station makes it possible to provide electric and thermal energy to such hard-to-reach regions as the Chukotka Autonomous Okrug, while not increasing the carbon load on the atmosphere.

Other promising developments are a block-modular Low-power nuclear power plant with a capacity of 6-10 MW with a Shelf reactor plant and ABV 6E. They are planned to be placed in isolated and hard-to-reach territories: in the Far North, in Central Africa, island states. The development of the ABV-6E is carried out by the Joint-Stock Company «I. I. Afrikantov OKBM» (Russian State Atomic Energy Corporation «Rosatom»), "Shelf" – Joint Stock Company «N.A. Dollezhal Research and Development Institute of Power Engineering» (Russian State Atomic Energy Corporation «Rosatom»). [6]

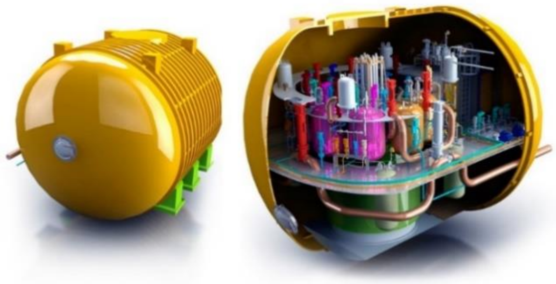

Figure 2: Energy capsule with unified reactor installation "Shelf". [6]

Also, one option for power supply to remote and isolated territories may be the construction of a low-power nuclear power plant with a BREST reactor. BREST is a Russian project of fast neutron reactors with a lead coolant, a two-circuit heat removal circuit to the turbine, and supercritical steam parameters. The project is being implemented as construction of a demonstration complex comprising spent nuclear fuel (SNF) processing plants and fuel fabrication in a closed fuel cycle, and an experimental reactor BREST-OD-300. The concept of a closed cycle of nuclear fuel use is to convert non-fissile isotopes of uranium into isotopes suitable for a chain nuclear reaction. This method allows both to consume the spent fuel in the same fuel campaign, and to isolate isotopes for fresh fuel.

VI. Conclusions

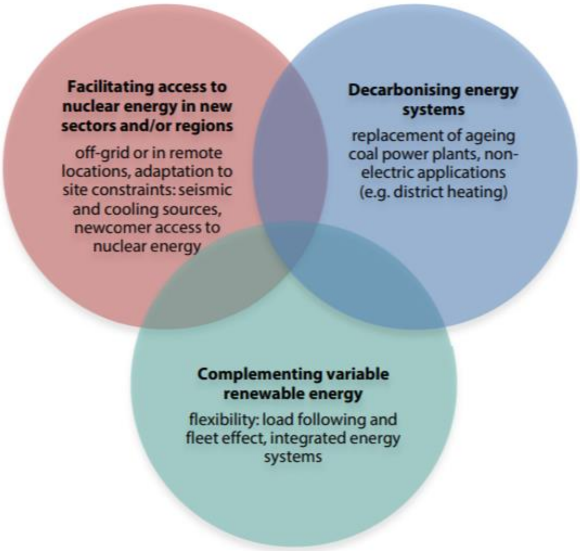

Figure 3: Applicability of SMRs. [7]

Thus, it is possible to summarize all the above as graphics (Fig. 3).

As the result, we conclude that the development of SMRs technologies and its use is a strategic reserve in the short term (in the next 10-15 years) to solve global problems.

In addition, we believe that introducing SMRs will solve the problem of electricity generation in hard-to-reach regions, as well as increase the market for small modular reactors, which will open up new opportunities for further technology improvement and the search for new solutions.

And it can also be added that the need for small modular reactors is growing both in Russian and in the world market, so it would be the right decision to develop this area of energy and bring Russian developments of small modular reactors and low-power plant projects to the world market.

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Information about authors:

Simanov Nikita Sergeevich, student of group s-AES-61, Yuri Gagarin State Technical University of Saratov, 410054, Saratov, ul. Politechnicheskaya, 77, nikitasimanov@ya.ru

Propisnov Nikita Alekseevich, student of group s-AES-61, Yuri Gagarin State Technical University of Saratov, 410054, Saratov, ul. Politechnicheskaya, 77, nikita.propisnov@mail.ru

Propisnova Natalia Aleksandrovna, student of group s-AES-61, Yuri Gagarin State Technical University of Saratov, 410054, Saratov, ul. Politechnicheskaya, 77, mellitrisssa@yandex.ru