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SVBR-100: NEW GENERATION NUCLEAR POWER PLANTS FOR SMALL AND MEDIUM-SIZED POWER APPLICATIONS

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ABSTRACT - Small nuclear power plants can provide a better platform for decentralized energy systems providing better levels of accessibility, safety and environmental friendliness. Small modular reactors with lead-bismuth coolant (SVBR-100) which are being developed in Russia are considered to be the solution of choice for smaller and decentralized energy systems of the future. This paper discusses the current state and future opportunities of the SVBR-100 reactors and also describes the SVBR-100 key performance indicators.

1. A new platform of the decentralized energy system

In the 21st century, safe and sustainable pace of development of the world's economy depends on our ability to build a better energy infrastructure that would provide efficient access to energy resources globally while reducing greenhouse gas emissions. An increasing number of countries show strong interest in decentralized, small-scale energy systems.

Small nuclear power plants can provide a better platform for decentralized energy systems providing better levels of accessibility, safety and environmental friendliness. Small nuclear complexes can provide electricity, heat / steam and desalinated water to remote residential areas and industrial complexes. They are also a viable replacement for aging fossil and larger nuclear plants.

Nuclear power plant should not only integrate well into a distributed energy system but it also must be inherently safe, compact, and acceptable in terms of non-proliferation, safety of nuclear fuel cycle (including the spent fuel), and radioactive waste management. Historically, key challenges for small nuclear complexes were related to safety, load following capabilities, operational and maintenance simplicity, and economical efficiency.

All these challenges have been addressed in 100-600 MWe multi-modular nuclear power complexes which are based on the SVBR-100 reactor module – an integral 100 MWe lead-bismuth fast reactor with inherent safety and high proliferation resistance features. Small modular reactors with lead-bismuth coolant are being developed in Russia jointly by companies from public and private sectors are considered to be the solution of choice for smaller and decentralized energy systems of the future.

2. Proven Performance and Leading Technological Expertise

SVBR-100 reactor has been developed by leading Russian nuclear research and design institutes: Institute for Physics and Power Engineering (IPPE) and JSC OKB "Gidropress" [1]. The design is based on more than 80 reactor-years operational experience of Pb-Bi cooled reactors for propulsion applications [2]. The SVBR supply chain involves leading technological, engineering and manufacturing expertise of Russian nuclear industry integrated by JSC "AKME-engineering" - a 50/50 joint venture of the State Russian Atomic Corporation "Rosatom" and private partner En+ Group, which is a part of the Basic Element Company.

Table 1. SVBR-100 Power Plant Specifications

Reactor thermal output	280 MW(th)
Electricity	101 MWe
Process steam*	580 tonnes/hour, saturated steam, p=6.7MPa, T~282.9°C
Municipal heat*	max. 81 MW(th)
Desalinated water*	max. 200 000 tonnes/day
Design load factor	90%
Fuel campaign duration	7-8 years (for UO_2 fuel with 16.3 wt% U-235/U enrichment)
Load following capability	0.5-2% per minute in 70-100% power range
Reactor module weight	270 tonnes
Reactor module dimensions	4.5 / 7.86 meters (diameter/height)

**- if appropriate equipment is installed*

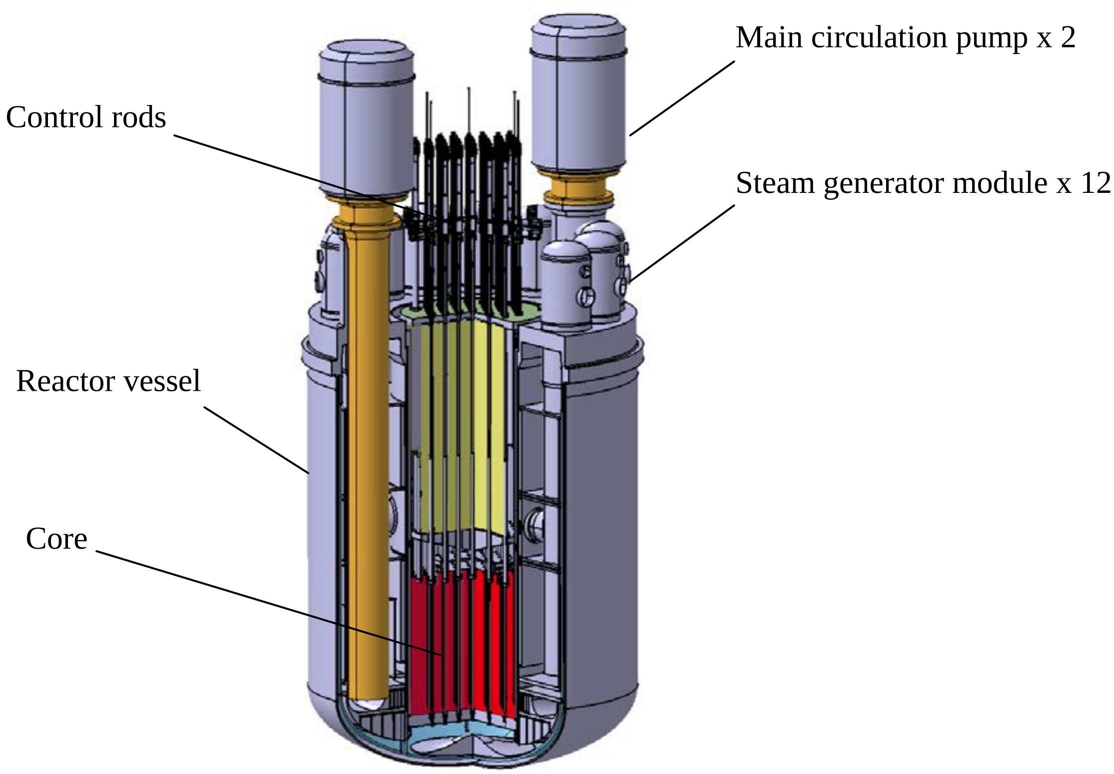

Figure 1 SVBR-100 Reactor Layout

3. Sufficient non-proliferation protection

Due to the natural properties and design of SVBR-100 the reactor has sufficient non-proliferation protection which along with site & transportation safeguard and organizational measures minimizes the risk of un-authorized access to the fissile materials during the lifetime. The key SVBR-100 non-proliferation features are:

- UO_2 fuel enrichment is 16,8 wt% U-235/U on average, and no fuel pellet has enrichment above 19,5 wt% U-235/U. Fuel breeding ratio is below 1.
- Refueling is performed using special heavy equipment, which remains the property of supplier.
- Reactor refueling is performed in large time intervals (once in every 7-8 years) and can be easily inspected by IAEA.
- Reactor design excludes breeding blankets, where plutonium can be accumulated.
- Possibility of the access to the fuel assemblies during fuel campaign is technically eliminated.
- Partial refueling during the operation is impossible.
- Spent nuclear fuel (SNF) contains highly radioactive minor actinides (2%) that serve as additional intrinsic barrier in plus to safeguard and IAEA inspection.
- Spent fuel assembly after cooling is transferred to the supplier country.

4. SVBR Project schedule and key milestones

Current status of the project is as follows:

- The site for pilot power unit has been chosen and approved by authorities and public hearings.
- Pilot plant design and site-specific works are under way.
- Reactor module design and R&D to support licensing are under way.

According to the project schedule the following milestones will be completed in the future:

- In 2013 construction license will be obtained, design completed.
- In 2017-2018 operating license will be obtained.
- In 2018 the construction of the pilot power plant will be completed.

Design development and demonstration of SVBR 100 is included as a priority initiative in the Russia's National Program to support development of innovative energy technologies.

5. References

[1] ZRODNIKOV, A.V., TOSHINSKY, G.I., KOMLEV, O.G., DRAGUNOV, YU.G., STEPANOV, V.S., et al., "Innovative Nuclear Technology Based on Modular Multipurpose Lead-Bismuth Cooled Fast Reactors", Progress in Nuclear Energy, Vol. 50, Issues 2-6, March-August 2008, pp. 170-178.

[2] GROMOV, B.F., TOSHINSKY, G.I., STEPANOV, V.S., et al., "Use of Lead Bismuth Coolant in Nuclear Reactors and Accelerator-Driven Systems", Nuclear Engineering and Design, Vol. 173, 1997, pp. 207-217.