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Three Russian Designs of Small Reactors: Unitherm, KLT–40S, and SVBR–10

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ABSTRACT – The main features of three Russian designs of Small Modular Reactors (SMR) are briefly presented in this extended abstract based on a comprehensive literature review. The rationale behind developing these SMRs is to relieve dependency of remote locations on seasonal shipments of fossil fuels and to provide them with a constant power and/or hot water supply.

1. Introduction

In the north part of Russia, only a negligible part of the territory lies within the region of locally operating power grids. Almost 27% of power supply to the northern settlements comes from about 5,000 autonomous low–capacity (less than 30 MW) power plants, which are mainly comprised of diesel power plants and gas–turbine facilities. Input from all renewable sources is only around 117 MW. Such low density of power supply sources, along with poor infrastructure and long chain seasonal fuel shipments cause a significant increase in fuel costs. For the outermost regions, shipment costs account for up to 80% of fuel costs. This, in its turn, leads to 5 – 10 times higher prices for produced power (around 55 – 66 cents/(kW·h)) compared to that produced at local power grids [1]. Therefore, a search for a source of stable power supply independent of seasonal shipments of fuel arises. These requirements are met by low–capacity Nuclear Power Plants (NPPs). Estimates of construction costs show that low–capacity NPPs will be economically efficient if capital costs for them will not exceed 10$/W [2].

Currently, it appears that there are three advanced designs of SMR being actively developed in Russia. One of them is Unitherm SMR developed at Research and Development Institute of Power Engineering (known both as RDIPE and NIKIET). The other two are considered as prospective power units installations on a floating NPP: KLT–40S SMR developed at Afrikantov and SVBR–10 SMR developed at Gidropress.

2. Comparison of SMRs

Table 1 presents a comparison of main parameters of Unitherm, KLT–40S and SVBR–10 SMRs.

As it may be seen from Table 1, primary coolant circulation for Unitherm and SVBR–10 reactors is designed to be due to natural circulation. Refueling interval for both Unitherm and SVBR–10 SMRs is projected to be at least 20 years, while that for KLT–40S is only 3.5 years.

Table 1. Main parameters of Unitherm, KLT–40s and SVBR–10 [3–5].

Parameter	Unitherm	KLT–40S	SVBR–10
Reactor type	PWR	PWR	Lead–bismuth cooled fast reactor
Thermal power, MW_{th}	15–50	150	43.3
Electric power, MW_{el}	3–10 (maximal) 1.5–5 (with 4–29 Gcal/h of heat output)	35 (with 25 Gcal/h of low–grade heat output) 19.4 (with max thermal power output of 73 Gcal/h)	24 (maximal, without central heating) 12 (with max thermal power output of 50 Gcal/h)
Primary circuit pressure, MPa	16.5	12.7	0.1
Primary circuit inlet/outlet temperature,°C	250 / 330	280 / 316	320 / 480
Primary circuit circulation mode	Natural	Forced	Natural
Steam pressure at steam generator outlet, MPa	3.9 –1	3.72	4.2
Steam temperature at steam generator outlet,°C	235–310	290	410
Core service life, h	145,000	21,000	135,000
Max refueling interval, years	25	3.5	20
Fuel enrichment, %	19.75	15.7 (maximal)	18.4 (on average)
Development stage	Design	Being constructed	Conceptual

Besides generation of electricity, all of the three reactors design concepts can be used for district heating, seawater desalination, and process steam production. The user–specific purpose of the NPP will impact the combination of equipment components and may also determine the characteristics of the reactor [6]. For instance, the use of steam at low parameters for district heating and potable water production requires turbine generator unit be operated at backpressure. This sufficiently increases total plant efficiency and, for the case of Unitherm SMR, allows using a thermal siphon as an intermediate cooling circuit. As a result, the mass and size of the reactor could be significantly reduced.

Major components for all of the three reactors are standard and can be readily manufactured. Reactors will be constructed at the producer's location, and later will be delivered ~~either~~ to the user.

3. Conclusions

Brief overview of three Russian designs of SMRs (Unitherm, KLT–40S, and SVBR–10) was made. These SMRs appear to be a primary choice of a power plant for remote areas in view of their wide range of applications: power production, district heating, water desalination, and process steam production. Depending on users location either of the designs may by chosen for further development; the design could be modified according to user–specific needs.

4. Abbreviations and acronyms

NPP	Nuclear Power Plant
RDIPE	Research and Development Institute of Power Engineering (Moscow, Russia) (NIKIET is the corresponding Russian abbreviation)
SMR	Small Modular Reactor

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