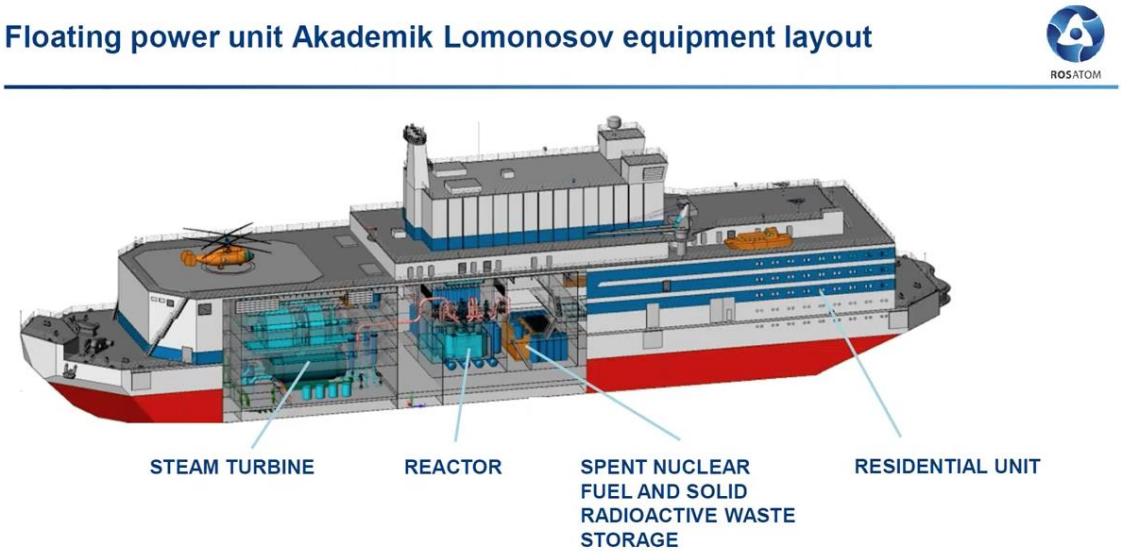
Russia's *Akademik Lomonosov* – The First Modern Floating Nuclear Power Plant (FNPP)

Peter Lobner, 15 May 2021

1. Introduction

Designated Project 20870, construction of *Akademik Lomonosov* started on 15 April 2007, when the keel was laid at the Sevmash shipyard in Severodvinsk, which also is Russia's premier submarine building shipyard. Originally, *Akademik Lomonosov* was expected to supply power to the Sevmash shipyard itself and the town of Severodvinsk, in Northwest Russia.



Cutaway drawing showing the general arrangement of the Akademik Lomonosov. Source: Rosatom

In August 2008, the hull of *Akademik Lomonosov* was transferred to the Baltic Shipyard in St. Petersburg, where a second "keel laying" was held in May 2009. Plans for deploying the FNPP were reconsidered, leading to the final selection of Pevek, a remote Arctic coastal city in Russia's Far East. The FNPP was launched on 30 June 2010 and outfitting continued with the vessel secured dockside at the Baltic Shipyard. Two un-fueled OKBM Afrikantov KLT-40S modular pressurized water reactors (PWRs) were installed in October 2013.

After work on the vessel and reactor systems was completed in April 2018, *Akademik Lomonosov* was towed 4,000 km (2,485 miles) around Norway to Murmansk, where the reactors were fuelled and tested at Rosatomflot facilities, which also support their nuclear-powered icebreaker fleet. In June 2019, the Russian nuclear regulatory agency Rostekhnadzor issued a 10-year license to Rosenergoatom to operate *Akademik Lomonosov* until 2029.

After successfully completing testing, *Akademik Lomonosov* departed Murmansk on 23 August 2019 and was towed 4,770 km (2,964 miles) along the Northern Sea Route, arriving at its final destination on 9 September 2019 at a new protected pier at Pevek, which is about 980 km (609 miles) west of the Bering Strait.

Akademik Lomonosov was towed from St. Petersburg to Murmansk and then to Pevek, a total of 8,770 km (5,453 miles). Source: Daily Mail online / Leo Delauncey (22 May 2018)

Akademik Lomonosov departs Murmansk on 23 August 2019. Source. Rosatom

Akademik Lomonosov being pushed toward its pier in Pevek on 9 September 2019. Source: Nuclear Engineering International

Lomonosov at its pier in Pevek. Source: Ruptly via RT.com

Pevek in summer. Source: Wikimapia

Pevek in winter. Source: Wikimapia

2. FNPP vessel design

The *Lomonosov* is a flat bottom, unpropelled barge comprised of three decks and 10 compartments. The vessel measures 144 meters (472 ft) long, 30 meters (98 ft) wide, and has a displacement of 21,500 metric tons. The vessel has quarters for a crew of 70, which includes the nuclear staff responsible for operating the reactors and ship's staff responsible for all other ship systems and functions.

3. Reactor design

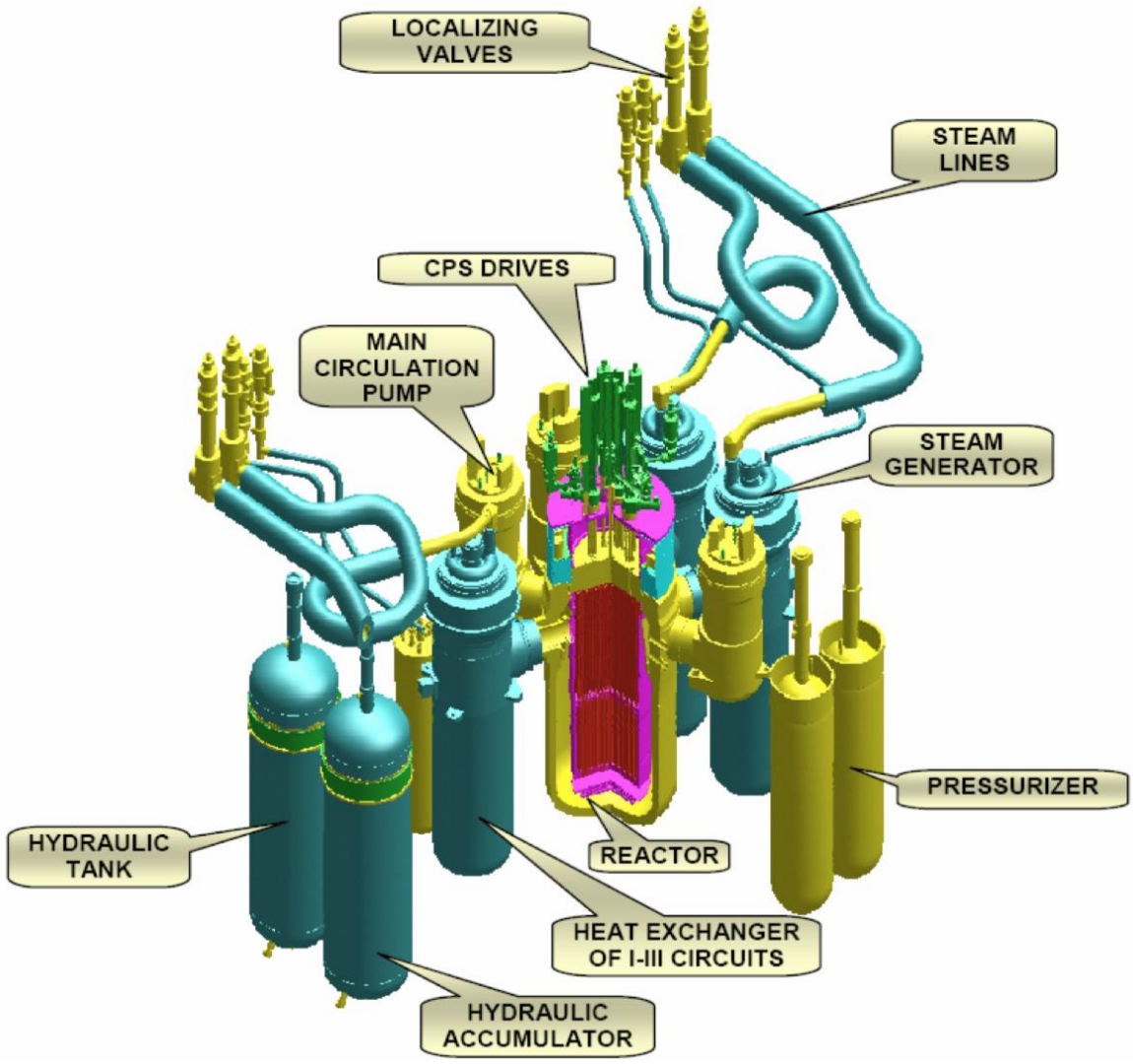
The *Akademik Lomonosov* has two 150 MWt / 35 MWe KLT-40S modular PWRs developed by OKBM Afrikantov (http://www.okbm.nnov.ru/en/).

The KLT-40 family of reactors has the same modular PWR design as Afrikantov's OK-900 and OK-900A, but with a lower enrichment (< 20% enriched) reactor core. The OK-900A has more than four decades of operational use in the propulsion systems of Russia's six Arktika-class polar icebreakers, most of which have retired from service. The first KLT-40 has been in operation since 1988 in the propulsion system of the *Sevmorput* icebreaking cargo ship. The similar KLT-40M has been in use since 1989 in the propulsion systems of the two Taymyr-class shallow water icebreakers. The KLT-40S used on *Akademik Lomonosov* is the latest variant of this small, modular, marine PWR.

The two KLT-40S modular reactors were assembled and tested at Atomenergoproekt in Nizhniy Novgorod before being transported to the Baltic Shipyard for installation in October 2013. In the following photo, the compact, modular design of the reactor vessel (center, green), four steam generators (grey) and four main coolant pumps (small, green) is evident.

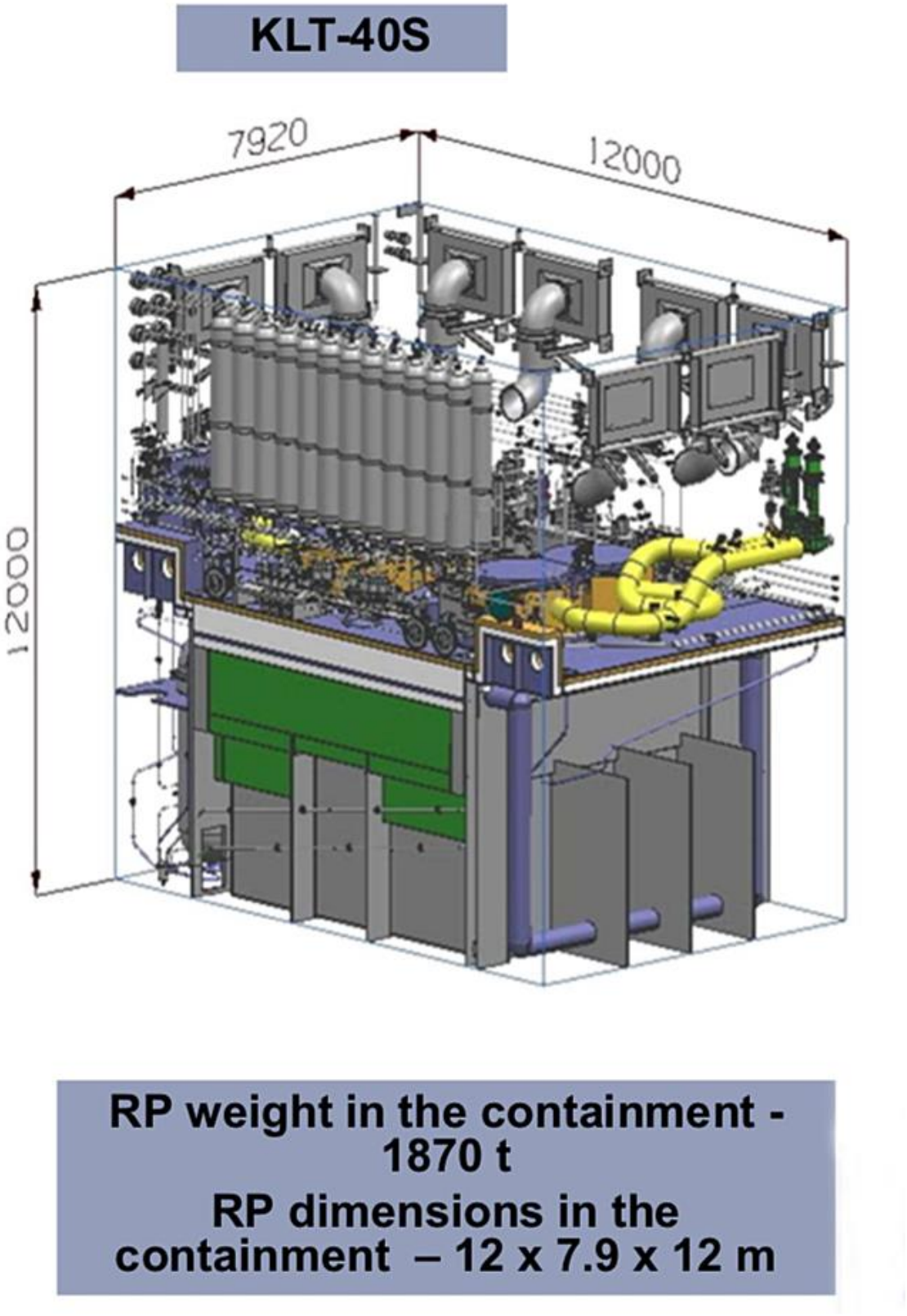
(Above) KLT-40S modular primary system being installed on Lomonosov. (Below) KLT-40S in place with a tarp over the reactor vessel and four main circulation pumps. The four steam generators are visible. Source: Barents Observer

The complete primary system, with external pressurizer vessels and hydraulic accumulators for a safety injection system, is more complex, as shown in the following diagrams.



General arrangement of the KLT-40S complete primary system (note that two steam generators and one main circulation pump have been removed from the near side of this graphic to show the reactor and other features). Source: OKBM Afrikantov

Aboard *Lomonosov*, each KLT-40S unit is packaged into a compact rectangular containment volume, as shown in the following diagram.



Arrangement of a KLT-40S in its containment volume.
Source: OKBM Afrikantov / Atomenergomash (April 2017)

4. FNPP operation

The *Akademik Lomonosov* originally was expected to cost about $140 million. Actual project cost is now estimated to be about $574 million, including about $107 million for new infrastructure in Pevek.

Akademik Lomonosov started providing electricity to the isolated grid of the Chaun-Bilibino energy center of Chukotka on 19 December 2019. Regular commercial operation began on 22 May 2020. When the last of four aging Bilibino nuclear power plants is shut down (tentatively scheduled for 2025, but with a possible extension in the works), *Lomonosov* will be the main source of energy for the Chukotka region.

Lomonosov's KLT-40S reactors have a 2.5 to 3 year refueling interval. The reactors are designed for a 100,000 hour / 12-year operating cycle between "factory repairs" in a shipyard. During a 12-year operating cycle, the FNPP will use its installed refueling equipment to refuel the reactor dockside three or four times. There is a spent fuel and solid waste storage compartment aboard *Lomonosov* for safely storing spent fuel and solid waste.

At the end the 12-year operating cycle, the reactors will be shut down and *Lomonosov* will be towed back to the Rosatomflot shipyard in Murmansk for "factory repairs," which would include scheduled maintenance, repairs, reactor refueling, and spent fuel and radioactive waste removal. At the conclusion of this shipyard period, *Lomonosov* will be ready for its next 12-year operating cycle. It will be towed to its next assigned port, which could be Pevek (if another FNPP has not already taken its place) or a different port.

Service life of the KLT-40S reactors is expected to be 300,000 hours / 40 years in 3 operating cycles separated by two "factory repair" periods at 12 year intervals. Based on the successful service life extension programs implemented for Russia's oldest nuclear-powered icebreakers, it may be possible to extend the service life of the reactors beyond 40 years.

After decommissioning, *Lomonosov* will be towed to a deconstruction and recycling facility. No spent nuclear fuel or radioactive waste will

be left in the Arctic. Spent fuel will be taken to special storage facilities already established in mainland Russia.

5. For more information

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