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HTGR–POLA as the forerunner for high temperature nuclear poligeneration for industry in Poland and Europe

NATIONAL CENTRE FOR NUCLEAR RESEARCH ŚWIERK

Mariusz Dąbrowski[1], Maciej Skrzypek[1*], Dominik Muszyński[1], Janusz Malesa[1]

[1]National Centre for Nuclear Research (NCBJ), ul. A. Soltana 7, 05-400 Otwock-Świerk , Poland

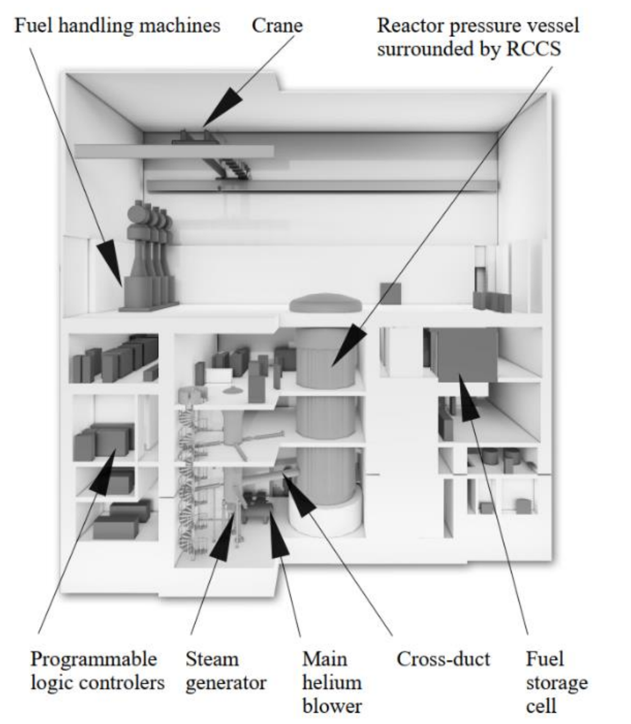
* Corresponding author email: maciej.skrzypek@ncbj.gov.pl

1. Introduction

HTGR-POLA is a reactor design developed by the National Centre for Nuclear Research (NCBJ) in collaboration with the Japan Atomic Energy Agency (JAEA). While NCBJ and JAEA are the main partners driving this project, they receive engineering support from several domestic industrial companies: Energoprojekt Katowice, MHI (Mitsubishi Heavy Industries), Fuji Electric, and Toshiba ESS (Toshiba Energy Systems and Solutions).

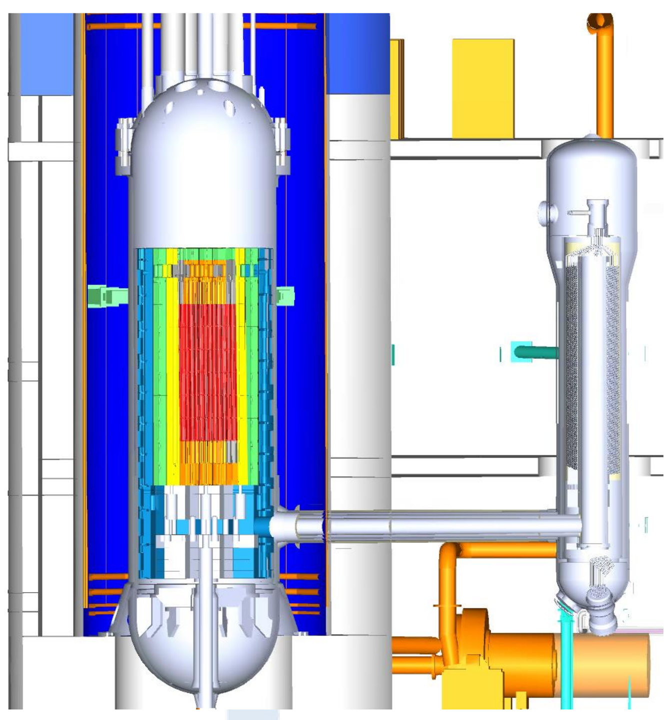
2. Design philosophy

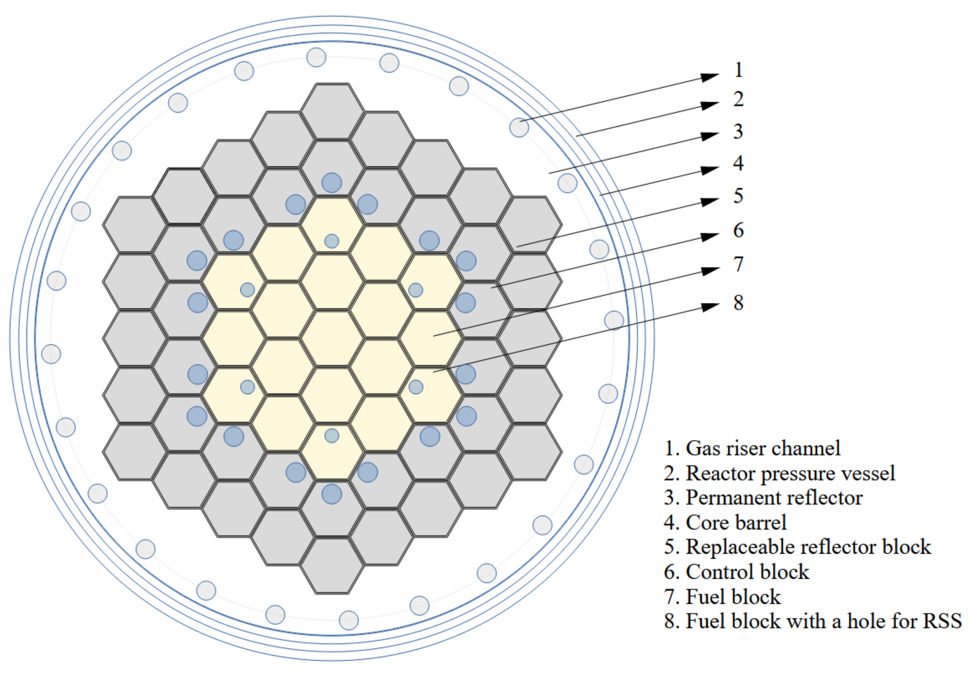
HTGR-POLA is a small-scale, prismatic-type, helium-cooled, graphite-moderated research HTGR with a thermal power of 30 MW_t. It is planned to be constructed at the NCBJ's site. This reactor is designed to enhance human resources, industry, and regulatory competencies while serving as a research tool and technology demonstrator for industrial applications. It combines elements from the GEMINI+ industrial reactor concept and Japanese HTTR research reactor, featuring a unique core configuration tailored to Polish needs. It aligns closely with the future industrial-type FOAK 180 MW_t HTGR reactor.



2. HTGR-POLA – key mission objectives

- facilitate the licensing and demonstration path for higher power commercial reactors;
- demonstrate and examine HTGR technology along with its practical application in an industrial environment;
- support structural materials and TRISO fuel research;
- enhancing safety assessment methods and tools (code validation, regulatory support, etc.);
- building competence in design, construction, operations, and training;
- exploring new radiopharmaceutical production methods.





3. The threefold role of the modern HTGR-POLA

Experimental function:

- tests of the technological components in micro- and small-scale,
- prospective expansion into hydrogen production plant or other industrial processes,
- concept development and experiments related to the integration of the reactor with various end-user test installations.

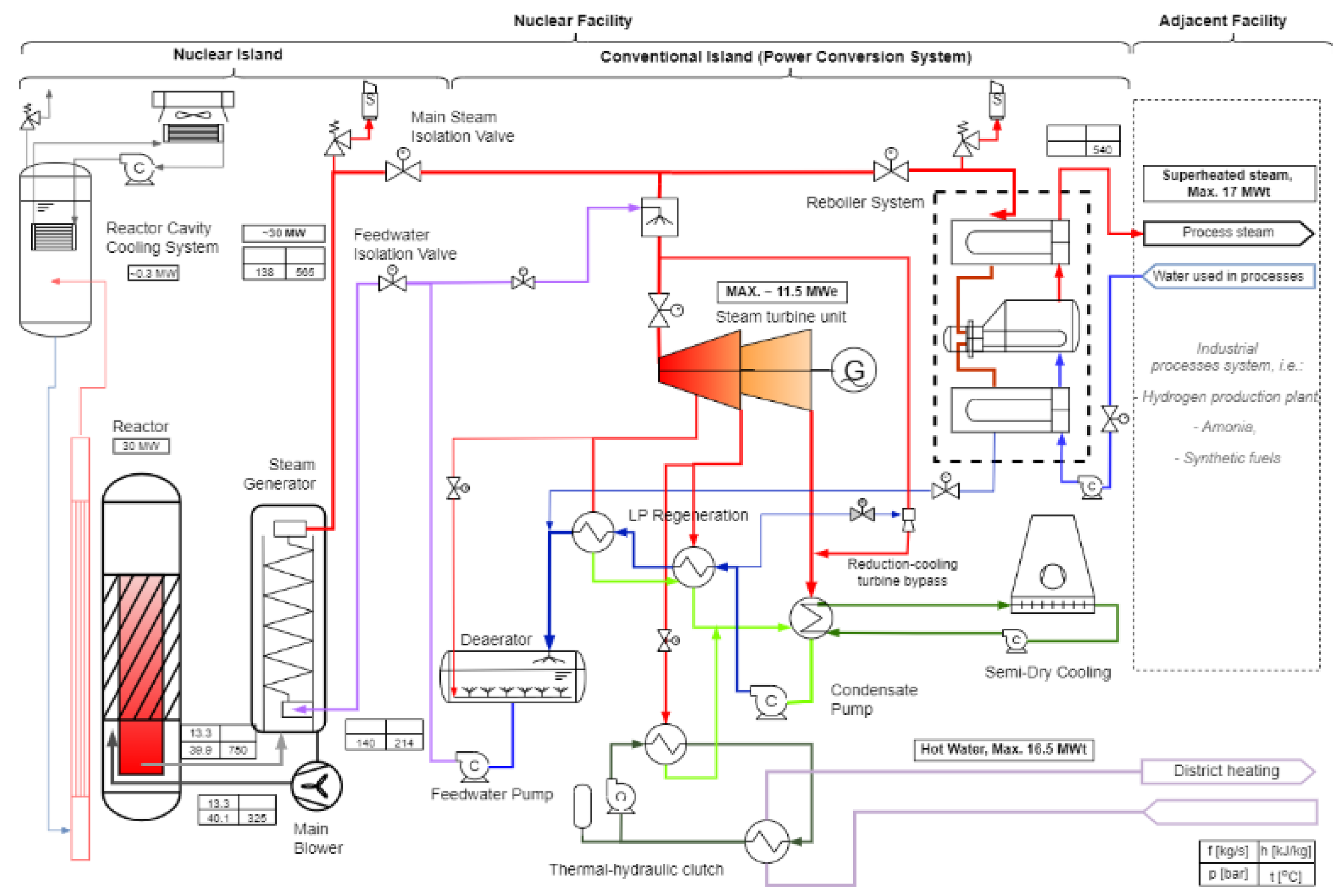
Research function

- passive safety tests,
- operational safety tests under normal and accident conditions,
- material and component tests at high temperature and neutron flux,
- HTGR specific codes and models validation,
- support to the Polish regulator (PAA) in commercial design licensing,
- life cycle TRISO fuel research,
- exploring new radiopharmaceutical production methods.

Utility function – most important: cogeneration capabilities and system flexibility

- **Mode 1: e**lectricity production for the HTGR own needs and for the NCBJ campus, including the CIŚ supercomputer centre and the MARIA research reactor.
- **Mode 2**: production of heat for NCBJ municipal purposes (domestic hot water and heating network) and various process applications in NCBJ research and production facilities (e.g. chilled water production using compression adsorption units).
- **Mode 3:** generating high-temperature steam for industrial demo-scale installations. Integration through the reboiler acts as a physical barrier between HTGR and end-user. Possible industrial installations includes production of H_2, ammonia, synthetic fuel, etc.

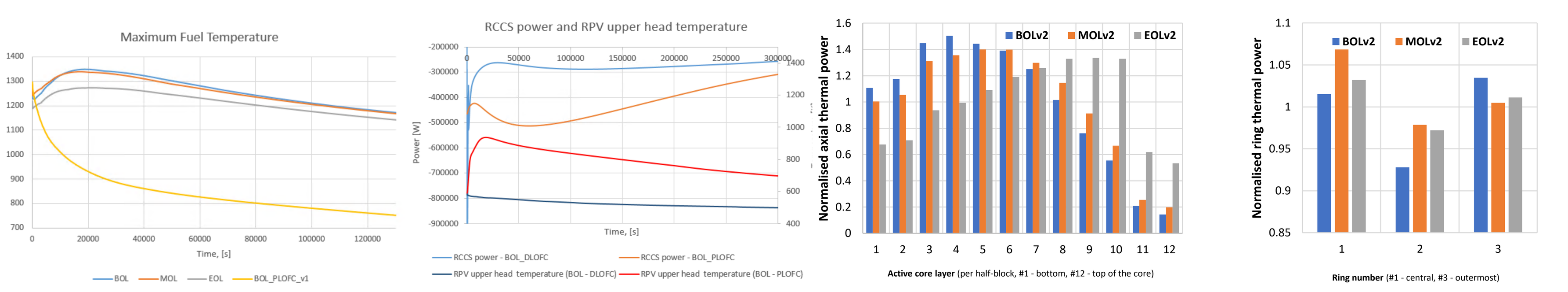
Parameter	Mode 1	Mode 2	Mode 3
Reactor (steam generator) power	30000 kW	30000 kW	30000 kW
Electricity power (gross)	11512 kW	9001 kW	2899 kW
Plant efficiency	38.37%	86.72%	74.88%
District heating power	0 kW	17015 kW	0 kW
Process steam mass flow	0 t/h	0 t/h	25 t/h
Condenser power (heat)	18211 kW	3663 kW	7112 kW
Cooling power	18534 kW	3743 kW	7242 kW



4. Nuclear Steam Supply System

The NSSS consists of a reactor pressure vessel, steam generator, and helium blower. The thermal power of HTGR-POLA is 30 MW_t. The reactor outlet coolant temperature reaches 750°C and 4 MPa, and is directed to the steam generator, where it produces superheated steam with parameters typical of those in fossil power plants: 565°C at 135 bar. The steam is split into two main flows, directed to the steam turbine and to the reboiler, which generates final process steam for various end-user test applications.

5. Safety demonstration – DLOFC and PLOFC scenario



DLOFC: The total power extracted from RPV during accident progression mostly does not exceed 300 kW. Thanks to the RCCS the reactor vessel is cooled and its temperature can be kept below the safety limit corresponding to selected RPV steel. PLOFC: The RCCS exchange rate is much higher for PLOFC scenario and can exceed 500kW causing the core to be cooled down very effectively. During accidents, no fraction of the fuel was overheated, the maximum fuel temperature did not exceed the fuel limit (1600°C), and a wide safety margin was maintained. The design fulfills the safety criteria for operation specified in the reactor documentation.

6. Development Milestones HTGR-POLA

2012 – 2019	Preliminary studies and technological innovation	Complete
2019 – 2021	Pre-conceptual design phase and technology validation	Complete
2021 – 2022	Conceptual Design Phase	Complete
2022 – 2024	Basic Design Phase	Complete
2025 – 2028	Licensing Phase	Planned
2025 – 2028	Detailed Design Phase	Planned
2029 – 2032	Construction	Planned
2033	Commissioning	Planned

7. Acknowledgments

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