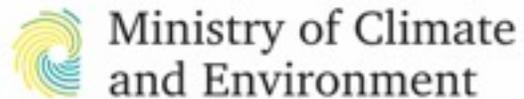




Conceptual Design of EUHTER (Polish Experimental HTGR)

Prof. Mariusz Dąbrowski, NCBJ



NARODOWE
CENTRUM
BADAŃ
JĄDROWYCH
ŚWIERK

FISA 2022 & EURADWASTE '22 - SNETP FORUM

2nd of June 2022, Lyon, France

Polish heat market for clean and advanced nuclear technologies

Current status (fossil fuels)

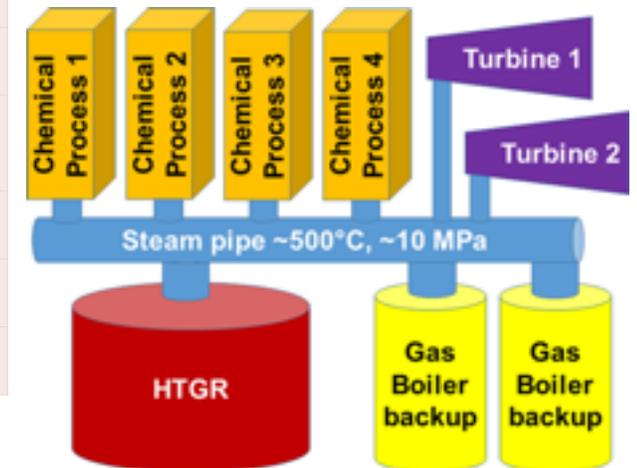
Cogeneration:

- 13 largest chemical plants need 6500 MW of heat at $T=400-550^{\circ}\text{C}$
- They use 200 TJ / year, equivalent to burning of >5 mln t of natural gas or oil

Electricity:

- ~50 units of 200 MW_e to be replaced >2035

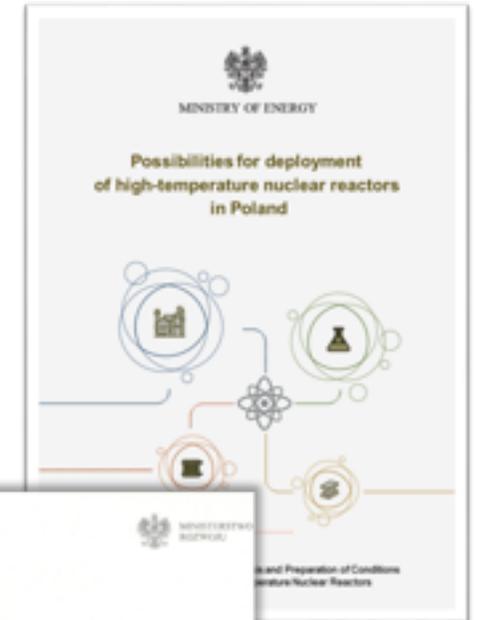
Plant	boilers	MW
ZE PKN Orlen S.A. Płock	8	2140
Arcelor Mittal Poland S.A.	8	1273
Zakłady Azotowe "Puławy" S.A.	5	850
Zakłady Azotowe ANWIL SA	3	580
Zakłady Chemiczne "Police" S.A.	8	566
Energetyka Dwory	5	538
International Paper - Kwidzyn	5	538
Grupa LOTOS S.A. Gdańsk	4	518
ZAK S.A. Kędzierzyn	6	474
Zakł. Azotowe w Tarnowie Moszczicach S.A.	4	430
MICHELIN POLSKA S.A.	9	384
PCC Rokita SA	7	368
MONDI ŚWIECIE S.A.	3	313



Polish path to nuclear cogeneration - political

IMPORTANT GOVERNMENTAL ACTIVITIES:

- Minister of Energy appointed **Committee for deployment of high-temperature nuclear reactors in Poland** in July 2016. Report with results of the Committee's works published in January 2018. Minister accepted the report, took note that deployment of HTGR reactors in Poland is desirable and requested Ministry to prepare further steps.
- **Strategy for Responsible Development** - the governmental program for Polish economic development - adopted in February 2017, contain e.g.: Deployment of HTGR for industrial heat production. The project for this action is: Nuclear cogeneration – preparation for construction of the first HTGR of 200-350 MW_{th} supplying technological heat for industrial installation.



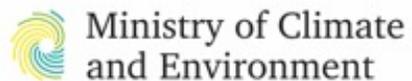
Polish path to nuclear cogeneration - technical

Important technical activities:

- In **GEMINI+** (2017 – 2021) project. The main design options for HTGR fitting the requirements for cogeneration use in Europe (head - G. Wrochna, since Jan. 2020 - J. Malesa).
- **Industrial HTGR** with power 165 MW_{th} (180 MW_{th}), steam temperature T = 540°C, pressure p = 13.4 MPa, and steam prod. 230 t/h to fit Polish industry demand.
- Within the frame of national strategy program **GOSPOSTRATEG-HTR (GoHTR)** (*cf. presentation of A. Boettcher - the head - at session TS6/P3*) the National Centre for Research and Development funded the grant of about 5 Million \$ for joint project of MKiŚ (MCE), NCBJ and IChTJ (Institute for Nuclear Chemistry and Technology) entitled “Preparation of legal, organisational and technical instruments for the HTR implementation” (Gospostrateg1/385872/22/NCBR/2019) (**finished 30.03.2022**).



Polish HTGR experimental (demo) and industrial construction plans



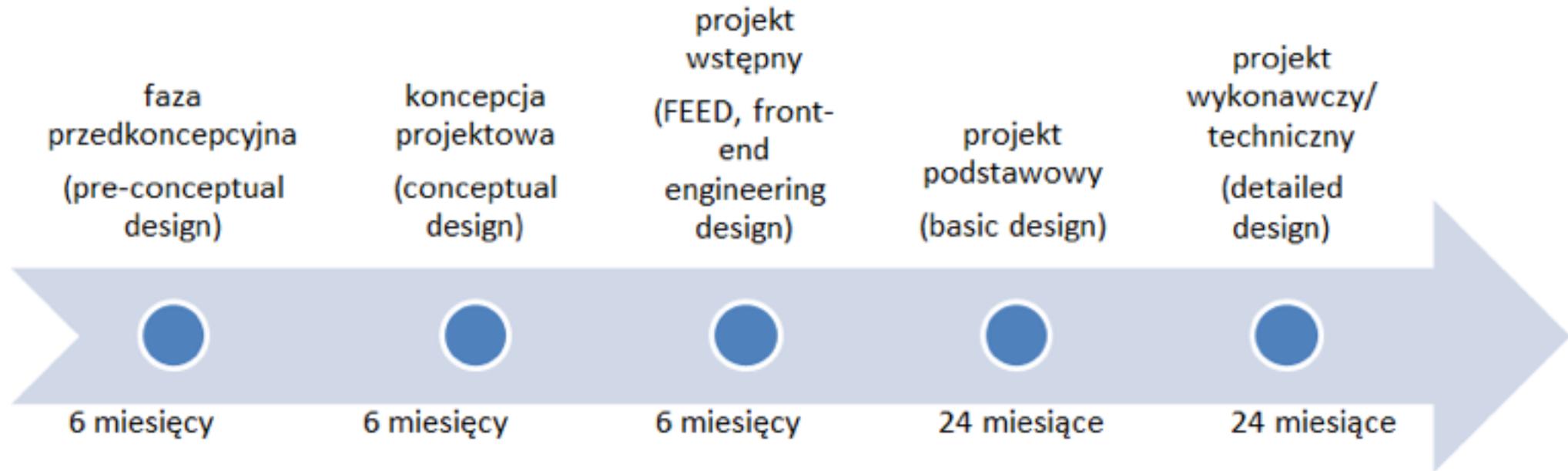
Preliminary HTGR implementation plan*

Phase	Reactor type	Thermal power	Number of blocks	Construction cost evaluation	Timescale
I	Research at NCBJ Świerk	30 MW	1	0.35 bln \$	2024 - 2028
IIPF	Prototype FOAK - First Of A Kind (No 1)	180 MW	1	0.75 bln \$	2029 - 2033
IIF	FOAK (No 2,3,4,5,6)	180 MW or 2x180MW (duoblock)	5	0.6 bln \$ or < 0.6 bln \$	2034 - 2040
IIN	NOAK - Next Of A Kind (No 7,8,9,10)	180 MW	4	0.5 bln \$	2040 - 2050
III	Serial	180-360 MW	10-20	0.5 - 0.75 bln \$	2040 - 2050



**Extension
for
European
heat
market is
also a
possible
objective**

Experimental HTGR design and construction perspective:



+ licensing (12 months) + construction (48 months)

Pre-conceptual design was finished in GoHTR project (30.03.2022)



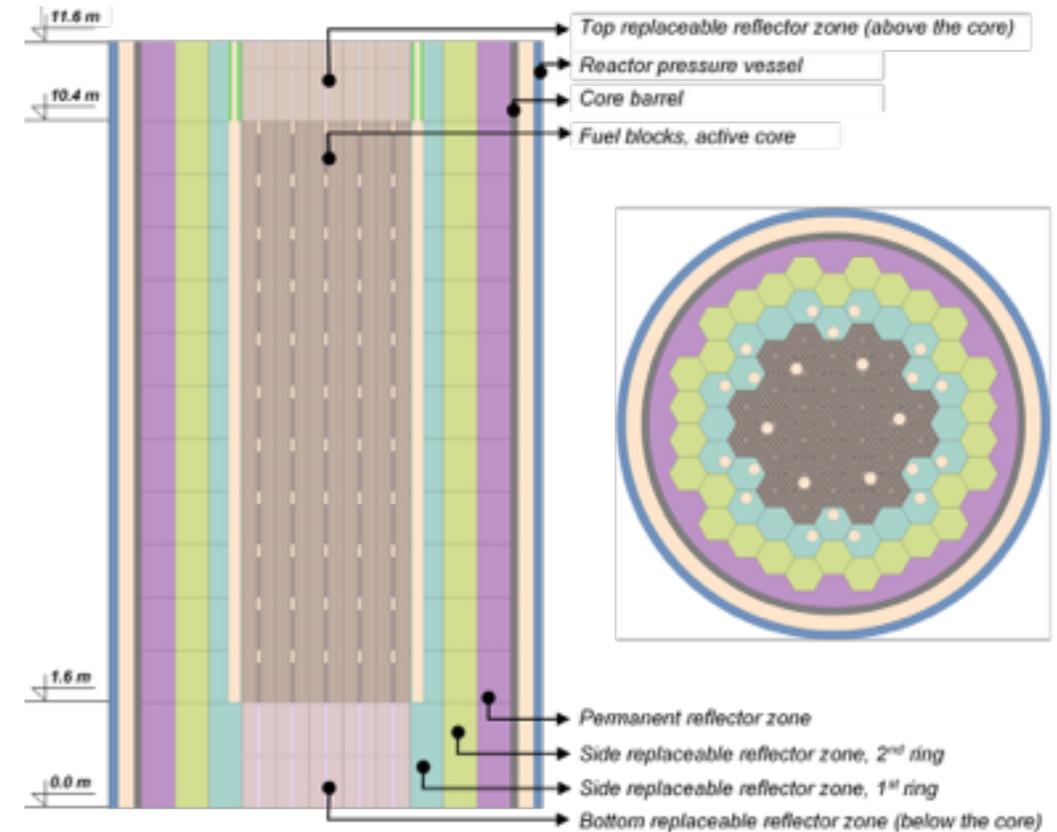
Characteristics:

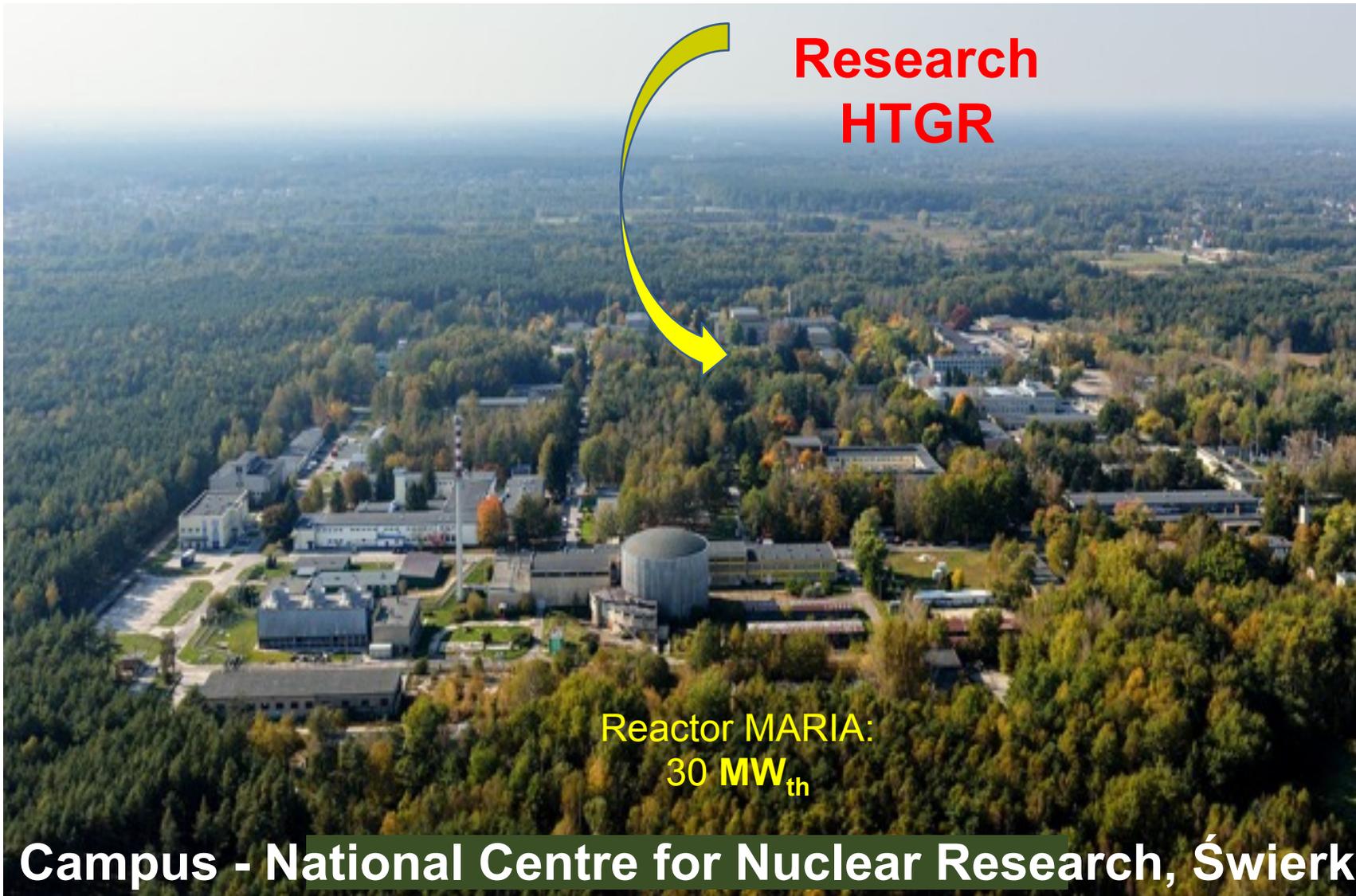
Working name:

“TeResa” (traditionally feminine name for Polish reactors, includes 2 letters from HTR)

Site: at NCBJ campus

Design based on GEMINI+ (down-scaling 180 MW_{th} to 40 MW_{th})





**Research
HTGR**

Reactor MARIA:
30 MW_{th}

Campus - National Centre for Nuclear Research, Świerk

www.ncbj.gov.pl

Experimental HTGR concept and basic design project

Contract No 1/HTGR/2021/14 between the National Centre for Nuclear Research and the Ministry of Education and Science entitled “**Technical description of the HTGR gas-cooled high-temperature research nuclear reactor**” (signed 12.05.2021).

The contract determines that the conditions for the construction of a high-temperature research reactor in Poland will be created and that the **conceptual design and further most of the basic design and preliminary safety report of such a device will be prepared**. The reactor will be a prismatic type HTGR using TRISO fuel producing approximately 30-40 MW_{th} at an outlet temperature of 750 °C.

Time: 1.06.2021 – 1.06.2024.

Cost: 60 million PLN, approx. 17 million \$

Project monitored by the council for the development of technology for HTGR reactors (since 20.08.2021)

Chair - Minister of Climate and Environment (MCE) - **funding body**;
Deputy Chair - Minister of Education and Science (MES) - **technical supervision**;

Members:

- secretary of state (MCE),
- undersecretary of state (MCE),
- undersecretary of state (MES),
- director of National Fund of Environment and Water,
- director of NCBJ,
- experts

Project objectives

Tasks (1 & 2 - Department of Material Science +  (cf. presentation of J. Jagielski at session TS6/P4; 3, 4 & 5 - Reactor Design Group):

1. Preparation of **laboratory facilities** with the necessary accreditations and a quality management system necessary to perform research work in the process of **licensing materials** for HTGR technology.
2. Performing **tests of materials** that can be used for the construction of HTGR, in terms of compliance with the requirements of HTGR technology.
- 3. Development of the basic design of the HTGR reactor (basic / preliminary design according to IAEA-TECDOC-881, Fig. 4.1, page 36, LOD = Level Of Details according to BIM = Building Information Modelling; EN ISO 19650 standard) – LOD minimum 200.**
4. Performing verification **simulations** for the project and preliminary HTGR safety report in accordance with the requirements of the Regulation of the Council of Ministers of August 31, 2012 (Journal of Laws, item 1043).
5. Preparation of selected **elements of the preliminary safety report** (PSR) for HTGR in accordance with the Regulation of the Council of Ministers (as above, item 1043, 2012) on the scope and method of conducting safety analyses conducted before applying for a license to build a nuclear facility, and the scope of the preliminary safety report for a nuclear facility.

PROJECT TASK 3 - CONCEPTUAL AND BASIC DESIGNS PREPARATION

Development of the basic design of the HTGR reactor:

- a) preparation of the **conceptual design (phase I)** based on the preconceptual (detailing the mission and functions of the reactor, the basic characteristics of the core and fuel, the primary cooling cycle as well as the elements of equipment and construction) **(1-9 months)**
- b) preparation of the **conceptual design (phase II)** (design of power processing devices, control system and other components and systems with auxiliary devices) **(10-15 months)**
- c) preparation of the **basic design - the conventional island (phase I)** (turbine, pumps, heat exchangers, reboiler, condenser cooling system and heat discharge to the environment)
- d) preparation of the **basic design - the conventional island (phase II)** (development of the remaining elements of the structure and integration of the conventional part systems)
- e) preparation of the **basic design - the nuclear island (phase I)** (design of core, reactor vessel, helium cooling system)
- f) preparation of the **basic design – the nuclear island (phase II)** (reactor control and safety systems, fuel reloading systems)
- g) preparation of an **integrated (conventional and nuclear islands) design for a nuclear installation (phase I)** (systems, structures and components with determined physical and technical parameters necessary to define the safety features of the installation)
- h) development of an **integrated design for a nuclear installation, part II** (proposal of an industrial research and demonstration installation cooperating with the reactor circuit, integration with power supply systems, land development plan)

DESIGN TEAM (current status)

MARIUSZ DĄBROWSKI (head),
AGNIESZKA BOETTCHER,
WOJCIECH BRUDEK,
JERZY CETNAR,
WACŁAW GUDOWSKI,
JANUSZ MALESA,
DOMINIK MUSZYŃSKI,
SŁAWOMIR POTEPSKI,
JÓZEF SOBOLEWSKI,
MACIEJ SKRZYPEK,
JERZY ZEP (project manager)

Perspectival - 10-20 people:
mostly young generation, plus
10 Ph.D. students (3 ladies) of project

**“New reactor concepts and safety analyses
for the Polish Nuclear Energy Program”**

www.phd4gen.pl

Grant from National Center for Research
and Development (NCBR) (POWR.03.02.00-00.1005/17-02)





STRATEGIC PARTNER - JAEA, Japan

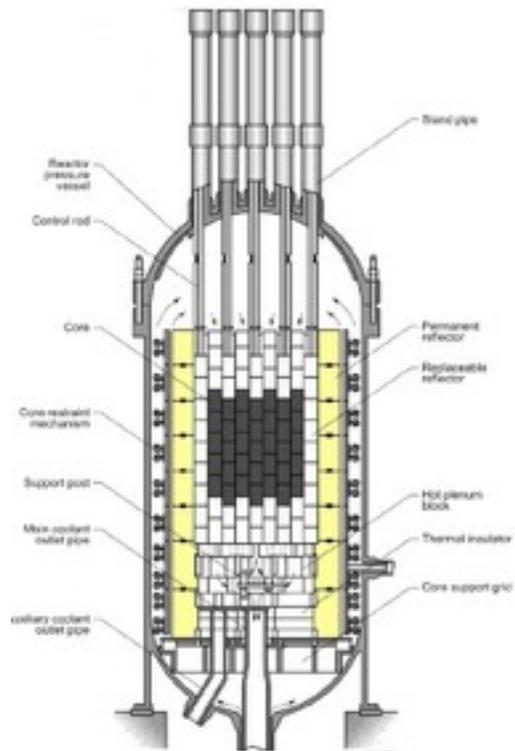


Strategic Partnership between the Government of the Republic of Poland and the Government of Japan for the years 2021-2025 allows cooperation in the field HTGR between the **NCBJ and JAEA (Japan Atomic Energy Agency)**.

The partnership allows for the **transfer of knowledge and support** to NCBJ on both concept and basic design level based on Japan's team **HTTR (High Temperature Test Reactor)** experience.

Already **consulting** the concept design JAEA proposal with NCBJ updated "TeResa" concept looking for the best option.

High Temperature Test Reactor



Conceptual design of the Polish Experimental HTGR - in progress

Philosophy of design:

- research reactor can serve building competence (human resources, industry, regulator, etc.), research tasks, and also a *small-scale demonstrator* of HTGR technology for industrial applications;
- the design should *combine features of the industrial reactor* as planned by the GEMINI+ project and *proven elements* of the HTTR as *a test reactor*;
- it is expected to lead to a unique core and a reactor design *matching specific Polish requirements* in research, demonstration and applications;
- one of the objectives is that the power of the reactor should be as high as possible (order of 30 MW_{th}) in order to *maximize similarity* with an industrial type FOAK 180 MW_{th} reactor design.

The concept of the experimental HTGR reactor of 30 MWt

Reactor mission:

1. Testing industrial applications;
2. Material research (structural materials and graphite);
3. Monitoring and improvement of the safety functions (code validation, support to regulator (PAA), etc.);
4. TRISO fuel research and tests;
5. Competence building (design, licensing, supply chain management, construction, operation - personnel training, inspection etc.);
6. Search for new methods of radiopharmaceutical production.

Experimental function:

1. Tests of the technological components in small- and micro-scale (coupling tests to reboiler);
2. Tests of efficiency of heat storage and recovery in a special buffer;
3. Prospective connection to a hydrogen production plant or other user process;
4. Concept development and experiments related to the integration of the reactor with renewables.

The concept of the experimental HTGR reactor of 30 MWt

Research function:

1. Passive safety tests;
2. Operational safety in normal and simulated accident conditions tests;
3. Tests of materials and components in high temperature and strong flux;
4. HTGR specific codes validation;
5. Support to Polish regulator (PAA) towards future licensing of the commercial design;
6. Life cycle TRISO fuel research;
7. Search for new radiopharmaceutical production methods in HTGR.

The concept of the experimental HTGR reactor of 30 MWt

Utility function - our very important concern - cf. USNC project on UIUC (University of Illinois Urbana-Champaign) campus:

1. Production of high-temperature heat in the form of steam for industrial plant demonstration technology through coupling with reboiler constituting a physical barrier between HTGR and the plant;
2. Electricity production for HTGR's own needs and for NCBJ (e.g. demand for the CIŚ supercomputer and the "Maria" reactor, etc.);
3. Production of heat for NCBJ municipal purposes (domestic hot water, hot water in the heating network) for various process purposes of NCBJ research and production installations (e.g. production of chilled water using compression adsorption units).

Polish Experimental HTGR design – status of May 2022

Conceptual and basic design is supported by the results of the **Gemini+** project rescaled from 180 MWth commercial reactor to 30-40 MWth research/demo.

Pre-conceptual phase due to GoHTR project ("TeResa" - 40MWth research reactor in Świerk) – **finished on 31.03.2022**.

Work on the conceptual design (detailing the mission and functions of the reactor, the basic characteristics of the core and fuel, the primary cooling cycle as well as the elements of equipment and construction, design of power processing devices, control system and other components and systems with auxiliary devices) – **till 31.08.2022**.

Start of work on basic design - 1.09.2022. Extending collaboration with JAEA and its business partners on the basic design.

Looking for **more experts and industrial partners** on the design and construction.

Thank you!



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www.ncbj.gov.pl

Funding:



Supervision:

