EU & SMR: TEPLATOR district heating

CTU Prague
UWB Pilsen
Radek Skoda
June 2024

ENEN2plus project

Building European Nuclear Competence through continuous Advanced and Structured Education and Training Actions

MOBILITY Rules until 31 JAN 2024 HERE

MOBILITY Rules as of 1 FEB 2024 HERE updated !!!!

HERE for FAQ (payment time…report…platform…)

HERE to consult the list of already APPROVED GROUP EVENTS

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Energy 45 (2012) 288–295

Contents lists available at SciVerse ScienceDirect

Energy

journal homepage: www.elsevier.com/locate/energy

Small modular reactors: Simpler, safer, cheaper?

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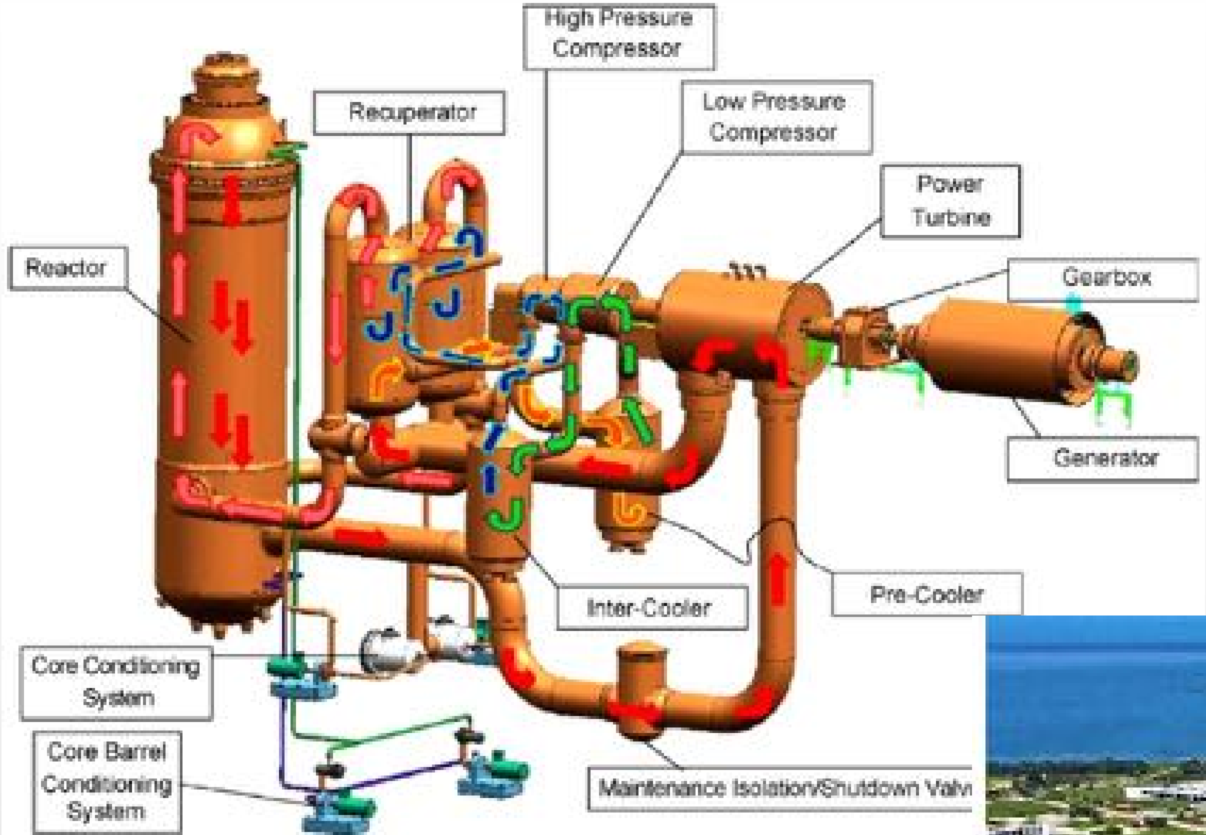
A R T I C L E I N F O

Article history:
Received 4 September 2011
Received in revised form
10 January 2012
Accepted 31 January 2012
Available online 17 March 2012

Keywords:
Small modular reactors
Safety
Efficiency
Feasibility
Economy

A B S T R A C T

Nuclear energy can play a very significant long-term role for meeting the world's increasing energy demands, while simultaneously addressing challenges associated with global climate and environmental impact. Many nations of the world, particularly the Asia/Pacific Rim countries, are actively engaged in a major expansion of their nuclear energy complex. The degree to which nuclear energy can address long-term energy needs, either globally or regionally, will be dictated by the pace and adequacy of technical and policy solutions for waste, safety, security, and non-proliferation issues, as well as the capital cost of construction. Small Modular Reactors (SMRs) could successfully address several of these issues. SMRs offer simpler, standardized, and safer modular design by being factory built, requiring smaller initial capital investment, and having shorter construction times. The SMRs could be small enough to be transportable, could be used in isolated locations without advanced infrastructure and without power grid, or could be clustered in a single site to provide a multi-module, large capacity power plant. This paper summarizes some of the basic features of SMRs for early deployment, several advanced


High Pressure Compressor
Recuperator
Low Pressure Compressor
Power Turbine
Reactor
Gearbox
Generator
Pre-Cooler
Inter-Cooler
Core Conditioning System
Core Barrel Conditioning System
Maintenance Isolation/Shutdown Valv

Nuclear district heating solution TEPLATOR

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Flame temperatures of common gases and fuels [edit]

Gas / Fuels	Flame temperature
Propane in air	1980 °C 3596 °F
Butane in air	1970 °C 3578 °F
Wood in air (normally not reached in a wood stove)	1980 °C 3596 °F
Acetylene in air	2550 °C 4622 °F
Methane (natural gas) in air	1950 °C 3542 °F
Hydrogen in air	2111 °C 3831 °F
Propane with oxygen	2800 °C 5072 °F
Acetylene in oxygen	3100 °C 5612 °F
Propane-butane mix with air	1970 °C 3578 °F
Coal in air (blast furnace)	1900 °C 3452 °F
Cyanogen (C_2N_2) in oxygen	4525 °C 8177 °F
Dicyanoacetylene (C_4N_2) in oxygen (highest flame temperature)	4982 °C 9000 °F

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Nuclear district heating

Beznau, Bohunice, Haiyang, Temelín, Zaporozhye ...

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Unit 3 of Slovakia's Mochovce nuclear power plant reaches 90% power

Pamela Largue • Aug 16, 2023

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Mochovce Nuclear Power Plant. Image credit: Slovenské Elektrárne

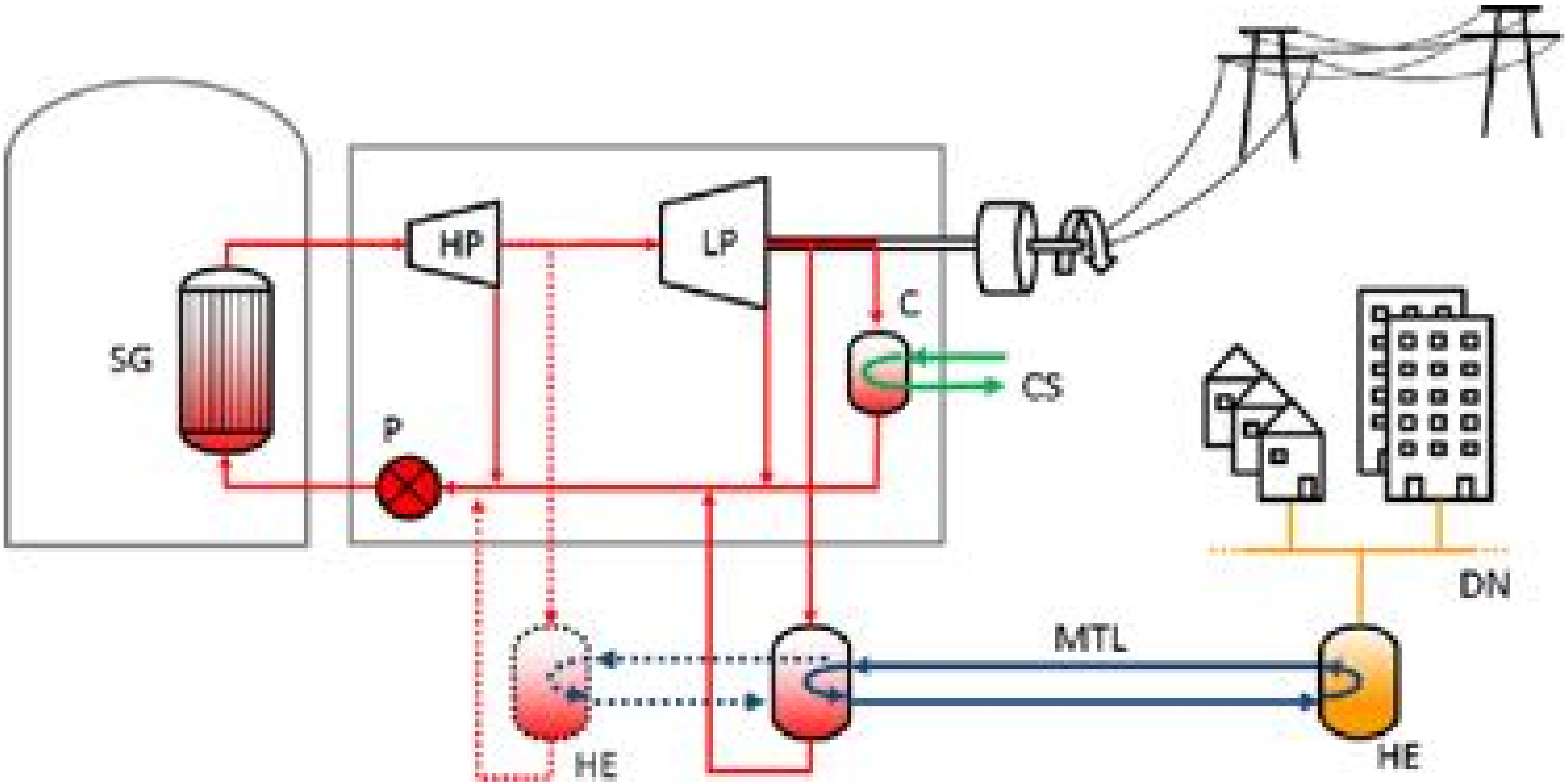
Slovakian energy company Slovenské Elektrárne has increased the power at unit 3 of the Mochovce nuclear power plant to 90%.

Energy start-up tests will continue until the next power level is reached, which will be 100%.

According to Slovenské Elektrárne, the complete functioning of the 3rd unit is expected to be reached between September and October this year and will be confirmed by a 144-hour demonstration run at 100% power. This will mark the end of the energy start-up stage.

The new nuclear unit in Mochovce will have an installed capacity of 471MW, which will cover approximately 13% of the total electricity consumption in Slovakia, states the energy company.

The Mochovce nuclear power plant is situated in the south of Slovakia, between Nitra and Levice. It consists of four blocks, the first of which began supplying electricity to the grid in the summer of 1998.


HP
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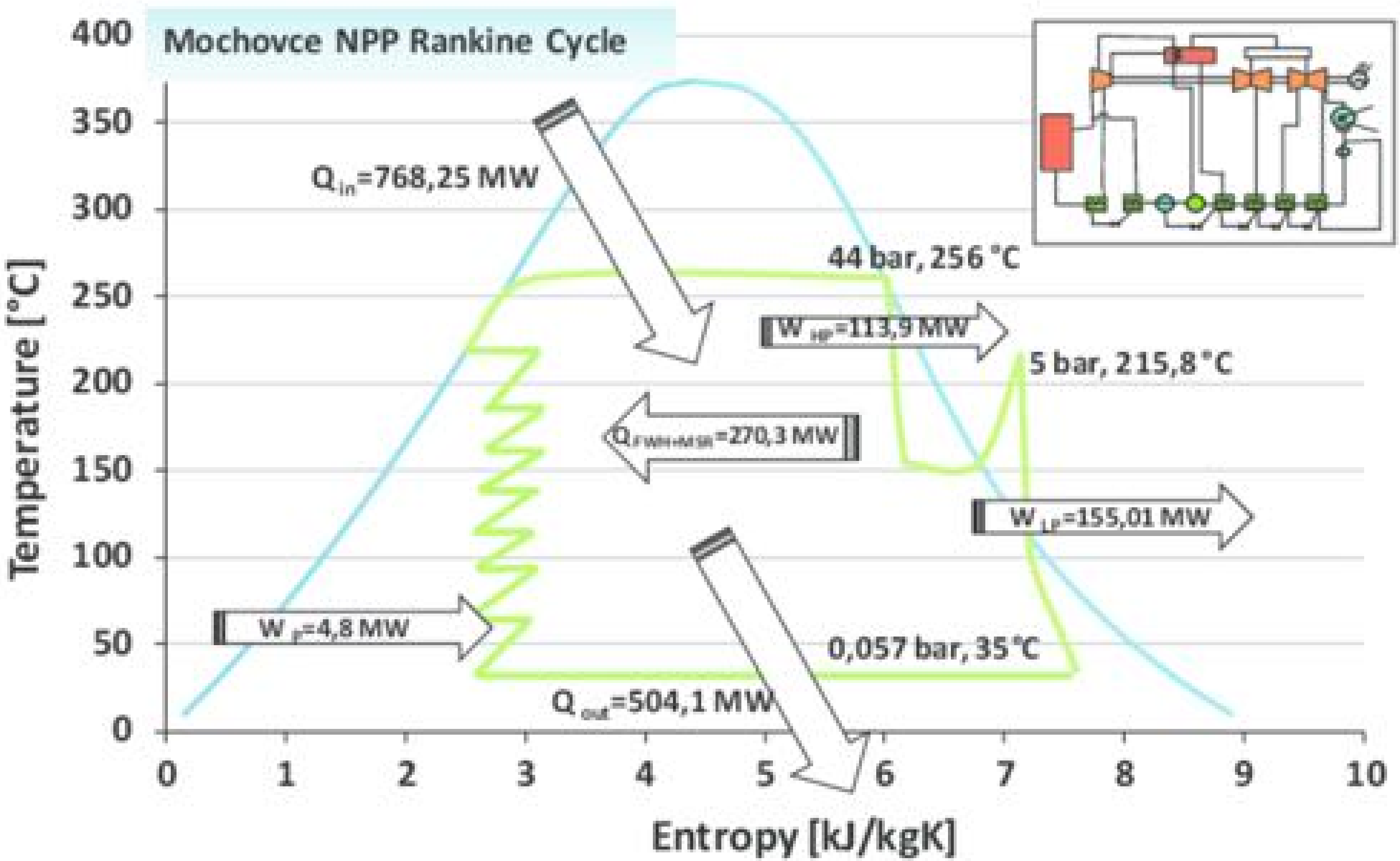
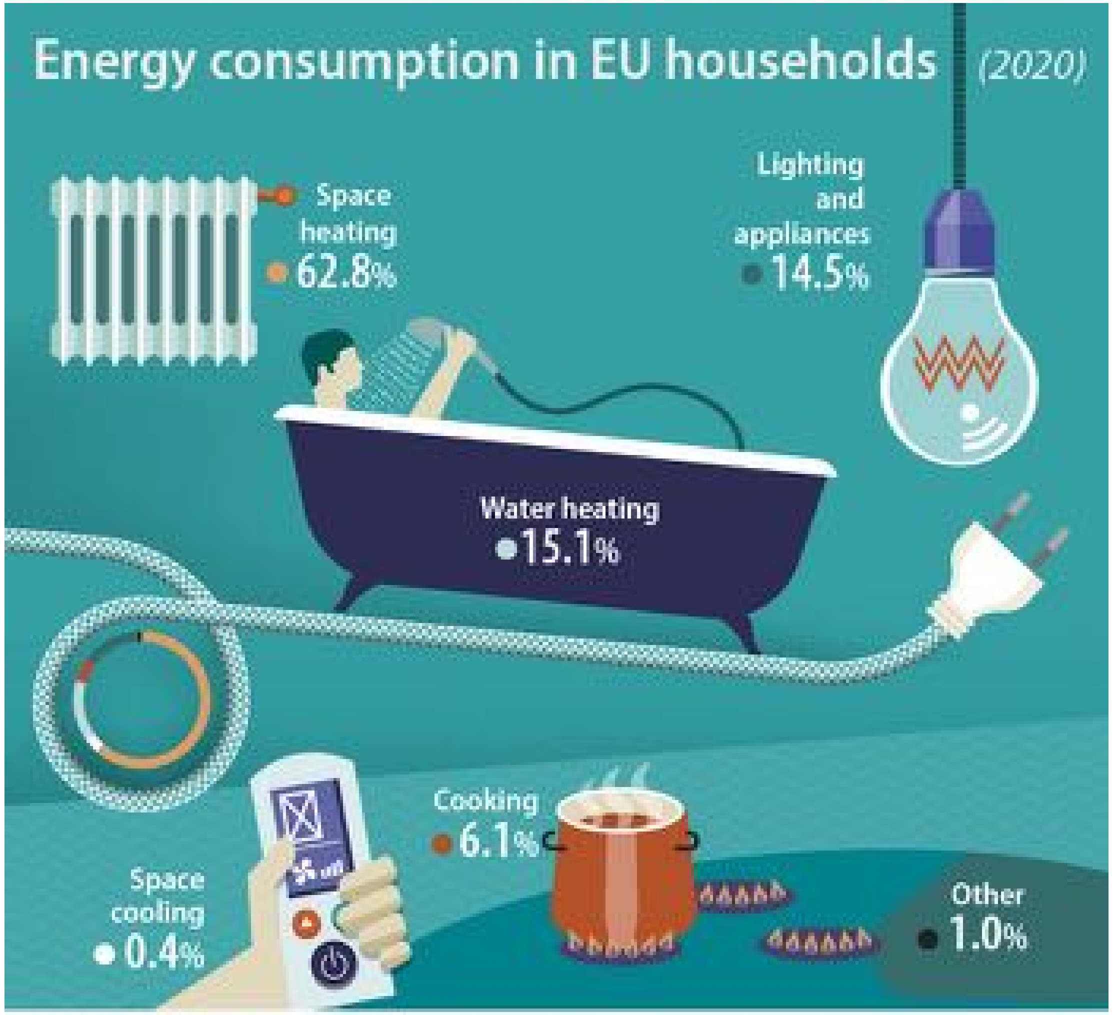


Fig. C.1. TS Diagram of Mochovce NPP Steam Cycle (1 turbine out of 2).

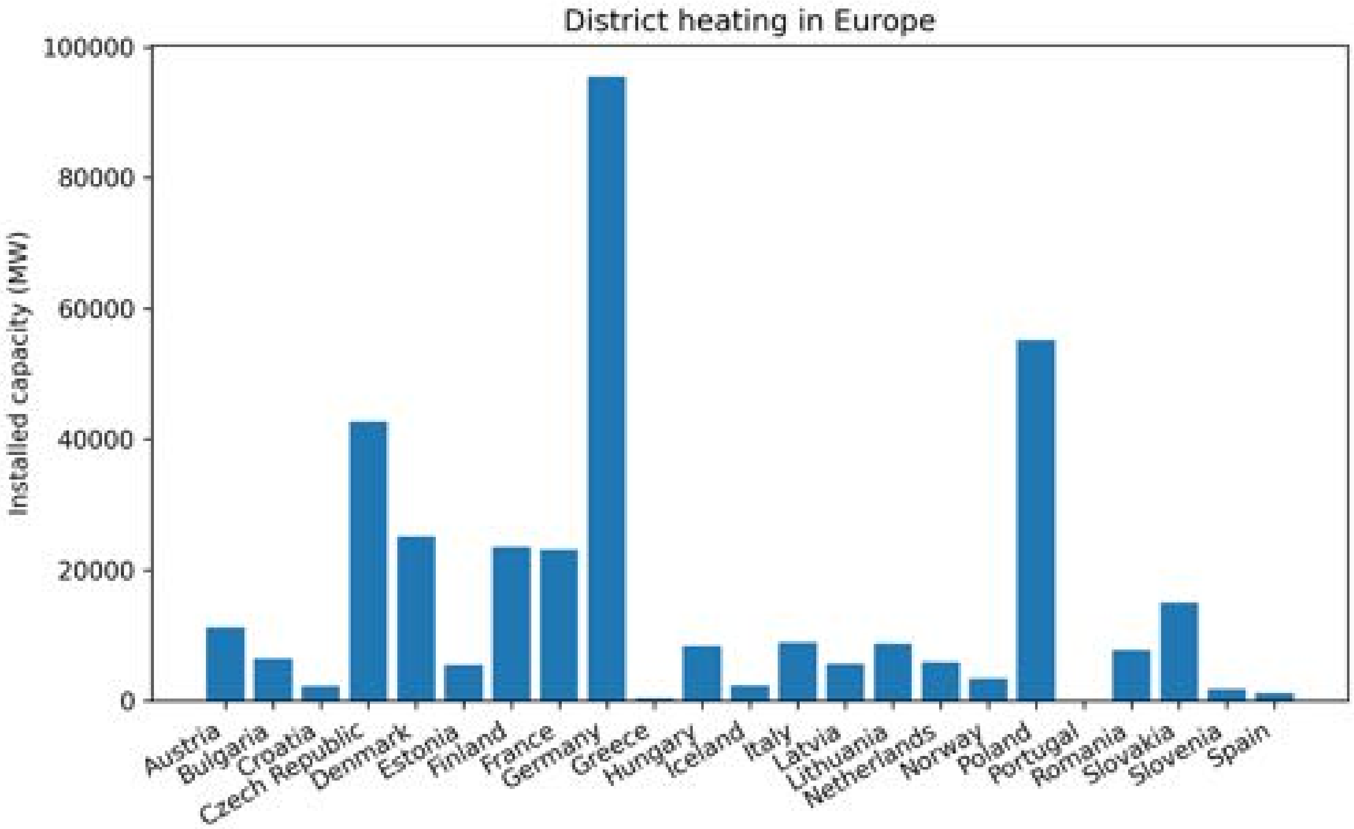
Energy end-use



ec.europa.eu/eurostat

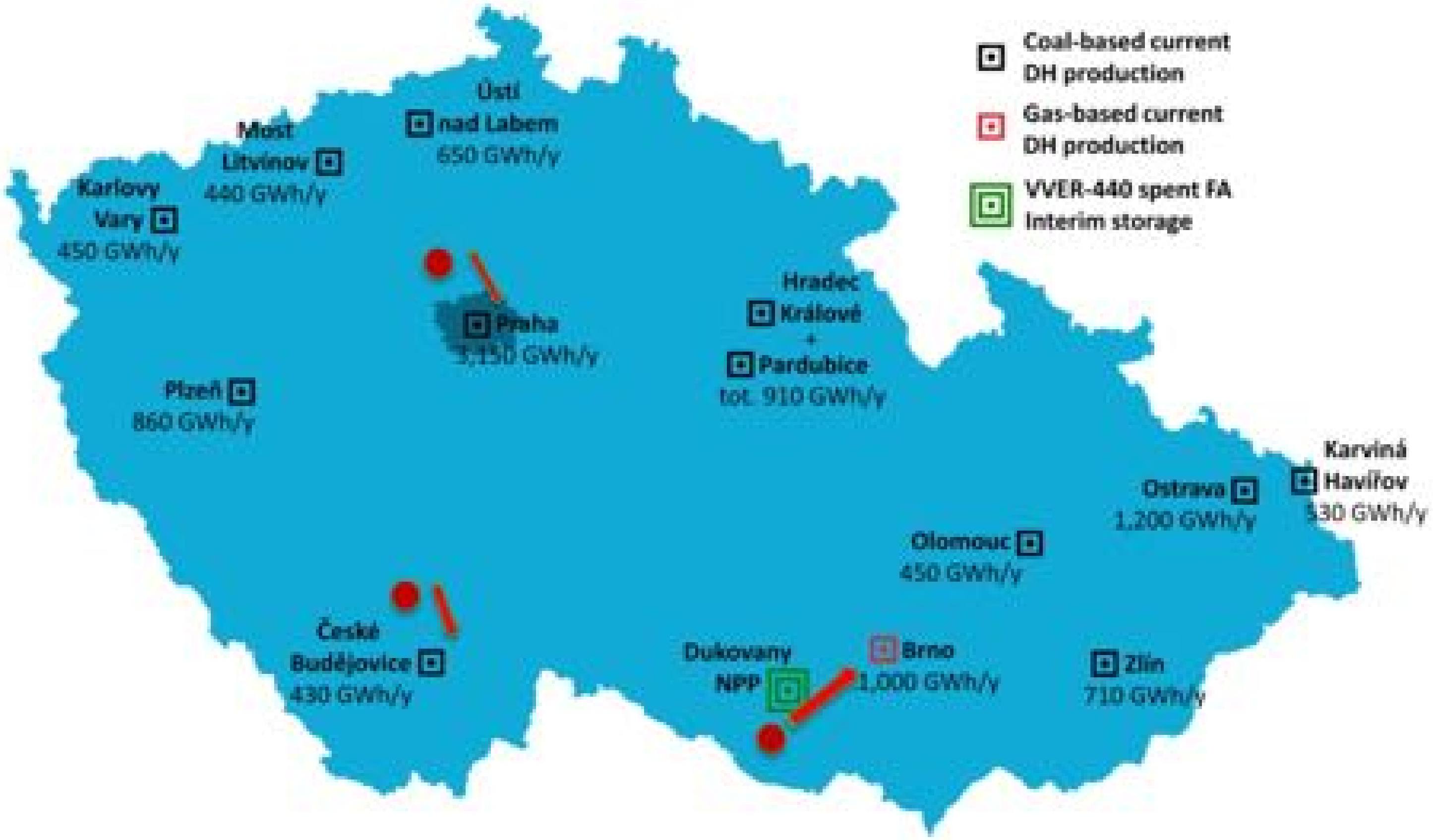
District heating in Europe

Total installed DH capacity in EU: 353 767 MW_{th}



Nuclear district heating

Possible locations in Czech Republic



Teplator – Nuclear reactor for district heating

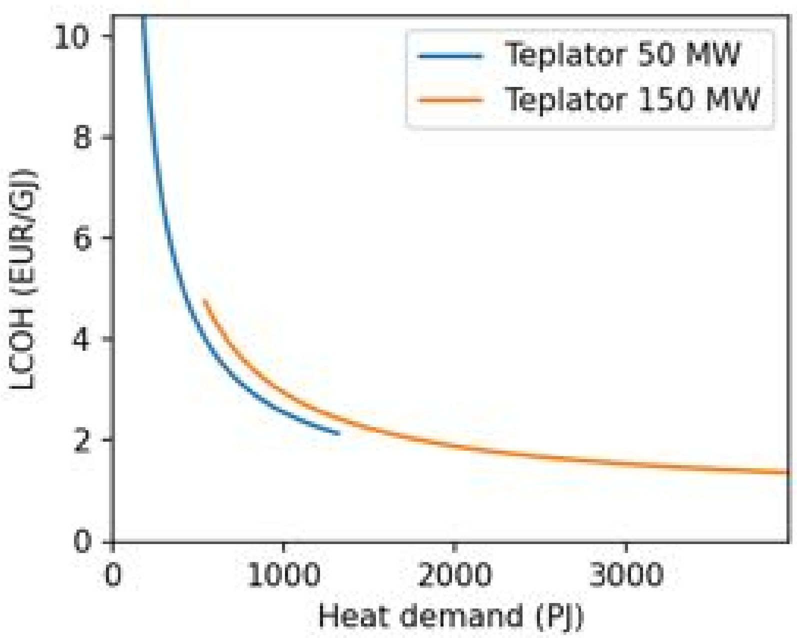
- Started at
- Czech Technical University in Prague
- and University of West Bohemia

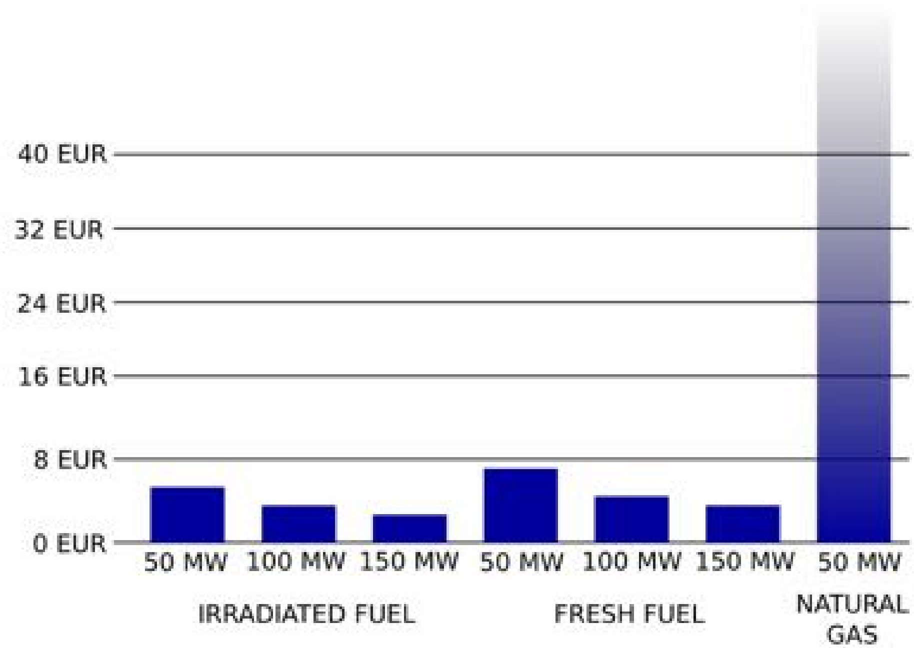
Teplator – Nuclear reactor for district heating

- **Pressure tube reactor**
- **Thermal power: 50 MW-150 MW (based on variant)**
- **Cooled and moderated by heavy water**
- **Low operating parameters**
  - **Pressure << 2 MPa**
  - **Core outlet temperature << 200 °C**
- **Fuel same as in VVER-440 reactors**

Teplator – Nuclear reactor for district heating

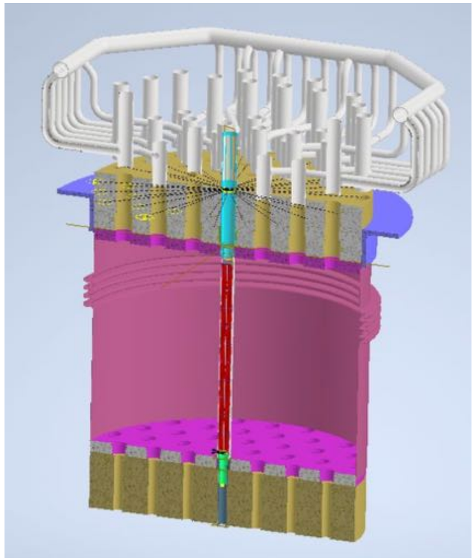
- **Capability to operate on various power levels without significant change of installed technology; based on location needs and certification.**





Teplator – design evolution

Progress: 2019 -> 2024

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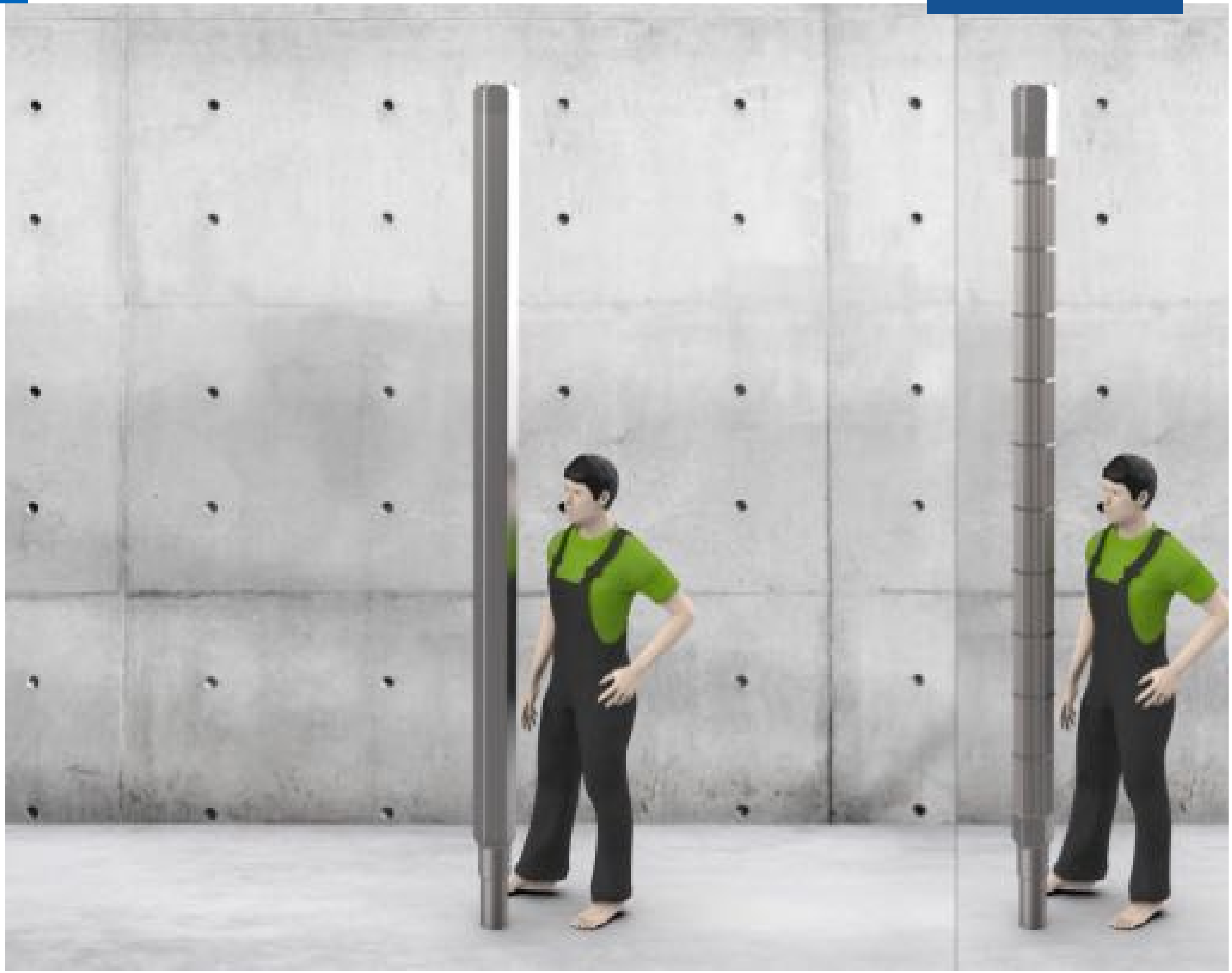

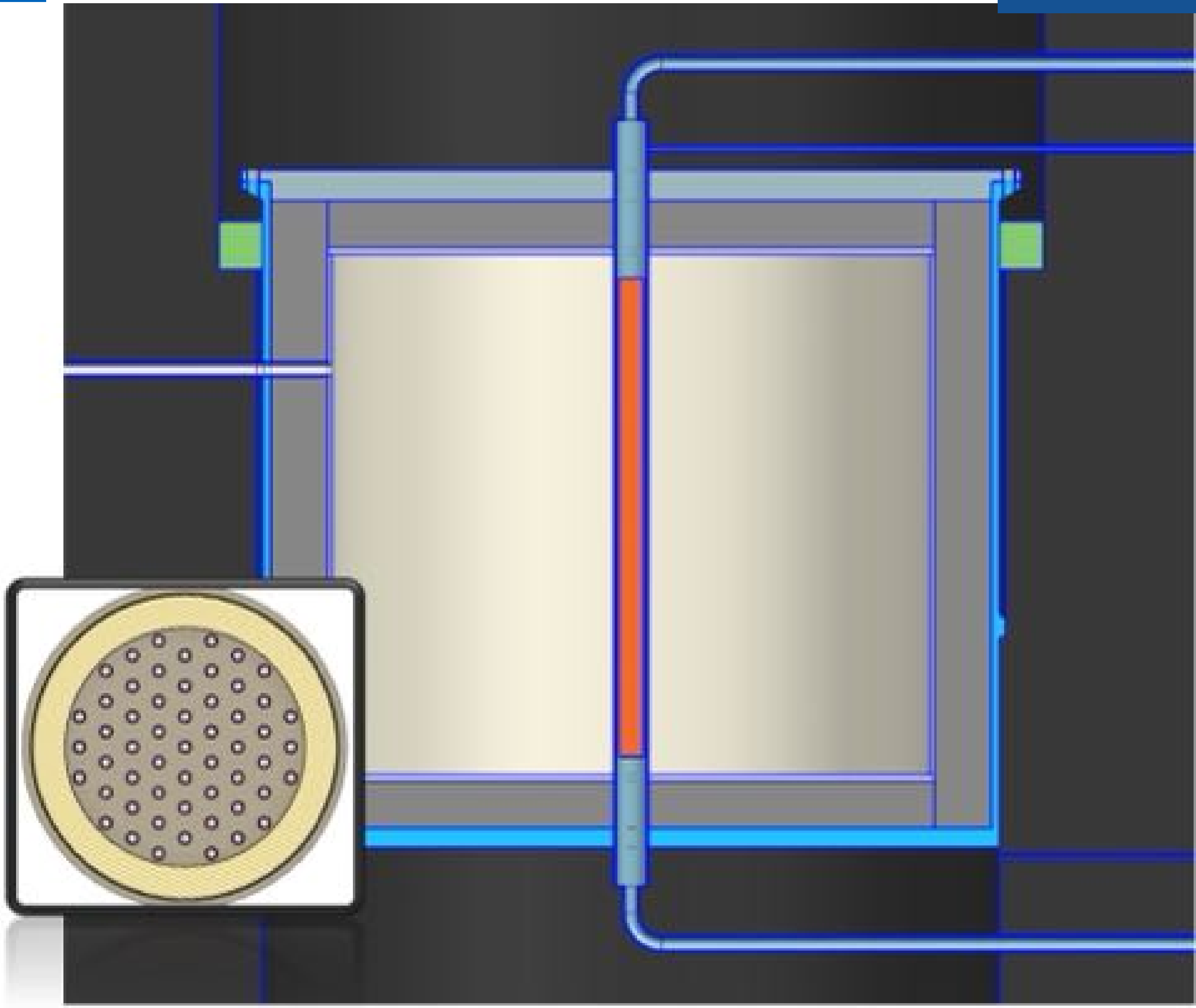

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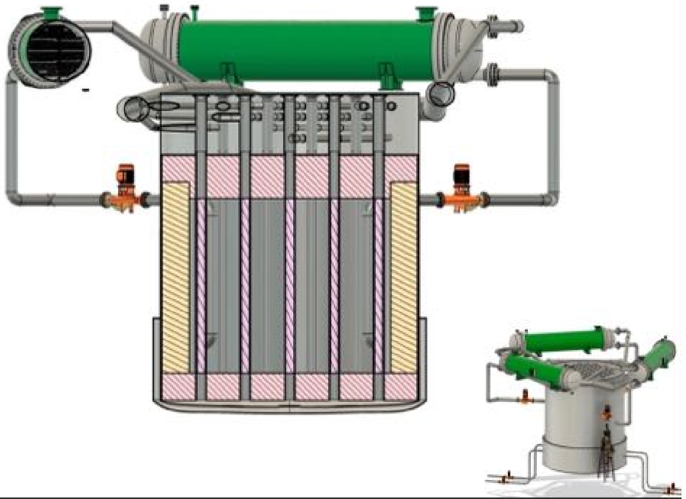
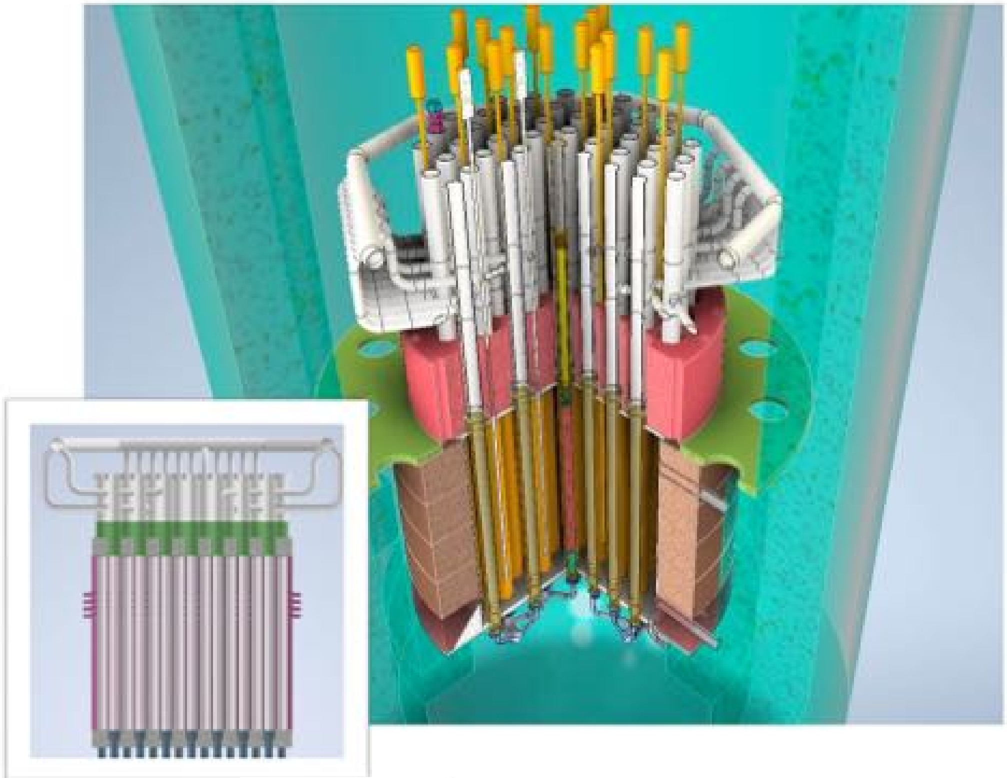
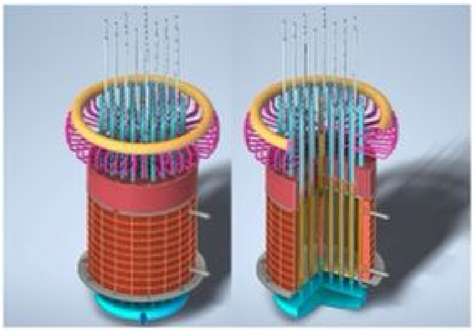
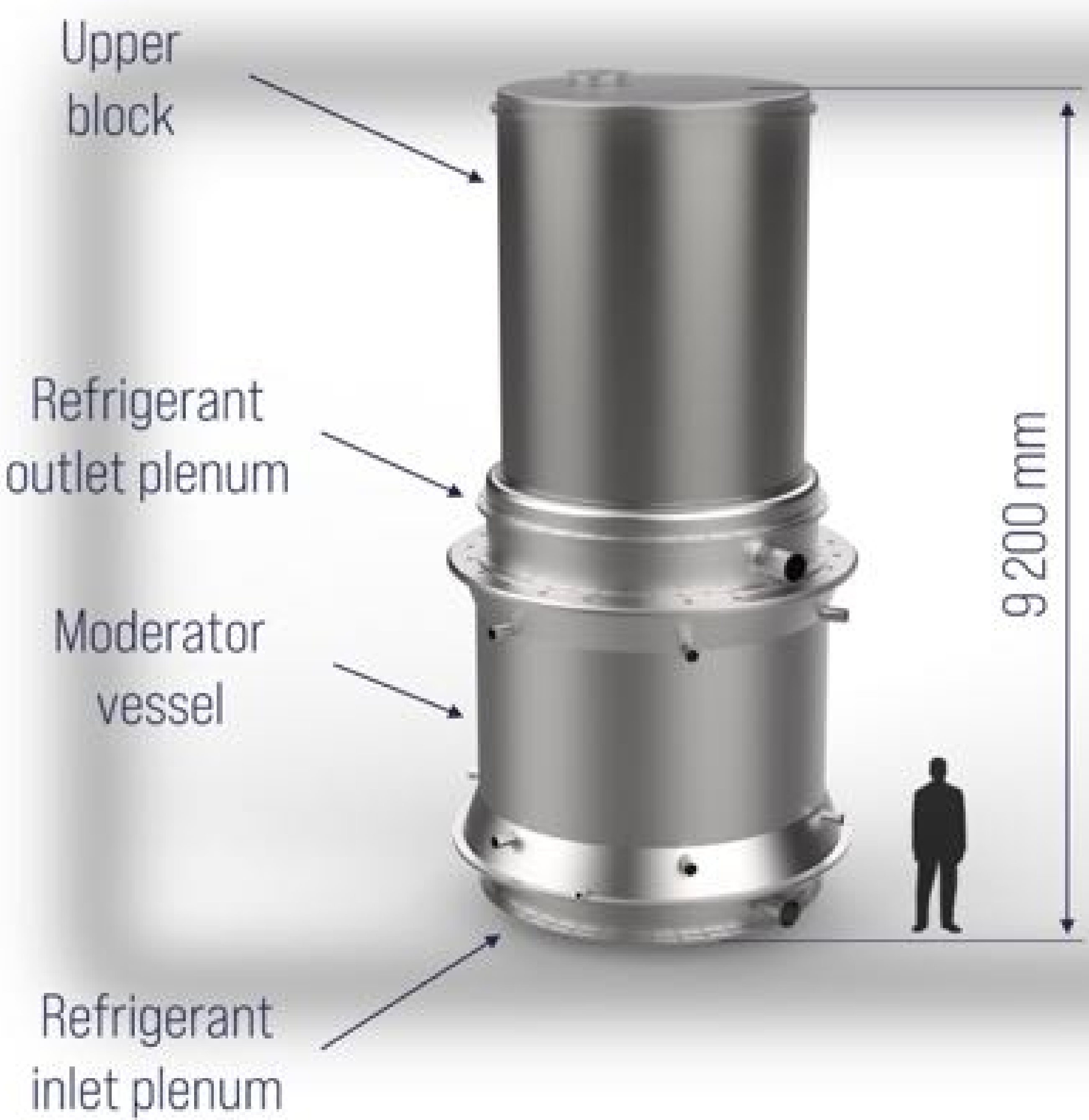
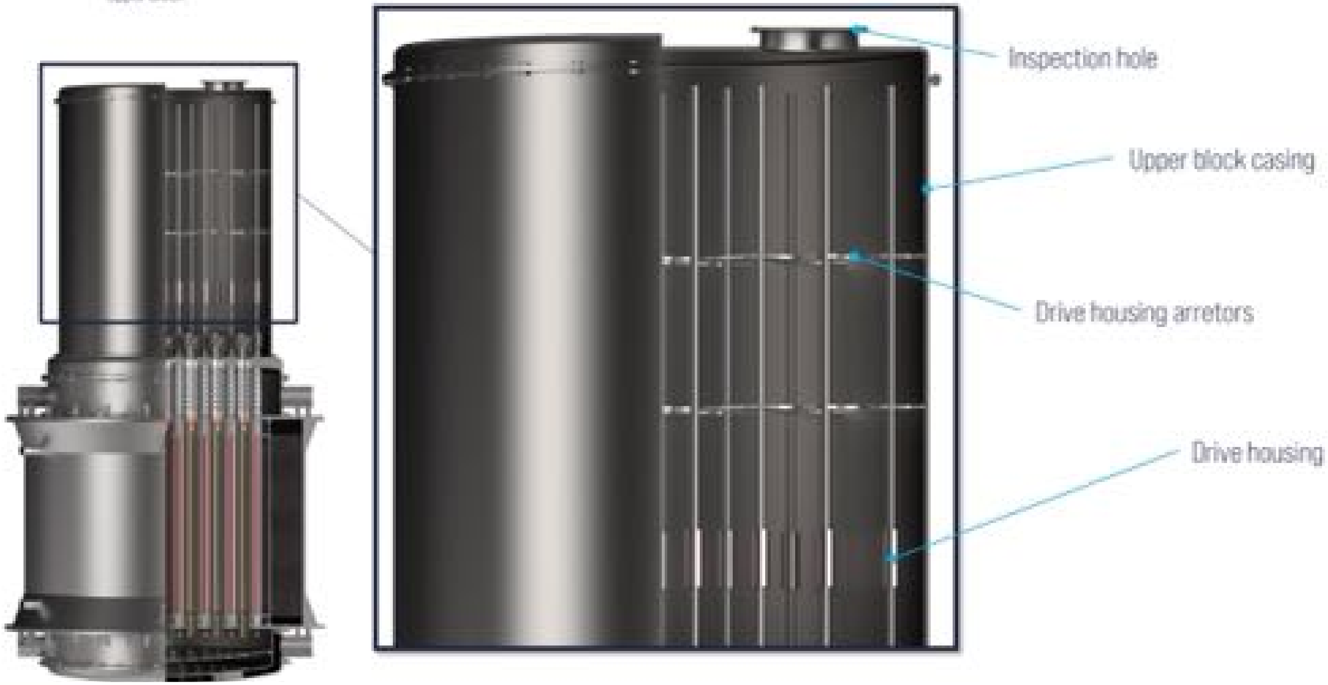




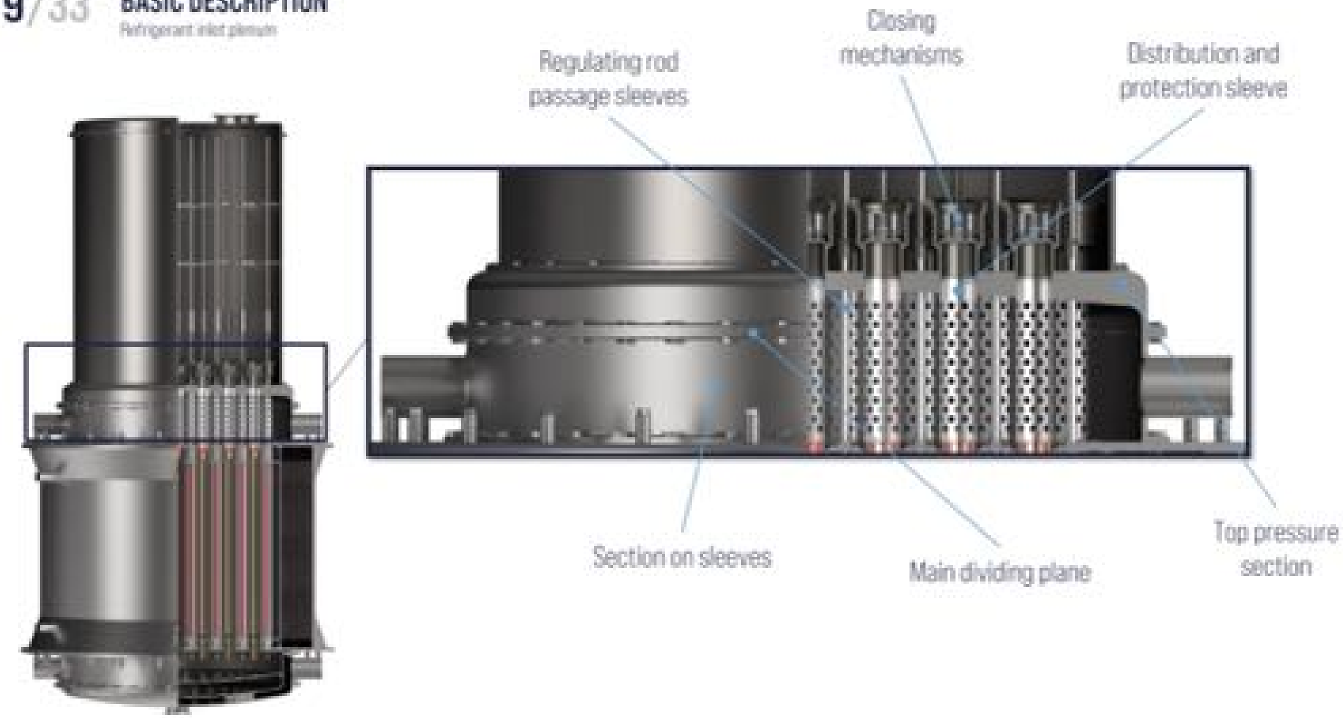



Upper block
Refrigerant outlet plenum
Moderator vessel
Refrigerant inlet plenum
9 200 mm



9/33 BASIC DESCRIPTION

Refrigerant inlet plenum




Centering ring
Support ring

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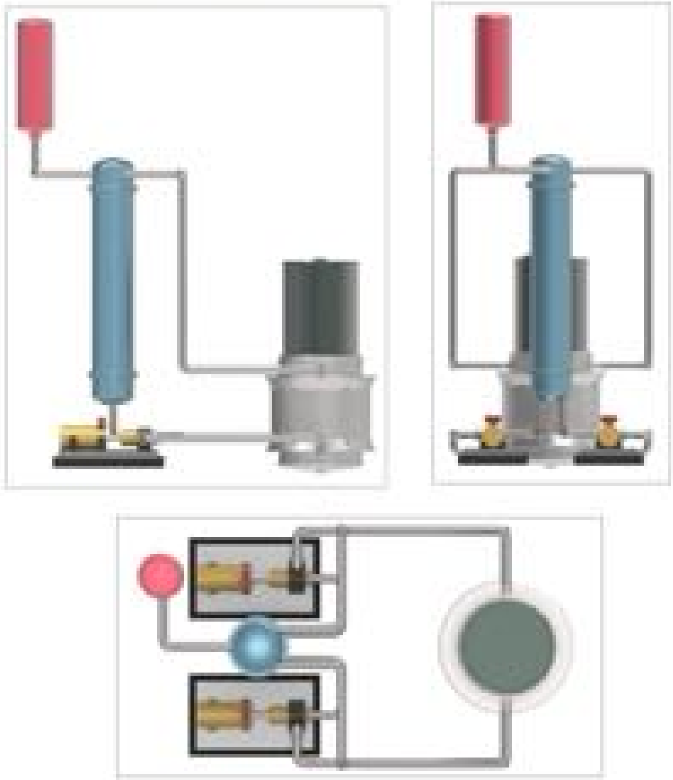
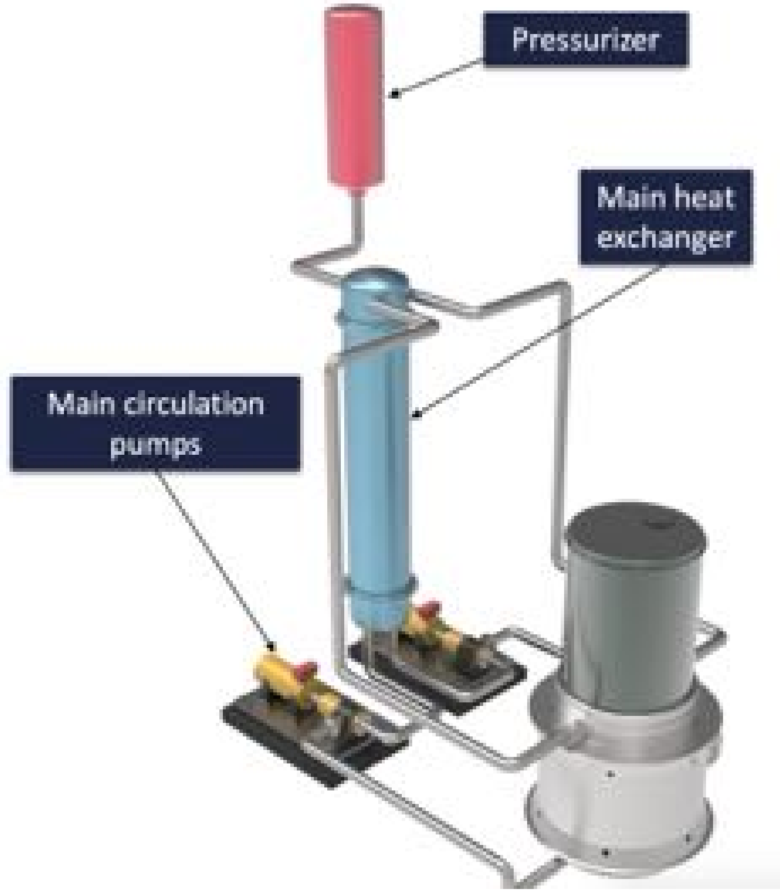
Technology

Basic description

The technology around the reactor is very sophisticated and complex

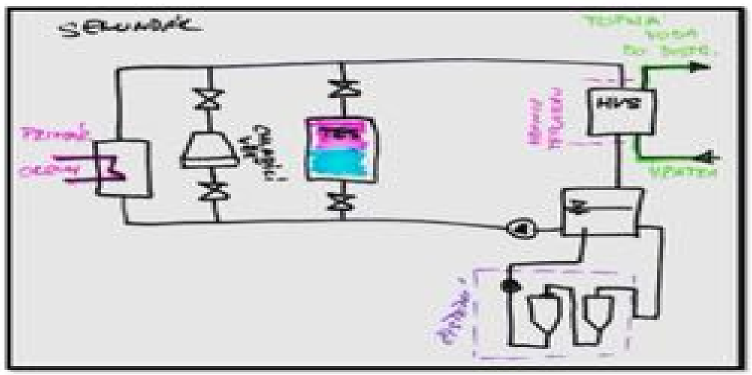
24/33 Teplator primary circuit layout

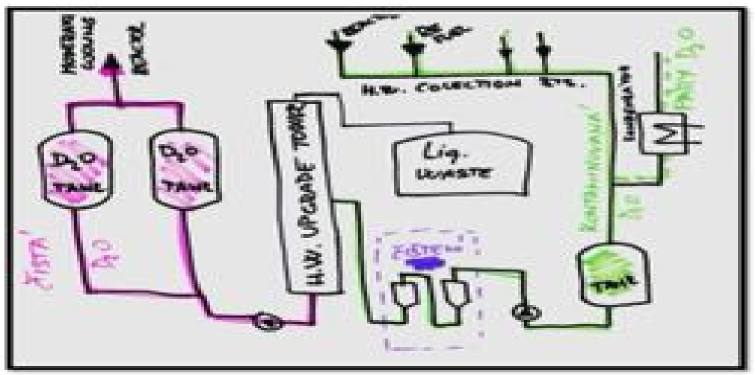




25/33 TECHNOLOGY

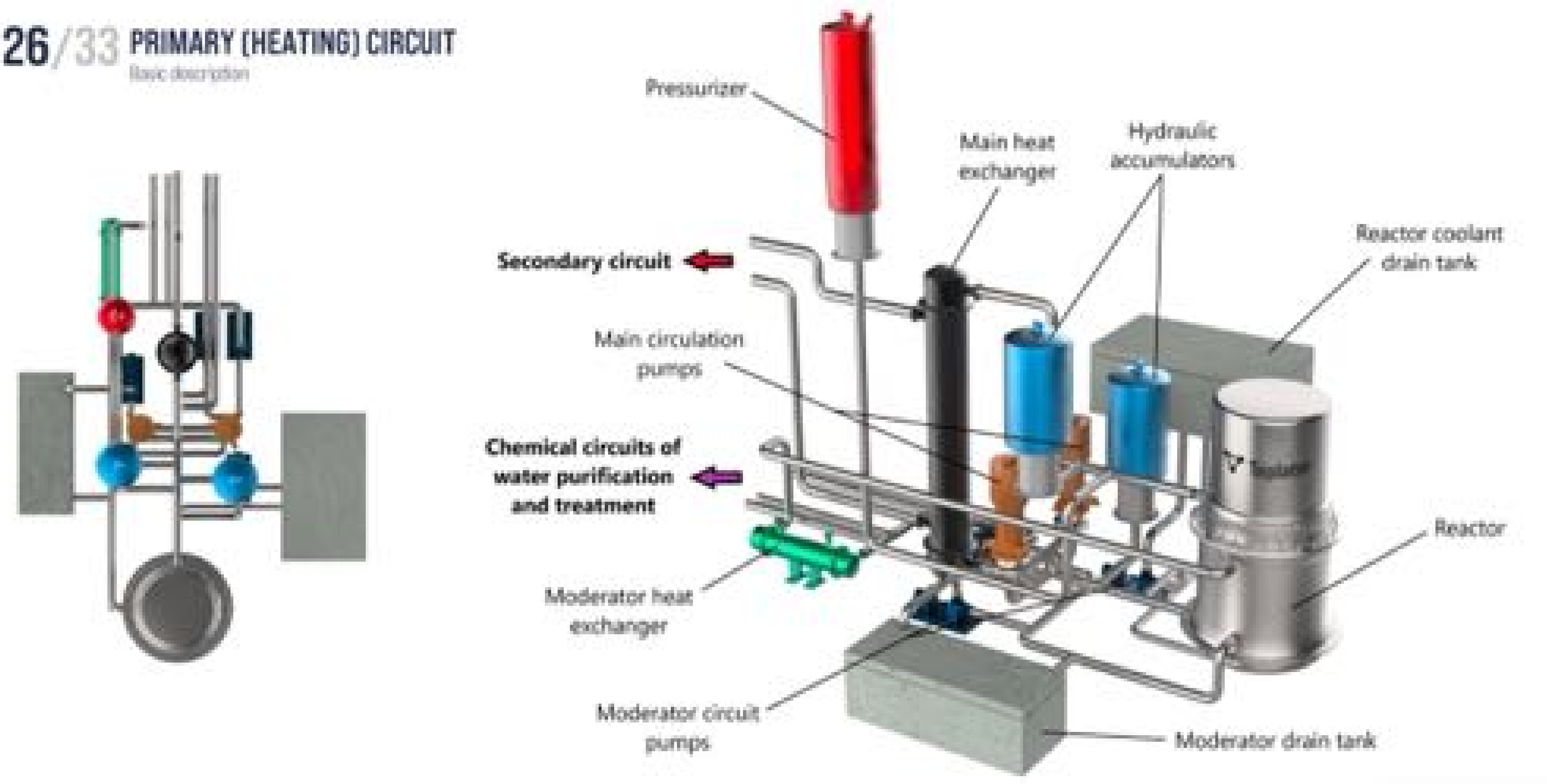
First drawings





26/33 PRIMARY (HEATING) CIRCUIT

Basic description



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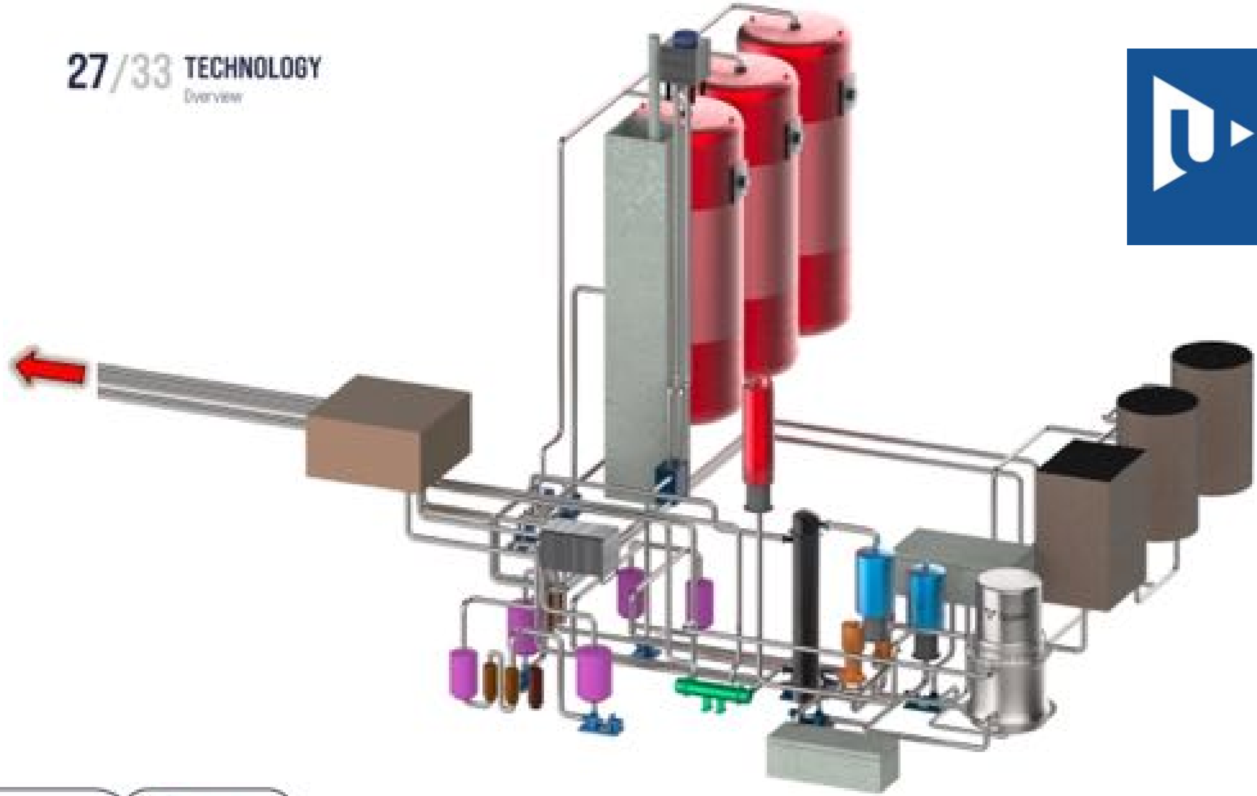
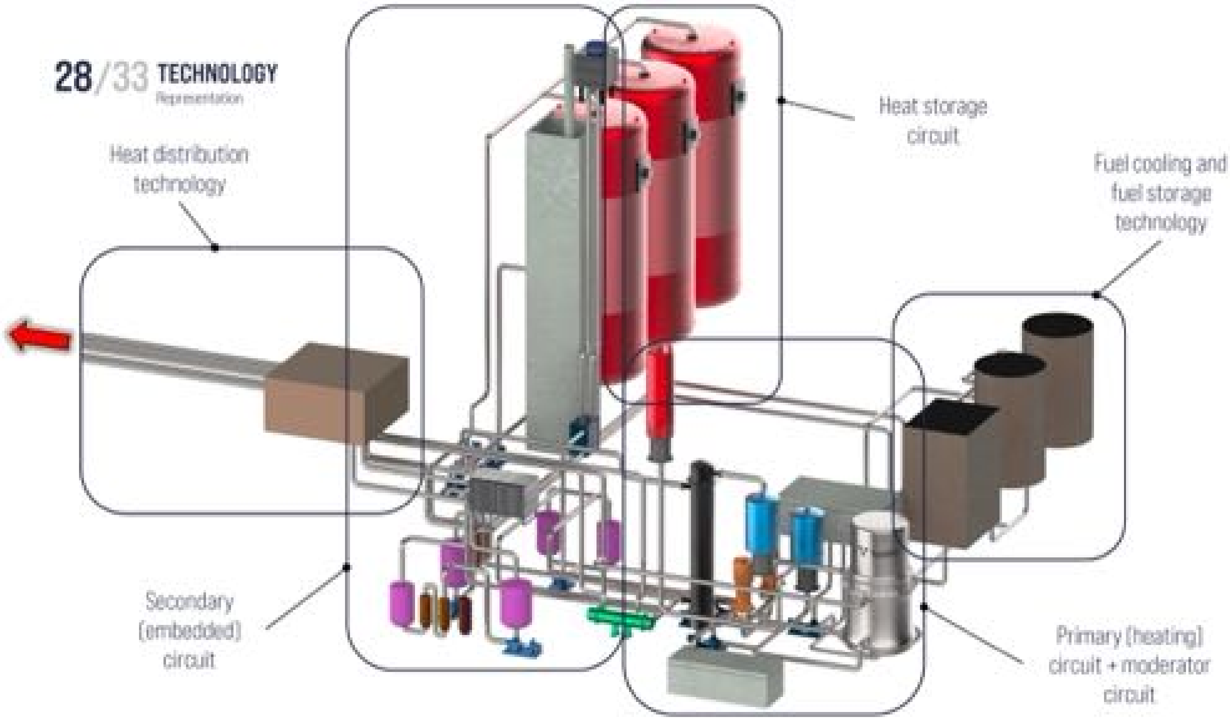
27/33 TECHNOLOGY
Overview

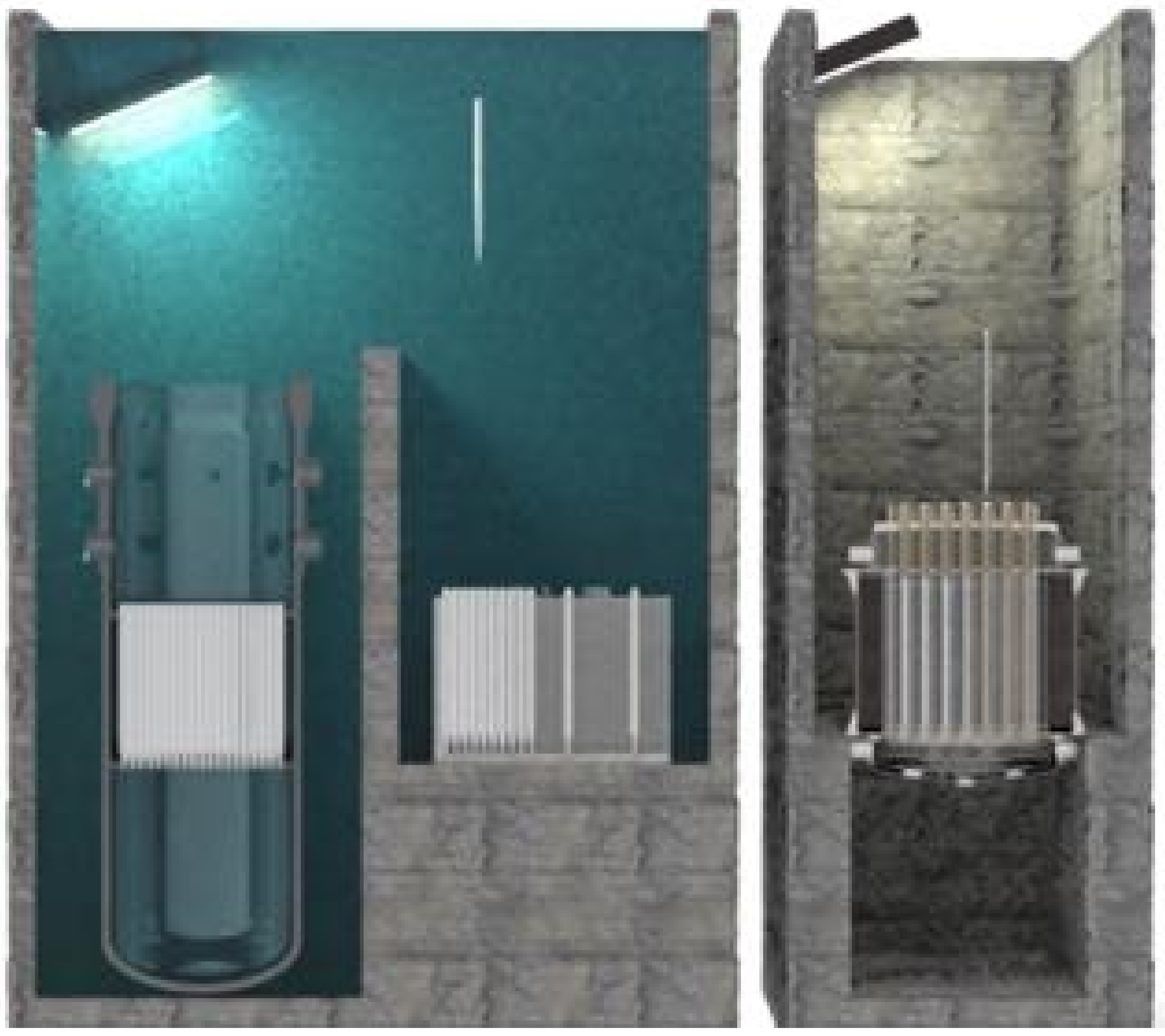


28/33 TECHNOLOGY
Representation



Fuel handling

Base principle



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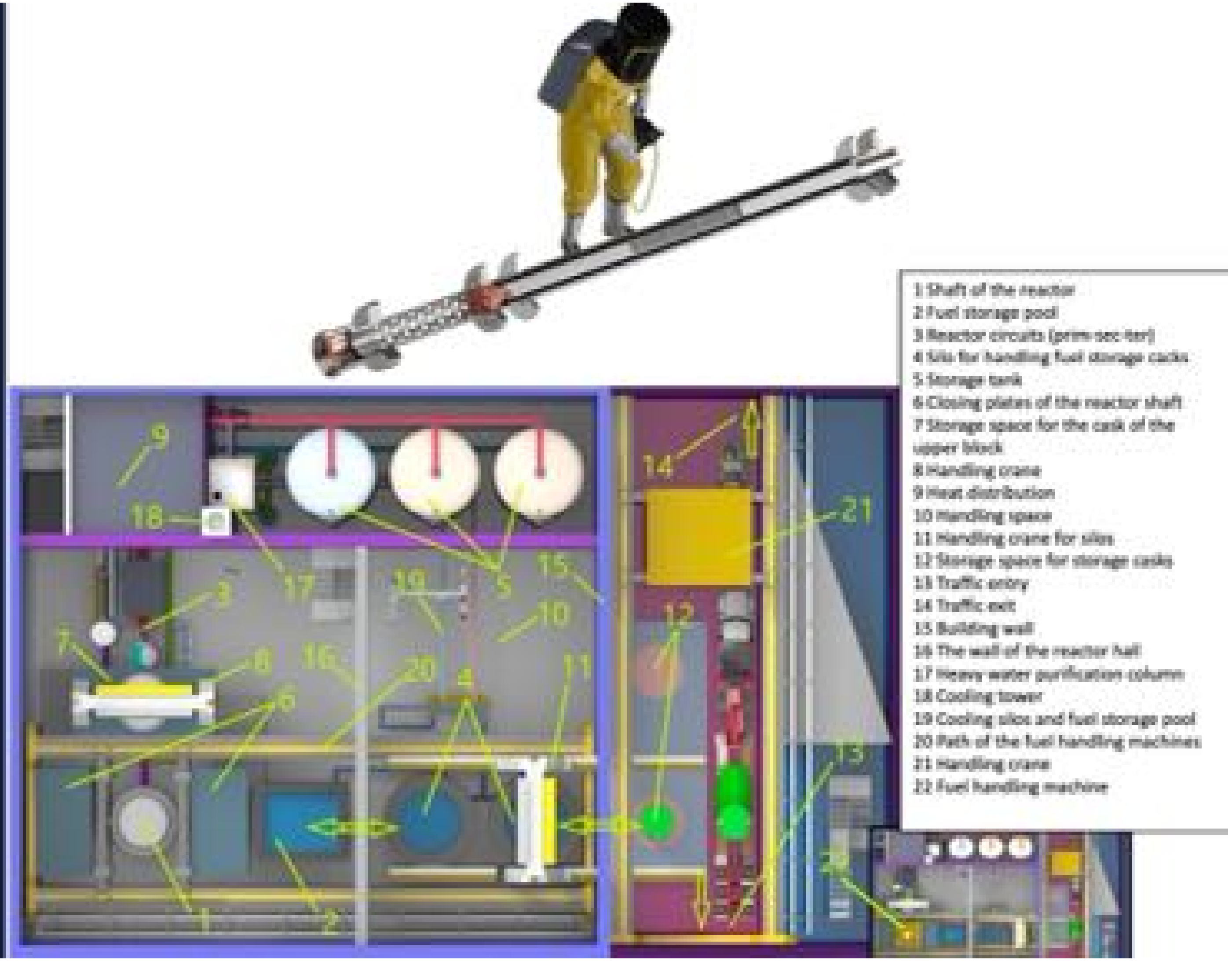
Fuel handling

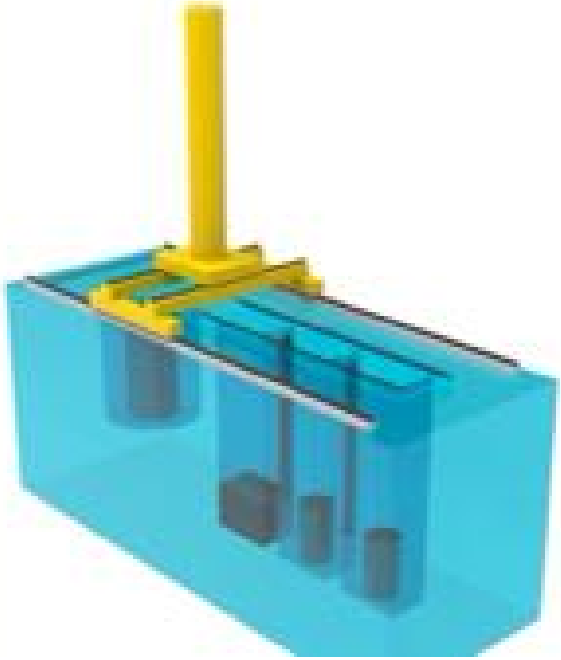
Where will the fuel travel?



31/33

Fuel handling

Fuel hangling machine design procedure



Teplator won Public Award for Urban Project of the Year 2023 and the award of the National Centre for Construction 4.0

Future steps

- Licensing process VDR in Canada
- Finalizing basic design based on FOAK parameters
- MoU with Slavutych, Ukraine, for a FOAK

Case study - Pilsen

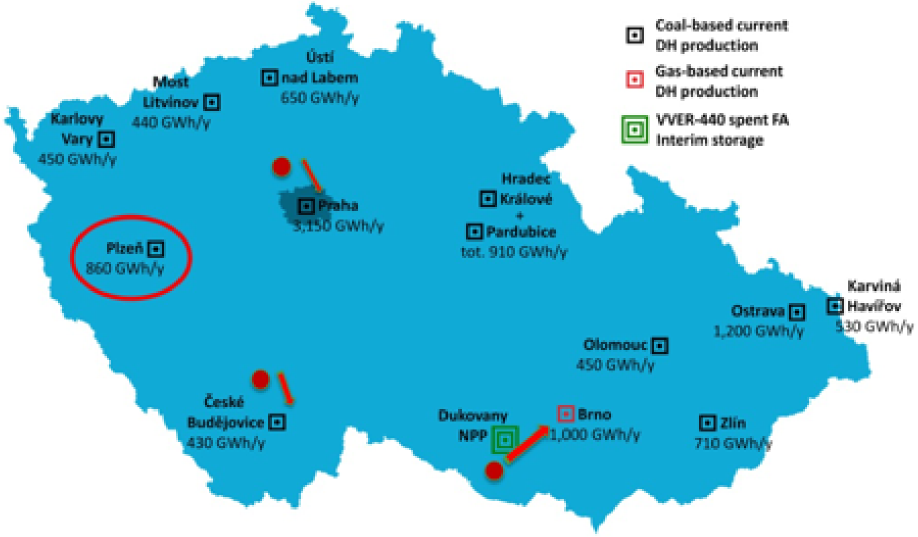
Population: 171 707

Area: 137.6 km^2

Weather: Mean annual temperature 9.1 °C
Mean winter temperature -1.5 °C

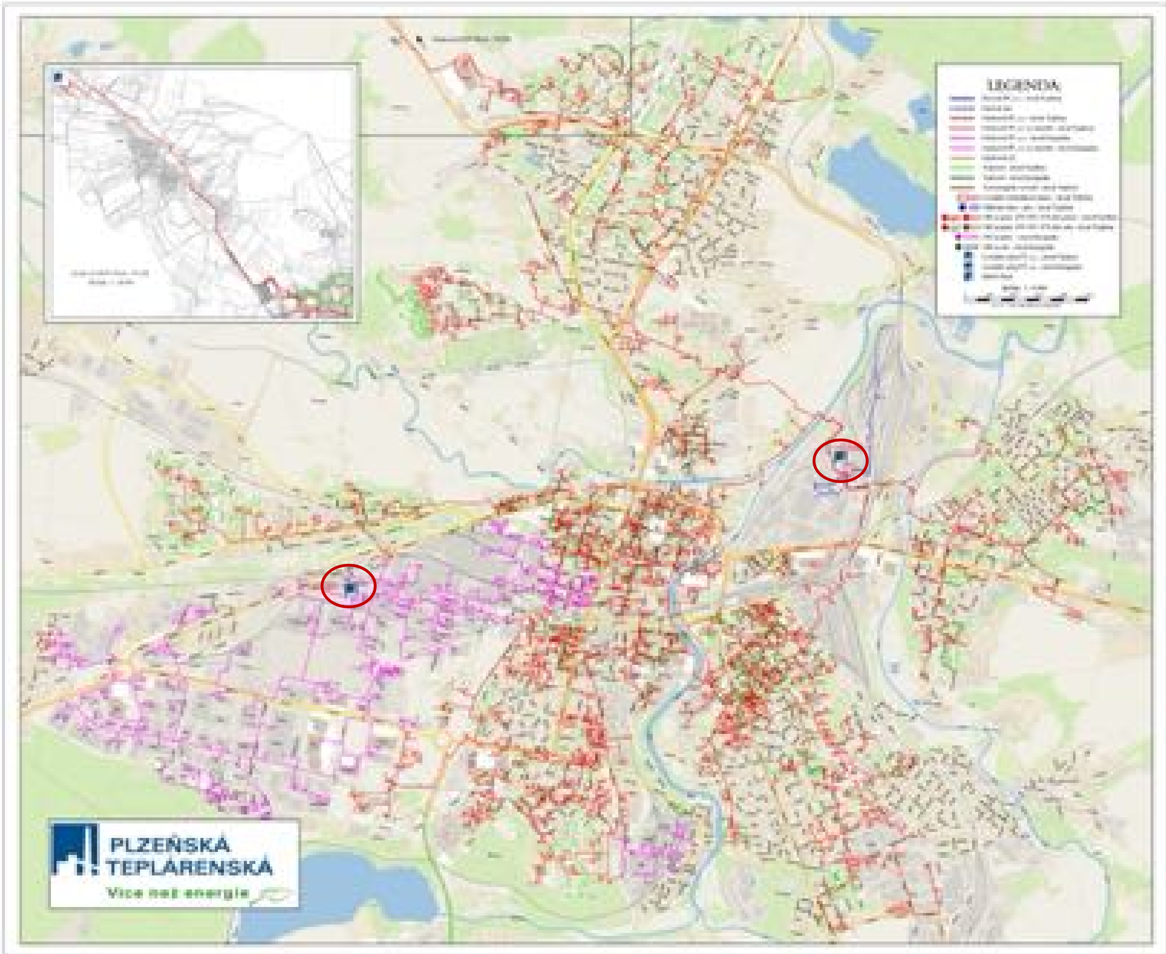
District heating: 3 330 TJ/year (2021)

Heat supplier: Plzenska Teplarenska, a.s.



Case study - Pilsen

District heating map

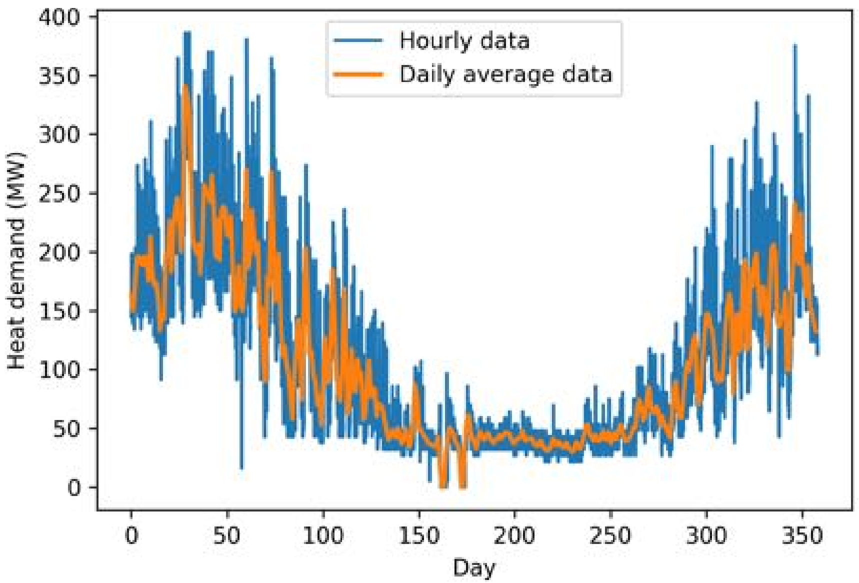


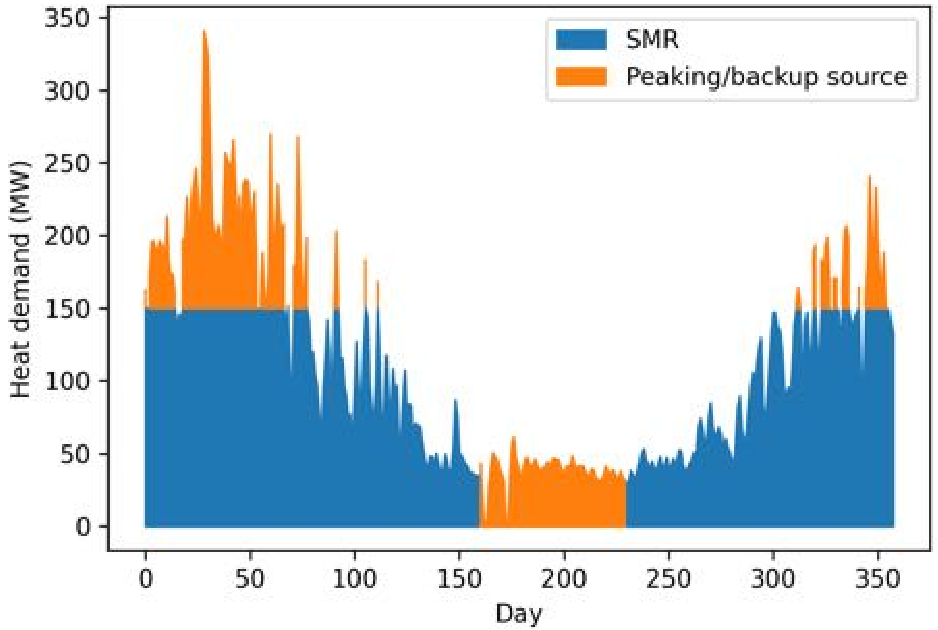
Case study - Pilsen

SMR can be placed outside of cities same as waste burning stations

Case study - Pilsen

- **SMR coupled with a peaking source.**
- **Hourly variation covered by Thermal Energy Storage.**





Case study - Prague

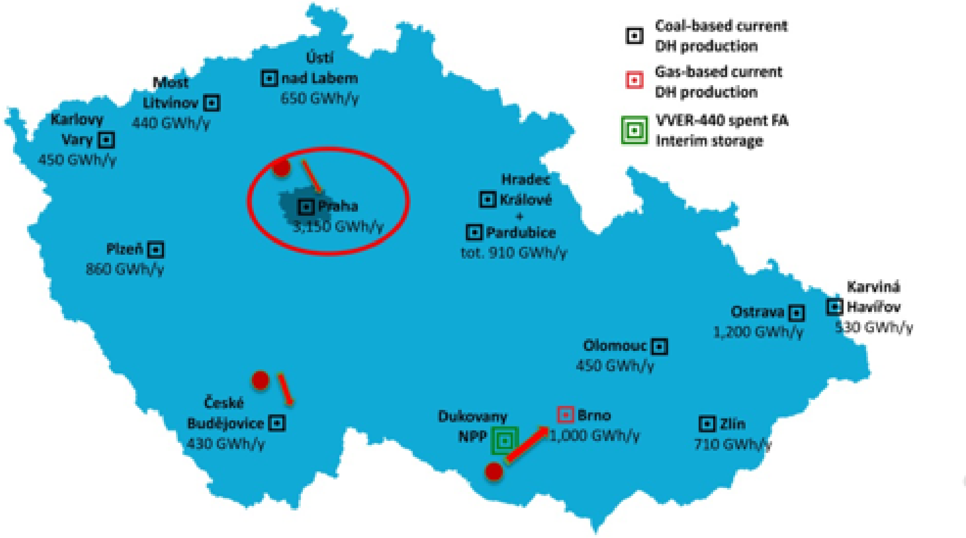
Population: 1 309 000

Area: 496.2 km^2

Weather: **Mean annual temperature 9.8 °C**
Mean winter temperature 1.6 °C

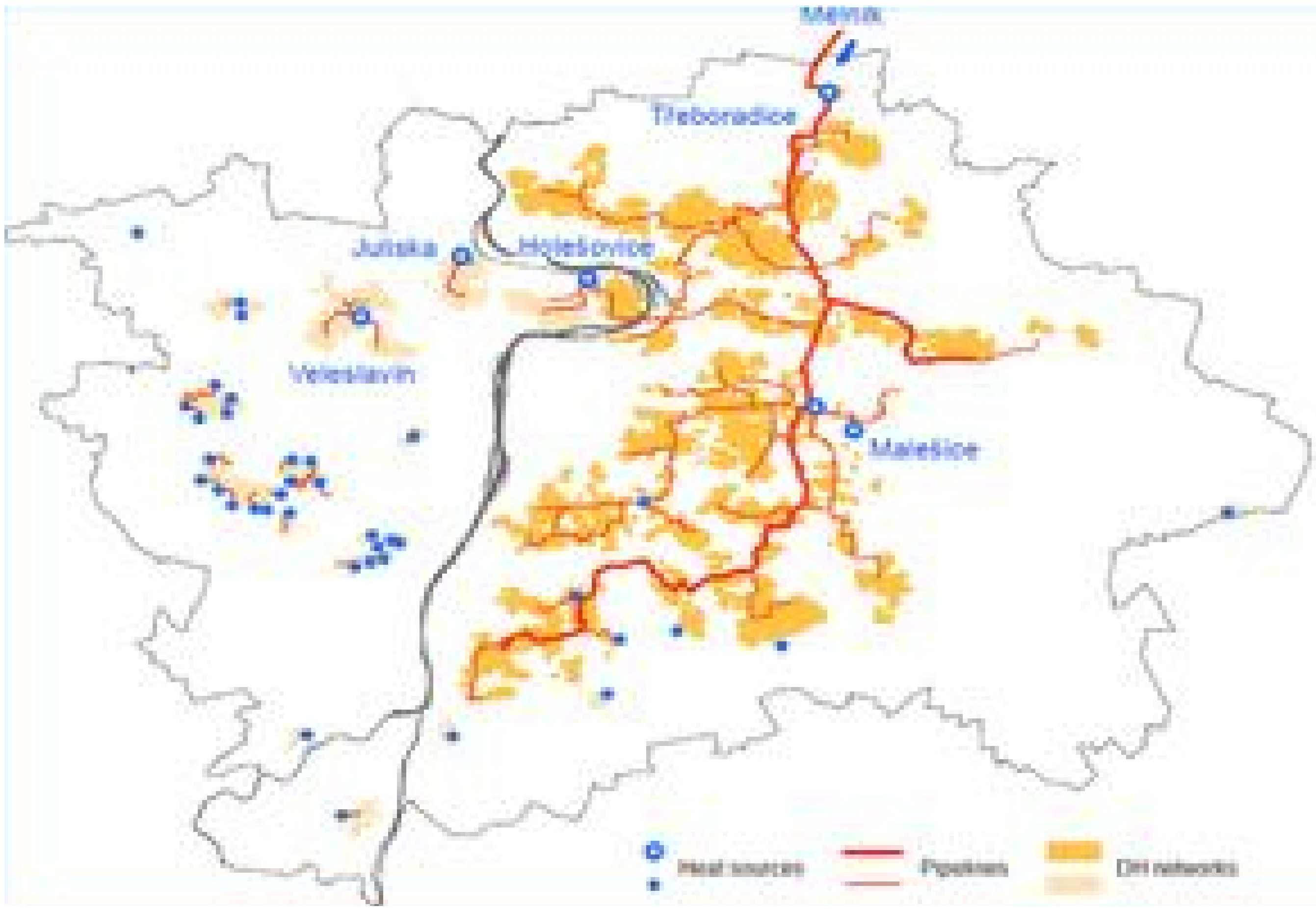
District heating: **11 340 TJ/year (2021),**

9 000 TJ from Melnik I



Case study - Prague

District heating map



Thank you for your attention.

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