



GEMINI 4.0

HTGR for building a low-carbon future for transport and industry

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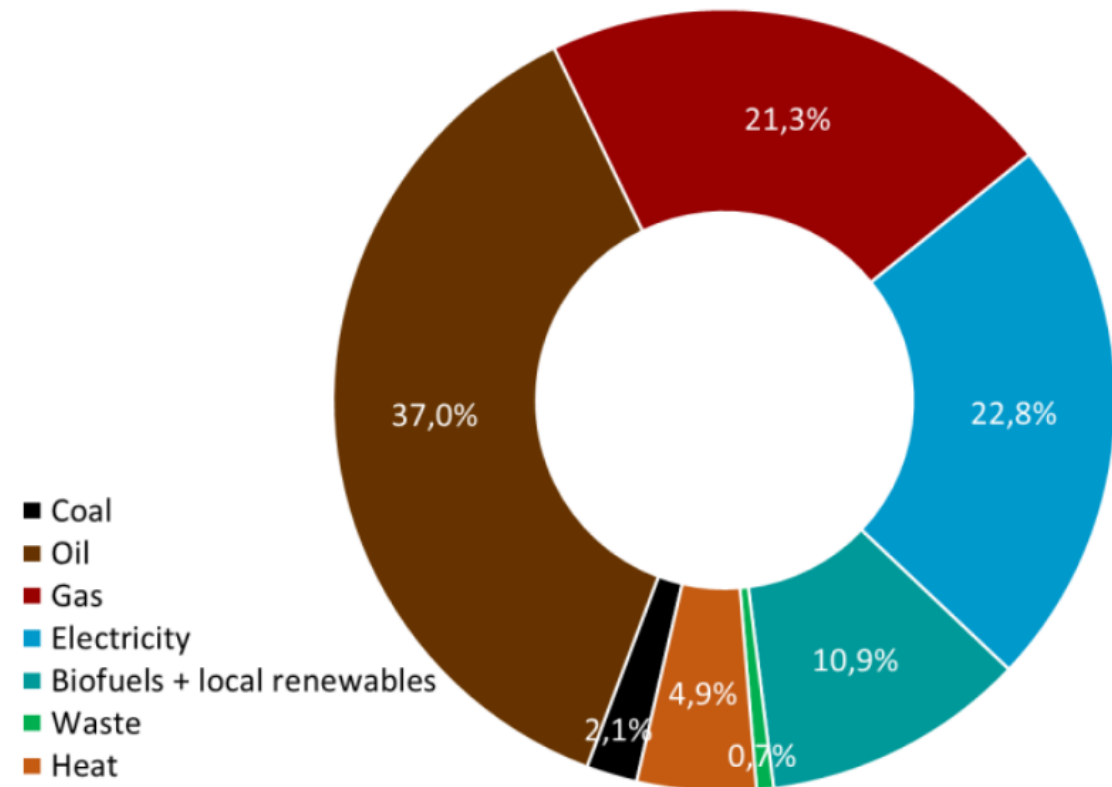
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GIF NEaNH Workshop, 3 October 2022, Toronto, ON

Ambition: Build an economy with net-zero GHG emissions by 2050 in Europe

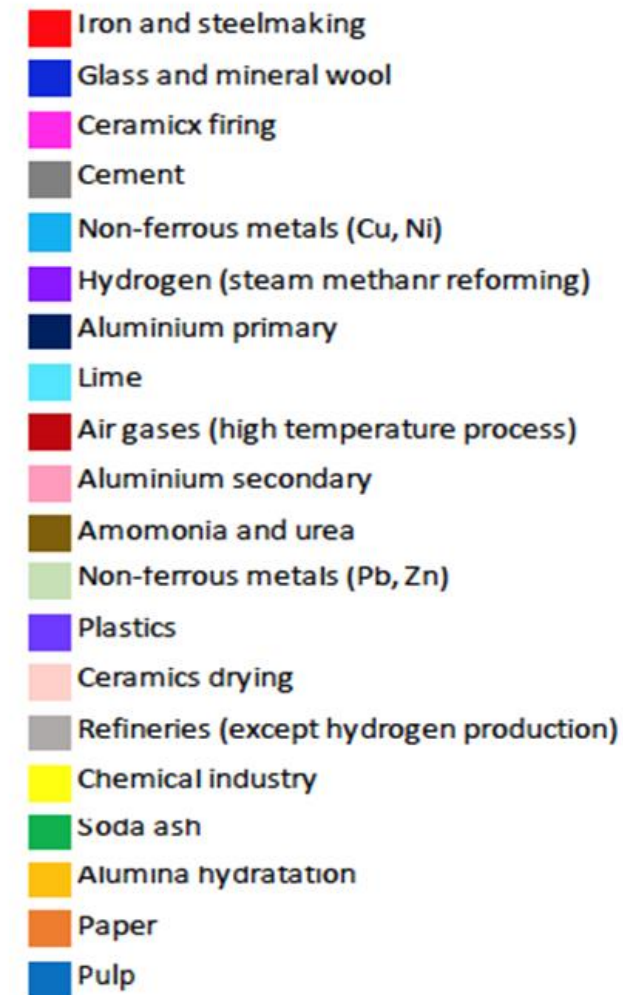
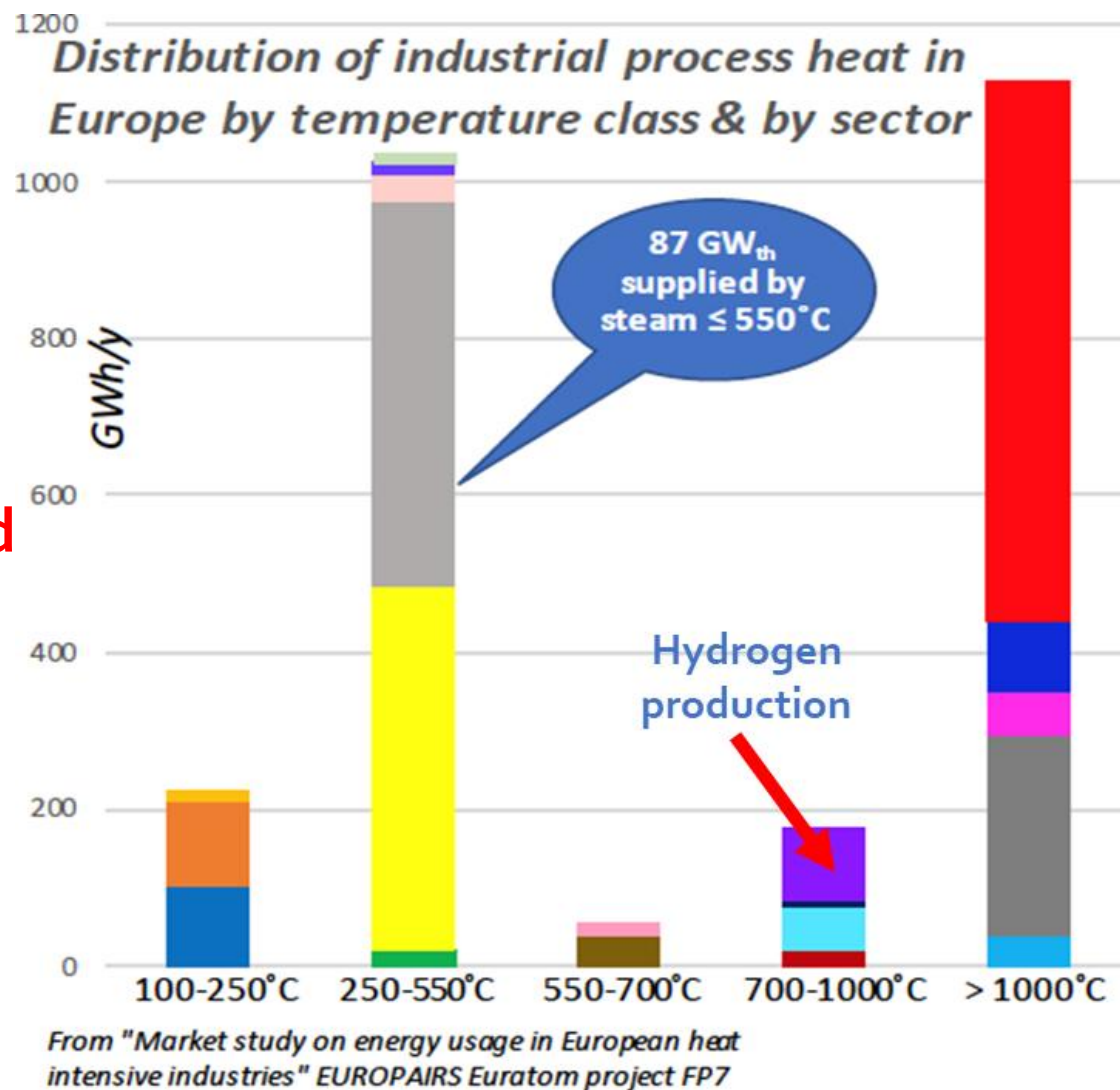
- approx. 60% of final energy consumed in Europe is produced from combustion of fossil fuels
- Main uses are for process heat, as transportation fuels and for residential heating.
- The Nuclear Cogeneration Industrial Initiative of SNETP has identified early the suitability of HTGR for efficient and safe **cogeneration of low-carbon electricity and process steam, and the large market potential.**

European total final energy consumption by end user in 2019
acc. to data from eurostat(2021)



The EU market for process heat

First target:
(Petro-)Chemical sites
with existing fossil-fired
steam networks



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Background of NC2I

- **2000:** HTR-TN started retrieval of legacy knowledge from earlier European HTGR developments and launched several new technology projects (HTR-N/-F/-M/-E/-L, RAPHAEL, PUMA, EUROPAIRS, ARCHER).
- **2010:** HTR-TN has merged into NC2I as part of SNETP, with the objective to further develop the technology of nuclear cogeneration in industry and to accelerate demonstration.
- **2014:** NC2I launched the **GEMINI Initiative with international partners** to support **early industrial demonstration of nuclear cogeneration** (now poly-generation with, in addition, H₂ production)



➔ **NC2I promotes HTGR for efficient and safe poly-generation of low-carbon electricity, process heat and H₂**

GEMINI Initiative

The **GEMINI Initiative** is promoting development and deployment of HTGR for efficient and safe cogeneration of low-carbon electricity, process steam, H₂ and other energy products.

Most recent EU projects launched by NC2I:



- **GEMINI+** (2019 – 2021)
 - Defined main design options of a modular HTGR (suitable temperature range, high TRL)
 - Built the basis of a licensing framework (non-LWR, new non-electric applications)
 - Confirmed the feasibility of an early demonstration
 - **GEMINI 4.0** (2022 – 2025)
 - Demonstrate that a GEMINI+ reactor can cogenerate simultaneously and economically process heat, electricity and hydrogen
 - Corroborate the GEMINI+ results: complete safety analysis, improve licensing readiness
 - Evaluate the development of a HALEU TRISO fuel supply chain in Europe
- + NC2I supports the Polish plan for development of nuclear cogeneration in industry and aligned the GEMINI projects to support early demonstration.



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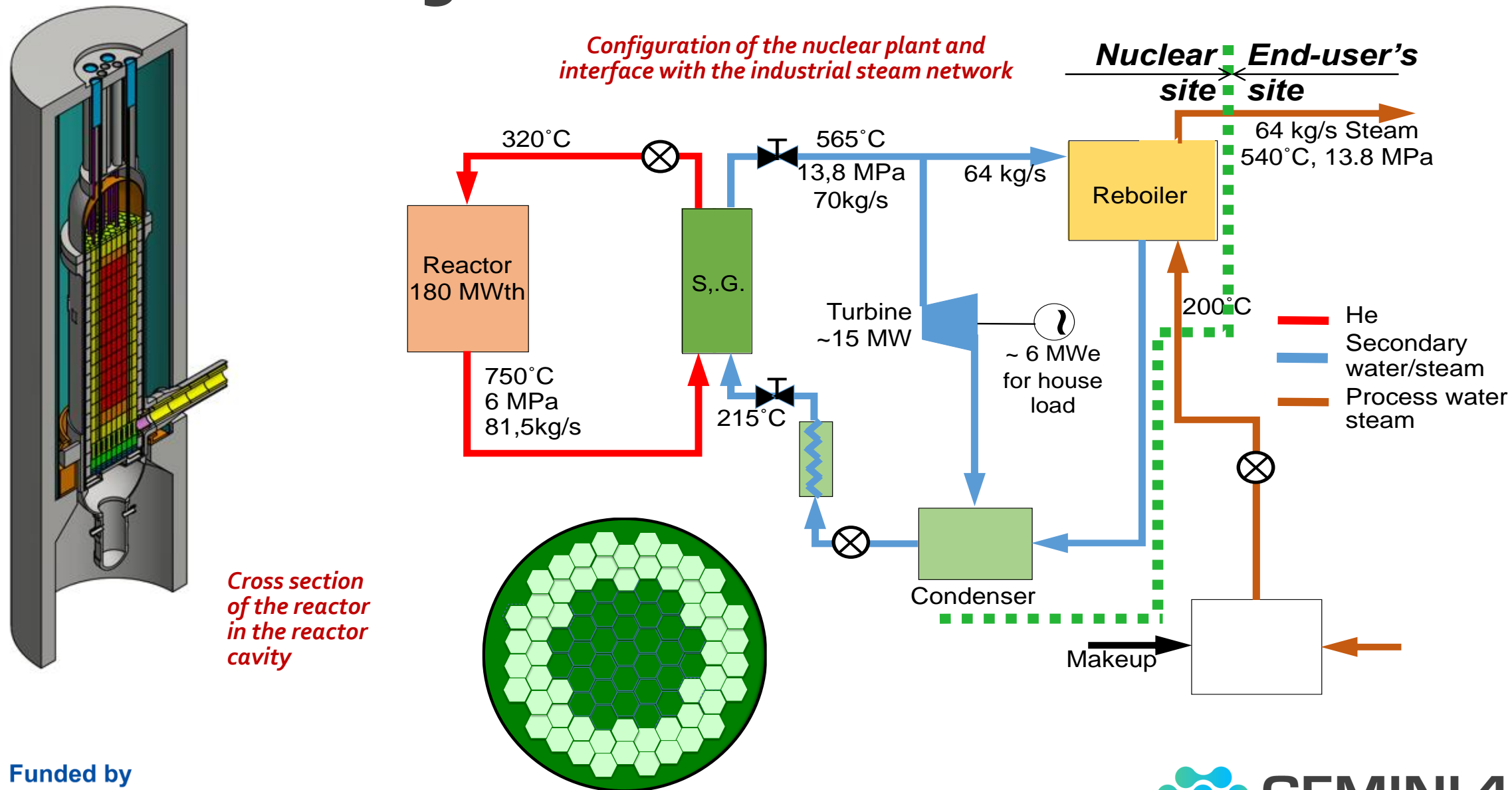


GEMINI and HTGR demonstration in Poland

- The Polish government has placed HTGR technology among the **national top priority projects since its 2016 “Strategy of Responsible Development”**, to considerably reduce natural gas imports, which represent the principal heat source and feedstock for the chemical industry.
- Poland wishes to develop HTGR technology, for industrial applications, via the EUHTER project of an experimental reactor on the NCBJ site, for which the conceptual design has been completed.
- NCzI supports the Polish HTGR project in the frame of the GEMINI+ and GEMINI 4.0.



GEMINI+ Design Basis



GEMINI+ solution for industrial cogeneration

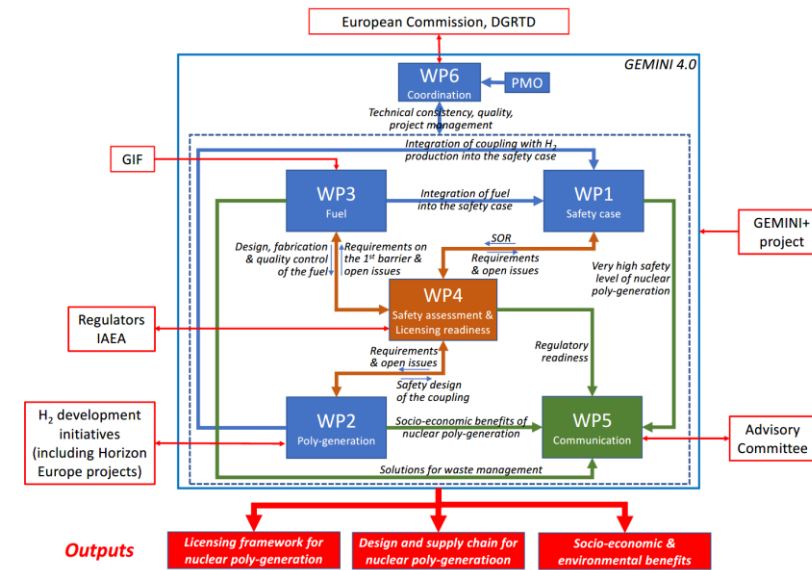
- Block type fuel design with cylindrical core
 - Compact design
 - Low power: 180 MW_{th} reactor delivers 165 MW_{th} to customer
 - Flexibility to adapt to variable industry needs → market ↑
 - Uses mature technology (< 800°C, secondary steam cycle)
 - Steam only supplied by the nuclear plant to the customer via steam distribution network.
If electricity is needed, industrial site can use part of the steam from the network
 - **Standardised plug-in solution**
 - Use of non-nuclear industrial turbo-generator set → cost ↓
 - Reactor and industrial steam network separated by an intermediate water/steam circuit
 - No radio-contamination of the steam product
- Modular manufacturing & construction facilitated
• Transportable by road → cost ↓

GEMINI 4.0 Project Structure

5 technical Work Packages

- **WP1:** Optimizing safety and competitiveness of the GEMINI+ system
- **WP2:** Towards full decarbonization of European industry with nuclear poly-generation (simultaneous production of electricity, process heat, hydrogen and derivatives)
- **WP3:** Fuel technology options and fuel cycle strategy for the GEMINI+ system
- **WP4:** Assessment of the licensing readiness of the GEMINI+ system for multipurpose industrial cogeneration
- **WP5:** Nuclear High Temperature cogeneration for European citizens
- **WP6:** Project management

Duration: 3 years (June 2022 - May 2025)



GEMINI 4.0 Partners

BENEFICIARIES



ASSOCIATED PARTNERS



Advisory Committee

- **Franck CARRE**, scientific director of CEA Nuclear Energy Division and former advisor of CEA High Commissioner
- **Marc DEFFRENNES**, former official of the European Commission and expert at OECD/NEA, now founder and chairman of the NGO weCARE
- **Kirsty GOGAN**, Senior advisor to the UK government on climate and energy policy, consultant on strategies for accelerated deployment of zero carbon technologies
- **Rafal KASPROW**, CEO of SYNTHOS Green Energy
- **Jozef SOBOLEWSKI**, Director of HTR development at NCBJ, advisor of the Minister of Climate and Environment and former director for nuclear energy at the Ministry of Energy, member of the Euratom Scientific and Technical Committee and Chairman of NC2I
- **Farshid SHAHROKHI**, Director of HTR technology, Framatome Inc.
- **Rauli PARTANEN**, award-winning science and non-fiction writer and energy analyst



weCARE



synthos
green energy



Narodowe Centrum Badań Jądrowych
National Centre for Nuclear Research
ŚWIERK

JRC collaboration partner

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Thank you

Get in touch for more information!



All reports of the project will be available for download on the GEMINI4.0 website: **www.gemini-initiative.com**



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