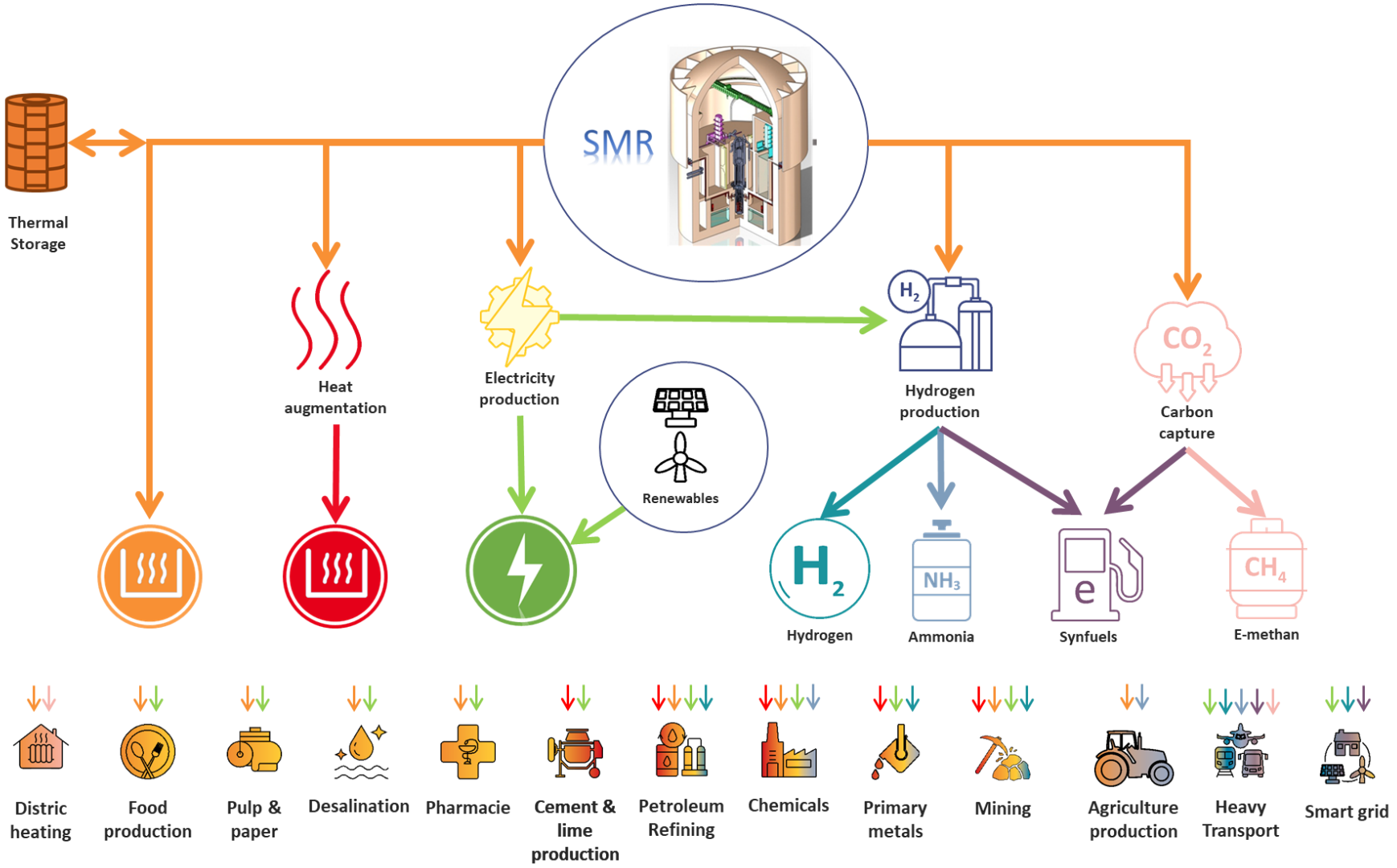

International Conference on
small modular reactors
and their applications
21–25 October 2024, Vienna, Austria

IDNES a CEA project dedicated to SMR concept for decarbonization beyond pure power generation

Philippe AMPHOUX – French Alternatives energies and Atomic Energy Commission (CEA)

SESSION 5.1: Non-Electric Applications for SMR

SMR for decarbonisation
Capacity to adress a large scope of industrial ecosystems



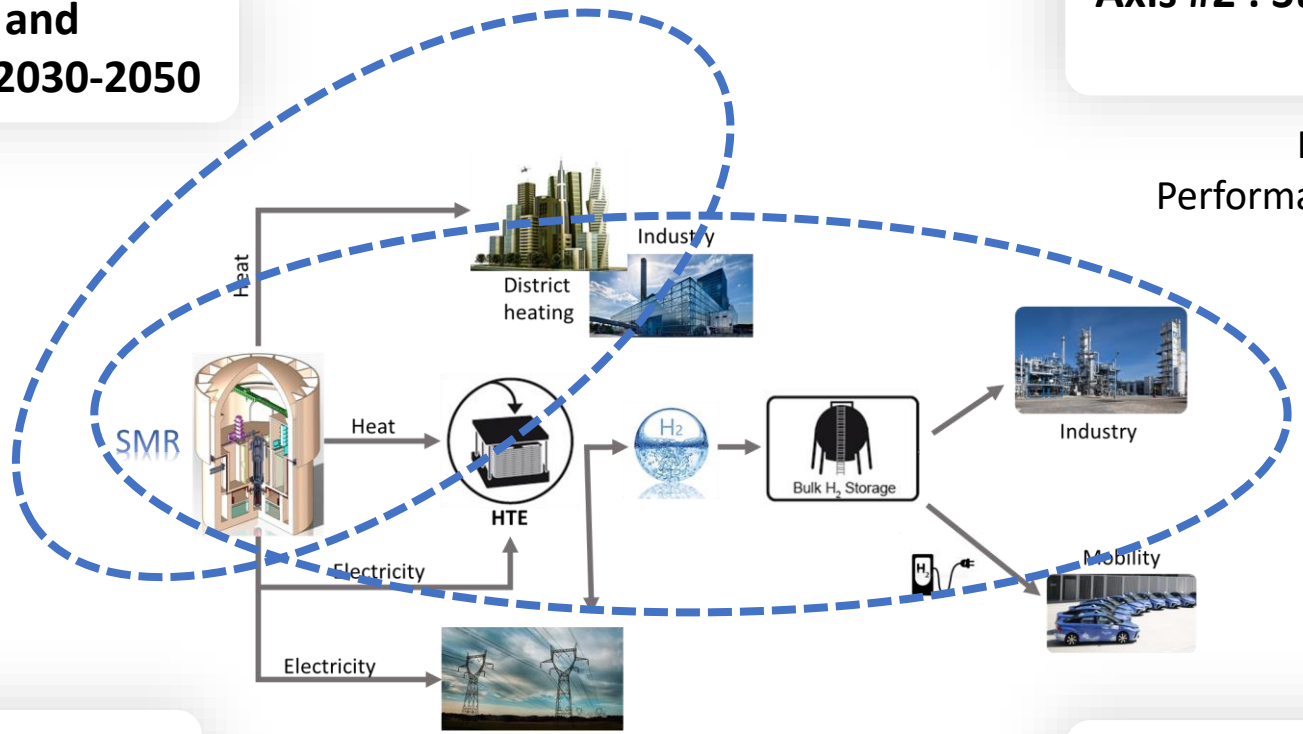
Key points

- Decarbonized heat
- Cogeneration Heat / Power
- Synthetic molecules
- Thermal storage

IDNES Project
Main R&D areas

Axis #1 : Market studies and identification of future needs 2030-2050

High level needs
Specifications
Performances required



Axis #2 : Study of an SMR dedicated to heat production

Heat production SMR
Performance & costs Vs market needs

ARCHEOS
ADVANCED REACTOR CONCEPT FOR HEAT OPTIMIZED SUPPLY

Axis #3 : Study of an SMR dedicated to hydrogen and E-molecules production

Coupling systems of an SMR with HTSE (High Temperature Steam Electrolysis → H_2)
Performances & costs Vs market needs

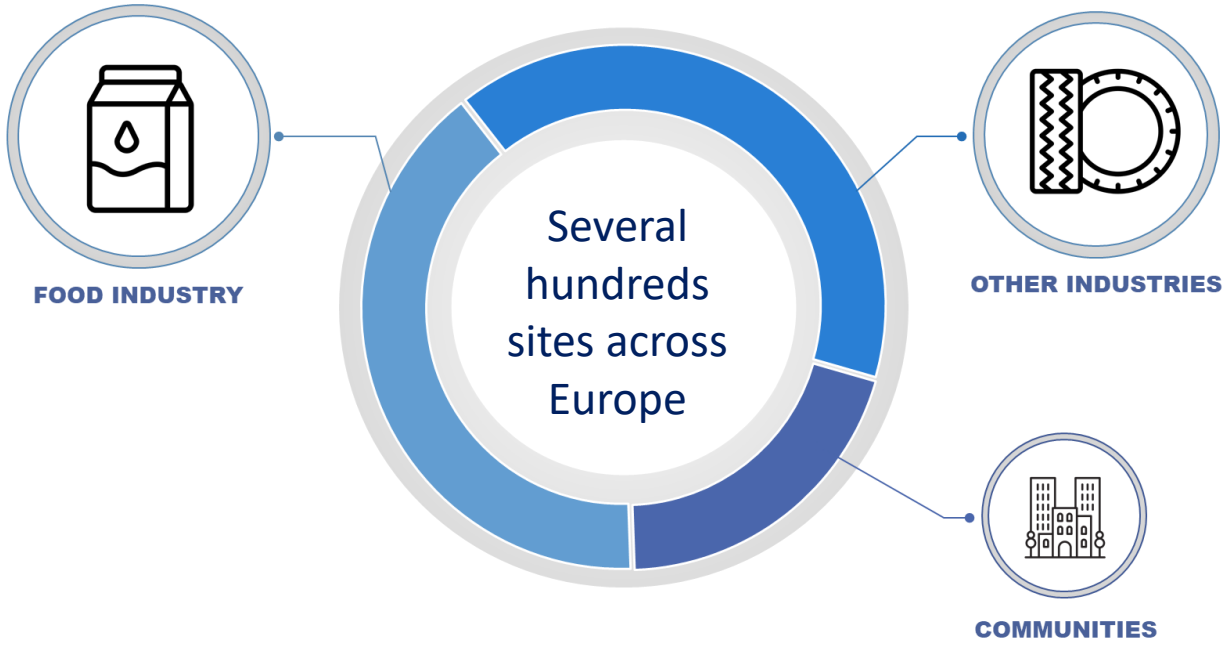
Axis #4: R&D on innovative Energy Conversion Systems including storage

Multi vector systems
Desalination, Carbon capture, e-fuels
Storage
Integration of other energy sources & storage

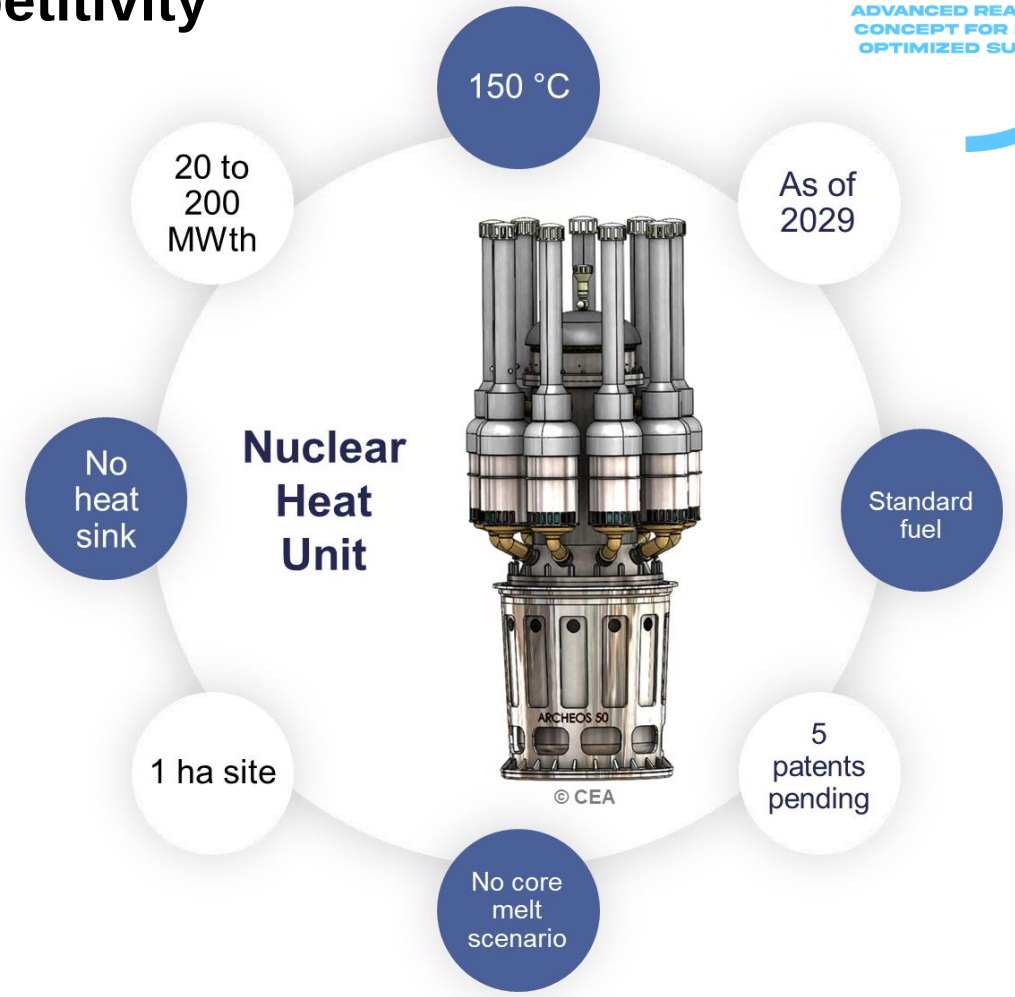
Pure heating reactor ARCHEOS

Market pull approach to design

- **Reactor concept dedicated to supply the market heat <150°C**
- **Drivers of conception: safety, simplicity, competitivity**



ARCHEOS
ADVANCED REACTOR CONCEPT FOR HEAT OPTIMIZED SUPPLY

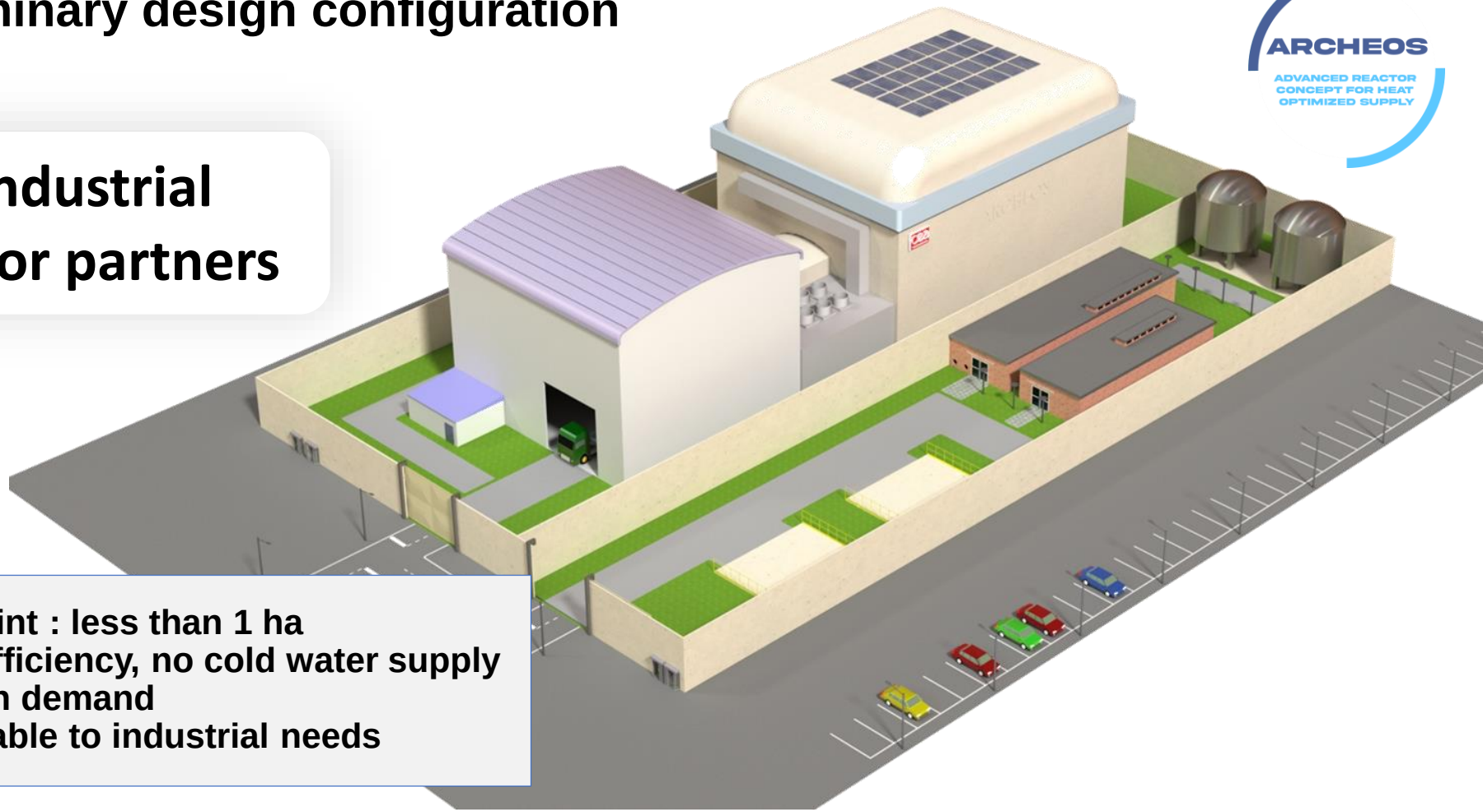


Pure heating reactor ARCHEOS

Serving territories, industries and municipalities

- **Current status: Preliminary design configuration**

Transition to an industrial project and search for partners



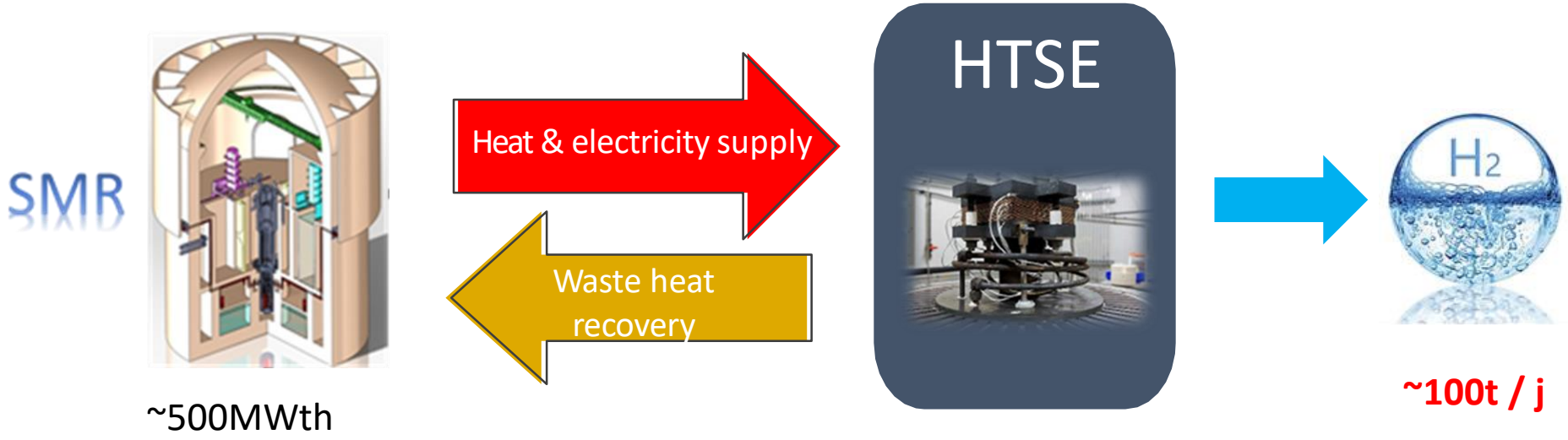
- Optimized footprint : less than 1 ha
- Total energetic efficiency, no cold water supply
- Energy source on demand
- Power / T° adaptable to industrial needs

HYDROGEN PRODUCTION

Using SMR in cogeneration

- **Coupling 2 technological bricks:**
  - SMR & power conversion system (Heat to Power)
  - High Temperature Steam Electrolyser (GENVIA)

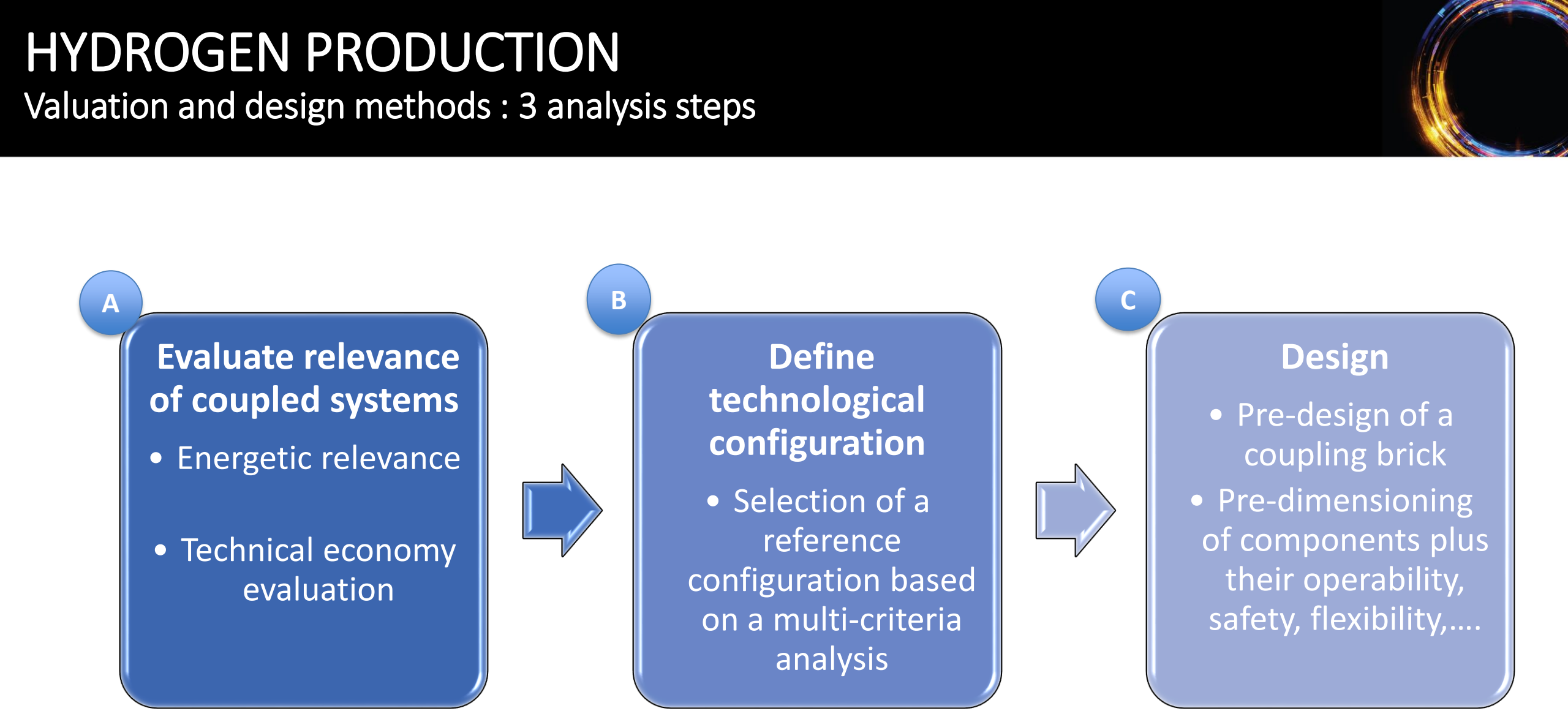
- **Associated issues:**
  - HTSE development to industrial scale
  - Energetic efficiency of the coupling
  - Safety & security of the system
  - Global operation of the system



- **Massive decarbonized energy**
- **Production of Energy on demand**
- **Cogeneration : maximize the efficency**

HYDROGEN PRODUCTION

Valuation and design methods : 3 analysis steps



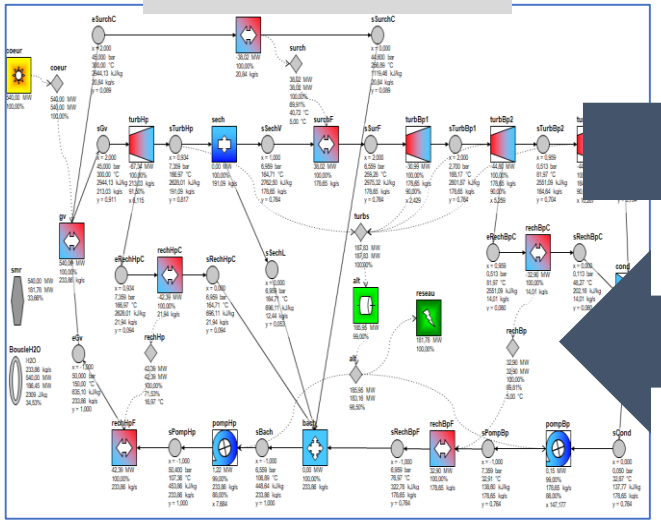
HYDROGEN PRODUCTION

Step 1 : Energetic relevance of coupled systems

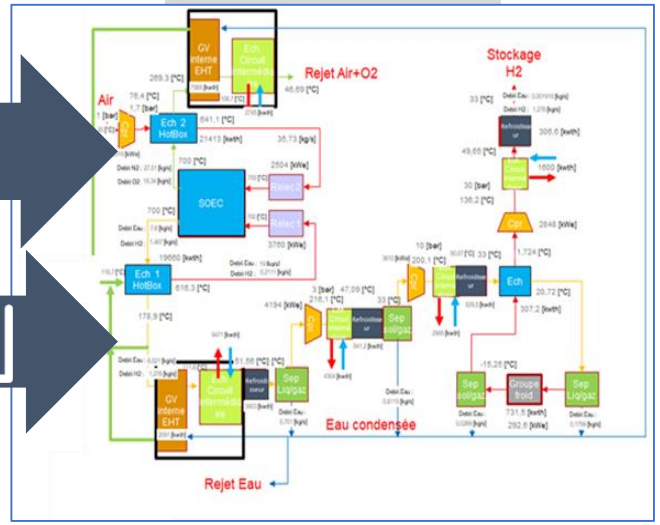
A

- **Simulation of the energy relevance of SMR-EHT cogeneration coupling using a global, multi-parametric approach.**
- **Identification of various relevant coupling configurations: definition of heat exchange points and modalities**

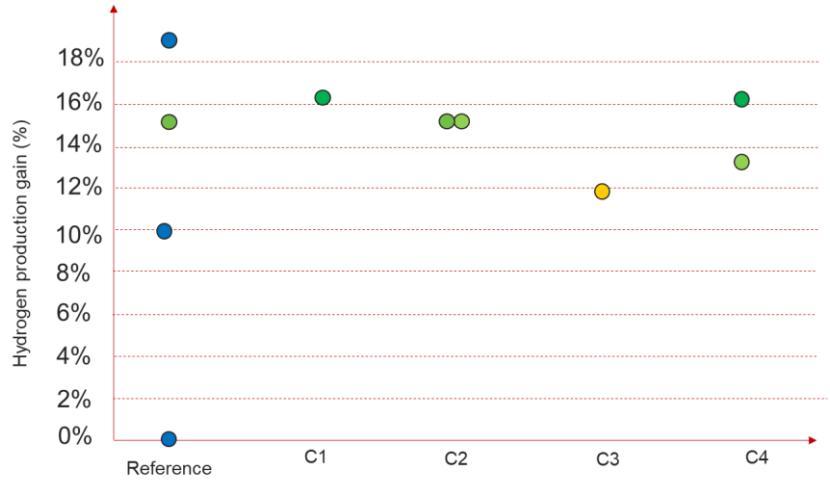
SMR



HTE



Comparison of relative hydrogen production with an uncoupled reference



Results : + 15% (average) hydrogen production by considering coupling in cogeneration heat / electricity

HYDROGEN PRODUCTION

Steps 2 & 3: Define technological configuration

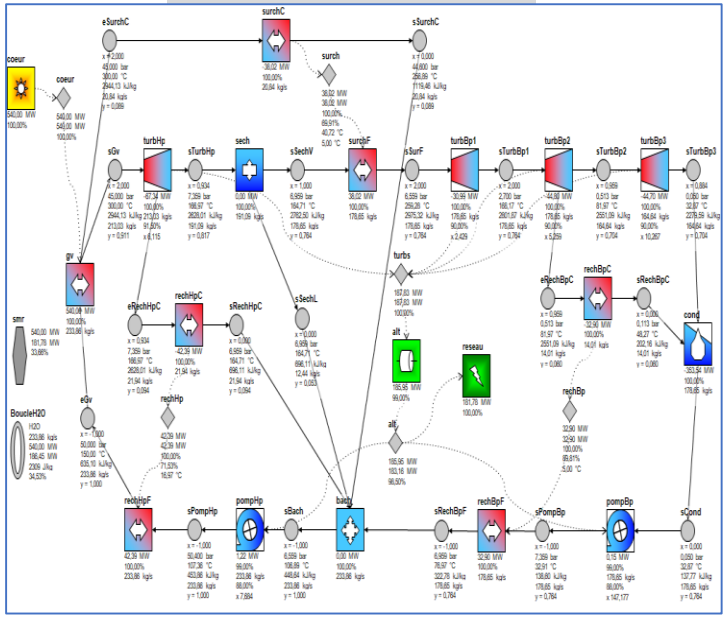
B

- **Selection of the best configuration by multi criteria approach (among about 25 proposals)**

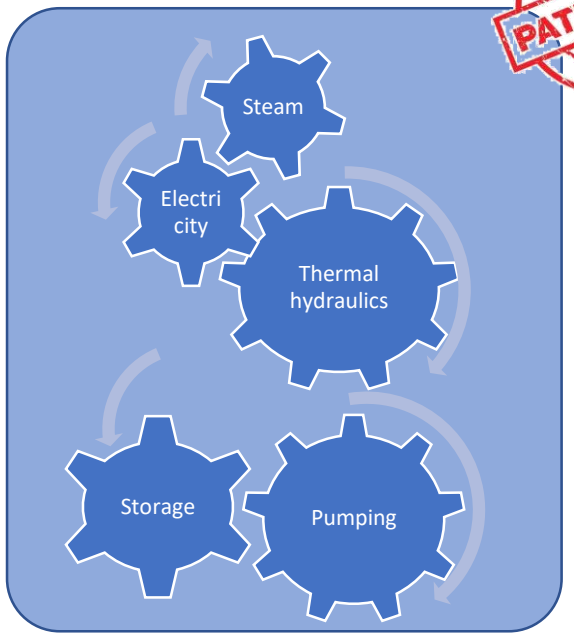
C

- **Design: component sizing, general architecture, steady-state and transient operation, balance of plant including safety/security analysis …**

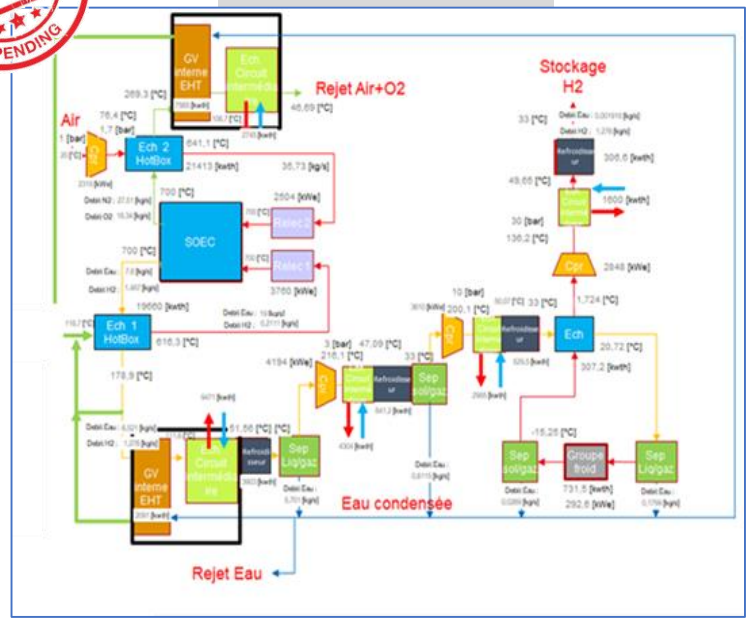
SMR



Technological brick



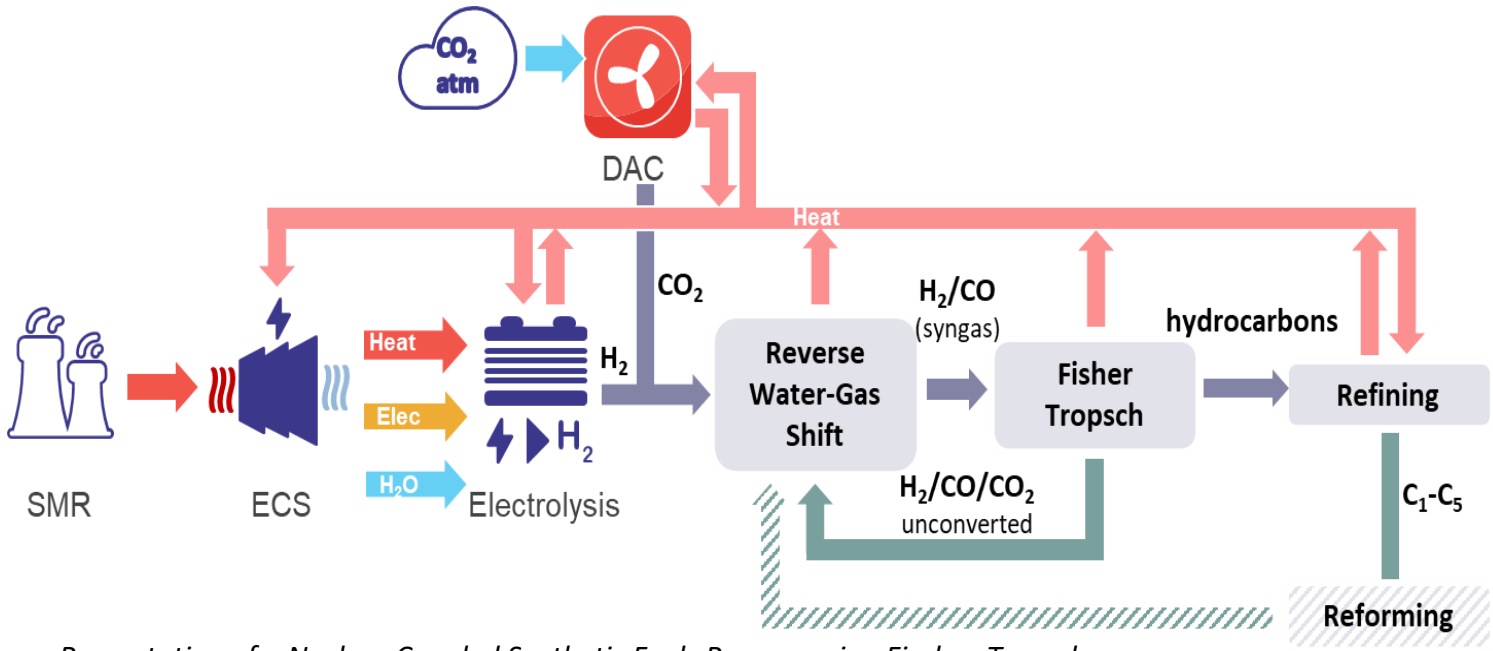
HTE



Presentation of a Nuclear coupled with HTSE Process for hydrogen prodcution

Nuclear Synthetic Fuels production
Global configuration

- **Combine Hydrogen & CO_2 capture:**
  - **Identified reference chain**
  - **Technological bricks : SMR, ECS, DAC, HTSE, RXGS, FT**

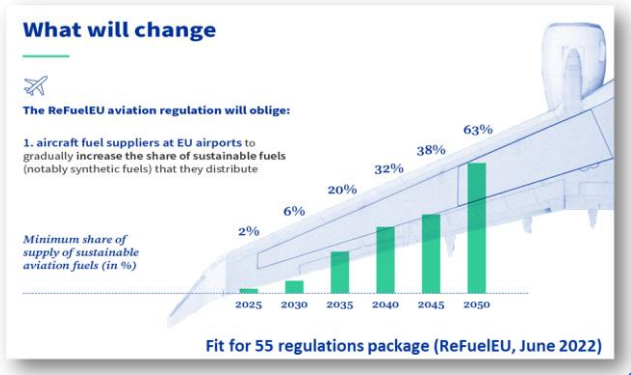


Presentation of a Nuclear Coupled Synthetic Fuels Process using Fischer-Tropsch

Main design drivers :

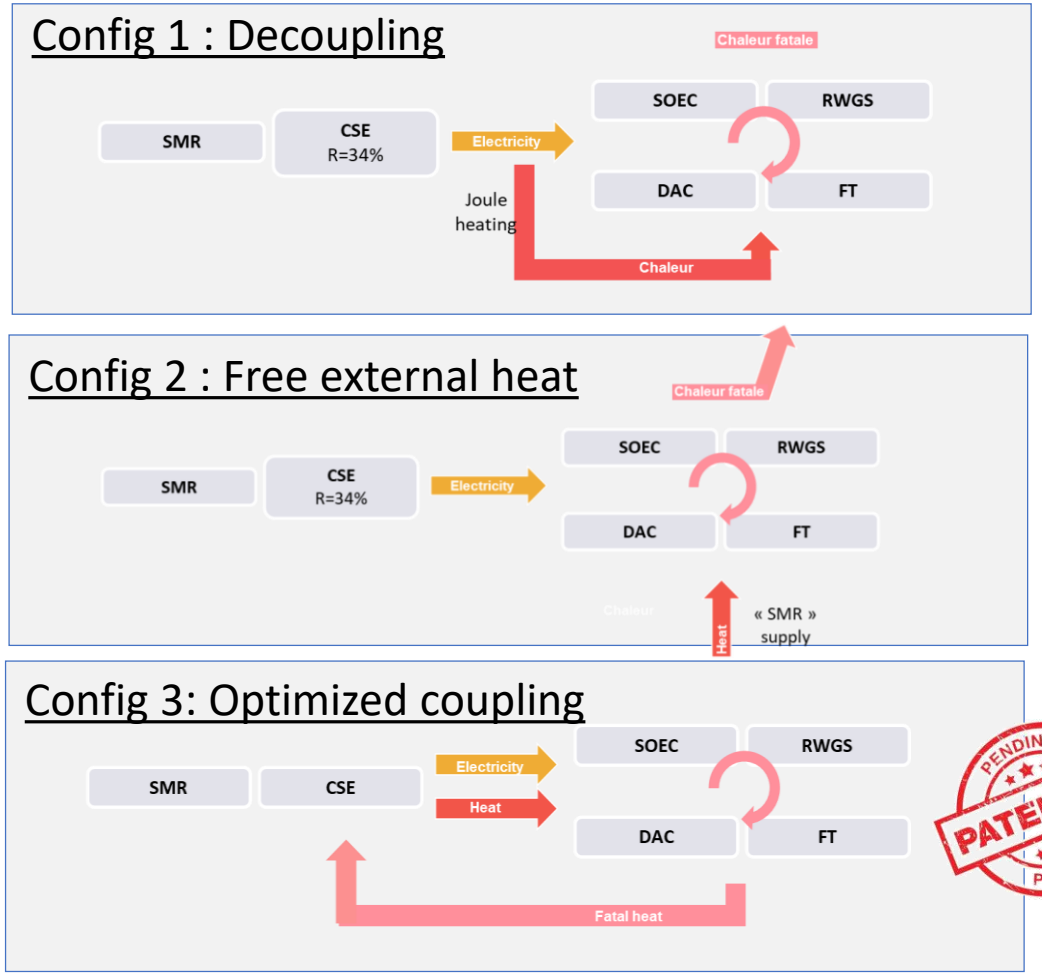
- **Integrated Energetic Efficiency**
- **Recycling of uncovered reagents (H_2, CO_2, CO, H_2O)**
- **Reforming of unwanted by-products (C_1→ C_5)**

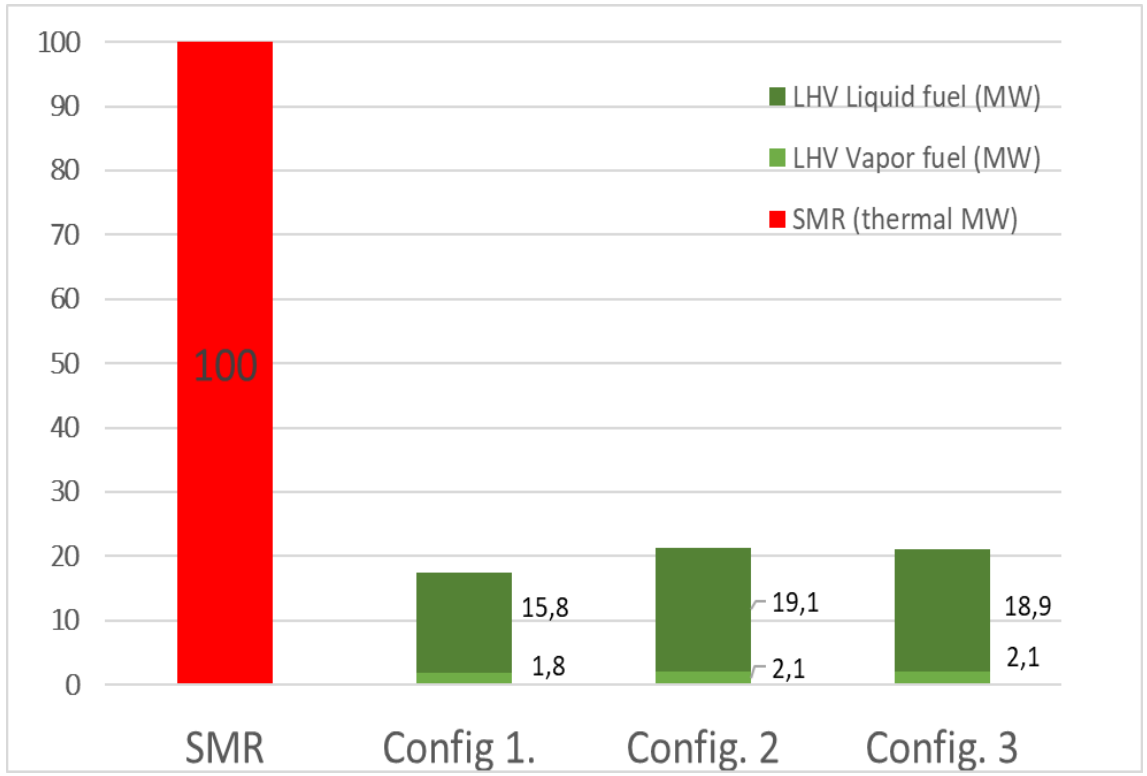
Focus on E-fuel



Nuclear Synthetic Fuels production
Energetic efficiency optimization

- Evaluation of the energetic relevance of the coupled stystem





simulation results of LHV produced with a nuclear integrated system in different configurations

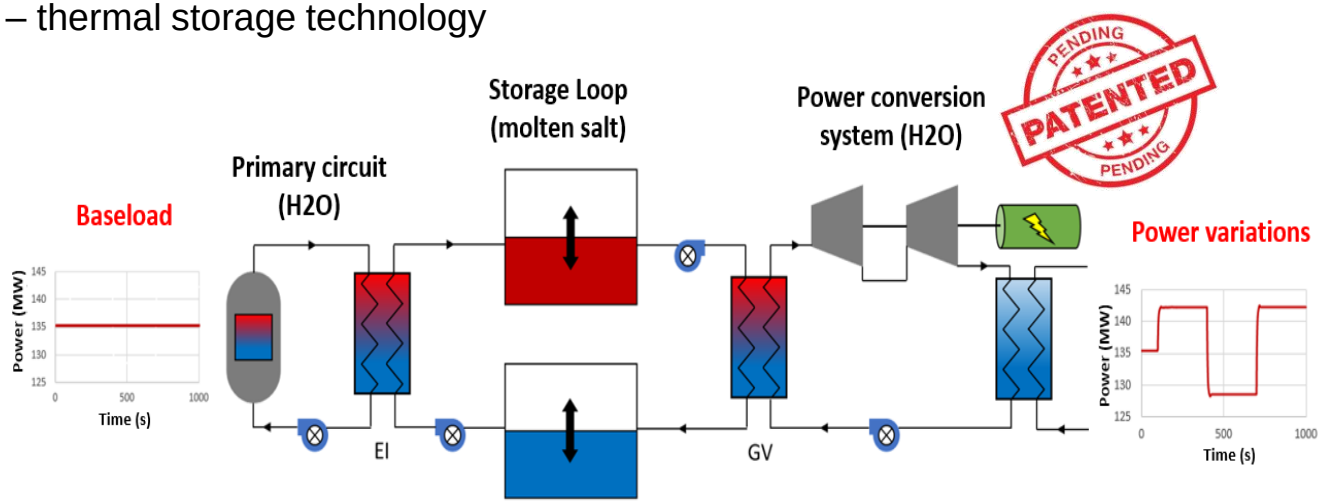
- Life Cycle Analysis under progress

Thermal storage
For greater flexibility

- **Context:**
  - Increasing share of renewables in the power mix
  - Compatibility between SMR Power – grid flexibility requirements – thermal storage technology

- **Technical configuration:**
  - Two tanks facility filled with molten salt
  - Storage loop implemented between the primary circuit and the power conversion system

- **Key benefits:**
  - Flexbility for the grid
  - Profitability for SMR
  - Safety issues



Presentation of a Nuclear power plant configuration with two tanks storage system

Energy	Total mass of salt	Volume of a tank (h =14m - φ = 39m)	Tanks number	Heat Exchangers power
2592 MWth	104 k tons	16 410 m^3	6 (3x2)	324MWth

Preliminary design of tank using HITEC salt for daily flexibility

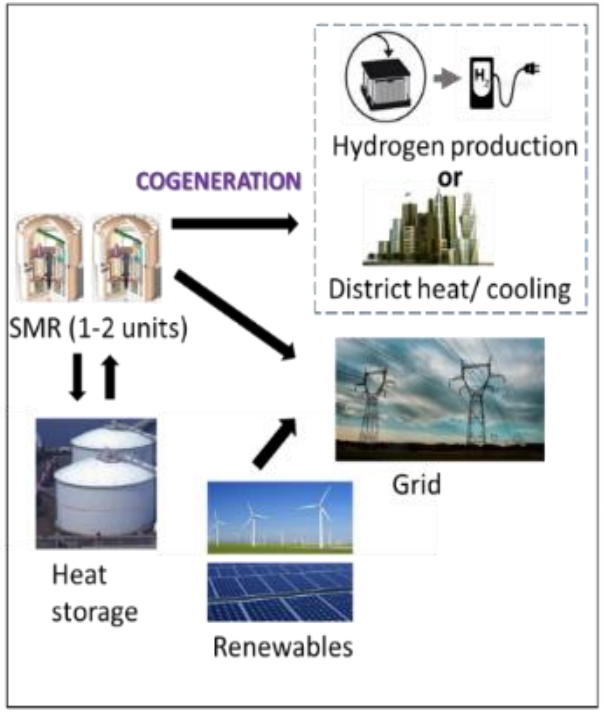
TANDEM, a horizon-europe project

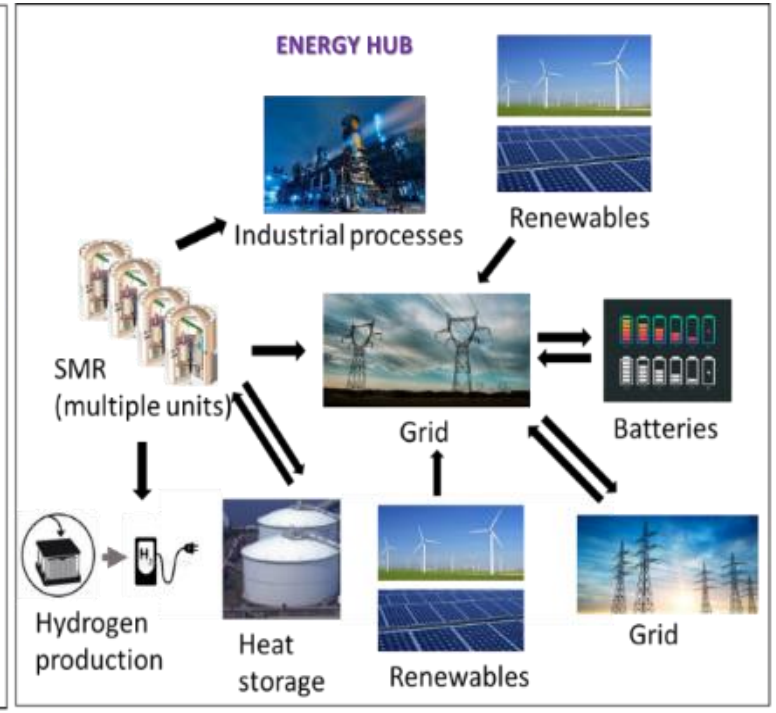
about integration of SMRs into carbon-free hybrid energy systems

2022 → 2025

High-level objectives:

- Assessing the **safety compliance of SMRs to be integrated** into the future European energy mix
- Providing **guidance on the future integration of SMRs and AMRs into well-balanced hybrid energy systems** in the case of a deployment scenario





18 partners from 8 European countries, composed of: universities, research institutes, TSO, industrials and engineering organizations

THANK YOU FOR YOUR ATTENTION

CONTACT

Pierre GAVOILLE : pierre.gavoille@cea.fr
Philippe AMPHOUX: Philippe.amphoux@cea.fr

Co-Authors : Jean-Michel RUGGIERI, Eric HANUS, Claire VAGLIO-GAUDARD, David HAUBENSACK, Nicolas ALPY, Clément LIEGEARD, Franck MORIN, Jean-Baptiste DROIN, Charly BOUDOT, Nicolas TAUVERON, Fabrice BENTIVOGLIO, Frédéric DUCROS, Luc BERTIER, Coralie QUADRI