

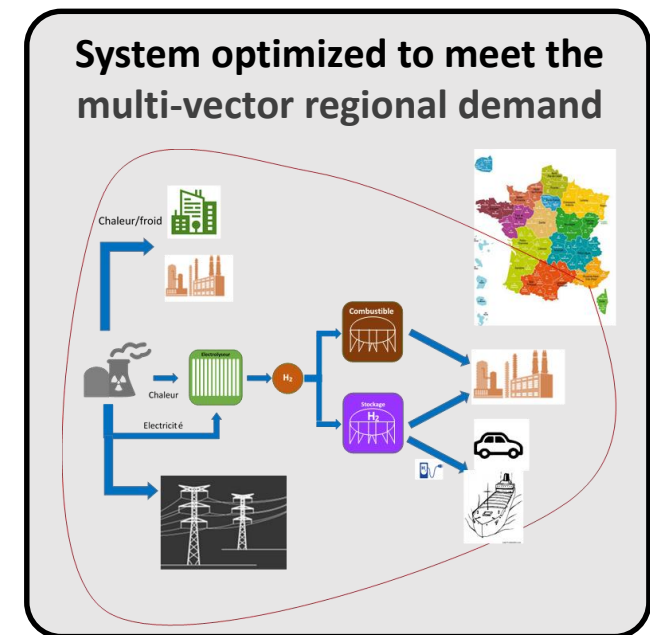


# R&D at CEA on PW-SMR

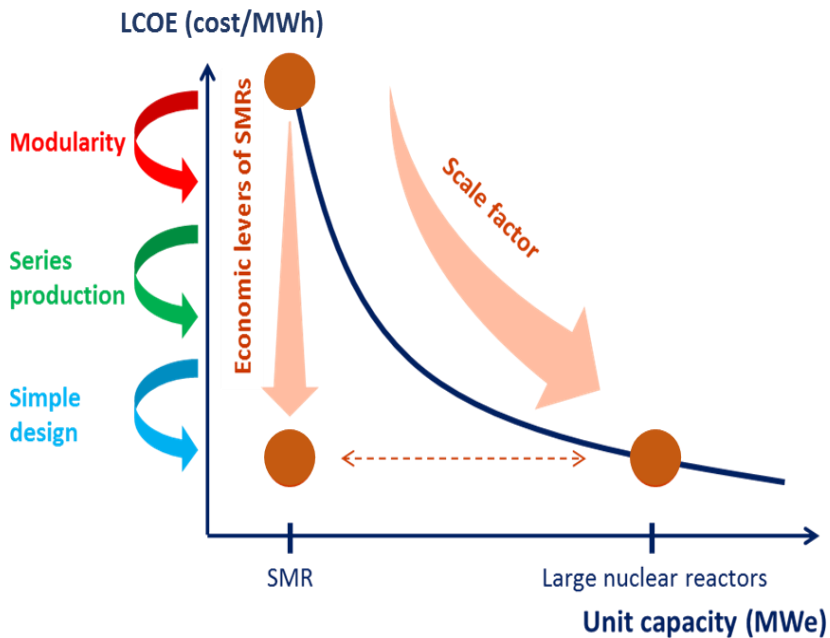
**Eric HANUS, project manager**

**Energiforsk Annual Nuclear Conference on SMR, January 20, 2021**

1. SMR: a new paradigm
2. The NUWARD™ project (electricity production)
3. The ELSMOR project (licensing issue)
4. R&D on SMR systems dedicated to heat/hydrogen applications



In order to counter the scale effect, it is necessary to operate three levers:



- **Simple and safe conception**

Simplified architecture reduces initiating events  
Lower residual heat facilitates the use of passive safety systems

- **Modular conception & manufacturing**

Modules are manufactured and tested in factories  
Modules are transported in containers  
Reduction of onsite construction time

- **Standardization & series effect**

Standardization, normalization  
Serial production of components  
Major construction program

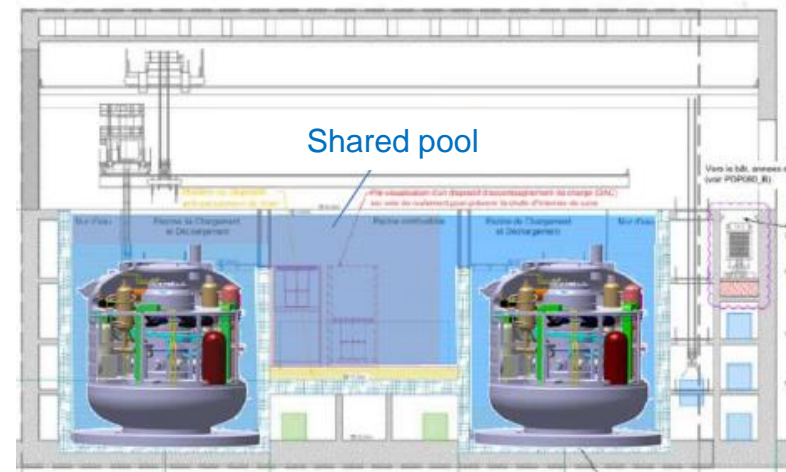
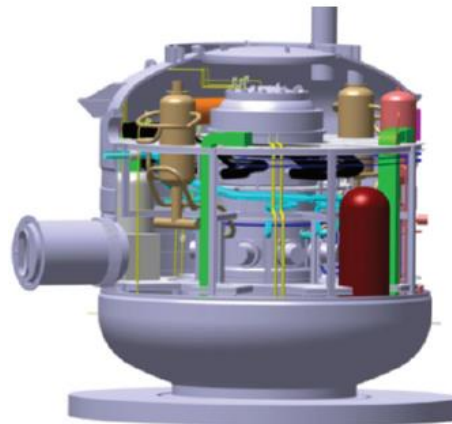
## 2. NUWARD™: DESCRIPTION OF THE PRODUCT

- A **340 MWe power plant** including **2 reactors** (2x170 MWe) in a single nuclear building

An integrated reactor...

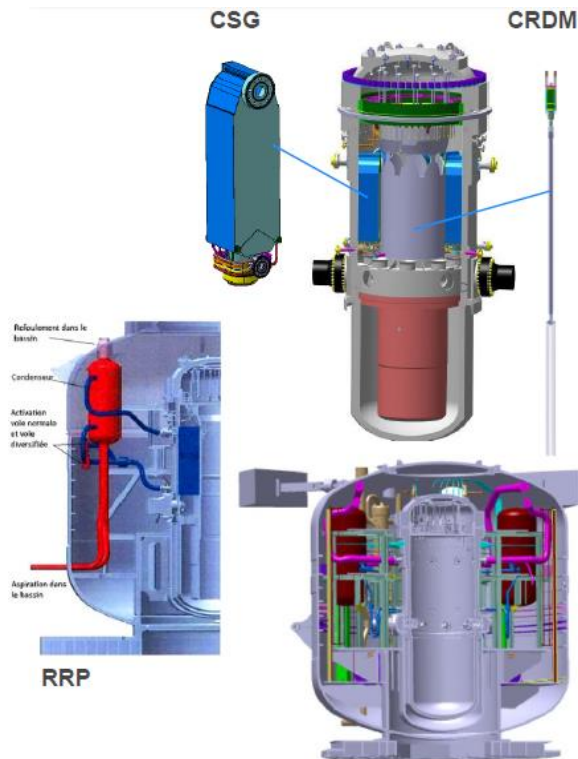


... integrated in a metallic containment immersed in a water basin



- **Low carbon energy, flexible and continuous generation**, complementary with renewable intermittent sources and large nuclear power plants to :
  - replace 300-400MWe coal-fired power plants
  - power remote municipalities and intensive industrial sites,
  - supply networks that cannot be connected to high or medium sized reactors

NUWARD™ design based on technological innovations - under development - which provide significant benefits



INNOVATION	IMPACT
Integrated architecture	<ul style="list-style-type: none"> <li>• Primary cooling system inside RPV</li> <li>• Reduced LOCA</li> </ul>
Plate Steam Generators (CSG)	<ul style="list-style-type: none"> <li>• Compactness</li> </ul>
Immersed Control Mechanisms (CRDM)	<ul style="list-style-type: none"> <li>• Elimination of rod ejection risk</li> </ul>
Passive Core Cooling (RRP with S-CSG)	<ul style="list-style-type: none"> <li>• Passive residual heat removal</li> </ul>
Boron Free Core	<ul style="list-style-type: none"> <li>• No clear water plug</li> <li>• Simplified effluent treatment</li> </ul>
Metallic containment	<ul style="list-style-type: none"> <li>• Tightness + immersion in water wall</li> </ul>
Semi Buried NI Building	<ul style="list-style-type: none"> <li>• Protection against external hazards</li> </ul>

## 2. NUWARD™: ROADMAP & PARTNERSHIP

Study of feasibility 2012-2015



Pre-Conceptual Design 2017-2019



→ Conceptual Design 2019-2022

nuward



Basic Design + pre-licencing

nuward

Detailed Design + licensing

nuward

**NUWARD™ will be available to meet market needs by 2030**

**EDF, with its strategic partners and the support of the French government, is open to international cooperation:**

**NUWARD™ launched at IAEA General Conference in Sept. 2019**



**Framework agreement signature in Sept. 2019 between Westinghouse, EDF & CEA to explore potential cooperation on SMR development**

# 3. SMR: LICENSING & ELSMOR PROJECT



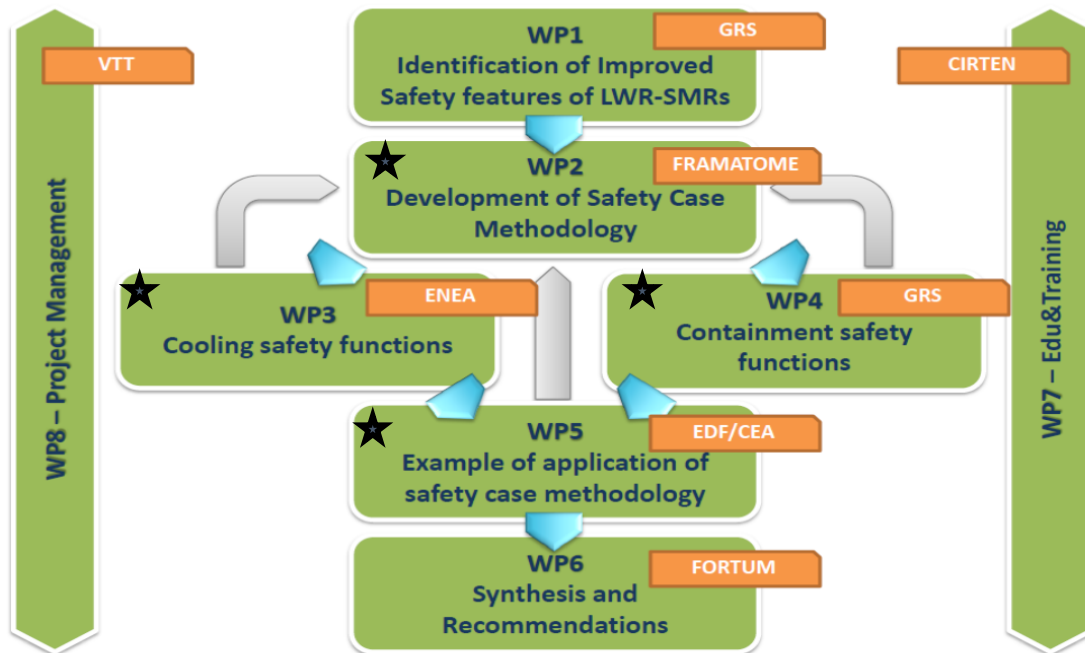
ELSMOR aims to create methods and tools for the European stakeholders to assess and verify the safety of light water small modular reactors (LW-SMR) that would be deployed in Europe



Funded from the Euratom research and training programme 2014-2018 under Grant Agreement No. 847553

## ELSMOR proposal

towards European Licensing of Small MOdular Reactors



Within the energy transition program (carbon neutrality by 2050), a **new research field has been launched at CEA on PW-SMR and hybrid systems:**

## **Axis #1 : Market studies and needs identification (hydrogen and heat) @ 2040-50**

- Definition of the expected performances for the innovative SMR systems

## **Axis #2 : Studies on SMR dedicated to hydrogen production**

- Systems with a SMR coupled to HTE (High Temperature Electrolysis)
- Performances & cost versus market needs & systems safety

## **Axis #3 : Studies on SMR dedicated to heat**

- Preconception studies on heat-supply SMR concepts
- Performances & cost versus market needs & systems safety

## **Axis #4: R&D on innovative Energy Conversion Systems (ECS)**

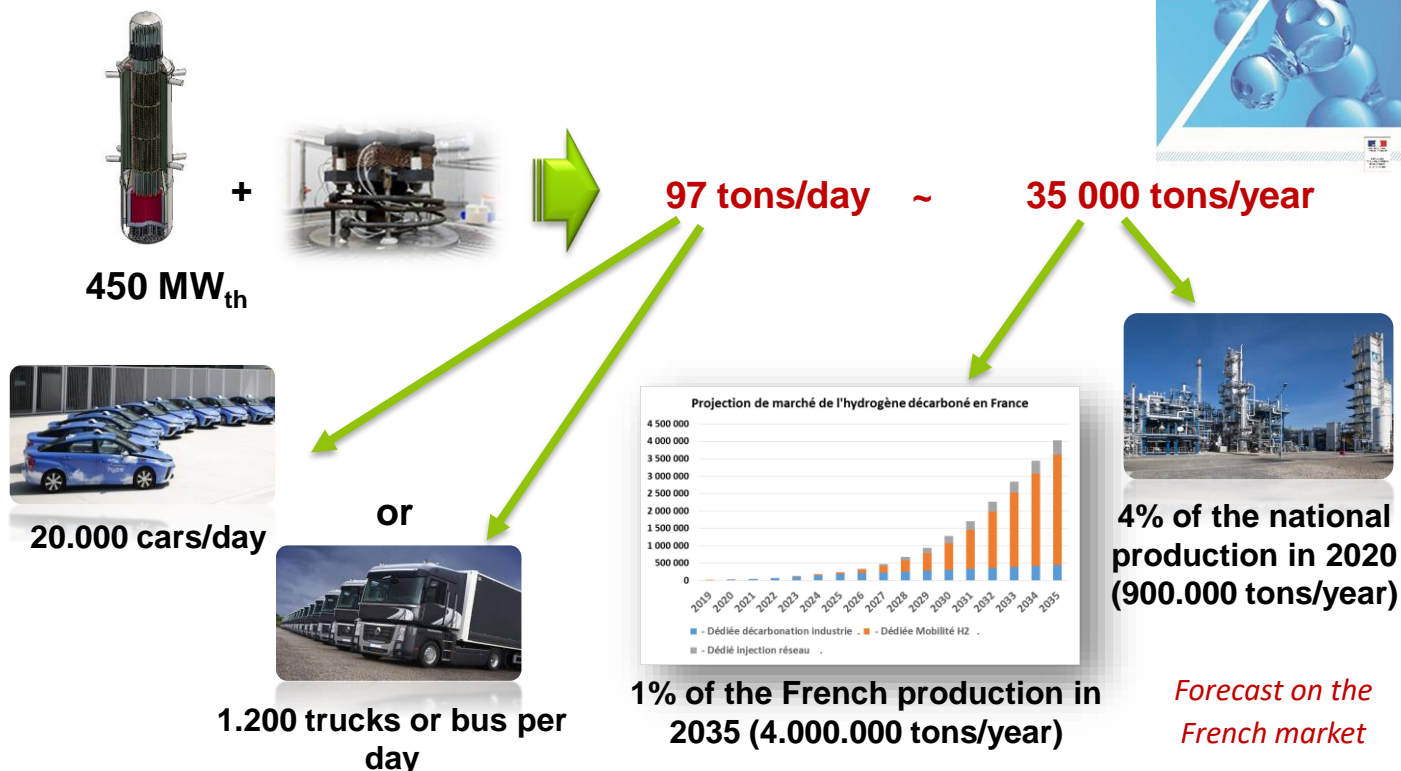
- Study on multi-vector ECS (power, heat, H<sub>2</sub>, drinking water)
- Optimization when considering storage (battery, thermal energy, gas...)
- Integration with other energy sources : PV, wind turbines, fuel cells...





## Towards a decarbonated H<sub>2</sub> production:

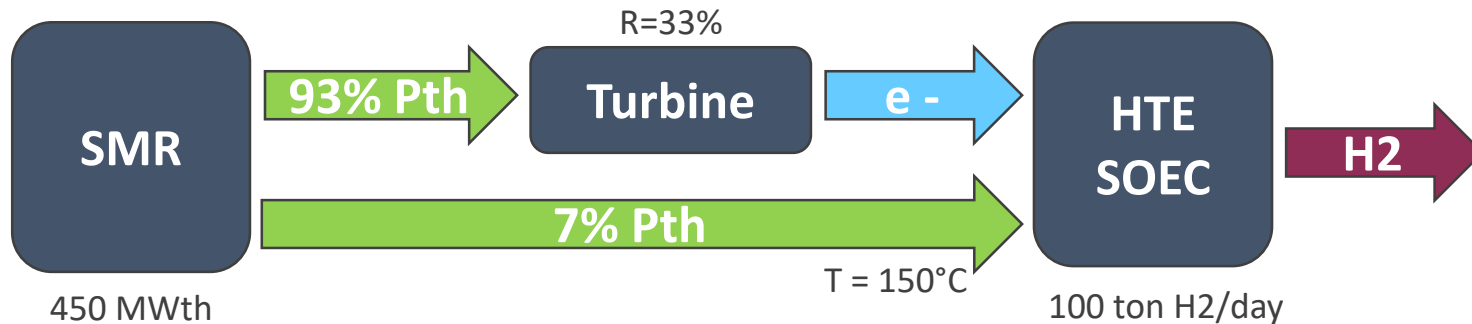
- Mobility vector with electricity
- Decarbonate industrial hydrogen



## Association of 2 technological bricks developed at CEA:

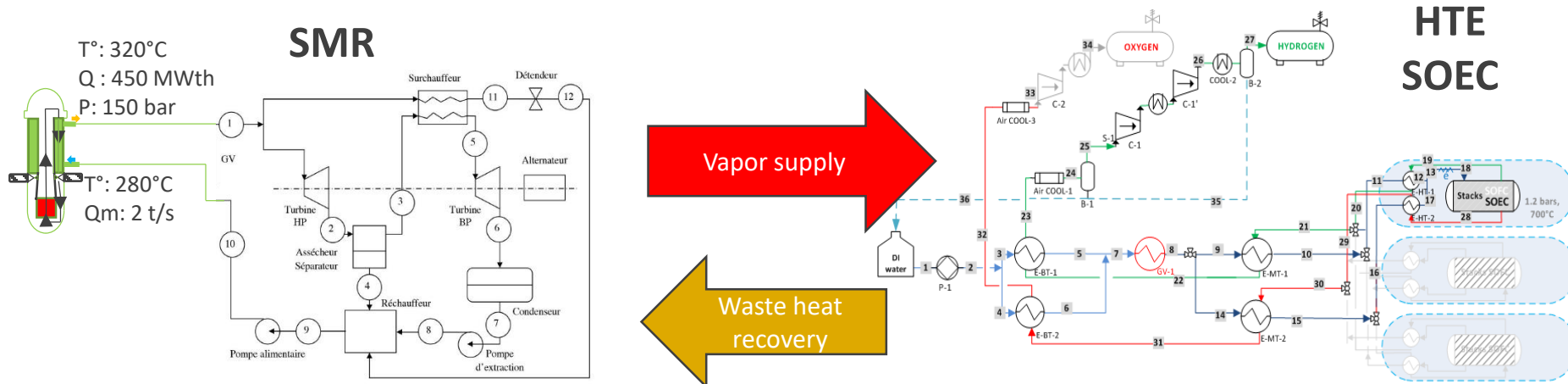
- ✓ High temperature electrolysis : high yield, need for heat & electricity, possible use as SOFC and thus power supply
- ✓ SMR : heat and electricity supply in cogeneration mode, power consistent with a H<sub>2</sub> production unit, location close to the H<sub>2</sub> demand

### Thermal integration challenge:

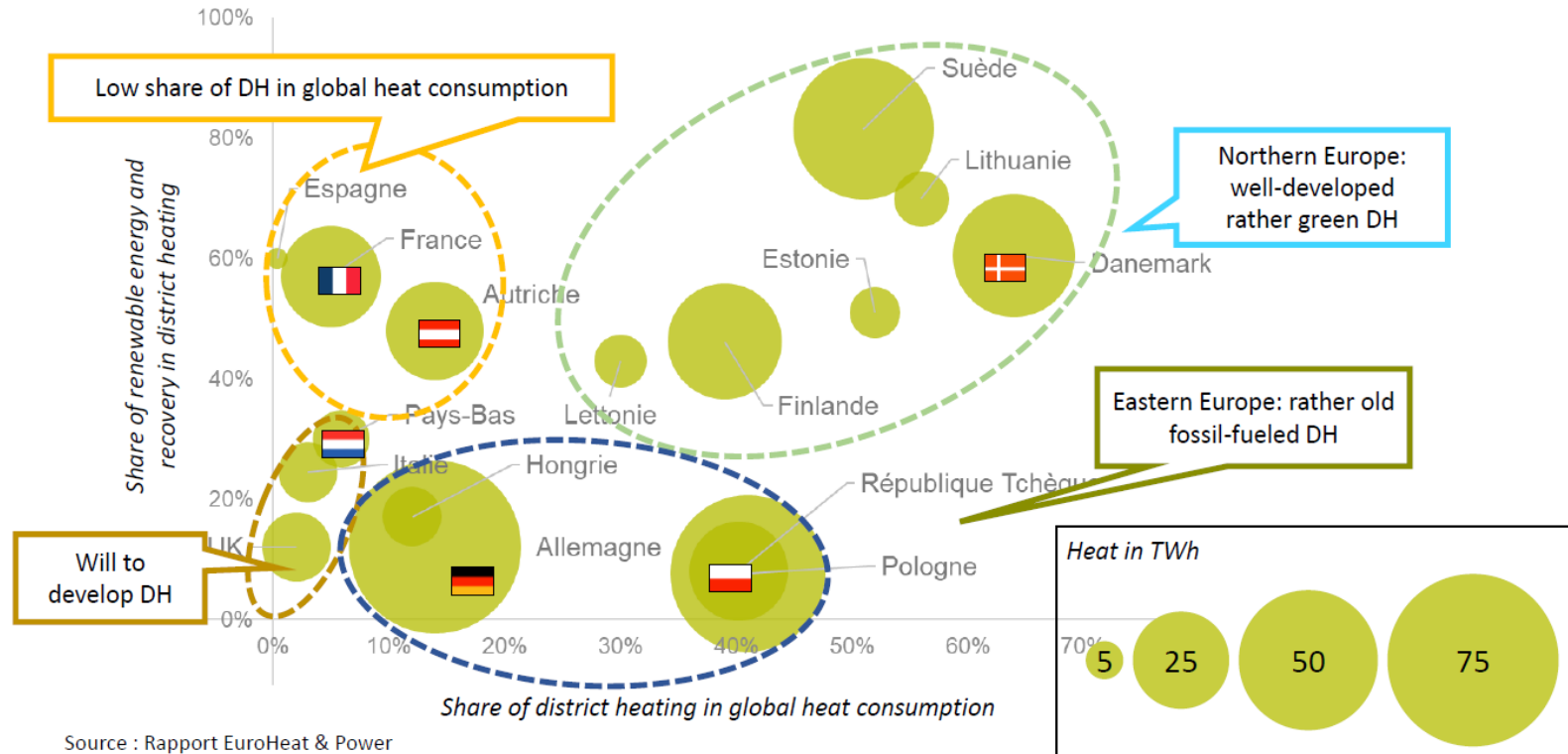


### Technical work:

- ▶ Vapor / heat Intake points in SMR Scheme
- ▶ Direct / indirect supply mode
- ▶ Recovery of waste heat from HTE to SMR



## District Heating are quite diverse in Europe



### In France<sup>1</sup>, heat demand, $T < 250^{\circ}\text{C}$

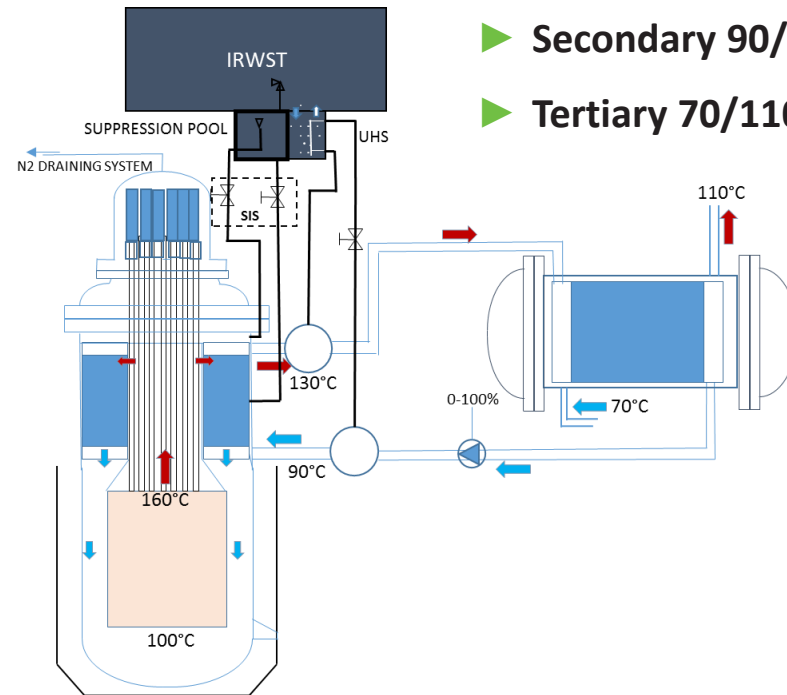
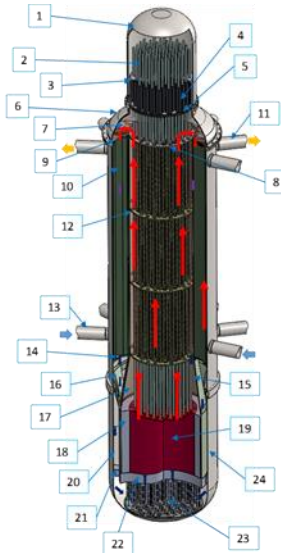
- 100 TWh for industry
- 450 TWh for district heating
- district heating average power  $\sim 40\text{MWth}$

### In Finland<sup>2</sup>, district heating segmentation

- 13 units at 120MWth
- 72 units at 24 MWth

## SMR functional requirements:

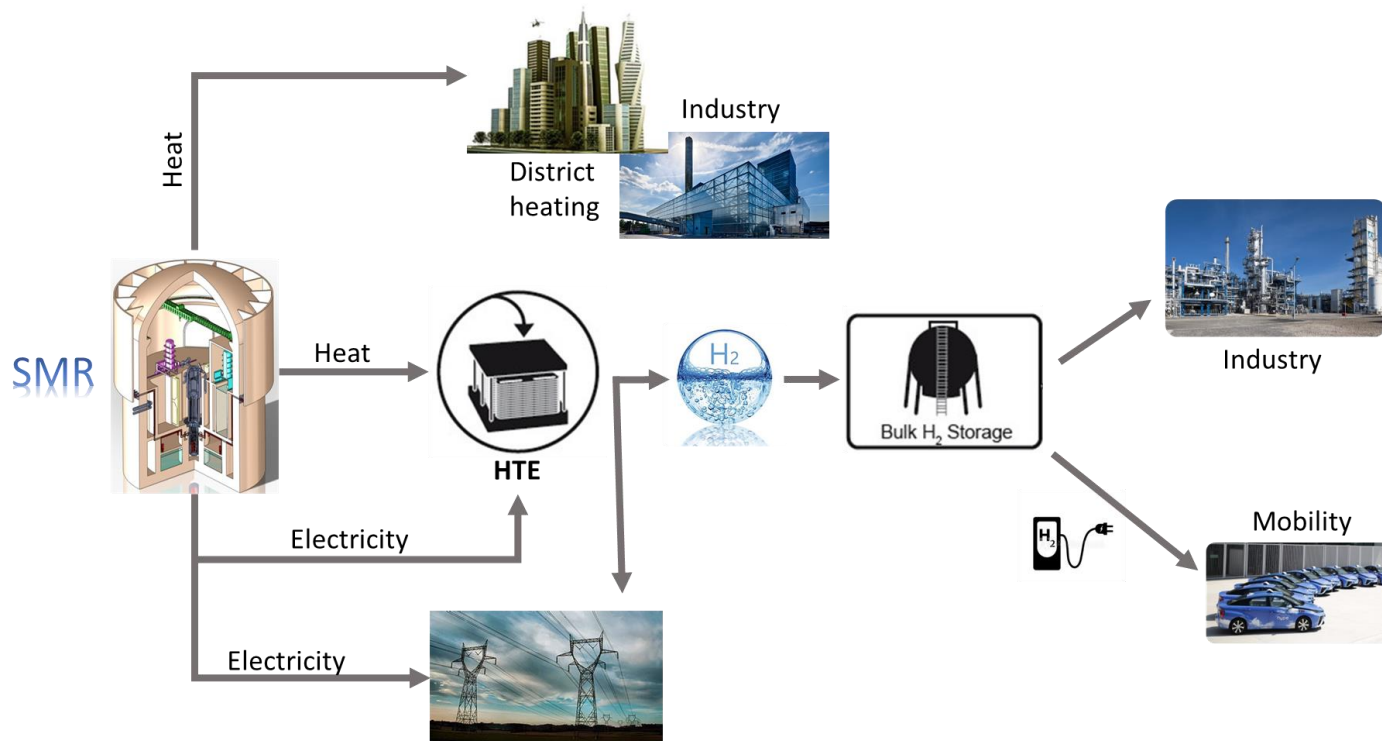
- Nominal Power 100 MWth
- Heat production: water 110°C back 70°C
- No Primary Pump
- Boron-free core management
- Load following (30% to 100% P<sub>nom</sub>)
- Passive safety design



- ▶ Primary 100/160°C - 10 bar
- ▶ Secondary 90/130°C - 12 bar
- ▶ Tertiary 70/110°C < 10 bar

- Interesting perspectives with a low (p,T)
- Undergoing design studies to downsize the nominal power from 100 to **20 MWth**

The objective of this R&D work is to bring some techno-economics data to evaluate the feasibility of such SMR hybrid systems to propose a carbon-free solution to the moving multi-vector use of energy.



**Nota:** within the next EURATOM call 2021-2022, CEA is promoting a proposal about SMR – heat & hydrogen

## R&D activities on PW-SMR are :

- Participating in the industrial NUWARD™ project
- Developing R&D on hybrid SMR systems to decarbonize heat applications and hydrogen production
- Promoting projects at European scale: ELSMOR, proposal for next call...

**Thanks for your attention: any questions?**