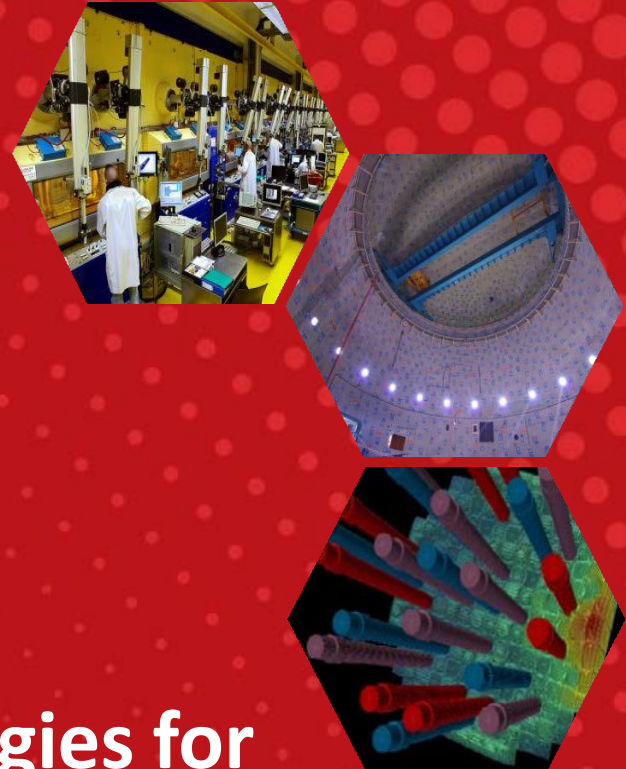




DE LA RECHERCHE À L'INDUSTRIE

Potential of SMR technologies for cogeneration and hybrid energy systems

Jean-Michel RUGGIERI – CEA – NUCLEAR ENERGY DIVISION



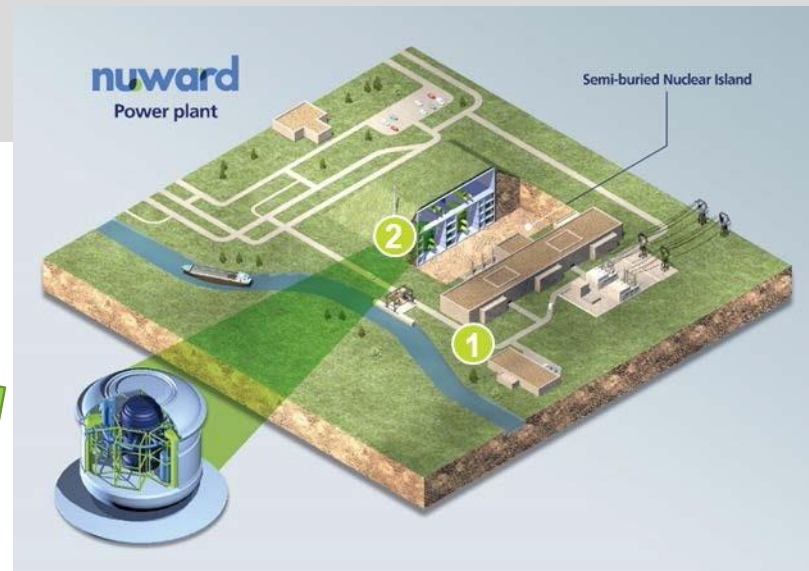
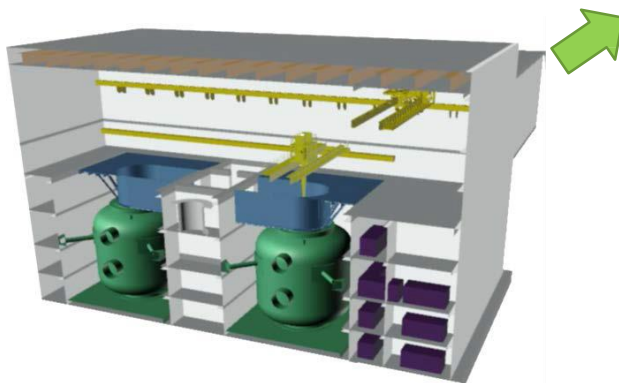
SMR for international market to decarbonize electricity

- Nuward™ Initiative
- ELSMOR: European Union R&D Project

Hybrid Systems Studies using SMR and Renewables

- Innovative Decarbonized Nuclear Energy Systems initiative
- Market driven approach of energetic system
- Multi energy vectors for nuclear application

A New Commercial Nuclear Power Plant to replace a 340 MWe Coal based electricity plant



1 CONVENTIONAL ISLAND

2 NUCLEAR ISLAND

Open to international cooperation



Framework agreement with Westinghouse



Thermal Power	2 x 540 MWth
Electrical power output	2 x 170 MWe
Thermal Efficiency	> 37 %
Plant design availability	> 90%
Nb. of loops	Integrated
Operation cycle length	Up to 24 months
Design service life	60 years
Instrumentation & Control	Full Digital

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

ELSMOR proposal towards European Licensing of Small MODular Reactors

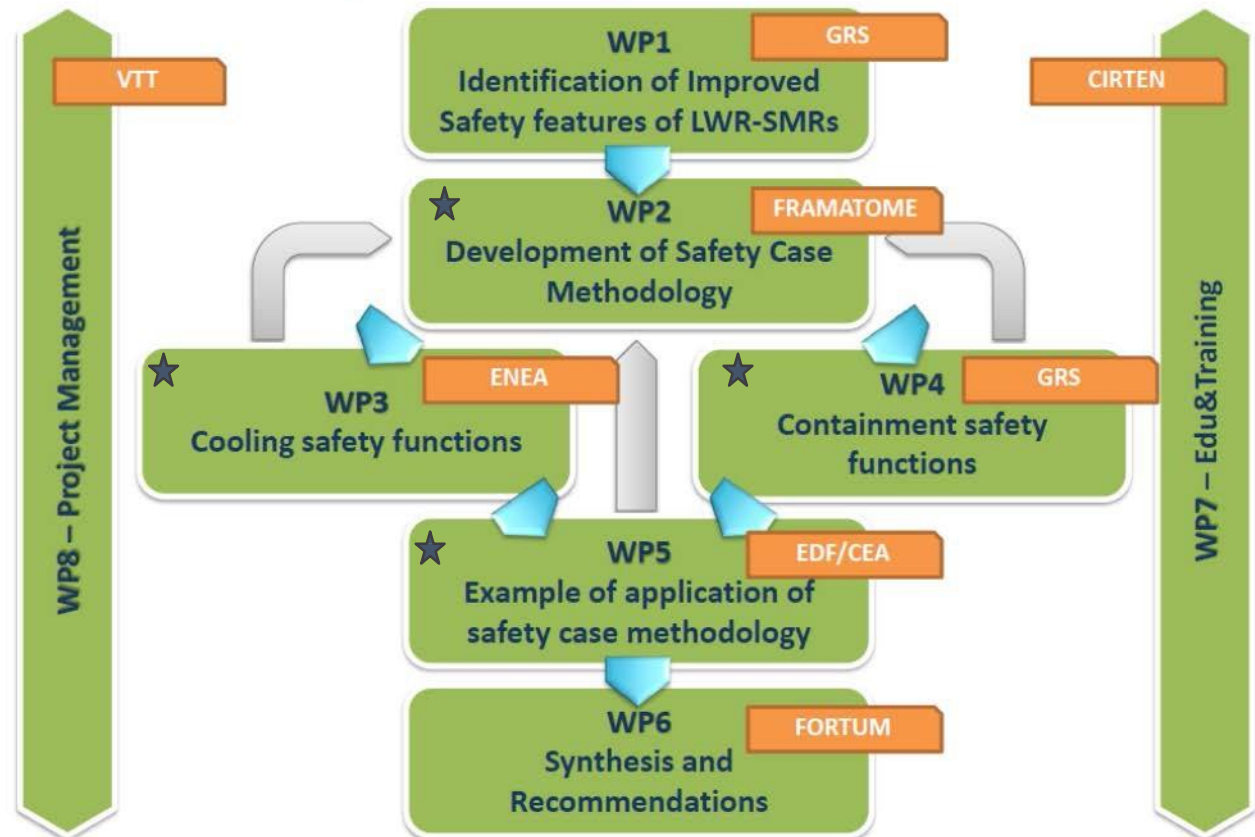
Budget 3.5M€

VTT / FORTUM
(Finlande)

CEA / EDF /
TECHNICATOME / IRSN
/ FRAMATOME (France)

CIRTEN / ENEA / SIET
(Italie)

GRS (Allemagne)
PSI (Suisse) JRC
(Europe) LEI
(Lituanie),
Energorisk (Ukraine)





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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

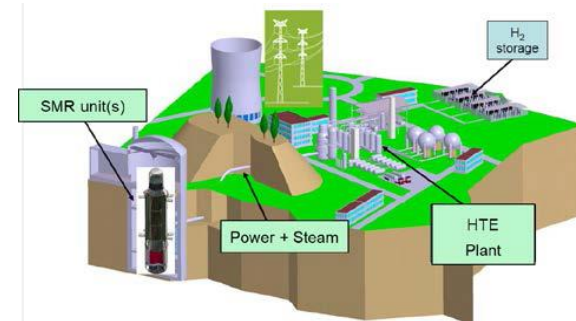
- Systems with a SMR coupled to HTE (High Temperature Electrolysis)
- Performances & cost versus market needs & systems safety

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)

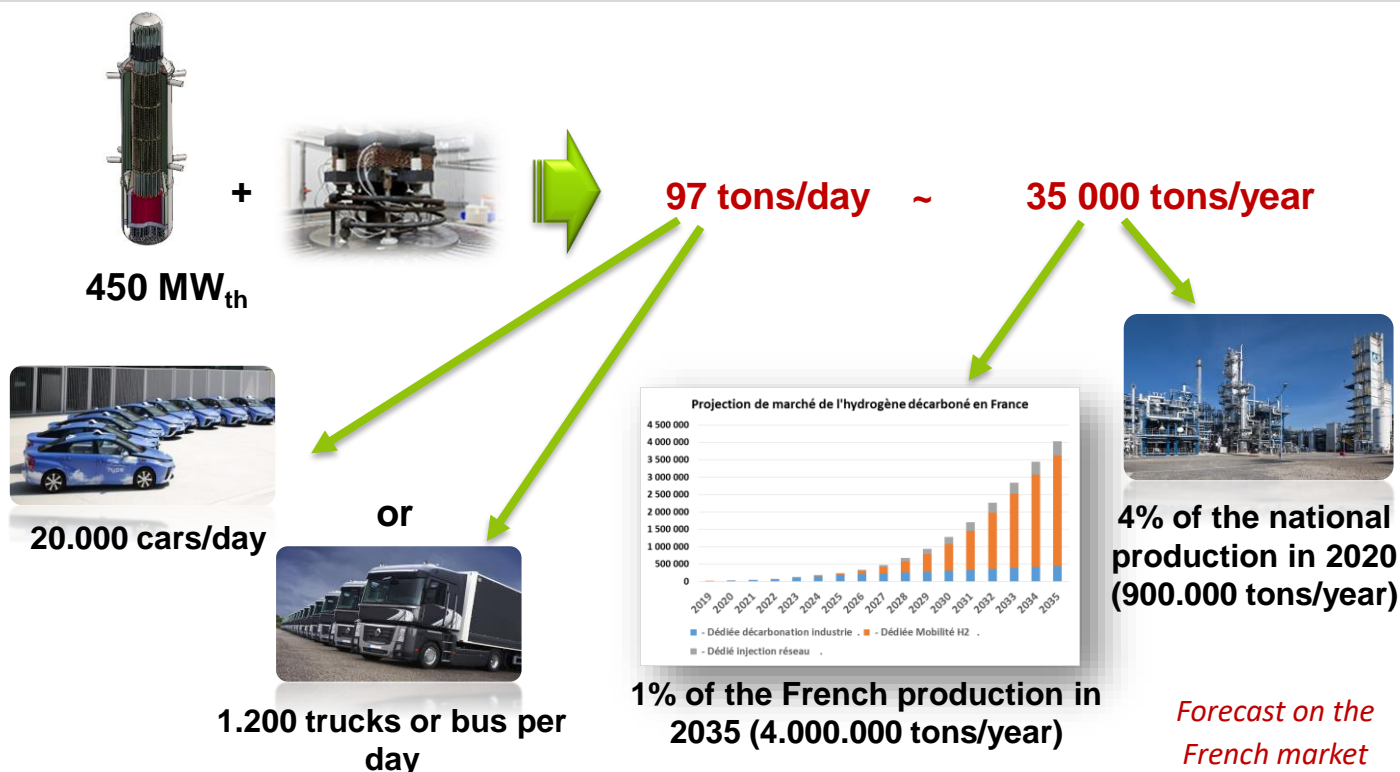
- Study on multi-vector ECS (power, heat, H₂, drinking water)
- Optimization when considering storage (battery, thermal energy, gas...)
- Integration with other energy sources : PV, wind turbines, fuel cells...



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

Towards a decarbonated H₂ production:

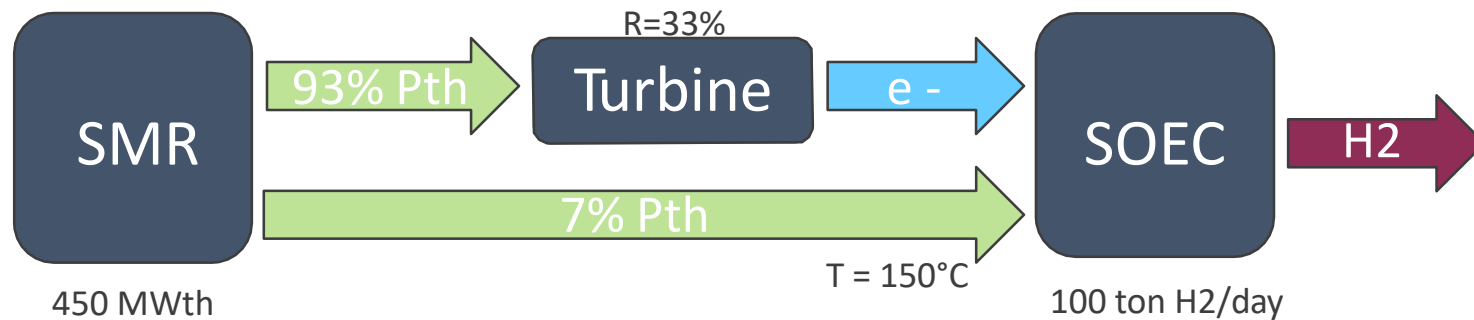
- Mobility vector with electricity
- Decarbonate industrial hydrogen



Association of 2 technological bricks developed at CEA:

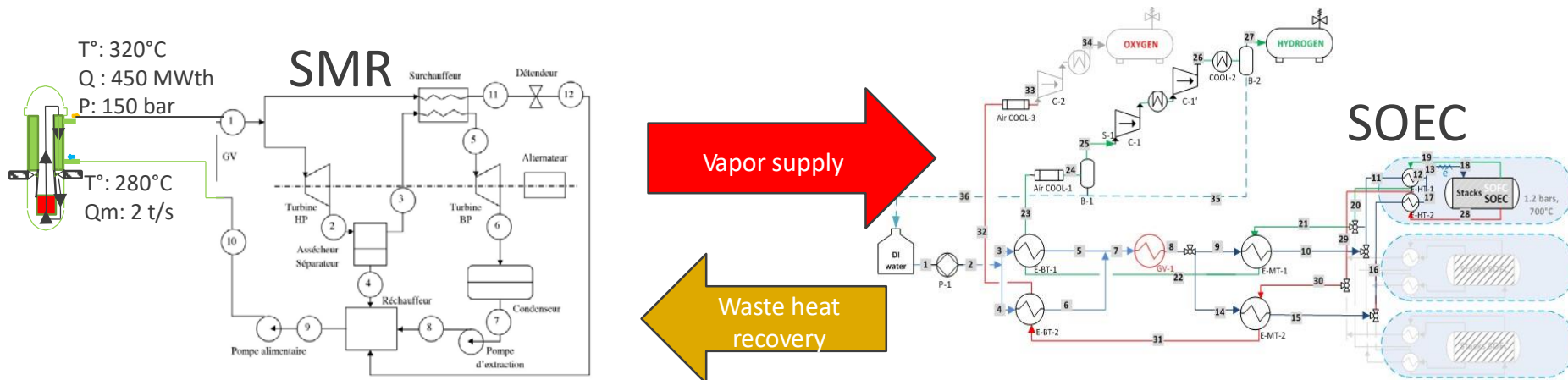
- ✓ High temperature electrolysis : high yield, need for heat & electricity, possible use as SOFC and thus power supply
- ✓ SMR : heat and electricity supply in cogeneration mode, power consistent with a H₂ production unit, location close to the H₂ demand

Thermal integration challenge



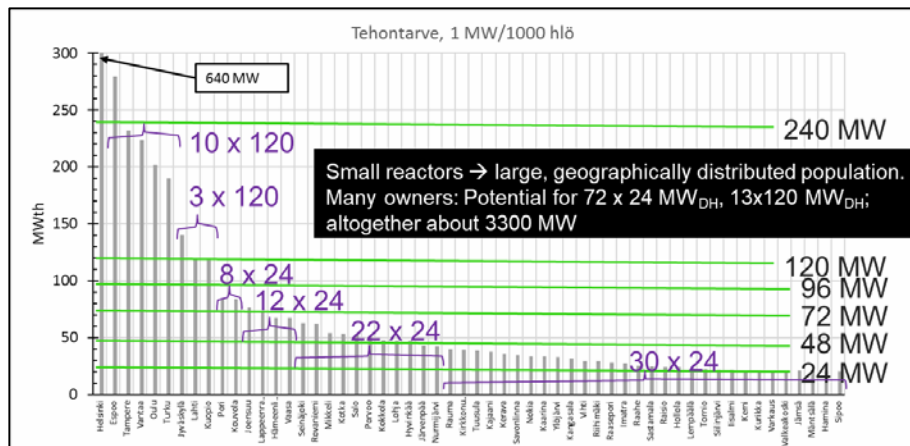
Technical works:

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



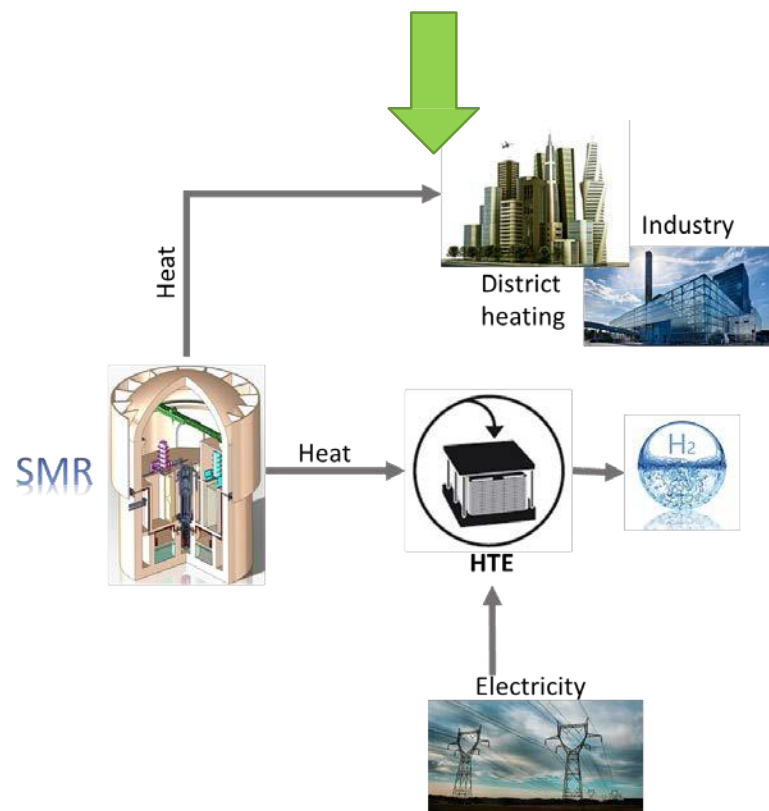
- 13 units of 120MWth
- 72 units of 24 MWth

Prof. Juhani Hyvärinen
Lappeenranta Univ. of Tech.
NUGENIA Forum, Paris, 2019



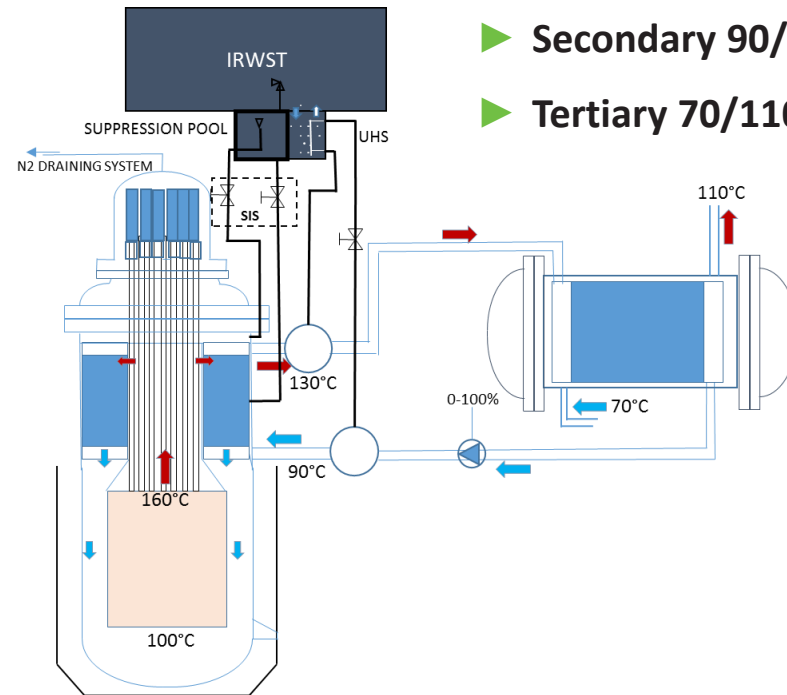
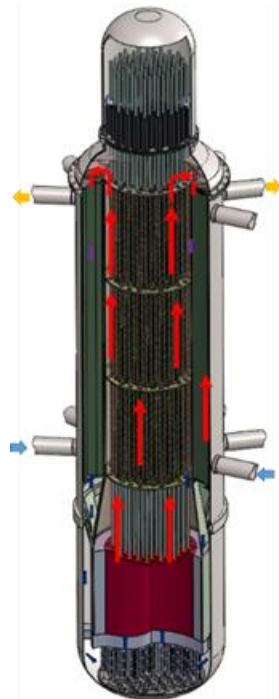
- 100 TWh for industrial needs
- 450 TWh for district heating
- Average power of district network 40MWth

- Need to update the market analysis for district heat and industrial needs at horizon 2040
- Design studies to Downsize the nominal Power from 100 to **20 MW_{th}**



SMR functional requirements:

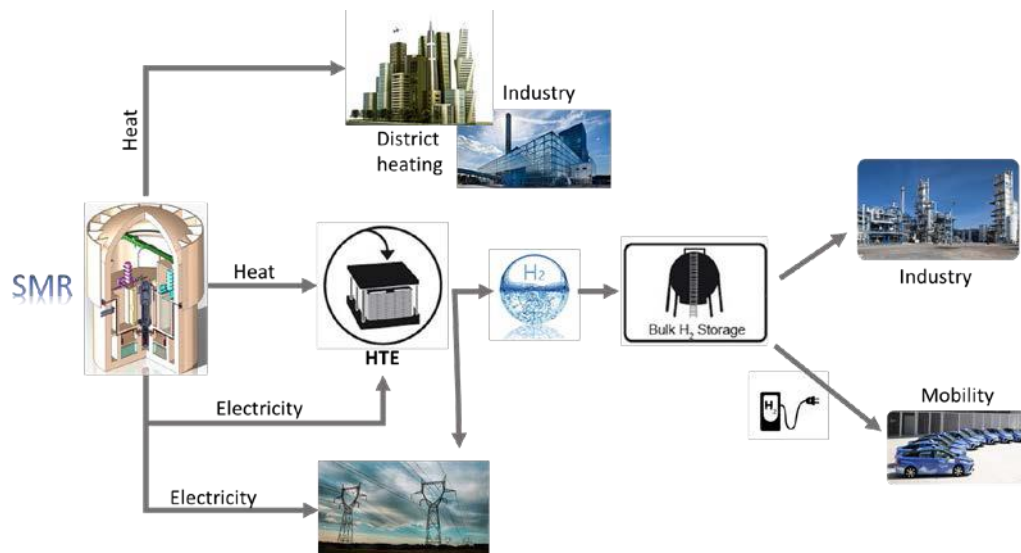
- Nominal Power 100 MWth
- Heat production: water 110°C back 70°C
- No Primary Pump
- Boron-free core management
- Load following (30% to 100% P_{nom})
- Passive safety design



- ▶ 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**

- **Market driven approach using systemic approach: Horizon 2050**
- **First studies of technological bricks**
 - SMR for district heating or industry
 - Coupling SMR / High Temperature Electrolyze
- **To propose Innovative Conversion Energy Systems to ensure reliable energy production and stability of the networks using:**
 - Nuclear, PV, Fuel Cells and wind turbine
 - Storage of different size (hours, month, season) and type (heat, gas, electrochemical, ...)
 - Cogeneration: electricity, hydrogen, desalination, heat



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?

THANK YOU FOR ATTENTION