Potential of SMR technologies for cogeneration and hybrid energy systems

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Commissariat à l’énergie atomique et aux énergies alternatives - www.cea.fr
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

- **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

Open to international cooperation

Framework agreement with Westinghouse
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.

**Budget 3.5M€**

**VTT / FORTUM**
*(Finlande)*

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

**CIRIEN / 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

Forecast on the French market:

- 450 MWth
- 20,000 cars/day
- 1,200 trucks or bus per day
- 97 tons/day ~ 35,000 tons/year

- 4% of the national production in 2020 (900,000 tons/year)
- 1% of the French production in 2035 (4,000,000 tons/year)
(2/2) SMR for H2: Technical coupling of SMR / SOEC

Thermal integration challenge

- 93% Pth from SMR to Turbine
- 7% Pth from Turbine to SOEC
- R=33%
- T = 150°C
- 100 ton H2/day
- 450 MWth

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

- SMR: T°: 320°C, Q: 450 MWth, P: 150 bar
- SOEC: T°: 280°C, Qm: 2 t/s

Vapor supply
Waste heat recovery
(1/2) SMR FOR HEAT : ONGOING WORK

**Finland Market analysis : 56 towns > 20 000**

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

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

- 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 MWth

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**French Market, need for heat <250°C**

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

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Commissariat à l’énergie atomique et aux énergies alternatives
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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% Pnom)
- 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**
Summary R&D on SMR beyond electricity production

- **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