Brief presentation of the TANDEM Euratom project: objectives, activities, expected outcomes, status

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Technical Workshop on Modelling and optimization tools to assess hybrid energy systems integrating nuclear reactors
"Le Benedettine" Congress Centre, Pisa, Italy, February 20-21, 2025.

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Outline

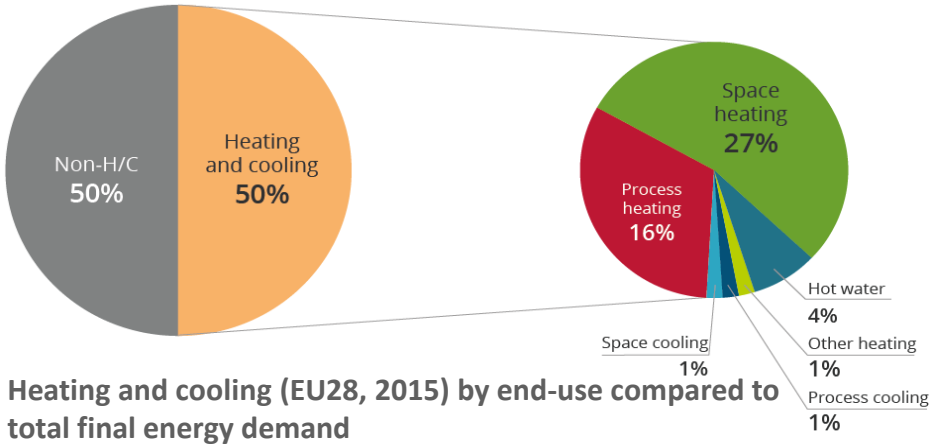
- Brief description of the project
- Illustration of some TANDEM technical outcomes

Brief description of the project

Energy context in EU: energy needs

- Objectives set by the European Commission for climate (Fit for 55 package, 2021):
  - In 2030: reduction of greenhouse gas emission by 55%
  - **In 2050: carbon-neutrality**

- Heating and cooling: current needs



Heating and cooling (EU28, 2015) by end-use compared to total final energy demand

Source : Heat Roadmap Europe

- Hydrogen: projection needs

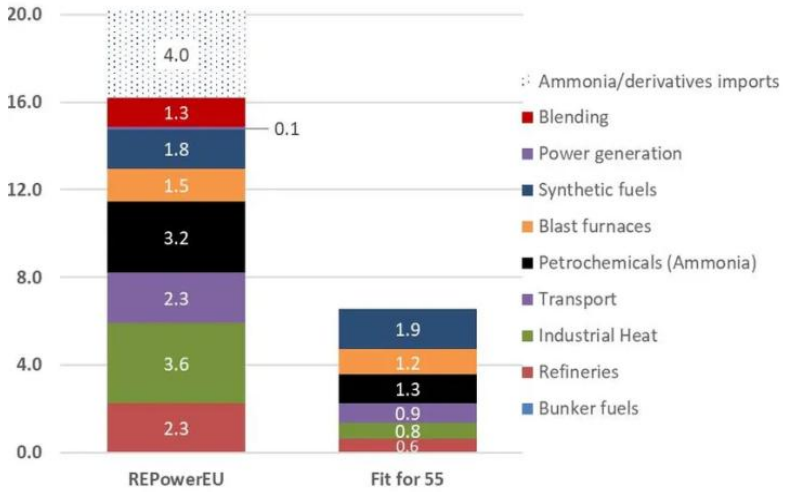


Illustration through the use of green hydrogen in 2030

Source : REPowerEU Plan

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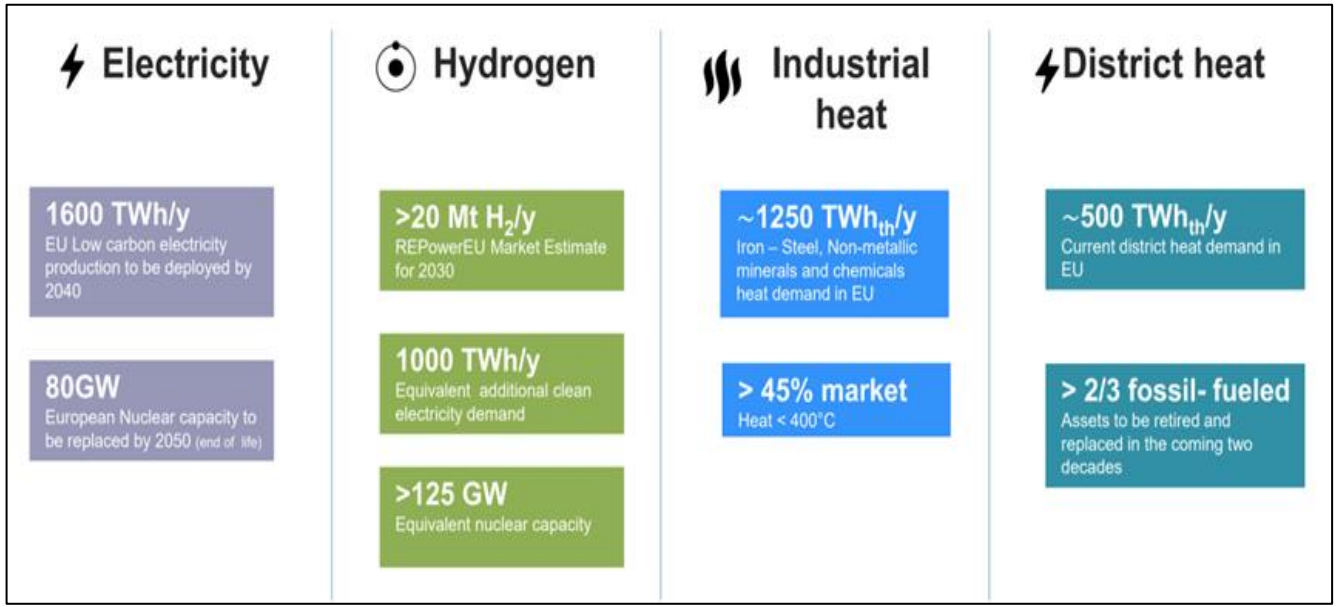
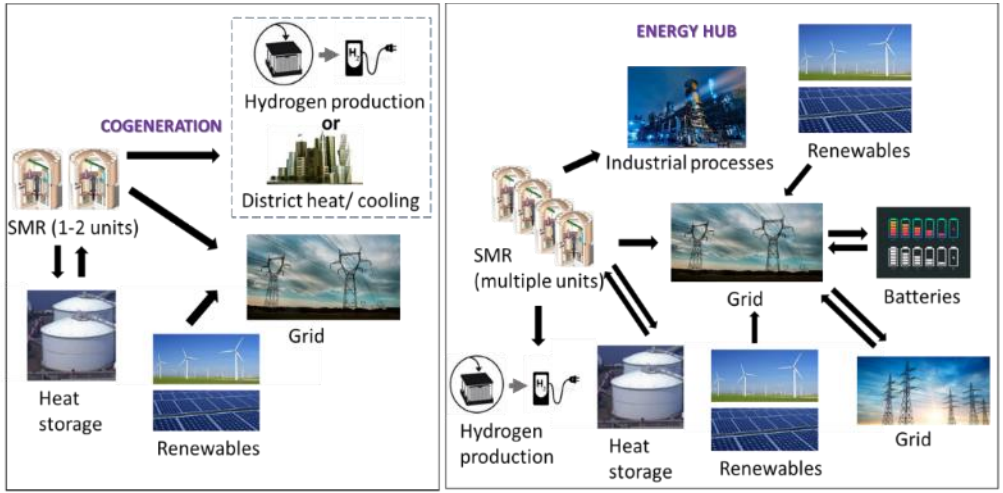
Energy context in EU: energy needs

Energy market needs in EU



Source: TANDEM/Deliverable 1.3

Need to study Hybrid Energy Systems



Multipurpose SMRs for electrical and non-electrical applications are well suited to operate flexibly in ***tandem*** with other energy sources and energy storage systems to provide **electricity, heat and hydrogen**. Thus SMRs can **be "hybridized"** with other energy sources, storage systems and energy conversion applications; they are **integrated into hybrid energy systems.**

Integrated vision of the energy mix

=> New topics to be adressed due to the system approach: nuclear safety, flexibility of energy production, techno-economics, environmental impact, citizen engagement, etc.

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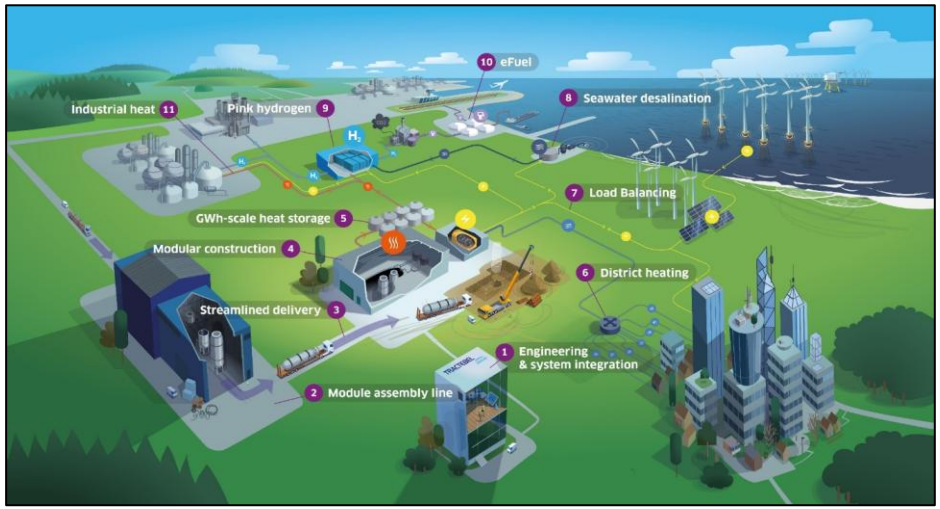
Illustration of Hybrid Energy Systems at a local scale



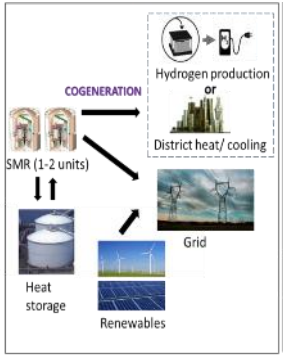
Courtesy of Tractebel

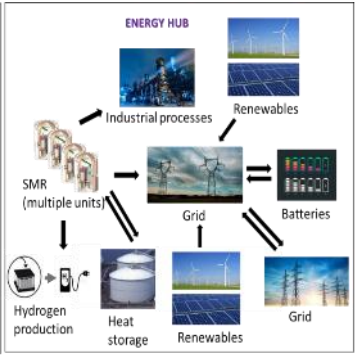
Objectives and ambitions of the TANDEM project

TANDEM: Small Modular ReacTor for a European sAfe aNd Decarbonized Energy Mix

High-level objectives:

- Assess the **safety compliance** of **SMRs** to be **integrated** in the future European energy mix
- Provide **guidance in a deployment perspective** for the future integration of SMRs and AMRs into well-balanced hybrid energy systems
- **Create an enabling environment** for the development of hybrid energy systems based on SMRs and AMRs





Ambitions of TANDEM:

- **Promote versatile SMRs integrated into hybrid energy systems** as reliable, resilient, and affordable clean energy options in Europe
- **Become a pioneer initiative** in gathering efforts and expertise around the development of SMR integration into hybrid energy systems in Europe

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General description of the TANDEM project

- Submission of the project in October 2021 to a EURATOM call for EC funding (topic: NRT01-02 « Safety of advanced and innovative nuclear designs and fuels »)
- Project start: September 1, 2022
- Project duration: 36 months
- Budget: 3.8M€ (including EC grant: 3.4M€)
- Organization leading the project: CEA (French Alternative Energies and Atomic Energy Commission)

- For further information :
  Browse our website: https://tandemproject.eu/
  Follow us: https://www.linkedin.com/company/tandem-project-eu/

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What is the EURATOM program ?

- **EU's key funding program for nuclear research and innovation,** with a budget of 1.38 billion euros between 2021 and 2025. It stems from the Euratom Treaty establishing the European Atomic Energy Community, and was signed in 1957 in Rome, along with the Treaty establishing the European Economic Community.
- **Objectives of the EURATOM Research and Training program:**
  - ✓ To improve and support nuclear safety, security, safeguards, radiation protection, safe spent fuel and radioactive waste management and decommissioning, including the safe and secure use of nuclear power and of non-power applications of ionising radiation
  - ✓ To foster the development of fusion energy as a potential future energy source for electricity production
  - ✓ Fto acilitate collaboration and strengthen the impact of research and innovation in developing, supporting and implementing EU policies while tackling global challenges. It supports creating and better dispersing of knowledge and technologies.

TANDEM consortium

Belgium:

Czech Republic:

Finland:

France:

Germany:

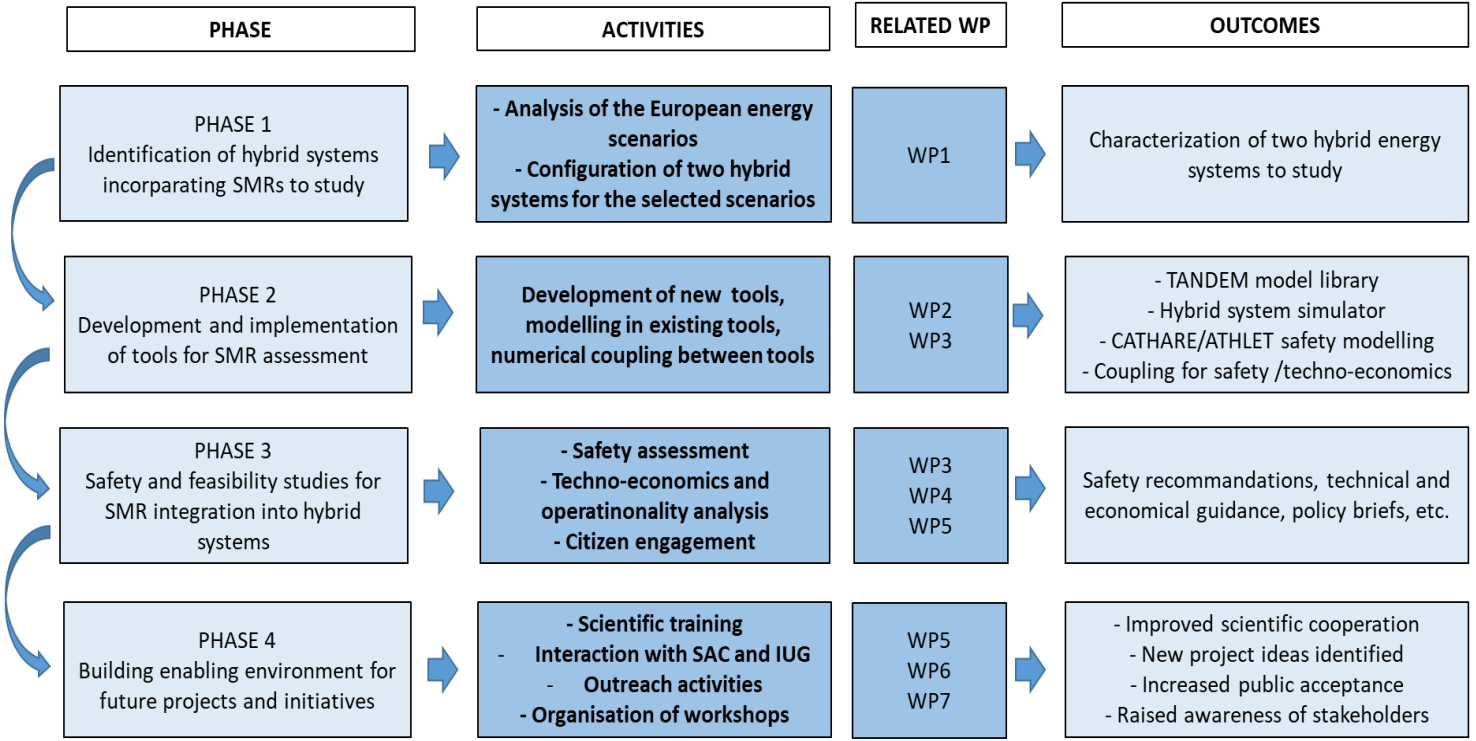
Italy

Spain:

Ukraine:

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

Overall methodology implemented in the project



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Modeling and simulation strategy in TANDEM

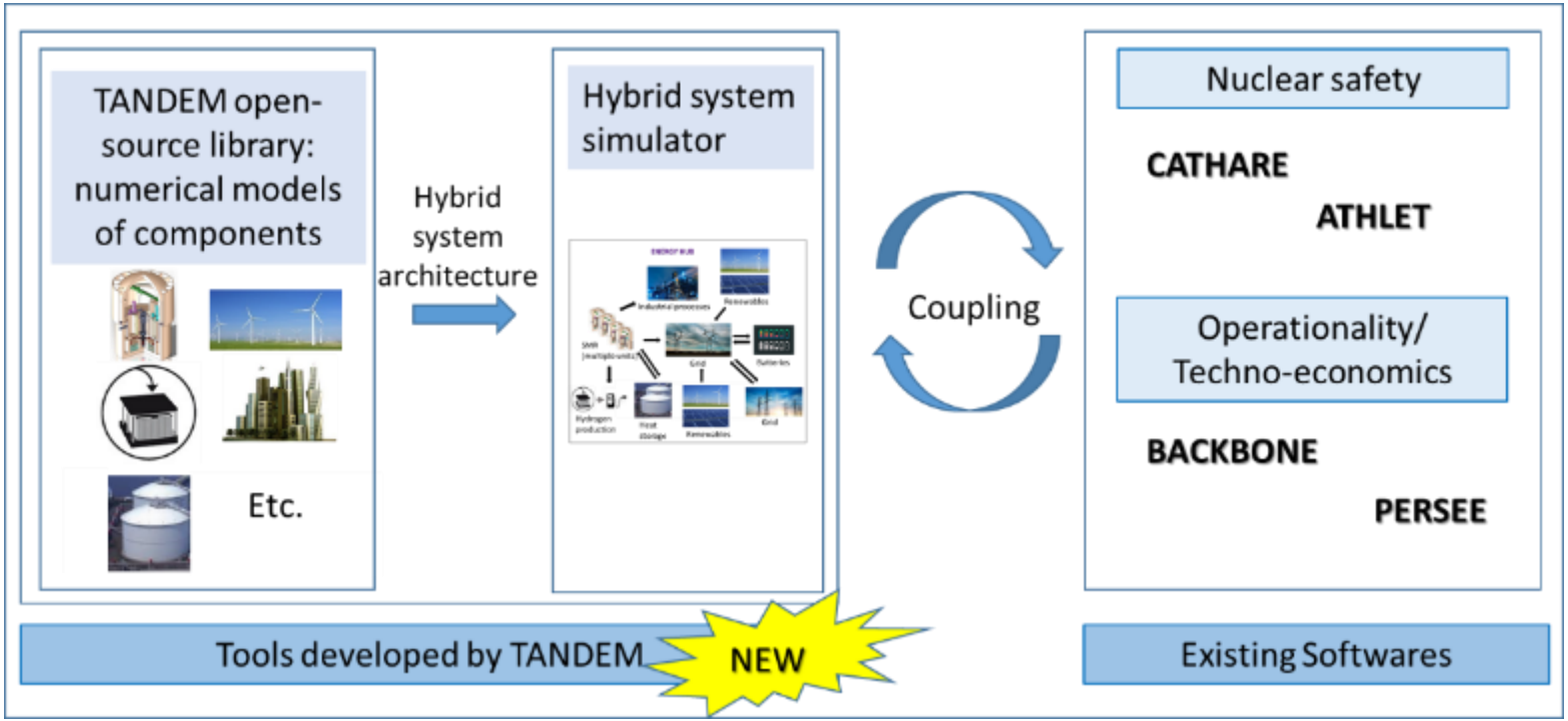
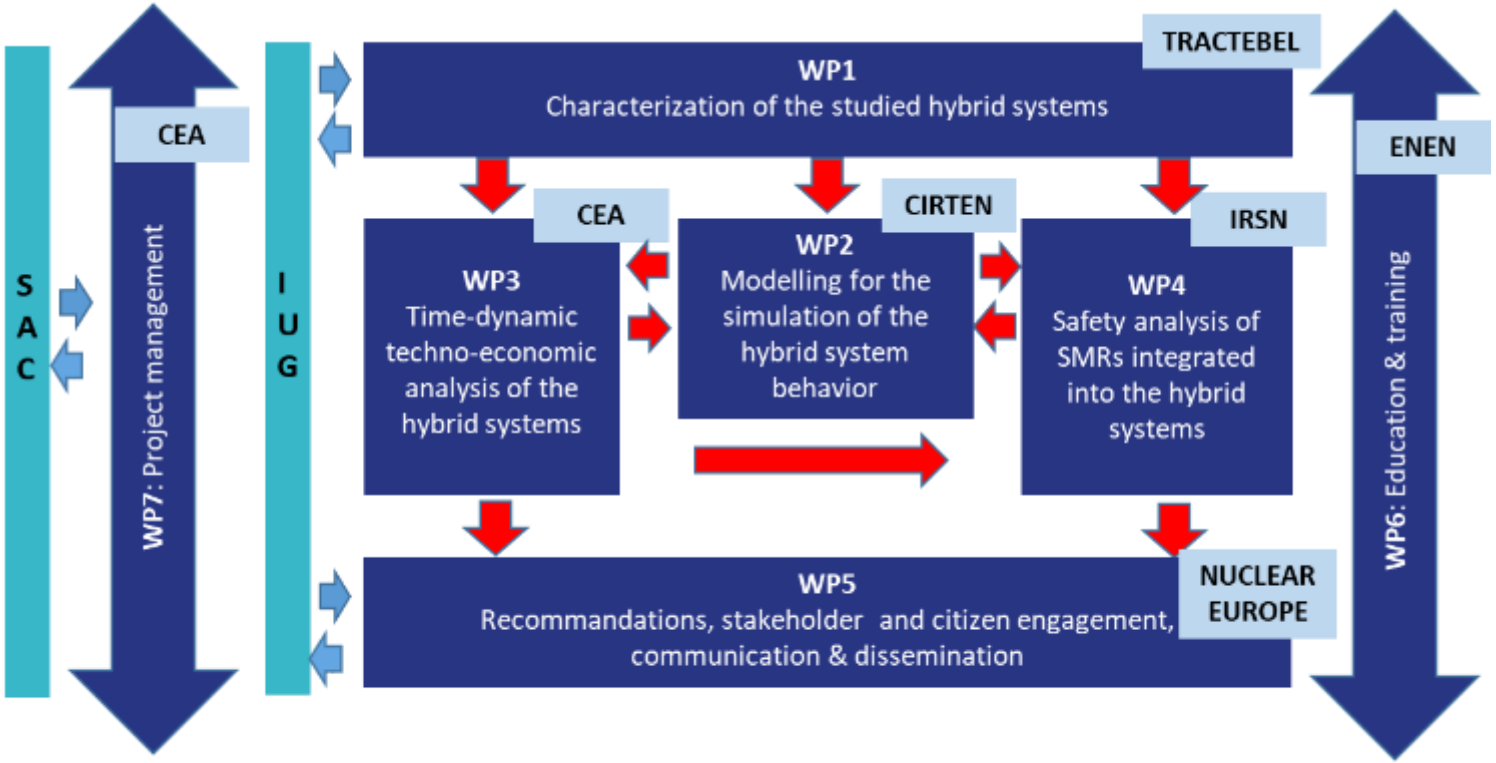


Illustration of some TANDEM technical outcomes

Work Package breakdown



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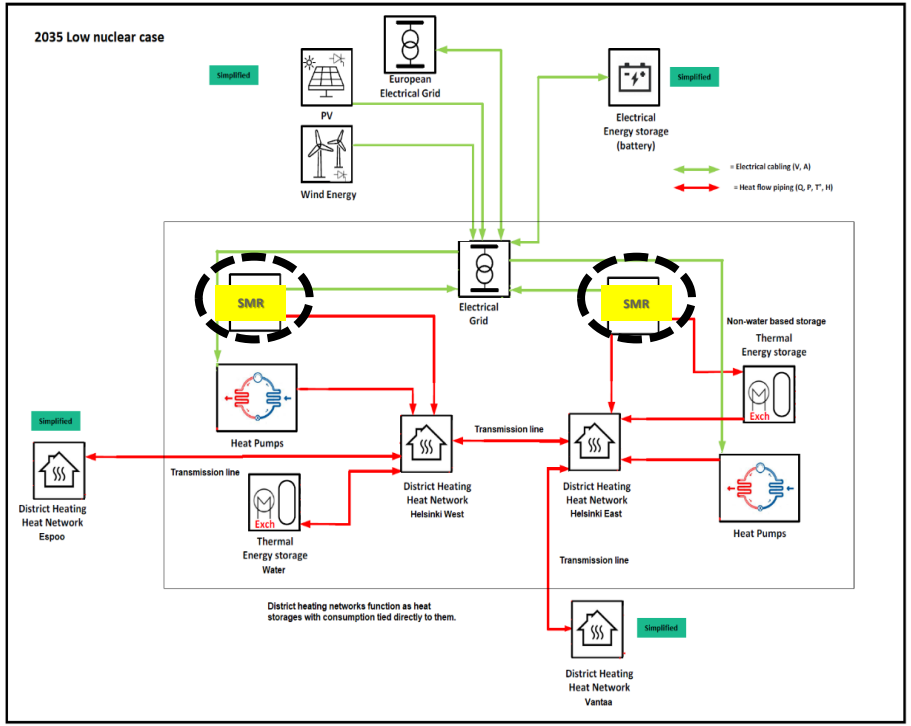
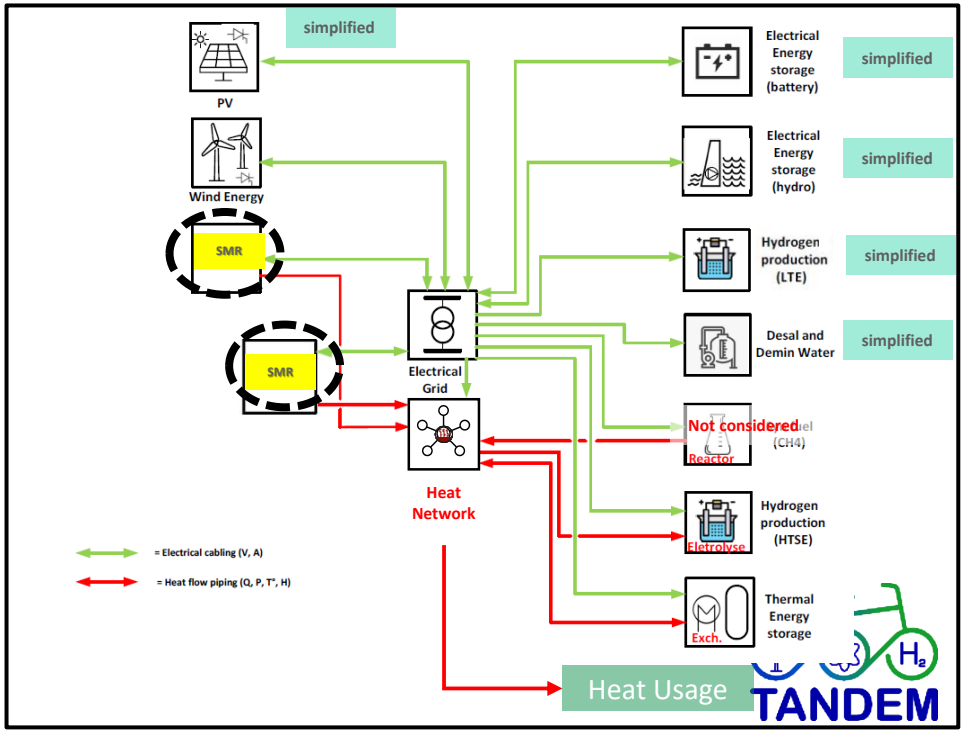
WP1: Generic configurations of HES to be studied

Energy scenario in 2050: low-carbon HES





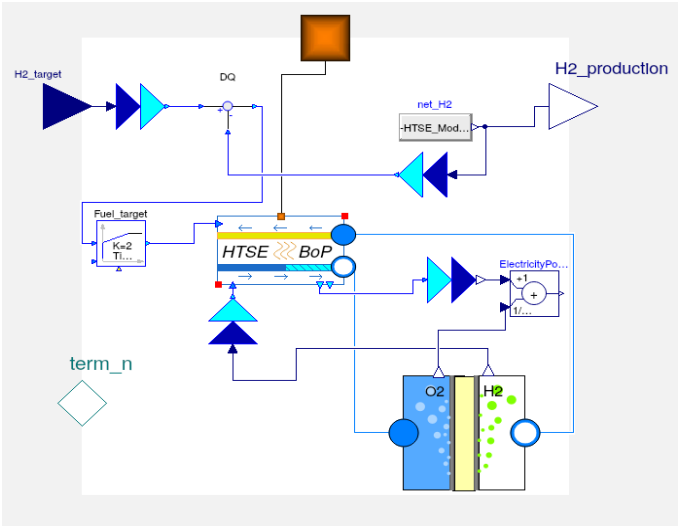
Source: TANDEM/Deliverable 1.4

WP2: TANDEM modelica-based library

TANDEM open-source library available at: https://gitlab.pam-retd.fr/tandem/tandem
Documentation: TANDEM/D2.3: Modelica model description for the 'TANDEM' library

List of models available in the library

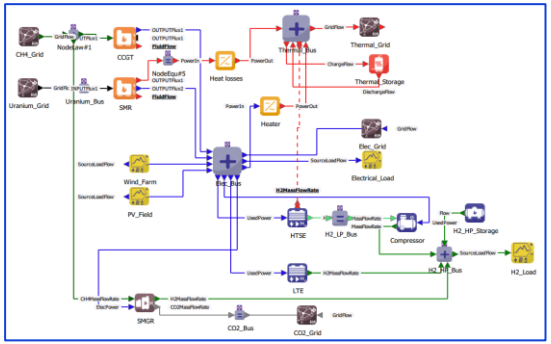
- **SMR**: a) Nuclear Steam Supply System;
  b) Balance of Plant and Power Conversion System.
- **Combined Cycle Gas Turbine** (simplified).
- **Heat pump** (simplified).
- **Electrical Grid**.
- **District Heating Network**.
- **Storage** : a) Thermal; b) Electrical (simplified).
- **Desalination** (simplified).
- **H_2 production**:
  a) Low temperature electrolizer (simplified);
  b) High temperature steam electrolyzer.

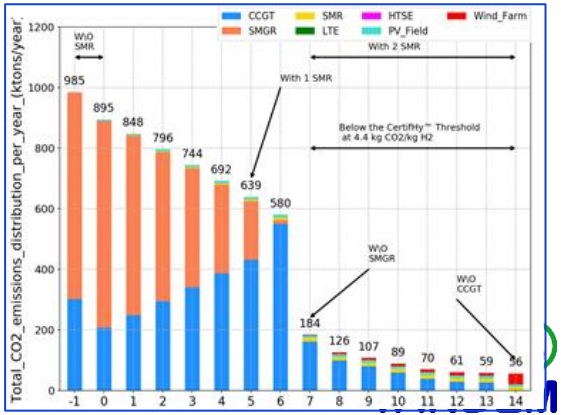


G. Simonini et al, "Integrating Small Modular Reactors into Hybrid Energy Systems: the TANDEM Modelica library", Proc. Int. Conf. IAEA on SMRs and their applications, Vienna, Austria, October 21-25, 2024.

WP3: Illustration of techno-economics studies for the energy hub

- Due to the difficulties of accessing the detailed characteristics of the energy fluxes involving several industrials in existing European harbours, it was decided to arbitrarily set an initial architecture involving a CCGT, a photovoltaics field, an offshore wind farm, and energy storage systems, to produce constant hydrogen and electricity loads.
- In the study, optimization process implemented in the PERSEE tool: it is based on the optimization of an objective function by finding an optimal sizing of system components.
- Study conducted with a 20 year lifetime project with a hourly one-year simulation
- Fourteen optimal states have been run by increasingly limiting CO_2 intensity (considering both CO_2 grey and direct emissions).





Source: TANDEM/Deliverable 3.2

WP4: Extension of conventional safety approach when SMR integrated into hybrid energy systems

- ❑ Use of nuclear power plants for cogeneration effective for many years in several countries [*IAEA, No NP-T-4.1, 2017*], mainly for desalination and district heating applications

⇒ Configurations often considered as the juxtaposition of two industrial processes with a customer-supplier relationship and a small number of interfaces. Risks seen as independent, considering the other process as a potential external hazard

- ❑ **Considerable work carried out on safety for reactors operated in cogeneration in the framework of the European Nuclear Cogeneration Industrial Initiative** (NC2I), as a pillar of the Sustainable Nuclear Energy Technology Platform (SNETP), for (very) high temperature reactors ((V)HTR)

⇒ Useful general safety considerations for nuclear co-/poly-generation

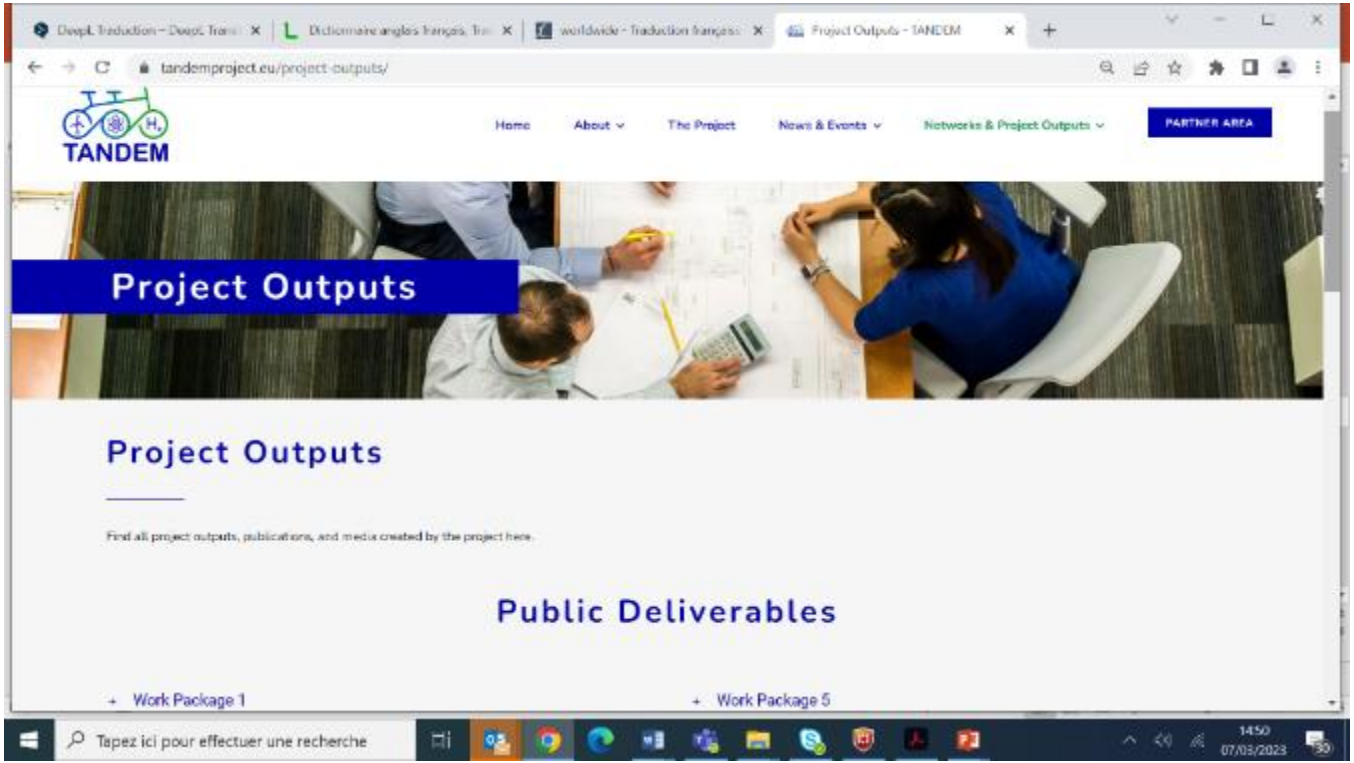
- ❑ **SMR integration into hybrid energy systems induces multiple and more dynamic interfaces** between the nuclear reactor and non nuclear components of the hybrid energy system

⇒ **Need for the development of additional specific guidelines for safety analysis**

⇒ **Definition of "hybridization transients" to be studied in TANDEM**

Source: TANDEM/Deliverable 4.2

To access TANDEM deliverables



All our technical deliverables for the European Commission are public.

They are available on our website: https://tandemproject.eu/

Connection of TANDEM with various stakeholders and international initiatives

- **A Scientific Advisory Committe (SAC)**: representatives from IAEA, EC-JRC, INL, MIT

  Objective: 1/to provide feedback and recommendations on the results, scientific choices and directions of the project; 2/ support interactions with other European and international initiatives which the SAC members are involved in and which are related to the activities of the project

- **An Industrial User Group (IUG)**: a dozen of members

  Objective: to engage with TANDEM in a constructive dialogue around: 1/ the technological feasibility of the hybrid energy systems incorporating SMRs, 2/ the different energy markets and their particularities, 3/ regulatory, societal and economic issues related to the implementation of such systems.

- **Other Euratom projects on SMR/AMRs safety and nuclear cogeneration**, such as NPHyCo, GEMINI 4.0, ELSMOR, SASPAM-SA, ESFR-SIMPLE, ENEN2+, SANE, ENDURANCE,EASI-SMR.

- **Other international initiatives**, such as the IEA/Task Force 44 on HYdrogen from Nuclear Energy (HYNE)

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Conclusion

- Constantly evolving energy paradigm and strategy at the international level, EU level and country level => Important for the TANDEM project not to get results that depend on these changes

- In the context of the different initiatives promoting the integration of sustainable energy sources to the energy mix, the overall aim of TANDEM:
  - ✓ to highlight the potential role of SMRs and AMRs in the development of the future European low-carbon energy mix and
  - ✓ to build an open and long-term community that will ensure expertise in the domain and support the wide acceptance of SMRs and AMRs at different levels

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Announcement of TANDEM events

- **TANDEM stakeholder engagement workshop:** in Brussels, March 26
- **Final TANDEM workshop** to share our results (meeting fully open): in Brussels, July 2

TANDEM Partners

Get in touch for more information:

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https://www.linkedin.com/company/tandem-project-eu/

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