PASTELS

Passive Systems: Simulating the thermal-hydraulics with experimental studies

Progress towards simulation of passive safety systems

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SNETP FORUM 2021 – Towards innovative R&D in civil nuclear fission – February 3, 2021 – Virtually

This project has received funding from the Euratom research and work programme for 2019-2020 under grant agreement No 945275

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1. Context & objectives of the project

Context

- Passive systems are new options given to nuclear power plant designers to replace or complement active systems, mainly used in nuclear power plants

- Their main advantages come from their capability to rely on natural phenomena to ensure their functioning
  - Passive systems operate on "weak" forces: gravity, difference in density, pressure, etc.
  - Some classified support systems may become unnecessary: cooling chain, power supplies (diesel, batteries, switchboards), control command, ventilation, etc.
  - No need for human intervention for their activation and functioning during the duration of their mission

⇒ Passive systems have the potential to increase significantly nuclear power plant safety, reduce investment and operation costs and improve public acceptance (especially in the post-Fukushima era)

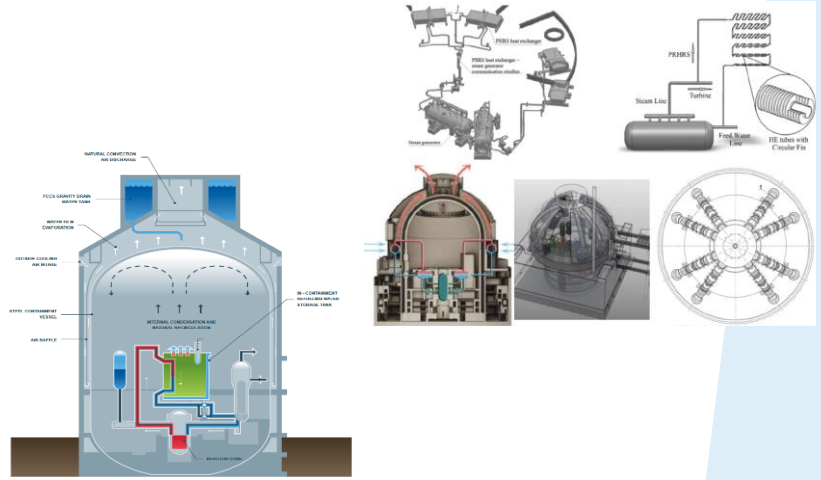
However, these strengths have yet to be assessed with respect to European safety philosophy and standards…

Context

- Without being a universal solution, outside the European Union, innovative passive systems have been chosen as parts of several nuclear power plants in many recent designs of GEN III reactors (from Small Modular Reactor to high power reactor)

Type	Model	Vendor	Country
PWR	AP1000	Westinghouse	USA
PWR	AES 2006 V392	Rosatom AEP Moscow	Russia
PWR	AES 2006 V491	Rosatom AEP St Petersburg	Russia
PWR	VVER TOI	Rosatom	Russia
PWR	CAP 1400	SNPTC	China
PWR	ACP1000	CNNC	China
PWR	APR +	KEPCO	South Korea
BWR	ESBWR	GE HITACHI	USA / Japan
BWR	AB1600	TOSHIBA	Japan
BWR	KERENA	Framatome	Germany
PHWR	EC6	Candu Energy Inc.	Canada
PHWR	AHWR	Bhabha Atomic	India

- European manufacturers have little first-hand experience with thermal-hydraulic behavior of these systems
  - Lack of experiments (experimental and numerical)



- Despite their *intrinsically safe* character, this interesting property remains to be proven at the same level as for active systems

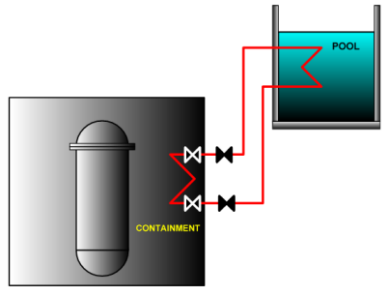
⇒ **In-depth analyses and studies are still needed to properly evaluate the benefit of such systems and identify, if any, the drawbacks.**

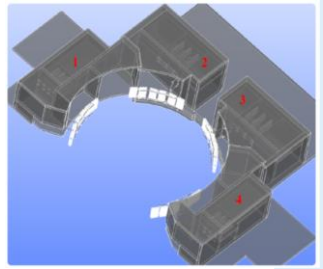
⇒ **Finally, to be able to estimate the relevance of the implementation of such system in a new plant design, the system needs to be correctly designed and integrated into the safety demonstration**

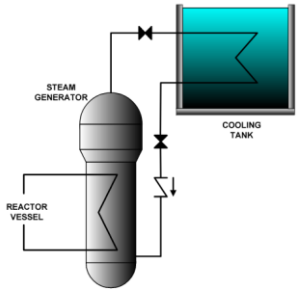
Objectives of the project

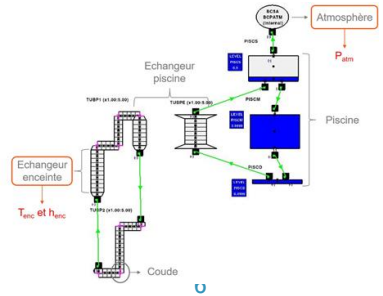
The overall objective of PASTELS is to considerably enhance the knowledge of European nuclear actors in their ability to design and deliver innovative passive safety systems and simulate their behaviour to support the safety demonstration

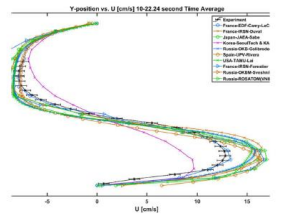
- Focusing on two specific innovative passive systems: **Containment Wall Condenser (CWC) and SAfety COndenser (SACO)**
  - These systems are already integrated in the design of nuclear reactors abroad and could be of interest for European nuclear designers, operators and regulatory bodies
- Increasing significantly the European expertise on Passive Systems
  - Strengthening the capacity of the existing calculation tools, at appropriate scales, to simulate the relevant thermohydraulic phenomena
  - Developing coupling methodologies to provide robust multi-scale simulations able to accurately design and verify the performance of passive systems
  - Validating the performance of these codes by means of well-designed new experiments
  - Taking advantage of these experiments to evaluate new innovative designs of passive systems up to advanced TRL levels











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2. Partnership and baseline

Partnership and baseline

PASTELS brings together eleven European organisations with complementary skills and expertise which, by combining altogether, will make significant progress in the study of passive systems

H2020 Euratom program (NFRP-2019-2020-04 – Innovation for Generation II and III reactors)

CONSORTIUM		
	Participant short name	Participant organisation name
	EDF (coordinator)	ELECTRICITE DE FRANCE
	ENEA	AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE
	CEA	COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES
	FRA-G	FRAMATOME GMBH
	GRS	GESELLSCHAFT FUR ANLAGEN UND REAKTORSICHERHEIT (GRS) gGmbH
	USTUTT	UNIVERSITAET STUTTGART
	IRSN	INSTITUT DE RADIOPROTECTION ET DE SURETE NUCLEAIRE
	LUT	LAPPEENRANNAN-LAHDEN TEKNILLINEN YLIOPISTO LUT
	PSI	PAUL SCHERRER INSTITUT
	UJV	UJV REZ, a. s.
	ART	ARTTIC

- 11 partners in Western and Eastern Europe
- EU Grant Agreement n° 945275
- Project duration : 01/09/2020 - 28/02/2024 (42 months)
- EU financial contribution : 2,993,262.76 EUR

The PASTELS project has obtained the NUGENIA label on 23/09/2019 (Certificate number: 2019NUG0076)

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3. Methodology & work breakdown structure

Methodology

- The PASTELS project is organised in 5 workpackages:
  - WP1 dedicated to the overall project management
  - WP5 dealing with dissemination and communication
  - WP2, WP3, WP4 for technical works on selected passive systems (experimental and numerical works)

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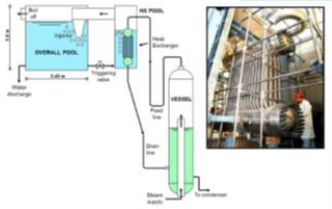
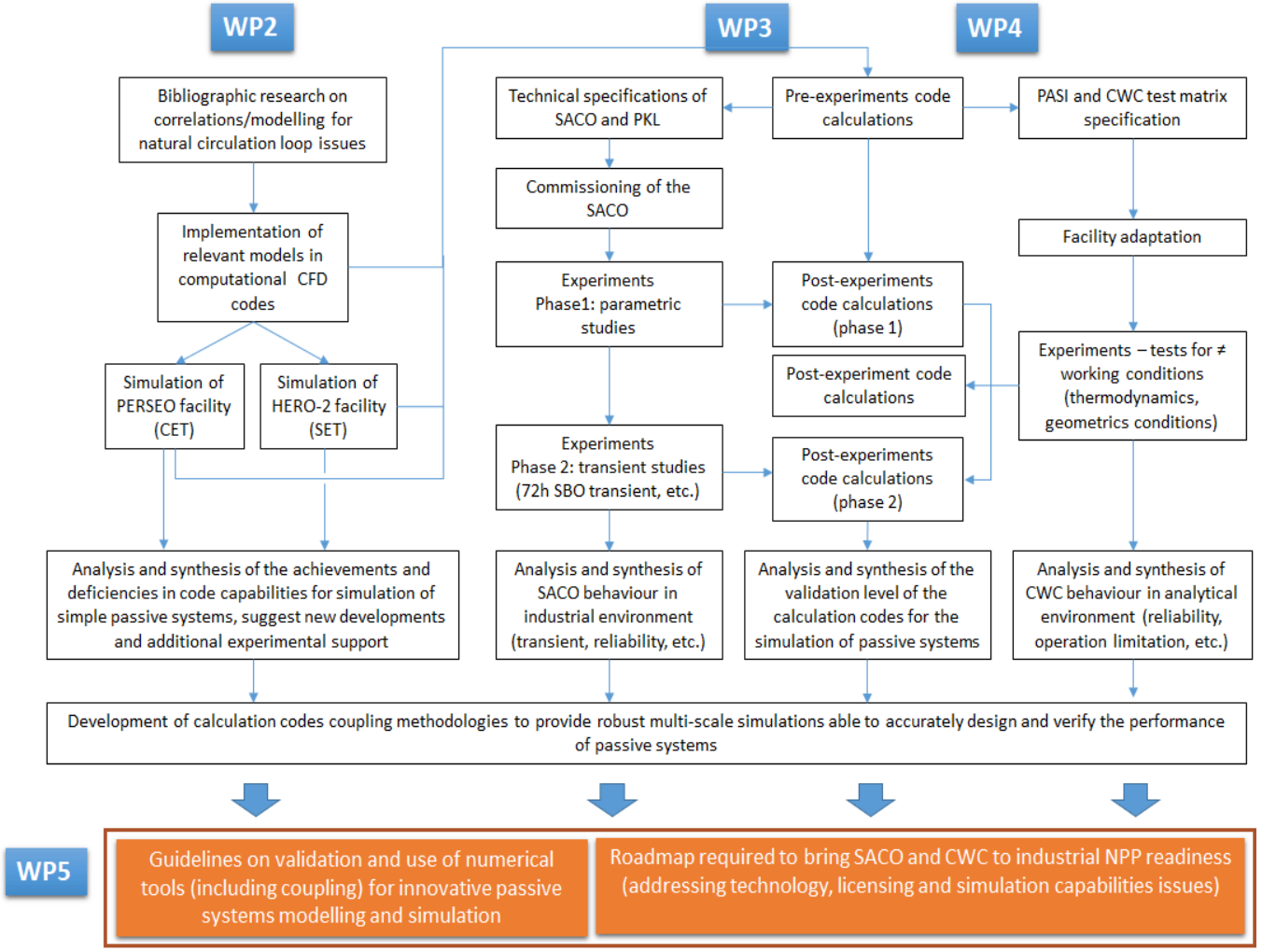
- PASTELS is structured on a step-by-step approach based on the available Best Practice Guidelines
  - Separated-effect and combined-effect validation (WP2: HERO-2, PERSEO)
  - Integral-scale validation (WP3 & 4: PKL-SACO and PASI-CWC)
  - Benchmarking between the various numerical tools involved
  - Development of coupling methodologies → getting the advantages of the different modelling scales in the same calculation

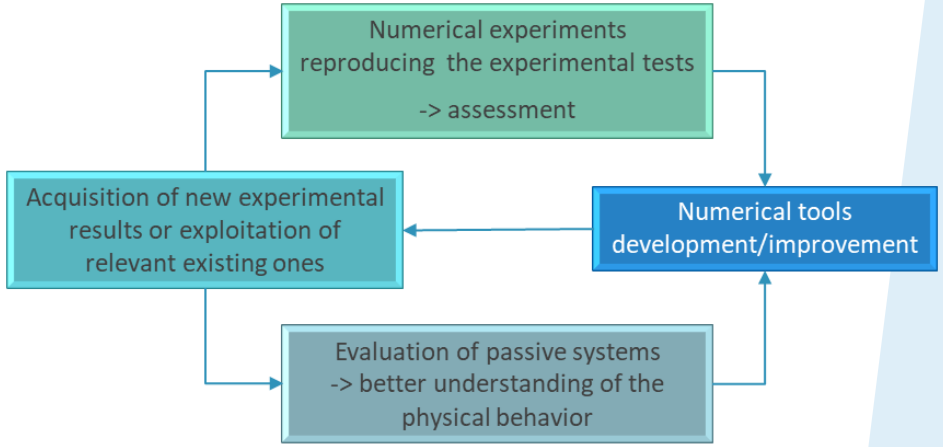
- PASTELS will rely on existing skills:
  - Existing numerical tools acting at different scales: system, CFD and severe accident scale
  - Existing experimental database to validate codes on separated-effect and combined-effect test (HERO-2, PERSEO)
  - Existing experimental facilities which will be adapted to build new test campaigns on SACO and CWC



Work breakdown structure



- Work scheme for the 3 technical WP is similar and overlaps
  - Knowledge acquired / improvement obtained in each of the WPs will be used by others



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4. Main expected results

Main expected results

- Extensive experimental data covering multiple scenarios
  - SACO and CWC data obtained on PKL (FRA-G, Erlangen) and PASI (LUT, Lappeenranta) test facilities
  - Existing Separated Effect Tests (SET) and Combined Effect Tests (CET) data generated in PERSEO and HERO-2 facilities (ENEA) simulating behavior of thermosiphon loop of SACO
  - Understand the physical behaviour of these systems for a large range of boundary conditions
- Assessment and improvement of several European tools used for conception and safety demonstration
  - Based on the new, relevant experimental data
  - Different numerical tools, acting at different scales (system and CFD codes, codes coupling)
  - Methodologies and guidelines for validation and use of numerical tools for innovative passive systems
- Guidelines for SACO and CWC implementation and roadmap for European version of SACO and CWC

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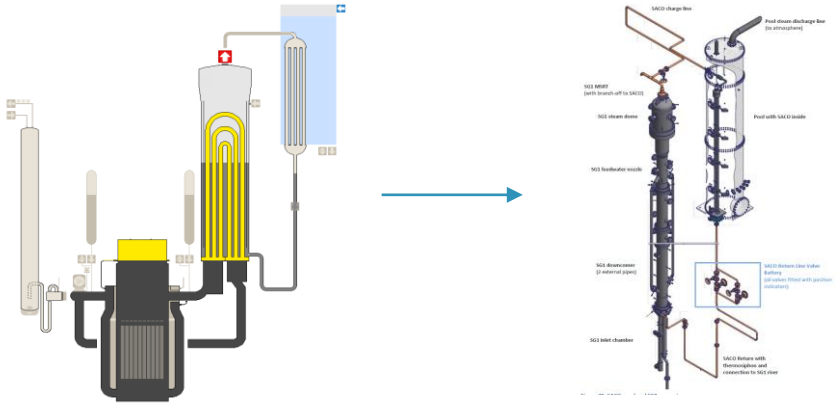
5. First technical results

First technical results

PASTELS project started 5 months ago (reminder)

- WP2 - CET and SET activities
  - Release of a “Bibliographic research on the phenomena related to the natural circulation”: attempt to have the “state-of-the art” information available in the literature concerning key phenomena and theoretical models and the means of testing or experimentation associated with them . The objective is to identify relevant models that could be integrated into the numerical tools used within PASTELS in order to improve simulation results on passive systems

- WP3 – PKL-SACO activities
  - Release of a “PKL & SACO Technical Description & Design Review Report”: the design of the straight vertical SACO that will be used in the framework of the project has been defined and validated by the consortium
  - SACO component are ordered and work on building structure modifications has started



PKL-SACO design	
Height of bundle	5.4 m
N° of tubes	4
Internal diameter of the SACO pool	1.4 m
Height of the SACO pool	~7.3 m
Design power	450 kW

- **To be continued**: numerical activities on Hero-2 and pre-test on PKL-SACO and PASI-CWC will begin in S1 2021

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- Technical Leaders:
  - Christophe HERER (IRSN) –> SET & CET activities
  - Simon SCHOLLENBERGER (FRAMATOME) -> PKL-SACO activities
  - Joonas TELKKÄ (LUT) -> PASI-CWC activities
  - Michael BUCK (USTUTT) -> dissemination and communication activities
- Website:
  - https://www.pastels-h2020.eu (under construction, available Q1 2021)
  - https://cordis.europa.eu/project/id/945275

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Thank you for your attention

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