GEN IV International Forum

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Overview and Update of SCWR Activities within GIF

Mr. Armando Nava, CNL, Canada

26 November 2024

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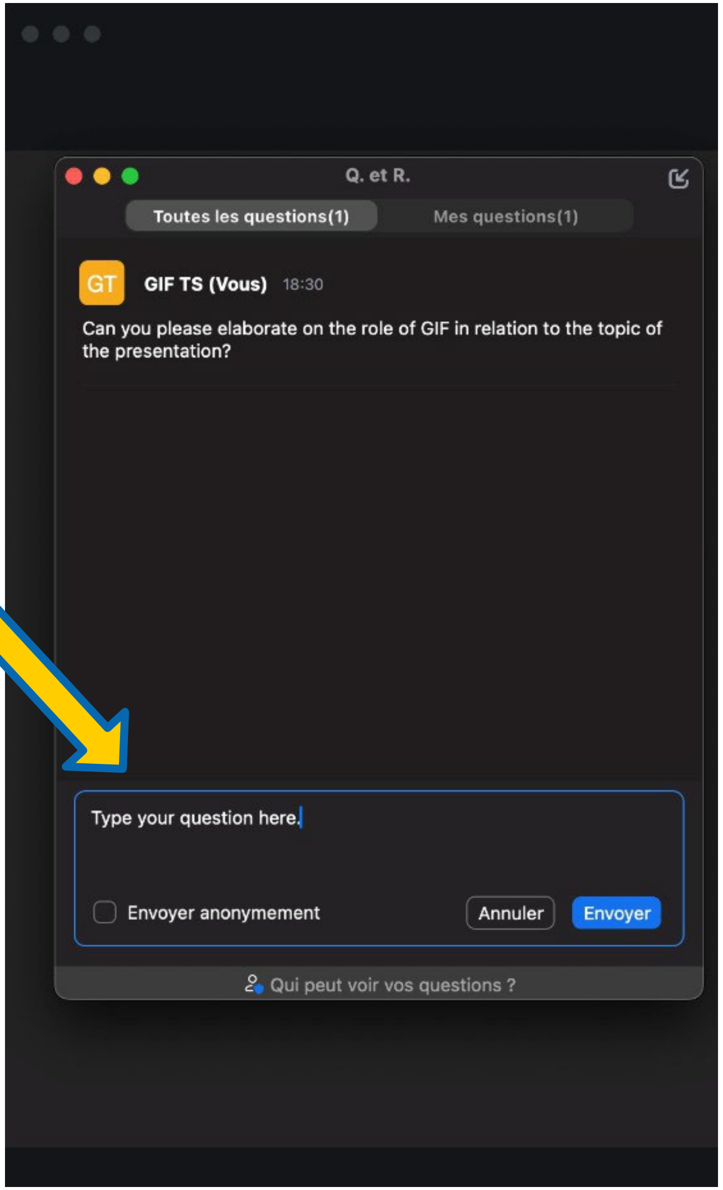

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26 November 2024

Meet the Presenter

Mr . Armando Nava Dominguez has a Bachelor’s degree in Energy Engineering, specialized in Nuclear Thermalhydraulics and a Master’s degree in Nuclear Thermalhydraulics. He joined the Canadian National Laboratories (CNL) in 2005 as a Thermalhydraulics Analyst, specializing in code development and validation of the subchannel code ASSERT-PV.

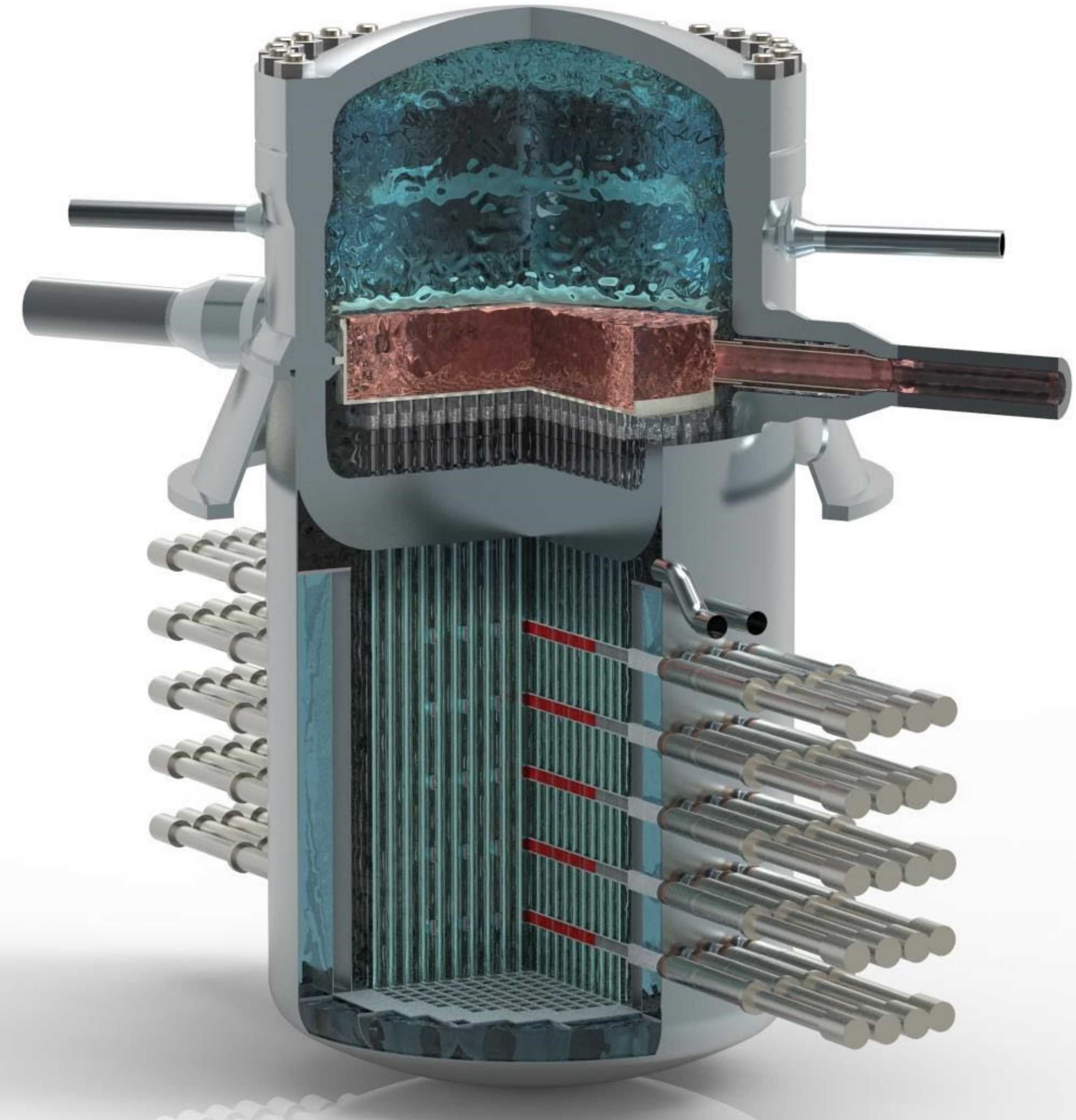
He joined the Canadian Super Critical Water Reactor (SCWR) team in 2011 as part of the Generation-IV International Forum (GIF) program. He is the Canadian member and co-chair of the SCWR Thermalhydraulics and Safety under GIF. He is currently the chairman of the system steering committee for the SCWR under GIF.

At CNL, he is the Technical and Project Lead of the SCWR Gen IV project, and Head of the Advanced Reactor Technologies section. In addition, he has five years of experience in the private sector conducting deterministic and probabilistic safety analyses of nuclear power plants.

Email: armando.nava@cnl.ca

Outline

- Why SCWR?
- Supercritical fluids in the power industry.
- Previous SCWR concepts.
- R&D activities and collaborations.
- Knowledge gaps.
- Advantages and disadvantages.
- Opportunities.
- Questions.



Why SCWR?

- What is critical about supercritical?
- Why supercritical?

"Increasing thermal efficiency is effective in reducing capital costs and the volume spent fuel and radioactive waste per generated watt of electricity."

Oka Yoshiaki, Superlight Water Reactors and Super Fast Reactors.

- Is a technology already used in the power sector.
- The number of supercritical fossil-fired plants (SC-FFP) worldwide is larger than that of nuclear power plants.
- SCWR is the only water-cooled reactor selected by GIF.

"There is nothing critical about supercritical. Super critical is a thermodynamic expression describing the state of a substance where there is no clear distinction between the liquid and the gaseous phase (i.e. they are a homogeneous fluid). Water reaches this state at pressure above 22.1 megapascals (MPa)"

Ingo Paul

https://documents1.worldbank.org/curated/en/924431468740714825/pdf/multi-page.pdf

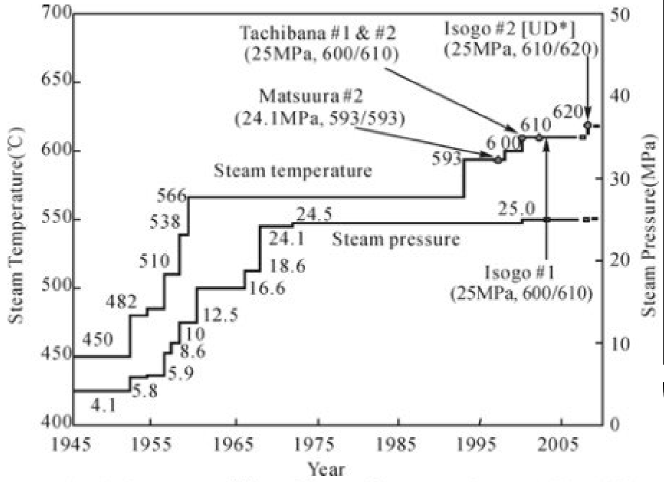
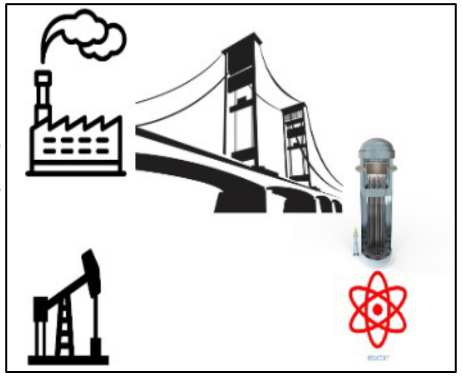


Fig. 4 Steam condition history in Japan & EPDC's USC power plants

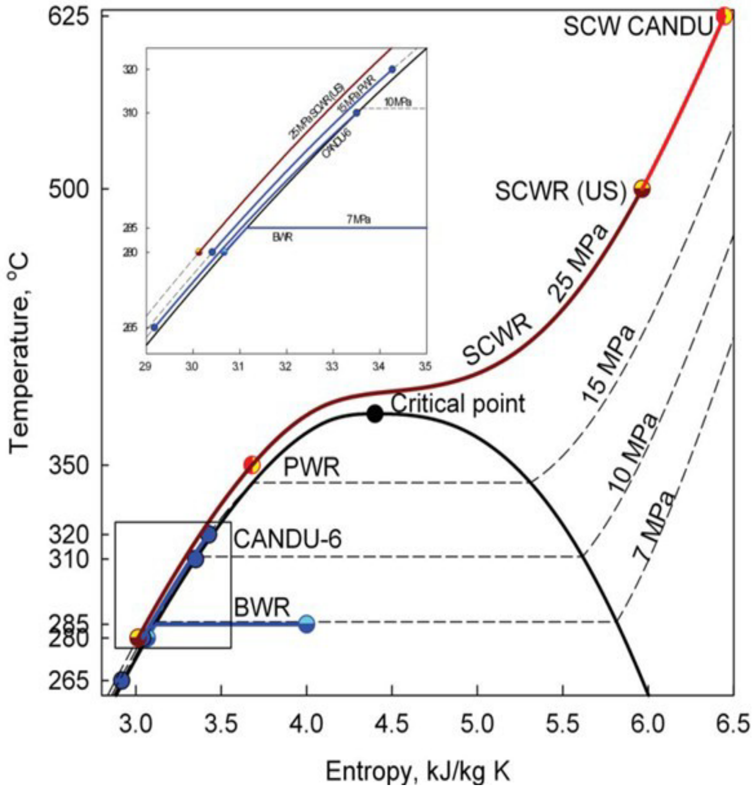


Supercritical technologies

Otsuka, T., Kaneko, M. (2007). Development History and Operation Experience of Ultra-supercritical (USC) Power Plants. In: Cen, K., Chi, Y., Wang, F. (eds) Challenges of Power Engineering and Environment. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-76694-0_39

Why SCWR?

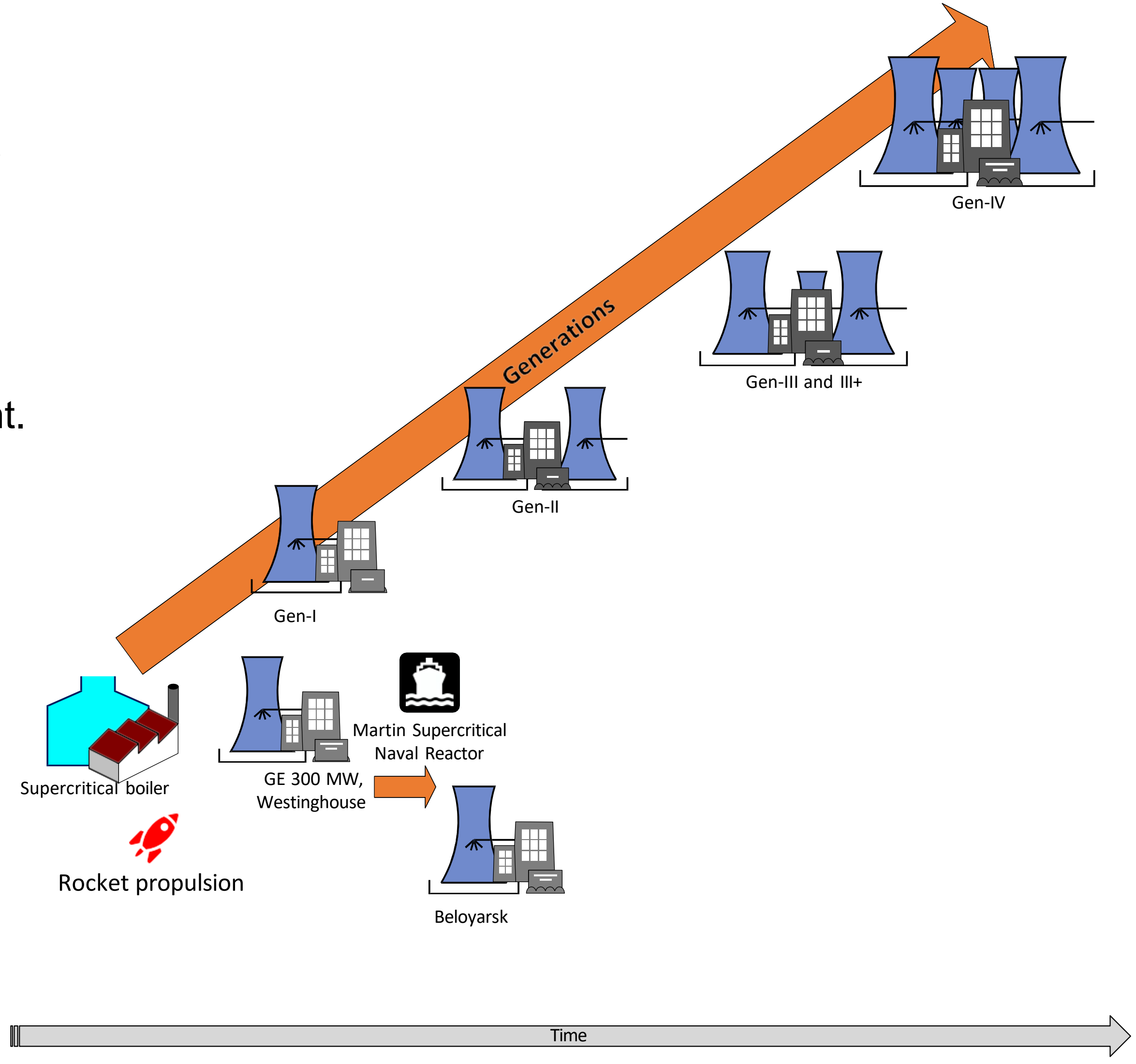
- Presently, most commercial water-cooled reactors are water-cooled.
- Allowed us to develop a large body of knowledge on water-cooled technology.
- SCWR is an evolutionary step from previous water-cooled reactors. Several components can be used from previous generations and FFP.
- It is an ***extension*** of current knowledge.
- SCWRs offers practicability and industrialization.
- However, radiation is an unknow factor in SC FFP.



Pioro, I. L., and R. B. Duffey. 2007. *Heat Transfer and Hydraulic Resistance at Supercritical Pressures in Power Engineering Applications. Heat Transf. Hydraul. Resist. Supercrit. Press. Power Eng. Appl.* ASME Press.

Water-cooled reactors –An evolutionary path

- Supercritical fossil fired plants.
- NASA studies on thermalhydraulics (for SC fluids).
- Water-cooled reactors (subcritical).
- Supercritical GE (300 MW), Westinghouse.
- Martin naval propulsion concept.
- Superheated Beloyarsk nuclear power plant.
- Super LWR and FR.
- High Performance Light Water Reactor.
- Canadian SCWR.
- CSR-1000.
- ECC-SMART.
- Canadian SCW-SMR.
- CSR-150.



History 1950-1960

- Supercritical FFP:
  - Philo #6 125 $MW_{e,}$ **31 MPa**, 621 °C (1957).
  - Eddystone #1 325 $MW_{e,}$ **34.5 MPa**, 649 °C (1959).
- First BWR & PWR.
  - Dresden Unit 1, 180 MW_e (***subcritical***) 1960.
  - Shippingport Atomic Power Station 60 MW_e (***subcritical***) prototype.
  - Yankee Rower 185 MW_e (***subcritical***) 1961.
- First SCWR concepts
  - GE 300 MWe 1959 (Not constructed)
  - Westinghouse Atomic Power Department 1957? (Not constructed)
- Timing favored subcritical reactors.
- Nuclear reactors are built to run for multiple decades.

Beznau nuclear power plant in Northern Switzerland takes the honour of being the oldest nuclear power currently in use. Construction on the plant began in 1965 and Beznau 1 began producing power on 1 September 1969, with Beznau 2 following in 1972.

UNCLASSIFIED HW-59684

UC-81, Reactors-Power (TID-4500, 14th Ed.)

SUPERCRITICAL PRESSURE POWER REACTOR

A Conceptual Design

By

The Staff of
Reactor Engineering Development Operation

March 18, 1959

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

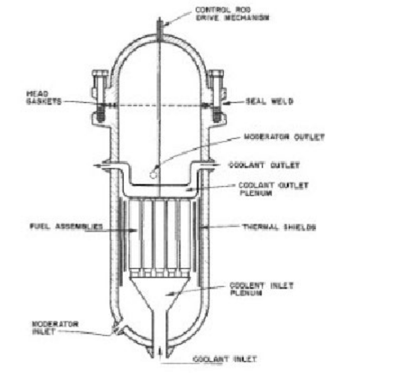
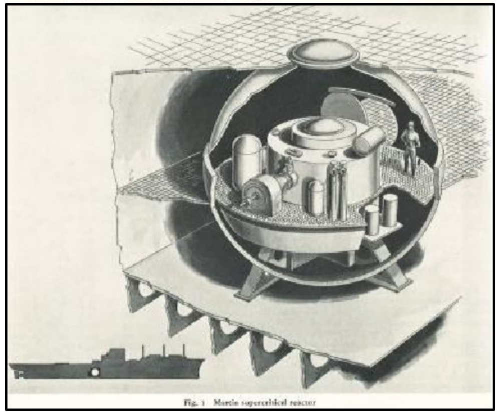


Figure 7

Schematic-Core and Pressure Vessel Schematic-
Westinghouse Reference Design

Conceptual Study of a Supercritical Reactor Plant for Merchant Ships



Marchaterre, J. F., and M. Petrick. 1960. *REVIEW OF THE STATUS OF SUPERCRITICAL WATER REACTOR TECHNOLOGY*. Argonn IL (United States).

Pravda, M.F., and Lightner, R.G. 1965. Conceptual study of a supercritical Tractor Plant for merchant ships. Nuclear power sysmposium, Philadelphia, Pa. Marine technology, p.p. 230--238

SWI swissinfo.ch — Swiss perspectives in 10 languages

News › Swiss Politics ›

Study to assess if Swiss nuclear reactors could operate beyond 2030

https://www.swissinfo.ch/eng/swiss-politics/feasibility-of-oldest-swiss-nuclear-reactors-under-review-post-2030/74491335

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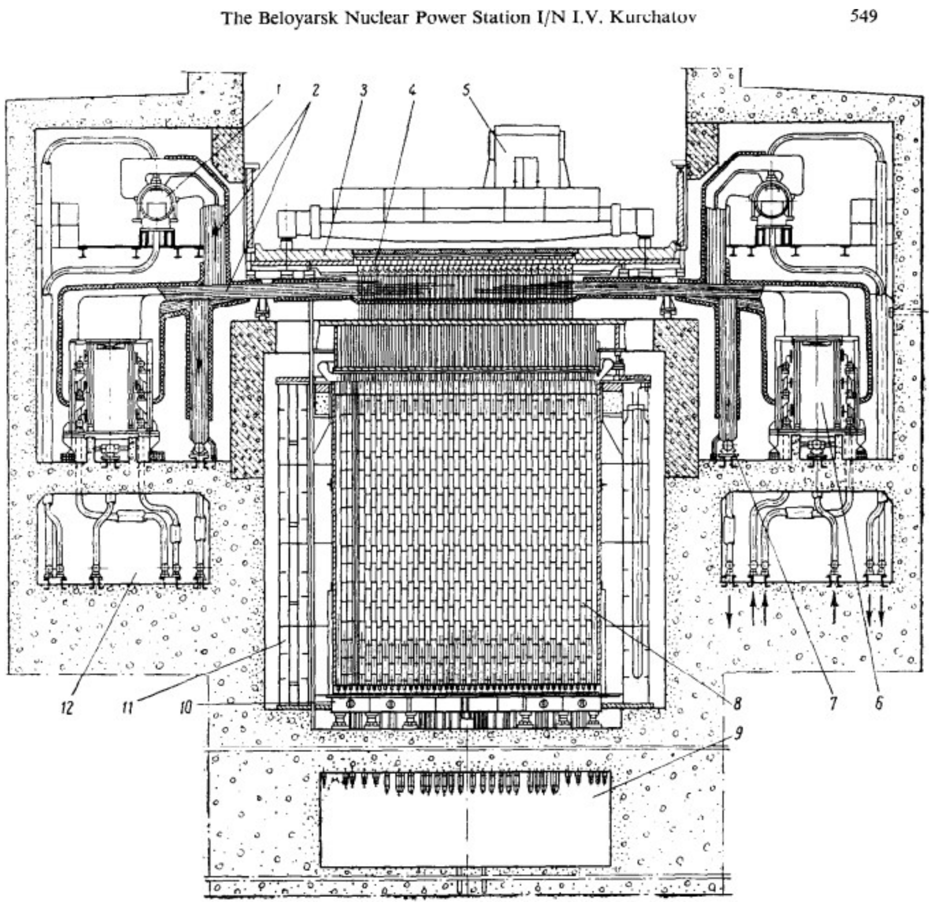
Beloyarsk

- Reactor built in the former Soviet Union.
- On April 26th, 1964, Beloyarsk NPP supplied current to the power system.
- Used superheated steam (500 °C) but operated at subcritical conditions.
- Operational experience is important for SCWR as we have some knowledge on the material's behavior under high temperatures.



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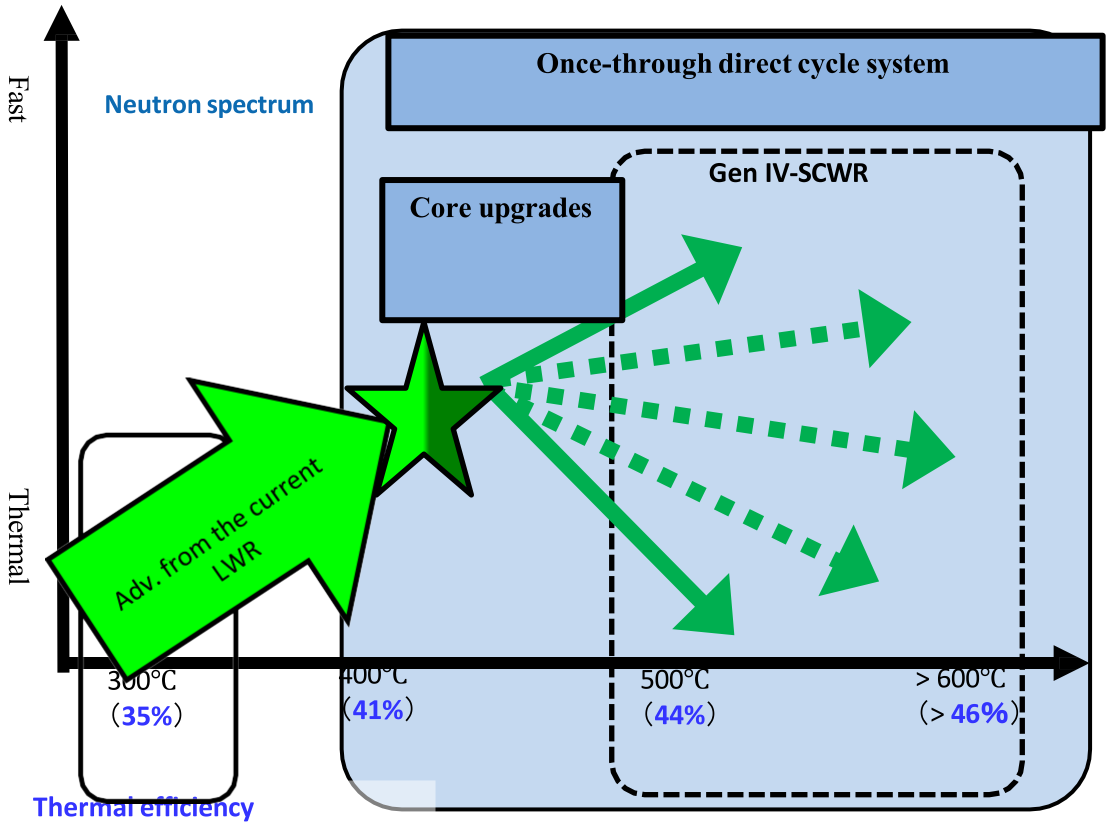
Aleshchenkov, P.I., Mityaev, Y.I., Knyazeva, G.D., Lunina, L.I. Zhirnov, A.D. and Shuvalov, V.M. 1964. The Beloyarsk nuclear power station I/N I.V Kurchatov. Atomnaya Energiya,16, 489.

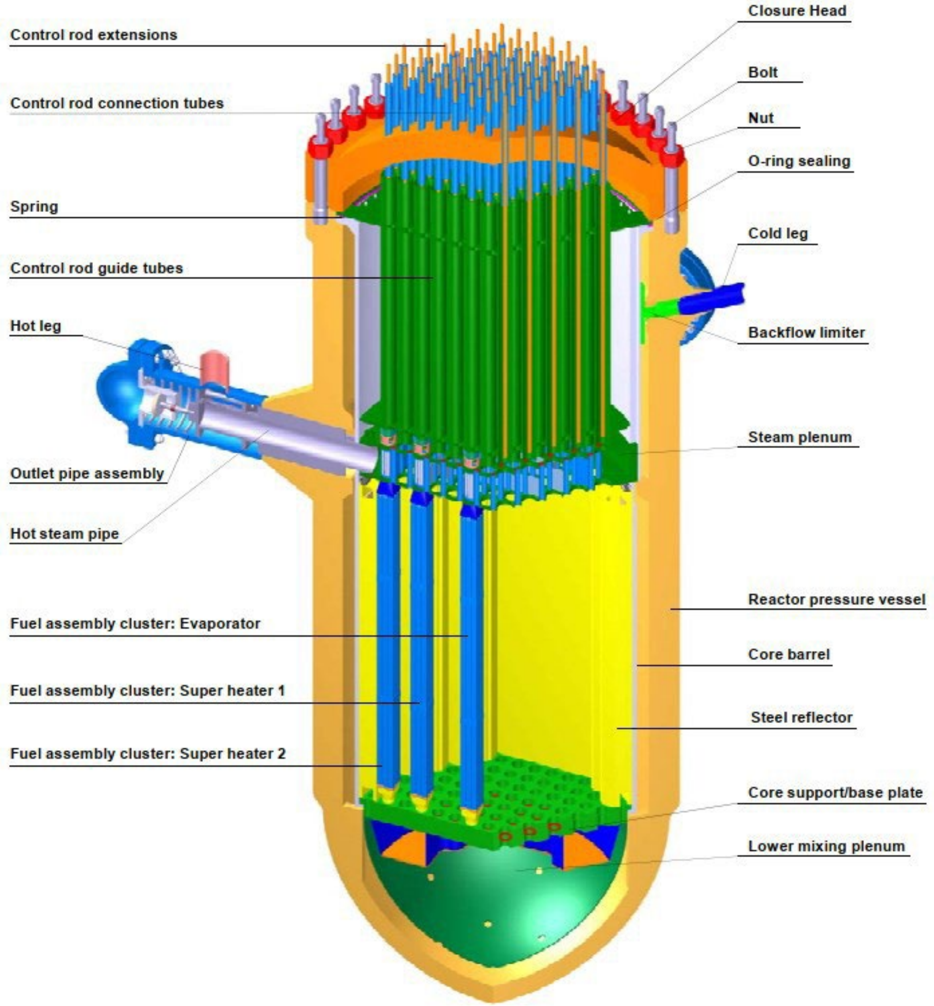
Super LWR and Super FR

- Prof. Oka from Japan worked on supercritical water-cooled reactors for many years.
- His work is the basis/foundation for most of the new SCWR concepts.
- Prof. Oka's book Super Light Water Reactors and Super Fast Reactors summarizes the process of conceptualization for an SCWR.
- Multiple Universities in Japan are working on SCWRs.
- Prof. Akifumi, from Waseda University is working on SCWRs.



High Performance Light Water Reactor

- Concept developed by the EU.
- HPLWR is a SCWR.
- Aiming at a new power of 1000 MW_e and a net efficiency of 44%.
- Core outlet temperature set at 500 °C.
- System pressure of 25 MPa.
- Vertical orientation.
- Two-flow passes.
- Safety systems borrowed from current LWRs.



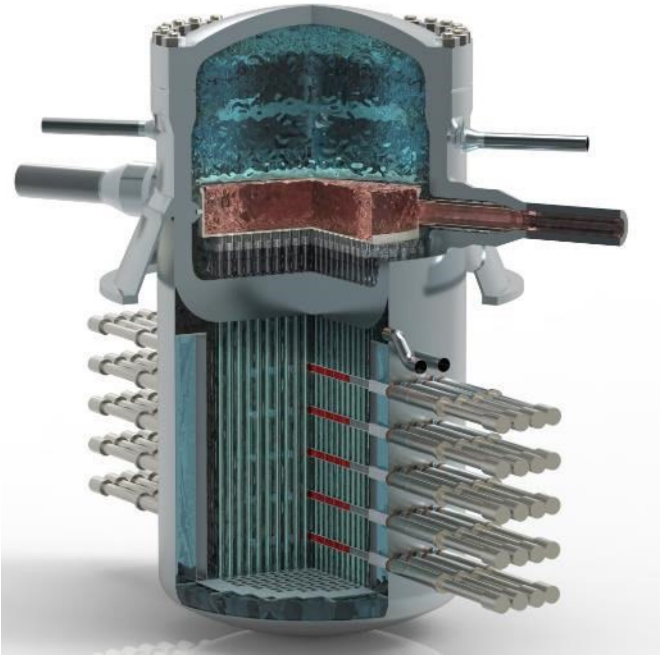
Starflinger J. & Schulenberg T. (eds.) 2012. High Performance Light Water Reactor : Design and Analyses. Karlsruhe: KIT Scientific Publishing. DOI: https://doi.org/10.5445/KSP/1000025989

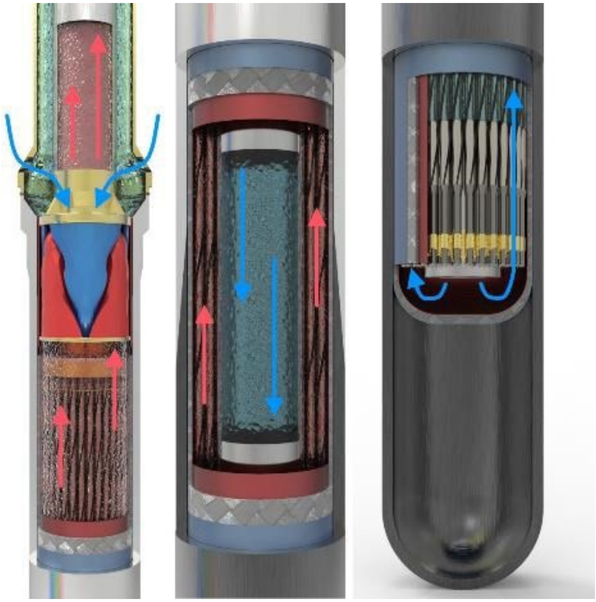
Canadian SCWR

- Canada also conceptualized the Canadian SCWR.
- Based on CANDU reactors (Canadian technology.)
  - Pressure tubes and heavy water moderated.
- However, some ideas were taken from LWRs:
  - Direct cycle.
  - Vertical orientation.
  - Safety systems from LWRs, such as ICS.

Operates at 25 MPa, with an inlet coolant temperature of 350 °C and outlet of 625 °C.

Thermal efficiency of ~48%.

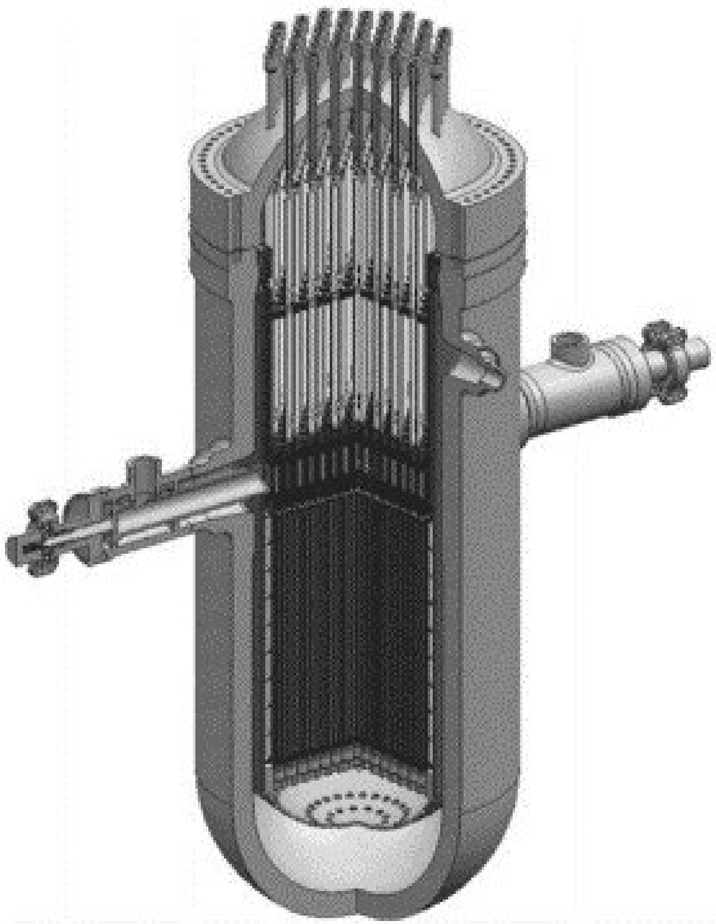


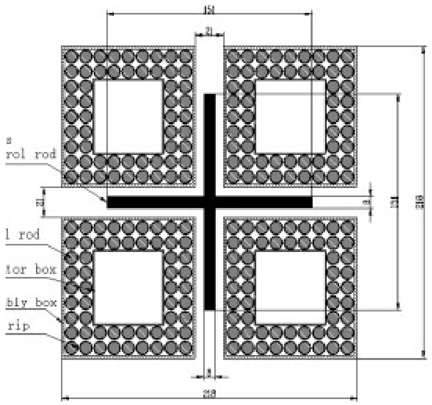


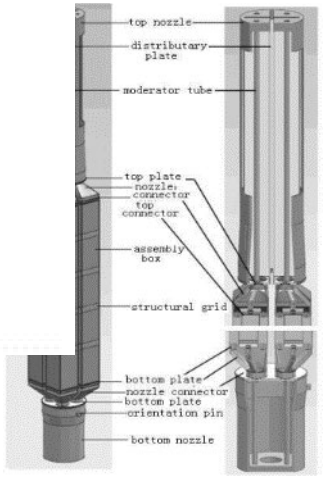
Pioro, I. L. 2023. "Handbook of Generation IV Nuclear Reactors: A Guidebook." *Handb. Gener. IV Nucl. React. A Guideb.*, 1–1079. Elsevier. https://doi.org/10.1016/C2019-0-01219-8.

CSR-1000

- China also developed a SCWR concept called the CSR-1000.
- Cooled and moderated with light-water.
- The primary circuit is a direct cycle consisting of a two-pass, thermal neutron reactor.
- Thermal power of 2300 MW_t
- Thermodynamic efficiency ~43.5%.
- Inlet coolant temperature 280 °C and outlet coolant temperature of 500 °C.



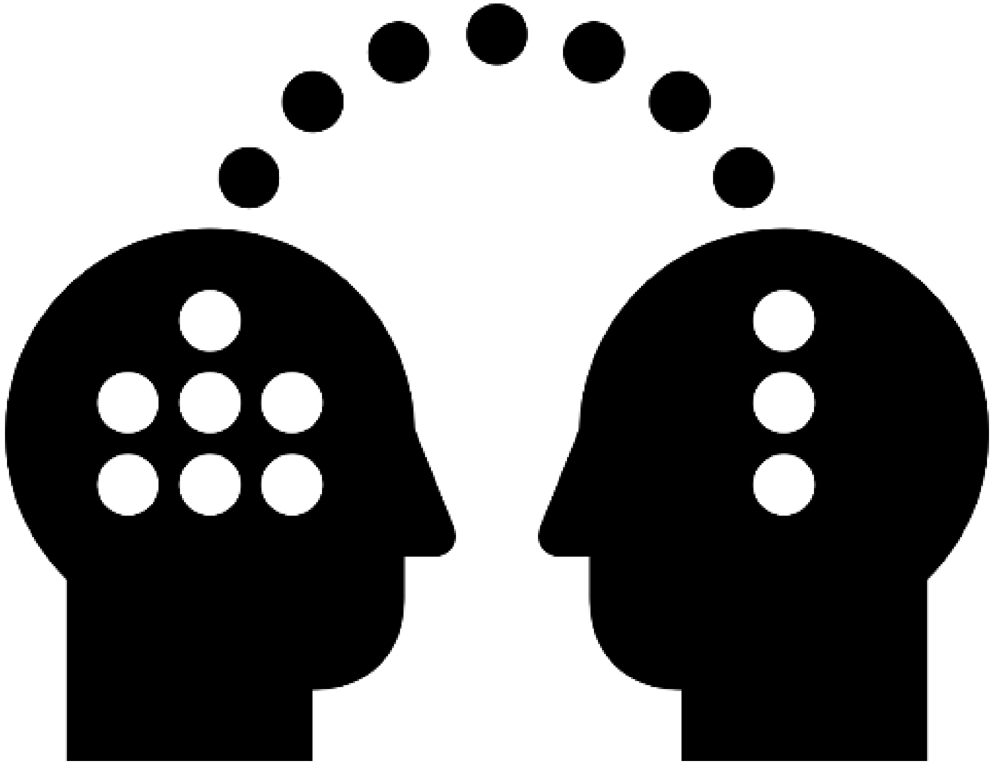




INTERNATIONAL ATOMIC ENERGY AGENCY, Status of Research and Technology Development for Supercritical Water Cooled Reactors, IAEA-TECDOC-1869, IAEA, Vienna (2019)

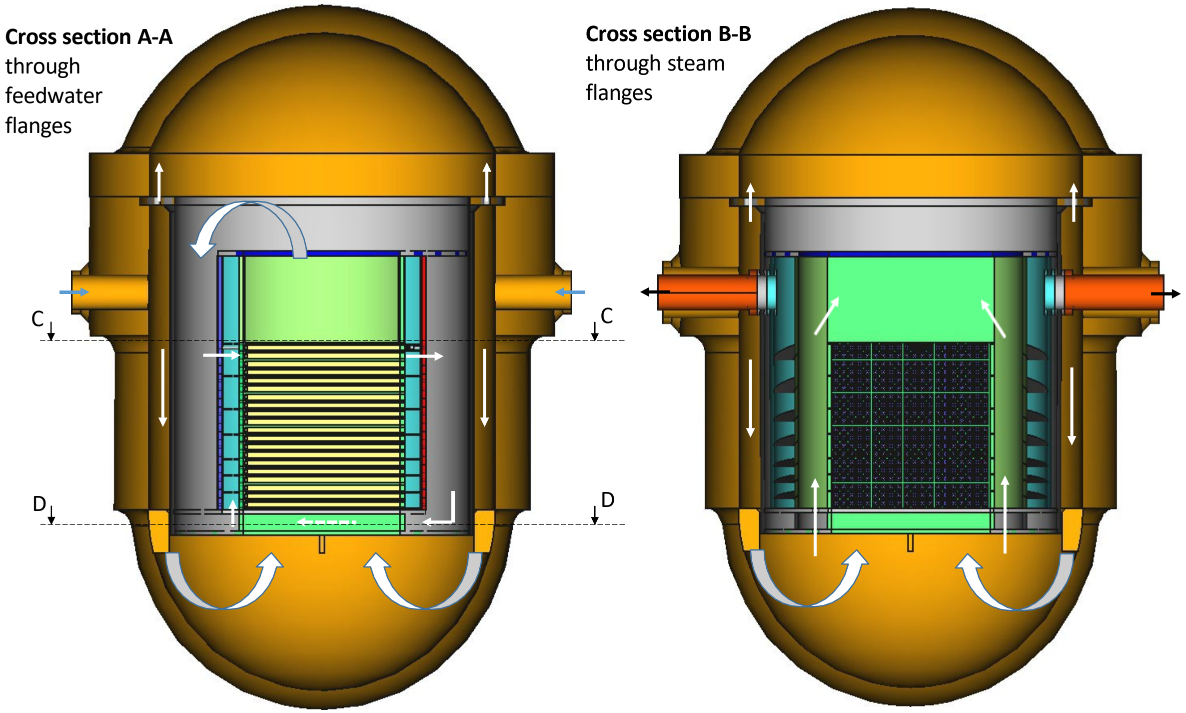
New SCWR Concepts

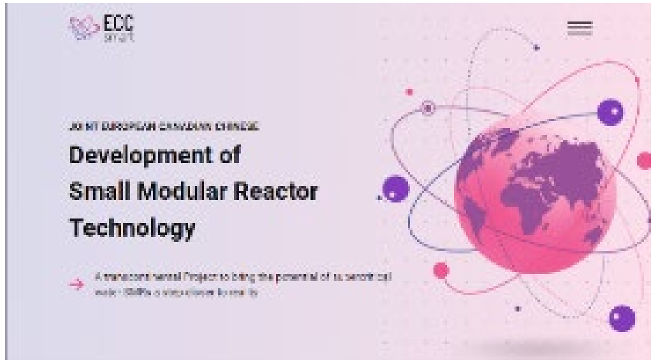
- The SCWR group faced a generational gap challenge.
- Multiple experts who developed SCWRs retired.
- New group took the initiative and proposed a new project under the Horizon 2020 platform in the EU.
- Canada and China were invited to participate in the project.
- Aim to develop a supercritical water-cooled small modular reactor (SCW-SMR).

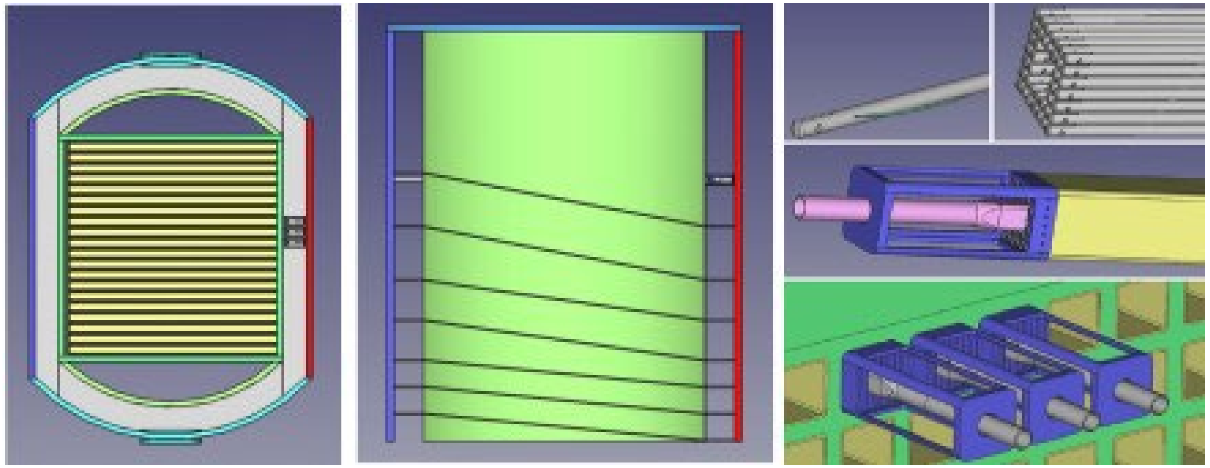


ECC-SMART

- Reactor developed by the EU.
- Support from various institutions.
- Main characteristics:
  - Horizontal orientation.
  - 80 MW_e.
  - 7 passages.



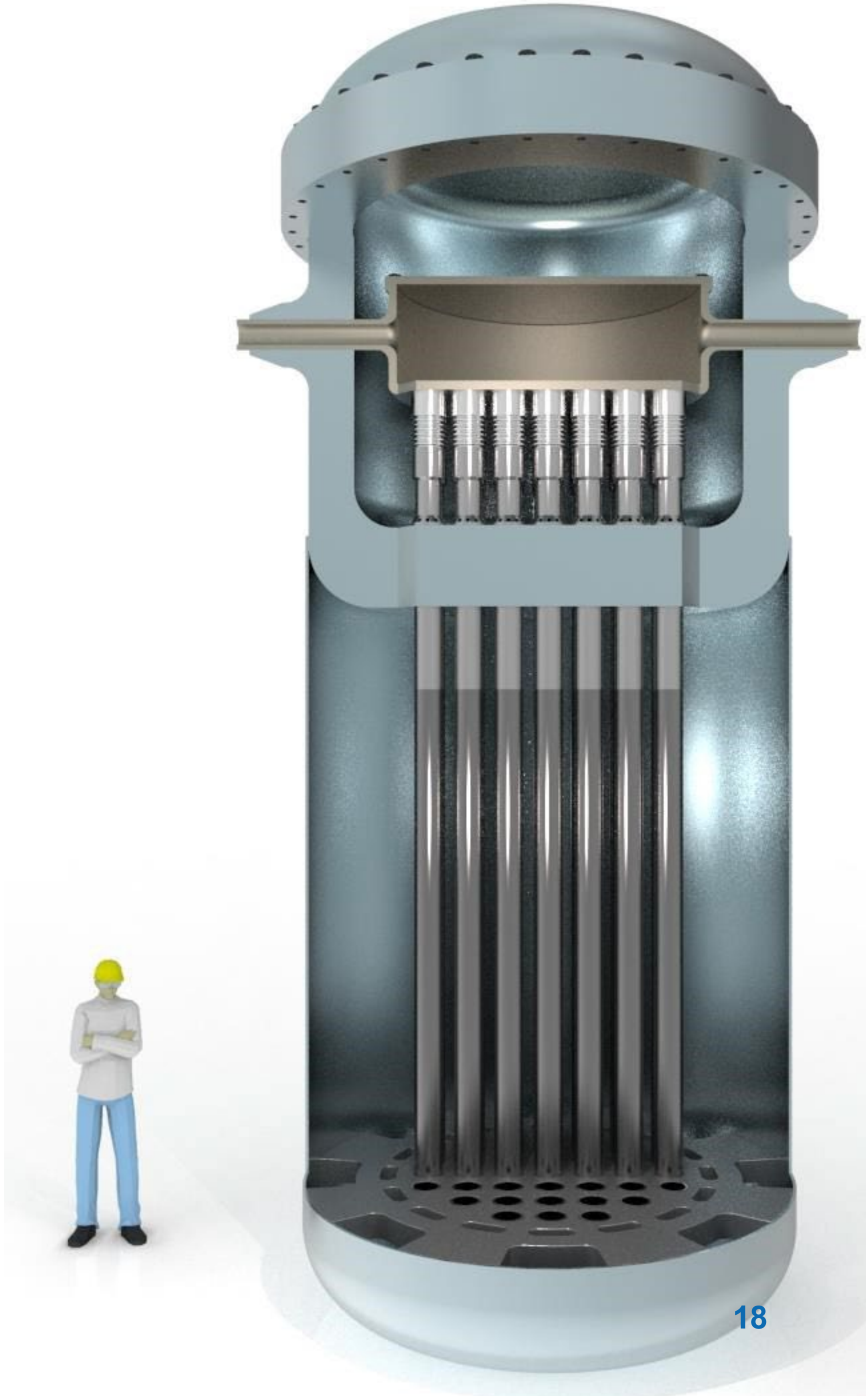




https://ecc-smart.eu/

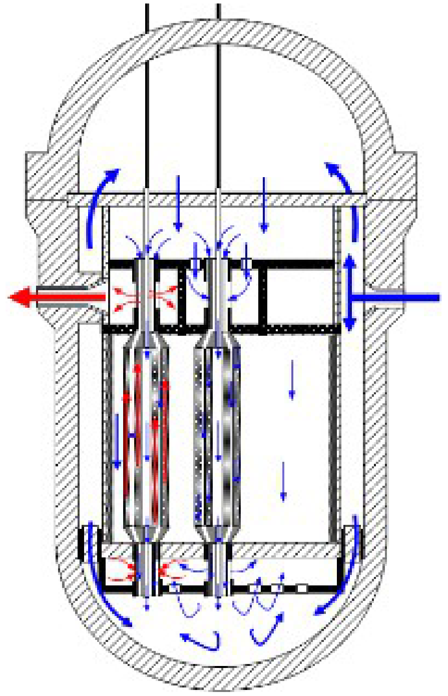
Canadian SCW-SMR

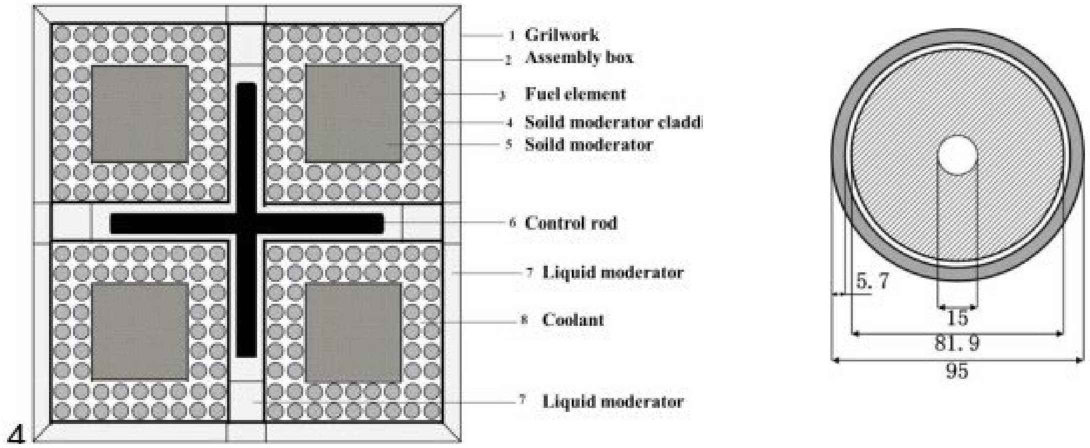
- CNL is working on this concept.
- Based on the Canadian SCWR.
- Scaled-down version.
  - 188 fuel channels.
  - 4 m active length.
  - Inlet coolant temperature 290 °C.
  - Outlet coolant temperature 500 °C.
  - Pressure 25 MPa.
  - 300 MW_e.



CSR-150

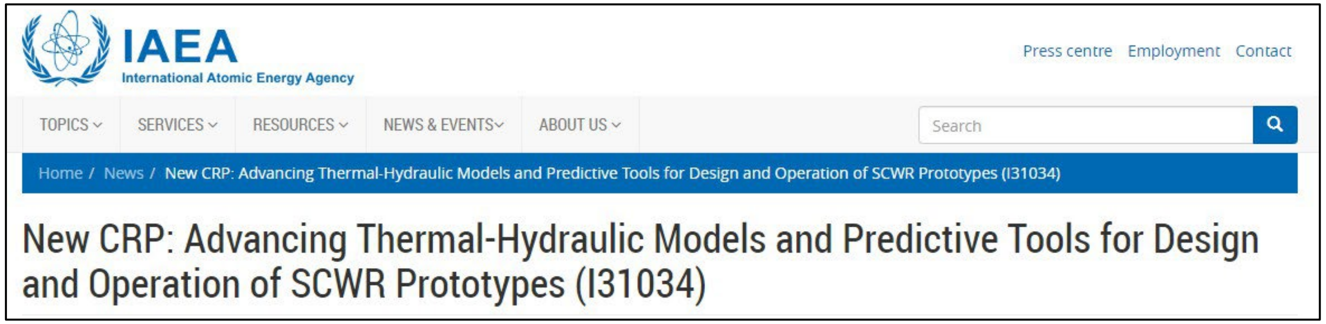
- NPIC is working on this concept.
- Based on the CSR-1000.
- Scaled down version.
  - 45 fuel channels.
  - 2.5 m active core length.
  - Inlet coolant temperature 280 °C.
  - Outlet coolant temperature 520 °C.
  - Pressure 25 MPa.
  - 150 MW_e.

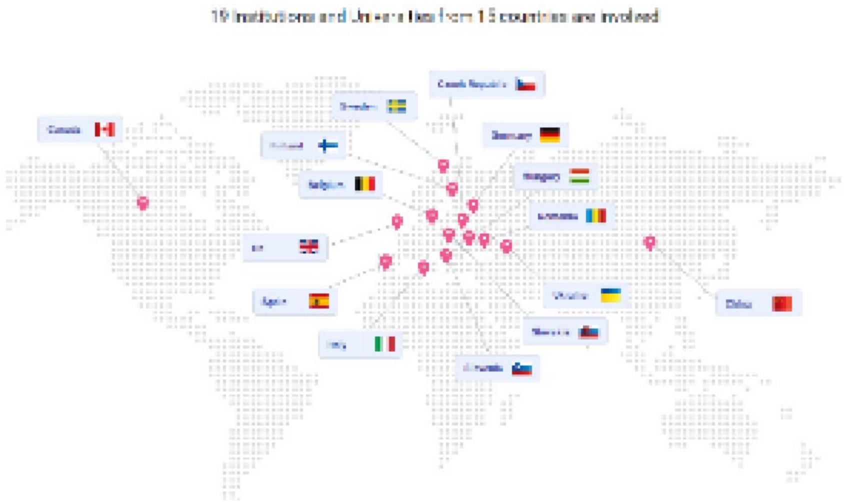




Collaborations supporting GIF SCWR

- SCWR TH&S **PMB**.
- SCWR M&C **PMB**.
- The **ECC-SMART** project.
- **IAEA CRP** “Advancing Thermal-Hydraulic Models and Predictive Tools for Design and Operation of SCWR Prototypes.”

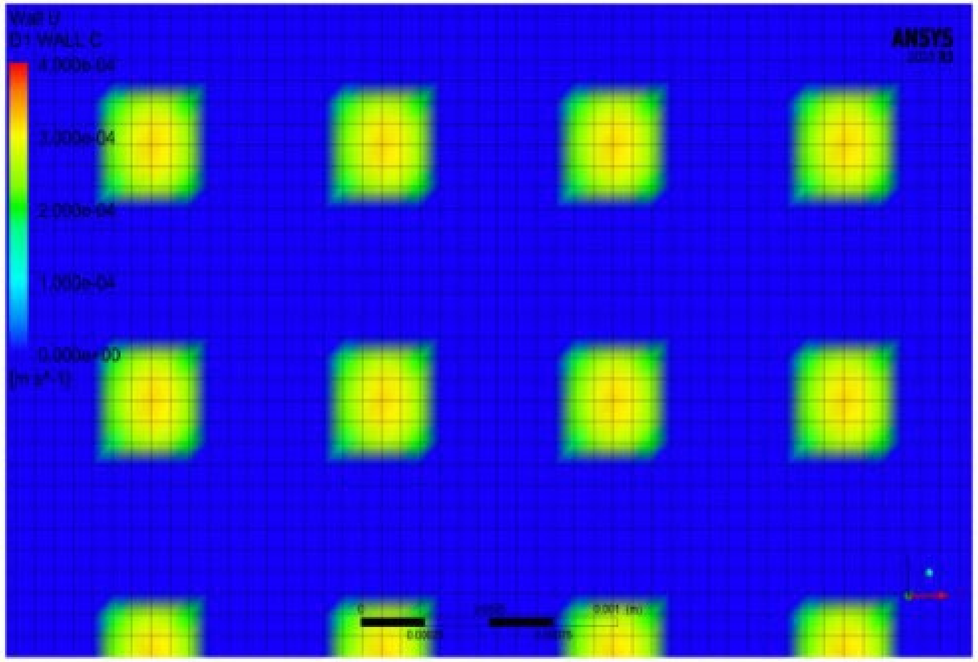


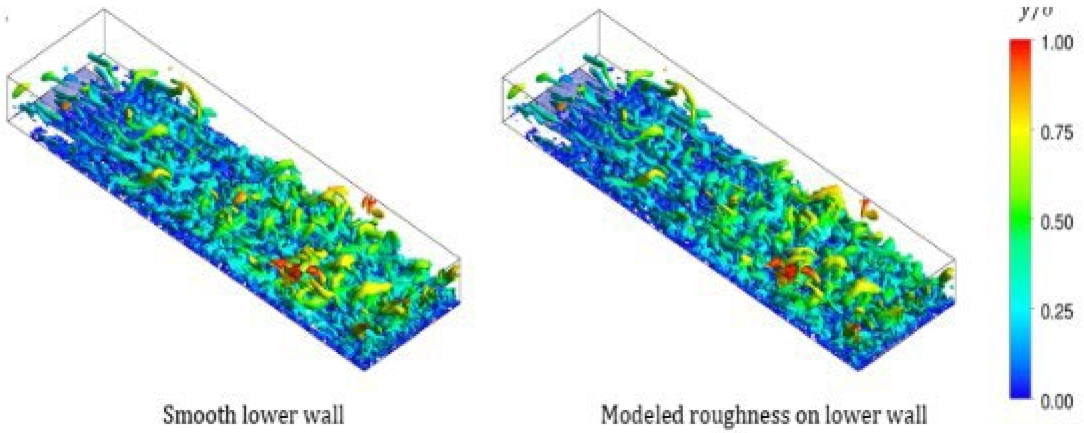


Thermalhydraulics and Safety

Heat Transfer

- Heat transfer under supercritical conditions.
- Experimental campaigns.
- Several experimental datasets are available now.
- Multiple geometries and fluids have been used in the experiments.
- Allow for verification of CFD, subchannel and system codes.
- Multiple international benchmarks have been carried out —latest organized by NPIC.
- Correlation and model development.
- CHF near the critical point needed for start-up and shutdown of SCWRs.



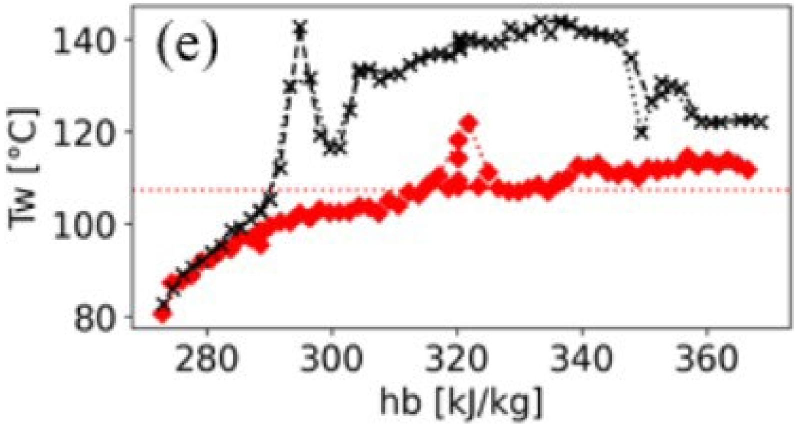


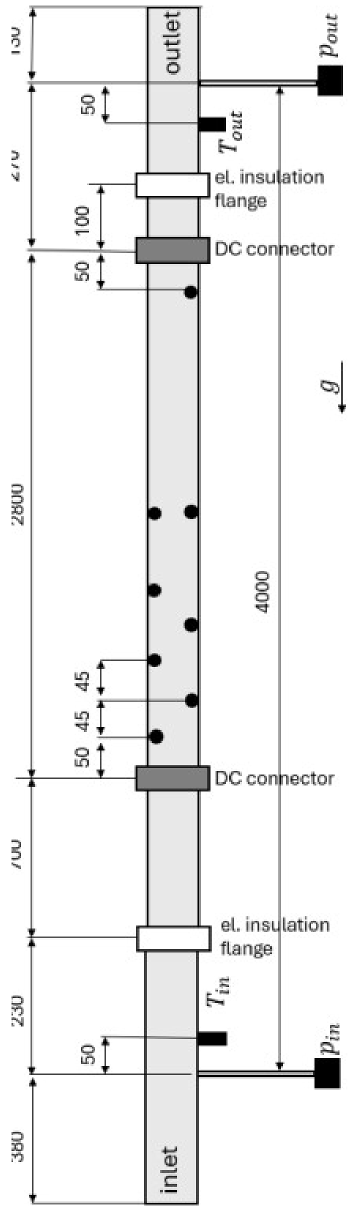
Heat Transfer

- KIT carried out experimental campaigns under the ECC-SMART.
- KIT (Germany) and CVR (Czech Republic) worked together to prepare the test section.
- Test section has internal rough surface.
- Study the effect of surface finishing on heat transfer.
- Data shared among participants.
- Heat transfer deterioration delayed.

Karlsruher Institut für Technologie

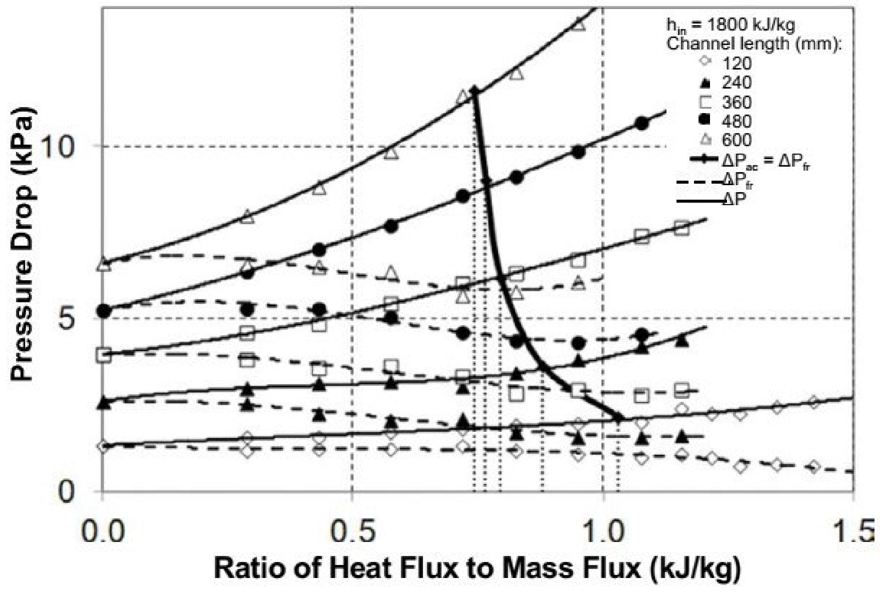
CVŘ Centrum výzkumu Řež

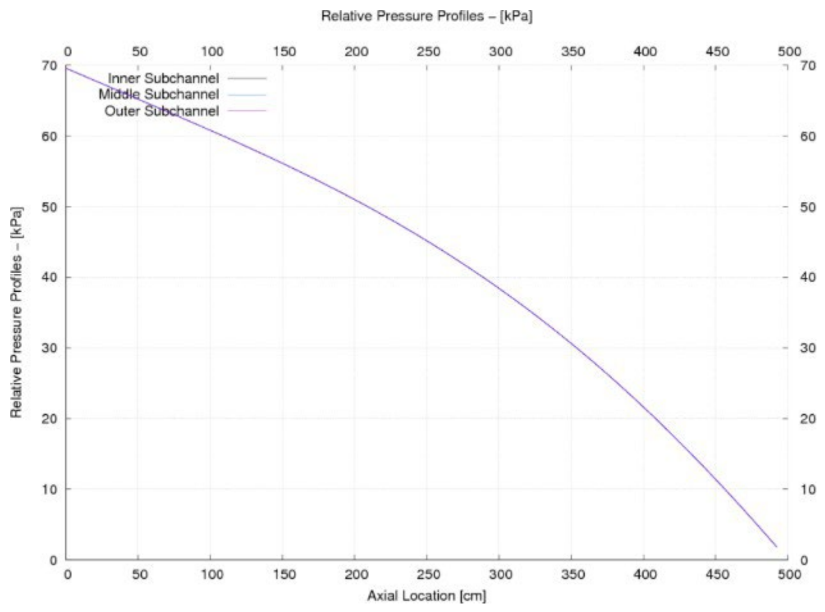




Hydraulic Resistance

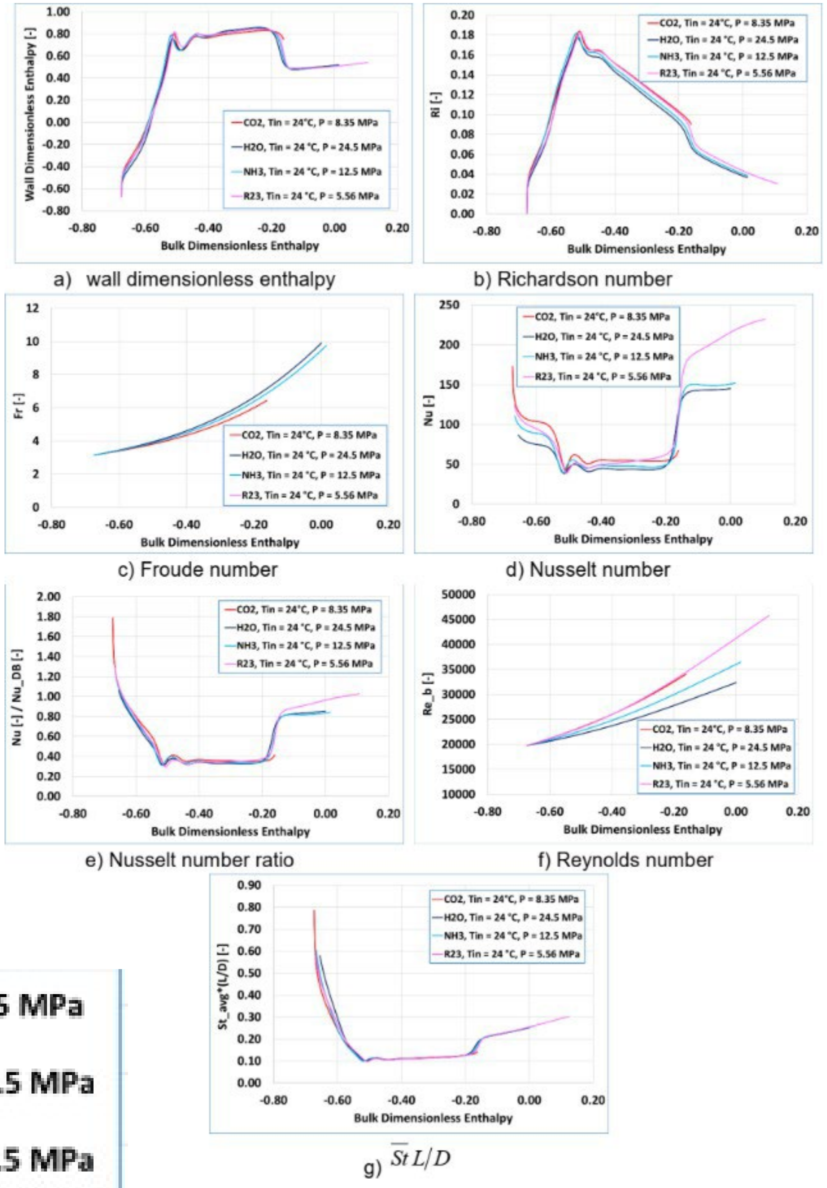
- Important to properly dimension pumps and estimate pressure losses.
- Correction factors proposed for friction.
- Several datasets available.
- Recent data from KIT is valuable for understanding the effect of diabatic rough surfaces on hydraulic resistance.

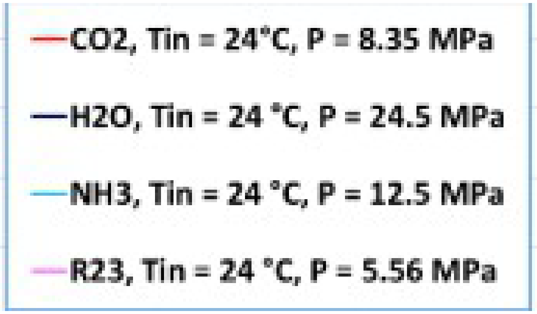




Similarity studies

- Several institutions are working on this area.
- However, the University of Pisa is leading this effort.
- The adoption of the fluid-to-fluid similarity theory allows for identifying boundary conditions that, if properly imposed to different fluids, may produce similar heat transfer behaviour no matter the fluid properties.
- Further understanding of the role of dimensionless numbers in the development of correlations.





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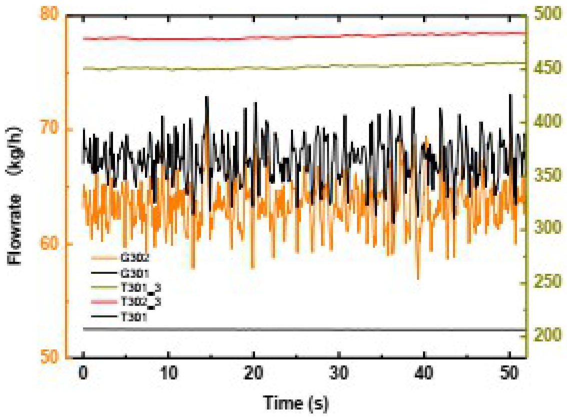
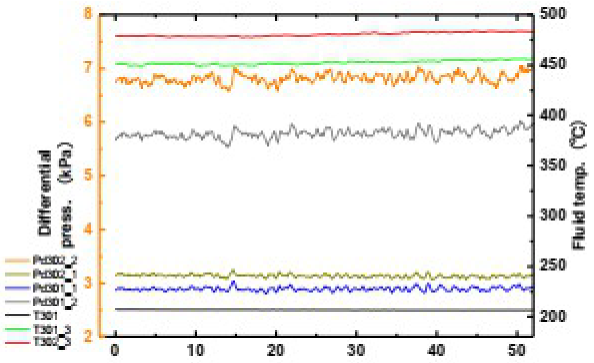
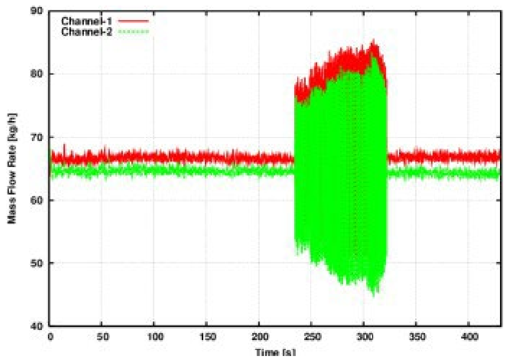
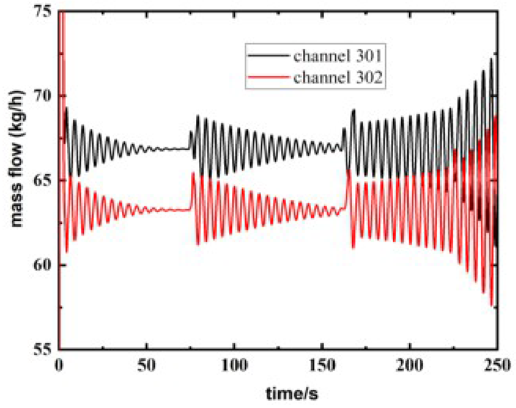
Flow instability

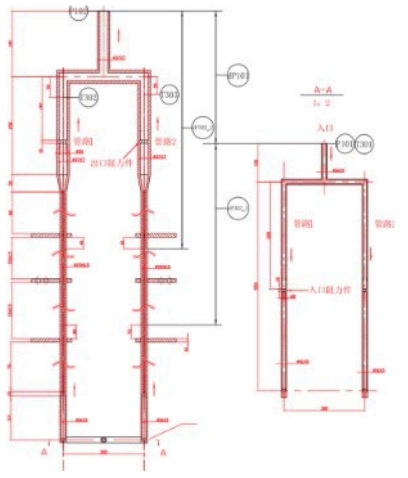
- Similarly to BWRs, SCWRs experience a change of density across the reactor core.
- Need to study the possibility of flow instabilities.
- Multiple experiments have been performed, including natural circulation and parallel channel instability.
- International benchmark under the ECC-SMART project called *International benchmark study on SCWR thermalhydraulic characteristics (IBSCTH).*

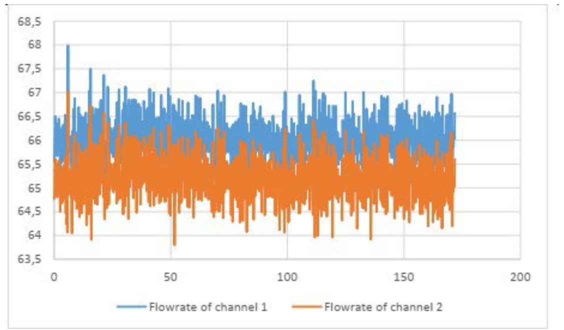






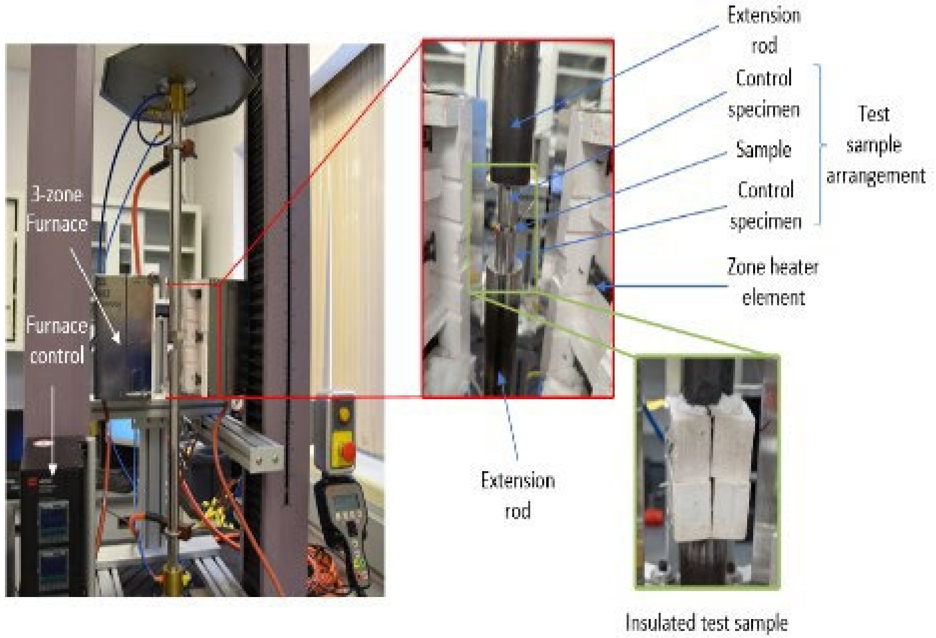


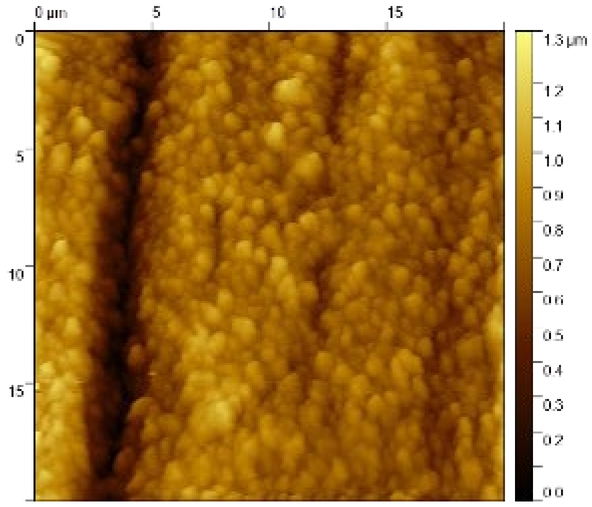


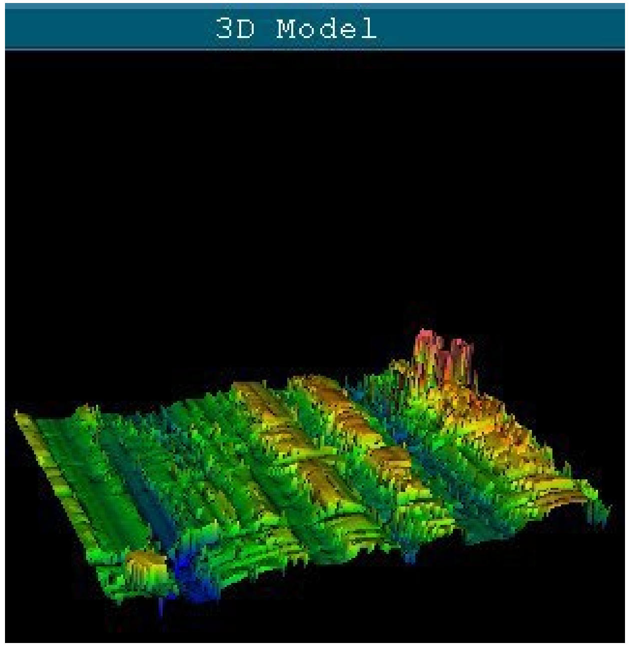


Surface finishing

- Supercritical water is a corrosive environment.
- Understand the effect of increased roughness on the cladding material.
- Effect of surface finishing on heat transfer and hydraulic resistance.
- Delay of heat transfer deterioration.
- Cross-cutting activity.







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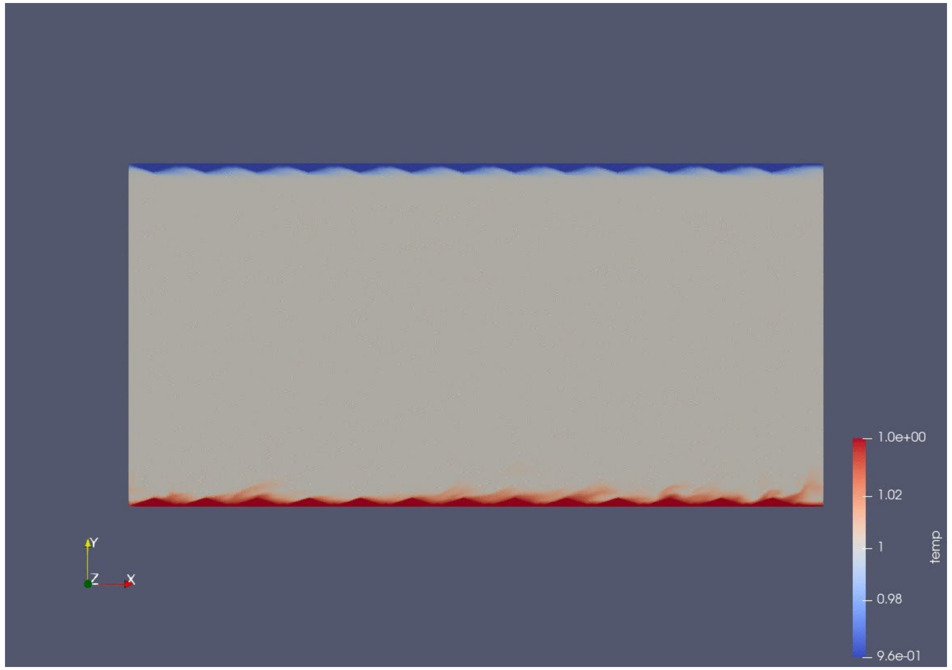
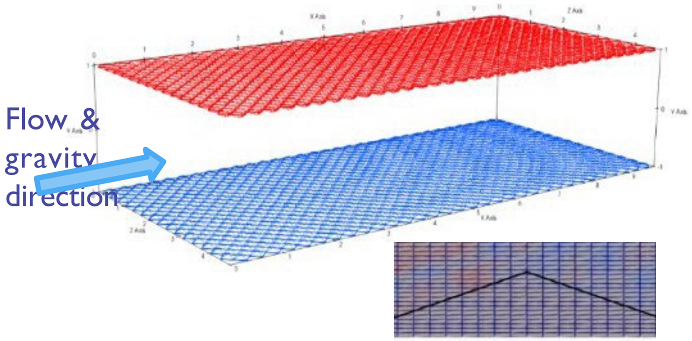
Surface finishing

- KIT experiments.
- DNS studies carried out by KIT (Germany), University of Sheffield (UK), Carleton University (Canada).
- Direct numerical simulation (DNS) offers a good opportunity to complement experiments by providing detailed information on flow and thermal fields. This improves our understanding of the physics even though simulations are currently limited to low Reynolds numbers.



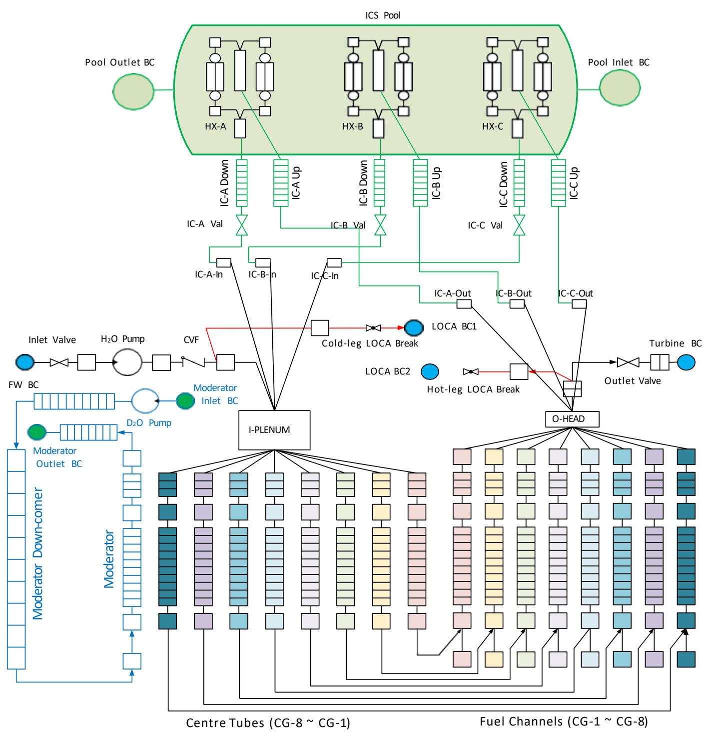


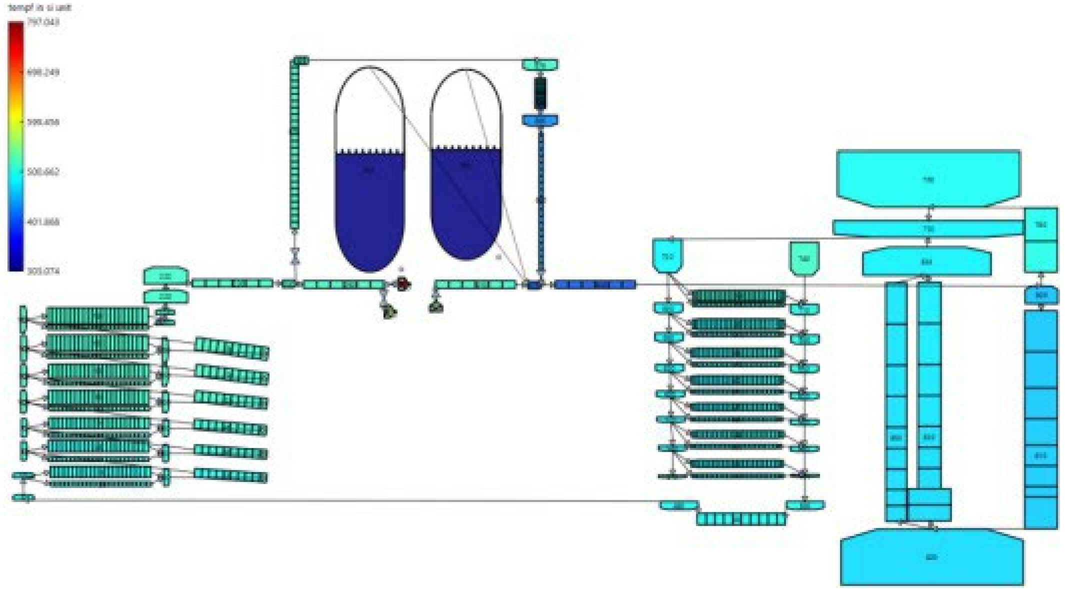
Resolution of roughness height in fluid mesh

Safety Analysis

- Components borrowed from LWR and PTHWR (e.g. CANDU).
  - LOCA.
  - Loss of feedwater accident (LOFA).
  - Station black out (SBO).
  - Japan working actively on this area.

CATHENA Idealization of SCW-SMR Concept with ICS



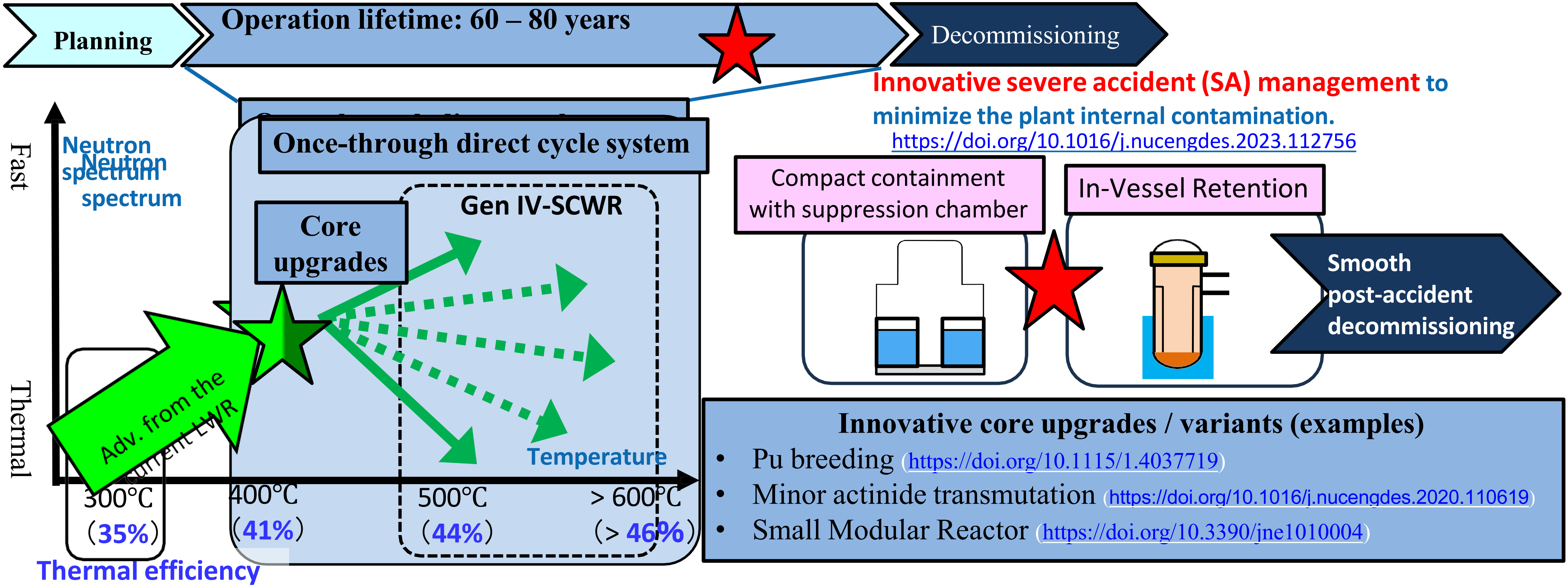


The Scope of Japanese SCWR R&D: Resilient SCWR Development

- The conceptual development of the **once-through direct cycle system** started in 1989 (The Univ. of Tokyo→ Waseda Univ.).
- After the Fukushima Daiichi accident (2011), the conceptual development at Waseda Univ. in collaboration with Tohoku Univ., Osaka Univ., and JAEA aims for **improved RESILIENCE in R&D**. **The TWO key points are:**

Technical continuity from **the current technology** and the **core upgrades during the operation lifetime**.

Innovative SA management to minimize the plant internal contamination for **smooth post-accident decommissioning**.



Materials and Chemistry

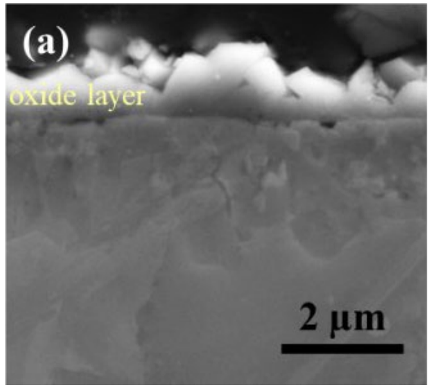
Workshop on structural materials for Gen-IV SMR concepts

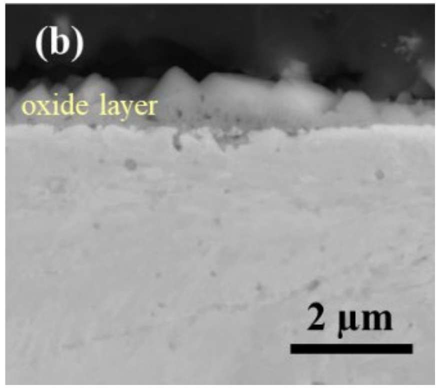
- In November 2023, a workshop on structural materials for Gen-IV SMR concepts was organized under the ECC-SMART project.

The workshop on structural materials for IV generation small modular reactors held in CIEMAT (Madrid) was a significant opportunity for engineers, researchers, and students to gather together on a future-oriented theme. Not only did the meeting update the community on internationally performed activities and European projects but also it showcased results of ongoing projects such as ECC-SMART. It also provided valuable insight into the state of advanced materials, different nuclear systems, licensing processes, data management and research on accident-tolerant fuels. Furthermore, it proved to be an excellent opportunity for university students to learn about upcoming summer schools and workshops related to the topics. The workshop provided a unique space for networking and engaging in discussions about the future of the systems, as well as addressing questions that remain unanswered.

Oxidation

- Identify a suitable cladding candidate for SCWR conditions.
- Corrosion experiments using autoclaves.
- Two international round-robin tests were completed.
- Currently assessing:
  - Alloy 800H.
  - Stainless steel 310S.
  - Aluminum Forming Alloy (AFA).
  - Chromium coated Zircaloy.





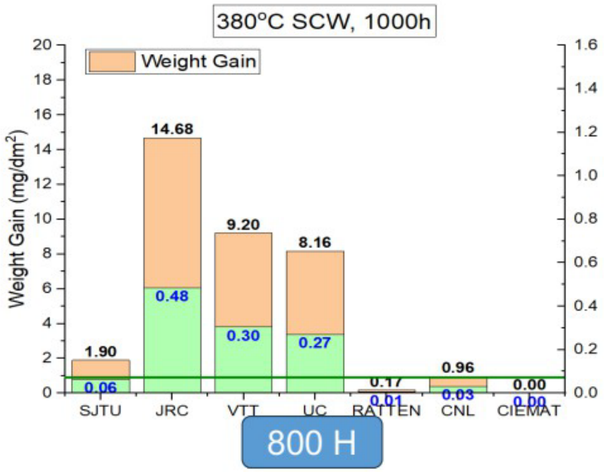
Oxidation

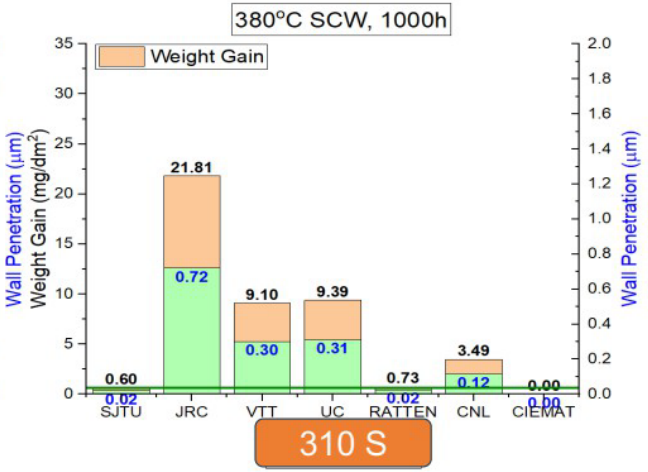
- Oxide growth experiments.
- A large databank is now available.
- ECC-SMART project is evaluating results to propose an improved model.
- SJTU proposed a harmonization process for carrying out experiments.
- Information needed as part of design limits.
- Materials and water chemistry for SCWRs book (By D. Guzonas).
- 3rd international round-robin under discussion.

Test Temperature (°C)	Pressure (MPa)	Test Duration (h)*	Oxygen Concentration (ppb)	Test Type #
380	23	1000 and 7000	150	Immersion Corrosion & SSRT
380	25	1000 and 7000	150	Immersion Corrosion & SSRT
500	23	1000 and 7000	150	Immersion Corrosion & SSRT
500	25	1000 and 7000	150	Immersion Corrosion & SSRT
1200 (steam)	1	Few hours	-	Loss of Coolant Accident (LOCA) simulated conditions

SSRT (Slow Strain Rate Testing): compares crack initiation in thin-walled components like cladding; Immersion Corrosion testing: analyzes oxide layer formation and stability; LOCA (Loss of Coolant Accident) test: tests material response to extreme thermal and pressure conditions. * SSRT tests were performed until specimen fracture.

NOTE: 380°C is close to the $T_{critical}$ of water and 500 °C is the average operating T of the SMR-SCW. Both are relevant from a corrosion and reactor design perspective.





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Oxidation at LOCA conditions

- VTT, as part of the ECC-SMART project, conducted oxidation experiments at 1200°C with steam.
- Support design basis accidents LOCA and SBO.

Corrosion tests are ongoing; preliminary results from A800H and 310S corrosion tests after 1000 hours are shown below:

A) At 380°C, Alloy 800H exhibits lower weight gain and both alloys show a low wall penetration (calculated based on the model proposed by David Guzonas). At 500 ºC both alloys see increased weight gain as it is expected due to the effect of temperature, but 310S maintains superior overall performance with lower weight gain and wall penetration (< 20 μm wall penetration in 30000h at 500 ºC). it is reasonable considering the higher Cr content in SS 310S. The data also highlights significant variability between laboratories, underscoring the influence of testing conditions on material behavior.

B) Results from SSRT show intergranular crack initiation sites on alloy 310 S only at 500 ºC (SSRT with A 800H and AFA are not finished yet).

C) At 1200°C, alloy 800H showed significant mass gain (~5 mg/cm²) with intact oxide layers, while steel 310S experienced mass loss due to oxide exfoliation. The thick oxide layers on 310S seem to contribute to its detachment, particularly after 15 hours of exposure.

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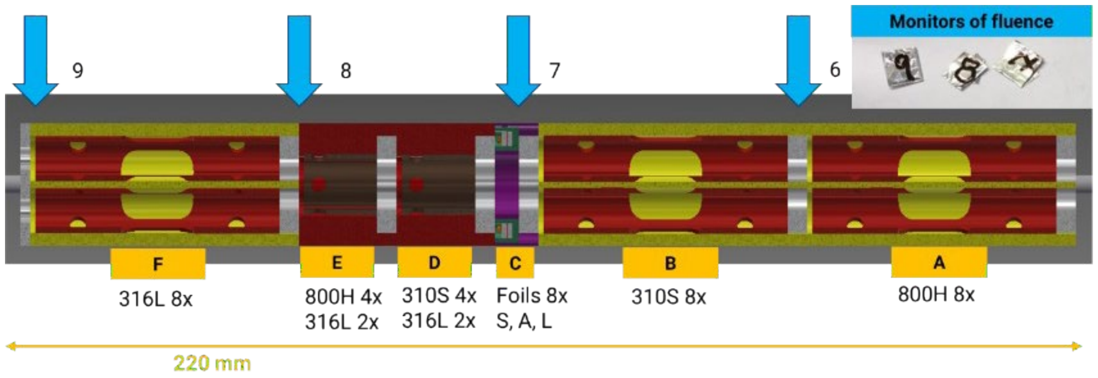
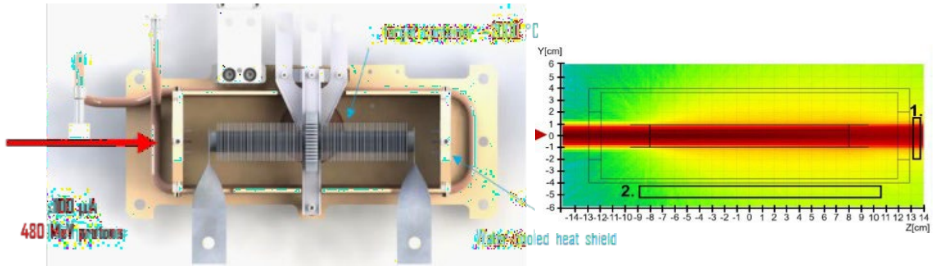
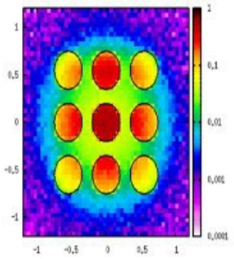
Radiation effects

- In addition to the effect of the flow conditions (i.e. pressure and temperature), radiation also impacts the material's properties.
- Transmutation of elements.
- Displacement of elements.
- Change of mechanical properties overtime.
- CVR in the Czech Republic conducted irradiation experiments using the LVR-15 research reactor.
- CNL in Canada conducted high-energy proton irradiation using the TRIUMF accelerator (in British Columbia, Canada).
- Collaboration with University of Waterloo for He implantation.
- Results are under analysis.







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Workshop on PIE

- A Workshop on post irradiation examination (PIE) took place in CVR under the ECC-SMART project.
- International participation.
- Important to move forward on new reactor concepts.

Workshop on Post Irradiation – Examination (PIE)
26-30 August 2024

Research Center Rez

CVŘ | Centrum výzkumu Řež

The Post-Irradiation Examination (PIE) Workshop brought together experts in nuclear research to explore the latest advancements in PIE techniques. The workshop attracted a dynamic group of 20 early-career researchers and students, aged between 18 and 30, from across the globe, all eager to enhancing their research skills and academic expertise.

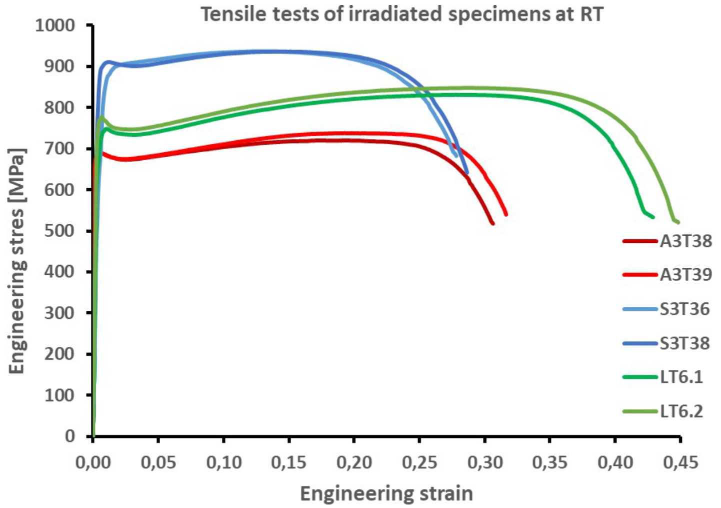
Participants gained insights on:

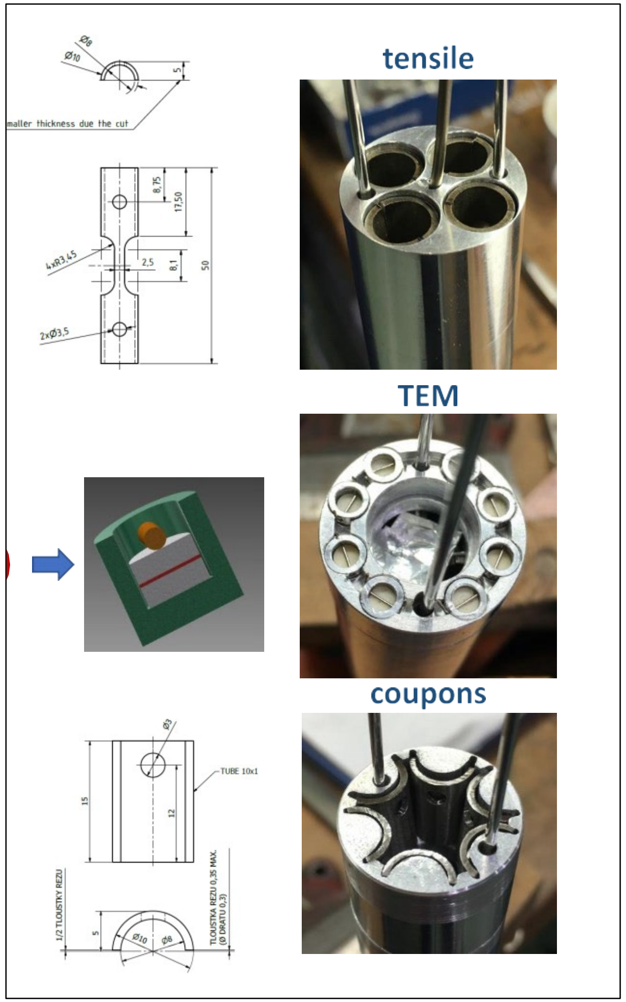
- Irradiation experiments
- Dosimetry
- Fuel inspection
- Safety regulations
- Advanced material testing
- Applications of PIE in future nuclear technologies

The workshop offered a comprehensive platform for sharing critical knowledge on the long-term operation and safety of nuclear reactors, along with hands-on experience through tours of research reactors and facilities.

Mechanical tests

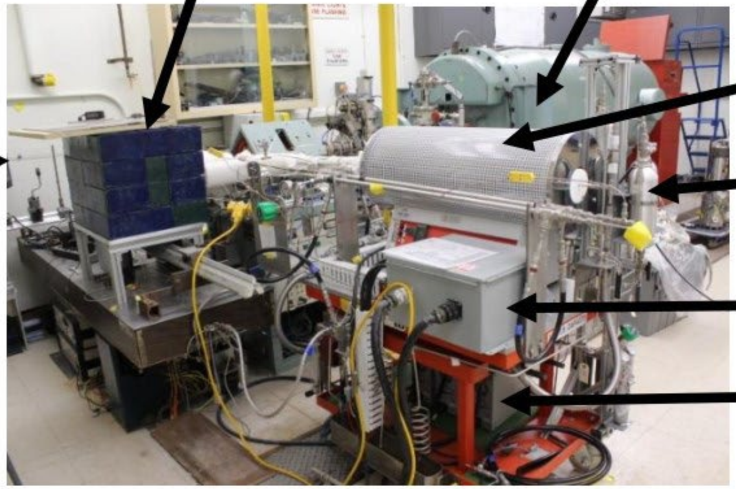
- Understand the material behavior after being exposed to SCW conditions and/or irradiation.
- Characterization of the material from the mechanical point of view.
- Yield stress and ultimate tensile strength.





Radiolysis

- The coolant of a nuclear reactor experiences irradiation as well.
- Water radiolysis is the breakdown of water into its constituent parts by ionizing radiation.
- These new species need to be removed/controlled from the system.
- However, there is very little information of radiolysis under SCW conditions.
- Preliminary results point out that it is possible to suppress the radiolysis.
- Mainly computational analyses have been completed, but we need experimental data to verify the predictions.
-



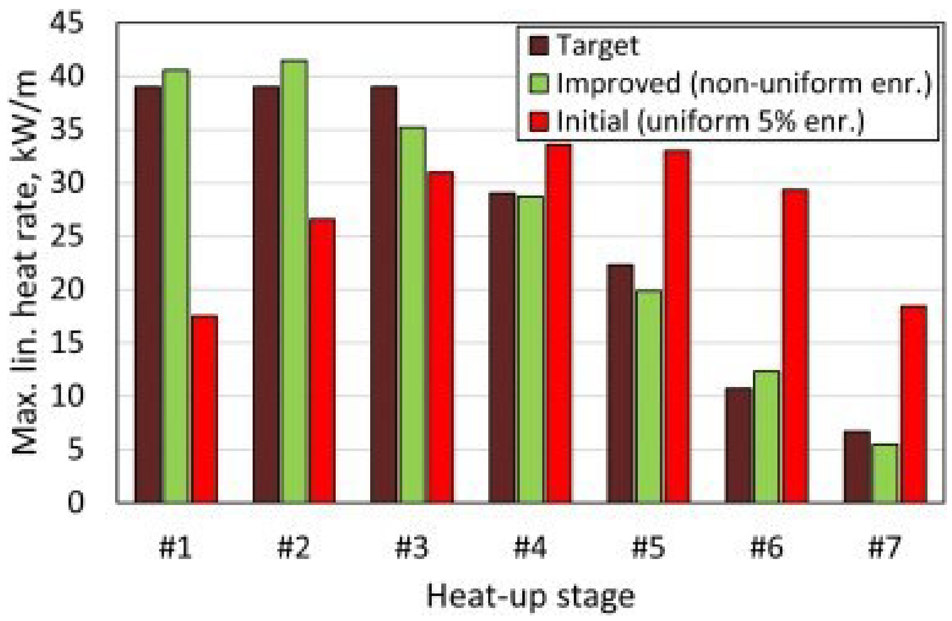
Supercritical water rig

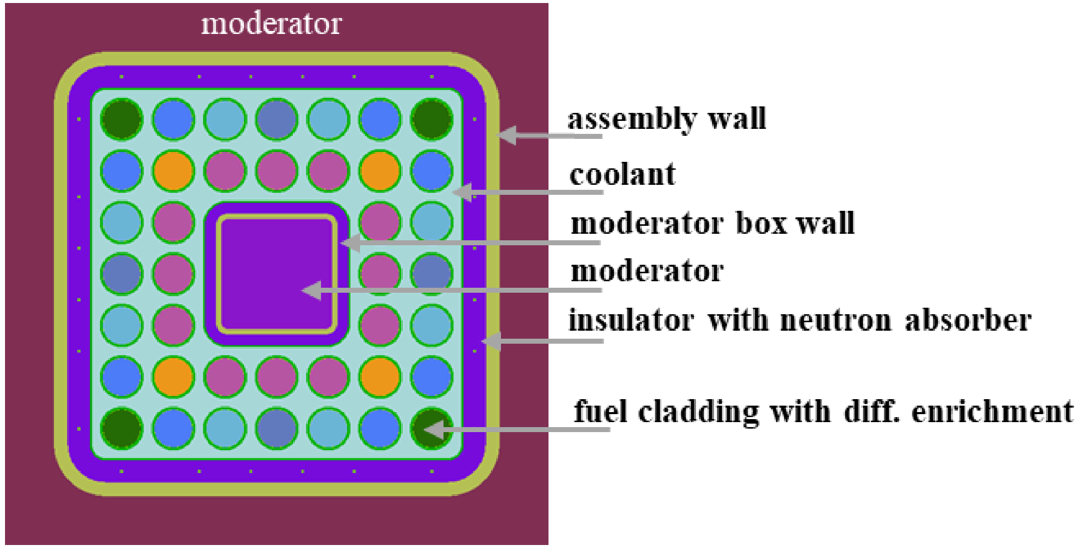
Corrosion product transport

- Another important area is corrosion product transport.
- Most SCWRs proposed a direct cycle.
- Conversely to BWRs, no dryers and steam separators are needed in SCWRs. However, knowing what type of corrosion products are transported to the turbine is important.
- CNL is currently working on this area.
- Improving the loop to have a better temperature control, and thus more reliable data.

Reactor Physics

- The University of BME conducted most reactor physics analysis.
- CNL and BME organized a benchmark to assess computational tools.
- Coupled physics code Serpent with the thermalhydraulics system code Apros.
- Obtained reactor power distributions for proposed ECC-SMART reactor.
- Core models were developed with special attention to the reactivity reserve, achievable cycle length (over 2 years without shuffling) and power distributions with the highest power generation in the first few heat-up stages.





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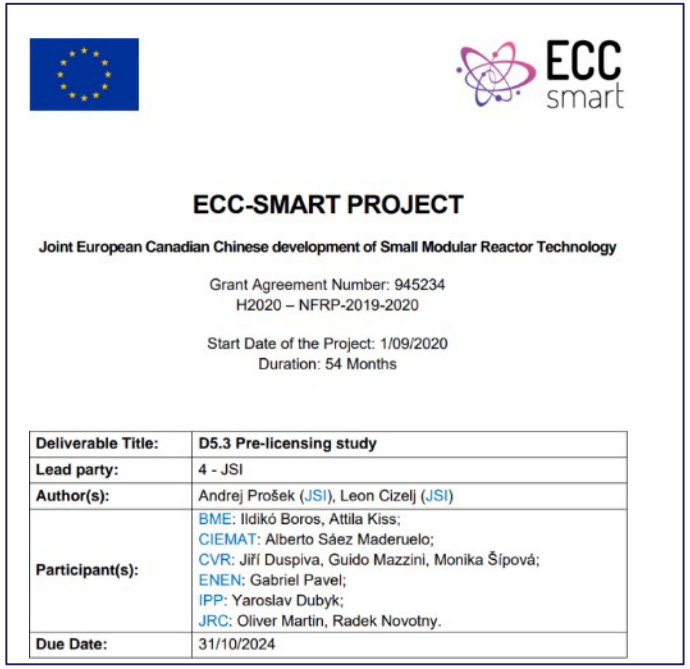
Licensing

- Under the ECC-SMART project, a work package called Synthesis & Guidelines For Safety Standards focuses on developing generic and specific safety criteria and requirements for the SCW-SMR concept.
- Current nuclear standards lack provisions for supercritical applications, including high pressure, high temperature, and the combination with neutron irradiation.
- Under the GIF RSWG, two design requirements documents for SCWRs were completed.
- Under the ECC-SMART, a new pre-licensing document was completed.



ECC smart

ECC-SMART PROJECT

Joint European Canadian Chinese development of Small Modular Reactor Technology

Grant Agreement Number: 945234
H2020 – NFRP-2019-2020

Start Date of the Project: 1/09/2020
Duration: 54 Months

Deliverable Title:	D5.3 Pre-licensing study
Lead party:	4 - JSI
Author(s):	Andrej Prošek (JSI), Leon Cizelj (JSI)
Participant(s):	BME: Ildikó Boros, Attila Kiss; CIEMAT: Alberto Sáez Maderuelo; CVR: Jiří Duspiva, Guido Mazzini, Monika Šípová; ENEN: Gabriel Pavel; IPP: Yaroslav Dubyk; JRC: Oliver Martin, Radek Novotny.
Due Date:	31/10/2024

ECC smart

ECC-SMART PROJECT

Joint European Canadian Chinese development of Small Modular Reactor Technology

Grant Agreement Number: 945234
H2020 – NFRP-2019-2020

Start Date of the Project: 1/09/2020
Duration: 48 Months

Deliverable Title:	D5.1 Safety criteria and requirements for the SCW-SMR concept
Lead party:	Jožef Stefan Institute (JSI)
Author(s):	L. Cizelj, A. Prošek, M. Uršič, J.-C. de la Rosa Blul, O. Martin, A. Kiss, I. Boros, M. Hrehor, A. Toivonen, A. Nava-Dominguez, S. He, I. Otic
Participant(s):	JRC, CVR, KIT, BME, VTT, CNL, UoS
Due Date:	31/08/2021

Version Number: 0.1

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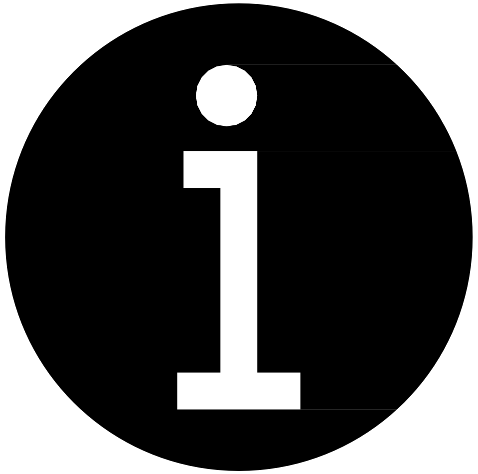
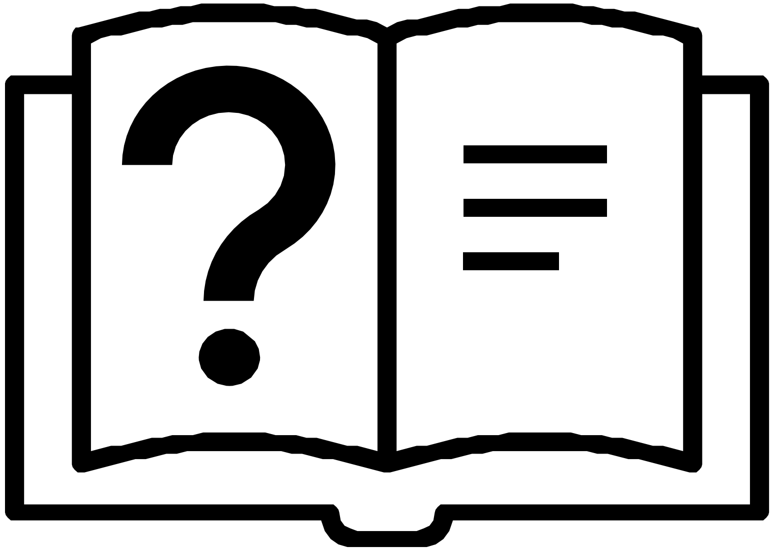
Knowledge gaps

- Neutronic cross-sectional data at SCW conditions.
- Radiolysis at SCW conditions.
- Corrosion product transport.
- CHF near the critical point.
- The effects of non-uniform power distribution on heat transfer.
- Natural circulation.
- Fuel qualification.





Advantages and disadvantages

- Supercritical fluids is a mature technology in the SC-FPP industry.
- However, never used in the nuclear power sector.
- Water-cooled reactors represent most commercial nuclear power plants.
- SCWR offers practicability.
- It is an ***EXTENSION*** of knowledge, not a different branch.
- Multiple system or components can be used from LWR, PTHWRs, and SC-FFP.
- Excellent platform to form highly qualified staff on water-cooled reactors.

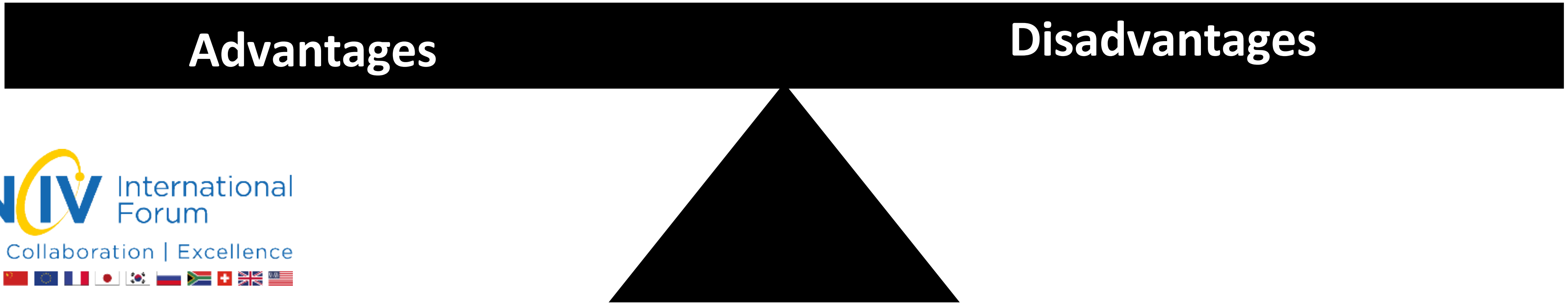
High-pressure system.

Supercritical term can be misleading. The word “critical” has several connotations.

Current water-cooled vendors are focused on Gen-III and Gen-III+ reactors.

However, sCO2 is becoming more popular in the nuclear industry.

Hyper-marketing is focused on non-water reactor technology.



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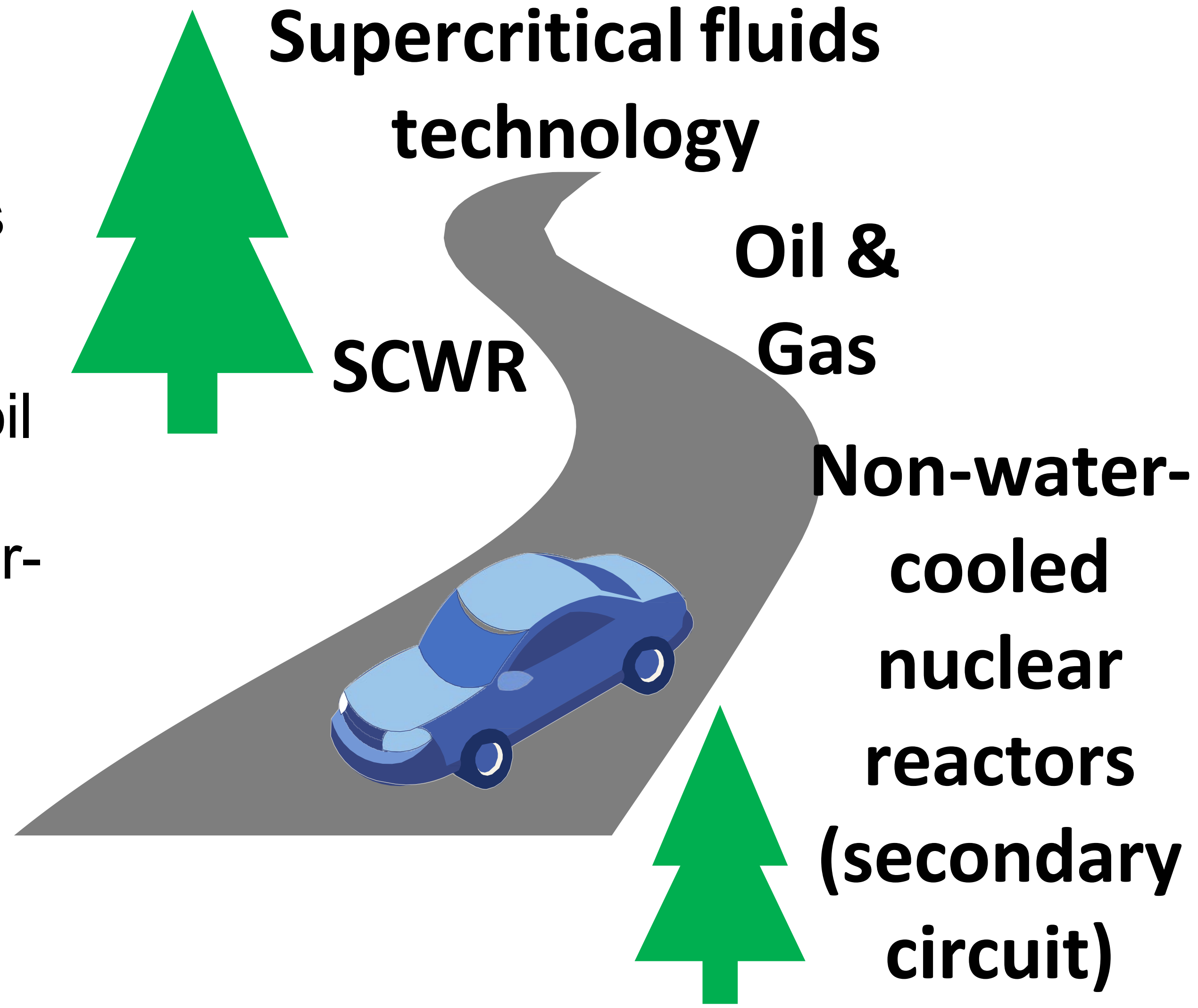
Opportunities

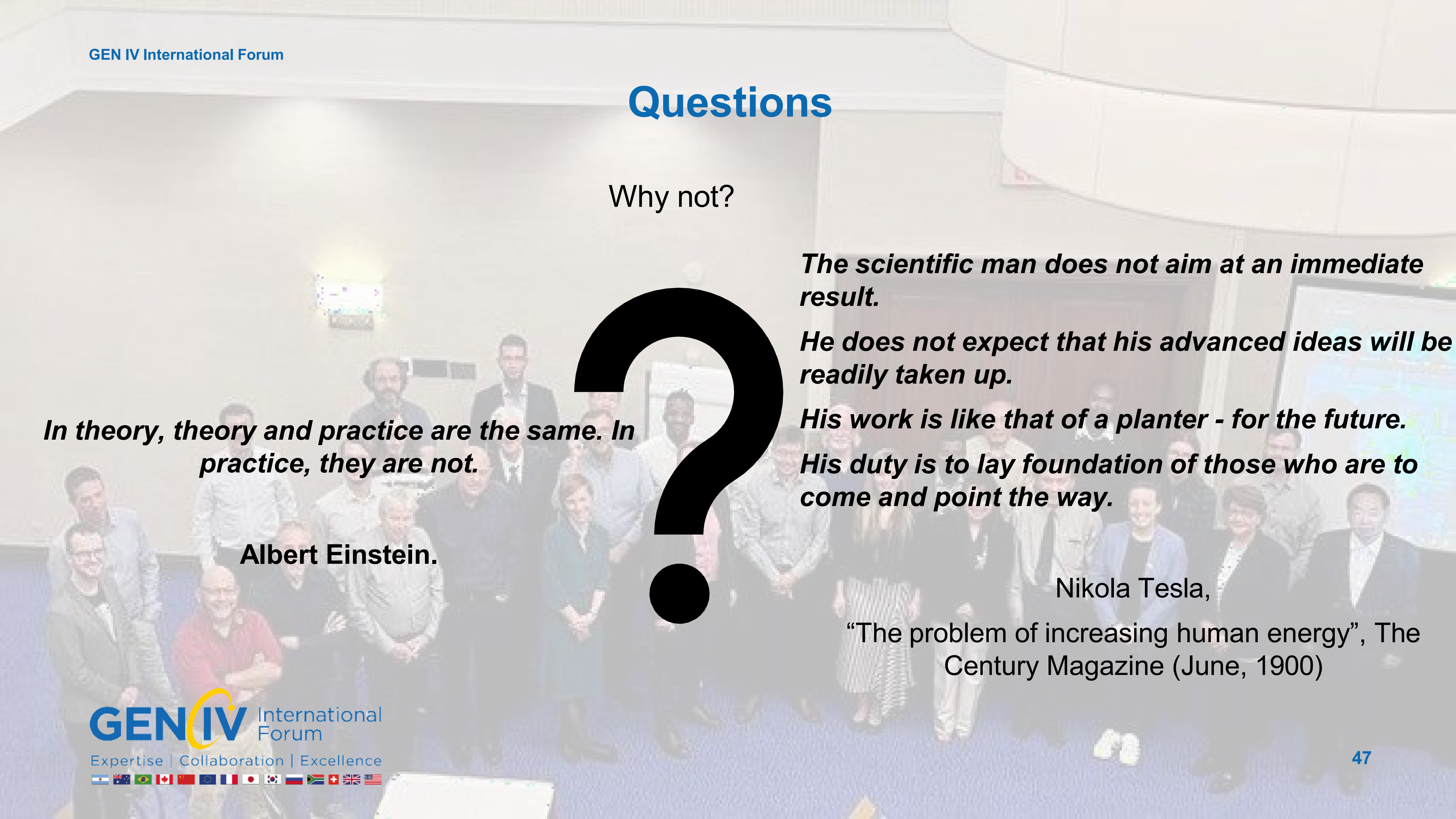
- Cross-cutting activity with non-water-cooled reactors.
- Several non-water-cooled reactors propose supercritical fluids for the secondary circuit.
- Work with other sectors, such as oil & gas sector to improve models.
- Pave the road for the Gen-IV water-cooled reactors.
- Support a smooth transition of water-cooled reactor technology.



Upcoming events

- The 11th International Symposium on Supercritical Water-Cooled Reactors will be held in Pisa.
- Thanks to Prof. Walter Ambrosini (University of Pisa) for supporting this technology and for his time in organizing this event.

Questions



Why not?

In theory, theory and practice are the same. In practice, they are not.

Albert Einstein.

The scientific man does not aim at an immediate result.

He does not expect that his advanced ideas will be readily taken up.

His work is like that of a planter - for the future.

His duty is to lay foundation of those who are to come and point the way.

Nikola Tesla,

“The problem of increasing human energy”, The Century Magazine (June, 1900)

Upcoming Webinars

Date	Title	Presenter
05 December 2024	Overview and Update of LFR Activities within GIF	Mariano Tarantino, ENEA, Italy
22 January 2025	Overview and Update of MSR activities within GIF	Jiri Krepel, PSI, Switzerland
12 February 2025	Overview and Update of VHTR activities within GIF	Gerhard Strydom, INL, USA