Grand Challenges

The Collaborative Computational Project in Nuclear Thermal Hydraulics CCP-NTH

The vision of the CCP-NTH community is to develop advanced modelling tools which incorporate the latest development in digital technologies and numerical algorithms, to improve nuclear reactor design and safety to help meet the UK's energy security goals and Net Zero commitments.

The Community

www.ccpnth.ac.uk

Next-generation nuclear reactors, that are currently under development, are aimed at achieving inherent safety using technologies, such as passive cooling. Such systems require a significantly advanced thermal-hydraulics approach to deal with much higher temperature pressure systems and/or non-conventional coolants, such as liquid metal and molten salts. The traditional methodology is insufficient to deal with the new challenges to be encountered. The aim of CCP-NTH is to support a community of researchers and engineers to develop and maintain computational methods and software packages which will modernise nuclear thermal hydraulics tools. These tools will meet the demands imposed through the development of advanced next generation nuclear reactor systems to be employed in the coming decades.

The Challenge

To transform computational thermal hydraulics capabilities that support the design, operation, and safety of nuclear reactors.

To meet the UK's energy security goals and Net Zero commitments, there is an urgent need to transform computational thermal hydraulics capabilities that support the design, operation, and safety of nuclear reactors. As the UK moves toward a low carbon and secure energy future, nuclear power continues to play a central role, and it is becoming increasingly important to develop advanced modelling tools that combine multiple physics processes operate across different scales and incorporate the latest digital technologies. These tools are essential for improving reactor design, ensuring safety, and supporting regulatory decisions. A key challenge is to accurately represent complex physical phenomena such as boiling, turbulence, and heat transfer under extreme conditions inside reactors.

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The Solution

To develop advanced modelling tools incorporating AI and machine learning techniques that are accurate and scalable.

The UK TH community are inspired to develop next-generation thermal-hydraulics tools that are not only accurate and scalable, but also making use of AI-driven workflows. These tools will include advanced Multiphysics solvers that couple fluid dynamics, heat transfer, and phase-change phenomena, as well as multiscale models that bridge fine-scale physics with system-level behaviour.

Machine learning techniques will be applied to reduce computational costs and enable faster, real-time insights without compromising physical accuracy. An AI-enhanced computational thermal hydraulics modelling framework, validated against multinational datasets, once developed will dramatically reduce simulation costs, accelerate design cycles, provide near real-time operational insights, and shorten licensing timelines.

The Outcome

Safe and efficient design of next-generation fission systems with CCP-NTH as a national hub for AI-enhanced thermal hydraulics platforms.

These capabilities are essential for the safe and efficient design and licensing of next-generation fission systems, including high temperature gas-cooled reactors and molten salt reactors, both of which are strategic priorities under both the UK's advanced modular reactor programme and energy security agenda. Overcoming technicalities is crucial for building trust in simulations, reducing uncertainty, and speeding up the development of next generation nuclear technologies.

These improvements will strengthen public and regulatory confidence and support the UK's leadership in clean, secure, and innovative nuclear energy. CCP-NTH will support this leadership, reinforcing its position in international regulatory benchmarks, attracting industrial investment, and cultivating a skilled workforce in multiphysics and AI integration. CCP-NTH aims to serve as a national hub for validated, AI-enhanced thermal hydraulics platforms, driving safe, low-carbon innovation across both fission and fusion reactor technologies.

More Information

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