

**Second OECD/NEA EGMUP Task Force on Artificial
Intelligence and Machine Learning Benchmark Meeting
(TF-AIML-2)**

Announcement and Proposed Program

**Lucca, Italy
May 23, 2024 (track 2 afternoon)
In conjunction with the BEPU 2024 Conference**

Hosted by N.I.N.E. (Nuclear and Industrial Engineering), Italy

Background and Purpose of 2nd OECD/NEA EGMUP Task Force on AIML Benchmark Meeting

The second OECD/NEA EGMUP Task Force on Artificial Intelligence and Machine Learning Benchmark Meeting (TF-AIML-2) will be held on May 23, 2024, in Lucca, Italy, and is a follow up to the previous workshop. The TF-AIML-2 meeting will be held in conjunction with the 2024 Best-Estimate Plus Uncertainty (BEPU-2024) international conference as well as with other OECD/NEA Working Party on scientific issues and uncertainty of Reactor Systems (WPRS) meetings/workshops to facilitate co-ordination and sharing of work. The other meetings will be held in three parallel tracks at Lucca, Italy during the same week to combine efforts in common areas such as neutronics, thermal-hydraulics, and multi-physics modelling and uncertainty analysis and to make the participation more efficient. The meetings/workshops concerned are:

- *May 19, 2024 (morning)* – COBRA-TF (CTF)-10 a Hands-on Training Session (CTF-10)
- *May 19, 2024 (afternoon)* – CTF-10 User Group (UG) Meeting
- *May 20, 2024 (track 1 morning)* - Third OECD/NRC Lead-cooled Fast Reactor (LFR) Benchmark (LFR-3) Workshop - LFR Thermal-Hydraulics Stage
- *May 20, 2024 (track 1 afternoon)* - Third OECD/NRC Lead-cooled Fast Reactor (LFR) Benchmark (LFR-3) Workshop - LFR Neutronics Stage
- *May 20, 2024 (track 2 morning)* - Third OECD/NEA Fluoride High Temperature (FHR) Reactor Benchmark (FHR-3) workshop
- *May 20, 2024 (track 2 afternoon)* – Sixth OECD/NEA Rostov-2 VVER-1000 Multi-Physics Transient Benchmark (Rostov2-6) workshop
- *May 21, 2024 (track 1)* - Ninth OECD/NEA Sodium Fast Reactor (SFR) UAM Benchmark workshop (SFR-UAM-9)
- *May 21, 2024 (track 2 morning)* - Ninth OECD/NEA Time-Dependent Neutron Transport (C5G7-TD) Benchmark (C5G7-TD-9) workshop
- *May 21, 2024 (track 2 afternoon)* – Fifth Multi-Physics Pellet Cladding Mechanical Interaction Validation Benchmark (MPCMIV-5) workshop
- *May 20-21 (track 3), 2024* – 2nd OECD/NEA International School on Simulation of Nuclear Reactor Systems (SINUS-2)
- *May 22, 2024 (track 1)* – Seventeen OECD/NEA Light Water Reactor (LWR) Uncertainty Analysis in Modelling (UAM) Benchmark (LWR-UAM-17) workshop
- *May 22, 2023 (track 2 morning)* – Fourth OECD/NRC Liquid Metal Fast Reactor Thermal-Hydraulics Benchmark (LMFR T/H-4) Workshop
- *May 22, 2023 (track 2 afternoon)* – First OECD/NEA HTGR-TH Benchmark (Based on HTTF Data) workshop (HTGR-TH-1)
- *May 23, 2024 (track 1)* – Fourth OECD/NEA TVA Watts Bar 1 (WB1) Multi-Physics Multi-Cycle Depletion Benchmark (TVA-WB1-4) workshop
- *May 23, 2024 (track 2 morning)* - Summary session with presentations of recently concluded benchmarks: OECD/NEA First Burst-Fission-Gas Release Benchmark (BFGR) and OECD/NEA McMaster Core Thermal-Hydraulics (CTH) Benchmark

AI/ML have gained tremendous interest across all branches of nuclear engineering, driven by the increasing computing power, advancements in AI/ML algorithms, and the availability of user-friendly ML libraries. While it is widely acknowledged that AI/ML has great potential to enhance data-driven scientific computing problems in nuclear engineering, its potential has not been fully realized due to several challenges. First, there are no guidelines on how to apply application-agnostic AI/ML algorithms to high-consequence nuclear systems. Second, there are no AI/ML benchmarks based on realistic nuclear reactor measurement data or numerical simulation data to compare and validate various ML algorithms. Third, there are significant gaps in the trustworthiness assessment of AI/ML models for nuclear applications. In May 2022, the OECD/NEA Working Party on Scientific Issues and Uncertainty Analysis of Reactor Systems (WPRS) endorsed at its annual Benchmark Workshops the creation of a task force on “Artificial Intelligence and Machine Learning for Scientific Computing in Nuclear Engineering” under the auspices of its Expert Group on Reactor System Multiphysics (EGMUP).

The goal of this task force is to develop benchmark exercises that aim at evaluating the performance of AI/ML in multi-physics M&S of nuclear reactor systems. It will provide recommendations to the WPRS and the nuclear community on the scientific development needs (data, methods, and benchmark exercises) for trustworthy AI/ML applications in nuclear scientific computing problems. This benchmark will design and execute benchmark exercises on both single physics (reactor physics, thermal-hydraulics and fuel performance) and multi-physics coupled simulation problems. The exercises will target specific key challenges of each computational domain through interactions with the corresponding WPRS expert groups. A broad spectrum of AI/ML sub-domains will be explored, including supervised learning, unsupervised learning, reinforcement learning, deep generative learning, and probabilistic ML. In each benchmark exercise, the participants will use self-chosen AI/ML algorithms to perform tasks specified in the exercises. The development of the benchmark specifications will be conducted in two phases.

1. Phase I of the benchmark will focus on tasks related to regression, classification, dimensionality reduction and anomaly detection, and
2. Phase II of the benchmark will focus on tasks related to VVUQ, transfer learning, deep generative learning and deep reinforcement learning.

The first draft version of the Phase 1 specification for the benchmark exercise on Critical Heat Flux (CHF) was provided May 2023 to allow initial discussions during the WPRS Workshops in May 2023. Final specification for Phase 1 of this exercise was published in January 2024. The task force supervises the gathering and analysis of the participants results up to the end of 2024. The Phase 1 final report will be approved by mid-2025. The Phase 2 draft specifications are anticipated for the end of 2024. The task force will supervise gathering of results from the participants for Phase 2 up to the end of 2025 and approve the final Phase 2 report by mid-2026.

The information about the Task Force on AI/ML is provided at:

https://www.oecd-nea.org/jcms/pl_77779/task-force-on-artificial-intelligence-and-machine-learning-for-scientific-computing-in-nuclear-engineering

Scope and Technical Content of the Meeting

The topics to be addressed at the workshop include:

- Review and discussion of databases that will be used for evaluating the performance of AI/ML techniques in the benchmark exercises,
- Updates from the subgroup leads on the benchmark exercise development,
- Updates from the subgroup leads on the benchmark specification drafts for Phase I,
- Feedback and concerns of task force participants for the exercises and specifications,
- Discussion on the benchmark execution of Phase I in 2024,
- Discussion of templates for submitting participants’ results for Phase I,
- Discussion on relevant AI/ML work and activities for the Task Force.
- Discussion on potential interaction of this Task Force with other relevant activities such as LWR-UAM and the Task Force on Doppler Effective Fuel Temperature, Working Party on Materials Science Issues in Nuclear Fuels and Structural Materials (WPFM) Expert Group on Fuel Materials (EGFM), and
- Defining a work plan, schedule, and goals for the next year of the Task Force.

The proposed meeting program is attached as Annex 1.

Organization of the Meeting

The meeting is organized around the discussion of the benchmark exercises, benchmark specification preparation, TF participants’ concerns, Phase I execution and other benchmark-related activities. The subgroup leads are requested to present their progress on benchmark exercise development and benchmark specification preparation.

Participation in the Meeting

Participation is restricted to individuals from OECD/NEA member country institutions.

Organization and Program Committee of the Meeting

An Organization and Program Committee has been nominated to make the necessary arrangements for the TF-AIML-1 benchmark meeting and to draw up the final program, etc.

The members of the Program Committee are:

Xu Wu - *Principal Investigator and Chair*
North Carolina State University, USA

Gregory Delipei - *Co-Chair*
North Carolina State University, USA

Alessandro Petruzzi – *Co-Chair, and Local Host*
NINE S.r.l., Italy

Secretariat: **Oliver Buss**
OECD/Nuclear Energy Agency, France

Proposed Program of the Meeting

The proposed program was drawn up by the Program Committee and is enclosed as Annex 1.

Language of the Benchmark Workshop

The official language of the TF-AIML-2 meeting is English.

Proceedings of the Meeting

A summary of the TF-AIML-2 meeting will be published by the program committee after the meeting. The summary will be distributed free of charge to the participants in the meeting. The presentations will be available free of charge to the participants to download from participants' restricted area after the TF-AIML-2 meeting.

Contacts and Registrations

The annual benchmark workshops/meetings of the [Working Party on Scientific Issues and Uncertainty Analysis of Reactor Systems](#) (WPRS) and CTF UG Meeting and Training will be hosted by NINE S.r.l. in Lucca (Italy). The meetings will take place in three tracks in parallel during the week of May 19 to May 23, 2024, to exchange our results and lessons-learned for the different WPRS benchmark activities and to discuss future activities.

The link to registration page (there is no registration fee for the WPRS Benchmarks Workshops) for the WPRS-related workshops/meetings including CTF-10 registration, and overall program is:

https://www.oecd-nea.org/jcms/pl_89133/wprs-benchmarks-workshops-2024

In addition, there is a link to registration form for the CTF-10 UG Meeting and Training is at NCSU/RDFMG website:

<https://www.ne.ncsu.edu/rdfmg/cobra-tf/tenth-ctf-user-group-ug-meeting-and-training/>

Workshop Location

The meeting place/venue for the BEPU-2024 conference and the eleven meetings/workshops during the week of May 19 to May 23, 2024 is the Real Collegio, which is located inside the city walls of Lucca. The local information for transportation and hotels is given at:

<https://www.nineeng.com/bepu2024/index.php/conference-info/about-the-conference>

The schedule for the incoming WPRS Workshops, SINUS-2 school and CTF-10 Meeting and Training is given in the table below (all times in CEST):

The program and schedule of the meetings is shown below:

Sunday, 19 May 2024	<u>9:00-13:00</u>	CTF UG Training		
	<u>14:00-18:00</u>	CTF UG Meeting		
	<u>Starting at 18:00</u>	Registration & informal networking		
		Track 1	Track 2	Track 3 (SINUS)
Monday, 20 May 2024	<u>Starting at 8:00</u>	Registration		
	<u>9:00-13:00</u>	Lead-cooled Fast Reactor Benchmark (LFR) - T/H Stage	FHR - Fluoride High Temperature Reactor Benchmark	OECD NEA International School on Simulation of Nuclear Reactor Systems (SINUS)
	<u>14:00-18:00</u>	Lead-cooled Fast Reactor Benchmark (LFR) - Neutronics Stage	Rostov-2 VVER-1000 Benchmark	SINUS
Tuesday, 21 May 2024	<u>9:00-13:00</u>	Uncertainty Analysis in Modelling (UAM) for Design, Operation and Safety Analysis of Sodium-cooled Fast Reactors (SFR-UAM)	C5G7-TD: The Deterministic Time-Dependent Neutron Transport Benchmark C5G7-TD without Spatial Homogenization	SINUS
	<u>14:00-18:00</u>	SFR UAM	Multi-physics Pellet Cladding Mechanical Interaction Validation (MPCMIV) Benchmark	SINUS

		Track 1	Track 2
Wednesday, 22 May 2024	<u>9:00-13:00</u>	Benchmark for Uncertainty Analysis in Best-Estimate Modelling for Design, Operation and Safety Analysis of Light Water Reactors (LWR-UAM)	Liquid Metal Fast Reactor Core Thermal-Hydraulics Benchmark (LMFR T/H)
	<u>14:00-18:00</u>	LWR UAM including session on EGMUP Task Force on Doppler effective fuel temperature	HTGR T/H Benchmark based on HTTF Data
Thursday, 23 May 2023	<u>9:00-13:00</u>	TVA Watts Bar Unit 1 Multi-Physics Benchmark	9:00-11:00 Summary presentations of recently concluded benchmarks: - Burst Fission Gas Release (1h) - McMaster CTH (1h)
			11:00-13:00 EGMUP Task Force Artificial Intelligence & Machine Learning
	<u>14:00-18:00</u>	TVA Watts Bar Unit 1 Multi-Physics Benchmark	EGMUP Task Force Artificial Intelligence & Machine Learning

ANNEX 1

The Second OECD/NEA EGMUP Task Force on Artificial Intelligence and Machine Learning Benchmark Meeting (TF-AIML-2)

Host Organization

Hosted by N.IN.E. (Nuclear and Industrial Engineering)

Lucca, Italy

May 23, 2024

PROPOSED PROGRAM

TA01-10: Session codes

TA01. Introduction and opening remarks

TA02. Overview of Task Force activities and current status

TA03. Updates from the subgroup leads on the benchmark exercise development

TA04. Updates from the subgroup leads on the benchmark specification drafts for Phase I

TA05. Feedback and concerns of Task Force participants for the exercises and specifications,

TA06. Discussion on the benchmark execution of Phase I

TA07. Discussion of templates for submitting participants' results for Phase I

TA08. Discussion on potential interaction of this Task Force with other relevant activities

TA09. Action items, schedule, and goals for the next workshop (TF-AIMI-3)

TA10. Conclusions and closing remarks