Fourth OECD/NEA Tennessee Valley Authority (TVA) Watts Bar Unit 1 (WB1) multi-physics cycle depletion benchmark workshop (TVA-WB1-4)

Lucca, Italy
Thursday, May 23, 2024 (track 1)
In conjunction with the BEPU 2024 Conference

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

Announcement and Proposed Program

Background and Purpose of 4th TVA WB1 Benchmark Meeting

The fourth OECD/NEA Tennessee Valley Authority (TVA) Watts Bar 1 (WB1) multi-physics cycle depletion benchmark workshop (TVA-WB1-4) will be held on May 23, 2024 (track 1) in Lucca, Italy and is a follow up to the previous workshops. The TVA-WB1-4 meeting will be held in conjunction with the 2024 Best-Estimate Plus Uncertainty (BEPU-2024) international conference as well as with other OECD/Nuclear Energy Agency (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 are being 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)* – Tenth COBRA-TF (CTF) (CTF-10) Hands-on Training Session
– *May 19, 2024 (afternoon)* – CTF-10 User Group (UG) Meeting
– *May 20, 2024 (track 1 morning)* – Third OECD/NEA Lead Fast Reactor (LFR) benchmark - Thermal-Hydraulic (T/H) Stage (LFR-3 T/H) workshop
– *May 20, 2024 (track 2 morning)* - Third OECD/NEA Fluoride High Temperature (FHR) Reactor Benchmark (FHR-3) workshop
– *May 20, 2024 (track 1 afternoon)* - Third OECD/NEA Lead Fast Reactor (LFR) benchmark - LFR Neutronics (N) Stage - (LFR-3 N) 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)
– *May 22, 2024 (track 1)* – Seventeen OECD/NEA Light Water Reactor (LWR) Uncertainty Analysis in Modelling (UAM) Benchmark (LWR-UAM-17) workshop
– *May 22, 2024 (track 2 morning)* - Fourth Liquid Metal Fast Reactor (LMFR) Thermal-Hydraulic (T/H) 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 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
– *May 23, 2024 (track 2 afternoon)* – OECD/NEA Task Force Artificial Intelligence & Machine Learning meeting

Development of high-fidelity full-core modelling capabilities for Light Water Reactors (LWRs) within the completed US Department of Energy (DOE) Consortium for Advanced Simulation of

LWRs (CASL) activities resulted in the establishment of the Virtual Environment for Reactor Applications (VERA) for multi-physics applications. VERA includes a neutron transport solver MPACT, the core-thermal-hydraulic sub-channel code CTF, and the fuel performance code CTFFuel. For Verification and Validation (V&V) of VERA CASL has developed a set of benchmark progression problems ranging from simple two-dimensional pin cells to three-dimensional multi-physics reactor core problems. The detailed specifications were prepared by CASL with data for the Watts Bar Unit 1 (WB1) provided by the TVA and Westinghouse. As part of the cooperation activities between the US DOE and the OECD/NEA, part of the TVA WB1 data and specifications are provided to serve as a basis for the development of an OECD/NEA multi-cycle depletion benchmark for multi-physics tools with corresponding specifications in a NEA format. The OECD/NEA multi-physics benchmark draft specifications are based on Cycles 1 through 3 of the TVA WB1. We would like to acknowledge TVA and Westinghouse for providing the data and DOE CASL for preparing the CASL benchmark specifications for the Watts Bar Unit 1. The OECD-NEA TVA WB1 benchmark activities are in the framework of the Expert Group on Reactor System MUlti-physics (EGMUP) WPRS/NSC at NEA and are supported by the US DOE Nuclear Energy University Program (NEUP) project award. The benchmark team, consisting of North Carolina State University (NCSU), Westinghouse, and Idaho National Laboratory (INL) with the support of the Oak Ridge National Laboratory (ORNL), is preparing complete benchmark evaluation for review and inclusion in the IRPhE handbook. In such an evaluation additional work is being performed on multi-physics uncertainty and sensitivity analyses for each cycle depletion. Please note that the original models developed with the VERA suite for the CASL progression problems will be used but will be adapted for this comprehensive integral benchmark evaluation in which benchmark specifications have some differences with the definition of the CASL progression problems. The quality-assured and peer-reviewed benchmark specifications and a proposal for multi-physics, multi-cycle depletion evaluation protocol will be provided based on the IRPhE protocol. A quality assurance program according to the criteria specified by the DOE and IRPhE handbook will be established including internal review (NCSU/ORNL), second independent peer review (INL), and a third review by the Technical Review Group at the NEA/OECD.

Specifications based on the full three-dimensional (3D) reactor core configuration, with control rods and burnable poisons consistent with actual nuclear power plant designs are developed. Eight benchmark exercises are defined based of the first three cycles of TVA WB1 data. The exercises are organized in such a way that they span:

a) Exercise 1: Start-up Zero Power Physics Tests (ZPPT) – it is focused on validation of stand-alone 3-D neutronics model at Hot Zero Power (HZP) conditions;

b) Exercise 2: Hot Hull Power (HFP) Beginning of Cycle (BOC) Physical Reactor w/ Xenon – it is focused on validation of multi-physics steady-state model for HFP conditions (coupled neutronics/thermal-hydraulics/fuel model);

c) Exercise 3: Physical Reactor Cycle 1 Depletion - validation of multi-physics cycle depletion model for WB1 Cycle 1;

d) Exercise 4: Fuel Shuffle and Decay for Cycle 2 BOC ZPPT – perform Cycle 1 shuffle and accounting for fuel decay, accurately predicting reactivity at HZP BOC conditions of Cycle 2;

e) Exercise 5: Physical Reactor Cycle 2 Depletion – validation of multi-physics cycle depletion model for WB1 Cycle 2.

f) Exercise 6: Validation of Cycle 3 Fuel Shuffle and Decay BOC ZPPT Model

g) Exercise 7: Validation of Cycle 3 Multi-physics Depletion Model

h) Exercise 8: Ex-core transport calculations for reactor pressure vessel neutron fluence evaluation

Non-proprietary geometry information, reactor operating conditions, core fuel and poison loading patterns, Reactor Control Cluster Assembly (RCCA) bank positions and Instrumentation locations are provided in the draft specifications. Measured and operational data for the specified exercises are also provided. Information for performing uncertainty quantification and propagation in steady state and cycle depletion calculations is provided.

Benchmark Specification has been updated by the benchmark team to be discussed at the incoming benchmark workshop along with remaining missing information and needed clarifications. Output templates for the seven benchmark exercises have been developed and posted on the benchmark web-site.

The information about the TVA WB1 benchmark is provided at:
https://www.oecd-nea.org/jcms/pl_32202/tva-watts-bar-unit-1-multi-physics-benchmark

Scope and Technical Content of the Meeting

The topics to be addressed at the workshop include:

– Review and discussion of the updated specifications including templates for submitting participants' results,

– Presenting updated benchmark support data,

– Presenting updated experimental and measured data,

– Discussing missing information including uncertainty parameter information and needed clarifications,

– Presenting and discussing benchmark team' support and related studies,

– Participants' presentations on their modelling and results for the two benchmark Phases,

– Presentations on other related activities in PWR multi-physics cycle depletion validation and ex-core transport calculations for pressure vessel neutron fluence calculations,

– Defining a work plan and schedule for TVA WB1 activities.

The proposed meeting program is attached as Annex 1.

Organization of the Meeting

The meeting is organized around the discussion of the TVA WB1 benchmark specifications, preliminary results, participants' questions, and benchmark-related activities. The participants are requested to present their expertise and experience in benchmark-related modelling, verification and validation, uncertainty quantification/propagation and applications.

Participation in the Meeting

Participation is restricted to individuals from OECD/NEA member country institutions who agree to the benchmark non-disclosure agreement (NDA). Participants are asked to sign and send the corresponding NDA form to wprs@oecd-nea.org.

The TVA WB1 benchmark conditions to release form can be found at:
https://www.oecd-nea.org/upload/docs/application/pdf/2020-12/tva-wb1_conditions_for_release_2020.pdf

Organization and Program Committee of the Meeting

An Organization and Program Committee has been nominated to make the necessary arrangements for the TVA-WB1-3 meeting and to draw up the final program, etc.

The members of the Program Committee are:

> **Alessandro Petruzzi –** *Co-Chair, and Local Host*
> **NINE S.r.l., Italy**
>
> **Pascal Rouxelin** - *Co-Chair*
> North Carolina State University, USA
>
> **Scott Palmtag**
> North Carolina State University, USA

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 TVA-WB1-4 meeting is English.

Proceedings of the Meeting

A summary of the TVA-WB1-4 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 TVA-WB1-4 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.

Link to registration page for the WPRS-related workshops/meetings including CTF-10 registration, and overall program:

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/

Workshops' 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:

		Track 1	Track 2	Track 3 (SINUS)
Sunday, 19 May 2024	9:00-13:00	CTF UG Training		
	14:00-18:00	CTF UG Meeting		
	Starting at 18:00	Registration & informal networking		
		Track 1	**Track 2**	**Track 3 (SINUS)**
Monday, 20 May 2024	Starting at 8:00	Registration		
	9:00-13:00	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)
	14:00-18:00	Lead-cooled Fast Reactor Benchmark (LFR) - Neutronics Stage	Rostov-2 VVER-1000 Benchmark	SINUS
Tuesday, 21 May 2024	9:00-13:00	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
	14:00-18:00	SFR UAM	Multi-physics Pellet Cladding Mechanical Interaction Validation (MPCMIV) Benchmark	SINUS
		Track 1	**Track 2**	

Wednesday, 22 May 2024	9:00-13:00	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)
	14:00-18:00	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	9:00-13:00	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
	14:00-18:00	TVA Watts Bar Unit 1 Multi-Physics Benchmark	EGMUP Task Force Artificial Intelligence & Machine Learning

ANNEX 1

OECD/NEA TVA Watts Bar Unit 1 (WB1) multi-physics cycle depletion benchmark - Fourth workshop (TVA-WB1-4)

Host Organization

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

Lucca, Italy

May 23, 2024 (track 1)

PROPOSED PROGRAM

W01-12: Session code

May 23, 2024 (track 1)

W01. Introduction and opening remarks.

W02. Overview and status of benchmark activities.

W03. Discussion of the updated Specifications including specifying Exercise 8 and templates for submitting participants' results.

W04. Presentation of updated experimental and measured data.

W05. Presentation of updated benchmark support data.

W06. Discussion of missing information including uncertainty parameter information and needed clarifications in the benchmark specifications.

W07. Presentation and discussion of preliminary, and support studies.

W08. Presentations of reference analyses.

W09. Participants' presentations on their modelling and results for the first three exercises of the TVA WB1 benchmark.

W10. Participants' presentations on their modelling and results of PWR multi-physics cycle depletion calculations and ex-core neutron transport calculation for pressure vessel neutron fluence evaluations.

W11. Action items and schedule of benchmark activities - next workshop and plans.

W12. Conclusions and closing remarks.