

**Third OECD/NEA Tennessee Valley Authority (TVA) Watts
Bar Unit 1 (WB1) multi-physics cycle depletion benchmark
workshop (TVA-WB1-3)**

May 25-26, 2023

Bologna, Italy

Hosted by ENEA, Italy

Announcement and Proposed Program

Background and Purpose of 3rd TVA WB1 Benchmark Meeting

The third OECD/NEA Tennessee Valley Authority (TVA) Watts Bar 1 (WB1) multi-physics cycle depletion benchmark workshop (TVA-WB1-3) will be held on May 25-26, 2023, in Bologna, Italy and is a follow up to the previous workshops. The TVA-WB1-3 meeting will be held in conjunction 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. Nine other meetings are being held in two parallel tracks at Bologna, Italy during the same week in order 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 22, 2023 (track 2 morning) – Ninth COBRA-TF (CTF) User’s Group (UG) Meeting (CTF-9) followed by a hands-on CTF training sessions which will be conducted on Monday afternoon, May 22, 2023 and Tuesday morning, May 23, 2023 (track 2);
- May 22, 2023 (track 1 afternoon) – First Burst-Fission-Gas Release Benchmark (BFGR-1) workshop;
- May 23, 2023 (track 1) - Sixteen OECD/NEA Light Water Reactor (LWR) Uncertainty Analysis in Modelling (UAM) Benchmark (LWR-UAM-16) workshop;
- May 23, 2023 (track 2) – OECD/NEA HTGR-TH Benchmark introductory presentation and discussions;
- May 22-23 (track 3), 2023 – OECD/NEA International School on Simulation of Nuclear Reactor Systems (SINUS);
- May 24, 2023 (track 1 morning) - OECD/NEA Task Force on Doppler Effective Fuel Temperature meeting;
- May 24, 2023 (track 2 morning) – Fourth OECD/NEA McMaster Core Thermal-Hydraulics (CTH) Benchmark (CTH-4) workshop;
- May 24, 2023 (track 1 afternoon) – OECD/NEA Task Force Artificial Intelligence & Machine Learning meeting;
- May 24, 2023 (track 2 afternoon – LFR neutronics) – May 25, 2023 (track 2 morning – LFR Thermal-hydraulics) – Second OECD/NEA Lead Fast Reactor (LFR) Benchmark (LFR-2) workshop;
- May 24, 2023 (track 1 afternoon) – May 25, 2023 (track 1 morning) - Eight OECD/NEA Time-Dependent Neutron Transport (C5G7-TD) Benchmark (C5G7-TD-8) workshop;
- May 25, 2023 (track 2 afternoon) – Second Liquid Metal Fast Reactor (LMFR) Thermal-Hydraulics (T/H) Benchmark workshop (LMFR T/H-2);
- May 25, 2023 (track 1 afternoon) – May 26, 2023 (track 1 morning) - Third meeting on OECD/NEA TVA Watts Bar 1 (WB1) Multi-Physics Multi-Cycle Depletion Benchmark (TVA-WB1-3) workshop.
- May 26, 2023 (track 2) - Eight OECD/NEA Sodium Fast Reactor (SFR) UAM Benchmark workshop and First Liquid Metal Fast Reactor (LMFR) Thermal-Hydraulics (T/H) Benchmark workshop (SFR-UAM-8);
- May 26, 2023 (track 1 afternoon) – Fifth benchmark meeting on Rostov-2 VVER-1000 multi-physics transient benchmark (Rostov2-5).

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 CTFuel. 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 IRPhEP handbook. In such 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 IRPhEP protocol. A quality assurance program according to the criteria specified by the DOE and IRPhEP 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.

Draft 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. Seven benchmark exercises are defined based on 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.

Benchmark Specification has been updated to version 2.3.3 (January 2023) 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 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 modeling, 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:

Giacomo Grasso – *Co-Chair, and Local Host*
ENEA, 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-WB1-3 meeting is English.

Proceedings of the Meeting

A summary of the TVA-WB1-3 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-WB1-3 meeting.

Contacts and Registrations

The annual benchmark workshops/meetings of the [Working Party on Scientific Issues and Uncertainty Analysis of Reactor Systems \(WPRS\)](#) and TVA-WB1-3 Meeting will be hosted by ENEA in Bologna (Italy). The meetings will take place in two tracks in parallel during the week of 22 May to 26 May 2023 to exchange results and lessons learned for the different WPRS benchmark activities and to discuss future activities.

The link to registration page for the WPRS-related workshops/meetings (including TVA-WB1-3), overall program, and local information for transportation and hotels is:

https://www.oecd-nea.org/jcms/pl_71612/wprs-benchmarks-workshop-2023

Workshop Location

The meeting place for the ten meetings/workshops during the week of May 22 – 26, 2023, in three tracks is at the Zanhotel Europa, Bologna, Italy (in-person meeting). As mentioned above the local information for transportation and hotels is given at:

https://www.oecd-nea.org/jcms/pl_71612/wprs-benchmarks-workshop-2023

The program and schedule of the meetings is shown below:

	Track 1	Track 2	Track 3
Monday, May 22	Morning: MPCMIV Afternoon: Burst Fission Gas Release	Morning: CTF UG Afternoon: CTF Training	Morning: SINUS Afternoon: SINUS
Tuesday, May 23	Morning: LWR UAM Afternoon: LWR UAM	Morning: HTGR-TH Afternoon: HTGR-TH	Morning: SINUS Afternoon: CTF Training
Wednesday, May 24	Morning: Task Force on Doppler Effective Fuel Temperature Afternoon: Task Force on AI & ML	Morning: McMaster CTH Afternoon: LFR Neutronics	
Thursday, May 25	Morning: C5G7-TD Afternoon: TVA-WB1	Morning: LFR TH Afternoon: LMFR TH	
Friday, May 26	Morning: TVA-WB1 Afternoon: Rostov-2	Morning: SFR-UAM Afternoon: SFR-UAM	

ANNEX 1

OECD/NEA TVA Watts Bar Unit 1 (WB1) multi-physics cycle depletion benchmark - Second workshop (TVA-WB1-2)

Hosted by ENEA

Bologna, Italy

May 25-26, 2023 (Track 1)

PROPOSED PROGRAM

W01-12: Session code

Day 1: May 25, 2023 (Track 1 afternoon)

- W01. Introduction and opening remarks.
- W02. Overview and status of benchmark activities.
- W03. Discussion of the updated Specifications 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 and needed clarifications in the benchmark specifications.

Day 2: May 26, 2023 (Track 1 morning)

- 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.