

Foreword

Selected papers from the 2018 Best Estimate Plus Uncertainty International Conference (BEPU 2018)

Guest Editors

Alessandro Petruzzi
Nuclear and Industrial Engineering

Kostadin Ivanov
North Carolina State University

Evgeny Ivanov
Institut de Radioprotection et de Sûreté Nucléaire

The revised rule on the acceptance of emergency core cooling system (ECCS) performance in 1988 triggered a significant interest in the development of codes and methodologies based on best estimate plus uncertainty (BEPU) evaluations. Initially, the interest was focused only on loss-of-coolant accident analyses but has more recently moved to include other accident scenarios and disciplines other than thermal hydraulics. Starting from the list of requirements developed by the United States Nuclear Regulatory Commission and constituted by the code scaling, applicability, and uncertainty (CSAU) evaluation methodology, several BEPU methods were developed and applied around the world. Although 30 years have passed since the approval of the ECCS revised rule, and despite numerous efforts made by different organizations, BEPU methodologies still suffer from not being fully systematic and capable of dealing with multiphysics and multi-scale issues. These challenges continue to draw major interest from academia, national laboratories and institutes, and regulatory and industry researchers. Various investigations in advanced techniques, validation and uncertainty quantification methods, and measurement techniques have been carried out to enhance the understanding of the potentialities of BEPU approaches with respect to current industrial needs like major plant modifications, power uprates, lifetime extensions, cycle lengthening, increases in burnup, new advanced core and fuel designs, as well as ongoing plant operations.

For this special issue of *Nuclear Technology*, 15 articles were selected from a large pool of quality papers that were submitted to the 2018 Best Estimate Plus

Uncertainty International Conference (BEPU 2018), which took place May 13–18, 2018, in Lucca, Italy. In addition to this special issue, one more special issue is being published in *Nuclear Engineering and Design* for other papers selected from the BEPU 2018 proceedings.

BEPU 2018 was organized to provide a forum to exchange experience and views among professionals in the nuclear industry, specifically in the development and use of BEPU methods in safety analyses and design of nuclear installations. The conference addressed a broader spectrum of methods (with respect to the past, when the focus was primarily on thermal-hydraulic system codes) applied to reactor physics, fuel performance, and severe accidents, taking into account the multiphysics interactions and aspects of the problems. Another issue that has been addressed is the problem of the verification and validation of methods along with the supporting experimental programs. The outcome of the conference was an overview of the state of the art of BEPU methods with insights into the development and use of BEPU in licensing, design, and safety evaluations.

Approximately three hundred experts from more than 30 countries traveled to Lucca, Italy, to attend BEPU 2018, which was sponsored by the American Nuclear Society, the Nuclear Energy Agency, and the International Atomic Energy Agency and was also cosponsored by a local organizing committee led by Nuclear and Industrial Engineering. Over 250 draft papers were reviewed, and finally, a grand total of over 170 full papers were accepted and presented in technical

sessions. In addition, 21 invited keynote lectures, 13 plenary speeches, and 6 panel discussions addressed the state-of-the-art challenges in various areas of BEPU. The BEPU technical program committee and the special issue guest editors then coordinated efforts to select a limited number of papers and invited keynote and plenary lectures for consideration for archival publication in leading scientific journals. The authors were then invited to update their papers before submitting them for additional peer review for these journal special issues.

The papers in this special issue may be collected into four groups:

1. *General considerations about the BEPU approach*: The first three papers, “Challenges in Application of BEPU for Risk Evaluations,” “Best Estimate Plus Uncertainty (BEPU): Why It Is Still Not Widely Used,” and “Verification and Validation and Uncertainty Quantification of Code Models,” provide a review of the status and trends that indicate that applications of the BEPU concept in risk-informed evaluation of margins is gaining popularity and interest for application. Included are also discussions on enabling factors and constraints for BEPU from technical and global points of view, relying on scientific background as well as current practice with respect to its potential role in regulation and, more generally, in a decision-making process.

2. *Development of BEPU methods and techniques*: To this group belong the next four papers in the special issue, “The CASUALIDAD Method for Uncertainty Evaluation of Best-Estimate System Thermal-Hydraulic Calculations,” “RIPS, a Statistical Method for Characterizing the Limiting Scenario in a BEPU Approach,” “Applications of Multivariate Normal Bayesian Models in Nuclear Engineering,” and “Advanced Methodology for Uncertainty Propagation in Computer Experiments with Large Number of Inputs.”

These papers either propose new methodologies for BEPU applications in nuclear safety analysis in the licensing framework or present new techniques that provide an improvement on specific aspects of the BEPU approach.

3. *Applications of BEPU methods*: The next six papers of the special issue discuss specific applications of BEPU approaches related to code model (“Quantified Validation with Uncertainty Analysis for Turbulent Single-Phase Friction Models”), multiphysics simulation (“Uncertainty Quantification and Propagation of Multiphysics Simulation of the Pressurized Water Reactor Core”), reflow experiment simulation (“Global Sensitivity and Registration Strategy for Temperature Profile of Reflood Experiment Simulations”), recriticality risk analysis for the Fukushima Daiichi accident (“Proposal of a Statistical Evaluation Method for the Criticality of the Fukushima Daiichi Nuclear Power Plant”), simulation of mixing flows with computational fluid dynamics (CFD) (“BEPU Method Applied to CFD Simulation of Mixing Flows”), and an advanced approach to nuclear data uncertainty propagation through light water reactor core operation (“Cross-Section Generation Using TXT2NTAB Code for Uncertainty Propagation with Burnup Dependence”).

4. *Development of multiphysics, multiscale approaches*: the last two papers, “A Mutual Information-Based Experimental Design Framework to Use High-Fidelity Nuclear Reactor Codes to Calibrate Low-Fidelity Codes” and “Implementation of a Spacer Grid Rod Thermal-Hydraulic Reconstruction (ROTHCON) Capability into the Thermal-Hydraulic Subchannel Code CTF,” present and discuss an approach for using high-fidelity computational tools fluid to calibrate parameters in low-fidelity design codes.

We hope you enjoy this special issue of *Nuclear Technology* and look forward to seeing you at the next BEPU conference in Sicily, Italy, in May 2020.