



GIF Economic Modeling Working Group – IAEA Collaboration

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13^h GIF-IAEA Interface Meeting
IAEA Headquarters, Vienna, Austria
March 18-19, 2019

Outline

- ***Mandate and Membership of EMWG***
- ***Collaborative Activities with IAEA to date***
- ***Current Focus of EMWG***
- ***Outlook***

EMWG: Mandate and Membership

- ***Mandate: To develop methodology for assessment of Gen IV systems against GIF Economic Goals***
 - Life cycle cost advantage over other systems (lower LUEC)
 - Comparable financial risks (total capital investment cost (TCIC))
- ***Extended mandate:***
 - Maintain cognizance of challenges and opportunities for integration of Gen IV systems with renewables on the grid
 - Methodologies for economic impact of integration
 - R&D challenges to meet flexibility requirements
- ***Current membership: Canada, China, France, Japan, Russia, South Africa, South Korea, the USA, IAEA (observer)***

Collaborative Activities with IAEA to date

- **Focused on benchmarking of economic tools**
- **G4ECONS v2.0 and IAEA's Nuclear Economics Support Tool (NEST) in collaboration with INPRO and PESS**
 - Three types of fuel cycles: Thermal Gen IV SCWR, Break-even fast reactor, Burner fast reactor
 - Results used in the revision of G4ECONS to harmonize with NEST
 - Results published in *"Benchmarking of Nuclear Economic Tools"*, Megan Moore, Andriy Korinny, David Shropshire, Ramesh Sadhankar; *Annals of Nuclear Energy*, 103, (2017), 122-129
- **G4ECONS v2.0 and IAEA's Hydrogen Economic Evaluation Program (HEEP) in collaboration with NPTDS**
 - Large scale production of hydrogen using high-temperature steam electrolysis coupled with SCWR
 - Minor differences due to calculation of interest during construction
 - Results published in *"Benchmarking of Economic Models for Nuclear Hydrogen Production"*, Ramesh Sadhankar, Lauralee Sopczak, Donal Ryland, Rami El-Emam, Ibrahim Khamis; *Pacific Basin Nuclear Conference, San Francisco, USA, Sep. 30 – Oct. 4, 2018*

Revision of G4ECONS

- ***G4ECONS v3.0 (Excel-based) released for use; available on CD***
- ***Request can be made at (https://www.gen-4.org/gif/jcms/c_42161/g4econs)***
- ***Incorporates***
 - ***Lessons from benchmarking studies with IAEA***
 - ***Improved user interface***
 - ***Racks transuranic and fission product generation or destruction for fuel cycle study applications***
- ***Co-generation modules (hydrogen, desalination, steam) from v2.0 have been deleted***
- ***Training material under development***

Current Focus of EMWG

- ***Study of issues/challenges of integration of new nuclear with renewable resources***
- ***Position paper prepared for GIF***
 - Current challenges for nuclear power generation
 - Economic and technical significance of flexibility and grid reliability
 - R&D requirements for Gen IV reactors to meet flexibility challenges
 - Co-generation
 - Policies conducive to nuclear deployment
- ***Executive summary of position paper posted on GIF external website (https://www.gen-4.org/gif/jcms/c_9364/economics)***

GIF-IAEA Coordination Matrix – March 2018

Action Item From Interface Meeting	Next action	Comments	Action IAEA	Action GIF
Economics:	Continue discussions on areas of cooperation between GIF and NENP/PESS on economics. New areas identified: - Hybrid energy systems / integration renewables and nuclear (see meeting at IAEA in Nov) - Studies on (V)HTRs and process heat application economics - Multi-criteria evaluation tools and study of threshold effects - Contributions invited to Track 8 on economics at the GIF symposium (Oct 2018)	<ul style="list-style-type: none"> - G4-ECONS V3 beta release: Benchmark exercises completed and results available and reasons for differences well understood. - The GIF activities initially focused on cost calculation tools will probably be extended to a more comprehensive economic analysis for integrated systems - IAEA-NEST tool includes multiple cost models covering open and closed fuel cycles, multiple reactors, sensitivity analysis, comparisons to alternative energy sources, etc. Currently migrating NEST to a modular software platform from Excel and including GUI for ease of use by Member States. - China, India and Russia have completed INPRO Methodology Sustainability Assessments in the area of Economics on CFR-1000, CFBR-600 and BN-1200. - PESS initiated activity in integration of renewables and nuclear with study "Global Review of Integration of Renewable Generation in the Electricity Markets - NPTDS is finalizing a TECDOC on Options to Enhance Energy Supply Security using Hybrid Energy Systems based on SMRs 	A Van Heek (NE) J Phillips (NE) T. Jevremovic/ I. Khamis (NE) for hybrid systems and process heat applications	R Sadhankar (EMWG Co-Chair) T Harrison, M. Berthelemy could also help if necessary (for the work on integrated systems)

Continuing Information Exchange

- **IAEA presented activities relevant to EMWG at the last meeting in October 2018**
 - Nuclear cost basis project
 - Update on IAEA tools – NEST, HEEP, DEEP
 - Nuclear energy in markets with larger shares of variable renewables
- **EMWG members attend IAEA meetings and feedback to WG**
 - Technical meeting on Nuclear Renewable Hybrid Energy Systems for Decarbonized Energy Production and Cogeneration, Oct 2018
 - 16th INPRO Dialogue Forum on Opportunities and Issues in Non-Electric Applications of Nuclear Energy, Dec 2018
 - Workshop on Non-Electric Nuclear Applications: Options, Technology Readiness and Available IAEA Toolkits, Feb 2019
 - Technical Meeting on Costing Approaches for Nuclear Technology Developers, March 2019

Planned Activities

- **Assessment of available models for economics of nuclear-renewable integration**
 - *Briefing note produced on the assessment of four models (MIT, UofT, EPRI, INL)*

- **Maintaining watch on international work in the areas of nuclear hybrid systems, flexibility and grid reliability**

- **GIF workshop on flexibility of Generation IV reactors for deployment on the grid with renewable resources**
 - *Joint work shop with System Steering Committees (GFR, LFR, MSR, SCWR, SFR, VHTR) and Senior Industry Advisory Panel on May 29, 2019, Vancouver*

Outlook – Medium and Long Term

- ***Cost evolution FOAK to NOAK***
- ***Opportunities for reducing capital costs***
- ***Improvement of G4ECONS to include uncertainty analyses***
- ***Economic model for small modular reactors***
- ***Gen IV deployment scenario analysis***
 - ***Hybrid systems, energy storage, co-generation***
 - ***Policies for sustaining nuclear – reliability and resiliency of the grid***
- ***Financing of new nuclear***

Thank You!