Chapter 5. **Methodology Working Groups**

EMWG: Economic Modelling Working Group

The Economic Modelling Working Group (EMWG) was established in 2003 to provide a methodology for the assessment of the Generation IV systems against the two economic-related goals as follows:

- To have life cycle cost advantage over other energy sources (i.e. to have a lower levelized unit cost of energy); and
- To have a level of financial risk comparable to other energy projects (i.e. to have similar total investment cost at the time of commercial operation)

In 2007, the EMWG published the Cost Estimating Guidelines and an Excel-based software package G4ECONS v2.0 for calculating two figures of merit; the levelized cost energy and the total investment cost, to assess the Generation IV systems against GIF economic goals. These EMWG tools were made available to the public trough GIF Technical Secretariat which resulted in several publications demonstrating the EMWG methodology for economic assessments of Generation III and Generation IV systems, as well for the cogeneration applications such as hydrogen production.

G4ECONS v2.0 was also benchmarked against the economic tools of the International Atomic Energy Agency (IAEA); namely the Nuclear Economics Support Tool (NEST) and the Hydrogen Economic Evaluation Program (HEEP) and the results have been published in peer-reviewed publications [2, 3]. The lessons learnt from the benchmarking exercise and the feedback from the users informed the refinement of the G4ECONS tool. The EMWG released the new version, G4ECONS v3.0, with improved user interface, in October 2018.

In 2016, the EMWG started to investigate the challenges and opportunities for deployment of the Generation IV systems in the emerging energy markets with increasing share of renewable energy resources. The terms of reference for the EMWG were amended in 2018 to incorporate the expanded mandate to inform the GIF Policy Group and the Experts Group on the policies and the research and development needs for the future deployment of Generation IV systems.

Since October 2016, the EMWG worked collaboratively with the Senior Industry Advisory Panel (SIAP) to investigate challenges and opportunities for deployment of Generation IV systems in the electricity markets with significant penetration of renewable energy resources, and produced a position paper for the Policy Group. An abridged version of the EMWG position paper on the impact of increasing share of renewables on the deployment prospects of Generation IV systems was presented at the 4th GIF Symposium and an executive summary has been posted on the GIF external website. The study found that the Generation IV systems will have to be more flexible compared to the current reactors for deployment in the low-carbon energy systems and such requirements are already being proposed by the utilities. Large-scale energy storage and cogeneration applications would allow flexible dispatch, while ensuring high capacity utilization. Nuclear-renewable hybrid energy systems with adequate energy storage and cogeneration applications could, thus, meet the flexible demand from the grid while operating the power generators to full capacity to ensure overall economically viable operation. However, such flexibility considerations impose additional requirements on the research and development of Generation IV systems.

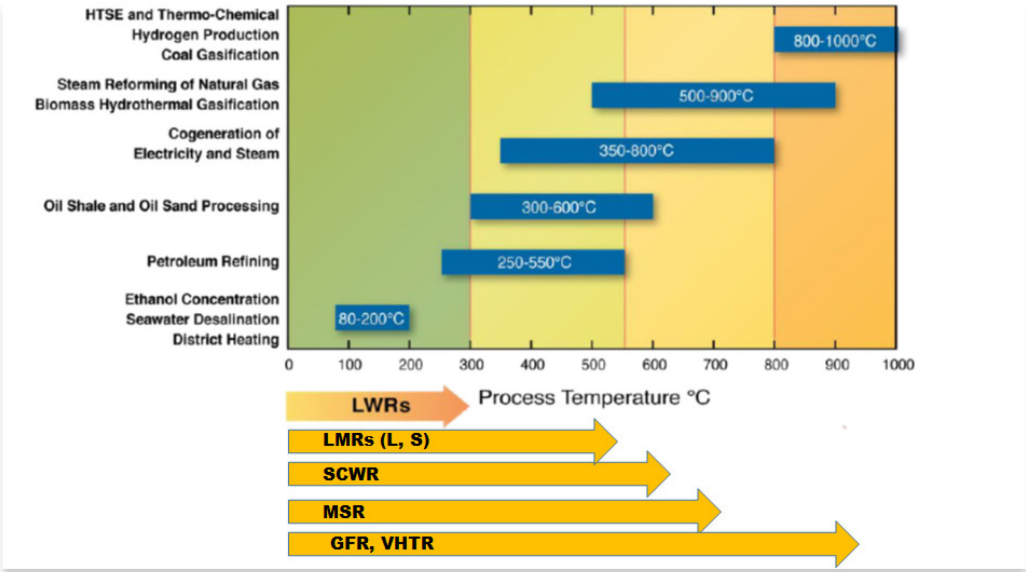
Activities in 2019

Main focus of the EMWG activities in 2019 was on flexibility considerations for the Generation IV systems. The advanced Generation IV reactors are significantly different compared to Gen III reactors. The Generation IV reactors use different fuels, different coolants and operate at higher temperatures, making the reactors suitable for applications beyond electricity production. Therefore, to evaluate the flexibility of Generation IV type reactors, Electrical Power Research Institute (EPRI) developed expanded flexibility criteria and proposed Technology Readiness Scales for Advanced Reactors, such as Generation IV systems. EPRI's expanded flexibility criteria consists of a set of three sub-criteria or attributes, as follows:

- operational flexibility;
- deployment flexibility;
- product flexibility.

Using these as a basis, EMWG developed a questionnaire to gather information on the extent to which the flexibility aspects are being addressed in the research and development of the six Generation IV systems. Subsequently, a workshop was held in May 2019 with the joint participation of the representatives of the six System Steering Committees, the SIAP, and the EMWG to discuss the R&D needs for flexibility and to identify opportunities for cross-cutting R&D. All Generation IV systems are being developed to be more flexible compared to the Generation III systems in terms of deployment flexibility (scalability and constructability) and the product flexibility (cogeneration applications). All Generation IV systems have higher outlet temperatures and thus are amenable to provide thermal energy for multiple industrial applications as shown in **Figure EMWG 1**.

Figure EMWG 1. **Product Flexibility of Generation IV Systems**



The evaluation of the operational flexibility requires validation through multi-dimensional physics calculations and can be performed after the systems are developed to sufficiently high technological readiness level. The EMWG produced a position paper based on the outcome of the questionnaire survey and the joint workshop and made recommendations to the Experts Group to provide guidance to the system developers to include flexibility requirements as part of the R&D, and to identify opportunities for cross-cutting R&D among the six Gen-IV systems. The EMWG also documented the capabilities of various economic models available for optimization of nuclear-renewable integrated systems.

To accompany the latest version G4ECONS v3.0 released in late 2018, training slides were prepared and are available for use by the GIF community.

Finally, the EMWG developed a set of Frequently Asked Questions and Answers for the GIF external website encompassing a wide range of related topics, including the use of the EMWG tools, benchmarking, figures of merit for economic assessment and external factors affecting the economic viability of nuclear, such as, integration with renewables, flexibility requirements and the system costs.

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