GEN IV International Forum
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Economic Modelling Working Group (EMWG) Activities

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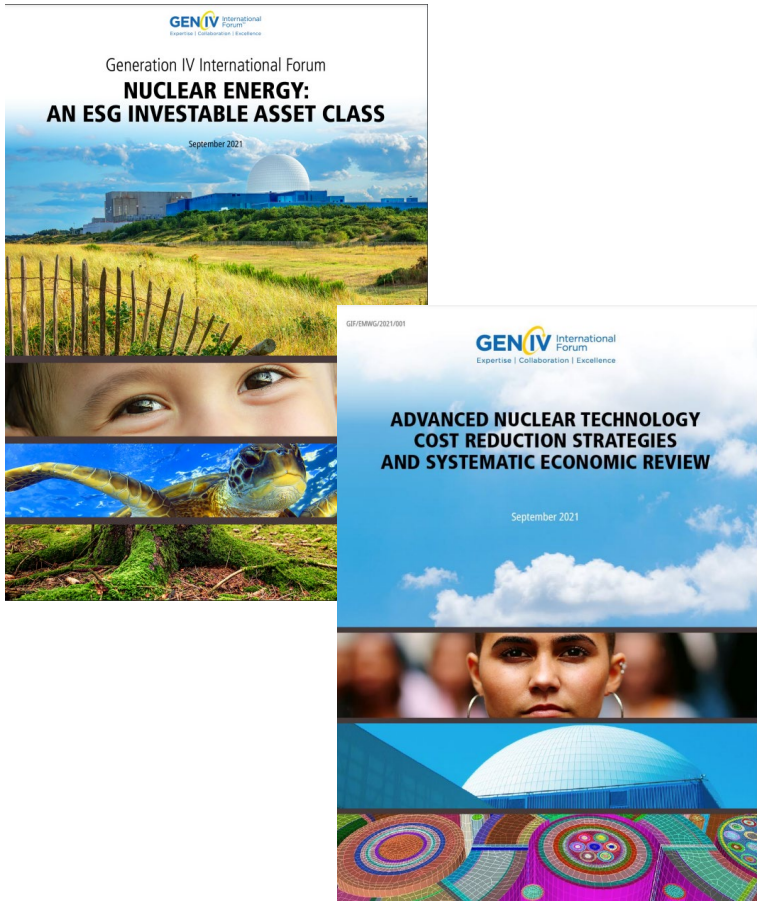
History of the EMWG

- The EMWG was established in 2003 to provide a methodology for the assessment of Generation IV systems against two-economic goals:
  - Life cycle cost advantage over other energy sources,
  - Financial risk comparable to other energy projects.
- In response, the EMWG created the following:
  - Generation IV Cost Estimating Guidelines: a cost estimation methodology that considers the unique characteristics of advanced reactors
  - G4ECONS: an excel based tool to aid in the implementation of the guidelines for the purpose of comparative economic analysis.
- Since 2003, the mandate of the EMWG has been updated to include other key economics factors important to advanced reactors, however maintaining and updating these key outputs have remained a focus of the EMWG.
- The EMWG Terms of Reference were updated in 2018 to include topics such as flexibility, and integration with renewable sources, acknowledging a shift from economic assessment for individual system levels to the integration of Generation IV systems into grids with other resources.

Major Accomplishments of the EMWG



Publication of the Cost Estimating Guidelines *(issued 2007)*

Development and Update of the G4ECONS Cost Model *(Version 3 released 2018)*

Benchmarking of G4ECONS with IAEA NEST & HEEP tools *(2017 & 2018)*

Position Paper on the Impact of Increasing Share of Renewables on the Deployment of Generation IV Nuclear Energy Systems *(2018)*

Joint EMWG/SIAP Workshop on Flexible Generation *(2019)*

Position Paper on Flexibility of GEN IV Systems *(2019)*

Report: "Nuclear Energy: An ESG Investable Asset Class" (2021)

Report: "Advanced Nuclear Technologies Cost Reduction Strategies and Systematic Economic Review" (ANTSER, 2021)

On-Going Activities within EMWG

- Maintain the “Nuclear Energy: An ESG Investable Asset Class” report
  - Lead by Fiona Reilly (U.K.)
- Advanced Nuclear Technologies Cost Reduction Strategies and Systematic Economic Review (ANTSER)
  - Lead by David Shropshire (U.S.)
- Update to EMWG Cost Estimating Guidelines and G4ECONS
  - Lead by Megan Moore (Canada).

ANTSER Cost Reduction Strategy #2: Design- Modularity-at-Scale

ANTSER Overview

- ANTSER was developed with 3 goals in mind:
  1. Create a methodology for creating impactful cost reduction strategies that crosscut a broad set of advanced reactor technologies
  2. Generate example cost reduction strategies using the ANTSER methodology
  3. Provide a path forward to improve the methodology and produce additional cost reduction strategies.
- Completed to date: Functional Containment (2021), Modularity-at-Scale (2022)
- Future topics for consideration under Design, Construction/Production, & Project Management:
  - Advanced Concrete
  - Fabrication processes
  - Digital Engineering
  - Reactor coolants
  - Plant commodities
  - Construction
  - optimization
  - Productivity enhancements
  - Natural uranium resource
  - Fuel Engineering
  - Seismic Protection
  - Economics & Sustainability
  - Margins and Tolerances
  - Others

Modularity Cost Reductions

1. **Reducing the share of the reactor built on-site,** reducing the management and complexity of site work.
2. Improving learning by **building a large number of smaller modular plants.**
3. Gaining direct labor work efficiencies including optimized labor use and coordination of trades, **by building modules in a controlled environments**.
4. Shortening construction schedules through **parallel construction**, reducing indirect and management costs, direct cost contingencies and owner's costs.
5. Reducing finance costs by **lowering capital requirements**, allowing quicker plant start-ups and revenue generation.
6. Computer-aided manufacturing that **integrates design changes with manufacturing processes** to minimize the design cycle.
7. Reducing operational and maintenance requirements through **simplifying and standardizing service requirements** and allowing **quick replacement of modular components** with a minimum of operational downtime.

Potential Modularity-at-Scale Cost Reductions

Reactor Size	Modularity Options	DoM Possible	Expected Cost Benefit on OCC	Limitations
Large NPP (Reactor)	NA	NA	NA	Conventional reactors have not been modularized due to mostly economy of scale reasons
Large NPP (Balance of Plant)	Multiple similar modules for foundation, shielding and containment structures	<10%	<10%	Due to safety requirements of conventional large reactors, the modules need to be thick and heavy, limiting transportability
SMR (Reactor)	Super modules	50%	20-30%	Initial need of satisfactory orders for scaling of manufacturing of modular reactors
SMR (Balance of Plant)	Multiple similar modules for foundation, shielding and containment structures	<20%	20-25%	Constructing and operating entire plant with limited number of reactor modules may impact the expected profitability
Microreactors	Entire unit being modular and ready to be operational	100% (absent siting)	20-60%	Initial need of satisfactory orders for scaling of manufacturing of modular reactors

Cost Estimating Guidelines and G4ECONS tool.

What are the GenIV Cost Estimating Guidelines and G4ECONS

- The GENIV Cost Estimating Guidelines provide a uniform set of assumptions, a uniform Code of Accounts (COA) and cost-estimating guidelines to be used in developing cost estimates for advanced nuclear energy systems. It discusses the development of all relevant life cycle costs for Generation IV systems, including the planning, research, development, demonstration (including prototype), deployment, and commercial stages.

- A MS Excel based software model, G4-ECONS, accompany this document. The combination of the software and guidelines facilitate the development of consistent, comprehensible cost estimates of generation IV reactors.

Why is an Update Required?

- The “Cost Estimating Guidelines for Generation IV Nuclear Energy Systems” were last published in 2007.
- Since 2007:
  - New reactor technologies including small modular reactors (SMRs) and microreactors are being developed, some very near to deployment.
  - The body of knowledge on nuclear energy economics has expanded to include additional concepts, such as:
    - modularization,
    - advanced manufacturing,
    - new finance structures,
    - multiple units on site,
    - semi- and autonomous operation,
    - new energy applications,
    - transportation systems,
    - new fuels (e.g., HALEU),
    - new regulatory frameworks, etc.
- In 2021, a survey of G4ECONS users was conducted. The survey highlighted the opportunity to improve G4ECONS by adding the following functionalities:
  - SMRs
  - Non-Electric Application (removed G4ECONS v3)
  - Uncertainty Analysis
  - Additional Training Sessions

Proposed Scope of Work

- Updated “Cost Estimating Guidelines for Generation IV Nuclear Energy Systems”, includes:
  - Update content based on current publications.
  - Consider the following for addition
    - Unique aspects of SMRs: factory fabrication/learnings, fleet economics, co-siting.
    - Expanded review of modularity to include aspects of SMRs and micro-reactors.
    - Coupled and uncoupled systems, non-electric applications/cogeneration.
    - Economic impact of flexible generation.
    - Cost associated with building supply chain (ex. factory, fuel fabrication, etc.).
  - Develop training, in coordination with the GIF Education and Training Working Group (ETWG).
- Updated G4ECONS v.4 that aligns with refreshed Guidelines report, includes:
  - Re-defined model framework for v.4 to meet new or modified needs of users.
  - Updated the G4ECONS v.4 model and user documentation.
  - Develop training module for G4ECONS v.4 (with support from ETWG).

Targeting early 2025 to publish revised GENIV Cost Estimating Guidelines document & release G4ECONS V4

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Thank you