2018 Gif Symposium Closing Remarks

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With Track Leaders

2018 GIF Symposium
Paris
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4th GIF Symposium & 8th Atoms for the Future

- ***~260 Participants*** *(133 + 125)*
  (Students, Young professionals, Policy makers, nuclear stakeholders)
- ***W. D. Magwood***
- ***Gen-IV systems:*** *a vision of reactor types that would symbiotically achieve all missions that nuclear can fulfill in low-carbon energy systems*
- ***GIF original goals:*** *advance systems R&D to demonstrate feasibility & performance + inform stakeholders and students*
- ***Symposium:*** *review achieve-ments and challenges*

Drivers for the development of Gen-IV systems

- ***Welcome*** *(SFEN, NEA)*
- ***Nice Future Initiative*** *(US-DOE)*
- ***Clean Energy Futures*** *(Energy for humanity, UK)*
- ***Heat market opportunities & HTR roadmap in Poland*** *(NCBJ)*

- *From nuclear renaissance to scepticism*
- *Climate change, clean air*
- ***Nuclear part of the solutions***
- *How to **bring nuclear forward**?*
- *Nuclear societies becoming think tanks: **Nuclear for climate***
- *Nuclear Innovation: Clean Energy **(NICE) Future***
- *Nuclear to displace fossil as dispatchable energy source*
- ***GIF:** non only **R&D**, bring to **market**, involve **regulators***
- *Biggest barrier is **cost***
- *HTGR for **heat market in Poland***
- *NC2I & NGNP Al. → GEMINI+*

Innovation & R&D for demo & deployment of Gen-IV

- ***Regulating Advanced Nuclear Technologies*** *(ONR, UK)*
- ***Advanced reactors – A paradigm shift*** *(US-NRC)*
- ***Development of Gen-IV systems: utility perspective*** *(EPRI)*
- ***Licensing Gen-IV: small company perspective*** *(Terrestrial Energy Canada)*
- ***Innovation in nuclear: an accademic perspective*** *(MIT)*

- *UK Clean Growth Strategy*
- ***ONR****: Risks* ***ALAR-Practicable***
- *UK: LWR, SFR, LFR, HTR, MSR*
- *US-NRC:* ***Risk informed Performance-based*** *licensing approach for Gen-IV*
- *Fundamental safety functions*
- *International coop. (****GSAR****)*
- ***EPRI****: uncertain context (gas, carbon, CCS, unknown…) Compelling: robust, competitive, <4000 $/kWe, flexible generation*
- *The value of Integral-MSR*
- ***Clean power: 200$/MWh without nuclear*** *– Load following or with* ***storage*** *& variable power to grid*

From R&D to Demo projects

- ***GIF R&D outlook*** *(GIF)*
- ***GIF R&D Infrastructures Task Force: Force, Challenge & Opportunities*** *(Euratom)*
- ***Overview of Gen-IV Demonstration in China*** *(CNNC)*

- ***2030 vision of GIF objectives***
- ***R&D****, Gen-IV related* ***new builds****,* ***outreach*** *to stakeholders: regulators (RSWG), industry (SIAP, EMWG), customers…*
- ***Emerging interest of industry***
- *Identify gaps i.e.* ***key experimental infra-structures*** *needed in support of Gen-IV (feasibility, performance) along with IAEA, NEA, EU-FP…*
- ***China*** *member of SFR, VHTR, SCWR + Observer of LFR, MSR*
- *CEFR → CDFR, HTR-PM 200 → 600, CLEAR, China's SCWR…*

From Demo to market opportunities

- ***Market perspectives and challenges of Gen-IV*** *(JAEA)*
- ***Nuclear energy in the UK and the role of Advanced Nuclear Technology*** *(NNL, UK)*
- ***Government and industry roles in commercialization of Nuclear Power*** *(EPRI)*

- *Original GIF criteria still apply for assessing the viability of Gen-IV systems: Safety, Sustainability, Economy, PRPP… with integrability with renewables becoming an additional requirement.*
- ***UK: Climate change Act: 80% decarbonization by 2050***
- *Clean Growth Strategy: nuclear, CCS, Renewable energies*
- *LWRs, SMRs + HTGR, LFR, MSR*
- *SMRs for non-electric applications*
- ***Enabling framework:*** *regulator, supply chain, siting, acceptance…*
- *Significance of public-private initiatives adapted to the evolving context to support first demos of new reactor types*

Progress on Gen-IV Systems

- ***SFR***
- ***VHTR***
- ***LFR***
- ***SCWR***
- ***GFR***
- ***MSR***

- ***Operating Gen-IV related reactors*** *(CEFR, BN600, BN800) + (FBTR, PFBR in India), HTTR, HTR10, HTR-PM…*
- ***New projects*** *(BN1200, BREST-300, CDFR, BREST, Myrrha, SVBR-100, HTR-PM600, EM², MOSART, FHR…)*
- *Growing Nb of* ***baseline concepts***
- ***Applications*** *&* ***Economics*** *(WP)*
- *R&D focused on* ***Design***, ***Safety*** *and* ***Operation*** *(WP, SDC/SDG)*
- *Advanced* ***Fuel*** *& fuel cycle,* ***Materials***, ***Coolant chemistry***, ***Power conversion*** *(electicity, H_2), Waste management*
- ***Experiments*** *&* ***Modelling/Simulation***
- ***ISI&R***, *Modularity,* ***Components***, *Balance of plant*
- *TRU recycling (FNRs)*
- ***Interest of private companies***

Progress on Gen-IV Systems

- ***Euratom*** *(EC)*

- ***ASTRID*** *(CEA)*

- *10y of **successful contribution** of Euratom to GIF, extended 2016-26*
- *JRC implementing agent*
- ***ESNII & NC2I** are public & private frameworks to mature Gen-IV reactor projects*
- *Contributions from FP7, H2020, ETPs, ERA, INCO…*

- ***ASTRID-600**: vision of next generation commercial SFR (CFV core, gas PCS, Fuel handling, Nat Conv DHR, core catcher…)*
- ***ASTRID-150**: new project, increased use of numerical simulation*

Integration of Gen-IV reactors in low-carbon energy system

- ***Energy storage for the AHTR Technology*** *(Eskom)*
- ***Base-load nuclear reactors with heat storage to by and sell electricity*** *(MIT)*
- ***Small modular LFR: comparison with PWR*** *(EU-US NERI))*
- ***Economic and financial analysis of Lead-cooled small modular reactor*** *(Tractebel)*
- ***Impact of increasing share of renewables on the deployment of Gen-IV nuclear systems*** *(GIF)*

- ***AHTR****: PBMR revisited with energy storage*
- ***Nuclear as baseload & power cycle with storage*** *– Nuclear with heat storage to come soon*
- ***Assets of LFR-SMR*** *& recommendations for marketability*
- *Nuclear challenged by RE Need for increased flexibility*
- ***Policies*** *needed to correct market flaws, ensure grid reliability and incentivize new nuclear capacity (zero-emission credits, carbon taxes, financing and electricity pricing…)*

Human capital development

- ***GIF Webinars: an online educational resource*** *(GIF)*
- ***Gen-IV fast spectrum reactors: course devpt and e-learning at KTH*** *(KTH)*
- ***Teaching sodium fast reactors at CEA*** *(CEA)*
- ***The SFEN/INSTN MOOC on "nuclear energy in France": objectives and results*** *(SFEN)*

- *Review of experiences in* ***innovative methods of education and training*** *in the area of Gen-IV systems*

- ***Web1: Atoms for Peace t The Next Generation (Jan. 2014, J. Kelly US-DOE)***
- ***...***
- ***Web25: Safety of Gen-IV reactors (Oct. 24, 2018, L. Ammirabile Euratom)***
- ***Web26: Allegro – Experimental GCFR (Nov. 28, 2018, L. Belovsky)***
- ***Web27: Russia BN600 and BN800 (Dec. 19, 2018, I. Ashurko)***

Safety and security

- ***New safety measures proposed for European SFRs in H2020: ESFR-SMART Project*** *(CEA)*
- ***Developing a MSR safeguards model*** *(B. Cipiti)*
- ***Development of Safety Design Guidelines for Gen-IV SFR*** *(GIF)*
- ***Source term analysis codes for pebble-bed HTGCR*** *(C. Fang)*
- ***GIF RSWG*** *(GIF)*
- ***GIF PR&PP WG*** *(GIF)*

- *RSWG & PRPP methodologies*
- *GIF RSWG engaged with NEA CNRA, CSNI &* ***GSAR***
- ***White papers*** *about Gen-IV systems main* ***safety features*** *& ISAM-based safety assessment – To be posted on website*
- *SFR, MSR & HTGR* ***safety studies***
- ***SDC/SDG initiatives****: consolidation of safety criteria*
- *SFR reports reviewed by GSAR and IAEA & VHTR, LFR, GFR, SCWR, MSR reports in progress*
- *Position papers with regard to current events (Fukushima, IRSN 2014 report…) and as input to IAEA, OECD/NEA, WENRA…)*
- ***White papers on PRPP aspects***

Fuels & materials for Gen-IV reactors

- ***Corrosion behavior of austenitic steel in SCWRs***
- ***USA's Advanced Reactor Technologies (ART) Graphite R&D Program***
- ***The chemistry of MSRs***
- ***ODS tempered martensitic steel for SFR high burn-up fuel cladding tube***
- ***Thermal expansion & thermal conductivity of actinides from first-principles calculations***
- ***Brief overview of R&D in Australia on materials for Gen-IV reactors***

- *Functionally graded **metallic composite (FGC) materials** such as Fe-12Cr-2Si as candidate piping and fuel cladding material in lead-bismuth cooled reactor*
- *Effect of the minor actinide content on the **irradiation behavior of MOX fuel***
- *Prediction of **physical properties of UO_2 and $(U, Pu)O_{2\pm x}$** in fuel performance codes with a new set of equations derived from experimental results*
- *Self-irradiation decreases thermal conductivity, the effect is almost completely recovered in the hot central part of the fuel*

Advanced components & Systems

- ***Can innovative way to work on a harmonized set of rules for Gen-IV reactors*** *(CEA)*
- ***Use of CAD models in ESFR-SMART EU Project***
- ***Progress in ASTRID gas power conversion system*** *(CEA)*
- ***Codes and standards development for next generation SFR in Japan*** *(JAEA)*
- ***Innovative designs of control rods in SFRs***

- *Development of **Codes and standards for Gen-IV systems** – Japan and EU experiences*
- *Development of **simulation tools** and models for project development and operation*
  - *By the use of Computer Aided Design (CAD) to create the 3D design of the whole reactor system*
  - *By the use of **system transient analysis** program to simulate the start up and shutdown process of Steam Genarator*
- *Development of **innovative solutions** for GEN IV system competitiveness*
  - *Innovative control rod design*
  - *Innovative Gas Power Conversion System*

Last but not least

- ***Posters***
- ***Elevator Pitch Challenge (EPiC)*** *(ANS & SFEN-YG)*
- ***Workshop: communication on nuclear issues*** *(SFEN)*
- ***Workshop: the climate frescoe*** *(UK)*

- ***Posters****: wide range of Gen-IV related topics*
- ***EPiC*** *with 15 candidates*
- *Top 3 PhD presentations & prize ceremony*
- ***Workshop:*** *getting the messages across, informing the public*
- ***Interactive workshop*** *on climate change*

General remarks

- ***Context***
  - ***Climate change, Clean air, Growth of renewables***
  - ***First builds of Gen-IV related systems, emerging interest of the industry and growing attention paid to market issues*** *(SIAP)*
  - ***Emerging interest of private companies in GIF member's activities thus favoring public-private initiatives***
- ***GIF in 2018 with Chairman F. Gauché***
  - ***Same set of 6 Gen-IV systems with more baseline concepts***
  - ***Significance of sustainability: fast neutrons & closed fuel cycles***
  - ***From 9 countries in 2000 to 14 members*** *(+ UK…)*
  - ***Development of non-R&D activities and cross-cutting actions***
    - » *White papers on systems assessments with GIF methodologies*
    - » *(Materials, Data bases, SDC/SDG, Infrastructure TF, AMMI-TF…)*
  - ***Extended outreach to outer community NEA/GSAR, IAEA, Education Networks…*** *(RSWG, EMWG, ETTF, PRPP…)*
- ***Encourage the Young Generation to give the place they deserve to Gen-IV reactors among Atoms for the Future***