Generation IV R&D Infrastructure Task Force (GIF RDTF)

EXPERIMENTAL INFRASTRUCTURE NEEDS - CHALLENGES AND OPPORTUNITIES

On behalf of the GIF RDTF

Roger Garbil (Chair), Alfredo Vasile and Sang Ji Kim (co-Chairs)

15-19 October 2018, GIF EG/Symposium/PG meetings, Paris, FR

Objectives of the GIF-RDTF

- Identify essential large (and key) experimental infrastructure needed in support of GEN IV systems R&D activities in terms of feasibility/performance as well as demonstration/deployment

- Facilitate R&D collaboration across GEN IV systems

- Promote utilization of experimental facilities for collaborative R&D activities among GIF partners. Facilitate GIF partners' access to the various R&D facilities in the GIF member countries

- An Opportunity to interact and benefit from the NEA Working Group on Safety of Advanced Reactors WGSAR but also related IAEA GFR, LMFNS technical meetings facilitating a cooperative approach to:
  - Identify and resolve key regulatory issues
  - Identify and address safety research needs

Modus Operandi of the GIF-RDTF

- GIF Policy Group decision at the 2017 spring meeting, GIF Policy Group approved Terms of Reference in October 2017, Kick-Off meeting mid-February 2018 at OECD/NEA Boulogne (FR)

- GEN IV System Steering and provisional System Committees
- SSC designated representatives to the GIF-RDTF
- GIF Experts Group members may also designate representatives
- GIF-RDTF reports to the GIF Policy Group vice chair in charge of external collaboration
- The GIF Technical Director supervises the activities of the GIF-RDTF and makes use of the GIF Experts Group for quality and completeness reviews

Members

Systems

- GFR VASILE Alfredo (RDTF co-Chair)
- MSR IGNATIEV Victor
- SFR HILL Robert
- LFR ALEMBERTI Alessandro
- SCWR LEUNG Laurence
- VHTR FUETTERER Michael

GIF Member Representatives

- Australia EDAWRDS Lyndon
- Canada LEUNG Laurence (SCWR)
- China To be nominated
- Euratom GARBIL Roger (EG, RDTF Chair), GLATZ Jean-Paul (SFR)
- France GASTALDI Olivier (SFR), BERTHELEMY Michel (EMWG), STORRER François (PG)
- Japan HAYAFUNE Hiroki (SFR)
- Korea KIM Harkrho (PG vice-Chair), KIM Sang Ji (RDTF co-Chair)
- Russia ASHURKO Iurii (EG, SFR), FOMICHENKO Petr, KLINOV Dimitri
- South Africa ZIBI Zukile, FIPAZA Mmeli
- Switzerland To be nominated
- USA HONG Bonnie, SOWINSKI Thomas (SFR), STANCULESCU Alexander (EG Director)

International Organisations

- IAEA MONTI Stefano
- OECD/NEA IVANOVA Tatiana
- GIF Technical Secretariat PAILLERE, Henri, DEFFRENNES Marc (SIAP), GROSCH Gisela

Modus Operandi of the GIF-RDTF Cont'd

- The GIF-RDTF **takes advantage of – and benefits from -** the GIF Member State's, IAEA's and NEA's relevant work in the areas of:
  - **R&D needs** Outlook(s) along with
  - R&D **infrastructures, databases, reports, compendium** and International Cooperation initiatives (e.g. IAEA CRPs, ICERR, NEA Joint Projects, NEST, NI2050, EURATOM Collaborative Projects and so on)
- Completion of the first objectives in time for presentation at the October 2018 GIF Symposium
- Completion of other objectives by the spring 2019 GIF Experts/Policy Group meetings
- Upon completion of the objectives, the GIF-RDTF, and the GIF System Steering and provisional Steering Committees are expected to maintain cognizance of infrastructure needs and approaches for their access as work evolves

SFR SSC Infrastructure Gaps

While global infrastructure currently exists to address some SFR R&D needs, the SFR SSC has identified the following key experimental and analytical infrastructure gaps:

- **Advanced fuel and material qualification:**
  - Need for fast neutron irradiation capabilities
- **Inherent Safety Testing**
  - Need for integral effects experimental facilities supporting SFR transient and safety analyses
  - Need for benchmark data on natural circulation transient behaviour
- **Advanced Energy Conversion**
  - Need for increased sodium – SCO2 interaction and heat exchanger testing capabilities
- **SFR Component Testing**
  - Need for large scale component in-sodium testing facilities
- **Safety Analysis**
  - Need for particle/aerosol tracing facilities to support SFR mechanistic source term activities
  - Need for test facility demonstrating molten fuel behaviour during severe accidents
  - Need for seismic performance test loop/facility
- **In-service Inspection**
  - Need for larger test sections for under-sodium ultrasonic sensor performance tests

Path Forward **(idem to all GIF SSCs)**

- SFR SSC members look to address some of these infrastructure gaps through a combination of modified and new facilities and potential facility sharing among members
- The GIF R&D Infrastructure Task Force currently aims to assist member nations in identifying access pathways to international capabilities and potentially developing international facility use access mechanisms within GIF

VHTR SSC Infrastructure Gaps (1/2)

- **VHTR Infrastructure Requirements**
  - He-cooled graphite moderated, fully ceramic coated particle fuel, high outlet T
  - passive decay heat removal
  - large graphite thermal buffer
  - → unprecedented level of inherent safety

- **Large international collaboration effort on fuel and material qualification in support to near-term demonstration.**

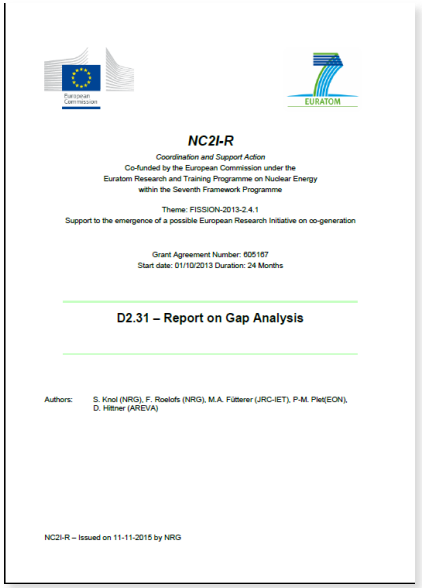
Euratom NC2I-R reports: infrastructure needs for licensing and demonstration (bottom-up + top-down incl. from OECD TAREF database), identification of priorities and gaps in view of licensing, construction and operation of a demonstrator.

Several mothballed test facilities could be recovered, new or repurposed test facilities have been constructed in support of China's HTR-PM demonstration, the US NGNP project, and the HTR programs in Korea, Japan and the EU.

- **Test facilities required for:**
  - Completion of fuel testing and qualification (fabrication, QA, irradiation, safety testing, PIE, waste reduction, recycling)
  - Qualification of graphite, hardening against air/water ingress, waste management, recycling
  - Coupling technology and related components (e.g. isolation valves, IHX)
  - Design Codes & Standards for new materials and components (e.g C-C, SiC-SiC)
  - Advanced manufacturing methods (cooperation with the GIF Cross-cutting Interim TF)
  - Cost cutting R&D and interaction with EMWG and industry to optimize VHTR design
  - Development, validation, uncertainty characterization of modern core analysis methods
  - Licensing and Siting: V&V of computer codes for design and licensing
  - Integration with other energy carriers in Hybrid Energy Systems
  - Analysis of HTR-PM start-up physics and demo tests
  - HTTR: safety demonstration tests and coupling to H2 production plant (subject to regulatory approval for restart)

VHTR SSC Infrastructure Gaps (2/2)

- **Accompanying efforts:**
  - Ongoing collaboration towards fuel and material qualification
  - Ongoing collaboration on V&V of computer codes
  - Enhance information exchange among vendors, private investors, new national programs, multinational organizations, and regulators
  - Factor in time/effort needed for qualification and specific regulator requirements
  - Large-scale test facilities for qualification of components and subsystems (steam generators, heat exchangers, the Reactor Cavity Cooling System, circulators with magnetic bearings, isolation valves, control rod mechanisms, instrumentation etc.)



NC2I-R

Coordination and Support Action
Co-funded by the European Commission under the
Euratom Research and Training Programme on Nuclear Energy
within the Seventh Framework Programme

Theme: FISSION-2013-2.4.1
Support to the emergence of a possible European Research Initiative on co-generation

Grant Agreement Number: 605167
Start date: 01/10/2013 Duration: 24 Months

D2.31 – Report on Gap Analysis

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NC2I-R – Issued on 11-11-2015 by NRG

EUROPEAN COMMISSION
Directorate General Joint Research Centre
Institute for Energy and Transport – Unit F.04

9 September 2015
PUBSY JRC96912

JRC TECHNICAL REPORT

D2.21 R&D and Industrial Infrastructures
rev. 0

Deliverable D2.21 for the FP7 NC2I-R Project
Grant Agreement Number: 605167

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Date	3.3.15	28/09/2015	05/10-2015	5.10.2015
Signature				

Path Forward Idem between all GIF SSCs

GFR SSC Infrastructure Gaps

The GFR SSC has identified the following key experimental and analytical infrastructure gaps:

- **Advanced fuel and material qualification:**
  - Need for fast neutron irradiation capabilities
  - Need for material testing under pressurized and high temperature conditions
- **GFR Component Testing**
  - Need for large scale component in-Helium testing facilities for the development of heat exchangers, blowers, valves, sealings and instrumentation.
- **Safety**
  - Need for integral effects experimental facilities supporting GFR transient and safety analyses
  - Need for integral tests for transients with fast depressurization.
  - Need for test facility demonstrating U-Pu carbide fuel behaviour during severe accidents.
  - Need for benchmark data on natural circulation transient behaviour

Path Forward Idem between all SSCs

MSR SSC Infrastructure Gaps

The MSR development needs for the 2018 + 10 years period can be expressed in terms of the following grand challenges

- **Identifying, characterizing, and qualifying**
  - successful salt and materials combinations for MSRs.
- **Developing integrated reactor performance modeling and safety assessment capabilities**
  - that capture the appropriate physics and fuel chemistry needed to evaluate the plant performance over all appropriate timescales and to license MSR designs.
- **Demonstrating the safety characteristics of the MSR at laboratory and test reactor levels.**
- **Establishing a salt reactor infrastructure and economy**
  - that includes affordable and practical systems for the production, processing, transportation, and storage of radioactive salt constituents for use throughout the lifetime of MSR fleets.
- **Licensing and safeguards framework development to guide research, development and demonstration.**

Path Forward Idem between all GIF SSCs

LFR SSC Infrastructure Gaps

- **Identify a specific licensing process for demonstrator/prototypes able**
  - to help developers/regulators working together towards the development and licensing of a new system while maintaining their respective roles (Phased approach?)
- **Promote E&T activities on the HLM technology**
  - in order to prepare regulatory experts to the task requested by the licensing process for innovative reactors
- **Address the lack of experimental facilities for Fast Neutron Irradiation and the consequences of thereof**
- **Try to identify procedures to help functional test of passive systems (for example during outages)**
  - without the need to put in operation the passive system (for passive systems with moving fluids and strong changes of temperature and pressure conditions testing may become a challenge)
- **Help the development and qualification of new fuel / reprocessing technologies**
- **Address specific needs related to material / surface coatings / irradiation**
  - **As parts of the present R&D are devoted to corrosion-resistant coatings / surface treatments - develop a framework to help speed-up qualification and integration of such new techniques** taking into account the difficulties of having experimental tests and qualification performed in the «ideal» simultaneous conditions of coolant environment, mechanical load and irradiation.
  - **Help the definition of prototypical conditions to transfer results from heavy ion irradiation to neutron irradiation** in order to speed up the development and market uptake of new materials, especially those having the combination of surface coatings with structural materials already qualified at high dpa irradiation levels
  - **Increase support to the development and update of Codes and Standards for HLM technology**

Path Forward Idem between all GIF SSCs

SCWR SSC Infrastructure Gaps

- **SCWR is a Gen-IV system evolved from the current nuclear reactor systems**
  - Existing infrastructure are applicable

- **Established infrastructure specifically for high pressures and high temperatures**
  - Supercritical autoclaves and loops are available for material testing (Canada, China, EU)
  - Supercritical water test facility constructed for in-reactor material testing (also applicable for fuel testing) (EU)
  - Several thermal-hydraulics test facilities have been established for small-scale fuel assemble experiments (Canada, China)

- **Infrastructure needs**
  - Fuel qualification testing loop (China, EU)
  - Physics experimental facility (Canada)
  - Thermal-hydraulics test facility for full-scale fuel qualification (China)
  - Integral safety test facility (Canada, China)

Path Forward Idem between all GIF SSCs

Modus Operandi of the GIF-RDTF, cont'd

- IAEA's, NEA's and GIF Member State's **relevant work on R&D needs, infrastructures, databases, reports, compendium e.g.**
  - IAEA https://nucleus.iaea.org/sites/lmfns/Pages/default.aspx database of Facilities in Support of Liquid Metal-cooled Fast Neutron Systems Facilities is available, a compendium to be published soon. It is complementing
  - The Advanced Reactor Information System (ARIS, https://aris.iaea.org/),
  - The Research Reactor database (RRDB, https://nucleus.iaea.org/RRDB/RR/ReactorSearch.aspx) and
  - OECD/NEA Research and test facilities database (RTFDB, https://www.oecd-nea.org/rtfdb/)
  - OECD/NEA Task Group on Advanced Experimental Facilities (TAREF) on SFR and GFR but also the Support Facilities for Existing and Advanced Reactors (SFEAR)
- **Use this opportunity to mainly support any SSC's update of existing** IAEA and NEA **databases** and compendium

Challenges and Opportunities

- Identifying Key Nuclear R&D, Innovation and Infrastructures needs
  - What technologies will be needed in 10 years? 30 years? 50 years?
  - What R&D is needed to make these technologies available?
  - How do we regain the ability to push innovation into application?
  - Is multilateral cooperation part of the solution?
- Challenges and Opportunities
  - Develop a broad, common agenda for nuclear technology innovation to contribute to the sustainability of nuclear energy in the short/medium (2030) and long term (2050)
  - Identify and find solutions to barriers or delays to innovation
  - Identify infrastructure requirements and share global R&D assets
  - Establish plans of action to enable deployment of technology innovations
  - Consider multilateral and multi-national approaches to obtain early regulatory insights without compromising regulatory independence

Challenges and Opportunities

- Advanced Research Programs are Struggling in Many Countries:
  - Funding levels are shrinking
  - Research infrastructure is aging and contracting
  - Expert scientists and engineers are retiring and fewer young people are available to replace them
  - Political will and interest to fund large nuclear technology activities is difficult to sustain over the life of programs
  - Increasing cost and regulatory requirements
  - Strains in the industrial supply chain
- International Cooperation initiatives and International Frameworks agreements to be capitalised
  - GIF MSs, IAEA CRPs, ICERR, NEA Joint Projects, NEST, NI2050, EURATOM Collaborative Projects, Innovative Legal and Funding opportunities (e.g. InnovFin, AISBL), Transnational access to infrastructures (e.g. US NSUF), and so on

Conclusion, perspectives

- GIF Member States (MSs) experience is a consistent success in pursuing excellence in nuclear science research and technology
- Close collaboration within GIF MSs, OECD/NEA and IAEA, International Frameworks agreements
- Stakeholders structured dialogue on R&D policy, safety improvements, holistic approach, early involvement in regulatory and decision making
- Industry driven initiatives, technology platforms should be capitalised

GEN IV International Forum

NEA Nuclear Energy Agency

IAEA.org International Atomic Energy Agency

enen european nuclear education network

GAIN Gateway for Accelerated Innovation in Nuclear

eTP European Technology Platforms

Thank You!


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SEDAN 1957
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SINDS 1957
INSIEME
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Schedule, WP2018-19 and Outlook

■ EG/PG meeting	15-19/10/2017	RDTF ToR approval
• RDTF Kick-off	19 February	**TF, Work programme**
• Audio-call	6 April	Prep., Call for abstracts
■ EG/PG meeting	14-18/05/2018	**Abstracts**
• Audio-call	21 June	Abstracts, Mapping, Gaps
• Audio-call	15 September (x)	TF Paper + 1st Draft report
• WGSAR meeting	10-12 October	PPT Infrastructure Gaps
■ EG/PG meeting	15-19/10/2018	**EG/PG 1st report** (skeleton)
■ **2018 Symposium**	16-17/10/2018	**Track 4 Infra., TF + Papers**
• Audio-call	mid-November (tbc)	Funding. Eval., W-shop Agenda
• IAEA GFR, LMFNS	5-6, 12-13 December	IAEA Infrastructure updates
• Audio-call	mid-January 2019 (tbc)	2nd Draft report
• Workshop (tbc)	2 days March (tbc)	Exp. + private sector Needs
• Audio-call	mid-March (tbc)	2nd report update
■ EG/PG meeting	April/May 2019 (tbc)	**EG/PG 2nd report**

Thank You!

EURATOM FISA 2019 and EuradWaste '19

NUCLEAR DAYS 2018

SNETP ESNII NC2I EERA JPNM

ANNUAL FORUM 2018

Industrial perspective for nuclear energy production

NUGENIA

www.nugenia.org • www.snetp.eu

EU/EURATOM Nuclear Events

2013 Symposium

In collaboration with the Lithuanian Presidency

14-17 October 2013
Vilnius, Lithuania

http://cordis.europa.eu/fp7/euratom-fission/fisa-euradwaste-2013_en.html

ENS YGN

15 years enen 2003–2018

In collaboration with the

Romanian Presidency

of the Council of the EU

In Pitesti (RO)

3-7 June 2019

Mark up your calendar!

European Commission

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