GIF 活動概況

各SSC/WG/TFの活動は、HP及び年報に記載があります。
ここでは、外部の機関との関係、近年の成果について触れています。

Nobuchika KAWASAKI (GIF PD)

GIF and GIF partners

Link-GIF-Partners
Link-Partners-activities

GEN IV International Forum
Expertise | Collaboration | Excellence

Outside GIF

Inside GIF

Privat sectors

Non national SMR developers

GIF NEANH Gr

Non Electric Application of Nuclear Heat activities

NICE Future — NUCLEAR INNOVATION: CLEAN ENERGY FUTURE
AN INITIATIVE OF THE CLEAN ENERGY MINISTERIAL

Link-Flexibility

A dialogue on the role that nuclear energy can play in clean energy systems of the future. To bring nuclear energy from traditional, nuclear-only fora to a broader, cross-sectoral discussion on clean energy at the ministerial level.

GEN IV International Forum
Expertise | Collaboration | Excellence

PG/EG
Driver

SIAP
Opportunity supplier

SSC
Reactor system developer

WG/TF
Methodology developer
Opportunity developer

GIF as
6 types of Gen IV system developer
(Theoretically from SMRs to Large reactors if it fit to economical goal.
Historically country-base commitments.)

Potential partner

WORLD NUCLEAR ASSOCIATION

International organization that represents the global nuclear industry. More than 177 vendors/utilities, promoting understand of nuclear energy, developing **common industry positions, and contributing to the energy debate**.

IAEA
International Atomic Energy Agency

International Whole Nuclear Developer especially safety standards

Especially for the field of RSWG, PRPPWG, EMWG

NEA
NUCLEAR ENERGY AGENCY

Regulators

Intergovernmental agency that facilitates co-operation in nuclear safety, technology, science, environment and law. Especially **market, SMR, innovation, NI2050 & regulation needs. (including WGSAR)**

GIF RD-TF
AMME-TF

Link-RDTF
Link-AMME

R&D facilities, AMM technology developments

Nuclear related International Standards Organizations

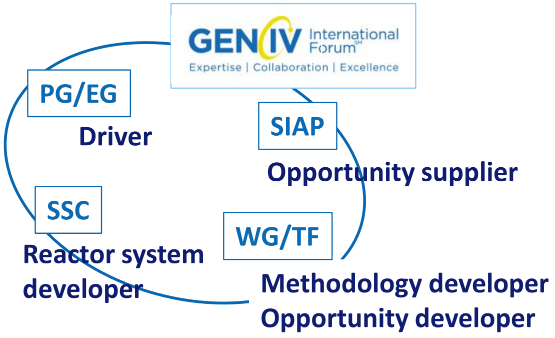
Other energy sources

Gen III+

GIF-IAEA relationship

GEN IV International Forum[SM]
Expertise | Collaboration | Excellence

International country groups developing Gen IV reactors.
12 active countries, with 6 Reactors SCs, 7 Methodology/Opportunity WG/TFs and SIAP.



Common activities

To commonly develop/review methodologies for advanced reactors

⇒ Safety standards like SDC/SDG (SFR, LFR, VHTR, SMR) , INPRO methodologies, related TECDOCs about risk-based approach, etc.

⇒ R&D facilities (Infrastructure needs and data base)

⇒ PRPP methodologies like IAEA NE-series documents on Safeguards by design

⇒ Economic codes (GIF G4-ECONS, IAEA-NEST tool)

To share strategies in the field of Non-electrical applications of Nuclear Heat

IAEA International Atomic Energy Agency

International Whole Nuclear Developer especially safety standards

IAEA TECDOC SERIES

Standards

Tools, databases, and Coordinated Research Projects

Common interests

Steering meeting : GIF-IAEA interface meeting with cooperate matrix including reactors / education & Training fields
Webinars/ Publications : List
Participating Meetings : IAEA side: GIF PG meeting, GIF RSWG ,PRPPWG, EMWG meetings
GIF side: IAEA TWG-FR, TWG-GCR, IAEA-INPRO Steering Committee

GIF-NEA relationship

common activities

International country groups developing Gen IV reactors.
12 active countries, with 6 Reactors SCs, 7 Methodology/Opportunity WG/TFs and SIAP.

Task Force on Safety Design Criteria

The Activities of SDC-TF

The GIF Policy Group established the safety and reliability goals for Generation-IV Nuclear Energy Systems in 2002 in a publication titled "Generation-IV Nuclear Energy Systems under the GIF Roadmap" and the GIF Risk & Safety Working Group proposed the "Basis for safety approach for design & assessment of Generation-IV Nuclear Systems". In addition, the SFR System Steering Committee set the design goals for the SFR systems in 2007 in the publication "SFR System Research Plan". It is recognized that domestic codes and standards will be used when developing the detailed designs of structures, systems and components. However, there is a large gap between the high-level safety fundamentals and the detailed codes and standards, as illustrated in below figure.

Figure 1: Hierarchy of Safety Standards

Safety Goals	Fundamental safety principles and common safety goals for all Gen-IV systems
Safety Design Criteria	A set of criteria reflecting GIF safety approach to achieve harmonized safety requirements of SFR system
Safety Design Guidelines	A set of guidelines on how to implement the design criteria and address SFR-specific safety topics
Country-specific codes and standards	Domestic regulations for design of reactor core, cooling system, and other structures, systems, and components

Risk & Safety Working Group (RSWG)

Generation IV nuclear energy systems will aim to achieve the following safety goals:

- to excel in safety and reliability;
- to have a low likelihood and degree of reactor core damage;
- to eliminate the need for offsite emergency response.

Lead-cooled Fast Reactor (LFR) System Safety Assessment (2020)

This document was prepared as a safety assessment for the Generation IV LFR system. The objective of the report is to review and identify the main safety advantages and possible challenges of the technology, to assess the current status of safety-related research & development (R&D) activities, and to identify future R&D needs for the LFR system. In preparing this analysis, the LFR pSSC has placed emphasis on the assessment of the fulfillment of the Generation IV goals, to highlight the attractiveness of the LFR technology for future extensive implementation. The report concludes that gaining safety and operational experience feedback through licensing and operation of demonstration plants is a prerequisite to bring the LFR to the industrial deployment.

Download the Assessment

Very High Temperature Reactor (VHTR) System Safety Assessment (2018)

Download the Assessment

Supercritical-water-cooled reactor system (SCWR) System Safety Assessment (2018)

Download the Assessment

Sodium-Cooled Fast Reactor (SFR) System Safety Assessment (2017)

This document was prepared as a safety assessment document for the Generation IV SFR systems through the feedbacks between RSWG and SFR System Steering Committee. The main

Intergovernmental agency that facilitates co-operation in nuclear safety, technology, science, environment and law.
Especially **market, SMR, innovation, NI2050 & regulation needs. (including WGSAR)**

Common activity: OECD/NEA CNRA WGSAR
Reviews of GIF SDC/SDGs,
Joint initiative on development of a Risk-informed Approach for event selection, component classification, and DiD assessment

Webinars/ Publications : List

GIF-CEM NICE Future relationship

Single issue focused initiative

A dialogue on the role that nuclear energy can play in clean energy systems of the future. To bring nuclear energy from traditional, nuclear-only fora to a broader, cross-sectoral discussion on clean energy at the ministerial level.

GIF position

- Flexibility is necessary attribution for future nuclear systems in sustainable energy market. GIF has focused on importance and effect of flexibility from early stage, and internally released “GIF POSITION PAPER ON FLEXIBILITY OF GEN IV SYSTEMS” in 2019. Presently GIF has voluntary Gr for Brainstorming on Non-Electric applications of Nuclear Heat (NEaNH) to develop TF (Task based on ToR).
- CEM NICE Future is an international initiative of the Clean Energy Ministerial. GIF is cross-sectoral partners of CEM NICE Future, and has co-developed flexible report "Flexible Nuclear Energy for Clean Energy Systems"

Common actions →

Coming action
(Presently under final modification)

= Contribution for
CEM 12 NICE future ministerial-level booklet
“Pathways to net zero using nuclear innovation”

Pathways to net zero using nuclear innovation

Generation-IV International Forum (GIF):

The six most promising nuclear energy systems identified by GIF are:
Sodium-cooled Fast Reactor (SFR)
Very High Temperature Reactor (VHTR)
Gas-cooled Fast Reactor (GFR)
Molten Salt Reactor (MSR)
Lead-cooled Fast Reactor (LFR)
Super Critical Water-cooled Reactor (SCWR)

The Generation-IV International Forum (GIF) is a multinational co-operative endeavor organized to foster the research and development needed to accelerate the deployment of the next generation of nuclear reactor systems. Since its foundation in 2000, GIF has identified six nuclear energy systems being the most promising to meet its objectives, assuming a deployment horizon beyond 2030.

As well as the GIF Goals of sustainability, safety, Proliferation, Risk, and Physical Protection (PRPP) and, economics, the flexibility characteristics are becoming increasingly recognised as essential attributes for future energy sources. In the NICE Future initiative's "Flexible Nuclear Energy for Clean Energy Systems" report, GIF set out the flexibility characteristics of Gen IV reactors in Chapter 13.

Sustainability is a key issue of Generation-IV reactor systems, as these technologies enable stable and long term utilization of nuclear across a broader clean energy system. These new designs aim to efficiently use uranium resources and further minimize waste and environmental load. The minimization of environmental load means not only being CO_2-free but also reducing the amount of high level radioactive waste by means of burning of long term radioactive nuclides of Minor Actinides in the spent fuel.

One particular benefit of the Generation-IV reactor systems is higher outlet temperatures ranging 700 to 950°C (i.e., VHTR, GFR, LFR, and MSR), and ~550°C (SFR). This high temperature brings flexibility of energy use. This includes non-electrical applications of their nuclear heat, such as hydrogen production, industrial process heat to chemical processing facilities, and efficient heat storage.

Hideki Kamide
Co-Chair of GIF
Chair of GIF

23

Pathways to net zero using nuclear innovation

The flexibility characteristics we pursue are categorized into three genres. Firstly, we look for Operational Flexibility such as Maneuverability, ramp rates, minimum power level, frequency control, island mode, and the flexibility of fuel. Secondly, we look for Deployment Flexibility such as Scalability, siting requirements, and modularity., Finally, we look at Product Flexibility: Cogeneration of hydrogen, heat applications, and isotopes. All Generation-IV reactor systems, from large electric-output type reactors to small modular reactors (SMRs), regardless of coolant, have such flexibility characteristics.

The operational flexibility of Generation-IV reactors including the heat storage can contribute to wider utilization of the variable clean energy such as solar and wind, by increasing the stability and reliability of the electricity grid. Operationally flexible electricity has a higher value in the market and contributes to the economy.

These flexibility characteristics depend on development histories of the reactors and market needs for different outputs. Recognizing the wide range of requirements for different markets, GIF started the Non-Electrical Application of Nuclear Heat (NEANH) Group, and began to make visual maps to show the relationships between influencing factors. This group mapped the six reactor systems (SFR, VHTR, GFR, MSR, LFR, SCWR), the three Power levels (large-scale reactor, small modular reactor, micro reactor), and the six products (Hydrogen-production, Heat production, Dispatchable electricity, Cold generation, Chemical products, Seawater desalination). Based on these discussions and activities, GIF has a plan to initiate a new Task Force for NEANH. The objective of this Task Force is to adapt flexible technologies to fit the present market, so this Task Force will connect other flexible activities outside GIF. I hope that
We hope

organizations and players involved with flexible energy technologies can make bridges to demonstrate the strong characteristics of these technologies, and GIF NEANH-TF can become one key part of the bridges.

When Gen-IV reactor systems are deployed, regulation is of key importance. GIF has developed SFR safety design criteria (SDC) and safety design guidelines (SDG) with the help of contributions and reviews by the IAEA and regulatory bodies of several SFR developing countries. Such activities have been expanded to other reactor systems like the LFR, GFR, and VHTR. Recently, GIF specialists have participated in several IAEA meetings of SMR safety regulation developments including the Generation-IV reactor concepts based on accumulated knowledge of the SDC and SDG. We believe that these activities contribute to regulations considering various safety characteristics of Generation-IV reactors.

Lastly, I truly appreciate the Clean Energy Ministerial's NICE Future initiative and Flexible Nuclear Energy for Clean Energy Systems report. The seven conclusions reached in Chapter 18 accurately summarize the present nuclear position and situation. I dare not to repeat these seven conclusions here, but I hope these messages will be shared by people in different positions and will be able to become the flexibility bridge that brings the next generation of nuclear reactors to life.

International Energy Agency (IEA): Fatih Birol, Director General

Covid-19 delivered an unprecedented shock to the world economy. But it also underscored the scale of the climate challenge: Even with the deep recession caused by the pandemic, global carbon emissions remain at unsustainable levels. Emissions in 2021 are expected to rise by 1.5 billion tonnes, the second highest increase in history.

GIF-CEM NICE Future relationship

Bran new common actions: Release common message

Release of "Key Requirements of Flexible Nuclear Power in a Clean Energy System"

1. **Expanded Access to Financing and Financial Products:** Nuclear energy power plants are high capital projects with low operating costs. Historically, especially with large-scale reactors, this has increased the financing costs to nuclear projects during the site licensing and construction phases. In some cases, international organizations have refused to finance nuclear projects due to the size and risk, instead favoring smaller projects. Whether through the advent of SMRs or the development of new financial products, in order for flexible nuclear energy to be successful it will need to develop a sustainable financing model that both reduces financing costs while simultaneously decreasing risk in nuclear investment during the construction phase and encouraging nuclear projects to be completed on a repeatable schedule. It will also be important for international and domestic clean energy financers to recognize nuclear as clean energy projects and include them in their portfolio of acceptable technologies.
2. **Expanded Modeling:** Long-term clean energy plans need to include diverse modeling that emphasizes system-wide decarbonization and pairing variable renewable energy with dispatchable forms of clean energy. These dispatchable forms of clean energy can include flexible nuclear energy, geothermal, hydroelectric, energy storage, and other forms of clean energy that should be better represented in long-term energy planning. There is a great opportunity to collaborate among these groups.
3. **Compensation for Energy System Services:** In many cases, nuclear flexibility is an economic as well as a technical problem. Many markets don't compensate nuclear energy for ramping down their power output even when it is used to accommodate other clean energy sources. While international market structures vary widely, it will be important for the value of flexibility in nuclear energy to be recognized and compensated. In some places, special capacity or ramping generation assets are compensated differently than bulk power production, and more innovation will be needed to compensate nuclear energy when it ramps its output on various timescales.
4. **Quantification of Value:** The value of dispatchable clean energy needs to be better socialized to stakeholders and customers. This is particularly relevant to nuclear energy which should engage energy users on the community level. This could be facilitated by rigorous scientific communication and outreach to raise awareness of the value of flexible nuclear energy.
5. **Regulatory Innovation:** Establishing a domestic nuclear energy program requires an internal regulator to license and guarantee the safety of nuclear power plants. These safety regulators are very important for the well-being of the global nuclear industry. These regulators are, by design, meant to be cautious in their acceptance of new nuclear technology or operating scenarios. While flexible nuclear energy has been demonstrated safely in several countries, more innovation is needed to help regulators everywhere understand the safety concerns of flexible nuclear operation, if they exist, and to address those concerns through rigorous analysis that maintains the same level of nuclear safety while rapidly deploying flexible nuclear innovation.
6. **Expand Products and Applications:** Non-electric applications of flexible nuclear energy also need to be developed from an economic and a technology integration perspective. This could also relate to incorporating flexible non-electric nuclear energy into multi-sectoral energy modeling.

Public open gates for outside GIF

1. GIF monthly webinars, news letters, annual reports, etc. in GIF-HP
2. Special webinar/open events/ like 20th Anniversary Celebration webinar, presently planning FORUM industry 2022
3. Open publications on Rector developments such as "Handbook of Generation IV Nuclear Reactors"
4. GIF open methodologies including Safety documents and PRPP evaluation methodologies
5. GIF methodological tools: ISAM, G4ECONS
6. Open activities in WGs/TFs (AMME survey, Future workshops including Non-Electric application of Nuclear Heat field)

Featured Recent GIF Publications

- 2019 Annual Report (2020 Annual Report is coming soon with References)
- 2018 GIF Symposium (We are planning Forum GIF INDUSTRY 2022)
- GIF R&D Outlook for Generation IV Nuclear Energy Systems: 2018 Update
- Handbook of Generation IV Nuclear Reactors, 2016 (Presently updating)
- The High Temperature Gas-Cooled Reactor, 2020 (M. Fütterer, et al., Reference Module in Earth Systems and Environmental Sciences, https://doi.org/10.1016/B978-0-12-409548-9.12205-5)
- Sodium Fast Reactor: Safety Design Guidelines on Safety Approach and Design Conditions (SA SDG), 2020
- LFR Safety Design Criteria (SDC), 2021
- Lead-cooled Fast Reactor (LFR) System Safety Assessment, 2020
- An Update of the GIF Proliferation Resistance and Physical Protection White Papers for the Six Gen IV Systems,2019 (Cipiti, B. et al, 9th INMM/ESARDA/INMMJ Joint Workshop. See PRPPWG-BIBLIOGRAPHY Rev. 8 April 2021)
- The GIF Proliferation Resistance and Physical Protection methodology applied to GEN IV system designs, 2019 (Cheng, L. et al., ESARDA'19: ESARDA Symposium 2019 - 41st Annual Meeting See PRPPWG-BIBLIOGRAPHY Rev. 8 April 2021)
- NICE Future Initiative/ Flexible Nuclear Energy for Clean Energy Systems, Chapter 13: Generation IV International Forum: Delivering Next-Generation Nuclear Systems, 2020
- Impact of Increasing Share of Renewables on the Deployment of Generation IV Nuclear Systems, 2018
- GIF workshop on R&D Infrastructures needs and opportunities, 2020
- R&D Infrastructure Task Force Final Report, 2021

Our Vision
To contribute to a sustainable global energy future providing reliable, safe and affordable clean, CO_2 free, electricity and heat for the world's benefit

Our Mission
To develop Generation IV nuclear energy systems that will deliver improved sustainability, economics, nuclear safety, security & proliferation resistance

What GIF brings
Expertise | Collaboration | Excellence

GIF's Current Strategic Themes
- Design and R&D of six types of Gen IV reactors
- International standardization of Safety Design and apply into Regulation
- Integrate Gen IV systems (flexibility, economics) and renewable energy systems in clean energy systems
- Enhance International R&D collaboration
- Attract a younger generation to the work of GIF and its goals

Great contributions by GIF colleagues