Your GIF Newsletter

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GEN IV International Forum
Expertise | Collaboration | Excellence

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Editorial by Lyndon Edwards, GIF Policy Group member for Australia

Does Size Matter?

Nuclear power reactors started small, at least in relation to the Generation III and III+ reactors built in the last decade. Indeed, the often prototype Generation I reactors built during the first decade of nuclear power production produced less than 100MW of electricity. Since that time reactors have continued to grow, and whilst the output of the early Generation II reactors were still usually less than 500MW, by the time Generation III reactors were developed the average size of new nuclear power plant was over 1000MW and the most recent Generation III+ reactors can be up to 1800MW.

This increase in size has been accompanied by a significant increase in complexity, build time and cost and it can be argued that this has contributed to the decrease in new nuclear power plant build rate in recent decades. Over the same period, there has also been a very large increase in renewable and smaller gas fired thermal power plant. This, together with the growing resistance to coal fired power stations has seen the average size of new electricity producing plant on most grids reduce markedly.

So it is not surprising that many of the exciting new developments in nuclear power generation are in Small Modular Reactors (SMRs). An IAEA report in 2020 listed 50+ SMR developers, most new to the nuclear industry. In addition, the majority were not Light Water Reactor (LWR) designs.

When GIF was started Generation IV reactors were envisaged to be large scale reactors similar in size to today's Generation III and III+ reactors. This is clearly no longer the case and GIF is currently working on methods to engage with this community.

One conduit for interaction that is already active is the GIF Advanced Manufacturing and Materials Engineering Task Force, which is described in greater detail later in this newsletter. The Task Force is investigating how advanced manufacturing can be used to reduce the time to deployment of new and novel reactors. The Task Force's engagement with the community has identified that qualification is a common concern and that collaboration investigating how it can be speeded up is highly supported.

On a personal note I have been fortunate to have been involved in Australia's journey to join and contribute to GIF. Australia specifically supports VHTR and MSR reactors through its research, both of which are suited for deployment as SMRs that can also be designed to be 'inherently safe' through appropriate air cooling. Australia has a technology-led approach to reducing carbon emissions and in its 2020 Low Emissions Technology Investment Roadmap Australia identified SMRs as a 'watching brief' technology.

The Australian Government is investing more than half a billion dollars into building strategic international partner - ships to make low emissions technologies cheaper than high emitting alternatives. Australia and the United Kingdom have recently signed a letter of intent to establish a partnership on low emissions solutions which includes SMRs and enabling technologies such as clean hydrogen.

Finally, it is worth noting that Australia's policy regarding civilian nuclear power has not been affected by its recent announcement to pursue nuclear marine propulsion.

The Australian Government has no plans to lift the longstanding moratorium on nuclear energy in Australia. It recognises that nuclear energy is a mature techno-logy used to deliver reliable electricity in many countries, with virtually no greenhouse gas emissions. Any decision to remove the current prohibition on nuclear power generation would require bipartisan agreement and wide-spread community support.

Australia continues to look at all emerging low emissions technologies as they evolve over time, including nuclear energy, and examine whether they are right for Australia.

Lyndon Edwards Professor, National Director, Australian Generation IV International Forum Research (ANSTO) and Australian representative of the GIF Policy Group

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Major events

Webinar Series 58 (28 October): Metal Fuel for Prototype Generation-IV SFR: Design, Fabrication and Qualification, Dr. Chan Bock Lee, KAERI, Republic of Korea

Webinar Series 59 (18 November): Geometry Design and Transient Simulation of a Heat Pipe Micro Reactor, Dr. Jun Wang, University of Wisconsin Madison, USA

Webinar Series 60 (15 December): Development of an Austenitic/Martensitic Gradient Steel Connection by Additive Manufacturing, Dr. Flore Villaret EDF, France

GIF Advanced Manufacturing & Materials Engineering Task Force

New technology can reduce the time to deployment of advanced reactors

Deployment of Gen IV reactors requires innovation in the nuclear supply chain, particularly in the areas of advanced manufacturing and materials engineering, if they are to be delivered on-time and on-budget. However, nuclear design codes dictate that only qualified materials and processes can be used and qualification can be a long and tortuous process.

This creates a barrier to market entry for Generation IV reactors. Also, current developments in advanced manufacturing are occurring faster than our ability to introduce new materials and methods into design codes potentially stifling innovation and hampering deployment. The GIF Advanced Manufacturing Materials Engineering Task Force was formed to see how collaborative R&D could be used to enable such advances to reduce the time to deployment of Gen IV and comparable advanced reactors.

In 2019 it undertook a survey of advanced nuclear reactor vendors, supply chain specialists, regulators and other experts which discovered that most advanced manufacturing methods were considered opportunities by potential end users and 90% of respondents identified the greatest obstacle to adoption was approval by codes and standards organisations.

In February 2020, just before the COVID-19 pandemic, the Task Force held an international workshop at the NEA in Paris designed to investigate how collaborative R&D in the field of advanced manufacturing can be used to reduce the time to deployment of advanced reactor systems.

Details of the workshop, which was attended by over 70 representatives from conventional and SMR vendors, nuclear supply chain suppliers, regulators and researchers can be found at:
https://www.gen-4.org/gif/jcms/c_115848/workshop-on-advanced-manufacturing

AMME-TF Innovation Workshop at the NEA in February 2020

The purpose of the workshop was to identify both the areas and the methods where collaboration could lead to a reduction in the time to deployment of advanced manufacturing for advanced reactors. Its attendees, from reactor vendors, nuclear supply chain firms, regulators, national laboratories and R&D providers enabled broad representation from across the Nuclear Industry and the cross functional break-out sessions were particularly engaging and successful. The output from the six break-out groups was discussed in the final session of the workshop and final conclusions established. The recommendation of the workshop was that collaborative activities should be actively encouraged in the following areas:

- Qualification: including new modality (e.g. real time process qualification).
- Design & Modelling: including sharing data for design optimization and Modelling & Simulation benchmarks

Although progress in 2020 was affected by Covid-19, the Task Force is currently organising further workshops to meet its goals. The next workshop will focus on how modelling and simulation could be used to shorten the time to qualification if new manufacturing processes. Details of the workshop are shown in the box below.

If you are interested in knowing more about the Task Force please contact the task force through its chair, its secretary or through the country representatives shown in the table below.

Lyndon Edwards, Chair, AMME-TF

AMME Workshop on Advanced Manufacturing
(Virtual)
8-9 November 2021

The workshop will focus on **Modelling and Simulation** in support of advanced manufacturing. Organized in an **interactive** way it will be the opportunity to exchange ideas on how Modelling and Simulation could accelerate the development and qualification of advanced manufactured components.

If you are interested in attending the workshop, **please email Davide Costa at davide.costa@oecd-nea.org**

AMME TF MEMBERSHIP

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The importance of treating nuclear waste from Gen IV reactors

High feasibility solutions for the treatment and disposal of nuclear waste arising from the deployment of any new nuclear reactor have never been more important. Concerns about nuclear waste and, in particular, the intermediate (ILW) and high (HLW) level waste from spent fuel, come second only to safety with regard to public acceptance of new nuclear builds. Although nuclear waste policy is a national responsibility there is broad international agreement that such nuclear waste is best disposed of in a geologically stable underground repository. There are presently two principal methods of dealing with the spent fuel from Gen II and Gen III reactors. In the simplest approach it is stored onsite for a considerable period and then encapsulated in a suitable canister before entering the repository. In the alternative, more complete solution, spent fuel is reprocessed, removing the fissile material for reuse leaving the waste fission products and actinides to be entrained in borosilicate glass using technology that was developed in the 1960s.

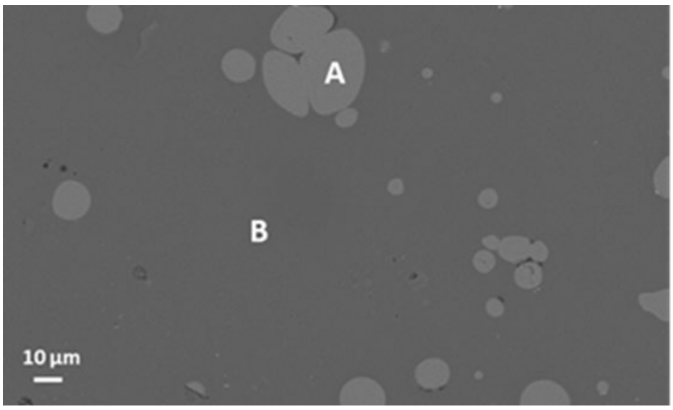
A key feature of Gen IV reactors is their ability to reduce the long-term radiotoxicity of their nuclear waste by closing the nuclear fuel cycle. Furthermore, Gen IV designs do not use standard LWR oxide fuel. Consequently, spent fuel storage and disposition is not likely to be a suitable solution for Gen IV reactors and bespoke waste treatment and disposal solutions are required. However, despite more than 60 years of international collaboration on the design and development of a range of waste-forms, vitrification remains the single predominant approach. Consequently, many high-level wastes (HLWs) that challenge vitrification as a processing technology remain untreated and as a result only a small percentage of HLW (other than spent fuel) remains converted to a qualified waste-form. Furthermore, very little has been actually dispositioned in a geological repository. This situation is likely due to the lack of political and social acceptance of these geological repositories, debate over which waste-form is most suitable and the lack of engineering demonstration and deployment of processing solutions that are alternatives or complimentary technologies to vitrification.

Advanced high-temperature reactors present unique challenges as their nuclear fuel type is considerably different to that of current light water reactors. As such, both waste-form design and processing technologies need to be considered in tandem, with well-defined technology maturation plans. Whole of life strategies must be developed which can include initial spent fuel storage, reprocessing, and actinide burning to reduce the long-term radiotoxicity of the waste, but all options must provide an ultimate nuclear waste disposition pathway. Regulators can also drive this approach with developers and operators required to consider the wastes generated and provide disposition pathways as part of the approvals process for all nuclear facilities that produce ILW or HLW waste. Indeed, this has been the experience of ANSTO with its new ANM Mo-99 Nuclear Medicine Facility where a condition of the funding and licensing for this facility was to provide and implement a waste treatment strategy to treat production wastes. This led to the decision to build the world's first waste treatment plant using Synroc technology

Synroc processing technology employs hot-isostatic processing (HIPing) as a consolidation approach and allows the production of a range of wasteforms (ceramic, glass, and glass-ceramic forms) which can be tailored to the chemical, physical, and radiological properties of the waste. The different phases are used to lock up different radioactive species as exemplified by the figure below which shows how Synroc can be used to treat a FLiNak salt waste.

In this simple two-phase design the fluoride is incorporated into a highly insoluble CaF_2 crystalline phase (A), and the main phase (B) is a durable borosilicate glass which can incorporate the alkali from the salt and various fission products.

If actinides are also present in the salt then they can be captured in further crystalline phases through waste-form design.



Backscattered SEM image of a HIPed FLiNaK waste form

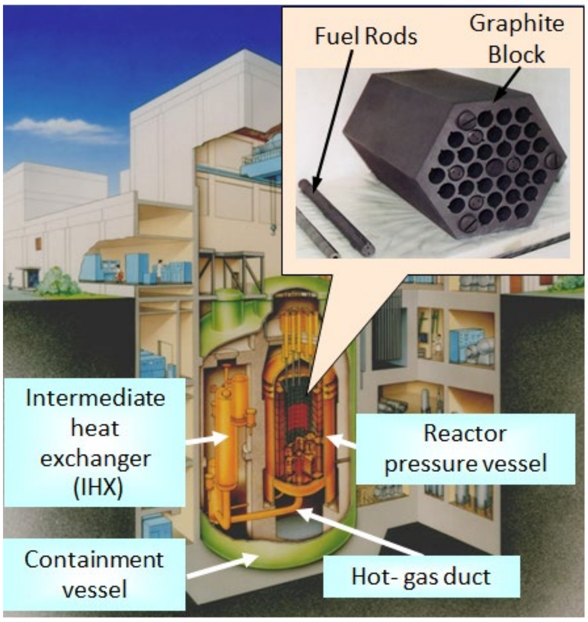
As Gen IV reactors approach deployment, there is opportunity to approach waste treatment differently. Careful consideration of waste treatment options from the outset is achievable. By considering waste treatment in the early stages, there may be the opportunity to realise longer term efficiencies and savings with improvements or changes to reactor designs being possible to facilitate waste treatment. These early investments will surely provide longer term benefits including improving societal acceptance and this could be key to how we as a nuclear community build back the trust of our public.



Lyndon Edwards, Dan Gregg and Rohan Holmes, ANSTO

Restart of the Japanese High Temperature Engineering Test Reactor

The High Temperature Engineering Test Reactor (HTTR) is a prismatic block type 30 MW high temperature gas-cooled reactor (HTGR) of the Japan Atomic Energy Agency (JAEA). The JAEA restarted operation of the HTTR on 30 July 2021. First criticality of the HTTR was in 1998, and many operation tests have been carried out since this time.



Cut view of the HTTR Reactor

The HTTR provided the world's highest temperature heat at 950°C outside a reactor during a high temperature test operation in April 2004. The JAEA has also carried out safety demonstration tests with the HTTR in relation to the inherent safety features of HTGRs.

While the HTTR was not severely damaged during the 2011 great earthquake in Japan, regulatory requirements were nevertheless enhanced in view of lessons learned from the accident at the Fukushima Daiichi Nuclear Power Plant, operated by the Tokyo Electric Power Company (TEPCO). After completion of the safety review by the Japanese Nuclear Regulation Authority (NRA) over five years in conformity with the new regulatory requirements, the JAEA restarted the HTTR without significant reinforcements. The licensing evaluation process by the NRA in fact demonstrated that core melt would not occur even in the worst beyond design-basis accident, without using active safety systems. As the momentum towards carbon neutrality by 2050 is building globally and the significant role of nuclear energy – and particularly advanced nuclear reactors – has been increasingly recognized, HTGRs are being considered as one of the more promising technology options, both for power generation and for hydrogen production.

The JAEA will be carrying out safety demonstration tests using the HTTR under the framework of an OECD/NEA international cooperation project. In addition, the JAEA plans to conduct various tests to confirm safety, core physics and thermal-fluid characteristics, as well as to confirm fuel performance via the operation of the HTTR. A demonstration plan for hydrogen production via the HTTR is also under discussion. JAEA is pleased to be contributing to the international community through these HTTR tests and efforts towards the establishment of global safety standards.

For more information on the HTTR restart, please visit:
www.jaea.go.jp/english/news/press/2021/073003/

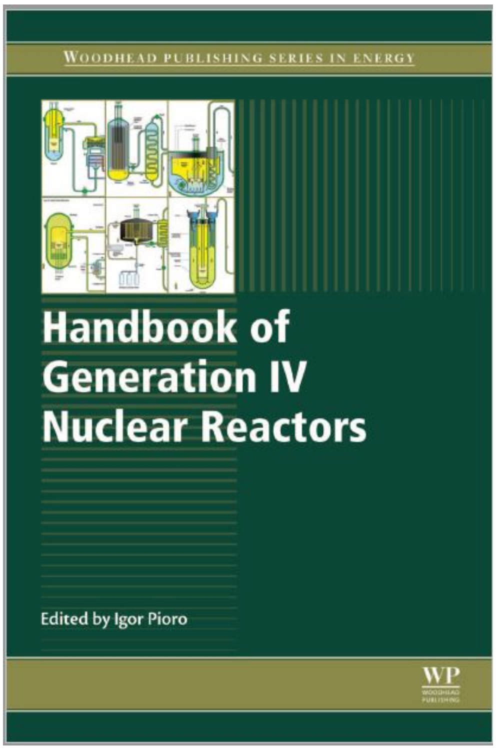
Masayuki SHINOZAKI
Director, Department of HTTR
HTGR Research and Development Center
Sector of Fast Reactor and Advanced Reactor Research and Development
Japan Atomic Energy Agency (JAEA)

China's HTR-PM reactor achieves first criticality

It is a great pleasure for GIF to congratulate our Chinese colleagues after the first of two high-temperature gas-cooled reactors of the demonstration HTR-PM plant at Shidaowan, in China's Shandong province, attained a sustained chain reaction for the first time on Sept 12 at 9.35am (WNN source). The reactor is scheduled to be connected to the electricity grid before the end of this year.

Workers in the HTR-PM control room bring the first reactor to first criticality (Image: China Huaneng)

The second edition of the Handbook of Generation IV Nuclear Reactors is in the final stages of completion



The International Generation IV Forum (GIF) produces a significant number of scientific publications each year, whether it is in a co-ordinated manner under its own direction (e.g. annual reports, white papers, position papers, technical reports) or via a considerable number of scientific papers by GIF members. Since 2016, GIF is also one of the rare nuclear scientific organizations to dispose of a handbook specific to its field, and a great deal of the credit for this is due to Mr Igor Pioro, editor of this reference work published by Elsevier. In 2021, given the success of the publication, Elsevier asked Mr Pioro to set about developing a second edition. The arduous task of writing, co-ordination, follow-up, revision and harmonization of chapters thus began once again. GIF is actively contributing to this effort via its experts, co-authors of numerous technical chapters, and via a general introductory chapter on GIF that has been entirely updated.

Note from Gilles Rodriguez, GIF Technical Director

“As the GIF Technical Director, I accord considerable importance to these types of reference documents because they serve as benchmarks or as signposts in the midst of the often-changing nature of scientific information that is available through a number of sources. Updates are nonetheless far from frequent considering the considerable effort that needs to be undertaken. Topical subjects related to advanced reactors have, however, evolved to such an extent in recent years that this new edition of the handbook arrives at a very timely moment to mark a new milestone. I therefore take this opportunity to welcome this second edition of the handbook and to inform our readers that we are currently considering a specific GIF initiative for the handbook’s official release.”

Igor Pioro, Ph.D., Dr. Tech. Sc., P.Eng. (Ont.), Fellow ASME, CSME & EIC Foreign Fellow of National Academy of Sciences of Ukraine Professor, Editor-in-Chief of ASME Journal of Nuclear Engineering and Radiation Science Faculty of Energy Systems and Nuclear Science Ontario Tech University (University of Ontario Institute of Technology)

New GIF Members: Welcome!

- **Policy Group (PG):** Mr Ping **Huang**, Deputy Director General for International Cooperation, CAEA (replacing Mr SHEN Lixin), **China**.
- **Sodium-Cooled Fast Reactor Project Management Board (PMB) on Advanced Fuel (SFR.AF):** Mr Boris **Tarasov**, Senior Researcher, JC “VNIINM”, **Russia**.
- **Sodium-Cooled Fast Reactor Project Management Board (PMB) on Component Design and Balance of Plant (SFR.CDBOP):**
  Mr Iliya **Pakhomov**, IPPE; and Mr Oleg **Vilenskiy** (Substitute), Afrikantov OKBM JSC, **Russia**.
- **Sodium-Cooled Fast Reactor Project Management Board (PMB) on Safety and Operation (SFR.SO):** Ms Olga **Peregudova** (Substitute), Researcher, IPPE, **Russia**.
- **Very High Temperature Reactor Steering Committee (VHTR SSC):** Mr Ali **Siddiqui**, Acting Head of Directorate, Advanced Reactors, CNL, **Canada.**
- **ETWG:** Ms Princess **Mthombeni**, Nuclear Stakeholder Management Advisor, Department of Mineral Resources and Energy, **South Africa**.
- **EMWG:** Ms Nadezhda **Salnikova** (Observer), Head of Business Development Department, Afrikantov OKBM JSC; and
  Mr Sergey **Panov** (Observer), Deputy Head of Economics Department, JSC "Proryv", **Russia**.
- **PRPPWG:** Mr Nikita **Dyrda** (Observer), Russia.
- **RSWG**: Dr Juan Carlos **De La Rosa Blul,** DG Joint Research Centre – JRC, Unit G.I.4 - Nuclear Reactor Safety and Emergency Preparedness, **Euratom**.
- **AMME TF:** Dr Yu **Kamiji,** Researcher, Nuclear Plant Innovation Promotion Office, JAEA, **Japan**.