THE *NUCLEAR NEWS* INTERVIEW

John E. Kelly: Regaining GIF's momentum

The chairman of the Generation IV International Forum is aiming to reinvigorate interest in the effort to develop the next generation of reactor technology.

The Generation IV International Forum (GIF), now into its second decade, was formed by a multinational agreement among countries that recognized that the future of nuclear energy depended on moving to the next generation of reactors and were willing to work together to make that happen. Some of the revolutionary designs being developed could be demonstrated within the next decade, with commercial deployment beginning in the 2030s.

The chairman of GIF is John E. Kelly, deputy assistant secretary for Nuclear Reactor Technologies in the U.S. Department of Energy's Office of Nuclear Energy. His office is responsible for the DOE's Generation IV reactor activities. As he also previously worked on advanced nuclear energy technology at Sandia National Laboratories, he is well aware of the potential of Gen IV systems, and also of what it will take to drive their deployment forward in the future.

Kelly has been a member of the American Nuclear Society since 1981, and for the past two decades he has held a number of leadership positions in the Nuclear Installations Safety Division. He spoke to International Editor Dick Kovan about the future of GIF and Gen IV reactors.


Photo: DOE

Kelly: "There is a lack of awareness about Generation IV, and we need to reinvigorate interest in Gen IV systems."

What were the origins of the Generation IV International Forum?

GIF got started in early 2000, at a time when few people were thinking about the future of nuclear power. In the United States, the DOE's civilian research budget had been "zeroed out," and it didn't look like a Generation III plant would be built. Credit must be given to William Magwood IV, who at the time was the director of the DOE's Office of Nuclear Energy, Science and Technology and is now a commissioner on the Nuclear Regulatory Commission. He realized that to move nuclear energy forward, we needed to think well beyond the current light-water reactors, basically to leapfrog to the next generation of reactor technology, which he dubbed Generation IV. These reactors would be safer and less expensive, would produce less waste, and would be more proliferation resistant than the current generation of operating plants, as well as the advanced systems that were then in the design stage. Magwood invited a number of countries with developed nuclear energy programs to come to Washington, D.C., in January 2000 to discuss this idea. He was uncertain about what the response would be, but it turned out that several countries were very interested, and that meeting began something quite remarkable, starting with the creation of the Generation IV International Forum.

What has been accomplished since then?

Over the next two years, the foundations of GIF were put into place, beginning with the preparation of a charter that was signed in July 2001 by the initial nine member countries: Argentina, Brazil, Canada, France, Japan, South Africa, South Korea, the United Kingdom, and the United States. These were later joined by China, Russia, and Switzerland, along with Euratom, to form the current 13-member forum.

This was soon followed by the development of the GIF Technology Roadmap, a program of work that has continued to move forward for over a decade, and the selection of advanced reactor systems on which to focus. At the start, there were well over a hundred reactor concepts being considered. Over the course of a year, a group of 100-plus scientists and engineers put together the criteria that next-generation systems should meet and agreed on six reactor systems to pursue with research and development programs. Those six are the sodium-cooled fast reactor (SFR), the gas-cooled fast reactor, the lead-cooled fast reactor, the supercritical water–cooled reactor, the very-high-temperature reactor (VHTR), and the molten salt reactor. Each

Overview of Generation IV Systems

System	Neutron spectrum	Coolant	Temp. °C	Fuel cycle	Size (MWe)
VHTR (Very-high-temperature gas reactor)	thermal	helium	900–1000	open	250–300
SFR (Sodium-cooled fast reactor)	fast	sodium	550	closed	30–150, 300–1500, 1000–2000
SCWR (Supercritical water-cooled reactor)	thermal/fast	water	510–625	open/closed	300–700, 1000–1500
GFR (Gas-cooled fast reactor)	fast	helium	850	closed	1200
LFR (Lead-cooled fast reactor)	fast	lead	480–800	closed	20–180, 300–1200, 600–1000
MSR (Molten salt reactor)	epithermal	fluoride salts	700–800	closed	1000

of these systems, which still make up the GIF family, is being developed through a set of projects that countries with an interest in that system have agreed to collaborate on. Within that structure of systems and projects, much has been accomplished.

Worldwide, about $5 billion has been invested in Gen IV technologies over the past decade. Hundreds of research reports on the reactor systems were published, fuel and materials were tested, and considerable work on safety and operation was undertaken. For example, the United States has done significant work on the TRISO fuel needed for the VHTR, developing fuel that performs better than any TRISO fuel has performed before.

What are the most pressing issues for GIF today?

First and possibly foremost is the position of nuclear power itself today, which is quite different from when GIF began. Starting around 2000, an enthusiasm for nuclear energy began building up around the world.

"As GIF has matured as an international organization, it has become apparent that we need to strengthen our ties with other international organizations."

While this enthusiasm continued for several years, as the global recession set in, followed by the accident at Fukushima Daiichi in Japan, the momentum slowed considerably. This has led to a key question for GIF: What is it going to take to rebuild the momentum we had a decade ago?

From a technical perspective, the biggest challenge is materials development. These advanced systems, which operate at higher temperatures than light-water reactors and have different coolants, require advanced materials that will be the building blocks of the Gen IV systems.

Another issue is the development of safety design criteria (SDC) for the SFR, which should be the first of the GIF systems to move through the viability and performance development phases to an actual reactor demonstration project. Two years ago, GIF recognized that a number of member countries would be building SFRs in the next decade or so, and that some commonality with regard to SDC was needed. Besides the desirability of harmonizing safety requirements across GIF members, it was also considered important that if GIF members were going to claim that Gen IV reactors were safer than previous systems, the safety criteria had to clearly demonstrate that claim. The Phase 1 SDC report for the SFR has been accepted by the GIF Policy Group and is now being externally reviewed by the regulators of many of the GIF members. GIF is also developing guidelines to help designers meet those criteria.

GIF launched a strategic planning activity in 2012. What is its status?

After more than a decade, it was time to step back and reflect on where GIF is now and where we need to go. This meant reviewing the technology road map set out in 2002 and updating it for the next decade. We also recognized that we could do a better job of collaborating on R&D within GIF, and we looked at ways to do that. In addition, besides the International Atomic Energy Agency and the OECD Nuclear Energy Agency (NEA), which have contributed greatly to the work of GIF, the past decade has seen a growth in the number of new specialist nuclear organizations, such as the Multinational Design Evaluation Program and the International Project on Innovative Nuclear Reactors and Fuel Cycles, whose work could add considerably to GIF's activities.

Following discussions among the members, the Policy Group defined a strategic planning exercise that covers three elements: updating the technology road map, strengthening R&D collaboration, and strengthening ties with other international organizations. The road map update, which reflects the progress over the first decade of GIF and lays out plans for the coming years, should be published near the end of 2013.

GIF has also identified a number of areas where improvements in collaboration are possible (for example, staff exchanges and facility sharing), which should lead to more efficient and effective cooperation.

Finally, as GIF has matured as an international organization, it has become apparent that we need to strengthen our ties with other international organizations. GIF has already reached out to the Multinational Design Evaluation Program, as well as to the IAEA and the NEA, inviting them to serve as external reviewers of the safety design criteria. Improving our relationships with such organizations will be important for the long term.

The implementation of the strategic plan will certainly be a key factor in GIF's regaining the momentum it had before.

How close are we to seeing a GIF demonstration project?

There are some actual Gen IV demonstration reactor projects already under way, with more to follow. These are national projects, rather than activities conducted within the GIF framework, which focuses on the R&D needs for demonstrating system viability and performance. We expect, however, that interested GIF members will be invited to participate in demonstration projects by host countries. For example, France is working on the design of a 600-MWe SFR demonstration project called Astrid, for which the United States is doing safety analyses to cross compare with the French results.

There has not been direct international involvement within the framework of GIF with Russia's BN-1200 project, a Gen IV SFR, with the goal of achieving economics that are competitive with LWRs. However, Russia is planning to build a new test reactor, the Multipurpose Fast Research Reactor, with the goal of developing an international user center. We see that as a very important step forward in collaborating on advanced reactors with Russia.

In December 2012, China resumed construction of its HTR demonstration project, which is scheduled to be connected to the grid by the end of 2017. The United States is very interested in exploring opportunities for participating in this project.

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How important is GIF to the United States?

The United States continues to be very supportive of GIF, which it sees as being in its long-term interest. Certainly, to meet President Obama's long-term environmental goals—specifically, reducing carbon emissions and dealing with nuclear waste long term—we are going to need Gen IV systems. Besides being carbon-free electricity sources, these reactors will also be less expensive and safer and will generate less waste than the current fleet.

The United States is particularly interested in the VHTR, which is able to produce high-temperature process heat that can be used in industrial applications. In support of this system, the DOE's next-generation R&D program has been concentrating on developing the fuel and materials, including the graphite used in HTR core structures and the structural steels for the pressure vessel. [See the accompanying sidebar for further information about U.S. priorities.]

What has been the impact on GIF of the Fukushima Daiichi accident?

The original goals set by GIF—sustainability, economics, safety and reliability, and proliferation resistance—have not changed in the aftermath of the accident in Japan. In fact, the accident has reaffirmed GIF's aggressive safety goals as being even more important now. Generally, we are aiming for significant safety improvements over Gen III systems, moving toward what is termed inherent safety, which goes beyond passive safety. The desirability of designing inherent safety into Gen IV reactors became crystal clear after Fukushima.

Does GIF look at Gen III systems as well?

It is now recognized that for Gen IV to be successful, there has to be a successful Gen III deployment in order to create the industrial base—that is, the design and manufacturing capabilities—for future Gen IV projects. At the same time, GIF's push to improve safety has had an impact on Gen III systems, as passive safety is now taking root in their designs.

Does industry have an involvement in GIF?

There are a couple of ways in which industry is directly involved. GIF established the Senior Industry Advisory Panel, which meets once a year to review GIF activities and results and provides the Policy Group with advice and recommendations. Every GIF member can nominate up to three people to sit on this panel, which is made up of senior representatives from vendors, utilities, and companies interested in nonelectric applications of nuclear technology. As these are the people who will actually be deploying Gen IV systems, we wanted to engage them early to get their advice on the best ways to proceed.

In addition, member countries involve their major nuclear companies, as well as their national laboratories, in the GIF R&D program.

Is it time for GIF to take a more active role in setting priorities for national programs?

That is an interesting question. The GIF members all have slightly different objectives and different reasons for selecting a particular reactor system. Nevertheless, under the GIF framework, which is a collaborative one, if two or more countries are interested in working on a particular reactor or research topic, there is really no reason not to. At the same time, from the perspective of the Policy Group, it is important to ensure that progress is being made. We want GIF R&D to be challenging and important. In addition, we want the systems to make meaningful progress, and we are developing metrics that will not only help us measure progress but will also help highlight the importance of the work.

From the U.S. perspective, the DOE emphasizes the importance of our participation

U.S. priorities for the Generation IV International Forum

The concept of the Generation IV International Forum was first proposed by the United States, which continues to be a strong supporter of GIF. The United States' priorities can be grouped into three main areas: policy, knowledge management, and technology.

From a policy perspective, Gen IV systems offer the opportunity to develop nuclear energy systems that produce carbon-free electricity, are less expensive, and generate less nuclear waste than today's reactors. These systems directly support the administration's goals of limiting carbon emissions.

From a knowledge management perspective, the number of people who worked on the precursors to Gen IV systems is very limited. To address this, the DOE's Office of Nuclear Energy is investing up to 20 percent of its research funding into U.S. universities in order to develop the next generation of nuclear engineers and scientists. This investment should help ensure the transfer of the information base developed by the United States to the next generation.

From a technology perspective, the U.S. research and development program has been focused on the sodium-cooled fast reactor (SFR) and the very-high-temperature reactor (VHTR). Fast reactor technology was conceived early in the nuclear era as a means to fully utilize the energy content of uranium resources by increasing efficiency through the conversion and consumption of actinides, which ultimately reduces the amount of high-level radioactive waste that is generated. The United States was a pioneer of fast reactor technology, with its efforts including work on several SFR facilities and demonstration programs, among them the two Experimental Breeder Reactors, the Fermi-1 commercial power reactor, and the Fast Flux Test Facility.

The current U.S. fast reactor program is focused on long-term, science-based R&D that supports increasing the performance of fast reactor technology. This can include enhancing the safety, reducing the cost, boosting the electrical power output, and developing technologies for improved system operation or maintenance. In addition, work is under way on advanced materials, inspection technologies, advanced energy conversion systems, advanced compact reactor concepts, advanced fuel handling systems, and advanced modeling and simulation code development.

The United States also supports the VHTR, through the Next Generation Nuclear Plant (NGNP) Demonstration Project, because of its promise for nonelectric applications and its inherent safety features. NGNP was originally envisioned to produce electricity and/or hydrogen, but upon further analysis, it was determined that refocusing its mission on the production of high-temperature process heat for industrial applications would facilitate an even greater market opportunity for the VHTR.

The U.S. R&D program on VHTR technology has focused on several areas that are intended to reduce the technical uncertainties regarding the technology. Key among these has been the development of a proven process for manufacturing and qualifying the TRISO-coated particle fuel used in these gas-cooled reactors. To date, post-irradiation examination tests have subjected the TRISO fuel to temperatures of 1700 °C with no release of fission products. Hypothetical accident conditions would subject the TRISO fuel to temperatures of less than 1600 °C, providing a margin of well over 100 °C.

Other areas of research for GIF have been graphite and high-temperature materials development, computational safety methods development, and work with the U.S. Nuclear Regulatory Commission on a licensing framework for high-temperature gas-cooled reactors.—*D.K.*

in projects of other countries. For example, Argonne National Laboratory is working closely with South Korea on its SFR design. We are also looking at the possibility of Oak Ridge National Laboratory's working with China on its molten salt reactor concept while exploring other opportunities.

What features have most contributed to GIF's success?

At the ANS Winter Meeting in San Diego last November, the first two GIF chairmen—Magwood and Jacque Bouchard, of France—shared their thoughts on why the GIF concept developed quickly and has endured. First, it was a bold new idea that turned out to be attractive to many countries. It is still that great idea that keeps us focused on the program's aims. Its start also coincided with the beginning of significant increases in oil prices, which helped reinforce the need for advanced nuclear systems.

They also noted that getting the right legal structure in place was very important for GIF's success. Considerable time was spent resolving legal issues to allow joint research while protecting commercial and intellectual property rights. Furthermore, having the level of investment we had early in the program ensured that it had the manpower behind it to succeed. There is still a tremendous amount of enthusiasm for GIF.

What are the priorities for your term as chairman, and do you have some final messages for our readers?

First, the priority for my three-year term of office, which started in January, will be to implement ideas and recommendations developed during the strategic planning exercise.

In addition, GIF needs to be "rebranded" to renew its appeal and regain the momentum needed to progress. In this respect, GIF must reconnect with stakeholders, continuing to inform them of the importance of its goals and the progress being made. Within GIF, there is still room to improve how we collaborate, with the aim of becoming a high-performing organization.

There is also a lack of awareness about Generation IV, and we need to reinvigorate interest in Gen IV systems. They are exciting and hold great promise if we put in the R&D. China's construction of a Gen IV demonstration reactor is a very important step, and I am very hopeful that other countries will follow suit in the not-too-distant future.

Finally, we also see these programs as magnets to attract the next generation of researchers, not only for Gen IV but for the whole nuclear industry. We will need more nuclear energy in the future, along with the workforce and the technology to get us there. We need the next generation of people to deliver the next-generation reactors. NN

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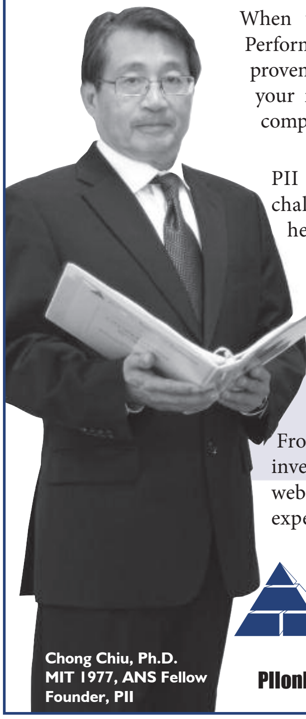

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