

## 6. Nuclear Power in a Global Context

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### Profile (January 2008)

Dr. Gail H. Marcus is presently an independent consultant on nuclear power technology and policy. She recently completed a three-year term as Deputy Director-General of the OECD Nuclear Energy Agency (NEA) in Paris. In this position, she was responsible for the program of work and budget for the agency. From 1999 through 2004, Dr. Marcus served as Principal Deputy Director of the Office of Nuclear Energy, Science and Technology. There she provided technical leadership for DOE's nuclear energy programs and facilities, including the development of next-generation nuclear power systems. Other responsibilities included production and distribution of isotopes for medical treatment, diagnosis and research, and oversight of DOE test and research reactors and related facilities and activities. From 1998-1999, Dr. Marcus spent a year in Japan as Visiting Professor in the Research Laboratory for Nuclear Reactors, Tokyo Institute of Technology. She conducted research on comparative nuclear regulatory policy in Japan and the United States.

Previously, Dr. Marcus had been in the US Nuclear Regulatory Commission (NRC). She served in a variety of positions including Deputy Executive Director of the Advisory Committee on Reactor Safeguards/Advisory Committee on Nuclear Waste; Director of Project Directorate III-3, providing regulatory oversight of seven nuclear power plants in the Midwest; and Director of the Advanced Reactors Project Directorate, where she was responsible for technical reviews of advanced reactor designs.

She also served as technical assistant to Commissioner Kenneth Rogers at the NRC for over four years, providing advice and recommendations on a broad range of technical and policy issues of interest to the Commission. From this position she was detailed for five months to Japan's Ministry of International Trade and Industry, where she was NRC's first assignee to Japan, studying Japan's licensing of the Advanced Boiling Water Reactor.

Prior to her service at NRC, Dr. Marcus was Assistant Chief of the Science Policy Research Division at the Congressional Research Service (1980-1985). In this position, she was responsible for policy analysis in support of Congress covering all fields of science and technology, and played a lead role in policy analysis and development for energy, nuclear power, and risk assessment and management.

### Organization:

From 2001-2002, Dr. Marcus served as President of the American Nuclear Society (ANS), an 11,000 member professional society. She is a Fellow of the ANS and of the American Association for the Advancement of Science (AAAS). She is a former member of the National Research Council Committee on the Future Needs of Nuclear Engineering Education, and served three terms on the MIT Corporation Visiting Committee for the Nuclear Engineering Department. She is just completing a term as the elected Chair of the Engineering Section of AAAS.

### Publication:

Dr. Marcus has authored numerous technical papers and publications. Her research interests include nuclear regulatory policy, energy technology and policy, risk assessment and management, international nuclear policy, and advanced nuclear technologies.

### Education:

Dr. Marcus has an S.B. and S.M. in Physics, and an Sc.D. in Nuclear Engineering from MIT. She is the first woman to earn a doctorate in nuclear engineering in the United States.

## Introduction

For this essay, which is scheduled to be my last one of this series, I thought hard to find some theme that was very important, and that might help tie together many of my earlier observations. After much consideration, I decided that the subject of nuclear power in an international environment would be a suitable topic.

If there is any one fact that has arisen again and again in the course of my own career, it is that nuclear power does not operate in a social or geographic or political vacuum. The fate of nuclear power is affected by the economy, by other energy sources, by environmental concerns—and by what is happening elsewhere in the world. Today, with a number of new countries wanting to join the “club” of countries with nuclear power plants, the international link is more important than ever.

A large part of my career has been directly or indirectly in the international arena. My international work has included work in the safety and safety research areas for the Nuclear Regulatory Commission, two assignments in Japan, work in the advanced reactor area for the Department of Energy, activities in the American Nuclear Society, and work for the Nuclear Energy Agency of the OECD in Paris. These positions have given me a unique opportunity to observe international issues from a variety of perspectives.

In this essay, I hope to bring together a number of my observations on international issues over the course of my career. I would like to summarize how international issues affect the nuclear community, now and in the future, and what the nuclear community should do to deal with the international aspects of our world most effectively.

## Why Collaborate?

I have often speculated on why countries should want to collaborate. After all, for countries with large nuclear programs, like Japan and the United States, collaboration often seems to involve more giving than receiving—paying a larger fraction of the cost, providing a larger share of the facilities, and frequently, having to compromise with nations that carry less of the financial burden by diverting resources to activities that may be of lesser priority for Japan and the U.S. Correspondingly, countries with smaller programs tend to feel that their interests are generally subjugated to the interests of the larger countries.

Of course, working together, whether it involves people or nations, always involves compromises, and generally, each party thinks he or she is the

one making the greater concessions. But people and nations continue to work together because, even when it isn't always obvious, in the end, each party does gain something that makes the compromise worthwhile overall. For example, it is clear that, in general, the smaller countries gain access to facilities and expertise beyond their own resources. While it may seem less clear what the larger countries gain, they too often benefit from facilities they may not each possess. For example, in the research area, many facilities in the U.S. have been shut down over the years. Therefore, for the U.S., international research collaboration provides access to facilities outside its own borders. These are often facilities in other large countries, such as Japan and France. However, there are also outstanding research facilities in a number of smaller countries that are used in international collaborative projects. These include the Halden Reactor in Norway, and the Petten facility in the Netherlands, to name just two.

## Nuclear Safety

In addition, all countries share the benefit of exchanges of the best science and the best practices in the critically important area of safety. We in the nuclear field have long heard the refrain, “An accident anywhere is an accident everywhere.” We also know that fact to be true. We have seen what happened to the nuclear industry around the world following the accident at Three Mile Island (TMI) in 1979, and even more so, after the accident at Chernobyl in 1986. Underlying the euphoria today over the growing prospects for a nuclear revival, we all quietly worry about what the impact might be of another such accident anywhere in the world.

It is true that the industry has taken many steps in the last 30 years to reduce the risk of another serious accident. In the United States, utilities that had previously maintained a strict independence learned to work together to share information and encourage best practices. These exchanges have taken place mainly through organizations such as the Institute for Nuclear Power Operations (INPO), which was established following the TMI accident, and through the reactor owner's groups.

Globally, a similar exchange began to take place through the World Association of Nuclear Operators (WANO), which was established following the Chernobyl accident. Intergovernmental organizations, in particular, the IAEA and the Nuclear Energy Agency (NEA) of the OECD, have played an important role as well. The work of these organizations encompasses a large variety of activities, including inspections to help assess facilities and foster the exchange of best practices, training pro-

grams to share knowledge, publication of documents to further facilitate the spread of information on a large variety of safety-related subjects, workshops and meetings for exchanges on specialized topics, and management of joint research projects on safety issues.

These organizations have continued to develop and refine their programs over time, adding new issues as they are identified, and enhancing their programs based on new needs and interests. It is important to point out that they also work together to try to coordinate their overlapping interests and activities. As a result, there have been a number of joint activities, including meetings and publications, and cross-participation in each other's programs. These interactions have enabled the programs of the different organizations to minimize duplication and redundancy, to make the most effective use of available resources, and to tap the full range of expertise on subjects of common interest.

**Development of Advanced Technology**

Increasingly, the international community is working together on the development of new technology as well. When I joined the Department of Energy at the very end of 1999, just after returning from a year in Japan as a Visiting Professor at the Tokyo Institute of Technology, the first project I worked on was the start-up of the Generation IV International Forum (GIF). That activity facilitated the initiation of joint research activities among a small group of countries with active nuclear R&D programs and interests. It was joined shortly afterwards by the IAEA International Project on Innovative Nuclear Reactors and Fuel Cycle (INPRO), which included more countries and, among other things, developed tools that countries could use to assess their needs and to determine what technologies could best help them meet those needs. Both programs have continued and evolved over the last few years as interest in new nuclear power plants has grown.

Furthermore, these two programs have been joined by a number of more specialized initiatives aimed at bringing the international nuclear community together for different shared goals. These programs have included:

- The World Nuclear University (WNU) (an initiative of the World Nuclear Association (WNA), the IAEA, and the NEA directed at educational efforts);
- Several initiatives aimed at addressing the important issue of fuel supply assurance, including

Russia's Global Nuclear Power Infrastructure (GNPI), the U.S.'s Global Nuclear Energy Partnership (GNEP), Japan's IAEA Standby Arrangements System for the Assurance of Nuclear Fuel Supply, and other multilateral mechanisms;

- The Multinational Design Evaluation Program (MDEP), aimed at coordinating licensing reviews and harmonizing regulatory approaches among a small group of countries; and
- Regional initiatives such as the Asian Network for Education in Nuclear Training (ANENT) and the European Nuclear Education Network (ENEN).

It is noteworthy that the model for international cooperation in at least one specific area has become a model outside the nuclear area as well. The GIF concept has spawned similar initiatives, such as the International Partnership for a Hydrogen Economy. This imitation demonstrates the growing importance of international collaboration in all our major technological endeavors.

Of course, international collaboration did not start with GIF. It has long been a factor when the construction of very large, expensive facilities is required for advanced basic research, such as has been the case for CERN (the European Organization for Nuclear Research), the ITER program (originally the International Thermonuclear Experimental Reactor), the Large Hadron Collider, and other projects. What is different about GIF and the other initiatives is that the collaborations are not in support of basic scientific research or of single, very large, research facilities, but rather, in support of safety studies for operating facilities and for the further commercial development and deployment of nuclear technology. The latter, particularly, is a potentially difficult area for collaboration because there could be competing commercial interests in the future.

**Challenges Ahead**

Today, we stand at an interesting turning point for the nuclear industry. We are faced with the simultaneous forces of increased interest in nuclear power in countries without previous experience in the field, with an increasing globalization of the supply chain for manufactured systems and components, and with a worldwide recession that will make large construction projects more difficult. For all of these factors, international actions are of importance, but there are some special issues associated with the new entrants to nuclear power.

*New Entrants to Nuclear Power*: The prospect of countries without previous nuclear power pro-

grams adopting the use of nuclear technology is both exciting and sobering. It is exciting to think about the benefits that adequate supplies of power can bring to some poorer countries, and to think about the impact that such a technological program can have in spurring other technological opportunities. However, for those countries that have had nuclear power programs for a long time, there is also the realization of how long it took them to learn all the lessons needed to operate nuclear power plants safely and effectively, and of the considerable national infrastructure that is required to support nuclear power operations. These include the development of laws and regulations governing all aspects of the use of nuclear power, the establishment of a competent regulatory authority, and the institution of training programs to produce the technicians, engineers, operators, inspectors, and other skilled personnel needed to build and run nuclear power plants.

All this infrastructure is essential to establishing the safe operation of nuclear power plants in these countries, which is important for health and safety in that country and for its neighbors, and as previously noted, is also important for the long-term viability of nuclear programs worldwide. Furthermore, all of this infrastructure needs to be introduced well in advance of the construction of the first power plant, and it all requires time, money, and expert assistance. The international community has recognized this need, and is beginning to take appropriate actions. The IAEA has stepped up with a number of activities specifically geared towards these potential new entrants to the nuclear power community. A number of countries also provide various kinds of assistance on a bilateral basis. Just a few of the growing number of examples include: Japan, which is providing educational opportunities and other assistance to countries in their region; Korea, which, as noted in my last essay, has an educational program aimed at the members of the Asian Nuclear Safety Network; and the U.S. Nuclear Regulatory Commission, which hosts temporary assignees from other countries for "hands on" opportunities to work in a regulatory office.

To their credit, some of the countries exploring the nuclear option have also been very proactive in beginning to establish their own infrastructures early in their planning processes. While I am not aware of all activities underway in all countries, the United Arab Emirates provides a very good example of the type of activity that is going on. The UAE is developing legislation to establish a nuclear regulatory authority, but even in advance of that, has set up an office and has brought in a number of regulatory experts from around the world to help

in establishing the regulations and the procedures the country will need when reactors are built and operated. It is also noteworthy that some countries with existing nuclear power plants are taking steps to update their infrastructure before they expand their nuclear programs. For example, Armenia has one operating VVER and one that was previously shut down. As it looks to the future, it is working with the NRC on training, expert missions, and in other areas, and is working to bring its regulations into harmony with those of other countries.

*General issues* : Other issues apply equally, or almost equally, for countries that currently have nuclear power plants and for new entries.

One of these issues is nuclear fuel supply assurance. The concern to date among the developed countries has mainly focused on the proliferation potential of the nuclear fuel cycle. This is a very real and difficult concern. However, even if proliferation were not an issue, most of the new countries operating nuclear power plants, now and in the future, will not have a large enough demand to warrant operating the full fuel cycle. They will need an assured supply of fuel. It should be noted that the problem of fuel supply is not unique to nuclear energy. The same issues have arisen over cutoffs of the natural gas supply from Russia to Europe, and over periodic concerns about the stability of the oil supply from the Middle East. In fact, for nuclear power plants, which do not need a continuous supply of fuel, or a large volume of fuel, providing that assurance is conceptually easier than it is for fossil fuels. As noted above, the countries that have enrichment facilities are well aware of this problem, and several activities are underway to establish a system that would provide an assured fuel supply. Continued attention to this issue is needed to assure the development and implementation of mechanisms that accomplish the non-proliferation objectives, but at the same time, provide the user countries a guarantee that the supplier countries can't, in the future, withhold fuel as a political tool for unrelated purposes.

Several trends are leading toward an increasing international harmonization of regulations for nuclear power operation. One trend is the entry of more small countries into the marketplace. They will undoubtedly purchase reactors from other countries, and with the reactors, they will likely find that it will help to "import" much of the regulation from the supplier country. However, a more important factor is the internationalization of many of the corporations supplying components and systems for nuclear reactors. As these companies supply utilities in several large countries, it will be more efficient if they can design and build

to regulations that are compatible from one country to another. The effort to move to such a multilaterally compatible system of regulatory requirements has already started through the MDEP. The current economic downturn gives added urgency to this need.

While initial attempts to work together on regulatory issues were very cautious, there seems to be a growing sense that much more can be done to bring regulatory requirements closer together. Naturally, the many differences in legislation, legal systems, and other factors among all the countries with nuclear power plants mean that the movement toward more commonality between regulations in different countries will be slow and difficult, and it may never be possible to make everything completely consistent. Still, the goal should remain to continue to move incrementally toward more common standards. Starting with a new reactor design and with selected areas, as MDEP has done, is a reasonable way to approach such a large task.

One of the concerns about moving toward more common approaches has always been that countries would cede responsibility to another country or to an international organization, and that this would, in the long run, be detrimental to safety. Clearly, this does not have to be the case, and MDEP is being very careful to assure that its efforts to improve efficiency are balanced with the need to maintain strong regulators in every country. The need for each country to maintain an independent regulatory system is especially important as regulators begin to share the results of their regulatory reviews. Further care will be required as the results of regulatory research and analysis are shared beyond the countries now participating in MDEP to countries that may have less experienced regulators.

## Future Directions

The factors that are causing the increasing internationalization of nuclear activity will continue, so we can expect more and more initiatives to assure that we reap all the benefits of such internationalization without introducing weaknesses into nuclear power production activities. The countries sponsoring the initiatives I have highlighted are well aware of both the opportunities and the challenges, and have, to date, been responsive to them. Continued diligence in these areas is needed.

As I have described, the spectrum of activities focused on international issues today ranges from activities by individual countries, to activities of a small group of countries on a specific issue, to a

broad range of activities by multinational organizations. While most of these groups are governmental, it is noteworthy that some are international industry organizations.

It is clear that most of the national and targeted multilateral activities described above need to continue, although clearly, the ad hoc multilateral partnerships may well change form over time, especially if the focus changes or different countries become involved. For example, the multiple proposals for a fuel supply assurance mechanism share the same objective, so it is likely that the ultimate mechanism will reflect a merger of the best ideas. (In addition, changes in GNEP, the US program, are likely in the current Administration.) It is also clear that there is likely to be an expanding role for the assistance that countries like Japan and the U.S. can offer in educating nuclear professionals from other countries and in providing them with experience working within their institutions.

The role of the two intergovernmental organizations, IAEA and NEA, will continue to be very important. Some of their current activities will become even more critical in the future, but there are some emerging new areas that merit more attention. Currently, with all the new countries that are interested in acquiring nuclear power plants, IAEA should give a very high priority to assisting these countries. The IAEA, of course, can also be expected to have an important role in the fuel supply assurance area. IAEA also has many ongoing activities that will continue to be important, including their various inspection programs for facilities in member countries, and activities outside the nuclear power area.

The smaller size of NEA's membership clearly facilitates its role in developing new tools and products. Historically, following the development phase, these tools have often been passed on to IAEA for the necessary implementation in a larger number of countries. That practice should continue. NEA has also historically had a very strong program of management of research activities in facilities around the world. Most of this has been associated with safety research, but the same management principles apply to any kind of research, and this strength should be exploited.

In terms of technical areas, it is clear that fuel cycle activities, and in particular, reprocessing, will become more important for both organizations than they have been in the past. There is room for significant R&D, as well as analytical work, to explore technologies for reprocessing that minimize proliferation risks, and that address options for

using the reprocessed fuel in thermal and fast reactor cycles. These are areas where NEA might well be able to make more of a contribution in the future. NEA and IAEA need to work closely in this area, and IAEA must address the need for new and enhanced protective and other measures that may be required, particularly with advanced reprocessing technologies.

## Conclusion

This is the last of this series of essays. It is very fitting to end the series by talking about international issues, as most of my other themes have had some type of an international aspect. In this regard, it is important to conclude this essay by reemphasizing the importance of the nuclear community working together. In the first place, doing so should improve the efficiency of many nuclear-related activities, to the benefit of all. Furthermore, mutual cooperation is a self-preservation measure. If working together helps assure that all countries operate to a similarly high standard and helps prevent a serious accident, it will be to the benefit of all countries that operate nuclear power plants.

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## Conclusion of Series

I hope that, collectively, I have been able to show in my essays some of the important activities going on in the nuclear area today, and to identify what I think are the challenges—and opportunities—the nuclear industry faces in the years ahead.

I have enjoyed writing about these important topics and sharing some of my thoughts. I hope you have enjoyed reading them and have benefited in some way from my experiences and observations. I have sometimes worried that my thoughts are very simple and obvious, but I have been heartened to hear from several people that they found interest and value in what I had to say.

I would like to express my sincere appreciation to the staff and management of JANUS for giving me the opportunity to write these essays for the readers of their web pages. I hope I have met their expectations as well. I particularly want to thank Junko Sugaya for initiating this idea and for working with me to check the accuracy of the essays and to assure that some colloquial English expressions were interpreted in a manner that would be understandable. I think I taught her a few new English expressions, but I also learned a lot from her about how some terms are understood in Japanese. I also wish to thank the translators for all their efforts to make the best possible translations of the essays.

In closing, I want to let you know that, in the coming weeks and months, I plan to continue to explore these themes and others in my new blog, Nuke Power Talk (<http://nukepowertalk.blogspot.com>) and I invite all of you to look for me there. (The Marcus Room now has a link to the blog.) Next year, I am looking forward to coming back here to the Marcus Room, and I hope to “see” all of you here again.

So for one final time, I thank you for your attention, both in reading this essay and in reading the rest of the series. I will continue to welcome your reactions to this and any of my previous essays, as well as to what I post in the future on my blog. Look for me back here in the next year. In the meantime, my e-mail address is:  
ghmarcus@alum.mit.edu.

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