9. Milestones and their Meanings

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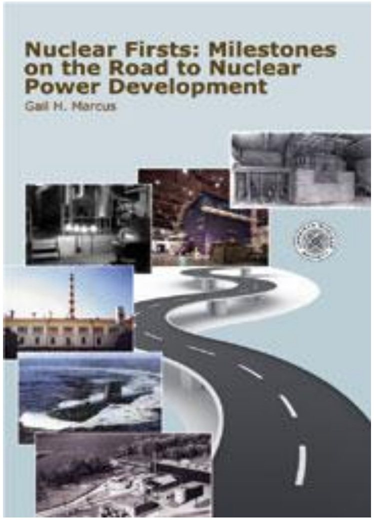
Dr. Gail H. Marcus is presently an independent consultant on nuclear power technology and policy. She recently completed a three-year term as Deputy Director-General of the OECD Nuclear Energy Agency (NEA) in Paris. In this position, she was responsible for the program of work and budget for the agency. 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.

I am pleased and proud to report that my first book has just been published. It is entitled *Nuclear Firsts: Milestones on the Road to Nuclear Power Development*, and it provides a historical overview of the technological and other developments around the world that have led to the nuclear power program that exists around the world today.



I had several ideas in mind when I started the book. I wanted to document milestones, but I had in mind a particular kind of milestone—the first of every technology or other achievement. I did not want to cover every nuclear plant built. I did not even want to cover the first in every country or in every state of the United States. Those are important in their own spheres, but I wanted achievements that were global firsts. I did not want to cover the biggest of each type of reactor, or the most reactors in a country, state, or site. These achievements are certainly a kind of milestone, but I felt that they were milestones that could be altered over time—by the next larger reactor, or the next country, state or site to build more reactors. A first of a kind, I felt, would stand the test of time.

When I started the book, I truly thought there would be only a handful of developments to report. The usual historic references, after all, seem to be: first, to Chicago Pile Number 1 (CP-1), where Enrico Fermi and his colleagues provided the first proof of a sustained, man-made fission reaction under a stadium at the University of Chicago on December 2, 1942; second, to the lighting of the iconic four light bulbs at the Experimental Breeder Reactor I (EBR-I) in Idaho on December 20, 1951; leading, third, to the lighting of the town of Arco, Idaho by power from the Boiling Water Reactor Experiment III (BORAX-III) reactor on July 17, 1955; and finally (at least in US accounts), to the startup of the Shippingport Atomic Power Station in Pennsylvania on December 18, 1957.

Of course, I knew there were more milestones than that, and that is why I started to write the book. I knew from other things I'd read that some of the important milestones took place outside the United States, and in fact, that power reactors began operating in the old Soviet Union and in the United Kingdom before the startup of Shippingport. I wanted to identify when pressurized water reactors had first started operating. I knew there had been reactors developed for space applications, for desalination, and for other purposes. I believed that the organizations and activities that sprung up to support the fledgling nuclear industry made important contributions to nuclear power development and should also be recognized. I wanted to include coverage of enrichment and reprocessing, and the use of different types of fuel.

But the more I delved into the history of nuclear power, the more milestones I found. I kept discovering forgotten, or nearly forgotten, achievements and events. Experiments from the earliest days on all the technologies we are now labeling "new" and "advanced"—liquid metal reactors, molten salt reactors, gas-cooled reactors, and more. Many ideas were tested very early on. Among them was a very, very small (1/3 of a watt!) demonstration of the generation of electricity from a reactor that took place in 1948, several years before the four light bulbs were lit in Idaho. And, of course, I turned up a number of developments outside the United States. I ended up with a list of about 80 milestones for which I provided brief summaries.

I was struck almost equally by what I did not find. One of the observations of what I did not find is particularly relevant to a Japanese audience. There were some countries, Japan among them, that are now major forces in nuclear power technology and operations, but that achieved very few "firsts" based on my definition. I did actually find a couple of true firsts for Japan, and reported them in the book, but I found none at all for China and Korea. It's possible I missed something here or there. However, the primary reason that there appear to be so few "firsts" from Asian countries is simply that Asian countries entered the nuclear power arena later.

This leads quickly to the conclusion that being first is not the only measure of success, and certainly not the best measure of success. While being first often confers some advantages, in the nuclear field, the opposite seems to be true. As the book amply demonstrates, the early nuclear experiments were beset with many accidents. The whole world learned from those, and many of our current approaches to nuclear safety have their origins in the hard lessons learned from the early accidents.

Even leaving accidents aside, it is clear that the US nuclear power program has suffered from the fact that it deployed so many slightly different reactor designs, and that, in many cases, one utility, or even one site, built and operated several different types of reactors. Japan and France had the opportunity to observe the difficulties of that approach and to adopt another path.

Clearly, by almost every measure, the nuclear programs today in several other countries match or exceed those of the United States and several of the other nuclear "pioneers," despite the earlier start of the pioneers of nuclear power. Therefore, the apparent imbalance in coverage of different countries in the book is not a reflection of the success of various national nuclear programs, but rather a reflection of the focus of the book on "firsts" that largely took place when only a few countries were active in the field. One might easily imagine that, if someone were to write a new book on nuclear firsts several decades from now, the mix of countries represented will be considerably different than the mix in my book.

Despite the imbalance, I felt a book that provided a historical perspective on the technology development would be of general interest among nuclear professionals. Unlike other historical books, this book does not focus much on personalities or backroom politics. Many of those books have been written, and they are very useful, but they generally have not addressed all the threads of activity in the early days of nuclear power. Rather, this book takes a look at the earliest efforts to develop the various nuclear technologies—both those that became the standards in the industry today, and those that appeared (at the time, at least) to be dead ends.

The second thing I noticed that I sometimes could not find was all the information I wanted about the history of a facility or event. This in fact surprised me more than the imbalance between countries. I had set out to assemble a standard set of information on each facility and event I covered—the date it first started, size, fuel used, etc. I also wanted to include a photograph of the facility or event in the book, and I preferred to use a photograph taken about the time the facility started up. I was amazed that sometimes pieces of what I wanted were not available. It was difficult to find an exact date of startup. The information on the size of the reactor and its fuel composition was ambiguous or contradictory (in some cases, because there were changes throughout the life of the plant). Most surprisingly, in some cases, photographs were difficult to find.

In thinking about this observation, I realized the problems I was finding related to some of the work I had done on *knowledge management* while I was at the US Department of Energy and at the OECD/Nuclear Energy Agency. The concern in these agencies was primarily about the loss of research data with the passage of time. In some cases, the research data, although old, remained important, either because research facilities had been closed and experiments could not easily be repeated, or because of renewed interest in technologies that had been abandoned. The fact that, in some cases, even the most basic information about the facilities is difficult or impossible to find is graphic proof that there are basic deficiencies in how we have documented what has been done in the past.

Knowledge management is a topic in itself, and I cannot cover all the many aspects of this important area in this essay. Let me simply say that one would hope that, with all the advances in technologies for storing and sharing data, it will be easier to retain information in the future. However, technology is not everything. Human involvement is still needed to decide what to store and to assure that the storage is accomplished, and the evolution of data storage media will probably necessitate continuous efforts in the future to assure that information is transferred to new media as old ones become obsolete.

Of course, I hope the book is important to people more for what I did find than for what I didn't find. I think in that regard that my most noteworthy observation is, as I noted earlier, that so many of the technologies we are now looking at again were really conceived in the earliest days of nuclear power development. In trying to look at why some technologies advanced and others languished, one can see that the story gets very complex. Sometimes, one technology advanced over others because of another application. The most notable case of this is the well-known link of pressurized water reactors to the development of nuclear power for submarines. Sometimes one technology was abandoned because the original application envisioned was abandoned, as was the case for molten salt reactors for aircraft propulsion. Sometimes, one technology was simply a little ahead of or behind another in its development and there was an urgency to make a decision.

One could argue that some of these decisions might not have been the best decisions. The book does not try to second-guess history. Rather, I might observe that some of these decisions are now effectively being revisited in advanced reactor R&D programs that are looking at some of the abandoned technologies. Thinking again to someone writing another history of nuclear firsts in the future, I imagine this could confuse the issue. Is the real "first" the work done in the 1940s and 1950s, or is it the work that will be done in the 2010s and 2020s? That will be a problem for some other author to figure out!

More about the book, as well as a link for ordering it, can be found on my personal blog.

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