3. Nuclear Power Plants and Cheese

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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.

Introduction

While he was Chairman of the U.S. Nuclear Regulatory Commission (NRC), Ivan Selin is reputed to have said, "In France, there are 365 kinds of cheese and one kind of reactor. In the United States, it's the opposite."

The statement was a reference to the fact that the U.S. nuclear industry and the NRC were at that time struggling with the consequences of having essentially customized many, if not most, of the nuclear power plants built in the United States. The United States had a fleet of over 100 reactors that included both Pressurized Water Reactors (PWRs) and Boiling Water Reactors (BWRs). The fact that they had one vendor for BWRs, three major vendors for the PWRs and several architect-engineers had resulted in numerous variants of both designs.

Further, the licensing process that existed in the United States in those days provided no significant benefit to duplicating a single design, as each license application required a complete review of the design, even if it had been previously approved. This encouraged tinkering to improve the design and to particularize it for specific sites and utilities. Finally, as a result of competitive procurements, and perhaps for other reasons, several utilities had, over time, purchased plants from more than one vendor. Some even operated both BWRs and PWRs, and a few operated PWRs from two different vendors.

By contrast, France had adopted a single technology, PWRs. Over the years, the design of their reactors had been improved, but the improvements had been introduced in step-wise fashion and applied to a group of plants rather than changing plant by plant. Thus, the French fleet consisted of a few "generations" of PWRs, with a number of identical plants built in each generation.

While it is usually the United States and France that are contrasted, because of their diametrically opposite approaches, it is worth noting that Japan has taken what might be called a middle way. Japan, unlike France, has both BWRs and PWRs in its fleet. However, Japan, unlike the United States, has fewer variations of each design. Furthermore, most of the utilities have chosen one technology (BWR or PWR), and no utility, except one (Japan Atomic Power Company), operates both types of reactors.

Both the reasons for such different approaches in each country and the consequences of those differences have long been debated.

Analysis

Among the reasons that have been suggested for the different paths taken by each country are:

- National culture (that is, the propensity of Americans to be individualists, and to want to invent new ways to do things);

- The fact that the United States began developing its fleet earlier than France or Japan (which meant it was the first country to test out many concepts, necessitating more changes as they "pioneered" discoveries of what did and did not work well);

- The fact that the United States had numerous small utilities, while Japan had about ten, and France had only one;

- The stronger central governments in France and Japan and their active role in promoting national industrial development policies; by contrast, the lack of central planning in the United States and the extremely competitive market that developed among its vendors; and

- The fact, previously mentioned, that U.S. regulation did not give any benefit in its licensing process to designs that had already been approved.

All of these, as well as other factors, probably had some role in the different evolution of the nuclear industry in each country. However, rather than dwell on the past, it is of more interest to examine the consequences of what happened in each country and to explore what might be necessary—and possible—to change the course of nuclear power development in the future to overcome drawbacks of particular approaches.

The consequences of each approach can be summarized rather simply:

The benefit of continuous modification to reactor designs is, potentially, the ability to reap the benefits of experience most rapidly. Observations drawn from experience about how to overcome any problems encountered, how to improve operability, or how to reduce costs can be implemented immediately in the next plant. There is no need to wait to accumulate a number of modifications.

The downside, of course, is that unique reactors limit the opportunities for economies of scale. Different designs need different components, different operational procedures, and different training. Staff cannot readily be moved from one unit to another. The resources required to solve any problems or develop any improvements cannot be spread over as many units. Different regulatory reviews need to be conducted for each design.

By contrast, standardization provides utilities and regulatory authorities with many efficiencies and economies of scale. The resources required to solve a problem or to design improvements need to be invested only once, but can be applied a number of times. Likewise, the licensing reviews required to approve a change need to be conducted only once, but can be applied a number of times. Procedures documents need to be written only once, but can be used in several plants. Maintenance and operating staff can move from one facility to another. Economies of scale may allow for cost reductions in some components.

The only real downside of standardization is the potential for one serious generic problem to idle a whole fleet. That downside has been discussed many times. To date, however, such a severe problem has not materialized. The problems that have been identified have not been sufficient to require immediate shutdowns of all affected plants. Rather, it has been possible to implement corrections in a staged fashion. This is not to say that a more severe problem is impossible. Further, it is clear that the pressure on the regulator not to shut down all reactors at once could be considerable if a very serious generic problem is ever identified. However, the extensive experience does suggest that the potential for severe generic problems is not a strong argument against standardization. In addition, the existence of "generations" of plants makes it likely that a generic problem would not affect the entire fleet of reactors anyway.

In considering the pros and cons of standardization, Japan's "middle way" would seem to result in the best of both worlds. Japan's utilities draw all the benefits of dealing with only one kind of reactor technology, including the efficiencies possible from their investments in training and developing procedures, and the flexibilities of staffing. While each individual utility may have some risk of experiencing a generic problem, overall, the country enjoys some protection from such a possibility.

The Japanese regulators have a somewhat smaller benefit, since they do have to deal with both BWR and PWR designs. However, Japan still has more standardization within each of these designs than does the United States, so the Japanese regulator still doesn't have to deal with as many design variations as does the U.S. regulator.

Looking Ahead

It may be tempting to attribute such differences to national character or religious background, as Confucianism promotes the idea of a "middle way." That may well be so. However, the situation is too complex to attribute everything to one factor and to assume that change is impossible. I am less interested in what led to the current status than I am in looking ahead at how the situation is evolving in each country, and in what can be done to push each country towards a path that avoids past pitfalls and adopts the best practices of other countries.

In this regard, it is interesting to look at the situation today. When I first lived in Japan in the early 1990s, utilities in the United States were beginning to merge and consolidate. I used to make presentations about the U.S. situation to Japanese audiences. In those presentations, I sometimes said, half-jokingly, that with the mergers and acquisitions I was seeing in the United States, perhaps someday there would be only about ten utilities in the United States, just as is the case in Japan.

Today, I feel that prediction is not so far-fetched! Perhaps we will not reach ten utilities in the United States, but we now have a far smaller number of nuclear utilities than existed in the past. Between 1990 and the present, the number of utilities operating nuclear power plants has dropped by almost a factor of 2. (The Nuclear News "World List of Nuclear Power Plants" showed 50 utilities operating nuclear power plants in 1990, counting the joint operation of San Onofre by Southern California Edison and San Diego Gas and Electric as one utility. Twenty-one of these utilities operated only one unit. The 2008 edition of the same table lists 27 entities, including both owner-operators and operators, operating nuclear power plants. Only seven of these entities operate just a single unit.) More consolidations are possible.

This fact alone goes a large way toward overcoming one of the biggest difficulties of the past in the United States—the existence of so many utilities in the business of operating nuclear power plants, many of them owning only one unit. With fewer utilities operating nuclear power plants, and fewer utilities with only one nuclear plant, utilities in the nuclear business are much more likely to be able to benefit from some of the economies of scale that the Japanese utilities have long enjoyed.

I also suspect that U.S. utilities have come to the realization that a significant extra effort is required for one utility to operate nuclear plants of different types, and will be less likely to follow that path in the future. It should be noted that there has been no institutional change made in US law or regulation that would prevent a utility from purchasing reactors of different designs from different vendors. It is not impossible that we will see some utilities do so, particularly if not all the vendors presently in the market are able to continue to compete. Nevertheless, in the future it should be the exception rather than the rule.

In addition, the licensing process for new reactors has been changed in the United States. Now, there is benefit in referencing a previously certified design in a new license application. This change should help create pressure for the U.S. nuclear industry to minimize design changes for each new unit.

However, the outcome of this change is not guaranteed. Even now, in the early stages of license applications for a new generation of reactors in the United States, many of the applicants are, for one reason or another, not referencing a previously certified design, and design changes to previously certified designs are already being proposed. Some of this situation may be temporary, and as more designs are certified, there may be less of a perceived need to submit applications that do not reference a certified design. At this stage, it is impossible to know for sure, but the experience so far raises at least some concern that the United States may end up with less standardization than it expected.

All of this is in contrast to the situation in France and in Japan. In France, the single utility that operates throughout the country almost guarantees that the past practices will continue. In Japan, the situation is more complex, but the continued existence of the current utility infrastructure, and the recognition of the benefits that the Japanese utilities have achieved by specializing in one technology certainly make it both likely and desirable for the present approach to be maintained.

Therefore, in the next round of nuclear development, we are likely to see some convergence in the approach to acquiring new reactors in some of the major nuclear countries. In particular, we will most likely see a significant change in approach in the United States, and less change, if any, in Japan and France.

So What Does All This Have To Do With Cheese?

Before I answer that question, I should point out that the quote attributed to Chairman Selin has been reproduced in several different ways, some of them simply saying "hundreds" of types of cheese in France. Furthermore, this quote has an antecedent in a quote attributed to Charles de Gaulle: "How can anyone govern a nation that has 365 different kinds of cheese?" (This quote also seems to exist in several forms, some saying "246" types of cheese, but the point is the same.)

What I find interesting is that Charles de Gaulle used the cheese to illustrate the diversity in France—presumably of the population that produced and consumed so many kinds of cheeses—while Chairman Selin flipped the argument, and sought to show a uniformity in France (of reactors, at least) and a diversity in the United States.

The real message to me in comparing cheese and nuclear power plants in France and the United States is that it gives us a chance to consider some of the many factors that influence the development of nuclear power, to consider the pros and cons of the outcomes, and to try to factor this understanding into future decisions.

Of course, we are not dealing with simple one-on-one interactions. In reality, the reasons for the uniformity in the reactors operated in France and the diversity of the reactors operated in the United States are complex. Predicting what changes can or cannot be achieved in each country is similarly difficult. Clearly, a country that has many kinds of cheeses can, for a variety of reasons, have considerable uniformity in its nuclear power program. France, like Japan, now has a strong national government system and a tendency towards industrial policy at the national level. In the United States, there is less of a tradition for pursuing industrial policy at the national level. Furthermore, in the past, the US regulator took a more passive role with respect to the evolution of the technology and offered few incentives for design standardization. The benefits of some standardization have now been recognized and an evolution in that direction is underway for the next generation, suggesting that a country that started out with multiple unique designs can move toward greater standardization.

Both Chairman Selin and I have lived in France at different times in our careers, so I am sure we both know that, depending on how you count, there are considerably more than 365 different kinds of cheeses. I know that I tried to enjoy as many as possible while I lived in France!

For cheese, the great variety of cheeses is generally a benefit. It is certainly a benefit to a cheese lover such as myself. For nuclear power plants, variety has some benefits, but also some drawbacks. Fortunately, the situation with respect to nuclear power plants seems to be changing in the United States. In the future, people will, I hope, continue to be able to observe that there are numerous varieties of cheese in France, but I also hope that they will not see as much diversity in the designs of reactors operating in the United States.

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As always, I welcome comments and feedback. I can be reached at:

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