1. Making Predictions about the Future

Gail H. Marcus, Consultant, USA

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.

In thinking about what might be a good theme to launch this series, I was reminded of a saying by Yogi Berra, an American baseball player who became famous for making statements that were technically incorrect, but unintentionally humorous. My favorite of his many homespun philosophical pronouncements is: "It is hard to make predictions, especially about the future." [For more of the quotes of this most famous American philosopher, Google "Yogi Berra" or see http://en.wikiquote.org/wiki/Yogi_Berra]

This thought came to mind because I have been thinking about how much our perspectives on the needs for energy and the problems of energy sources have changed in the last few years.

After all, it was not that many years ago that no one had heard of global warming, and no one was thinking about the possibility of very rapid growth in the economies of some of the world's most populous developing countries.

Should we have been able to anticipate these trends sooner? There probably were a few visionaries who did predict them. It probably simply seemed to the rest of us that these concerns were not sufficiently real to merit doing something about them.

Maybe the problem is not so much that it is hard to make the predictions, but that it is hard to make the decision to do anything about a potential problem that seems to be a small probability event some time far in the future.

There have been some other concerns raised in recent months that are, perhaps, not quite as difficult to grasp. I am thinking particularly about new revelations about some of the new technologies developed to save electricity or reduce our use of oil. The two most recent examples are: 1) worries about mercury contamination of the environment from energy-saving light bulbs, and 2) rising food prices, due at least in part to the growing use of agricultural land to raise corn for ethanol production. I hear about these events mostly from a U.S. perspective, but I think both are ultimately global issues.

Should we have been able to anticipate these trends sooner?

In these case, I think the answer is yes. I do recall hearing, several years ago, that turning corn into ethanol could affect food supplies and food prices. What was not as predictable, perhaps, was that other factors (drought, cost of oil, etc.) would accelerate the process so much. Today, the United States is moving towards a ban on incandescent light bulbs in a few years. We already know about the health hazards of mercury. Yet, it seems we have put the ban in place without starting to plan for the recovery of the mercury from used light bulbs.

I should emphasize that these are only the two most recent examples in a long series of concerns that have arisen for just about every energy-related technology that has been introduced. In fact, in the early days of the automobile, it was widely considered a technology that would reduce the very serious pollution problem that resulted from the growing use of horse-drawn carriages in cities! No one understood the health impacts of automobile emissions or could envision that the use of automobiles would reach proportions where the emissions would be a significant matter. In the early days of nuclear power, it too was seen only as solving existing problems. None of the concerns we hear about today were yet foreseen.

Perhaps the real point is not that we need to have perfect powers of prediction, but rather, that we need an infrastructure that is robust and responsive. We need solutions that will work for a variety of scenarios.

For global warming and energy security, it seems to me that some of the best measures to address the possible trends are things your grandmother could have told you are good for you:

A balanced diet is important. The solution to our problems isn't just nuclear power, or just renewable energy, or just energy efficiency. The solution is all of these and more. Likewise, we can't get all our oil from one part of the world, particularly if it is an unstable or adversarial source.

Plan for a rainy day. We can't just keep doing what we have been doing and assume everything is going to be fine. We need to plan for our future. We need to develop more advanced technologies that utilize resources more efficiently and that produce less pollution. We need to try to develop ways to remove or sequester carbon from coal burning, we need to design nuclear plants that address today's concerns, we need to try to make renewable energy more cost-effective, we need to develop alternatives to meet transportation needs, and we need to pursue fusion. We need to explore for more resources, fossil and nuclear. This includes unconventional sources (like tar sands for fossil fuels and seawater for uranium) and alternative fuels (thorium, in the case of nuclear).

Be thrifty. We need to use everything and use it

efficiently. This means we need to implement greater energy efficiency, both in energy production and transmission, and in applications. This includes advanced power production technologies.

Cleanliness is important. It will do us no good to meet our energy needs if we choke ourselves in the process. We need to address both particulate emissions and carbon emissions, whether by cleaning up fossil energy sources, or by substituting nuclear and renewable energy sources. We also need to address solid waste issues. For nuclear power, this means exploring all the options for dealing with used fuel—short- and long-term storage, and using more of the energy value of the fuel.

Don't put all your eggs in one basket. We can't count on any one technology—not nuclear power, not renewable energy, not clean coal, not carbon sequestration. In particular, we can't count on possible improvements in technologies that have not yet been developed, or in potential resources that have not yet been discovered. Some research will meet its objectives, but some won't. We need to pursue several alternatives.

I would add one thing grandma might not have said—**we need more of everything.** We need more electrical power, and we need more transportation fuels. We need a lot more for developing countries, but we also continue to need some more for developed countries as our economies become more dependent on computers and telecommunications and transportation.

So, when you look at issues like global warming and security of supply, all indications lead to the conclusion that we should continue to develop and use a variety of energy technologies, that we should emphasize technologies that emit little carbon dioxide, and that we should favor technologies that have fuel resources available from a variety of places around the globe.

What does this mean for nuclear power in particular?

I think it means that nuclear power is an attractive component of any future energy mix. It emits little carbon and it offers a diversity of resources. It is not "the" solution. It is not the right choice everywhere, it cannot meet all transportation needs, and it must be operated with the highest levels of vigilance at all times. It can and should be part of the mix of energy technologies, today and in the foreseeable future.

I think it means that we should continue the current initiatives to develop advanced nuclear reactor technologies that are more efficient, and we should continue to explore the development of technologies that would allow us to use more of the energy content of uranium fuel.

We also need to begin to address the concerns about the adequacy of uranium resources in the longer term. While it is clear that the resources are sufficient now, any large-scale increase in the use of nuclear power will necessitate exploration for additional uranium resources, the development of methods to recover lower quality ores more efficiently, more efficient enrichment processes, higher fuel burnups and/or recycling to use resources more efficiently, and perhaps the development of ways to recover unconventional resources (such as uranium from seawater) and to use thorium in the fuel cycle (as India is already doing). To address proliferation concerns, as well as for economic reasons, we also need appropriate administrative measures to assure fuel supplies to all countries.

One perceived deficiency of nuclear power is the waste issue. While the quantity of waste is small compared to coal, the radioactivity is a long-term concern to many people. To date, this remains a difficult issue in almost every country. Here again, I would say that we should not count on any one measure or any one development to address this problem. For too long, the nuclear industry in the United States has been relying on the building and opening of a repository at Yucca Mountain to "solve" the waste disposal problem. We abandoned the exploration of other potential disposal sites, we abandoned the development of reprocessing, we didn't look sufficiently at other options, temporary or permanent, to reduce or reuse used fuel. These avenues need to be explored, both in the U.S. and elsewhere.

For the more specific issues I raised—the ethanol problem and the mercury from energy-efficient light bulbs—the use of prediction may be more relevant because the time spans are shorter and the issues are more limited.

It was predictable that turning corn into ethanol would affect food supplies and food prices. I recall hearing that concern raised several years ago. What was not as predictable was that other factors (drought, cost of oil, etc.) would accelerate the process so much. Nevertheless, we should have had a plan in place to help prevent a sudden crisis, and in the longer term, we should be working to develop ways to produce ethanol from cellulose products. Today, the United States is moving towards a ban on incandescent light bulbs in a few years, and worldwide, incandescent light bulbs are being displaced by more energy-efficient mercury

light bulbs. We therefore should be actively developing a plan to assure that the light bulbs will be disposed of properly, and in the longer term, we need to be developing energy efficient light bulbs that do not need mercury.

So in summary, I have to agree with Yogi Berra. It is hard to make predictions, especially about the future. When we first deploy a new technology, its impact is so small, it may be hard to see what the impact could be on a larger scale. It is hard to guess what other factors may change the picture—weather patterns, economic developments, competing technologies.

Our best strategy is to assure that our energy mix and our long-term energy development plans are "right" for a variety of predictable scenarios, and to be ready to make shorter-term adjustments when the unexpected happens. Members of the nuclear profession should play an active role in promoting the need for a robust global energy strategy. If we can achieve this objective, we might be able to claim that we can at least predict that, in the future, we will be able to meet the growing energy demand with a mix of clean, low-carbon energy sources.

***

In future essays, I hope to explore several specific issues, including the internationalization of the nuclear enterprise and the question of waste disposal. I also hope we can have some fun—my husband insists I should write about nuclear power plants and cheese. Does that whet your appetite?

Thanks for your attention, and I hope to "see" you in this space again next time. In the meantime, I will welcome your reactions to this essay.

My e-mail address is: ghmarcus  alum.mit.edu.

(An image charactor is used intentionally for @-sign. Please cut the image and put a keystroke @-sign)

July 2008