Key Points in Post-Fukushima Speeches

William F. Martin

1) **April 4, 2011 -** Council on Foreign Relations with Ambassador Fujisake**:** *The Long-Term Effects of the Tohoku-Pacific Earthquake: Energy Implications for US-Japan Relations.*

Key Points:

- Express sympathy for the victims for the Tohoku region.
- This disaster highlights the importance and strength of the US-Japan relationship.
- What the decrease in nuclear will mean for Japan and how the effects can be mitigated and what are the implications for Japan, and indeed the world, for this new energy reality?

2) **June 8th, 2011 -** Council on Foreign Relations**:** *Energy: Looking Back, Looking Forward 90 Years.*

Key Points:

- Express sympathy for the victims for the Tohoku region.
- How we arrived at the current world energy situation and what can be learned from Fukushima and how this will affect the future of world energy supply?
- There will be more people and larger energy demand in the coming years and this will require a utilization of all energy sources (oil, coal, nuclear, gas and renewables) if this challenge is to be met.

3) **August 3, 2011 -** Center for Strategic and International Studies**:** *Partnership for Recovery*

Key Points:

- How can Japan meet its energy demands in the coming decades with the diminished growth of nuclear power?
- What has Japanese energy policy looked like over the past decades?
- What can Japan do in the short, medium and long-term to address these challenges?

4) **October 3, 2011 -** Hoover Institute with Nobel Laureate Burton Richter: *International Nuclear Energy*

Key Points:

- There will be large growth in nuclear power, especially among developing nations and newcomers.
- This will have large safety and security implications and nuclear established nations (including Japan and the US), must be at the forefront of global safety initiatives.
- If action, in a multilateral fashion, is not taken and business as usual continues, there will be large and dangerous safety and security ramifications.

Long-Term Effects of the Tohoku-Pacific Earthquake:
Energy Implications for US-Japan relations

William F. Martin, former US Deputy Secretary of Energy

Presentation before the
Council on Foreign Relations and Mansfield Foundation

Washington, DC

April 4, 2011

Good morning Ambassador Fujisaki and Ambassador Schieffer. Let me first express my admiration for the endurance, perseverance and bravery of the people of Japan, especially of the Tohoku region. I've had the honor to visit Sendai for each of the last twenty-two years and enjoy the hospitality of the gracious people and the beauty of the region.

Current Situation

My topic today is the energy picture of Japan in the medium to long-term in light of the Fukushima events. But first, let me say that it is my understanding from friends in Japan that this is an ongoing crisis and, while there are some signs that progress is being made, we are far from seeing the plants in stable condition. In this environment there are moment-by-moment challenges that persist – but, as each day goes by, we hope the situation will improve. Even once the event is controlled, the enormity of the cleanup will take months and years, and we stand ready to work with Japan on that challenge too.

My thoughts and prayers go out to the many heroes we have seen and the extraordinary work of the employees of TEPCO and volunteers from other utilities that are carefully meeting this crisis as well as for the government officials who are overseeing their safety. We know that Japanese government and industry are working 24/7 on Fukushima. Japan is working hard to make all available facts known to the public as quickly and as openly as possible.

The accident also reinforces the U.S.-Japan special relationship. Our NRC, DOE, U.S. military, and the rest of our government and private sector (including through INPO) are hard at work, in Japan and in the United States, to assist by responding to Japanese technical requests or requests for material assistance. We are true friends and partners, and this is a very special relationship that we have. The U.S.-Japan partnership is stronger than ever. I believe that Japan will get past these terrible events.

Now let me turn to the medium and longer-term perspective by first reviewing a few statistics about the basic energy situation of Japan and the role of nuclear power going forward.

- First, Japan is one of the most energy efficient countries in the world with the lowest use of energy per unit of GDP. It is also the most efficient in terms of carbon as Japan produces more GDP per unit of carbon produced.

- Second, nuclear energy supplies roughly 30% of Japan's electricity from its 54 reactors. At any one time only about three quarters of Japan's nuclear reactors are being used as the remaining reactors are closed for safety inspections.

- Third, Japan's total electricity generation is approximately 158 GW(e) for a country of 130 million people. So a 1 GW(e) reactor produces enough electricity for a city of roughly a million people. Thus, the six Fukushima reactors produced enough electricity for approximately six million people.

- Fourth, thermal plants (oil, coal, gas) have also been affected by the quake--in total an additional 10 GW(e) are currently "under review" or repair. In the very short term Japan will need more refined products to generate electricity.

- Fifth, the electric grids between the West of Japan (Osaka, Nagoya) are quite different than those of the East of Japan (TEPCO, Tohoku) and only a maximum of 1 GW(e) is possible to move from West to East. But the economic impact affects all of Japan. For example, it was reported that Toyota assembly lines had to stop production in Nagoya (in the West) because of a lack of parts being delivered from the East (Tohoku region).

- Sixth, Tohoku Electric Power Company, which supplies the city of Sendai, reconnected almost all of its customers in a week.

The Implications

Japan is resilient, starting with its people, but the heavy toll on the nuclear facilities and public attitude is likely to have a long-term impact. How will Japan meet its energy security requirements? How will it be respectful of the climate issue? Importantly, what will be the role of U.S.-Japan partnership, a partnership that has undoubtedly been strengthened due to this crisis?

- Prior to the earthquake, nuclear energy in Japan was projected to go from 30% of electricity to as much as 50% by 2050. At today's juncture, I expect priority will be given to the "repowering and relicensing" of existing reactors after a careful review of safety as recently announced by the Prime Minister. The hope is that most of the 54 reactors now under operation will be relicensed in the future minus those that are not repairable.

- Another priority would be to continue construction of additional reactors in appropriate sites and to increase the flexibility of the grid by developing more compatible transmission infrastructure between the East and West of Japan.

- Finally, Japan respects the need to close the fuel cycle and reprocess nuclear fuels to extend the life of uranium reserves, as well as provide for more efficient long-term storage. Some argue that reprocessing of fuel is not necessary given adequate supplies of global uranium resources – but as a country that has no indigenous energy resources, nuclear power and recycling offer the opportunity to be partly sufficient in energy reserves – vital for the energy security and economic performance of Japan.

But realistically, nuclear power may not reach 50% of total electricity supply; a more reasonable figure might be 35 to 40%. How will Japan meet the rest of its electrical needs? There are four ways: coal; LNG; advanced renewable technologies; and the Japanese term *mottainai,* which means conservation.

- Today, coal fuels about 25% of electricity production. Under earlier policy assumptions, coal was going to be almost totally phased out but today, given its economic attractiveness and the need for Japan to maintain a balance in electrical generation, I expect that coal will be about 15% of the energy mix in 2035 and emphasis will be put on clean coal technology and burning.

- A big push will come for LNG. I expect LNG imports to Japan will increase significantly before mid century. Gas has the advantage that it is available from a variety of sources (Qatar, Russia, Indonesia and Australia) and it is considered a clean energy source. As I will discuss later, there is the possibility of greater US LNG export to Japan.

- There is also scope for advanced renewable technologies such as wind, solar and, of course, hybrid vehicles. Overall *mottainai* will remain a priority.

Japan's Projected Electricity Supply (%)

	2009	**2035 (estimate)**
Nuclear	29	30
Coal	25	15
LNG	29	35
Oil	7	5
Hydro	8	5
Renewables	2	10

Bottom line: I expect that Japan will remain committed to its goal of diverse fuel sources to provide a 'best mix' energy policy that includes nuclear energy.

Global Energy Scenarios

Let me say that the impact on nuclear power is going to be worldwide. Prior to the earthquake there were some 442 reactors globally producing about 375 GW(e) of electricity. The IAEA had estimated this could climb to 650 GW(e) or more by 2050. This estimate may be too high in the post-Fukushima environment. It is important to note however, that Japan and the United States have roughly 40% of total world nuclear capacity. Therefore, what happens in our two countries is going to have a dramatic effect on world energy and the environment. Interestingly, while many nations have called for review of safety of existing plants in light of the lessons of Fukushima, it appears that nuclear programs worldwide are proceeding, although perhaps "new build" will be slowed somewhat.

The importance of diversity of fuels and source – a concept that is highly valued in Japan – is even more important in light of Middle East events, coupled with the Fukushima accident. These two events have fundamentally and significantly changed the world's energy and environmental prospects. To give you an example, in order to meet "normal" energy requirements of the next twenty to twenty-five years, the IEA had estimated that nuclear energy would increase by at least 25% and world oil production would have to rise from 80 to l00 million barrels per day.

In the post-Fukushima/new Middle East world, neither of these assumptions is likely to be accurate. In light of the new developments, I expect the world is likely to become more dependent on coal – and this will require an acceleration of clean coal and carbon capture and sequestration technologies. Much of the world's incremental increase in electricity generation will be met by natural gas/LNG, coal and renewable energy resources. Shale gas is an important new source, especially in the U.S., that could allow the U.S. to meet our own needs and also be an exporter to Japan and Europe. Renewable technologies will need to be accelerated if they are to have even a modest impact since they start from such a small base. The governments and private sectors of the U.S. and Japan as partners will have a major role in all of these areas.

US-Japan Relations

I was heartened to see the Sendai airport, seemingly washed away by the tsunami, now being partially restored and a center of humanitarian assistance led by Japanese Self Defense and U.S. forces. We have officials from DOE and NRC on the scene helping the Japanese government respond. One valuable contribution is radiation monitoring with advanced U.S. equipment. U.S. data has been an important source to confirm Japanese data, especially as it relates to radiation levels. The quick response of the United States underlines the strength and depth of the friendship between the U.S. and Japan. Ambassador Mansfield called the U.S.-Japan relationship the most important bilateral relationship in the world. He would have been proud of the Americans and Japanese confronting this crisis and, as an expert in science, he would be deeply involved in the

discussions of the post-Fukushima changes. So, let me conclude by asking how can we strengthen the U.S.-Japan relationship?

- First, the lessons learned from the experience of Fukushima should be carefully reviewed. In the first instance it is important that Japanese industry and government have their own internal review and be transparent with their results. I have been impressed with the detailed statistics and information being provided by so many sources in Japan, both public and private.

- Secondly, consultations have already begun between the Japanese and U.S. governments and I am confident that these efforts by the Department of Energy and Nuclear Regulatory Commission will proceed in the environment of positive and transparent cooperation. Engaging the private sector is also important in these deliberations. President Obama has created a blue ribbon commission to evaluate long-term storage of spent nuclear fuel. This would be a good forum for Japanese experts to testify about the situation and the lessons learned so that the U.S. can benefit from the Japanese situation in evaluating our own long-term storage of high-level waste.

- Third, we need to continue efforts to move toward a secure and environmentally sensitive energy future, an objective of both of our governments, recognizing that in the post-Fukushima world, the challenges will be greater but the effort toward energy security and environmental quality must proceed and nuclear must be part of that mix. I have earlier suggested that LNG imports will expand in Japan. The U.S. and Japan should seriously discuss the possibility of export of gas from the U.S. to Japan – in the short term from the Gulf of Mexico and over the longer term the possibility of Alaskan North Slope gas exports (a concept supported by Ambassador Mansfield during the Reagan-Nakasone energy talks in 1983). Japan and the U.S. should continue and accelerate their joint effort to find secure and environmentally friendly sources of energy. As the two most advanced technological nations in the world we can accelerate the advancement of renewable technologies. At the same time, we must be aware that energy systems change slowly and that just a small shift in our energy balances requires time, effort and capital investment – and that these decisions will be made primarily by the private sector in a highly competitive environment.

- Fourth, the world community should learn from the lessons of Fukushima. Some areas for greater consultation and cooperation might include: review of equipment available for emergency workers; review of plant details such as emergency power requirements, including the concept of "black start" – electric generating capacity resident at each power-plant so that electric service is guaranteed to be available even under the more-than-worse tsunami type conditions. In terms of spent fuel, one might review the use of dry cask storage. There is also much to be learned about radiation collection and reporting and, alongside this, better education of the public about radiation. Working together as Team U.S./Japan, we can strengthen international efforts, especially within the IEA and the IAEA, and

work together to stimulate other nations toward sustainable energy futures, of which safe and secure nuclear power will be an indispensible part.

- Fifth, a very important forum that can strengthen global nuclear safety is the Nuclear Energy Summit initiated by President Obama a year ago. Leaders from almost fifty countries gathered in Washington to look at the issue of nuclear safety, security and safeguards. The next meeting of world leaders will be in South Korea in the spring of 2012. I would hope that world leaders can use this important meeting to evaluate the lessons of Fukushima and also recommit to sustainable and secure energy resources, including nuclear power. An important objective should be to strengthen the International Atomic Energy Agency.

- Finally, over the last fifteen years I have had the privilege of convening the Santa Fe Seminar, a seminar that brings together senior Japanese government and business leaders with their American counterparts to discuss U.S.-Japan nuclear cooperation. We have routinely held these seminars every two years and hope the next meeting will be held in November as part of our continuing series. Convening U.S. and Japanese leaders together to learn the lessons of Fukushima and, at the same time, discussing the nuclear and energy situation in the medium and longer term of our nations is very timely.

As a Japanese colleague said, this is not the end of nuclear, this is the beginning of a new era of nuclear power. I would add, this is the beginning of the new energy and environmental era, a future that the U.S. and Japan can embrace, not only for our own countries, but for the whole world. It is often said that Japan respects the three E's, (energy, economy and the environment) and in terms of nuclear the three S's (safety, security and safeguards). This respectful attitude developed in Japan is a good model for the U.S. and, indeed, the world.

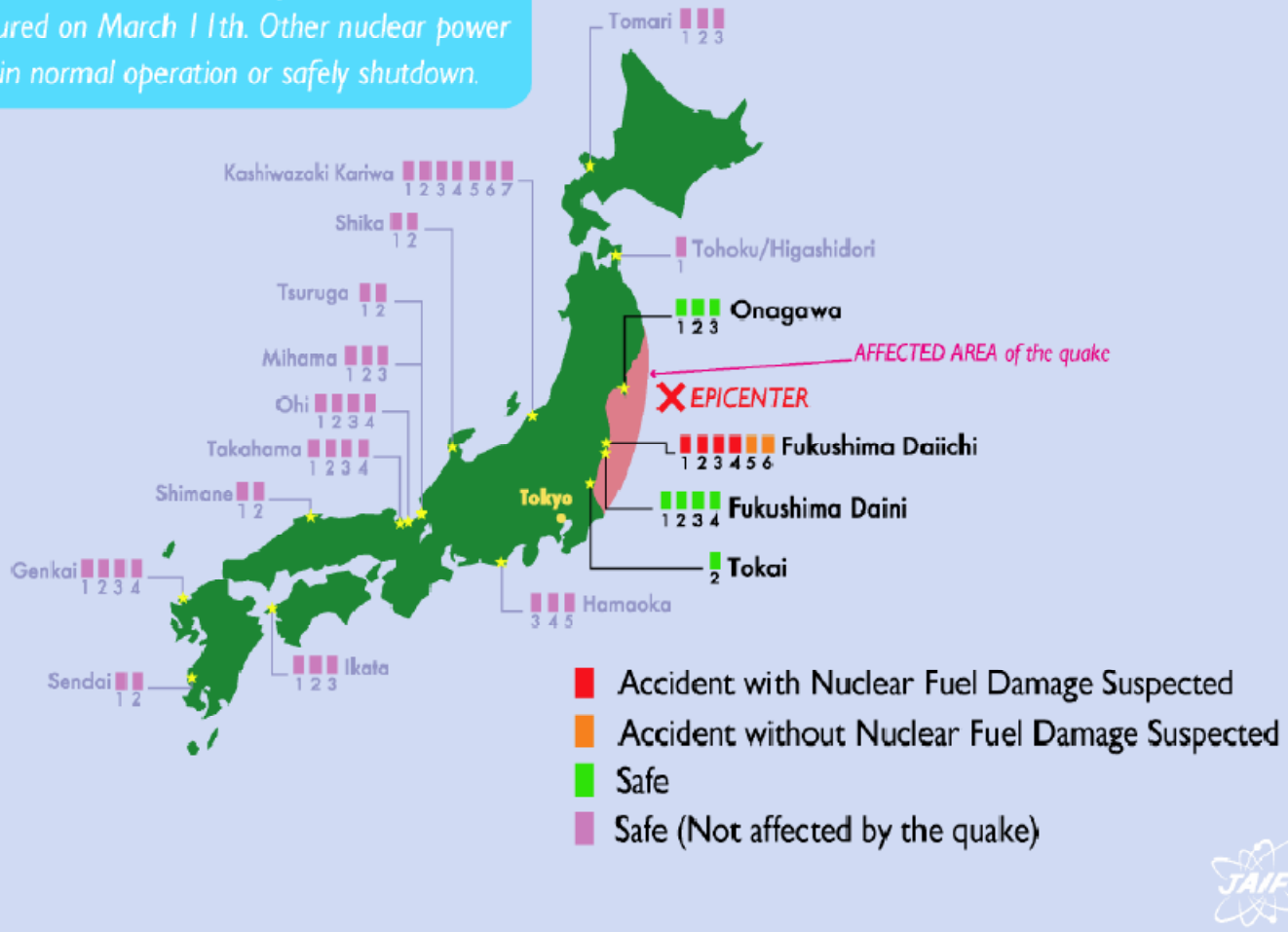
In fact, President Obama and Secretary Chu this week called attention to the importance of reducing oil imports in the U.S. and reaffirmed their support for nuclear power. Interestingly, the Japanese have long understood that reducing carbon has both energy security and environmental benefits. This is something Republicans and Democrats can come together on. Rather than divide parties and nations, energy should be a uniting feature of the global economic, energy and environmental future.

I would like to end with a personal story. My son, Chris, is pursuing his doctorate at the Primate Research Institute of Kyoto University. His research center is in Inuyama in Aichi prefecture near Nagoya. He works daily with the chimps of PRI, including the world's most famous chimp, Ai, who is a frequent guest on NHK television. She is well known for being able to remember ten numbers flashed on a computer screen and then punching out the same sequence. When the quake and aftershocks hit, Chris could slightly feel the quake but the chimps started screaming in fright. It seems chimps are, by most accounts, far more sensitive than their human counterparts. As I watch the reruns of the tsunami hitting the shores of Tohoku, I cannot forget not only the human toll, but the toll on the animals and other wildlife. I was pleased and a bit apprehensive when Chris

told me, “Dad, Professor Matsuzawa wants me to join a convoy to save the chimps in the Tohoku region.” Regrettably the roads did not allow for the expedition but it is an indication of how sensitive and respectful the Japanese people are to the environment and to all the inhabitants who live on these beautiful and fragile islands. Thank you.

Status of the Nuclear Power Plants after the Earthquake

The accident that brings environmental impact is going on at several units in Fukushima Daiichi nuclear power Station after the earthquake occured on March 11th. Other nuclear power plants in Japan are in normal operation or safely shutdown.



As of 3/30/11

COUNCIL on FOREIGN RELATIONS

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The Japan Studies Program, together with The Maureen and Mike Mansfield Foundation, presents a discussion on:

Long-term Effects of the Tohoku-Pacific Earthquake: Implications for U.S.-Japan Relations

Monday, April 4, 2011 — 8:30 AM to 11:00 AM

REGISTRATION & BREAKFAST RECEPTION: 8:30 AM to 9:00 AM

INTRODUCTORY REMARKS: 9:00 AM to 9:30 AM

His Excellency Ichiro Fujisaki, *Ambassador, Embassy of Japan*
The Honorable Tom Schieffer, *Former U.S. Ambassador to Japan*

DISCUSSION: 9:30 AM to 11:00AM

Akira Chiba, *Minister of Congressional Affairs, Embassy of Japan*
Charles Lake, *Chairman, Aflac Japan*
William F. Martin, *Chairman, Washington Policy and Analysis*
Sheila A. Smith, *Senior Fellow for Japan Studies, Council on Foreign Relations*
The Honorable Tom Schieffer (presider)

This meeting will be held at CFR's Washington Office at 1777 F Street, NW, Washington, DC 20006.

Amidst the crisis and uncertainty, one thing seems clear: the Japan that emerges from this series of disasters will be a changed nation. While immediate attention is rightly focused on responding to Japan's ongoing nuclear and humanitarian emergencies, it is also critical that political leaders are prepared for the changes and the choices we may face in the near to long-term. The above panelists have wide-ranging expertise in areas including Japanese politics, Asian security and the U.S.-Japan alliance, Japan's energy portfolio and nuclear power industry, and Japan's private sector. Addressing these and other related topics, this roundtable will provide an opportunity for the policy community to begin a conversation on the purposeful leadership that will be necessary to aid in Japan's emergence as a stronger nation.

To attend, please contact Sophia Yang at 202.509.8449, or by email at syang@cfr.org.

This invitation is not transferable.

Energy: Looking Back, Looking Forward 90 Years

Council on Foreign Relations 90th Anniversary Series on Renewing America

Harold Platt House, New York, June 8, 2011

William F. Martin, former Deputy Secretary of Energy and Chairman, Nuclear Energy Advisory Committee of the Department of Energy

Introduction- The Role of Foreign Affairs in US Energy Policy

We all hope to live to be a healthy 90 years old and the Council on Foreign Relations has succeeded. As a member since 1983, I have had the opportunity to observe the Council for almost 30 years but my first association with it came in 1976 when Bill Bundy asked me to travel to Iran to complete the manuscript of the article entitled: *Can the World Afford OPEC Oil*.[1] At that time my boss was Carroll Wilson, Vice Chair of the CFR and the first manager of the AEC who had written several pieces in Foreign Affairs on energy, including *A Plan for Energy Independence*.[2] My colleague, Joseph Perkowski, of Idaho National Lab, crunched the numbers. Alongside Dr. Perkowski, and also working with Carroll Wilson, was Amory Lovins, who later published *Energy Strategy: The Road Not Taken* in Foreign Affairs, where he spoke of Soft Energy Paths,[3] an policy approach based on energy efficiency and renewable energy development.

Several of us were also working with Maurice Strong out of our MIT offices as Maurice pulled together the first UN environmental conference in Stockholm and reported his lessons learned in a 1973 Foreign Affairs article entitled *One Year After Stockholm*.[4] One can track the analytical and substantive views on energy policy in other significant articles in Foreign Affairs, among them articles by Daniel Yergin and Edward Morse. Most Foreign Affairs articles not only looked at energy methodologies and projections but also put them in a global geo-political context. This was a very key theme in a Trilateral Commission study we conducted in 1997 entitled*: Maintaining Energy Security in a Global Context*.[5] It was also the central theme in the Department of Energy's major study on energy security in 1987 entitled: *Energy Security: A Report to the President*[6] and is a key element of the ongoing work of the Department of Energy, the Energy Information Administration and the International Energy Agency. The studies are noted here are to call attention to the substantial intellectual investment made by the analytical and policy community of the United States over the last forty years. This is in addition to the US

[1] Khodadad Farmanfarmaian, Armin Gutowski, Saburo Okita, Robert V. Roosa and Carroll L. Wilson, "How Can the World Afford OPEC Oil?" July 1975, http://www.foreignaffairs.com/articles/24538/khodadad-farmanfarmaian-armin-gutowski-saburo-okita-robert-v-roo/how-can-the-world-afford-opec-oil.
[2] Carroll L. Wilson, "A Plan for Energy Independence." *Foreign Affairs*, July 1973, http://www.foreignaffairs.com/articles/24435/carroll-l-wilson/a-plan-for-energy-independence.
[3] Amory B. Lovins, "Energy Strategy: The Road Not Taken?" *Foreign Affairs*, October 1976, http://www.foreignaffairs.com/articles/26604/amory-b-lovins/energy-strategy-the-road-not-taken.
[4] Maurice F. Strong, "One Year after Stockholm." *Foreign Affairs*, July 1973, http://www.foreignaffairs.com/articles/24438/maurice-f-strong/one-year-after-stockholm.
[5] http://www.wpainc.com/PDF/Maintaining_Energy_Security.pdf
[6] Energy Security, A Report to the President, Department of Energy Report, 1987, http://www.wpainc.com/PDF/Energy_Security.pdf.

experts, such as my colleagues on this panel, and government agencies that have a good grasp on the fundamentals of energy; including its opportunities and challenges. Unfortunately these are subjects too long for the Nightly News as it focuses exclusively on the gasoline price.

History

As part of the 90th anniversary of the Council, this session is looking at the role of energy and the environment. My friend and DOE colleague David Sandalow is better qualified to discuss the environment, so I will defer to his thoughts. This piece will look more at the geo-politics of global energy and, within that framework, examine options for the United States. After all, it was probably the oil embargo of 1973 that brought energy to the forefront of modern policy debates. The world had become hooked on oil, in part due to the development of the gas powered engine and rapid economic growth of the post World War II period.[7] Many countries before and after World War II began to use coal and indeed, as Professor Wilson predicted, coal use would expand rapidly as a key element of industrialization. As the first general manager of the Atomic Energy Commission, he was less optimistic about nuclear power, but foresaw it contributing as much as 20% of electricity by the year 2000. This was a major conclusion of the Workshop on Alternative Energy Strategies, our energy project that he headed which involved several Council on Foreign Relations members, including Carroll Wilson, John Conner, Dick Gurstenberg, Thornton Bradshaw and Guy Stever.

During the 70s, we also saw the beginning of the International Energy Agency, the organization of consuming countries established by Henry Kissinger. It was unique in that it had super-national powers. If one member was short on oil by as much as 7%, then other members were obliged to share oil. In essence, we all shared the burden. But as the Iranian Revolution and second oil shock demonstrated, IEA countries could face dramatic price increases even from a modest shortfall. Although the market only lost 2% of its oil, prices went up by a factor of four in 1979 to $45 per barrel. The cause: overbuilding of stocks by nations. Like consumers who top off their gas tanks in a shortage, countries did the same thing and put added pressure on the market, inducing large price increases. At the onset of the Iran-Iraq war, IEA countries followed a different strategy: the coordination of stocks at levels of disruption below the 7% trigger, and it worked.

Stock-build, coupled with stockpile coordination in times of an emergency remains the key international element for emergency preparedness whether it be from natural forces, as was the case for Katrina, or oil supply disruptions brought about by geo-political events. This remains a very important, and little known, factor of US energy policy. Although we have built sizeable stocks in the Strategic Petroleum Reserve, their use is largely dependent on coordination with other oil consumer nations. Our protection is based not just on the oil in the SPR, but rather the collective total reserves of all energy consuming nations. In the event of an oil market crisis, the best economic and political strategy for the US is to coordinate our stock draw so as not to aggravate further the price of oil. The oil price gradually declined during the 80s to a point that it reached $10 per barrel in 1987, a price that, among other things, is credited with collapsing the

[7] James E. Akins, "The Oil Crisis: This Time the Wolf Is Here," *Foreign Affairs*, April 1973, http://www.foreignaffairs.com/articles/24416/james-e-akins/the-oil-crisis-this-time-the-wolf-is-here.

Soviet economy, which was dependent on oil earnings for two-thirds of its hard currency on energy sales.[8]

Energy policies of free markets and deregulation brought about relief from the government controlled policy of the 1970s and unleashed the power of market forces. Indeed, the slow economy of the early 1980s was replaced by rapid economic and energy growth for almost twenty years as market forces and free trade expanded around the world. As predicted by our MIT models,[9] energy intensive industries were exported to developing nations with cheap labor and a hunger for economic development. As these countries industrialized, they purchased more goods and appliances.[10]

There were two dynamics at play that resulted in a doubling of world energy demand in the last forty years. First, the growth of manufacturing in less developed nations (particularly East Asia) and second, the increase in energy use by industrializing countries as their appetite for a higher standard of living increased. For example, at $1000 per capita income, a family may purchase a cooker; at $2000 per capita a heating system; and at $5,000 per capita a first car. We are seeing these dynamics in newly industrializing nations today. Free trade and investment policies have resulted in manufacturing transfer from the US to abroad and this has raised the standard of living of the world, increased the world's energy appetite and provided US consumers with less expensive goods, many of which are energy intensive. In a CFR meeting five years ago, I presided over a session with Senator Joseph Lieberman. We came to the counter-intuitive conclusion that the energy demand growth in China was induced largely by consumer needs in the US. If one considers the energy content of imports into the US, our energy use was much higher and, in fact, China's was lower in terms of manufacturing used for purely domestic use. This reminds us of the field of "energy accounting" that gained popularity in the late 70s; essentially calculating the content of energy in individual products.

Current Situation

Markets are fundamentally different today than they were in 1972. At the same time the percentage of energy sources contributing to overall demand has remained relatively stable. The issue is: who is producing the energy and who is consuming it? In the 1970s, 70% of Middle Eastern oil went to Europe and the US; in sharp contrast today 70% goes to Asia. Also in the 1970s, 70% of the world's oil was controlled by the major western oil companies (the so-called seven sisters); today almost 90% is controlled by state oil companies.

In the last thirty years we have seen natural gas and LNG emerge as important sources of energy and nuclear power now meets about 15% of the world's electrical needs. New technology for exploration and drilling has dramatically increased the recoverable reserves of oil and gas. OPEC produced 25 mbd in 1975 and today it produces about 29 mbd, therefore, most of the world's incremental oil supply increase has been achieved by greater production outside OPEC through enhanced recovery in places such as the North Sea and the United States.

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[8] Peter Schweizer, *Victory*, Page 75.
[9] WAES Report of 1997: Energy Supply to the Year 2000, http://www.wpainc.com/PDF/Energy_Supply_to_the_Year_2000.pdf.
[10] See work of Allen Strout of the World Bank http://dspace.mit.edu/bitstream/handle/1721.1/27275/MIT-EL-86-020WP-19615368.pdf?sequence=1

Coal has also seen a significant increase as the "electricity workhorse" of India, China and the United States. Ulf Lantzke, the former Executive Director of the International Energy Agency, said in Foreign Affairs that coal use could increase threefold between 1970 and 2000.[11] Finally, shale gas has emerged as a tremendous source of energy for the United States. Rather than import LNG in the future, the US is in the position to be completely self sufficient and export gas. LNG terminals built to receive gas can now send it abroad, helping the US trade balance in the long-term.

Nuclear power has grown steadily throughout this period, but concerns raised by the Fukushima accident will slow development. Fukushima was not a nuclear accident (compared to TMI and Chernobyl); it arose out of a natural disaster. Fortunately, the situation has thus far been contained. We applaud our Japanese friends, both in government and in industry, for their tremendous bravery and skill in managing this dangerous situation. The IAEA team's recent evaluation was critical of the lack of sufficient seawall protection against the tsunami but also noted: "The response on the site by dedicated, determined and expert staff, under extremely arduous conditions has been exemplary and resulted in the best approach to securing safety given the exceptional circumstances."[12]

There will be lessons to be learned from Fukushima. But first we need the facts, then the assessments, followed by the application of the lessons in the US and worldwide. Next week, the DOE Nuclear Energy Advisory Committee will receive our first briefing on the situation and we hope to analyze the impact of Fukushima on not only the Japanese situation, but importantly the US.[13] We also hope that the President's Blue Ribbon Commission on America's Nuclear Future will make recommendations about the future of high-level waste storage in the US.

Clearly, nuclear power must continue to play an important role in the US, Japan, Europe and elsewhere. As newcomers to nuclear seek the benefits of this non-emitting source, an effort must be put forth to ensure they are abiding by strict safety, as well as non-proliferation guidelines. It is essential that the IAEA be strengthened. This was a major recommendation of the Nuclear Security Summit convened by President Obama during the spring of 2010 attended by fifty heads of state. The resulting communiqué calls for action in fifty areas of concern.[14] In addition to this effort, a good set of recommendations for strengthening the IAEA can be found in the 2008 IAEA 20/20 project report. As the report states, "The IAEA will have the responsibility to help newcomer states put in place the necessary infrastructure needed to develop nuclear energy safely, securely and peacefully."[15]

Energy efficiency has also played an important role, perhaps the most important role, in the last forty years. Early US standards for autos mandated better performance (CAFÉ Standards), but the major contributor to better efficiency was the price itself, essentially reliance on market forces. The one to one relationship between energy and economic growth has been cut in half and even more so in the OECD countries where the service economy has largely taken the place

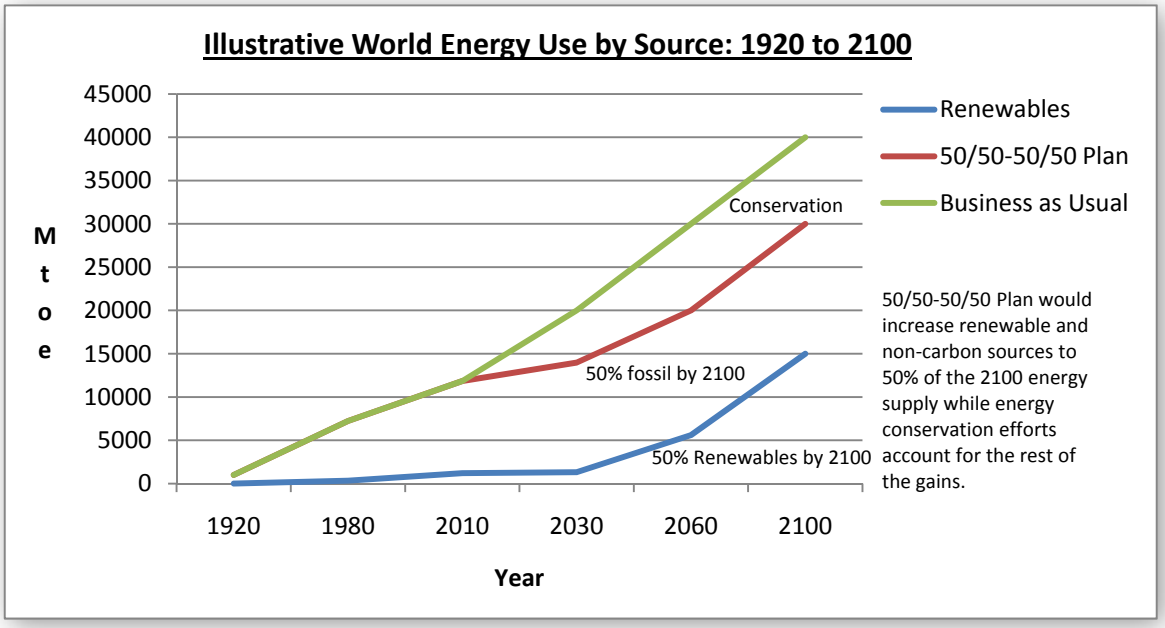
[11] Ulf Lantzke, Expanding World Use of Coal." *Foreign Affairs*, Winter 1979/1980, http://www.foreignaffairs.com/articles/33332/ulf-lantzke/expanding-world-use-of-coal.
[12] http://www.world-nuclear-news.org/RS_First_IAEA_report_on_Fukushima_0106111.html
[13] http://www.ne.doe.gov/neNeacOverview.html
[14] http://www.whitehouse.gov/the-press-office/communiqu-washington-nuclear-security-summit
[15] The IAEA 2020 Report, 2008, Page VI: http://www.iaea.org/newscenter/news/pdf/2020report0508.pdf.

of the manufacturing sector. With political stability and freedom in Eastern Europe, we see energy growth rising. And, as the Middle East Spring continues to progress into fall and winter and beyond, there are hopes that economic prosperity will follow and, with that, energy demand in the Middle East will increase.

The Future

For the foreseeable future, there will be great need to rely on fossil fuels: oil, gas and coal. Energy systems change slowly. It takes 12 years to replace the auto stock; 50 years to replace housing and as much as 100 years to turnover industry. The good news is that major growth of energy development will be in industrializing countries and nations such as China, India and Brazil will be able to leap frog to better, newer and more efficient technologies than those which supported OECD industrialization.

The following illustrative energy chart spans almost two centuries of energy supply and demand, going back to 1920 and going forward to 2100. Projections are hazardous but for simplification's sake, we've used the same economic growth rate (1.4%) of the last ninety years carried forward over the next ninety years. We've then utilized a 50/50 and 50/50 plan. Energy growth is assumed to be 0.7% per year (roughly 50 % of economic growth) and half of all supply is assumed in the year 2100 to be non-carbon sources (wind, hydro, tidal and nuclear) and half carbon sources (oil, gas and coal). If one looks at what it would take to achieve these levels (more than a doubling of energy by the year 2100), it is clear that the ramp for renewables will have to be swift and steep. Fortunately, the world has abundant fossil fuels to begin making the transition to more sustainable energy sources by the end of the century. Again, this chart is only illustrative and one can make several alternative assumptions; this is only one case. The projections to 2030 are in fact the current official EIA and International Energy Agency projections but may be optimistic given the Fukushima accident and continued global economic lag.



It is appropriate for the world leaders to endorse renewable energy sources, especially as they seek climate friendly energy policies. As the chart suggests, however, the world will be dependent for several more decades on fossil fuels and a key issue is burning these fuels more cleanly. A high priority is the clean burning of coal. Second is greater efficiency in thermal electricity generation. We point, for example, to the already high standards of the thermal plant in Sendai Japan, which recently received the prestigious Edison Award for outstanding energy project of the year. This plant reaches 58% efficiency, compared with thermal plants elsewhere as low as 33%. Third, nuclear power must play a role if we are to achieve the 50/50 balance between fossil and non-carbon energy sources. Today the world has approximately 450 nuclear reactors globally. Over a ninety-year period, existing plants will need to be decommissioned and new plants built. We will need hundreds of additional reactors if nuclear is to maintain its share of the global electrical market. This will be a very hard task in light of Fukushima but one expects the lessons of Fukushima will make nuclear power safer and more secure.

We expect that oil may level off at about 120 million barrels per day. This rate of production can continue well into the next century, assuming that advances in recovery continue. We would expect that oil producing states, especially Saudi Arabia and the Gulf states, will want to use the valuable molecules of oil and gas for 'higher added value,' thereby maximizing their economic potential in the century ahead. It is also noteworthy that Saudi Arabia maintains some 3 million barrels per day spare capacity that can be brought on stream in the event of an emergency in oil markets. Elsewhere, we are seeing that natural gas and shale gas are abundant globally. Given the positive attributes of these sources (in terms of carbon production), we expect that many nations will opt for gas to produce their electricity especially in the 'short-term' of the next 30 years as nuclear slows and nations continue to generate more energy with less carbon release.

Today's session comes in a series on Renewing America. What can be said of the US energy situation in light of the geopolitical setting described earlier? The focus of this paper has been largely international, in essence because it is difficult to separate US policy from world energy development, emergency preparedness and geo-political developments. But from a domestic perspective, the US is blessed with perhaps the best energy situation of any nation, although wary consumers worry and complain about $4.00 per gallon gasoline. Abundant supplies of fossil fuels, coupled with nuclear power and the potential for technological advances guarantees energy sufficiency for the US, especially compared to our friends in Asia and Europe.

Imports from the Western hemisphere will remain important, especially from our Canadian and Latin American neighbors. Today, major investment is taking place in oil sands to import to the United States and higher global prices have stimulated the rig count and oil production is not in decline. The large opportunity for shale gas is being tapped. It is significant, widespread and will allow the US to export LNG in the future. Nuclear power safety is being evaluated in light of Fukushima but the more than 100 US nuclear plants provide 20% of US electricity. As a framework for considering US energy futures, please see the charts at the end of this paper which are matrices for the evaluation of the world's current and future energy profile.

The STEP chart shows major uses on the left hand side and major supplies on the top. This is a standard form of reporting energy statistics popularized by WAES (MIT) and the IEA in the 1970s. It is an accounting approach to energy statistics and projections. What makes it valuable is that the sums, in term of energy and carbon released, are shown on one page and practice with the matrix shows that there are no easy solutions. This matrix was the basis of the

recommendation provided to the DOE in evaluating alternative climate strategies. If, for example, one wants to reduce carbon by 82% by 2050, as the President has suggested, then this framework can evaluate different technological pathways. Rather than talk of overall energy limits, this disaggregated approach allows for better analysis and policy contemplation, step by step.

European countries approach energy in a somewhat different way. We would expect France to maintain a strong nuclear program. Germany may opt for more gas from Russia and even imports of electricity from nuclear powered France. Italy has the benefit of close sources in North Africa and the Middle East. Collectively, we would expect the EU to move toward greater reliance on renewables and conservation, recognizing that politicians' hopes for quick renewable development may not succeed given the lead times for making a difference and generally higher costs per Btu produced. Russia will benefit from markets in Western Europe and Asia but growing demand domestically may mean that Russia will support more nuclear power, freeing up valuable natural gas for export.

Further, it is expected that Japan will seek greater renewables and maintain its existing nuclear power program after safety evaluations are completed in the post-Fukushima environment. Japanese talent for innovation will also present itself in greater reliance on renewables and advanced designs for automobiles that rely on less fossil fuel use. China is already greatly expanding all possible avenues of energy development and imports with an attitude of 'clean energy' but with the most probable path is of greater coal use. China is likely to pursue an ambitious nuclear power program. We expect India to also rely on coal and greater nuclear power use, and it is well positioned to benefit from greater gas imports, especially from the Middle East.

Over the next 90 years, we would hope that there would be some resolution of political difficulties in Iran which will open up its tremendous export potential for natural gas, which Europe and South Asia could benefit from. Complex transit and gas development in Central Asia could also provide gas to both Europe and Asia, benefiting the economic development of former states of the Soviet Union. In Latin America, we could also expect continued indigenous development of energy, namely oil and gas, and the expansion of alternative fuels for transportation as is the case today of Brazil. African nations could benefit from indigenous energy resources, namely plentiful oil and gas, and turn to state of the art renewable energies. A key issue in Africa, parts of Asia and Latin American is electrification, an essential element of raising the quality of life in the next fifty years. Efforts should be made by OECD nations to transfer clean low carbon emitting energy technology to industrializing nations.

In summary:

1. The world has the need for energy for economic development, energy security and environmental quality both individually for nations and collectively as members of the global community. World population is estimated to increase from 7 billion to over 10 billion by 2100. Maintaining economic progress and an increase in quality of life will require a three-fold increase in energy supply by 2100.

2. Oil will remain a very key source of energy as nations industrialize. There may not be peak oil, but rather a plateau of oil as producer states seek to maintain production and

fuel their economies over the longer term and to seek value added in oil and gas production by expansion of petrochemicals.

3. Natural gas and shale gas use are likely to increase significantly in all regions. Gas is competitively priced, available and a less carbon intensive fuel compared to coal and oil.

4. Nuclear energy will remain important, but the renaissance of nuclear that was hoped for is clearly set back. The challenge will be enhancing the safety of old reactors, continuing research into new reactors (especially small modular reactors) and finding solutions to long-term storage, all balanced against the need for a strengthening of non-proliferation and greater responsibility of the IAEA. (By 2100, we should begin to see the fruits of fusion energy as hoped for from the global energy project ITER.)

5. Renewable energy resources are on the rise, but remain less concentrated and therefore less economical than conventional sources for the moment. But political commitments from Washington to Bonn to Tokyo raise the opportunity for research that can lead to more rapid deployment. By 2100 renewables (solar, wind, hydro and tidal) and nuclear energy, the non-carbon sources of energy, could be half of all energy supplies: a challenging but achievable goal.

6. The clean use of coal is perhaps the number one challenge of the energy community. Coal will be used; in fact, the use of coal will be accelerated. Coal production could at least double by the year 2100. Coal is the easy economic choice as it is widely available but for reasons of local, regional and global environmental concerns it must be used more cleanly. This can be accomplished in three ways: first, greater efficiency of thermal conversion for electricity; second, cleaner ways of burning coal; and finally, developing capacity for carbon capture and sequestration.

7. Concentration on how energy is used is also important. Energy efficiency is a number one priority in meeting future needs. It is interesting to note the evolving energy policy in Japan which challenges consumers to not only seek energy efficiency for the short-term, but to make a long-term commitment to Mottainai (conservation).

8. Energy emergencies will need to be met by strengthened international efforts. This will require the expansion of the existing IEA to include China, India, Brazil, Russia and oil producing states. If the IEA does not expand to include non-members, then a new mechanism will be necessary so that a truly global energy agency is created.

9. By the year 2l00, ninety years from now, we will see fundamental shifts in the world's economy toward Asia and hope for economic expansion in the Middle East, Africa and Latin America. OECD countries will comprise a smaller percentage of the world economy and world energy use but it will take the technological leadership capabilities of the OECD nations, especially the US, Japan and Europe, to bridge to the new century.

10. The United States is as well positioned as any country in the world to succeed and to make the transition to affordable, energy-secure and environmentally responsible energy sources over the next 90 years. We have abundant natural resources and rich human intellect and innovation capital in our universities and national laboratories. Continued reliance on market forces will induce success in achieving greater efficiency and new supplies. And we have friendly neighbors with accessible rich exports and continued geo-political presence that can maintain the global environment necessary for a flourishing energy trade, thereby benefiting all nations.

As we face a planet of 10 billion people in 2100, compared to less than 2 billion in 1920, the challenge grows for clean and affordable energy to fuel future world needs. A child born today will likely be alive in 2100. Interestingly, as we increase the longevity of human life we also create greater energy needs per person. Looking back from 2100, one wonders about the many interesting articles that will be written on energy, the environment and geo-political concerns as the Council on Foreign Relations celebrates its 180th anniversary.

William F. Martin has served as Special Assistant to President Reagan, Executive Secretary of the National Security Council and Deputy Secretary of the US Department of Energy. He has also served as President of the Council of the United Nations University for Peace in Costa Rica. He has held positions in the MIT Energy Laboratory, Department of State, Department of Defense and the National Security Council. During the second oil crisis he served as the special assistant to the Executive Director of the International Energy Agency. He currently serves as Chairman of the Department of Energy's Nuclear Energy Advisory Committee and for eight years served as Chairman of the Council on Foreign Relations Energy Security Group. This paper represents his personal views and not those of the Department of Energy.

Illustrative World Energy Use by Source: 1920 to 2100[16]

Mtoe	**1920**[17]	**1980**	**2010**	**2030**[18]	**2060**	**2100**[19]
Oil	96	3107	4360 (37%)	4925 (35%)	5000 (25%)	3750 (12.5%)
Gas	-	1235	2958 (25%)	3304 (24%)	4600 (23%)	7500 (25%)
Coal	910	1788	3285 (28%)	4423 (32%)	4800 (24%)	3750 (12.5%)
Hydro and Tidal	-	148	378 (3%)	321 (2.2%)	600 (3%)	2250 (7.5%)
Nuclear	-	186	697 (6%)	750 (5%)	1000 (5%)	2250 (7.5%)
Renewables (Solar/Wind)	-	12	126 (1%)	250 (1.8%)	4000 (20%)	10500 (35%)
Total World Energy Demand	**1006**	**7223**	**11854**	**13973**	**20000**	**30000**
Total World Population in Billions[20]	1.86	4.45	7	8	9.5	10

World Energy Demand by Region

Mtoe	**1920**	**1980**	**2010**	**2030**	**2060**	**2100**
OECD	-	4072	4742	5542	8000	12000
Non-OECD	-	3043	7112	8431	12000	18000
World	1006	7223	11854	13973	20000	30000

The 50-50-50-50 Plan

These charts demonstrate the historical trends of energy and make some illustrative projections. For the period 1920 to 2010, the world grew at approximately 1.4% on average GNP.[21] In this same period the average energy growth rate was about 1.5% percent per year. For the 50/50-50/50 plan, there would be a 50% decrease in energy intensity, so the rate of energy growth would be 0.75%. Thus by 2100, the world can meet its increased energy needs while incorporating environmental and carbon concerns by cutting down the share of fossil fuels to 50% of the total supply.

[16] This is assuming the success of the '50/50' plan where there is 50% added conservation and 50% added supply.
[17] In 1920, the world was primarily reliant on coal and oil to meet its energy needs as other forms (nuclear, hydro etc) had not been developed yet.
[18] Forecasts for the years 2010 and 2030 are supplied by a combination of information from the IEA and EIA, though these were forecasted before the events of Fukushima and are in some cases optimistic in regards to nuclear and renewable development, so they have been slightly modified.
[19] Projections for 2060 and 2100 are rough approximations and rely on the world embracing the 50-50-50 plan to achieve these goals.
[20] Population projections taken from the US Census Bureau and the UN Dept. of Economic and Social Affairs.
[21] University of California Berkeley Dept. of Economics
http://econ161.berkeley.edu/TCEH/1998_Draft/World_GDP/Estimating_World_GDP.html

STEP Supply-Demand Integration Model and Methodology

STEP Assumptions and Scenario Cases

1. Energy Prices (EIA base case; higher prices to induce conservation, fuel switch)
2. Government Policies (business as usual; carbon reduction policies; R and D budgets)
3. Technology Assumptions (historical, current best, future best)
4. Pace of Capital Stock Turn-Over (autos - l0 years; homes -50 years; industry 75-100 years)
5. Energy Security/Carbon Reduction Cases (historical, current best technology, projected "best" technology)

STEP Methodology

For different scenario cases, determine energy demand by category, energy supply, and energy supply-demand integration

1. Determine energy consumption and carbon emissions for each category (ie. economic activity x energy efficiency).
   A. Economic activity derived from macro-economic model (tons of steel) to ensure consistency of categories (ie. tons of steel consistent with autos produced) based on GNP
   B. Each demand sector has energy efficiency or carbon intensity based on technology choice (historical, current, best) determined by price and technology availability
2. Determine fuel mix for each demand category (historical and based on price of fuels and government policy)
3. Add up final demand for key demand sectors
4. Determine energy transformation sector
   A. Fuel mix for electrical generation (depends on price, government policy)
   B. Efficiency of electricity generation process (historically 33%; current 37%; best future?)
5. Add up columns (across and down) and determine "primary energy demand"
6. Determine energy supply parameters (domestic, imports or exports)
   A. Impact of price and policy on fuel choices in demand sectors
   B. Impact of price and policy on electricity
7. Determine most effective government R&D
8. Feasibility of scenarios in real-world business applications

STEP Results

1. Each demand line item would afford opportunity to showcase key technologies (transport, commercial, residential, industrial)
2. Integration would occur as fuel choices for each sector are made (oil, coal, renewables, electricity)
3. Renewables can be both direct (remote power) or part of electrical transformation (large-scale)
4. Total energy (energy efficiency) and total carbon output is thus determined by demand sectors, supply options and energy transformation
5. Alternative Scenarios chosen would bracket
   A. Base EIA case—no change in policy
   B. 450 ppm reduction case—what set of assumptions would be required to achieve this case (economic growth, energy prices, technology success).
6. Leads to the conclusion that 450 ppm case can be achieved if . . .
7. What are the costs and benefits of this? Key issue is to quantify the externalities of not achieving this 450 ppm case (and lower oil imports)
8. A key factor is the discount rate used for the future. A high interest rate devalues the future and makes adjustments very expensive.
9. Translate model results into practice in the presentation

STEP Goals

1. STEP endeavors to seek efficiency in energy and carbon in every cell of this matrix
2. STEP seeks to ensure consistency of forecast (economic, policy)
3. STEP seeks to showcase key technologies in each cell
4. STEP seeks to determine what sets of assumptions achieve 450 ppm and the costs/benefits
5. STEP approach allows for framework to discuss government-business partnership
6. STEP methodology enables comparison of US with other nations, a framework for bilateral/IPCC/IEA discussions

Major Sectors	Petroleum	Natural Gas	Electricity	Coal	Renewable Sources*	Nuclear	TOTAL
Transportation							
Light-duty vehicles							
Commercial light trucks							
Bus Transportation							
Freight Trucks							
Passenger Rail							
Freight Rail							
Domestic Shipping							
International Shipping							
Recreational Boats							
Air							
Military Use							
Lubricants							
Pipeline Fuel							
Other							
Industrial							
Manufacturing							
Aluminum							
Cement							
Chemicals							
Computers, Electronics, Appliances, Electrical Equipment							
Fabricated Metals							
Food and Beverage							
Forest Products							
Foundries							
Glass and Fiber Glass							
Heavy Machinery							
Mining							
Petroleum Refining							
Plastics and Rubber Products							
Steel							
Textiles							
Transportation Equipment							
Other							
Commercial							
Space Heating							
Space Cooling							
Water Heating							
Ventilation							
Cooking							
Lighting							
Refrigeration							
Office Equipment (PC)							
Office Equipment (non-PC)							
Other							
Residential							
Space Heating							
Space Cooling							
Water Heating							
Refrigeration							
Cooking							
Clothes Dryers							
Freezers							
Lighting							
Clothes Washers							
Dishwashers							
Color Televisions and Set-Top Boxes							
Personal Computers and Related Equipment							
Furnace Fans and Boiler Circulation Pumps							
Other							
Primary Energy Demand							
Energy Transformation							
Electricity							
Synthetic Gas							
Synthetic Liquids							
Heat							
Energy Sector							
Total Energy Demand							
Domestic Supply							
Imports							
Exports							

*Renewable Sources currently include hydropower, solar, wind, geothermal, biomass, and ethanol.

Achieving Japanese Energy Security in a post-Fukushima World[1]

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August 31, 2011

Summary: In its post-Fukushima energy policy, Japan should continue to diversify its fuels and sources, as well as develop nuclear power, including nuclear reprocessing. A balanced energy portfolio should be pursued which reduces primary energy demand, yet provides economic progress for a maturing Japanese population. Energy technologies for mottainai and renewables can help Japan deliver "green exports" to an energy hungry world. Significant opportunities exist for the US and Japan to work together to achieve economic prosperity, environmental quality and energy security based on a new era of conservation, expansion of LNG imports, renewables and nuclear power.

In the wake of the Fukushima accident, there is a new reality for Japanese energy policy. Legitimate questions about the future role of nuclear power in Japan have arisen, and options must be weighed but it is important to balance this with the need to sustain the Japanese economy and provide quality of life to its citizens. Some key questions:

- What are the energy options for Japan that meet its economic, environmental and energy security objectives in the post-Fukushima period?

- What are the alternative futures for nuclear power? Official government projections had called for Japan to meet 50% of its electrical needs through nuclear power. Can Japan meet its overall energy security and environmental objectives with less than expected nuclear power growth? What would a slowdown in construction of nuclear power imply for reprocessing of nuclear fuel and the future of Rokkasho?

- How can the US and Japan remain competitive in forging the common objective of commercial deployment of nuclear power plants throughout the world, especially in newcomer states? What is the role within this future of small modular nuclear reactors?

- What are the options for meeting electrical demand with nuclear power in the short, medium and long-term? In the short-term, what is the capacity to meet demand through increased LNG and the reintroduction of some thermal plants? What is the cost of these measures? How will the electric utilities be able to meet the needs of higher short-term energy costs and the need to contribute to compensation of victims?

[1] This draft is revised from the August 3 version due to the contributions made by the article of Ryoichi Komiyama of the Institute of Energy Economics (http://www.worldenergy.org/documents/congresspapers/188.pdf)

- What can be done on the demand side to increase energy efficiency and implement mottainai? Are there specific technologies, such as heat pumps, that can be promoted more aggressively to Japanese consumers to achieve this?

- What are the likely patterns of Japanese economic growth in the future recognizing that the population of Japan is likely to decline from 120 million to less than 100 million within the next fifty years? What type of economy does this suggest as Japan seeks a higher quality more service oriented GNP?

- Can Japan achieve this by adopting more energy efficient appliances and autos? In the transportation sector, one possible strategy is to increase the penetration of electric vehicles, thereby reducing oil use and improving energy security. And in this scenario of greater usage of electric vehicles, what fuel share of electricity would ensure energy security and environmental benefits?

- How can Japan build a new energy economy based on optimism, economic opportunity and sustainable development? How can this energy economy not only provide energy to Japan but export potential for green technologies, including advanced energy efficiency appliances and autos?

- What does the current energy policy debate imply for US-Japan relations, especially common concerns over energy security, environmental quality and non-proliferation? What initiatives should be considered to strengthen US-Japan ties, recognizing that the two countries remain leaders in the global economy, technological advancements and shared democratic values?

I. The Four Phases of Japanese Energy Policy

As one who has been involved with Japanese energy policy since an initial visit to Japan in 1975, I've watched Japan's energy situation evolve over the last forty years. From an outside perspective, it appears that there have been three distinct phases of energy policy and now a new policy which will emerge in the post-Fukushima situation.

- Phase I – (1945 - 1972) Provide adequate supplies of energy to enable dramatic economic growth (doubling in a decade) by consolidating the nation's utility companies. During this twenty year period, Japan achieved unprecedented economic expansion. My first experience in Japan was to remember the six day work week and the admired policy of lifetime employment. This burst of economic activity that rose out of the devastation of WW II showed the perseverance of the Japan people and also their commitment to setting a target and achieving that target.

- Phase II – (1972 - 1980) The oil shock of 1972 brought a new era of energy security awareness to Japan. Oil prices had been below $3 per barrel and Japan's economic expansion was based on access to cheap oil from the Middle East, as well as inexpensive gas from Indonesia. Prices tripled during this period bringing about economic downturn globally. Japan responded with a strategy to diversify its energy economy (that was

highly dependent on oil) by diversification of fuels and diversity of source plus development of an aggressive nuclear power program and planning for recycling of nuclear fuel. Japan also committed itself to cutting emissions in half within a decade, thereby building a record of environmental quality. In 1984, Japan also began an aggressive build up of oil stocks following the beginning of the Iran-Iraq war and coordination through the International Energy Agency.[2]

- Phase III – (1990-2011) During this period, Japan refined its energy policy by adopting the three e's: energy security, environmental quality and economic competitiveness. Nuclear power expanded to 45 nuclear plants and a reprocessing center in Rokkasho was built. The US-Japan nuclear cooperation accord was signed in 1987 and a close US-Japan partnership to achieve the three s's was begun: nuclear security, safeguards and safety. The Kyoto Accord was signed in 1997 and the world's leading nations agreed to an historic agreement to reduce carbon and protect the earth's climate. Japan became a leader in this effort, especially through energy efficiency, nuclear power and achievement of high thermal efficiencies in power plants.[3]

- Phase IV – (Post-Fukushima) The Fukushima event has cast doubts on the safety of Japan's nuclear power plants. Although the responses to the crisis by Japanese industry and government has been remarkable, questions linger over the regulatory system and also the safety of nuclear power plants in quake prone zones. A major debate has begun in Japan regarding the pros and cons of nuclear power and to what extend Japan should rely on nuclear power in the future. The official forecast by the government of 50% nuclear share has been questioned and a key issue is the extent to which conservation and renewables can meet a growing share of Japan's future needs.

These four phases demonstrate how Japan's energy policy has been not one specific plan but an evolving process that incorporates the challenges (and opportunities) of the time in order to best prepare for the future.

II. Japan's Short, Medium and Long-Term Energy Policy

In thinking about Japan's energy future, it is useful to consider different strategies for the short, medium and long-term.

- Short-Term - In the short-term as nuclear energy is reviewed, emphasis will be placed on mottainai and fuel switching with reliance on LNG and older thermal plants. The goal is to sustain the Japanese economy and meeting consumer needs while ensuring public confidence in the renewal of nuclear power. A key issue in Japan, and within the US-Japan dialogue, is the issue of regulatory reform. It is hoped that as many nuclear plants

[2] I was honored during this period to be program officer of an international energy workshop headed by MIT's Carroll L Wilson, the Workshop on Alternative Energy Strategies. Japanese participants included Dr. Saburo Okita, Dr. Masao Sakisaki and Mr. Toshio Doko, head of the Keidanren. Our Japanese workshop was in Shimoda in 1975.

[3] During this period I was honored to be the US Chairman of the US-Japan energy working group that resulted in the Reagan-Nakasone agreement of l983 and a member of the senior US team that agreed to the US-Japan Nuclear Cooperation agreement of 1987. Since that time we have sponsored eight Santa Fe Seminars on US-Japan nuclear cooperation to deepen the relationship and chart innovative and cooperative means for cooperation)

as possible, from a safety and public confidence point of view, can be restarted within the next three years. During this period, evaluations should be forthcoming about the world energy situation and the likely global increase of use of fossil fuels that will subsequently increase prices and pollution.

Japanese Energy Use (2007 in TWh)

Coal	310
Crude	46
Products	109
Gas	289
Nuclear	283
Hydro	74
Geo	5.5
Other	23
Total	**1139.5**

- Medium-Term - In the medium to longer-term, Japan can find innovative ways to produce energy (nuclear, renewables etc.), conserve energy by improving appliance efficiency (mottainai) and build a new generation of efficient, electric vehicles. The electric sector will be very key in this transition to a new energy economy. High efficiencies in electrical generation should be sought (60%) as well as a balance of electrical generation sources (LNG/nuclear, energy/thermal/renewables etc.).

- Long-Term - Four important goals for long-term (20 years plus) energy policy would be: (1) zero primary energy growth while increasing economic growth by 1% per year (not life style changes but technology fixes by improving the efficiency of electrical devices); (2) greatly expand electric vehicles to as much as 50% of the market in twenty-five years; (3) adopt a 33/33/33) policy with approximately equal parts of : nuclear energy; LNG; and renewables (including hydro) in electricity production, recognizing that renewables will be making another significant contribution to the maintenance of zero energy growth by reducing demand for households, industry, business; (4) produce no more emissions than the 2000 level; and (5) generate economic growth via energy efficiency exports, namely efficient appliances and electric vehicles.

III. Energy Projections 2008 to 2050

Japanese imports of oil, gas, coal remain quite high, despite the efforts of last fifty years to diversity sources and supplies. It appears from the statistics that Japan also exports quite a significant quantity of refined oil products, importing crude and exporting it as products. Nuclear energy is the only significant domestic resource and renewables are currently only a small fraction.

- On the demand side, we see that industrial energy needs are met through coal, oil production and electricity. It appears there is some opportunity for expanding electrical use in industry and reducing oil products. We expect that coal is very attractive economically for industry and there may not be much enthusiasm for decreasing its use at this point. Residential and commercial are very electricity intensive and these sectors will likely grow in line with the aging of the Japanese population. There is also significant use of oil products in the transportation sector (i.e. gasoline for autos). Over time, a big opportunity exists for substituting electric vehicles for gas powered autos and

subsequently, for the Japanese export of electric vehicles for a "transportation hungry world."

- In the electrical sector, we see that in the short-term, LNG must substitute for nuclear power. Coal will also remain very important, almost as much as nuclear. Also, there is a significant amount of oil/products, hydro is reasonably small and other renewables are less than 5%. Over the longer-term, we would expect electricity demand to grow for the following reasons: (1) residential and commercial electricity will rise due to the aging of Japanese society and the attractive option of electrification; (2) Japanese industry will continue to move toward service oriented products that require higher electricity (i.e. more financial managers to manage Japan's oversees business/manufacturing; more service oriented jobs); and (3) a large opportunity exists for the automobile sector with electrification of autos.

- This raises the issue of how future electrical needs of Japan will be met. In my recent Council on Foreign Relations speech, we outlined the following adjustments to 2035 and here I've added to numbers to 2060 (% shares).[4] Please note that de-centralized renewables (i.e. solar panels) will be "counted" on the demand side by reducing consumption.

- The population of Japan is expected to decline from 130 million to 90 million by 2100. Over the last decade, the "real purchase" power per capita of Japan has increased from $22,000 to $34,000. Considering that the population is declining in Japan, per capita GNP can increase significantly per person without a significant increase in the overall GNP of Japan. The following chart, which was prepared before Fukushima by IEEE researcher Ryoichi Komiyama, demonstrates that final energy demand can decline even at a rate of economic growth of l% per year on average over the next forth years.

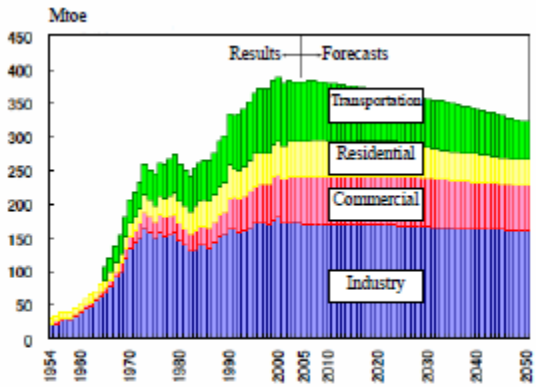


Figure 4-4 Final Energy Demand by Sector (Reference Scenario)

- For example, GNP per capita (purchasing power) could increase to $50,000 per capita by mid century with an average GNP growth at l% or below/year. This would suggest that energy growth need not increase that much and yet we will see a need for greater

[4]For full speech go to: http://www.wpainc.com/PDF/WFM_CFR_4-4-11_Speech.pdf

electrification. Electricity be at least a one third increase by 2050 assuming: (1) aging population; (2) the economy is based increasingly on services and finances (as production is transferred to developing countries), but "profits" remain in Japan; and (3) a great effort is made to electrify autos and to increase the efficiency of appliances and these products can be exported to premium markets (think of Japan as Lexus of manufactured products). All of this will require a TWh increasing from 1119.5 TWh to as much as 1300 TWh in 2060 (at a minimum).

- Thus the increase in electricity can be met with the following fuel mix contributions:

(TWh)	Coal	Crude	Products	Gas	Nuclear	Hydro	Geo/Renewables	Total
2007	310	46	109	289	283	74	28.5	1139.5
2035	195	26	54	445	290	75	115	1200
2050	100	0	0	450	400	75	275	1300

- In this case, nuclear energy must increase by at least 50%. Centralized (electric) renewables increase tenfold remembering that there will be still more renewables in homes, etc. which will reduce overall energy demand. LNG is kept at "comfortable" level in term of energy security. Overall, carbon in the electricity level is reduced from 2007 because of phasing out of coal and oil and increase in non-carbon sources (e.g. nuclear/renewables). In this case, overall primary energy may not increase.

- Overall import dependence does not increase (because the increase of the use of LNG is offset by electrification of vehicles). Economic growth per capita increases significantly (by a least a third) and Japan as a whole remains competitive internationally through the export of high end appliances and cars. Eventually, these technologies will be built "offshore," adding more value to the Japanese economy at less expenditure of energy. But to achieve these results, nuclear energy must at least double from today's level during the next 50 years.

What are the implications of less nuclear energy? This issue will be debated and it is important to reflect on the following chart which shows fuel share among major sources for overall primary energy in Japan:

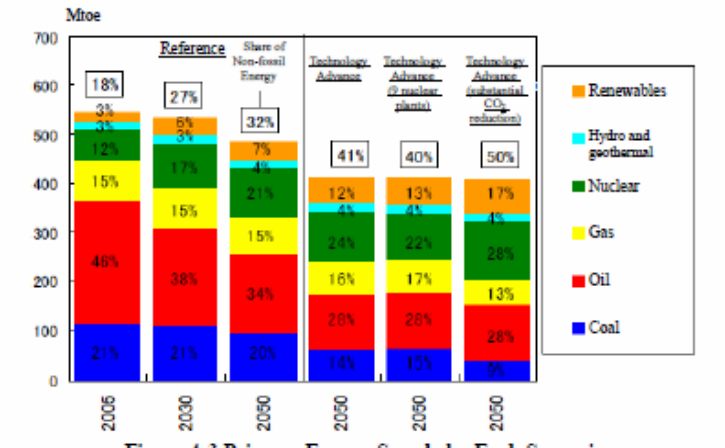


Figure 4-3 Primary Energy Supply by Each Scenario

- Overall electricity growth will need to grow to achieve greater savings in other sectors, especially transportation. Aggressive savings can occur with added conservation and technology advancements in renewable energy as seen in the "Technology advance case." But in this case nuclear power must also increase (not decrease).

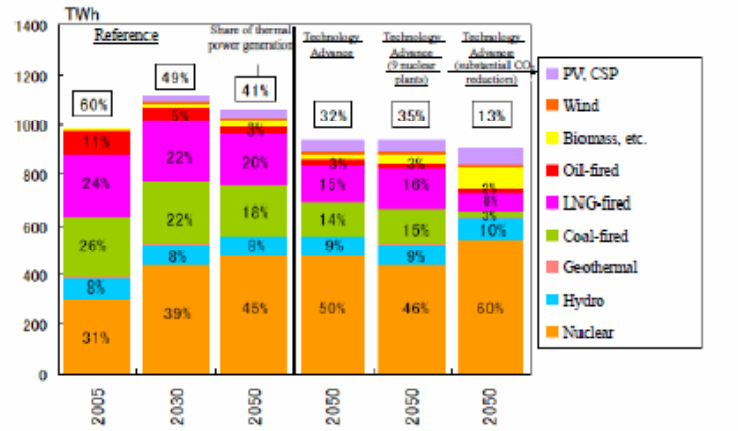


Figure 4-7 Power Generation Mix by Each Scenario

- In this forecast (prepared pre-Fukushima), nuclear power was required to increase to as much as 60% of electricity in order for Japan to meet aggressive carbon reduction plans. Consider if nuclear power were greatly reduced in these scenarios, what fuel source would make up the difference? It is clear that LNG can play a more important role, but this will require further reliance on uncertain international markets, requiring continued "diversification" of sources. Over the longer term, Alaskan North Slope might provide another key part of diversification.

- Renewables are foreseen to play an important role, but as seen from the chart they begin with a very low base. Aggressive policies to deploy renewables will be necessary to make a significant contribution. A recent Department of Energy study concluded that it is cheaper to have centralized electricity sources, rather than decentralized sources for the production of nuclear power. While renewables and other distributive electricity systems can make a contribution large base load demand is required and that will be primarily met by LNG, coal and nuclear power.

- Middle Eastern and Russian LNG pose potential energy security risks and are very inefficient from the standpoint of the conversion losses. Furthermore, natural gas producers must increasingly use their own gas for domestic purposes.

- Nuclear is the key to successful electricity growth in terms of energy security and environmental quality, with a 50% increase of nuclear energy needed at a minimum. Japan's future strategy will actually result in an increase of foreign sources of LNG, as well as some oil for transport as nuclear energy, coupled with reprocessing of the nuclear

fuel, remains a key element of energy security/diversification, as well as contributing to environmental quality.

- Bottom line: Japan can build aggressive renewables future but a mix of fuel is required and a balance between LNG, renewables, nuclear and mottainai.

IV. Program for US-Japan Cooperation

Over the past forty years, the United States and Japan have experienced significant cooperation, including the Reagan-Nakasone Energy Accord, the US-Japan Nuclear Cooperation Agreement as well as many generations of Santa Fe Seminars.

During each of these milestones, our two nations have had the opportunity to share expertise, expenses in R&D and to formulate a coordinated energy policy with each country's policies supportive of energy security and environmental concerns. Together, the US and Japan provide strong support for international energy security considering the fact that they represent forty percent of the world's economy.

In the future, we need to consider the global energy dynamic and the expansion of Asian demand while at the same time, looking at appropriate policies that keep the United States and Japan competitive in the global environment.

- Some areas that should be explored include expanding cooperation in the scientific understanding of radiation, especially as it applies to the return of productive life near the Fukushima site. At the moment there are over 800 square miles impacted by the radiation of the accident. Department of Energy officials and its globally respected network of national laboratories should be assisting Japanese officials in determining parameters of clean up – including the important issues of "how clean is clean" and " how safe is safe." Understandably, the Japanese public wants a 100% assurance—at the same time, life must go on, people want to return to their homes, industry wants to restart and schools want to reopen. US Government experience, especially DOE, can assist in this task with scientific evidence and experience.

- The Japanese should consider now the possibility of making the Fukushima nuclear power station an international site for understanding the complexities of the decommissioning of nuclear power plants. The dawn of nuclear power for electricity was in the 1960s and many nuclear power plants are reaching maturity. In some cases, the plants will be extended to as much as a 60 year life or even more, but in a practical sense, some nuclear plants will be decommissioned as will be the case of the Fukushima Daiichi plants. Coupled with the work on decommissioning can be an international program of safety, especially in the training of operators associated with newly developed nuclear programs in Asia and elsewhere.

- A third priority might be the establishment in Japan of a "PKO" – a peacekeeping-type operation to be activated in times of nuclear emergency. For decades the United States has had a program to assist nuclear emergency situations, including security threats to US

nuclear facilities and American cities. This program – run by the National Nuclear Security Administration (NNSA) also has an emergency international component that was evident during the Fukushima crisis. Associated with this is the coordination between nuclear power plants and nearby military installations. Valuable lessons from this working relationship begun after 9/11 were applied to the crisis of 3/11. Japan, for example, might take responsibility for a Pacific/East Asian response team, while the US could cover much of Latin America, Independent States of the former Soviet Union, Middle East and South Asia.

- A fourth priority is the use the experience of Fukushima in the establishment of a "safety first" culture in new nuclear energy programs internationally. The experience of Fukushima stimulates interest in reviewing post-Chernobyl protocols agreed by the IAEA – these protocols (including: Post-Accident Analysis and Review; Plant Safety Reviews and Technical Exchanges; Event Analysis and Safety Assessment; Emergency Notification and Assistance; Supporting Health and Environmental Networks; Liability for Nuclear Damage; Event Reporting; and Safety Codes and Principles.) should be reevaluated and strengthened in light of Fukushima. We need a more pronounced safety and security program in the IAEA and protocols that give the Agency some teeth in implementing and reviewing safety programs of member states. It is widely viewed that the IAEA is the nuclear watchdog – but this is primarily focused on safeguards; the issue of safety and security has been primarily a responsibility of member states – this should change after TMI, Chernobyl and Fukushima. A nuclear accident anywhere in the world is a nuclear accident for every nation.

- A fifth area of opportunity lies in collaborative nuclear energy research and development. Budgets in both the US and Japan are constrained, but we are interdependent on each other for research reactors – for example, the Idaho National Laboratory and Hanford National Laboratory can provide insight to future reactor design and fuel cycle technology. The Japanese nuclear research program can provide facilities and insight to US scientists in the areas of fast reactors and Monju facility. Also, the recent construction of the Rokkasho reprocessing plant can give American scientists insight to the issues of reprocessing, MOX fuel utilization and vitrified waste disposal. The US does not currently endorse reprocessing but as controversy over spent fuel disposal increases, it is clear that minimization of waste via reprocessing is one option the US should seriously consider and learn from the Japanese example.

- Finally, we should recommit each nation to energy security, reasonable energy prices and environmental quality, so necessary for each nation's economic, energy and environment future. Emphasis on the 3 s' – security, safety and safeguards should also be reinforced. Opportunities abound for technology development outside of nuclear energy: renewable energy resources, solar, geothermal and alternative fuel for vehicles (hybrid and electric). Development of clean coal technology remains a priority for each country. Lastly, we need to look at export possibilities of the US fossil fuels to Japan, including in the short-term LNG from the Gulf of Mexico and in the long-term from Alaskan North Slope.

International Issues Related to Nuclear Energy

Hoover Institution, October 3/4

William F. Martin and Burton Richter[1]

Introduction

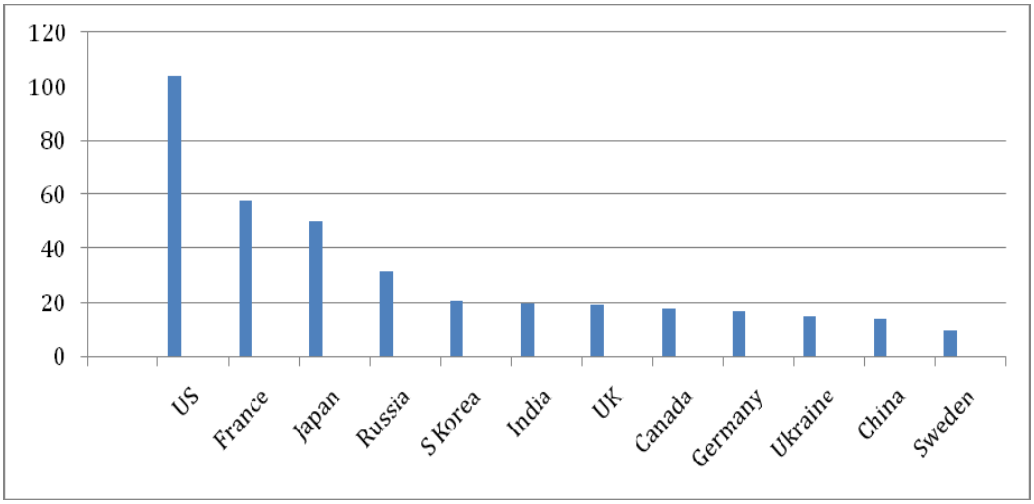
We are entering a new era of increasing demand for electricity, essential for economic growth in the developing world. Nuclear power is on the agenda of many of these nations, but there is a concern that they do not have the necessary legal and regulatory infrastructure to ensure safety and security, and in some cases, also do not have the will to dedicate enough financial and manpower resources to the endeavor. As we have learned once again from Fukushima, a nuclear accident anywhere is an accident that will have implications globally.

In the wake of the Fukushima accident in Japan, serious questions have arisen about the safety of reactor designs, emergency back-up systems, on-site spent fuel storage and the regulatory systems governing nuclear power. These debates are occurring actively across the world, but ironically the greatest impact is likely to be in OECD nations as their publics raise legitimate concerns about nuclear safety and security, while the greatest danger is likely to be in countries that lack a tradition of open discussion.

Worldwide Growth of Energy Demand

Today there are over four hundred and forty nuclear reactors operating in thirty nations.[2] As noted in the chart below, most reactors operating are in technologically advanced and nuclear experienced nations.[3]

Figure 1- *Existing Reactors Worldwide*[4]



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[2] World Association of Nuclear Operators: http://www.wano.info/

[3] Though it is interesting to note the three major nuclear accidents (TMI, Chernobyl and Fukushima) were all in 'technologically advanced' nations.

[4] Source: IAEA http://www.iaea.org/cgi-bin/db.page.pl/pris.oprconst.htm

But experience does not necessarily assure safety as we have witnessed the most severe nuclear accidents in the US, Ukraine and Japan. These experiences underscore the importance of developing nuclear energy with a "safety first" attitude, especially in nations that are new to nuclear power. If one compares Figures l and 2, it is clear that the growth of nuclear power is likely to be in nations experiencing rapid growth and need for electricity, many of which are not yet as advanced in terms of their governmental institutions.

Nations in Europe with a large and politically strong green agenda have been the ones most affected by the accident at Fukushima. The close proximity of nations that have turned against nuclear power (e.g. Germany) [5] and those that continue to support it (e.g. France) necessitates continued involvement of all European nations, regardless of their stance on nuclear. In the US, nuclear construction will slow due to lower electricity demand and gas prices. The US electricity sector is likely to remain primarily fueled by coal, natural gas and shale gas for some time.

While many industrialized countries pause for reflection, nuclear energy growth in industrializing nations will be rapid. The motivation for nuclear power in these countries arises from economic and political factors, as well as the prestige to have nuclear technology. A major reason for the growth of energy demand in developing countries has been the inspiration of world leaders in the early 1980s to commit to a regime of enhanced international free trade, allowing manufacturing to move to the most efficient and cost effective regions and countries. Thus, the steel industry moved from the US to Japan to South Korea to China and so forth.

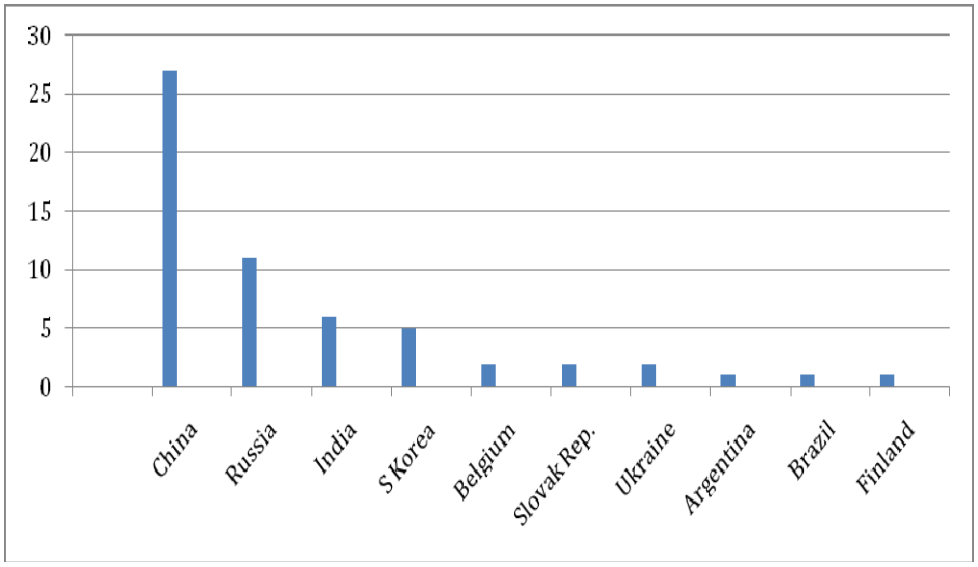
This shift in manufacturing resulted in higher energy/GNP ratios in industrializing countries, while OECD countries moved toward less energy intensive service industries. Thus, it is no surprise that the area of major energy growth of the last twenty years have been in China, India, Southeast Asia and Latin America. Likewise, the world's growth of energy will be in population intensive, low cost manufacturing nations.

Both the end of the Cold War and this economic expansion has lifted much of the world out of poverty and totalitarianism. It has also opened up the wish of economically developing nations to secure the nuclear energy option. Nuclear energy is viewed as advanced technology and as such, carries a certain prestige as well as economic benefit in a world of fluctuating oil and gas prices. And undeniably, it is a cleaner fuel than coal. The projections of the International Energy Agency, however, do show considerable coal growth.[6] In fact, coal may grow twice as fast as nuclear. Nevertheless, the reality is that we are likely to have at least 150 new nuclear plants in developing countries within the next 25 years and even at that pace the share of nuclear power is going to fall as a percentage of total electricity.

The issue is not the overall number of reactors globally, but the location of "new builds" of reactors. The 150 new reactors expected by 2035 will primarily be in nations beginning their nuclear energy programs, many of which are under construction now.

[5] Judy Dempsey and Jack Ewing, "Germany, in Reversal, Will Close Nuclear Plants by 2022." New York Times, May 30, 2011.
[6] International Energy Agency 2010 World Energy Outlook: http://www.iea.org/weo/

Figure 2 - *Nuclear Reactors Under Construction*[7]



Much of the already existing growth (reactors either planned or currently being built) is in China, Russia and India, which have huge projected future domestic power demand increases.[8] There are other nations that are also planning to expand their limited existing programs such as Poland, Lithuania, Argentina, Brazil, the Czech Republic, and South Africa. There are also nations with no nuclear energy programs today that have indicated they wish to enter the field such as Egypt, Ghana, Jordan, Indonesia, Malaysia, Nigeria, Saudi Arabia, the UAE, Vietnam, and possibly others.

The projections we show, therefore, are not wildly optimistic; they are, in fact, likely levels of growth of nuclear power even in the post-Fukushima world. It is true that public reaction in OECD countries has dampened the enthusiasm for nuclear energy expansion, but this is not the case in developing nations, especially those nations in the Middle East and Asia that are autocratically and/or centrally ruled. In these nations, it is the will of the government, not necessarily the will of the people, which will determine nuclear energy deployment.

During the 1970s, an energy economist from MIT's Energy Laboratory, Professor Alan Strout, did some innovative work on consumer purchasing patterns at different levels of per capita income. For example (in 1970 dollars), a consumer would be motivated to buy a small cooker at \$l00 per capita, a heater at \$250 per capita, a refrigerator at \$500 per capita, a car at \$1000/per capita, etc.[9] Imagine the purchasing power of a relatively youthful global population as it enters the workforce and begins families. Of course, the key to this is the jobless rate in developing countries and jobs are dependent on economic growth, which is dependent on consumer purchases. At the moment, the system is "stalled" somewhat but once the cycle of economic recovery begins, it is expected that energy growth will expand rapidly. Again, this will not be in the "mature" economies of the OECD countries, but rather the "energy hungry" world of developing nations as the world grows from 7 billion people to over 10 billion by 2100.

[7] Source: IAEA http://www.iaea.org/cgi-bin/db.page.pl/pris.opercap.htm
[8] Jeremy Carl, Fukushima and the Future of Nuclear Power in China and India, Hoover Institution, Stanford University, 2011.
[9] Alan M. Strout, *The Future of Nuclear Power in the Developing Countries*. (MIT Energy Laboratory: 1977). http://dspace.mit.edu/bitstream/handle/1721.1/31246/MIT-EL-77-006WP-04128995.pdf?sequence=1

The reason this fundamental economic analysis is necessary is to deflate the opinion that industrializing countries are purchasing nuclear power plants solely to gain "nuclear technology." Certainly this is one aspect of the wish to have nuclear reactors, but it is also in many cases wise economics as fossil resources might rise in price.[10] In any event, it is clear that nuclear power will grow, perhaps rapidly, due to energy security and economic reasons and less so because of the concern over climate change.

Let's take China as an example. From a relatively small base, China planned to build up to a capacity of 80 GWe on nuclear electricity in the next 20 years. Even so, nuclear power will meet only 5% of Chinese electricity by 2030.[11] So it is not an issue of "if" nuclear reactors will be built in industrializing countries, it is a matter of how many. And as Figure 2 demonstrates, the building is already underway and the race is on by commercial vendors to supply the nuclear energy option in the Middle East, Southeast Asia, Latin America, and in Eastern Europe. While the current global downtrend will slow this development somewhat, the growth potential is evident.

Criteria for Safe Nuclear Development

Measures to ensure safety, security and non-proliferation are weak, in part due to the fractured nature of the nuclear industry and the patchwork of national and international standards to ensure safe deployment and adequate regulatory oversight. Figure 3 demonstrates the adequacy of the "nuclear infrastructure" in selected regions of the world. This is simplistic, but it shows that there is little consistency in approaches to safety and security. It was surprising that an accident the size of Fukushima could happen in Japan, a nation widely regarded as one of the most technically competent in the nuclear world. While the analysis of Fukushima is not yet complete, it is already clear that a contributing factor was the weakness and lack of independence of the regulators, just as that was a major contributing factor to the Gulf oil blowout in the US. One can only imagine what would have happened in such a situation in a less technically competent country.

Learning the lessons of Fukushima will be important but applying them to existing nuclear energy nations as well as those that are seeking to develop nuclear programs will not be simple. The reality is that the growth of nuclear power will have to be accompanied by an unprecedented effort to ensure high safety standards and adequate independent regulatory authorities. There will also need to be a talent pool to operate nuclear power safely. Some nations, such as those in Eastern Europe, have the operating talent but may lack regulatory talent. Russia, Japan and France may have the needed talent pool, but their regulators are not totally independent. We are fortunate in the United States that we have a rigorous NRC; but that only came after learning the lessons of TMI, lessons that took decades to learn and apply in a modern society with a huge talent pool to draw upon from leading universities and national laboratories.

Another challenge of the nuclear world is the ferocious competition among vendors to sell nuclear reactors and services, often led by governments that are seeking international markets to deploy their nuclear energy reactors and systems. As was the case with the recent reactor sale to the UAE, the most economically competitive price is going to be the strongest inducement to

[10] The economic feasibility of nuclear power is a disputed topic as cost calculations can vary widely depending on externalities (e.g. waste disposal) incorporated into analysis.
[11] Jeremy Carl, Fukushima and the Future of Nuclear Power in China and India, Hoover Institution, Stanford University, 2011.

make the purchase.[12] Burdening competitive bids with safety options that add to cost is not likely to be successful. The world is seeking the VW of reactors, not the Mercedes or Lexus. One possible route for worldwide nuclear power growth is to encourage the vendor to put together an entire package of measures to build, implement, train and operate nuclear plants, including take-back of fuel -- basically a turnkey operation. This if coupled with international standards published by the IAEA, and adopted universally by nations new to nuclear as well as those that already have reactors, as well as an independent regulatory agency, would ensure "safety first."

Another issue is that the nations that have the highest safety and security standards (France, Japan and the United States) also have complicated export control regimes. The purpose, of course, is to ensure adequate safeguards but the result is that potential buyers may seek the less costly reactors that are built to lower standards. From the point of view of the United States, this has the practical implication of driving business to competitors who have less rigorous standards. A key element of international cooperation will be the need to improve the regime of technology transfer to a level comparable to the "COCOM" regime during the Cold War.[13] The US valuably insists bilaterally that a nation commit itself to higher standards; but as the US loses the commercial edge in international deals its political power will be reduced.

An interesting recent debate in the Nuclear Suppliers Group's resulted in a decision to refuse to ship sensitive technology to India despite assurances in the US-India nuclear deal. New NSG guidelines would make transferring such technologies more difficult, but it is interesting to note that France is aggressively pushing ahead regardless, as it sees the Indian commercial nuclear market as a huge opportunity.[14]

Complicating the situation is the debate that is emerging in forums like the IAEA. There is a well known balance that IAEA needs to achieve given its diverse membership. In essence, the grand bargain is that the Group of 77 seeks nuclear technology (not only in reactors/fuel cycle technology, but nuclear medicine and other non-electricity nuclear technologies) as a payout for support for non-proliferation, safety and security policies sought by the United States and other OECD/NEA nations. A recent review of the IAEA (20/20 Report[15]) revealed that this grand bargain is necessary to achieve a safe and secure nuclear future.

The legal reach of the IAEA, however, only extends to safeguards; it does not include safety and security. The IAEA can only advise on these functions. During the recent Fukushima accident, the IAEA had to have its Fukushima reporting approved by the Japanese Government prior to release, which led some to criticize the IAEA for its slow response. Today, the IAEA is a watchdog for non-proliferation, but not for safety, but there is hope that new mechanisms will be forthcoming. In its July 2011 letter to IAEA Director General Amano, the International Nuclear Safety Group outlined some of the steps necessary to strengthen the IAEA in this regard, including: increasing world safety standards; expanding peer review services; updating current conventions; and expanding international emergency response and preparedness.[16]

Key Issues:

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[12] As noted by the World Nuclear Association, one of the primary reasons the South Korean company KEPCO won the UAE contract over Areva was cost as well as speed on construction. "The choice was on the basis of cost and reliability of building schedule. An application for US Design Certification is likely about 2012." http://world-nuclear.org/info/inf81.html

[13] COCOM stands for the Coordinating Committee for Multilateral Export Controls, which existed from after WWII to 1994.

[14] Timothy J . Roemer France assures NSG waiver for India not undermined. The Economic Times, July 1, 2011. http://articles.economictimes.indiatimes.com/2011-07-01/news/29726119_1_clean-waiver-nsg-waiver-nsg-decision

[15] International Atomic Energy Agency 2008 20/20 Report: http://www.iaea.org/newscenter/news/pdf/2020report0508.pdf

[16] http://www-ns.iaea.org/committees/files/insag/743/INSAGLetterReport20117-26-11.pdf

- Infrastructure and regulation are the keys to a successful and safe nuclear program[17]. Of special importance is the independence of the regulatory body.[18] The events at Fukushima demonstrated the need for a strong independent regulatory system, even in technologically advanced nations. It must be remembered that the US Nuclear Regulatory Commission (NRC), today considered the 'gold standard,' was strengthened because of the lessons learned TMI.

- A strong knowledge base and human capital infrastructure is also necessary for the long-term sustainability of a nuclear program. This includes university programs, research programs, and a large pool of workers.[19] In many developing and newcomer nations, these do not exist and in developed nuclear nations, years of neglect and underfunding, coupled with an upcoming wave of retirements across all nuclear fields, will exacerbate the situation.

- Safety and security are essential parts of any nuclear program, because as we have learned from Fukushima, an accident anywhere is an accident everywhere for nuclear. Without a strong commitment to safety among all nations, worldwide nuclear power growth will be in jeopardy. Without public faith and confidence, especially in developed nuclear nations, nuclear power cannot advance.

- Nonproliferation concerns must also be considered in future technology-sharing agreements and commercial cooperation efforts. This will factor heavily in any government-to-government deal; and already does, as exporting nations (primarily the United States) are very concerned about the nonproliferation risks in newcomer nations. There is also a danger of increased proliferation risk as commercial competition among vendors and concern for sales (many vendors are either state backed or owned) may trump nonproliferation concerns. The nuclear supply change is global and the United States is only one of many supplier nations.

There are many areas of concern when considering nuclear power, the chart below displays which nations/regions are best positioned on each issue.

Figure 3 – *Where Nations Stand*

	Infrastructure	Regulation	Knowledge Base	Safety/Security	Nonproliferation
OECD					
East Europe					
China					
Russia					
India					
SE Asia					
L. America					
Middle East					

The above table uses the color coding below, from best (blue) to lacking (red).

[17] A detailed analysis of the necessary infrastructure is given in an IAEA report "Milestones in the Development of a National Infrastructure for Nuclear Power, IAEA Nuclear energy Series NG-G-3.1, 2007. It is quite detailed and few of the nations new to nuclear power meet a fraction of it criteria.
[18] Nuclear Regulatory Commission's Japan Task Force Report http://pbadupws.nrc.gov/docs/ML1118/ML111861807.pdf
[19] Nuclear Energy Advisory Committee 2008 Report *Nuclear Energy Policies and Technology for the 21st Century* http://www.ne.doe.gov/neac/neacPDFs/NEAC_Final_Report_Web%20Version.pdf

Priorities for Safety

Safety is the most important aspect for nuclear power in all nations with nuclear reactors. All nations should be evaluating current practices in light of the events at Fukushima. Not only developing nations and newcomers should be increasing safety protocols, as the events of Fukushima have demonstrated. In order to ensure safety in global nuclear operations, certain priorities must be set, including the following.

- Energy Policy Planning and Nuclear Energy: In making future energy policy decisions, nations (especially newcomer nations) must factor in all costs associated with nuclear energy, not just the "cash price" for the actual reactor system from the foreign vendor.[20]

- Independent Regulatory Authority: As we have learned from Fukushima, an independent regulatory authority is a must, not only for newcomer or developing nations but all nations that utilize nuclear power.[21]

- Location, Construction and Grid Connection: When determining locations of new reactors, potential natural disasters (e.g. seismic fault lines), population centers and access to the grid should be incorporated into planning.
- Safe Operation: All nuclear nations, both developed and developing, must strictly adhere to the principles of WANO,[22] as this organization is ideally positioned to be at the forefront of the implementation of new safety measures. However, as of now, WANO has no enforcement mechanisms.

- Emergency Preparedness: As demonstrated by the events at Fukushima, when planning for nuclear emergencies, all contingencies must be accounted for including: backup systems; evacuations; command, control, communication; and the role of military/police/national guard etc.[23]

- Security Measures: Though recent events have shifted the focus of nuclear security to preparing for natural disasters, it cannot be forgotten that a great human threat exists as well. Nuclear facilities will always be a potential target for terrorism and must be prepared accordingly.

- Safe Transport of Nuclear Fuel: As more nations, especially developing ones, embrace nuclear energy, there will be a marked increase in the transport of nuclear fuels worldwide (fuel rods, MOX, spent waste fuel, vitrified waste, etc.). International standards have already been universally adopted here.

- On Site Storage: Spent fuel storage on site is an issue for all nuclear nations, including the United States, which currently does not have a permanent waste disposal center. Standards for dry cask and fuel pool storage must be reviewed to reflect the "lessons learned" from Fukushima.[24]

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[20] IAEA 2007 Report, Considerations to Launch a Nuclear Power Programme: Page 9. http://www.iaea.org/NuclearPower/Downloads/Launch_NPP/07-11471_Launch_NPP.pdf
[21] Nuclear Regulatory Commission's Japan Task Force Report http://pbadupws.nrc.gov/docs/ML1118/ML111861807.pdf
[22] WANO 'Principles' http://www.wano.info/about-us/our-mission/
[23] Nuclear Regulatory Commission's Japan Task Force Report http://pbadupws.nrc.gov/docs/ML1118/ML111861807.pdf
[24] The Blue Ribbon Commission on America's Nuclear Future Draft Report http://brc.gov/sites/default/files/documents/brc_draft_report_29jul2011_0.pdf

- Talent Pool: Building an adequate talent pool (education needed for all aspects of the safe application of nuclear technology) is an essential step in establishing a successful nuclear program. This need also extends to developed nuclear nations, where much of the talent pool is close to retirement age.[25]

- Local Community Consensus: Building local consensus (cooperative agreements with local communities) when locating new reactors and nuclear facilities is important in order to facilitate public trust as well as engender an atmosphere of transparency. This also extends to public education on such issues as radiation standards.

- Liability: An adequate liability and compensation system (who pays in event of nuclear disaster) needs to be firmly established before nuclear operations commence in any nation, whether developed or developing. Essentially, the government must step in as the "payer of last resort" due to the scale of potential liability and compensation in the wake of a nuclear accident. The Convention on Supplementary Compensation for Nuclear Damage was put forth to remedy this situation, though not all nuclear nations (including Japan) have signed it.[26]

- Decommissioning: As reactors mature increased awareness of potential decommissioning problems is required. In this regard, the Japanese may consider making the Fukushima Daiichi plant an international center for studying decommissioning strategy. The experience of the Department of Energy and its national laboratories can make an important contribution in this regard.

- Nonproliferation Safeguards: These must be strengthened including onsite monitoring (primarily by the IAEA), especially as nations in proliferation risk regions employ nuclear power on an ever larger scale.

Key Players and Responsibilities

Now that areas of concerns in regards to safety have been documented in the previous section, it becomes necessary to determine where responsibility for fulfilling these obligations lies. The global nuclear energy game indeed has many players spread out between governments, companies and international organizations but what are their individual responsibilities and concerns?

Figure 4 – *Who is Responsible?*

	Commercial	Research	Nonproliferation	Safety/Security
Governments				
Int Orgs (IAEA, NEA)				
NGOs (Wano, INPO)				
Vendors (Areva, Toshiba)				
Operators				
Quasi Official (NSG)				
US Bilateral				
Educational Establishments				

The above table uses the color coding below, from most responsibility (blue) to least (red).

[25] Nuclear Energy Advisory Committee 2008 Report *Nuclear Energy Policies and Technology for the 21st Century* http://www.ne.doe.gov/neac/neacPDFs/NEAC_Final_Report_Web%20Version.pdf

[26] http://www.iaea.org/Publications/Documents/Infcircs/1998/infcirc567.shtml

- Governments: The most important entity, but as noted, there are variations of regulatory independence, talent pool and legal issues (including liability). There are also concerns about conflicts of interest, as governments are responsible for regulation but also for aiding in the commercial advancement of their respective nuclear industries.

- International Organizations (e.g. IAEA and NEA): International organizations, especially the IAEA, could potentially be the most crucial in enhancing worldwide nuclear safety and security. The IAEA has legitimacy among all parties (developed nuclear nations, developing and newcomers etc.) as an independent body.

- Quasi-official Organizations and NGOs: These include such multilateral groups as the Nuclear Suppliers Group, which is a coalition of national governments with the aim of preventing proliferation. There are also organizations to ensure worldwide commercial and operational nuclear safety, such as the World Association of Nuclear Operators (WANO) and the Institute of Nuclear Power Operators (INPO).[27]

- State Backed Vendors: Nations such as France, Russia and South Korea have large state backed or owned companies that are aggressively competing for a share of the world commercial nuclear power market. This has large safety, security and nonproliferation implications as conflicts of interest can arise. Also, as their influence in commercial nuclear increases, U.S. influence may wane on safety, security and non-proliferation. This is a strategic issue and requires a change in thinking about how U.S. industry and government interact to advance mutual interests.

- Electric Utilities and Plant Operators: The actual electric utilities are large players in whether or not nuclear power expands. The actual nuclear operators are also pivotal in the implementation and execution of new safety and security initiatives and must be included in any planning; in essence, they are the 'front line.'

- Inter-Governmental Agreements: Long established agreements between advanced nuclear powers (such as the US-Japan Nuclear Accord[28] and the US-Euratom Nuclear Accord[29]) have facilitated much scientific cooperation and expertise sharing over the past decades. As new nations push for nuclear power, there are also technology sharing agreements established or in the works between advanced nuclear nations and advancing newcomers (e.g. the US-India Nuclear Accord[30] and the US-UAE Nuclear Accord[31]).

- Educational Establishments: As nuclear power expands worldwide, educational establishments) will need to be enhanced and capabilities boosted, as not only does the talent pool originate from here but so does much of the groundbreaking research. At the university level, it will also be important to educate the future nuclear leaders of the world on the merits and necessity of safety, security and nonproliferation norms. In the United States, operators have benefited from the expanded program of community

[27] http://www.inpo.info/
[28] Text of US-Japan Nuclear Accord available at: http://nnsa.energy.gov/sites/default/files/nnsa/inlinefiles/Japan_123.pdf
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[31] Text of US-UAE Nuclear Accord available at: http://www.fas.org/man/eprint/uae-nuclear.pdf

colleges for a technical nuclear degree and one can envision a growing market for education and certification online, perhaps coordinated through the IAEA.

Case Examples: Where Nations Stand

Each nation involved with nuclear power has its own regulatory system, responsibilities and priorities for the future, which can make coming up with a 'global standard' difficult. The wide range of national situations is described below.

- United States: The US has a strong and independent regulator (NRC) derived from the 'lessons learned' from TMI (unique role of INPO). It also has a strong talent pool with a high technical ability. It does not engage in reprocessing and has problems with the implementation of permanent waste disposal (e.g. Yucca Mountain).

- France: It has a successful program based on standardization and a partially closed fuel cycle (reprocessing). Its government exercises control over its main operators, AREVA and EDF domestically, and is aggressive in pursuing international sales.

- UK: It has a successful program and has plans to expand with a decently sized pool of talent. It engages in reprocessing (for other nations) as well as limited international commercial endeavors.

- Russia: It has a large and scientifically diverse talent pool, a legacy of the Soviet Union, but serious safety, regulatory and nonproliferation concerns exist as it pushes aggressively into international commercial markets in its current incarnation of the ROSATOM State Nuclear Energy Corporation.[32]

- South Korea: This is a fast growing program (both in size and level of expertise) with a good safety, security and nonproliferation record (though there are some concerns about material diversion) but it wants to engage in domestic reprocessing. It is also a new but powerful player in international commercial deals (e.g. with the UAE). Korea Hydro and Nuclear Power Co. recently announced its intent to develop a reactor with enhanced safety features.[33]

- Japan: A previously strong proponent of nuclear power, Japan has a diverse and large program with the obvious complications arising out of the Fukushima accident. It will need nuclear in the long-run to meet its energy demand but the implications of Fukushima and lessons learned are far from settled.

- China: Asia's largest economy has a program that is fast expanding (both in size and level of technology) as it races to meet electricity demand. Though it is not a large player in international commercial markets yet, there is potential.[34] China is working on indigenous designs and intends to be a global supplier.

[32] http://www.rosatom.ru/en/
[33] http://english.cri.cn/6966/2011/08/31/2743s656094.htm
[34] Jeremy Carl, Fukushima and the Future of Nuclear Power in China and India, Hoover Institution, Stanford University, 2011.

- India: This is a huge potential market but currently the program is quite minimal. There are large nonproliferation concerns on the political side and liability/compensation issues in regards to international vendors successfully beginning projects.[35]

- South Africa: This is a small program but the government is very keen on expanding via international vendors. Also, it is currently in talks with other governments about inter-governmental agreements, including the United States.

Integrated Approaches to Global Safety and Security

With this expansion, especially in 'newcomer' nations, certain questions arise. Primarily, how can a nation without the necessary technological, regulatory and infrastructure development successfully create a safe and secure nuclear program? Nuclear nations would be well advised to follow the guidelines laid out in the 2007 IAEA report *Considerations to Launch a Nuclear Power Programme.*[36]

As demonstrated, many of the nations and regions where the primary growth in nuclear power is projected to occur have serious infrastructure, regulatory, knowledge and safety/security shortcomings. It will be essential to address these areas of concern if these programs are to be safe and secure. In these newcomer nations, will there be fuel-take-back arrangements? Will there be local storage and/or a geologic repository for used fuel? Should newcomer nations be allowed to enrich their own fuel? What are the nonproliferation implications? For this nuclear expansion to be successful, especially among newcomer nations, these issues must be resolved and the fuel cycle has to be closed in one-way or another (either through reprocessing of spent fuel or permanent disposal).

Safety and security, especially among newcomer nations, will be critical to the advancement of nuclear power globally. The natural place for the coordination of safety and security programs is the IAEA, which already has substantial infrastructure and experience in this regard but it must be recognized that though the IAEA has 'watch dog' status for safeguards, but the same is not true for safety in general, an important distinction.

It is one thing to identify the specific measures that need to be implemented. It is another to apply them systematically, fairly and globally. There are, of course, different degrees of balance between national self-interest and governance and international measures that benefit the "law of the commons." Anybody can come up with a checklist of what needs to be done, the key will be implementation and this could be quite complicated in terms of safe nuclear power operation globally.

Three Possible Scenarios

Business as Usual: First, one could consider the current situation as a "business as usual" case. Nuclear power is expanded primarily via commercial operations and priorities with a patchwork of national and international standards that are applied. Safety and security measures are not standardized and are a hit or miss proposition. This is an incremental approach where commercial interests and bidding set the standard in many countries. The advantage of this is

[35] Carl, Ibid.
[36] IAEA 2007 Report, Considerations to Launch a Nuclear Power Programme: http://www.iaea.org/NuclearPower/Downloads/Launch_NPP/07-11471_Launch_NPP.pdf

that nuclear power is primarily in the hands of the host nation. Respectable teams can be assembled internationally to assist in the development and training centers can be enhanced, even put "on-line". In this world we would expect that vendors would play an important role in furnishing turn-key operations. The main consideration of the buyer is likely to be price.

A key issue is maintenance, operation and safety reviews down the road as the task of running the reactor is left to the host nation. Regulatory systems will be established but their independence and effectiveness will vary. The opportunities for corrupt practices in "non transparent situations" may be prevalent, working against the interests of nations such as the US that have strong foreign anti-corruption legislation. The US can use its bilateral diplomatic powers in exchanges with new nuclear energy states to encourage safe nuclear development. A key issue will be the extent to which new nuclear states want to have domestic fuel cycle ability, something that the US has sought to minimize for over four decades.

Strengthened International Conventions: A second approach is to negotiate a stronger international safety and regulatory system with teeth. Clearly the international community is moving in the direction of standardizing safety, but we do not have the legal enforcement frameworks necessary to ensure compliance. International standards with strong legal enforcement by national authorities (the likely mode) or by international organizations (an unlikely mode) can help. Strong penalties may be necessary that can be applied to inadequate construction by vendors or irresponsible operation by operators. This approach would respect the intentions of nations but basically put international nuclear development under international legal guidelines.

We should review the Convention on Nuclear Safety[37] (1994), the Convention on Early Notification of a Nuclear Accident[38] (1986), and the Convention on Assistance in the Case of Nuclear Accident or Radiological Emergency[39] (1986) as they might be strengthened in light of Fukushima accident. The original conventions were established following the Chernobyl accident. Timely review and adjustment in light of Fukushima can strengthen these international standards.

We could also expect under this more aggressive approach that host nations would be encouraged to contract full nuclear services from their vendors. Agreement of vendors to "rules of the road" in the construction and operation of nuclear reactors might benefit the host nation -- and under these circumstances we would see an enhancement of WANO. Key to this system would be agreement among key nuclear suppliers to go beyond nuclear supplier group guidelines to a stronger, more comprehensive system that takes a systemic review of a country's nuclear development, including fuel cycle, reactor development, independent regulatory oversight, safe operation and back-end issues, including waste disposal. This approach is not without political problems. Weapons states have historically not wanted to open up their operations and stockpiles for inspection. Likewise, the US, France Russia, and Japan may not wish to abide by new international treaties.

This might become a serious international problem within the IAEA as the delicate balance between safeguards (wanted by OECD) and technology transfer (wanted by developing countries) is shaken, especially if the process is perceived as lecturing developing countries. It also goes back to the old argument similar to climate change and North-South debates: "You

[37] http://www-ns.iaea.org/conventions/nuclear-safety.asp
[38] http://www.iaea.org/Publications/Documents/Infcircs/Others/infcirc335.shtml
[39] http://www.iaea.org/Publications/Documents/Conventions/cacnare.html

industrialized countries had the opportunity to develop your programs as you wished; now you are telling us how to manage our programs." Indeed this would be the case and there could be issues of pride if outside contractors were given responsibility for "cradle to grave" services. Higher standards would necessarily result in an increase in reactor costs, perhaps adding 5% or more to the cost of a plant. The added cost could be split between the host country and the international community.

A Novel Approach: There might be another option - impractical perhaps but interesting if one continues the multinational approach to an extreme. One could imagine reactors being leased to the purchaser nation with the actual site of the reactor being international ground (like an Embassy). The international community would help subsidize the building of the reactor, buy the land, provide adequate safety features and produce electricity and take responsibility for the backup. The IAEA could have an independent regulatory body (built on United States NRC principles). The host country would be responsible for purchasing electricity with a long-term contract, enabling the international community to "bid out" the construction and operation to vendors. The expectation of this international approach would be that the host nation wants electricity and not necessarily the responsibility for running the plant. The international community is reassured that the "safety first" principle is applied and that the service would offer "cradle to grave" fuel services. The international body governing the construction and operation of the plants can thus begin to systematize and standardize key safety and regulatory concerns and raise the bar for safe operation. The host country would benefit via subsidization from a nuclear energy bank with oversight of the International Atomic Energy Agency.

The downside of this approach -- and it is a major downside -- is that it may reduce the impact of vendors from the United States with greater reliance on large, integrated state vendors - perhaps from Russia, South Korea, France and eventually China. One could argue that a multilateral approach may reduce safety to the least common denominator and work against the interests of the struggling US industry. Others can legitimately argue that the IAEA is not prepared to manage such an enterprise with burdensome governing procedures. Such a plan for international cooperation would need to be crafted with major input and leadership from the United States government and industry to ensure that safety, security and non-proliferation efforts are highly maintained.

These three approaches – and they are not mutually exclusive – illustrate the challenge of balancing national sovereignty and multilateral objectives; economy of electricity production versus the added costs implied by high security, safety and non-proliferation standards; and integrating the many private sector and government interests to provide for a safer global nuclear energy landscape.

The Role of the United States

The US was once the leader in the development of nuclear energy technology. However, in the last few decades we have started many things and finished nothing. Each new administration seems to bring in a change in direction. The United States, once the world leader in the development of nuclear energy, today is not even classified as among those leaders. Westinghouse, whose AP 1000 design is the first of the Generation III+ reactors to be licensed in the US, is a wholly owned subsidiary of Japan's Toshiba, and GE works in collaboration with Hitachi on nuclear reactors. We could have a major influence, but not until we get our own house in order and develop a coherent long range view. An example of a nuclear technology where the United States has 'started but not finished' is small module reactors or SMRs. This

highly promising tech (basically small, transportable, contained and fueled reactors) could become an area where the US can take the lead.

Where we are still the recognized leader is in the regulation and oversight of our fleet of reactors, including not only the government role, but the role of industry itself. The Three Mile Island accident led to a considerable strengthening of the powers of our NRC and to the creation by nuclear reactor operators of the Institute of Nuclear Power Operations (INPO) with a mission "to promote the highest levels of safety and reliability." This includes preparing a workforce for the future, and indeed INPO would be a model for capacity expansion in many countries.

INPO has led to a free exchange of operations information which in turn has enabled the industry to increase reactor "up-time" from about 60% before its creation to over 90% today. Generation of 50% more electricity from the same capital stock is a powerful incentive for cooperation. INPO's example has led to the creation of a similar World Association of Nuclear Operations (WANO), though WANO does not have the authority of INPO.

An encouraging sign of continued interest in some sort of US leadership, though mainly in regard to security and nonproliferation rather than energy, was the gathering of world leaders at the request of President Obama in April 20l0 to address the issue of accounting for and protecting nuclear materials. Not since the founding of the United Nations had so many leaders gathered on American soil. Fifty leaders pledged to a communiqué with 50 action items. This effort will be followed up with a second nuclear summit hosted by South Korea in April 20l2. Most of this summit will focus on securing nuclear materials and that is a wise approach since there are so many conferences on the "lessons of Fukushima" and safety.

At the same time it would be appropriate to introduce the importance of improving the international standards for safety, since all nations will be impacted in this increasingly small and interconnected world. For example, the US emergency response teams that can be deployed internationally as well as domestically could serve as model for a truly international response team, with French, Japanese and American personnel. Also, in regards to clean up efforts, the US DOE has much experience in this area (cleaning up former weapons sites in the US) and could aid in the current Japanese efforts (the 800 square mile zone in Fukushima) as well as teach its methods to an international response group.

Conclusions

In much the way that our energy system and financial systems are international, so is the nuclear world (energy, weapons, medicine and advanced technology). The difference between the financial and energy world is that massive physical damage can result from catastrophic nuclear events whether it be terrorism, lapses in safety or natural disaster. These can be intentional, due to human error or the product of natural events. One recalls the trigger situation of the Cold War where a small misunderstanding could have lead to catastrophic consequences. In a way, we were lucky with the Fukushima accident that it has been largely contained; a remarkable achievement by the Japanese industry and government. But if "it" can happen in Japan, Ukraine and the US, we need to take measures today to reduce the risk, especially as we reduce the broader risk of nuclear weapons and commit ourselves to gradual elimination of all nuclear weapons.

The issues are interconnected and yet the management is fragmented. A systematic approach to these issues needs to be taken. This is not necessarily a technology problem, although nuclear

technologies on the horizon with regards to reactors (SMR, Gen-IV) and fuel cycle technology will greatly assist our efforts. Rather, the challenge is one of collective responsibility in a global world. Nuclear radiation can cross borders as was the case with Chernobyl. The consequences of a safety failure can not necessarily be limited to the place where that failure took place so safety is not a purely national concern and requires strong international control.

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