JAPAN'S ENERGY CONUNDRUM

A Discussion of Japan's Energy Circumstances and U.S.-Japan Energy Relations

Edited by Phyllis Genther Yoshida

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Washington, D.C.

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Sasakawa Peace Foundation USA
Research Department
1819 L St NW #300
Washington, DC 20036
P: +1 202-296-6694
E: info@spfusa.org

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Preface

Sasakawa USA is pleased to bring together an outstanding group of senior scholars, all with extensive knowledge and experience, to analyze and explain the many facets of Tokyo's energy situation and its intersection with the U.S.-Japan relationship. This book provides insights into how Japan is seeking to resolve its current energy conundrum by balancing energy security, economic growth, environmental sustainability, and safety in the aftermath of the Great Eastern Japan Earthquake and Tsunami. It also recommends ways in which the U.S.-Japan energy security relationship can become stronger and collaboration deeper.

Japan's energy development, in particular, provides critical insights into how it has, so far, successfully managed to sustain economic growth even in the face of severe energy challenges. The contributors to this book and I all vividly remember and became involved in Japan's most recent energy challenge as a result of the tragic events of March 11, 2011. We provided advice and support to the U.S. and Japanese governments, helped explain developments to American and other audiences around the globe, and, most importantly, supported those affected through our long-standing personal connections and friendships. Japan's response to the 3-11 challenge continues, but it remains to be seen where that response will take the country. We hope this volume provides insights and useful suggestions as Japan shapes its energy future.

At the same time, global energy markets continue to alternate between long-term oversupply and undersupply and among different potential energy mixes, all of which generate energy security concerns but also push advances in state-of-the art technologies. While it is impossible to predict the future, we know energy will continue to be critical for the Japanese and American economies and for global security.

Sasakawa USA remains committed to identifying and raising issues of importance that deserve greater attention, coordination, and cooperation in the U.S.-Japan relationship. In this regard, in an era when energy and environmental issues are increasingly complex and intertwined with technological capacity and economic strength, it behooves us to understand the changes underway. We hope that this book contributes to a greater recognition by experts, policy makers, students, and the broader public of the critical role energy has played, and will continues to play, in economic growth, national security, and environmental sustainability.

Ambassador James Zumwalt
CEO, Sasakawa Peace Foundation USA

Acknowledgments

I greatly appreciate the contributors' work and support in helping us explain the context and significance of the Great Eastern Japan Earthquake and Tsunami for Japan's energy use and for U.S.-Japan cooperation. Energy security and energy resiliency are top concerns for both the United States and Japan. Indeed, both countries are undergoing profound changes in their energy sectors, driven in the United States by the unconventional gas and oil revolution and in Japan by the March 11, 2011 events that led to the shutdown of Japan's nuclear capacity. These changes have altered both countries' economies and the U.S.-Japan bilateral relationship. The outsized role both countries play internationally also is deeply affecting many aspects of the global energy picture, be it nuclear energy, energy efficiency or fossil fuels. Therefore, cooperation on energy and related environmental issues offers an opportunity to strengthen our bilateral relationship and spread the many fruits of our strong energy relationship globally.

I am thankful for the generous support of Sasakawa USA, especially its Chairman, Admiral Dennis Blair, who has long supported intellectual inquiry into Asian energy security issues and provided me with a platform to research these issues after my retirement from the government. The Sasakawa Peace Foundation in Japan, especially Nobuo Tanaka, its Chairman and former Executive Director of the International Energy Agency, who cares deeply about the future of U.S.-Japan energy relations also has provided me generous support and advice over the years. Both Chairmen also graciously agreed to share their thoughts with our readers by writing chapters. Sasakawa USA's Ambassador James Zumwalt, Chief Executive Officer, Dan Bob, Distinguished Senior Fellow, Junko Chano, President, and the rest of my colleagues all provided greatly appreciated advice and support.

As I spoke with the contributors, several names of those who have supported or taught many of us came up repeatedly. They include but are not limited to Kent Calder, Yoichi Kaya, Hugh Patrick, Richard Samuels, and Masakazu Toyoda. We appreciate their pioneering work on Japanese economic, policy and energy issues. I would be remiss not to mention the critical role played by my Ph.D. advisor and long-time friend, the late Dr. Eleanor Hadley, in encouraging me to study Japan and to spend my life in public service. We also could not have written this book without the analysis and information provided by the dedicated analysts of the U.S. Department of Energy and its Energy Information Agency, the Japanese Ministry of Economy, Trade and Industry's Agency for Natural Resources and Energy, and the International Energy Agency.

Finally, I am grateful for the support of my husband, Charles Yoshida, and sons, Matthew and Peter, who have cheerfully put up with my long hours and extensive travel over the years.

Dr. Phyllis Genther Yoshida
Editor

Contributors

Jun Arima

Jun ARIMA has been a Professor at the Graduate School of Public Policy, University of Tokyo since 2015. After joining in the Ministry of Economy, Trade and Industry in 1982, he held various positions related to international energy and environment issues including Counselor, Japanese Delegation to the Organisation for Economic Co-operation and Development, Head, Country Studies Division, Director of the International Energy Agency, Director, International Energy Division, Agency for Natural Resources and Energy, Deputy Director General, Global Environmental Affairs and Director General, Japan External Trade Organization London Office. He participated in the United Nations Framework Convention on Climate Change negotiations as one of the chief negotiators. In addition to the Professorship at the University of Tokyo, he serves as Visiting Professor, the International University of Japan, Project Leader for the 21st Century Public Policy, a Distinguished Senior Research Fellow at the Asia Pacific Institute of Research, Consulting Fellow at the Research Institute of Economy, Trade and Industry and Senior Policy Fellow on Energy and Environment, Economic Research Institute for ASEAN and East Asia (ERIA). He graduated from the Faculty of Economics, University of Tokyo.

Dennis Blair

Admiral Dennis BLAIR is Chairman of the Board and Distinguished Senior Fellow (Non-Resident) of Sasakawa Peace Foundation USA. He joined the foundation in 2014 and, as Chief Executive Officer from then until February 2017, led the team through a refocusing of its mission and a greatly expanded staff. Blair has long experience in Japan and Asia issues and also serves as a member of the Energy Security Leadership Council, and is on the boards of Freedom House, the National Bureau of Asian Research, the National Committee on U.S.-China Relations and the Atlantic Council. As Director of National Intelligence, from January 2009 to May 2010, Blair led sixteen national intelligence agencies, managed a budget of $50 billion and provided integrated intelligence support to the President, Congress, and operations in the field. Blair was president and chief executive officer of the Institute for Defense Analyses (IDA), a federally funded research and development center that supports the Department of Defense, the Department of Homeland Security, and the Intelligence Community, from 2003 to 2006. During his 34-year Navy career, Blair served on guided missile destroyers in both the Atlantic and Pacific fleets and commanded the Kitty Hawk Battle Group. Ashore, he served as Director of the Joint Staff and held budget and policy positions on the National Security Council and several major Navy staffs. Prior to retiring from the Navy in 2002, Blair served as Commander in Chief of the U.S. Pacific Command, the largest of the combatant commands. He graduated from the U.S. Naval Academy.

Tom Cutler

Tom CUTLER is an energy consultant specializing in Asian energy security and trade. He has nearly 40 years' experience in international energy affairs, including serving as Director for European and Asia Pacific Affairs at the U.S. Department of Energy until July 2013. He is currently President of Cutler International LLC. Cutler has numerous publications to his credit, including U.S.-Japan energy security, trade and investment, and strategic cooperation, and Asian energy security. He graduated from Lawrence University in Wisconsin and obtained his M.A. at The George Washington University.

Robert Alan Feldman

Dr. Robert FELDMAN is Senior Advisor to the Research Department of Morgan Stanley MUFG Securities. As part of Morgan Stanley's global economic team, he is responsible for thematic research on the Japanese economy, financial markets and policy developments. He also has an appointment at the Tokyo University of Science and Technology. He served as the Chief Economist of Morgan Stanley MUFG Securities from August 26, 2015 to March 8, 2017. He served as the Chief Economist Japan from February 1998 until September 02, 2015; Head of Fixed Income Research since July 2012; Head of Japan Economic Research since December 2007; and Co-Director of Japan Research since April 2003. Dr. Feldman joined the firm in 1998. Prior to this, he served as the Chief Economist for Japan at Citigroup Inc, Research Division from May 1989 to 1997. Dr. Feldman worked at the International Monetary Fund from 1983 to 1989 in the Asian, European and research departments. He worked at both the Federal Reserve Bank of New York and Chase Manhattan Bank. Dr. Feldman spent study years at both the Nomura Research Institute from 1973 to 1974 and at the Bank of Japan from 1981 to 1982. He has been Outside Director of ORIX Corporation since June 2010. Dr. Feldman is a member of several economic study committees of various ministries of the Japanese government and is a commissioner of the Japan-United States Friendship Commission. He is a regular commentator on World Business Satellite, the nightly business program of TV Tokyo. He has a Ph.D. in Economics from the Massachusetts Institute of Technology, and did his undergraduate work at Yale University.

Ken Haig

Dr. Ken HAIG brings a multicultural background (bilingual/bicultural English and Japanese fluency) and an unusual blend of experience in the worlds of policymaking, public affairs, and academia to U.S.-Asia relations. He is Director of Market Development and Regulatory Affairs at Oracle Utilities in Japan. He also is an Abe Fellow at Hokkaido University Graduate School of Public Policy. He has co-chaired the Energy Committee of the American Chamber of Commerce in Japan (ACCJ) since 2015. Prior to his time with Oracle, he served as an Assistant Professor of Political Studies at Harvard University and the University of California, Berkeley. He received a Fulbright-Hayes Fellowship under which he studied at Keio University, Japan from 2005-2007. He is a graduate of Harvard University, and received his M.A. and Ph.D. from the University of California, Berkeley.

Llewelyn Hughes

Dr. Llewelyn HUGHES is an Associate Professor at the Crawford School of Public Policy, Australian National University (ANU). He is also Research Director for GR-Japan, a government affairs and public policy consultancy focused on the Japanese market (http://grjapan.com/). Dr. Hughes' research focuses on the governance of natural resource markets, and the energy sector and climate change. In 2014, his book *Globalizing Oil* was published through Cambridge University Press. He holds a Bachelor of Arts from the University of Melbourne, Australia, a Master of Laws from the University of Tokyo, Japan and a Ph.D. from the Massachusetts Institute of Technology.

Ken Koyama

Dr. Ken KOYAMA is Chief Economist and Managing Director at the Institute of Energy Economics, Japan (IEEJ). He also is a Visiting Professor at Graduate School of Public Policy at the University of Tokyo; and an Adjunct Professor at Institute of Innovative Research at Tokyo Institute of Technology. He was awarded the degree of: (1) B.A. in Economics in 1982 from Waseda University, Tokyo, Japan; (2) M.A. in Economics in 1986 from Waseda University, Tokyo, Japan; and (3) Ph.D. in 2001 from University of Dundee, Dundee, Scotland. His specialized field of research is energy security issues and geopolitics of energy, and analysis for global energy market and policy issues with emphasis on the Asia-Pacific region. He has served as a member on energy policy related advisory councils and committees of Japanese government on many occasions. He also serves as a member of International Advisory Board, Energy Academy Europe (Netherlands) and International Advisor (Chair in Energy Economics) at the Energy Commission of Tenaga Nasional University (Malaysia). He was awarded the BrandLaureate's "Brand Personality Award 2016."

Jane Nakano

Jane NAKANO is Senior Fellow in the Energy and National Security Program at the Center for Strategic and International Studies (CSIS), which is a bipartisan think-tank based in Washington, D.C. Her areas of expertise include U.S. energy policy, global market and policy developments concerning natural gas, nuclear energy and coal, and energy security issues in the Asia Pacific region. She frequently writes and speaks on these issues at domestic and international conferences and to the media from around the world. She has also testified before Congress on U.S. liquefied natural gas exports. Prior to joining CSIS in 2010, Nakano worked in the Office of Policy and International Affairs in the U.S. Department of Energy (DOE), where she covered a host of energy, economic, and political issues in Asia. From 2001 to 2002, she served at the U.S. embassy in Tokyo as special assistant to the energy attaché. Nakano graduated from Georgetown University's School of Foreign Service and holds a master's degree from Columbia University's School of International and Public Affairs.

Michael Smitka

Dr. Michael SMITKA is a Professor of Economics at Washington and Lee University where he has taught since 1986. He is a highly regarded scholar and frequent contributor of articles on the Japanese economy, the U.S. and Japanese automotive industry and the Chinese economy. He is a past president of the Virginia Association of Asian Studies, and served as treasurer of the Washington and Southeast Japan Seminar. He has served as a judge of the Automotive News PACE Supplier of the Year Innovation Award since 1994. He was a Fulbright Researcher at Chiba University in 2006-2007. He graduated with an AB in East Asian Studies from Harvard University and a Ph.D. in economics from Yale.

Nobuo Tanaka

Nobuo TANAKA is Chairman of The Sasakawa Peace Foundation. He was Executive Director of the International Energy Agency (IEA) from 2007 to August 2011. He began his career in 1973 in the Ministry of Economy, Trade and Industry (METI), and has served in a number of high-ranking positions, including Director-General of the Multilateral Trade System Department. He was Minister for Industry, Trade and Energy at the Embassy of Japan, Washington DC. He has also served twice as Director for Science, Technology and Industry (DSTI) of the Paris-based international organization, the Organization for Economic Co-operation and Development (OECD).

Yukari Niwa Yamashita

Yukari Niwa YAMASHITA, as a Board Member for the Institute and the Director in Charge of the Energy Data and Modelling Center at the Institute for Energy Economics, Japan (IEEJ), is responsible for quantitative and qualitative analyses on energy and climate change policy issues. Her modeling team prepares the annual IEEJ Outlook, continues to develop a Practical Approach to Climate Change and performed analyses that contributed greatly to Japan's debate on a national energy mix. She is currently a member of the Zayed Future Energy Prize Selection Committee (United Arab Emirates), an Editorial Board member of The Energy Journal and a Clean Energy Education & Empowerment (C3E) Ambassador of Japan, an initiative under Clean Energy Ministerial (CEM). She is a graduate of the International Christian University in Tokyo and holds a M.A. from the University of Tsukuba.

Phyllis Genther Yoshida

Dr. Phyllis Genther YOSHIDA is the Senior Fellow for Energy and Technology at the Sasakawa Peace Foundation USA. She also is President of Pimmit Run Consulting LLC, a private consultancy on international energy and technology issues. Prior to joining Sasakawa, she served as Deputy Assistant Secretary for Asia, Europe, and the Americas at the U.S. Department of Energy (DOE), coordinating bilateral relationships and serving as the Lead Shepherd of APEC's Energy Working Group. She was the team leader of the International Energy Agency's 2016 in-depth review of the energy policies of Japan, and negotiated the establishment of the International Partnership for Energy Efficiency Cooperation (IPEEC). She also served as DOE's Director of the FreedomCAR and Fuel Partnership, a government-industry cooperative research partnership. Dr. Yoshida has written extensively on Japanese and international science, technology, and energy issues. She also has held policy and research positions over her career at the U.S. House of Representatives, the Japan Economic Institute, George Mason University and the U.S. Department of Commerce. As Director of the Department of Commerce's Asia-Pacific Technology Program, she received the Commerce Department's Gold Medal for expanding U.S. access to foreign science and technology, and Silver Medal for work creating the International Intelligent Manufacturing Systems Partnership. She received her B.A. from Carleton College, and M.A. and Ph.D. from The George Washington University. She was the first recipient of Japan's GARIOA/Fulbright Fellowship, under which she studied in 1983-1984 at the University of Tokyo, Japan.

PART 1:

SETTING AND CONTEXT FOR JAPAN’S ENERGY CONUNDRUM

Chapter One

Japan's Energy Conundrum

Dr. Phyllis Genther YOSHIDA
Senior Fellow, Sasakawa Peace Foundation USA

Introduction

Japan's energy policy for over a century has sought to compensate for geographic and resource vulnerabilities while supporting economic growth. More than any other major country, its actions have centered on lowering risk, maintaining security, and safeguarding an uninterrupted supply. It implemented policies quite successfully to achieve these goals through a commercial oligopolistic market tempered by a persistent government presence. Yet, more than once, Japan encountered challenges of such size and scope that it was forced to change policy direction dramatically and seek a new base energy source. These reoccurring challenges have constituted a frustratingly persistent and familiar conundrum; how to provide a secure, affordable and environmentally-friendly energy supply resilient to the unexpected in a country with inadequate domestic energy resources. The Great Eastern Japan Earthquake and Tsunami and its aftermath triggered the most recent such challenge.

Pre-World War II Challenges and Responses

Japan faced its first energy challenge in producing the fuel for its industrial expansion launched in the latter half of the nineteenth century, which it overcame by turning to domestic coal. As Professor Richard Samuels has noted, "Coal was the primary industrial fuel and feedstock for the first half-century of Japan's industrial transformation. Long before the industrial revolution started, however, the coal mines had attracted state intervention. In fact, coal was the first business of the Japanese state."[1] Coal mining, already fairly advanced by the early nineteenth century, was controlled by the governments of various *han* (feudal fiefdoms). The building of a strong and efficient coal industry set the scene for what would become a long series of transactional interactions between the state and industry that have defined Japanese energy policy ever since.

Energy also underlays the first important interaction between the United States and Japan when the U.S. Navy's need for a coaling station led to Commodore William Perry's expedition with the goal of "opening of Japan." The forced opening of its ports, in turn, cemented Japan's realization that it had to industrialize to avoid China's fate—accepting unequal treaties and ceding territorial and sovereignty rights to foreign powers. Japan recognized that it needed a reliable energy source to fulfill the Meiji era call for *fukoku kyohei* (rich country, strong army), and so restructured and instituted centralized regulation of the domestic coal industry.

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1 Samuels, Richard J. *The Business of the Japanese State: Energy Markets in Comparative and Historical Perspective,* (Cornell University Press: 1987), Page 68.

While domestic coal remained Japan's primary energy source for industrialization and economic growth until after World War II, by the early 1900s, Japan faced its second energy challenge: an increased need for oil—a resource almost non-existent in Japan—for air and naval power. Meeting that need played a critical role in Tokyo's policy decisions and its interactions with the United States.

By the 1930s, affiliates of Royal Dutch/Shell and Standard Oil of New Jersey/Standard Oil of New York held 30 percent of Japan's internal oil refining capacity. Japan produced only seven percent of the oil it consumed by late 1930s—about two million barrels of oil yearly from fields in Akita, Niigata, and Nutsu (an amount representing less than one day of U.S. production at the time). Most of the remainder came from the United States (80 percent) and the Dutch East Indies (10 percent).

In the 1930s, as in other industries Japan deemed strategic—but had substantial foreign ownership—Japan nationalized its refining industry. The 1934 Petroleum Industry Law gave the government the power to control imports, set quotas, fix prices, and make compulsory purchases to build the domestic refining industry and reduce the role of foreign companies. It also included a stockholding requirement of six months. The American Embassy protested and succeeded in postponing the stockholding provision but not the other provisions of the law.[2] The U.S. response was muted due to isolationism, the Great Depression and U.S. Secretary of State Cordell Hull's policy of avoiding serious crisis with Japan.

Foreseeing the oil embargo that would be imposed by the United States and its allies Britain and the Netherlands, Japan passed the Synthetic Oil Industry Law in 1937 to accelerate research and production of fuel from coal, a process Japan initially pushed in the 1920s.[3] However, advances came slowly. Meanwhile Japan's overseas territories of Formosa and Sakhalin added only another 2 million barrels of oil yearly. By the time of the embargo in 1941, Japan still depended on the United States for 80 percent of its oil. Japan's resource vulnerabilities and its need for oil thus played a major role in Japan's great gamble of going to war with the United States.

Post-World War II Challenges and Responses

In the first decade after the war, Japan pursued an energy policy of "coal first–oil second" with continued government support for the coal industry and restrictions on industrial use of oil.[4] By the mid-1950s, however, Japan faced its third energy challenge—finding a new cheap source of energy to support rapid economic growth and fuel Japan's new, internationally competitive, energy-intensive industries such as iron and steel.

Japan had quickly exhausted its small oil reserves, and the price of domestic coal had come to exceed that of imports due to advances in mining and falling shipping costs. Oil imports from the Middle East, meanwhile, declined in price due to increasing standardization and diffusion of technology, and increased reliability due to the security

[2] Hughes, Llewelyn. *Globalizing Oil, Firms and Oil Market Governance in France, Japan and the United States* (Cambridge, UK: Cambridge University Press, 2014).

[3] Stranges, Anthony N. "Synthetic Fuel Production in Prewar and World War II Japan: A Case Study in Technological Failure." *Annals of Science* 50 (1993): 229-65.

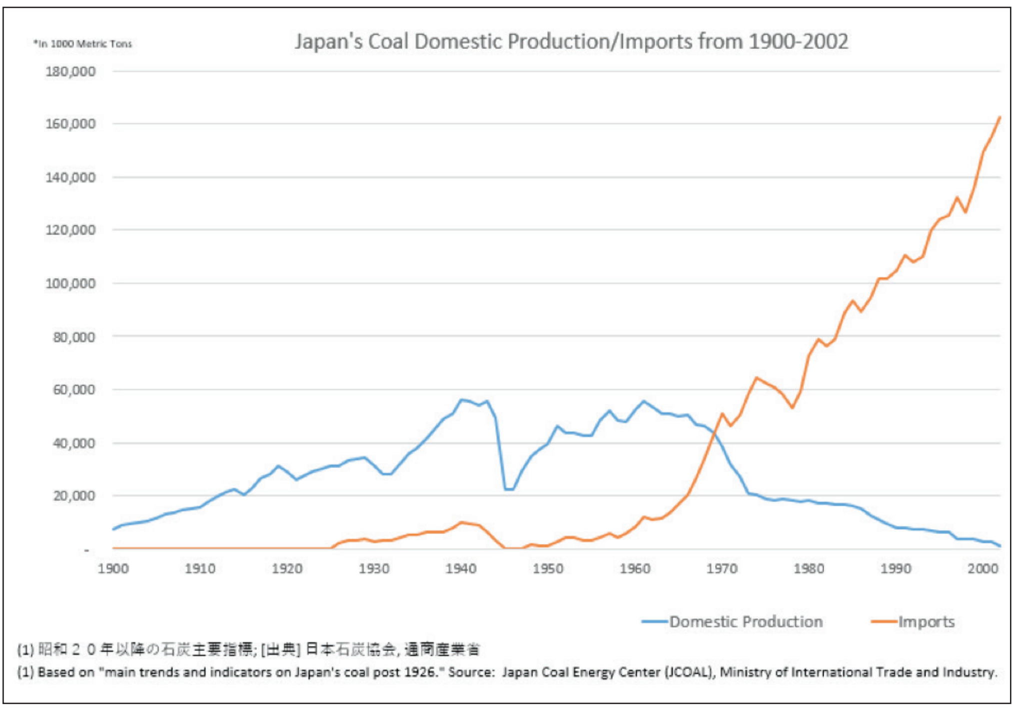
[4] Kobori, Satoru. *Japan's energy policy during the 1950s: reasons for the rapid switch from coal to oil*, Conference Paper at the Asia-Pacific Economic and Business History Conference, AEPBH09, 2009.

afforded by the Pax Americana. Japan thus lifted restrictions on oil's use and expanded port facilities for its importation. To ease the transition from coal, the Japanese government continued to subsidize what remained of its coal industry by limiting imports until the early 1990s.[5] However, between 1951 and 1971, the share of imported and domestic coal as a primary energy source declined from over 50 percent to 8 percent, with domestic coal production shrinking from a peak of 55 million tons in 1960 to slightly more than 16 million tons in 1985.

With Japan's rapid expansion in the 1960s, energy use grew too, sometimes faster than gross domestic production (GDP). By 1973, oil accounted for 80 percent of total Japanese energy consumption. Japan's energy policy now included two of the three "Es" (economic growth and energy security) that would become the basis for Japan's pre-Fukushima 2003 Basic Energy Plan.

Masakazu Toyoda, President of Japan's Institute of Energy Economics, says energy security means "to secure adequate energy at reasonable prices necessary for people's lives, and economic and industrial activities of a country."[6] This definition emphasizes maintenance of the availability and affordability of energy notwithstanding political events and actions, accidents, changes in demand, global competition, depletion of resources and/or lack of adequate investment.

Figure 1: Domestic Coal Production/Imports



Source: Ministry of Economy, Trade and Industry

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5 Hein, Laura E. *Fueling Growth: the Energy Revolution and Economic Policy in Postwar Japan* (Cambridge, Mass.: Harvard University Press, 1990).

6 Toyoda, Masakazu. "Energy Security and Challenges for Japan," 14 February 2012, http://eneken.ieej.or.jp/data/4856.pdf.

The plan's third "E," environmental sustainability, became an important factor in energy policy later, though concerns over the environment started gaining popular attention in the 1950s and 1960s due to toxic chemical spills and increased air pollution. The third "E" therefore adds acceptability to energy policy in addition to availability and affordability. Japan created a subcabinet-level Environment Agency in 1971; it later became the cabinet-level Ministry of the Environment in 2001. Japan also paid close attention to the passage of the Clean Air Act in 1970 in the United States, passing its own Clean Air Act in 1973.

Tokyo faced its fourth energy challenge with the onset of the first oil crisis in 1973-1974 when oil became both far more expensive and far less reliable. Japan was more dependent on oil than any other advanced economy at the time, and so quickly had to reinvent its energy policy and diversify its energy mix away from oil. It did so by expanding production of nuclear energy and consumption of liquefied natural gas (LNG). By 2011, oil had declined to 43 percent of Japan's total energy consumption from 80 percent in the 1970s.

The Atomic Energy Basic Law, limiting use of nuclear technology to peaceful purposes, was passed in 1955. Japan signed an agreement with the United States that same year to work together on the research and development of nuclear energy as part of President Dwight Eisenhower's global "Atoms for Peace" initiative. Japan's Atomic Energy Commission (AEC), established in 1956, promoted research and nuclear power development. The country's first commercial nuclear power reactor came online in mid-1966; in response to the 1973 oil crisis, Japan made nuclear energy expansion a national strategic priority. Nuclear power was attractive as a high-tech "domestic" energy source, the potential to create a new globally competitive industry, and environmental benefits compared to fossil fuels in terms of clean air. Japan also thought that its ability to reprocess spent nuclear fuel for use in nuclear power plants would enhance energy security by reducing its need for imported energy. When the first oil crisis started, Japan had five nuclear reactors in commercial operation and several under construction. The number expanded to 54 commercial reactors by 2010, which provided approximately 30 percent of electricity production. In addition, in plans announced that year, Japan sought to increase the amount to 40 percent by 2017.

LNG became a viable global commodity with the first commercial shipments to the United Kingdom from Algeria in 1964. Japan received Asia's first LNG shipment in 1969, and the country helped fund Brunei Darussalam's LNG industry, which started exporting in 1972. With the first oil shock, Japan's interest in the fuel escalated with a focus on the potential for reliable supply even more so than price. In their first contracts with Indonesian producers, Japanese utility companies agreed to a pricing scheme based on an "LNG element" linked to crude oil export prices and a "transportation element" based on a seller's cost of transportation, an arrangement that would become a major policy and economic irritant after the Fukushima disaster. By 1984, Japan was buying 72 percent of the world's LNG exports. While other buyers emerged creating a seller's market in the late 1990s, Japan remained the largest buyer, purchasing 66 percent of globally traded LNG in 1999 and 48 percent in 2002.

During this period, Japan also sought to use energy more efficiently, directing large amounts of funding into industrial processing and manufacturing. It built upon a history of sporadic conservation efforts begun in the early 1900s. In 2016, the American Council for an Energy Efficient Economy's (ACEEE) *2016 International Energy Efficiency Scorecard* ranked Japan as the second most energy efficient country, tied with Italy and just behind Germany.

In response to the 1973 oil crisis, Japan developed policies to increase energy self-reliance through expanded research, development, and utilization of alternatives to oil. In 1974, the Ministry of International Trade and Industry (MITI) launched its Sunshine Project to foster new solar, hydrogen, coal, and geothermal energy technologies.

The second oil crisis of 1978 reinforced Japan's shifting emphasis on LNG, nuclear power and energy efficiency. MITI, through the Agency for Industrial Science and Technology, launched its Moonlight Project to add energy conservation to the new energy technologies targeted by the Sunshine Project. Japan combined the two projects in 1993 along with work on environmental technologies to form the New Sunshine Program. The 1980 "Law Concerning Promotion of the Development and Introduction of Oil-Alternative Energy" led to the establishment of the New Energy and Industrial Technology Development Organization (NEDO), a special corporation funded by tariffs on crude and heavy fuel oil imports as well as a petroleum fuel tax to promote the development and introduction of new energy technologies.[7] Its mandate expanded in 1988 to promote industrial technologies.

Japan increased its role in climate change by hosting the 1997 conference that produced the Kyoto Protocol. Tokyo's ratification of the Protocol in 2002 included a pledge to reduce greenhouse gas emissions six percent below 1990 levels by 2012. As a result, Japanese energy policy placed additional emphasis on climate and the environment, while public support for new climate friendly technologies and industries increased. Japan made a new pledge in 2009 to reduce 2020 greenhouse gas emissions by 25 percent from 1990 levels.

Japanese policymakers announced the country's *Third Strategic Energy Plan* in June 2010. It included a proposed energy mix that was both more environmentally friendly and less dependent on imports by building on existing policies favoring nuclear power. The 2010 plan sought to expand nuclear power from 30 percent to 50 percent in 2020 of total electricity consumption and to 70 percent in 2030; to a much smaller degree, it also supported renewable energy.

March 11, 2011

The events of March 11, 2011, which rendered the 2010 plan obsolete, presented Japan with its fifth and latest energy challenge. New circumstances forced Japanese policymakers once again to undertake an in-depth review of the country's energy situation. The country shut all its nuclear reactors in the aftermath of the disaster at Fukushima and the resulting intensified anti-nuclear sentiment, and so faced an immediate 30 percent shortfall in electricity production. Over the longer-term, nuclear power seemed to have been ruled out as Japan's primary energy source in coping with geographic and resource vulnerabilities or enhance environmental sustainability.

Without nuclear power, Japan relied almost completely on imports of coal, oil, and natural gas to meet its primary energy demand. Meanwhile, Japan's GHG emissions

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7 Nakayama, Shigeru. *A Social History of Science and Technology in Contemporary Japan, Volume 4* (Melbourne, Australia: Trans Pacific Press, 2016).

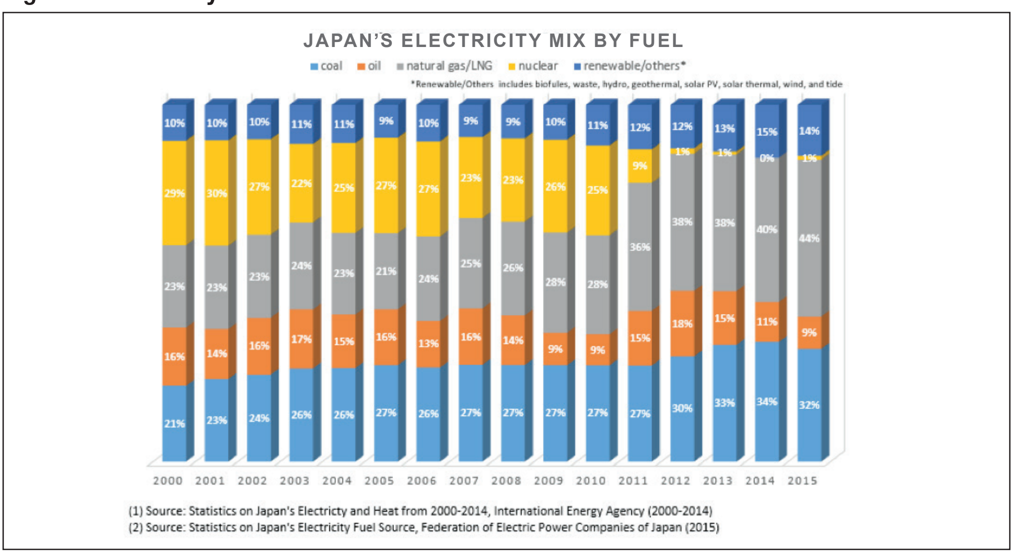
quickly increased, its trade deficit grew, and its economy slowed due to higher LNG prices, which doubled in large part because Japan's demand for the fuel increased 30 percent, forcing up electricity rates, which had already been among the highest in the world.

Once again, Japan's policymakers had to reconsider the energy market's structure and the government's role in advancing energy security, economic growth, and environmental sustainability. Their deliberations also took place in the context of a revolution in the global energy market brought about by new gas and oil extraction techniques perfected in North America that is creating a new phase of U.S.-Japan energy interactions. The prospect of U.S. LNG brought about a flurry of agreements with Japanese companies for purchases of LNG with 14 million tons contracted for delivery between 2017 and 2022. Japanese companies also are investing in U.S. LNG infrastructure. With the diversification of supply, Japan also has been able to begin to replace the system that linked LNG price to the crude oil import price.

The government scrapped the *Third Strategic Energy Plan* even before it was implemented, developing a fourth *Strategic Energy Plan* issued in 2014, the *Long-term Supply and Demand Outlook to 2030* released in 2015, and the *National Energy and Environment Strategy for Technological Innovation Towards 2050* adopted in 2016.

The new strategies posited a flexible and diversified energy supply-demand structure to meet energy security and climate change objectives. They called for a smaller role for nuclear energy than the 2010 plan; reductions in demand through energy efficiency, reform and deregulation of both the electricity and gas markets; accelerated deployment of innovative technologies in renewable energy, solar and wind in particular; optimization of the oil refining and distribution industry; promotion of efficient coal-fired power plants; robust investment in advanced energy research and development; and creation of a strong safety culture in a smaller nuclear industry. Policy now revolved around not just **E**nergy security, **E**conomic growth and **E**nvironmental sustainability—the "**3Es**"—but also included "**S**" for **S**afety. This plan's implementation is taking place in a market still defined by the events of March 2011.

Figure 2: Electricity 2015



Source: International Energy Agency, Japan Federation of Electric Power Companies

The Way Forward

Japan has faced its many energy challenges over the years and successfully managed to make necessary transitions in its primary energy sources through a commercial oligopolistic market tempered by a persistent government presence. What is different after March 2011 is a global energy market made more complex by changes in supply from the North American unconventional oil and gas revolution, changes in demand, particularly in China and Southeast Asia, and increased market competitiveness of renewable energy due to technological advances. Japan also has made a clear decision to deregulate its domestic electricity and gas markets more quickly than prior to 2011. Renewable energy production, while already underway, now is seen as imperative if the country is to overcome its latest energy challenge, especially if the role for nuclear remains limited.

What other ideas should Japan consider going forward? The International Energy Agency (IEA) does a peer review of the energy policy of each of its members approximately every four years.[8] The latest review for Japan, completed in 2016, is more consequential than usual given the complexity of the country's current energy circumstances.

As Japan moves forward, it begins with an energy market changed drastically by the events of March 2011. Total Japanese primary energy supply (TPES) in 2014 was 442 million tons of oil-equivalent (Mtoe). Fossil fuels dominated, accounting for 94.7 percent of TPES in 2014, a level not seen since the energy crisis of 1973-1974. The 2014 Strategic Energy Plan seeks to lower fossil fuel consumption by bringing some nuclear reactors back into operation, growing renewable energy, and advancing energy efficiency. Coal (imported) for use in highly efficient power plants is making a comeback as a lower cost alternative to oil and natural gas.

With only a handful of nuclear plants online, Japan still relies almost completely on imports for its total primary energy needs. In 2015, energy imports accounted for 434 Mtoe, out of which crude oil and oil products made up the biggest portion (49.5 percent), followed by coal (27.7 percent), and natural gas (22.7 percent). The strongest increases in energy imports came from natural gas (19.3 percent) and coal (4.3 percent).

In 2014, domestic production stood at only about six percent of TPES. Domestic production consisted of biofuels and waste (42 percent), hydro (26.5 percent), natural gas (9.7 percent), solar (9.3 percent), geothermal (9 percent), oil (1.9 percent) and wind (1.6 percent). This mix differs considerably from pre-Fukushima 2010 levels when nuclear accounted for 75.9 percent, renewables for 20.2 percent, and oil and gas for 3.9 percent. In the years just prior to the Great Japan Eastern Earthquake and the nuclear shutdown, domestic production ranged between 16 and 20 percent of TPES.

The key recommendations made by the IEA peer review committee for Japan to consider as it moves forward in implementing its post-2011 energy policy include:

- Strive toward a well-balanced and diversified energy mix, including renewable and nuclear energy, and efficient thermal power generation, taking into account safety, energy security, economic efficiency, and environmental protection.
- Take all necessary measures to meet the 2030 objectives and to continue toward 2050 objectives,[9] including by

[8] International Energy Agency. *Energy Policies of IEA Countries: Japan 2016* (Paris, France: OECD/IEA, 2016).
[9] As set out in the 2014 *Strategic Energy Plan*, the 2015 *Long-term Supply and Demand Outlook to 2030 and the National Energy and Environment Strategy for Technological Innovation Towards 2050.*

  - facilitating increases in low-carbon sources of primary energy and electricity supply, while addressing safety, cost, and public acceptance
  - continuing to gradually introduce fiscal incentives and stricter requirements for energy efficiency
  - ambitiously promoting Japan's proven and considerable potential for innovation in critical low-carbon technologies.
- Finalize the implementation of the electricity and gas market reforms as scheduled; ensure that the regulator and competition authority are adequately resourced; specifically, for electricity, facilitate and encourage building infrastructure for creating a well-integrated national grid and a market design that includes strong signals to locate generation where it is most valuable to the system.
- Continue to support renewable energy deployment and focus on
  - controlling additional burden on consumer tariffs from support costs and aligning support towards global benchmarks increasing the effectiveness of the support and reviewing it regularly to reflect advances in technology
  - facilitating the deployment of a technologically and geographically balanced portfolio
  - introducing neutral institutional arrangements to accelerate grid integration.

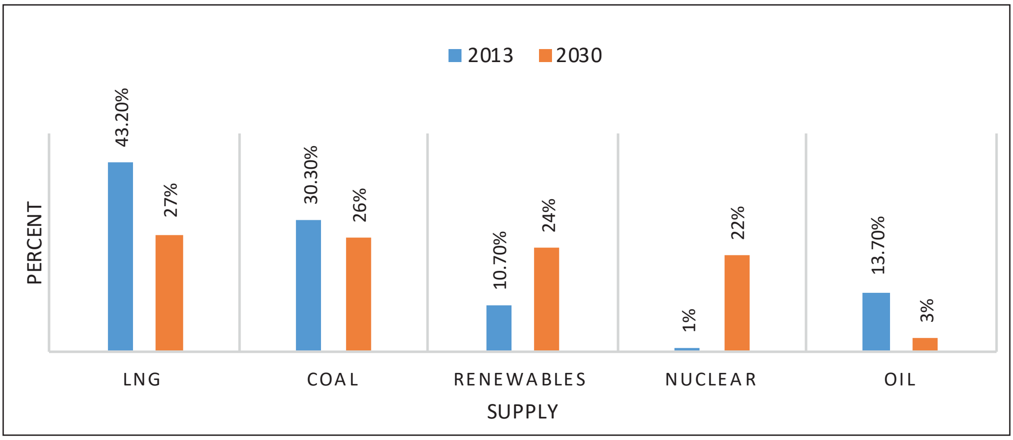
The report contains many specific recommendations for Japan's policymakers to consider that support the general recommendations listed above. These include recommendations related to climate change, energy efficiency, oil, coal, natural gas, electricity, renewable energy, nuclear energy, and research and technology. There is no energy silver bullet for Japan to successfully meet its latest energy challenge. Energy efficient, demand side solutions are necessary but are becoming more complex as they require an integrated approach among industries, cities, and the Japanese people. In addition, the structure of the energy market itself will change through deregulation, and the introduction and development of new technologies.

Conclusion

Just as Japan met previous energy challenges, Japan proved remarkably resilient in response to the Great Eastern Japan Earthquake and Tsunami, the disaster at Fukushima Daiichi, and dramatic changes in the global market. It managed to fill the gap in electricity supply and demand by replacing nuclear power with fossil fuels—especially LNG and coal, mandatory temporary cut-backs in industrial energy use, and other energy efficiency improvements. Economically, it was fortunate that oil and natural gas prices declined due to the rise in non-OPEC, primarily North American, production.

Longer term, however, the situation may become more difficult as the cost of oil and gas will remain volatile, the global energy market evolves, and environmental and climate concerns grow. Combined with Japan's COP21 goal to reduce GHG emissions by 26 percent from 2013 levels by 2030, it is unclear if the country's proposed energy policies and new energy mix will allow it to balance its objectives of energy security, economic growth, and environmental sustainability. Japan has also pledged to cut emissions by 80 percent by 2050 from current levels (2015) if that amount is compatible with economic growth. The proposed energy mix for 2050 is less detailed than that for 2030, but if nuclear is not phased out, the pledge suggests 30 percent nuclear, 40 percent renewables, and 30 percent fossil fuels. If nuclear is phased out, the amounts change to 50 percent renewables and 50 percent fossil fuels. The 2014 plan and the related measures announced in 2015 and 2016 are not sufficient to reach the 2050 target, especially if nuclear energy or other low-carbon energy sources are not brought back online quickly or coal use continues to expand.

Figure 3: Japan's Proposed 2030 Energy Mix



Source: METI

Japan once again faces an energy conundrum—the most complex to date. The country's current energy plans and the suggestions by the IEA all point in the right direction, but are they sufficient? The United States has played a role in each of Japan's energy challenges sometimes directly and sometimes indirectly. What role will its strong alliance and partnership with the United States play going forward? Can the two countries expand their research, development, and utilization of leading edge technologies for mutual benefit? Will the North American gas and oil revolution provide needed supply diversity? Will the U.S.-Japan nuclear partnership emerge stronger or weaker? Japan must figure out how, once again, to successfully balance energy security, economic growth, and environmental stability and do so safely if it is to remain a global leader.

Chapter Two

The Geopolitics of Asian Energy

Admiral Dennis BLAIR, (Ret.)
Chairman, Sasakawa Peace Foundation USA

Introduction

Every country's quest for energy security – having adequate and affordable energy supplies to support the economy – drive the geopolitics of energy. National economies are dependent on electrical power and transportation, both in turn relying on energy from a variety of domestic and imported sources. Electrical power generation uses coal, along with natural gas, nuclear power and renewable sources. Refined oil products dominate transportation energy. National governments therefore have a vital concern that supplies of energy for electrical power generation and for transportation are adequate and that energy prices are neither too high nor too volatile.

Energy security means not only an adequate supply and affordable price on a day-to-day basis, but also during natural disasters, political crises or even wars, when energy supplies will be under strain or attack, with potentially punishing economic results. For countries with substantial imports, these considerations focus attention on diversity of sources for imported energy materials, security of imported energy during transit by pipeline over land or by ship, and buffer stocks to counteract supply disruptions.

Neither the United States nor any major country in Asia is self-sufficient in energy. The United States, China and India use mostly domestic coal for electrical power generation, while Japan and Korea must import a variety of fuels to supply power plants. All must import half or more of the oil they use to fill the tanks of the cars, trucks, trains and airplanes of their citizens and businesses. The geopolitics of energy come into play in the relations between energy importing countries and energy exporting countries, in competition between importing countries for adequate and secure energy sources, and they often affect other issues between importing countries.

In recent years, growing global awareness of the dangers of climate change has introduced another powerful factor into the geopolitics of energy. All countries recognize that the continued unconstrained use of fossil fuel energy sources risks raising the earth's temperature to the point that it will cause economic and social disaster. Coal is the greatest source of greenhouse gas, the primary factor in climate change over which humans have control, with oil next. However, the costs of converting to less polluting energy sources today's fossil-fueled transportation and electricity sectors in both the developed and the developing world are huge. The energy geopolitics of climate change are primarily to convince other countries to reduce their use of fossil fuels drastically, while evolving more slowly and less expensively in one's own country.

The geopolitics of energy in Asia boil down to the quest of individual countries to ensure a reliable and affordable flow of imported energy into their economies under a range of conditions from peacetime through natural disasters through conflict. Countries sometimes take initiatives to use energy supplies or purchases to support friends and coerce enemies on specific political issues. There is a general desire to reduce the use of fossil fuels, but these considerations come into play only after a country is confident of its fundamental energy security in the immediate future.

International Energy Markets

Energy supplies come from international markets. The nature of international oil, natural gas and coal markets therefore heavily influence the geopolitics of energy. There are both private and state-owned companies in these markets, as well as cartels. The desire to make profits over time primarily drives private companies. National companies also want to make profits, but they often must provide direct cash flows to their governments from their revenues. Their governments also can direct them to withhold sales and deliveries to other countries for political reasons. The cartels have both economic and political objectives.

Oil

Because tankers distribute most of the oil in the international market around the world and the shipping costs are a small fraction of the value of the product, and there is a world market and price for oil. Both importing and exporting countries pay the international price. State-owned oil companies play a strong role in the market. Of the ten largest by revenue, half are state-owned[10] and they own about three-quarters of reported proven reserves.[11]

Transportation systems are the major user of oil, and transportation demand is generally inelastic. High world oil prices therefore translate directly into economic penalties for oil importing countries. Volatile oil prices also exact an economic penalty, as they make it impossible for companies and individuals to carry out efficient plans. If they plan conservatively, anticipating high prices, and prices stay low, they miss investment opportunities; if they plan for low prices, and prices rise, they must postpone investment or borrow.

The supply/demand relationship basically sets the international price over the long term. Horizontal drilling and hydraulic fracturing technologies developed in recent years have increased supplies in the United States, driving down the world price, but economic development, most of it in countries in Asia, is increasing demand, driving up the price. The U.S. Energy Information Administration (EIA) predicts that in coming years the price of oil will generally move higher.[12]

In the shorter term, a combination of natural and political events affects the price of oil. Hurricanes that strike the American Gulf Coast, interrupting refinery operations, cause the price to go up. So do political crises in the Middle East and civil wars in Libya. Both producers and importers take actions for both economic and political reasons that affect price and availability of oil. Producers act through state-owned national oil

[10] "Biggest Oil Companies In The World." World Atlas, http://www.worldatlas.com/articles/biggest-oil-companies-in-the-world.html.
[11] Ausick, Paul. "The World's Top 10 Oil Companies." 24/7 Wall Street. December 15, 2014, http://247wallst.com/energy-business/2014/12/15/the-worlds-top-10-oil-companies/.
[12] U.S. Energy Information Administration. International Energy Outlook 2017. September 14, 2017, https://www.eia.gov/outlooks/ieo/.

companies; consumers act by government restrictions in imports. In 2014, for example, the Saudi Arabian government directed Aramco, the largest oil company in the world, to increase its production in order to keep the world price of oil low. Saudi Arabia's objectives were to maintain economic and political pressure on both Iran and Russia by reducing their oil revenues, and to drive American shale oil producers out of the market.[13] Right now OPEC, a coalition of producers responsible for about a third of world oil production, is attempting to limit production to raise the world price.[14] Conversely, importers can agree to put pressure on individual exporters by refusing to buy oil from them. The United States and major European countries limited purchases of Iranian oil to pressure Iran to accept a freeze on its nuclear weapons development program.

With all this near-term uncertainty in the international oil market, the major countries of Asia all pursue a mixture of policies designed to reduce their overall dependence on imported oil over the long term, and develop tools to handle short-term events. Reducing oil use depends on the development of efficient public transportation systems, improvement in the fuel efficiency of gasoline-powered vehicles, and development of vehicles powered by other energy sources – electricity, natural gas and hydrogen. To deal with short-term supply shortages, countries build strategic stockpiles of oil, and make political decisions to join or work around international coalitions attempting to influence prices and availability.

Natural Gas

The international gas market has two very different components – pipeline-delivered and liquefied natural gas (LNG) delivered by ship. Worldwide roughly 90 percent of natural gas is distributed from well to consumer by pipeline.[15] 10-12 percent of natural gas consumed is piped to a liquefaction plant, cooled to liquid form, loaded onto ships, and sent around the world, where it is converted back to gas and piped on.[16] The proportion of LNG in world consumption is projected to increase, with new exports from the United States and expansion of exports from other producing countries.

The natural gas market in Asia is unique. With its maritime geography limiting the construction of pipelines, LNG carried in ships is much more important in Asia than in other regions. Japan and Korea are the top two importers of LNG in the world.

The pricing structures for pipeline gas and LNG sold on international markets are very different. Pipeline gas is generally bought and sold under negotiated long-term contracts that reflect the costs of producing and transporting it. The agreement between China and Russia in 2014 is the largest Asian agreement in recent years for pipeline delivered gas.[17] Although the details of the agreement are not public, the agreed price

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13 Solomon, Jay, & Said, Summer. "Why Saudis Decided Not to Prop Up Oil." Wall Street Journal. December 21, 2014, https://www.wsj.com/articles/why-saudis-decided-not-to-prop-up-oil-1419219182.

14 Reed, Stanley, & Krauss, Clifford. "OPEC Reaches Deal to Limit Production, Sending Prices Soaring." The New York Times. November 30, 2016, https://www.nytimes.com/2016/11/30/business/international/opec-energy-oil-saudi-iran.html.

15 World Energy Council. "World Energy Resources Natural Gas 2016," https://www.worldenergy.org/wp-content/uploads/2017/03/WEResources_Natural_Gas_2016.pdf, p. 19.

16 Clemente, Jude. "The U.S. Is Transforming The Global Liquefied Natural Gas Market." Forbes. April 16, 2017, https://www.forbes.com/sites/judeclemente/2017/04/16/the-u-s-is-transforming-the-global-liquefied-natural-gas-market/2/#423863fd4f23.

17 Downs, Erica. "In China-Russia gas deal, why China wins more." Fortune, June 20, 2014, http://fortune.com/2014/06/20/in-china-russia-gas-deal-why-china-wins-more/.

resulted from protracted tough negotiations between the governments, with the Russians pushing for guaranteed minimum purchases at a fixed price and the Chinese pushing for low and flexible prices.

LNG prices traditionally have been indexed to the price of oil under long-term contracts, and Asia has accounted for about three quarters of the LNG market. In recent years, a spot market and other flexible market mechanisms have developed, and Asian countries have been able to lower their natural gas import bills.[18] With the United States now exporting LNG from its shale gas production and production in Australia continuing to increase, it is expected that the spot market and other flexible pricing mechanisms will grow, providing both stability and lower prices to Asian importers.[19]

Use of the international gas market by governments for geopolitical purposes has been most evident in Europe. Russia in the past has leveraged its monopoly pipeline natural gas deliveries to Central and Eastern European countries for political concessions on a range of issues. In reaction, European countries have attempted to diversify their sources of supply by thickening the pipelines in Europe and taking advantage of increased LNG imports.

In Asia, the primary concerns with natural gas have been price and supply, rather than political advantage. Oil-linked supply contracts have been volatile and expensive for countries like Japan and Korea, completely dependent on LNG. Traditional LNG suppliers – Qatar, Australia and Indonesia – have not attempted to exert political leverage through their exports. The 2014 gas agreement between China and Russia had political overtones, but the primary issue was price. Japan has been in long-term discussions with Russia concerning increased natural gas imports, either as LNG or even through an undersea pipeline. While part of Japan's motivation is political – to provide alternative natural gas markets in Asia to Russia besides China – a major part is also economic – to diversify sources of supply.

Virtually all countries in East Asia are in favor of an Asian natural gas hub where a single price would be set, contracts and futures made and traded, and natural gas stored to buffer supply shortages. The competition lies in the structure and location of the hub, and Singapore, China, Japan and Korea all would like to participate.

Coal

China, India and the United States account for about 70 percent of world coal use, and all three produce almost all of what they consume.[20] Climate change concerns, as coal is the single largest producer of CO2 emissions worldwide, mostly drive the geopolitics of coal. China has announced that it will decrease its consumption of coal, and there are early indications that it is serious. Although it has withdrawn from the Paris accord, the United States projects decreased coal consumption, since natural gas power plants are less expensive; India and other developing countries, however, plan to increase the use of coal for electrical power generation, offsetting reductions in China and the United States.[21]

[18] U.S. Energy Information Administration. International Energy Outlook 2017. September 14, 2017, https://www.eia.gov/outlooks/ieo/.
[19] Ibid.
[20] U.S. Energy Information Administration, "International Energy Outlook 2016," p. 3.
[21] U.S. Energy Information Administration, "International Energy Outlook 2017, Executive Summary," pp 6-7.

Most of the effective pressure on national governments to reduce coal consumption comes from citizens within those countries rather than from external pressures from multilateral negotiations. One rare, minor and not very successful official attempt to reduce coal consumption in other countries was the attempt by the United States from 2013 to 2016 to restrict international financing for coal-fired power plants.[22] Most of the pressure on the United States and China to restrict the burning of coal has come from citizens who observe the effects of coal burning in the form of acid rain or air pollution, and who take note of increasing numbers of major unusual and more severe weather events. Although citizen pressure in India so far has not been powerful enough to affect government policies favoring economic development, the increasing pollution of major Indian cities should exert pressure on the government over time.

Energy Geopolitics of Major Asian Countries

While the United States and all major Asian countries seek energy security, their consumption, production, import and export situations are unique, and therefore their quests for energy security take different paths. In certain situations, countries can go beyond energy security considerations to use their positions as exporters or importers of energy to support other international interests, from limiting the proliferation of nuclear weapons through supporting the energy security of allies. However, the energy policies of most countries are intended to ensure that their economies cannot be strongly and adversely affected by the energy decisions of other nations or groups of nations, and to make sure that they cannot be harmed by energy shortages due to natural disasters.

Japan

Japan's energy policies are most strongly affected by two factors, one traditional and one more recent. The traditional factor is the country's virtually complete dependence on energy imports; the more recent factor is the shutdown of the country's roughly 50 nuclear power plants following the tsunami of March 11, 2011, that flooded the Fukushima nuclear power plant. The day before the tsunami, nuclear power plants had generated about 30 percent of the country's electrical power.[23]

In its latest energy policy, published in April 2014, Japan provided a good summary of its energy security objectives:

> "The point of the energy policy is to first and foremost ensure stable supply ('Energy Security'), and realize low cost energy supply by enhancing its efficiency ('Economic Efficiency') on the premise of 'Safety.' It is also important to make maximum efforts to pursue environment suitability ('Environment')."[24]

Despite importing 100 percent of the petroleum it consumes, Japan has been able to achieve a high degree of energy security in the oil sector through its robust public

22 Shear, Michael. "U.S. Says It Won't Back New International Coal-Fired Plants." The New York Times. October 29, 2013, http://www.nytimes.com/2013/10/30/us/us-says-it-wont-back-new-international-coal-fired-power-plants.html.

23 Silverstein, Ken. "Japan Circling Back to Nuclear Power After Fukushima Disaster." Forbes. September 8, 2017, https://www.forbes.com/sites/kensilverstein/2017/09/08/japan-may-be-coming-full-circle-after-its-fukushima-nuclear-energy-disaster/#5c5317da30e8.

24 Ministry of Economy, Trade and Industry. "Japan's Fourth Strategic Energy Plan." April 2014, http://www.enecho.meti.go.jp/en/category/others/basic_plan/pdf/4th_strategic_energy_plan.pdf, p. 17.

transportation system, very fuel-efficient vehicles, and a substantial strategic petroleum reserve. The American think tank Securing America's Future Energy (SAFE) publishes a ranking of the energy security of major nations, and Japan ranks third, higher than the United States or any Asian country.[25] Japan's oil intensity, the amount of oil it consumes per unit of GDP it generates, is the sixth lowest in the world. Higher oil prices therefore have less of an effect on the economy of Japan than on other countries.

Despite these measures, Japan is the third largest importer of oil in the world, and the largest importer of natural gas. Under these circumstances, the only logical energy security policy for Japan is diversification of sources for both oil and gas, and cultivation of good relations with suppliers.[26] This drive for diversification and good relations with supplier countries sometimes puts Japan at odds with its principal ally the United States, which enjoys the luxury of a much more advantageous energy security position. For example, as American policy towards Russia has grown increasingly antagonistic since Russia's annexation of Crimea, Japan has continued to seek improved relations. Part of its rationale is to find oil and gas deals that would ease Japan's dependency on the Middle East, and part to give Russia another Asian market for oil and gas exports besides China.

On occasion, Japan has acted against its general policy of maximum diversity of oil and gas sources. Although in 2003 Japan had imported 17 percent of its oil from Iran, after long negotiations it joined U.S. and European oil sanctions against that country, bolstered by strong public opinion in support of limiting nuclear proliferation.[27]

Another strong component of the geopolitics of energy in Japan is international energy cooperation. Part of this component is the expectation of more business overseas for Japanese manufacturers of energy equipment, but Japanese policymakers also believe that international energy cooperation can bring benefits for all in the form of greater supplies and more efficient use of energy. Japan has many cooperative energy projects in India, Southeast Asia, and even is committed to working with China despite strong tensions:

> "China, which has become the world's largest energy-consuming country, is expected to increase its presence in the international energy market. As for China's relations with Japan, tensions are growing in various aspects, so how to manage a relationship with rising China is a difficult and important issue. However, in the energy field, it is important to maintain an appropriate, cooperative relationship with China to tackle common issues, including the high LNG prices in Asia, as consumer and importer."[28]

The Fukushima disaster caused Japan to shut down all its roughly 50 nuclear power plants that had produced about 30 percent of the country's electricity.[29] Although the

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[25] Securing America's Future Energy, http://secureenergy.org/oil-security-index/.

[26] "It is important to make comprehensive diplomatic efforts to develop comprehensive and mutually beneficial bilateral relations with countries that supply Japan with resources, instead of merely forming relations based on resource trade. The countries include Saudi Arabia and UAE in the case of oil; Australia, Qatar, Malaysia, Russia and Indonesia in the case of natural gas; Australia and Indonesia in the case of coal; and Chile, Peru, Australia, Canada and South Africa in the case of metal resources."

[27] Kafura, Craig. "The Iran Deal and the US-Japan Alliance." The Diplomat, https://thediplomat.com/2016/03/the-iran-deal-and-the-us-japan-alliance/.

[28] "Japan's Fourth Energy Plan," April 2014, p. 81

[29] Ibid., 26.

government's initial plan was to recertify the safety of the plants, and to bring most of them back on line, popular opposition has been strong, as of March 2018, only six have returned to operation. The price of electricity has gone up in Japan,[30] so consumption fell, but the net result has been increased use of coal, natural gas and even oil for a period of time[31] to produce electricity, with adverse effects on both Japan's balances of payments and on its environmental objectives. It is impossible to predict whether the Government of Japan will be able to carry out its plan of restoring nuclear power to a major role in electrical power production in Japan. To the extent it falls short, however, there will be additional pressure on Japan to continue to diversify overseas energy sources, maintain good relations with source countries, and seek cooperative opportunities for energy development.

China

For the last three decades, China has been on an economic growth path unequalled in size and duration in human history. Adequate supplies of fuel for the transportation and electrical generation sectors have been fundamental to that growth, and China has adopted an "all of the above" and "no strings attached" policy for securing energy supplies both domestically and abroad. With double-digit economic growth, energy prices have been a secondary consideration. Energy security has been somewhat assured by the sheer scale of energy imports, which have necessarily come from diverse sources.

Coal, almost all of it domestically produced, forms the base of China's electrical power generation. Only in recent years has citizen outrage at the air pollution caused by indiscriminate coal burning in power plants and other industrial furnaces affected government policies. Now China has announced that it will cap and then reduce the use of coal, substituting wind and solar, nuclear and hydro sources, and emphasizing efficiency to reduce the size of demand growth. In 2014 for the first time, the Chinese government committed to a numerical limit on coal consumption.[32] In 2016, China submitted targets it would meet for reducing carbon emissions as part of the Paris Agreement. Initial indications are that the Chinese government is serious about these goals.[33]

It is only recently that China has seen the advantages of natural gas for energy security and for its climate change goals. In the past, natural gas provided less than 5 percent of China's energy consumption, and was almost all used by individual consumers by the bottle. Government fiat kept the price low, giving little incentive for domestic exploration or overseas purchases.[34] In addition, the domestic gas pipeline system in China was rudimentary.

In the past five years, China has taken a series of measures to increase the use of natural gas, with a goal of doubling to 10 percent gas's contribution to the overall energy

[30] U.S. Energy Information Administration. "Japan's electricity prices rising or stable despite recent fuel cost changes." September 9, 2016, https://www.eia.gov/todayinenergy/detail.php?id=27872.
[31] Gloystein, Henning. "After years of soaring growth, Asia's fuel demand falters." Reuters. April 13, 2017, https://www.reuters.com/article/us-asia-oil-analysis/after-years-of-soaring-growth-asias-fuel-demand-falters-idUSKBN17F0HU.
[32] Lander, Mark. "U.S. and China Reach Climate Accord After Months of Talks." November 11, 2014, https://www.nytimes.com/2014/11/12/world/asia/china-us-xi-obama-apec.html.
[33] The evidence is mixed about recent coal consumption in China. The rate of growth has been declining in recent years. However, most recently, there is evidence that Chinese coal use has again increased. See https://www.nytimes.com/interactive/2017/11/13/climate/co2-emissions-rising-again.html.
[34] EIA report on China, p. 3.

consumption of China by 2020.[35] Under a complicated scheme designed to cushion the effect on consumers, China has gradually raised prices to international levels. The big national energy companies, China National Offshore Oil Corporation (CNOOC), China Petrochemical Corporation (Sinopec Group) and China National Petroleum Corporation (CNPC), often working with foreign partners, have increased production in China and off its coasts. Development of higher production through hydraulic fracturing has been disappointing, frustrated by the geology and location of Chinese gas deposits.

China is on track to double its natural gas pipeline network, allowing both efficient distribution of domestic gas and greater imports. It has concluded pipeline and import agreements with Myanmar, and with several central Asian countries, increasing its pipeline imports to about 20 percent of natural gas supply per year.[36] The major unknown factor in China's pipeline gas imports is whether its 2014 agreement with Russia to develop the Yamal field for supply to China will produce the projected amounts of natural gas supplies.[37]

China also has greatly increased its imports of LNG. It is now the world's third-largest importer. It has obtained its LNG through a combination of negotiated long-term contracts and spot-market purchases, has built substantial re-gasification capacity, and is actively promoting Shanghai as an Asian natural gas hub.

China has access to all the natural gas it can absorb under current plans, and its expansion plans have few geopolitical effects. Its natural gas agreements in Central Asia were the first step in loosening Russia's preponderant economic and political influence on that region. The newly announced Chinese "One Belt One Road" initiative, which is much broader than natural gas agreements, now drives the economic competition between Russia and China in the region. However, the Sino-Russian relationship remains one of political and economic competition and cooperation.[38] The development of offshore oil production in areas of the East and South China Seas, where sovereignty is claimed by multiple countries, has had geopolitical effects. However, currently nationalism seems to drive these disputes much more than economic considerations.

The disputed boundary between China and Japan's exclusive economic zones (EEZs) in the East China Sea crosses natural gas fields. China in recent years has pushed its exploration and production wells into disputed territory, drawing protests from Japan.[39] Rather than being a driver of Sino-Japanese enmity, however, these natural gas developments are more a symptom of poor relations. Up to 2008, there were active negotiations between the countries for joint natural gas projects in the disputed areas. However, after 2010, when the Japanese government purchased the Senkaku/Diaoyu islands from private owners, tensions in the area increased, marked primarily by aircraft and ship deployments by the two countries to the vicinity of the islands. The Chinese projects and Japanese projects are a relatively minor part of the standoff in the East China Sea.

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[35] U.S. Energy Information Administration. "China leads the growth in projected global natural gas consumption." October 25, 2017.

[36] Ibid, p. 21.

[37] Mazneva, Elena. "From Russia With Love: A Super-Chilled Prize for China." Bloomberg. October 26, 2017, https://www.bloomberg.com/news/articles/2017-10-26/china-to-get-first-yamal-lng-cargo-as-russia-says-thank-you.

[38] International Crisis Group. "Central Asia's Silk Road Rivalries." July 27, 2017, https://www.crisisgroup.org/europe-central-asia/central-asia/245-central-asias-silk-road-rivalries.

[39] "Japan lodges protest against China's activity in disputed sea gas field." August 1, 2017, http://www.scmp.com/news/asia/east-asia/article/2104894/japan-lodges-protest-against-chinas-activity-disputed-sea-gas.

In the South China Sea, political rivalries have overshadowed the natural gas potential of the area. In 2011, Chinese government patrol vessels harassed Vietnamese oil exploration ships in disputed waters. In 2014, China sent an oil rig into waters Vietnam claims as part of its EEZ for several months of exploratory drilling. However, these incidents were minor compared to the 2015 and 2016 substantial expansion and construction of militarily useful facilities on seven Chinese-occupied islands in the Spratlys. China's policy for asserting control over the South China Sea currently is much more focused on sovereignty for political and military purposes than it is on natural gas development. In addition, a ruling of the Permanent Court of Arbitration has invalidated China's claims to an extensive EEZ in the South China Sea. Without a firm legal basis for drilling rights, even the Chinese state-owned natural gas companies would resist direction to make the investments required for long-term production in vulnerable offshore fields.

It is in the oil sector that China's quest for assured energy supplies has had the greatest geopolitical effects, as it moved into the position of the world's largest oil importer.[40] The basic Chinese energy security strategy has been to develop oil supplies from as many countries as possible, seeking both adequacy and resiliency of supply through diversity of sources. It has directed its national oil companies to bid for projects wherever it can around the world, even in unstable countries with fragile authoritarian governments. China's "no strings attached" approach has attempted to separate oil development projects from political involvement in the countries where it has projects, but it has been only partially successful. In South Sudan, for example, where China had invested in substantial oil development, it has recently joined peacekeeping efforts in Darfur to stabilize the region.[41] In Libya in 2014, China evacuated a large number of citizens, most of them involved in oil projects.[42] At the policy level, too, its international oil supplies have drawn it into geopolitics, causing China generally to cooperate with international initiatives to provide stability in oil-producing regions. For example, it cooperated to a limited extent in the multilateral oil sanctions against Iran that led to the agreement by Iran to limit its nuclear weapons development program.

One other geopolitical effect of China's increased oil imports has not been as positive, however. As China has imported more and more materials by sea to fuel its economic growth, the issue of the security of that shipping has become an issue in Chinese national security policy. Some in China, especially those favoring a larger Chinese Navy, have made the traditional argument that it is a matter of national security that China be able to protect shipping important to China's economic development. These arguments have made their way into official policy. In its 2015 defense white paper, entitled *China's Military Strategy,* is the observation,

[40] Crooks, Ed. "The global importance of China's oil imports." Financial Times. September 25, 2017, https://www.ft.com/content/e7d52260-a1e4-11e7-b797-b61809486fe2.

[41] China's Foreign Policy Experiment in South Sudan. https://www.crisisgroup.org/africa/horn-africa/south-sudan/288-china-s-foreign-policy-experiment-south-sudan.

[42] "Hundreds of Chinese workers are evacuated from Libya." BBC News. August 7, 2014, http://www.bbc.com/news/world-africa-28684555.

> "With the growth of China's national interests…the security of overseas interests concerning energy and resources, strategic sea lines of communication (SLOCs), as well as institutions, personnel and assets abroad, has become an imminent issue …"[43]

China has been building its Navy, and increasingly sending it overseas, and this capability has caused concern about China's intentions among a range of countries from India through Indonesia.

The American maritime strategist Alfred Thayer Mahan in his 1890 book *The Influence of Seapower on History,* first popularized the argument that national greatness depends on a country's access to overseas resources, and its ability to defend those resources from source back to the home country with naval power. Virtually all aspiring maritime countries since, from Germany through the Soviet Union, and now to China, used this argument as a rationale for a large and powerful Navy. In the modern era, it simply does not hold up to logical analysis. Since the end of World War II, there has been a consensus among the major powers that they should all protect global shipping as a benefit to all, and the only threats to shipping have come from small countries in restricted waters, most notably the "Tanker Wars" of the 1980s in the Persian Gulf. Indeed, China's first major deployments overseas have been to cooperate in the international naval patrols that have protected shipping of all countries against attacks by pirates operating out of Somalia. In addition, China has not optimized its naval development for protection of shipping, but for shows of force overseas and in future for a limited capability to put small numbers of aircraft and troops ashore.

In summary, China has used its increasing dependence on overseas imports, including energy imports, as a pretext for increasing its naval power. This naval buildup has caused both concern and offsetting military buildups in Asia by the United States, Japan and India, and in general has made cooperation with China more difficult for these countries.

China does have one legitimate concern with the security of its shipping, and this is in the context of conflict with the United States, for which the primary flashpoints are Taiwan and the Senkaku Islands. Should conflict occur in these areas, then it would be relatively straightforward for the United States to declare and enforce a war zone that would include major ports along China's coast, from Hainan to Shanghai, which would effectively cut off the major part of Chinese imports by sea. For petroleum, it would force China to institute rationing and use its strategic petroleum reserve, which it has built up in recent years. The effects of this military reality are a restraint on China's willingness to become involved in a conflict with the United States, as well as a determination to build up its maritime power to reduce this vulnerability.

In summary, the geopolitical effects of China's increasing imports of natural gas and oil are mixed. On the one hand, they are at times leading China to play a positive and responsible role in many areas of the world from which these hydrocarbons come. On the other hand, they are generating a sense of vulnerability that has resulted in a rationale for the development of military forces that can operate both in East Asia and in the Indian Ocean far from China that in turn cause fear and reactions to protect their own interests on the part of other countries.

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[43] The State Council of the People's Republic of China, *China's Military Strategy*, May 2015, http://eng.mod.gov.cn/Database/WhitePapers/index.htm, p.3.

India

India is increasingly important in the world energy picture. It is the third largest energy consumer in the world after China and the United States, the fourth largest consumer of oil, after China, the United States and Japan, and the fourth largest importer of LNG after Japan, South Korea and China.[44] With projected economic growth higher than any of those other four countries, India will become an even more substantial factor in the future global energy picture.

The government of India issued a draft National Energy Policy (NEP) in June 2017.[45] It frankly acknowledges the low energy efficiency of the economy, the heavy dependence on imported fossil fuels, the rudimentary state of that country's energy policies, and the multiple overlapping responsibilities of government agencies. A major focus of the plan is elimination of the price subsidies and price controls that discourage energy efficiency. It is an important goal, but in India and in many other countries the combination of popular resentment and entrenched interests makes this kind of reform very difficult.

The focus of the NEP is on poverty elimination, with the first energy policy objective "Access at affordable prices." Two of the most striking sections of the National Energy Policy are the discussions of the challenges of extending electrical service to the currently unserved 340 million Indians, and discussion of providing clean cooking fuel to the 40 percent of the Indian population that use firewood/chips, dung cake, kerosene and coke/coal.[46] The energy security issues of India are more basic than those of more developed Asian countries.

The NEP acknowledges the massive but inefficient role of domestic Indian coal production. Complicated subsidies and price controls have led to deep inefficiency in the operation of Coal India, Limited. The NEP calls for a doubling of domestic coal production and anticipates continuing imports of up to 25 percent of coal consumption. Although it discusses air pollution in major Indian cities, and proposes a series of measures to improve it, the NEP contains no discussion of the greenhouse gas effects of coal on global climate change.

The second goal of the energy policy is "Improved security and independence." The policy acknowledges that for the past decade imports of oil and natural gas have been increasing sharply, making the country less energy secure. It projects that import dependence will increase through at least 2040.[47] India has only a very small strategic petroleum reserve, offering little protection from supply interruptions. There are plans to increase it to the 90-day world standard by 2020, but it will be a difficult undertaking.[48] With a focus on poverty alleviation, and deep and increasing dependence on fossil fuel energy imports, it is little wonder that India bases its international energy policies on maintaining positive relations with all supplier countries, avoiding participation in sanctions regimes, and shifting the responsibility for dealing with climate change to more developed countries. In fairness, this last position has softened recently. These policies follow in the tradition of India's self-centered and non-aligned policies during the Cold War.

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[44] EIA Beta, https://www.eia.gov/beta/international/country.cfm?iso=IND.

[45] *Draft National Energy Policy, NITI Aayog, Government of India, Version as on 27.06.2017.*

[46] *Draft National Energy Policy, NITI Aayog, Government of India, Version as on 27.06.2017, p. 19.*

[47] Ibid, p. 27.

[48] EIA section on India: https://www.eia.gov/beta/international/analysis.cfm?iso=IND.

India imports most of its oil from the Middle East, and it goes to extraordinary lengths to avoid antagonizing any oil-producing country in the region. It notably did not join in international sanctions to pressure Iran to give up its nuclear weapons program, although it took a number of quiet moves behind the scenes to limit Iranian imports.[49]

India has ambitions to increase its natural gas imports. There are currently no gas pipelines crossing its borders, and the one planned line from Central Asia crossing Afghanistan and India's arch-rival Pakistan, presents extraordinary political risks. India is rapidly increasing its LNG imports. It has long-term contracts with Qatar, and makes additional substantial purchases on the spot market.

In summary, the future impact of India on the world energy picture will be to generate greater demand for fossil fuels. It has the highest projected economic growth rate among large countries, an inefficient coal production and electrical power sector, and declining production of oil and natural gas. Unless it can accomplish some very difficult structural reforms, India's imports of petroleum, LNG, and even coal, will continue to increase, absorbing a greater share of international fossil fuel trade, as other major countries reduce their imports, because of lower economic growth and energy security policies. With an international policy of cultivating good relations with all countries except Pakistan, especially countries with which it has economic interests, India can be expected to be an increasingly important advocate for international energy cooperation and stability.

United States

The United States plays an important role in the geopolitics of energy in Asia, both through its global economic, diplomatic and military policies, and through its energy imports and exports. The big American energy story in recent years has been the development of hydraulic fracturing of both natural gas and oil.

For LNG, the United States is now a net exporter, rather than an importer. LNG liquefaction plants for exports have now replaced a set of LNG gasification plants constructed for imports on the Gulf Coast in the 1990s. The largest LNG exports in 2016 went to the following countries, in order: Chile, Mexico, China, Argentina, India, Japan and South Korea.[50] Pipeline exports to Canada and Mexico dwarfed these seaborne exports, and total exports of natural gas comprise less than 10 percent of the 27 trillion cubic feet that the United States consumes every year.

For oil, the United States has become one of the top producers in the world, along with Saudi Arabia and Russia. Although the country still imports roughly half of the oil it consumes, because of refinery configurations and transportation arrangements, it has been exporting roughly 1.6 million barrels of oil per day (MMbd) of crude oil and refined products, mostly to North American neighbors.[51]

Energy security for the United States has always had both an economic and a national security element. Ever since the Arab oil embargo of the 1970s, successive administrations have called for "energy independence," with very little clear explanation of what

[49] Conversations of the author with retired Indian officials.

[50] U.S. Energy Information Administration. "U.S. Natural Gas Exports and Re-Exports by Country." https://www.eia.gov/dnav/ng/ng_move_expc_s1_a.htm.

[51] U.S. Energy Information Administration. "This Week in Petroleum: Crude oil and petroleum product exports reach record levels in the first half of 2017." September 27, 2017.

the concept meant. In fact, the source of American energy insecurity is the 93 percent dependence of the American transportation sector on oil. If the price goes up, American consumers and businesses have no alternative but to pay higher prices, no matter how much oil is produced domestically, with adverse effects on economic growth. The only oil producers capable of increasing production in the short term to reduce a price spike are in the Middle East, principally Saudi Arabia. It is for this reason that the United States has continued to be tied closely to events in the Middle East, concerned for the security of Saudi Arabia,[52] and the free flow of reasonably priced oil from the region. The current high level of American tight oil production does not change that situation. The only way to break this dependence is to reduce the role of oil in the transportation sector, through vehicles powered from alternative sources, and more efficient vehicles that continue to burn gasoline. There are encouraging initial steps in the deployment of electric vehicles and hybrids, but with 250 million American vehicles on the road, and prices at the pump that Americans believe they can afford, progress will be slow.

In the meantime, the United States in general is a *status quo* country in Asia. It has strong alliances, deep economic interests, and any changes in the geopolitics of the region would be to its detriment. Consequently, its overall policies tend to be reactive and stabilizing.

However, the geopolitics of American international energy policy are complicated and often contradictory. As an importer of oil, as the victim of supply shortages and price spikes, including those caused by OPEC, the United States has generally resisted government interference in world energy markets, despite their domination by national energy companies that take orders from foreign governments. The dramatic increase in American shale oil production combined with energy demand reduction caused by the world economic recession of 2008 has created slack in the world supply/demand balance. Oil prices since that time have been lower, lessening the concern about the threat of market manipulation by producers. The United States has always been ready to employ multilateral sanctions by importing countries against individual oil exporters. For years, it led multilateral oil sanctions against Iraq. More recently, the slack in the world oil market was also a factor in the American decision to pursue oil export sanctions against Iran. The loss of Iranian exports to the world market did not drive up the world price of very abundant oil.

The United States has tended not to use energy policies against its most powerful competitors, Russia and China. Apart from restricting financing of new exploration projects and sanctions against some energy executives, sanctions against Russia for its annexation of Crimea and aggression against Ukraine have not extended to oil.[53] The United States has actively assisted China in its attempts to exploit its own shale gas reserves,[54] and exports LNG to China.

As discussed earlier, American naval superiority is an implicit threat to China's oil and LNG imports in case of a conflict in East Asia over Taiwan or the Senkakus. Although

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[52] The relationship with Saudi Arabia has even been able to absorb the 2014 Saudi actions that drove many U.S. shale oil producers out of business.

[53] Sanctions passed by Congress in 2017 target companies that are connected to Russia's energy export pipelines. See H.R. 3364 – Countering America's Adversaries Through Sanctions Act, Pub. L. No.115-44 (2017). Also, see Dewan, Angela. "Russia sanctions: What you need to know." CNN. August 2, 2017. Accessed November 22, 2017. http://www.cnn.com/2017/07/25/europe/russia-sanctions-explainer/index.html.

[54] Author's conversation with Chinese energy experts.

no American national security official has discussed it publicly, it is of deep concern to paranoid Chinese military planners. The threat provides some restraint to Chinese aggression on the two issues, and forms part of the justification for the sustained buildup of Chinese maritime power in recent years. Because of the nature of the extended sea lines of communication for Chinese oil imports, and the vulnerability of large oil tankers, this vulnerability is unlikely to change for decades, if at all.

In general, then, American international energy policies have resisted interference and cooperation among producers for either economic or political reasons, but have favored cooperation among importing countries to punish or influence individual exporters. The United States has generally kept energy issues out of its relations with the most powerful countries, whether allies or competitors. Although the country is taking the initial steps towards breaking the dominance of oil in the transportation sector, energy security in oil will be a long time coming.

Conclusion

This chapter has surveyed the major international energy markets and the energy positions and policies of the United States and the three largest countries in Asia. It has discussed the geopolitics of the energy policies of these countries, the role that energy plays in their overall national security policies.

The weight of evidence is that the future of energy geopolitics in Asia will be more cooperative than confrontational, and that cooperative energy relations have a chance of being isolated from the great power rivalries of the region: America-China, China-Japan, India-China, America-Russia.

There are several factors involved: In the first place, international cooperation among the energy companies of the major powers, whether private or state-owned, is frequent and routine. In the second place, energy shortages and high prices hurt all countries, and none of the major countries has yet found a way to use its energy policies to punish or reward in a precise manner. There is no Saudi Arabia in East Asia with the means and incentive to move the market for its geostrategic purposes. In the third place, growing evidence of climate change has given a sense of common threat to all the major countries, although India lags the rest. Although it is not an overriding policy imperative for any country, domestic opinion in all countries favors common action to deal with the threat.

Unexpected developments could upset this hopeful scenario. Conflict between China and the United States over Taiwan, or among China, Japan and the United States over the Senkaku/Diaoyus could involve diversions or even attacks on energy shipping that would fundamentally change the geopolitics of Asian energy in the future. The United States and major Asian countries will meet conflict in the Middle East with cooperation, but conflict might also raise policy differences as oil supplies are threatened. Great power rivalry might intensify in the region, leading to a chilling of cooperation.

However, it is more probable that the United States and the major countries of Asia will see it in their interest to cooperate, which will ensure their individual national energy security within greater energy security for all. This cooperation in a large and vital sector of the world economy should contribute to sustaining peace in the region despite national rivalries.

Chapter Three

Japan's Energy Miracles

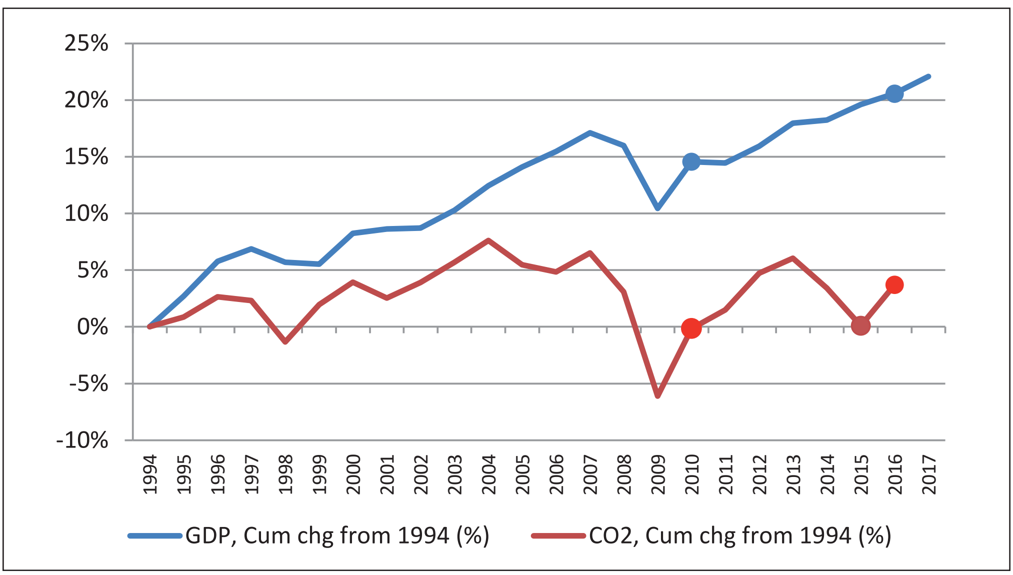
Dr. Robert Alan FELDMAN
Adjunct Professor, Management of Technology Program,
Tokyo University of Science
Senior Advisor, Research Department, Morgan Stanley MUFG Securities

Introduction

In February 2011, nuclear power provided about 1/3 of Japanese electricity. In June 2011, three months after the Fukushima nuclear accidents, it provided virtually none. Many feared that replacing this nuclear-generated electricity with fossil fuel-based electricity would be a knock-out blow for CO2 control. But it did not happen that way.

Japan has long been skilled at holding energy use and CO2 control. Indeed, between 1994 and 2010, real GDP rose by about 14.5 percent, but CO2 emissions were flat. Part of this performance derives from the increased share of nuclear power during that period. However, even though CO2 emissions have risen by about 4 percent since 2010, this performance since then has been, in one sense, even more extraordinary than before. Even losing 30 percent of power supply from non-CO2 sources, Japan still managed to hold CO2 increases to about 2/3 of the increase of real GDP. Regardless of whether one is a supporter or skeptic on nuclear power, analyzing the success of the post-Fukushima CO2 performance has lessons for a better energy future.

Figure 1: Real GDP and CO2 Emissions - Cumulative Changes since 1994



Sources: GDP data from Japan Cabinet Office; CO2 data from World Bank; and Morgan Stanley calculations.

Why has Japan Been Successful (So Far), Despite Fukushima?

There are two ways to look at the course of CO2 emissions, the Kaya Identity and an energy supply chain. Let us start with the Kaya Identity, which was used first in 1993, by Yoichi Kaya, one of Japan's premier energy researchers. The relationship is simple, but profound:

$$CO2 = \frac{CO2}{X} * \frac{X}{GDP} * \frac{GDP}{P} * P$$

Where CO2 is the emission of CO2 from human-based sources, X is the quanity of energy used, GDP is real output, and P is the population. In words, this says that total emissions equal the product of four factors, (a) CO2 intensity of the mix of energy used, (b) energy intensity of GDP, (c) the standard of living, i.e. real GDP per person, and (d) the population. When analyzing past and potential trends in CO2 emissions, this breakdown is extremely helpful.

Using data from the U.S. Energy Information Administration (EIA) on CO2 and total energy use, we compare the basic data and the Kaya Identity components for 2010 and 2015 (Figure 2). First, on the components, total CO2 emissions grew by 0.82 percent per year; this is not good, in light of the goals of actual reduction of CO2 emissions, but at least is below the real GDP growth rate of 0.98 percent. The amazing number is the total energy consumption – which fell by 1.83 percent per year.

Next, looking at the Kaya Identity components, the bad news was the worsening of CO2 intensity. This worsening derived from the shutdown of the nuclear power stations, and substitution of fossil-based fuels for the largest part of the primary energy needed. The good news came in the stunning improvement of energy intensity in GDP, which fell by 2.79%/year – a bit more than CO2 intensity worsened. While these two factors largely offset each other, the standard of living rose by about 1 percent, and the population declined slightly.

Figure 2: Japan — The Kaya Identity, 2010 vs. 2015

	Variable Name	Unit	2010	2015	CAGR
Total CO2 Emissions	CO2	bln tn	1,108	1,154	0.82%
Total energy Consumption	X	quads	21.5	19.6	-1.83%
Real GDP(PPP)	GDP	US$ bln (PPP)	4,319	4,535	0.98%
Population	P	Mln	127.3	126.8	-0.08%
CO2 Intensity	CO2/X	bln tn/quad	51.535	58.883	2.70%
Energy Intensity	X/GDP	quad/GDP	0.00498	0.00432	-2.79%
Standard of Living	GDP/P	$ GDP/Person	33.93	35.76	1.06%
Population	P	mln people	127.3	126.8	-0.08%

Note: Total CO2 emissions in this table may differ slightly from those in Exhibit 1, due to different data sources.
Source: U.S. EIA, International Energy Outlook, various years; and author's calculations.

In short, the first Japanese energy miracle was that energy intensity of GDP improved at such a whopping pace.

There was a second miracle as well. The second miracle was the transformation of energy supply that restrained the growth of CO2 (Figure 3). The huge drop of the share of nuclear power (12.5 percent) was filled very little by liquids – whose share rose only

0.7 percent. Indeed, the absolute amount of liquids used actually fell. There was a 2.8 percent rise of coal use; however, in light of the reduction of overall energy usage, the absolute amount of coal use rose by only 0.2 quads (from 4.1 to 4.3). The lion's share of the increase of fossil fuels came from natural gas – which emits about half of the CO2 per unit of energy that petroleum or coal do. Moreover, the increase of renewables should not be ignored (or exaggerated).

Figure 3: Japanese Energy Consumption, by Primary Energy Source, 2010-2015

								Shares		
	2010	2011	2012	2013	2014	2015	CAGR	2010	2015	Change
Total energy consumption	21.5	20.9	20.4	20.2	19.9	19.7	-1.8%	100.0%	100.0%	--
Liquids	8.9	9.0	9.5	9.1	8.6	8.3	-0.6%	41.4%	42.1%	0.7%
Natural Gas	4.1	4.7	4.9	4.9	4.9	5.0	0.9%	19.1%	25.4%	6.3%
Coal	4.1	3.9	4.1	4.3	4.4	4.3	0.2%	19.1%	21.8%	2.8%
Nuclear	2.8	1.6	0.2	0.1	0.0	0.1	-2.7%	13.0%	0.5%	-12.5%
Renewables	1.6	1.7	1.7	1.8	2.0	2.0	0.4%	7.4%	10.2%	2.7%

Source: U.S. EIA, International Energy Outlook, various years; and author's calculations.

To summarize, Japan's good performance – given the circumstances of the nuclear accidents – in restraining CO2 emissions stemmed from a major drop of energy intensity and a major shift toward less polluting sources of primary energy.

The Supply Chain Approach: Kaya Identity on Steroids

The Kaya Identity is useful because it summarizes a complex process in simple terms. However, some interesting detail is also lost. Hence, we also have created an "energy supply chain" for Japan, and compared 2010 to 2015 – again using EIA data. The supply chain (Exhibit 4) starts with the different types of primary energy sources, shows how they are converted to energy carriers (fuel and electricity), next shows the losses as these are delivered to final users, and then shows which sectors of the economy use the energy – and finally ends with net energy use.

Sources: The change of sources is exactly as seen in the previous table: (1) Extractables are down, and renewables are up; a significant amount of this shift is attributable to the government's feed-in-tariff (FIT) system for electric power. The FIT rates were initially set very high, and triggered a rush of investment into renewable energy, especially solar power; and (2) Among the extractables, LNG is up sharply and coal slightly, while petroleum is down and nuclear (which we include as an extractable, because uranium is mined) down very sharply.

Carriers: Given the overall decline of primary energy use, it is no surprise that both fuel and electricity production fell between 2010 and 2015. The drop of electricity was slightly larger in percentage terms. Within fuel, petroleum took most of the hit, while other fuels remained largely stable. Within electricity generation, nuclear dropped to near zero; the hole was filled first by LNG, second by renewables, and third by coal (and a bit of petroleum).

Figure 4: Japan's Energy Supply Chain, 2010 vs. 2015 (Unit: quads)

Primary Sources	2010	2015
Total	21.5	19.7
Extractables	19.9	17.7
Petrol	8.9	8.3
LNG	4.1	5.0
Coal	4.1	4.3
Nuclear	2.8	0.1
Renewables	1.6	2.0

Carriers	2010	2015
Total	21.5	19.6
Fuel Produced	12.9	12.0
Petrol	8.6	7.8
LNG	1.8	1.7
Coal	2.1	2.0
Nuclear	0.0	0.0
Renewables	0.4	0.5
Electricity Produced	8.6	7.6
Petrol	0.3	0.5
LNG	2.3	3.3
Coal	2.0	2.2
Nuclear	2.8	0.1
Renewables	1.2	1.5

Losses	2010	2015
Total	5.1	4.3
Fuel Loss	0.0	0.0
Electricity Loss	5.1	4.3

Deliveries	2010	2015
Total	17.0	15.4
Fuel Delivered	13.4	12.1
Residential	1.0	0.9
Industrial	0.9	0.9
Commercial	7.5	6.7
Transport	4.0	3.6
Electricity Delivered	3.6	3.0
Residential	1.2	1.1
Industrial	1.4	1.1
Commercial	0.9	0.7
Transport	0.1	0.1

Sector Use	2010	2015
Total	17.0	15.4
Non-Transport	12.9	11.7
Fuel	9.4	8.5
Electricity	3.5	3.2
Transport	4.1	3.7
Fuel	4.0	3.6
Electricity	0.1	0.1

Economy	2010	2015
Total	17.0	15.4

Source: U.S. EIA, International Energy Outlook, various years; and author's calculations.

Losses: By definition, losses are assumed to be zero for fuels – although this definition is a bit odd (for example, trucks have to deliver gasoline), we adopt it here, for ease of analysis. For electricity, losses actually shrank somewhat, from a loss rate of 59.3 percent to 56.6 percent. Thus, the Japanese energy miracles in part were supported by better performance of the electric grid.

Deliveries: The deliveries data show which sub-sectors saved the most. The standout is the commercial sector, which reduced usage of both fuel and electricity significantly. The industrial sector reduced electricity usage, but not fuel. The transport sector did exactly the opposite, reducing fuel, but not electricity.

Sector Use: By large sector, both transport and non-transport (e.g., heating, lighting) reduced use of fuel. Although the non-transport sector reduced use of electricity as well, transport did not do so – most likely because of the shift toward electricity-intense train usage, resulting from higher demand for public transport.

This more detailed view of energy usage in the 2010-15 period shows that improvements were concentrated is certain parts of each stage of the supply chain. In particular, the good CO2 performance was based on:

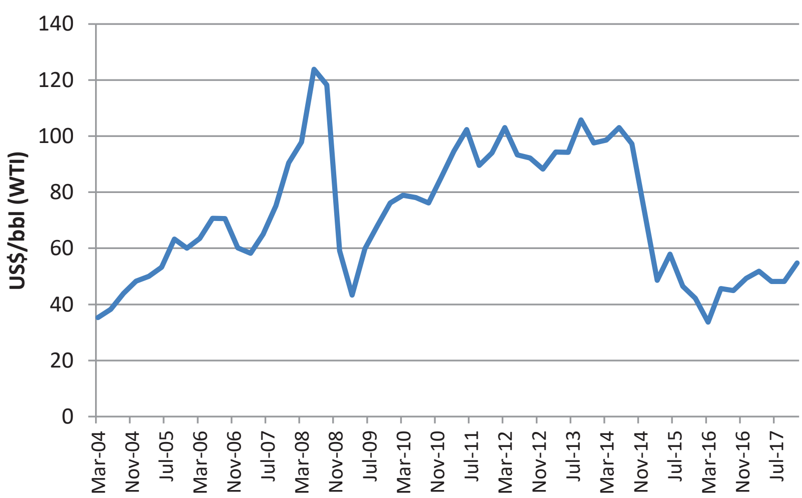
(a) Increased renewables use,
(b) A shift among extractables to lower-CO2 sources,
(c) A modest shift away from electricity,
(d) A reduction of losses in electricity transmission, and
(e) A strong effort by the commercial sector in particular to save energy.

Can the Miracles Continue?

While Japan's energy accomplishments in the wake of the Fukushima accident are praiseworthy, they also raise a difficult question: Are these accomplishments harbinger or artifact? Indeed, while the performance was impressive, the fact is that CO2 emissions are up, not down. Price matters too, because Japan remains highly dependent on external energy. Japan's energy future depends on whether it can redouble the efforts of recent years.

Let us start with price (Figure 5). Energy prices were already high when the Japanese energy miracle started. Indeed, prices had been rising steadily since 2004 – the frightening spike in 2007-08 increased attention to energy conservation. Some impact of higher energy prices is immediate, such as high gasoline prices leading to less auto travel, more efficient routing, and switching to other means of transport. Other impacts take much longer to realize, in light of the tendency for energy infrastructure to take long times to build and to be long-lived (and thus hard to abandon, even when a good alternative comes along). The upward trend of oil prices and the shock of 2007-08 could well have shifted energy investments toward high-efficiency alternatives, which bore fruit in improvements of energy efficiency in later years.

Figure 5: The Price of Oil (WTI), US$/bbl

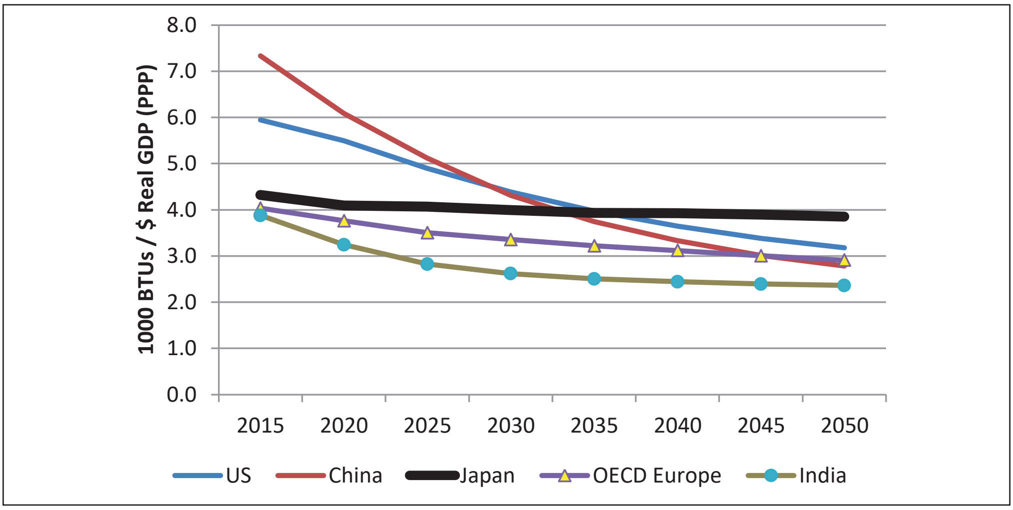


Source: Nikkei NEEDS.

Since 2014, however, energy prices have fallen sharply. The high price of oil in earlier periods had triggered oil investments in many regions, and the technology of shale oil developed rapidly in the 2005-15 period, increasing oil supply further. With demand edging up only slowly (and with shale gas bringing the overall supply of energy up), energy prices collapsed. The incentive to save energy dropped sharply as a result. It remains to be seen whether the ratchet effect from better technology on energy efficiency offsets the price effect from lower energy prices. The income effect from lower energy prices also could increase demand, canceling part of the reduction of CO2.

Another issue is how fast technology will spread. The latest outlook from the U.S. Energy Information Administration (EIA) is skeptical about Japanese prospects. In the latest *International Energy Outlook*,[55] the EIA presents projections for real GDP growth and total energy use. From these data, it is easy to derive the implicit projections for energy intensity of GDP (Figure 6). There is a striking difference between Japan and other nations: Energy intensity of GDP in Japan hardly improves at all over the 45 years of the projection period, while most other countries show substantial improvements. How can this difference be explained? Will Japan suddenly suffer from scientific *sakoku*?[56] Alternatively, is this a case of very slow diffusion of new innovations, due to economic circumstances?

Figure 6: Energy Intensity of GDP (Th Btu/$ Real GDP [PPP])



Source: U.S. EIA, International Energy Outlook, 2017, and author's calculations.

Modeling the diffusion of technology change has been a difficult task.[57] The canonical model is an S-Curve, where technology moves very slowly in the first few years (or decades), then diffuses very quickly for a short period, and then slows before reaching saturation.[58] However, this process applies to many interacting technologies simultaneously; therefore, the overall rate of efficiency improvement is hard to determine.

For the EIA's projection of energy intensity to be true, one would have to argue that the interaction of new energy technologies will result in some countries (both developed and emerging) having rapid technology diffusion, while others have slow diffusion.

[55] See Energy Information Administration. *International Energy Outlook*, 2017, at https://www.eia.gov/outlooks/ieo/pdf/0484(2017).pdf.

[56] "Sakoku" was the Edo period policy, enforced from 1633 to 1853, of closing the Japan to foreign influence.

[57] Among useful books on this issue are: Rogers, Everett. *The Diffusion of Innovations*, (Fifth Edition), Free Press, 2003; Valente, Thomas W. *Network Models of the Diffusion of Innovations*, (Second Edition), Hampton Press, 1995; Moore, Geoffrey, *Crossing the Chasm*, (Third Edition), HarperCollins, 2013.

[58] An example is hybrid electric vehicles. Ferdinand Porsche built the first such vehicle in 1900. (See "Prof. Ferdinand Porsche Created the First Functional Hybrid Car," at http://press.porsche.com/news/release.php?id=642. The car had a driving range of 200 km, and a top speed of 35 km/h.) The idea was largely dormant thereafter, until 1973, when VW produced a hybrid in the wake of the first oil crisis. As oil prices fell, the idea hibernated again, until revived by Toyota in the late 1990s. Toyota triggered the acceleration phase of the hybrid car S-curve began.

Key variables might be: (a) the level of real GDP, which helps to determine the size of the energy market; (b) the rate of real GDP growth (which determines the need for new energy, and hence for new energy technologies); and (c) the initial level of energy efficiency (which determines the economic incentive to introduce new technologies).

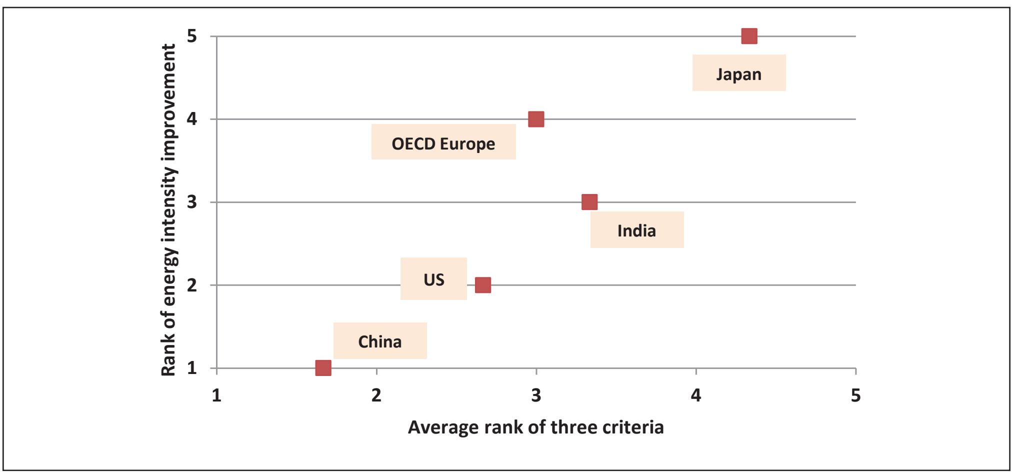
With these three variables in mind, how does Japan fare (see Figure 7)? First, real GDP is the smallest of the five countries considered, arguing for a slower rate of diffusion. Second, the rate of GDP growth is projected to be low, in light of demographics, arguing for a slower rate of diffusion. Third, the initial level of energy efficiency is high, arguing for a slower rate of diffusion. In short, all three elements argue for Japan to be slow. The EIA projections are at least consistent with this simple, macro-based diffusion model. The correlation between the average ranking of the three criteria and the ranking of EIA projections of energy improvement (See Exhibit 8) are very close.

Figure 7: Macro Criteria and Rankings

	Real GDP (2015 real $, PPP)	GDP growth (2015-50), CAGR	Energy Intensity (2015)	Energy Intensity Improvement (2015-50), CAGR	GDP Level Rank	GDP Growth Rank	Energy Intensity Rank	Average Rank	Rank of Energy Intensity Improvement
US	16.4	2.1%	5.95	1.8%	3	3	2	2.67	2
China	18.2	3.7%	7.33	2.7%	2	2	1	1.67	1
Japan	4.5	0.1%	4.32	0.3%	5	5	3	4.33	5
OECD Europe	19.8	1.3%	4.03	0.9%	1	4	4	3.00	4
India	7.3	4.3%	3.88	1.4%	4	1	5	3.33	3

Source: Data from EIA; Author's rankings.

Figure 8: Macro Criterial Average Ranking vs. Energy Intensity Improvement Ranking

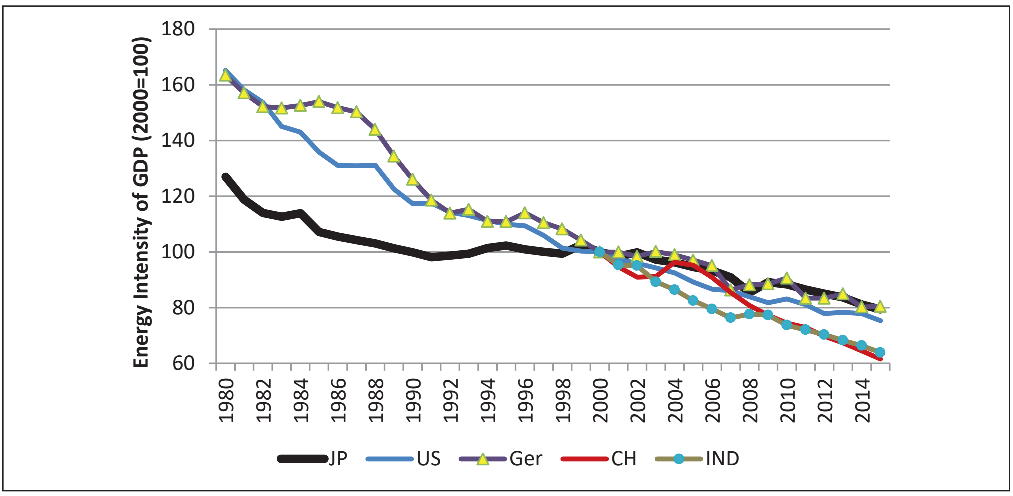


Source: Data from EIA; Author's rankings.

However, we are skeptical of the EIA conclusion for several reasons.

1. First, the slow level of Japanese real GDP growth may well be due to demographics, but other countries will face the same problem. Indeed, the Chinese population will begin to shrink in the mid-2020s, and thus the strength of this factor may be worse for other countries than the EIA projects.
2. Second, the nature of dependence of technology on macro factors may differ from the approach used in the model of the EIA. Especially today, when knowledge can be shared instantaneously through the internet, historical correlations of diffusion with macro variables may be less reliable. This factor may be especially important for Japan. Despite having moved in tandem in the 1980s, Japanese energy intensity stagnated in the 1990s, while U.S. and German energy intensity continued to improve (Figure 9). However, once the recessions of the 1990s ended and business investment restarted, Japanese energy intensity resumed its downward path, quite in line with improvements in the United States and Germany. The implication is simple: When overall investment stagnates due to macro factors, energy intensity stagnates as well.
3. Third, the mere ranking of factors cannot assign numerical sensitivity to the impact of any single factor; that is, even if the rankings are right, the growth rates of energy intensity of GDP for Japan could be wrong.

Figure 9: Energy Use per Unit of GDP (2000=100)



Note: Data for China and India begin in 2000.
Source: International Energy Agency, http://www.iea.org/statistics/, IEA Headline Energy Data, and author's calculations.

For these reasons, we are skeptical of the EIA's forecast of long-term stagnation of Japanese energy intensity improvement.

A Deeper Concern: Speed of Diffusion

Despite our skepticism on the EIA's numerical projections, we remain concerned about Japan's energy future. Our primary concern is about the speed of technology diffusion. We think that the diffusion contains three stages: Science, Innovation, and Entrepreneurship.

At the science stage, our concern involves both budgets and education. On budgets: The International Energy Agency (IEA – not to be confused with the U.S. government's EIA) review of Japanese energy policy in 2016 estimated that government spending on energy RD&D (research, development, and diffusion) was ¥0.29 trillion, or 0.06 percent of GDP. This is an extremely small amount, compared either to total energy imports (4.3 percent of GDP, on average, 2007-2016) or spending on social programs (about 22 percent of GDP). On education: As demographics quickly lower the number of students in Japanese schools, the ability of the nation to produce enough energy scientists will be further limited. Some universities are actively trying to recruit foreign students, and those students have an easy time obtaining employment in Japanese firms – due to the labor shortage. However, the attractiveness of Japan as a destination for students is hampered by the lower international ranking of Japanese universities and the relative lack of English-language programs.

At the innovation stage, we have few worries about the innate innovation capacity of the Japanese people. However, the heavy influence of vested interests in the energy industry tends to skew corporate innovation toward legacy technologies (i.e. incremental improvements), and away from novel ones. Even within government funded energy R&D, there remains a heavy emphasis on nuclear power research, to the detriment of vanguard technologies that other countries are pursuing.

At the entrepreneurship stage, the situation in Japan is even more worrisome. The amount of venture capital funding in Japan is extremely small, relative to other countries.[59] That said, the recent changes in the regulatory structure for the electric power industry have ushered in much more competition – for the first time since the regional electric monopolies were authorized in the early postwar period. Thus, the returns to entrepreneurship may be higher than before.

Conclusion

Japan's energy miracle of 2010-15 is under-appreciated. Despite the virtual elimination of nuclear power after the 2011 earthquake, Japan managed to contain the increase of CO2. This outcome was accomplished through changing the mix of primary energy and herculean energy saving efforts on the part of business. Policy aided the improvement, due to the effective feed-in-tariff system for electricity generation. Moreover, rising energy prices in 2004-10 also spurred more conservation.

Looking forward, the outlook may not be as good. The drop of global energy prices from 2015 has taken the edge off the need for conservation. The government has lowered feed-in-tariff rates substantially, especially for solar power. Meanwhile the official report on the "best mix" of energy for the country contains a role for nuclear power that would necessitate the building of new nuclear power stations – which is politically unlikely and probably not economic either. Vested interests continue to have tremendous power in the energy industry, and may further impact the science, innovation, and entrepreneurship in energy industries. These factors suggest that Japanese energy policy may have fallen into the Complacency phase of the CRIC cycle – a cycle of Crisis,

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[59] A 16 page report on global venture capital by Ernst&Young ("Back to Reality: EY global venture capital trends 2015" estimated that the U.S. saw $72.3 bln of venture capital deals (3916) in 2015, China saw $49.2 bln (1611), India $8.0 bln (528), and Japan only $0.8 bln (354). See http://www.ey.com/Publication/vwLUAssets/ey-global-venture-capital-trends-2015/$FILE/ey-global-venture-capital-trends-2015.pdf, p. 3.

Response, Improvement, and Complacency that describes the interaction of policy and markets.[60]

In earlier CRIC cycles (be they in the financial sector, industry, or government), the primary question is whether a Response is ready when a Crisis phase starts. If so, then the Crisis can be short-lived and in the end constructive. If not, then precious time will be lost.

[60] For an account of the CRIC cycle, see Feldman, Robert, "CRIC Cycle Reprint," Morgan Stanley, December 20, 2013. This report was originally published on April 4, 2001.

PART 2:

ROLE OF ENERGY SUPPLY AND MARKETS

Chapter Four

Reliance on Imported Fossil Fuels: Oil and Natural Gas

Dr. Ken KOYAMA
Chief Economist and Managing Director, Institute of Energy Economics, Japan

The Role of Fossil Fuels

Energy is essential for sustaining our lives and economic activities, and stable, sustainable energy supplies and prices are crucial for any society or state today. Today, the world's energy supply consists mostly of fossil fuels, namely oil, coal and natural gas. Like most of the rest of the world, Japan relies heavily on fossil fuels and will continue to do so for the foreseeable future. This chapter focuses on the role two of those fuels, oil and natural gas, have played and play in Japan's energy mix.

Oil

Oil is still the most important source of energy supply in Japan, accounting for 45.0 percent of total primary energy supply (TPES) in Japanese fiscal year (JFY) 2015. The share of oil in TPES was much higher during the 1970s, peaking at 77.4 percent in JFY 1973.

Because of the lack of domestic oil resources, Japan has been highly (almost 100 percent) dependent on imports for its oil supply. As for its import source, the Middle East has been the dominant source of supply to Japan with the share of Middle East crude oil in total crude oil imports peaking at 90 percent in JFY 1966.

Oil plays a critically important role in fueling the Japanese economy and civil life as an energy source used widely in variety of economic sectors. In JFY 2015, oil consumption in the transportation sector accounted for the largest share at 47.4 percent of total final oil consumption, followed by the industry sector (36.5 percent) and the household sector (13.9 percent).

Because of high oil dependence in TPES and Middle East import dependence, oil crises in the 1970s, with their higher oil prices and concerns over the physical shortage of oil, caused serious damage to the Japanese economy and civil lives. Since then, oil policy – more appropriately oil supply security policy has continued to be a top priority of Japanese energy policy. Since the 1970s, Japan's oil supply security policy has been a combination of five policies:

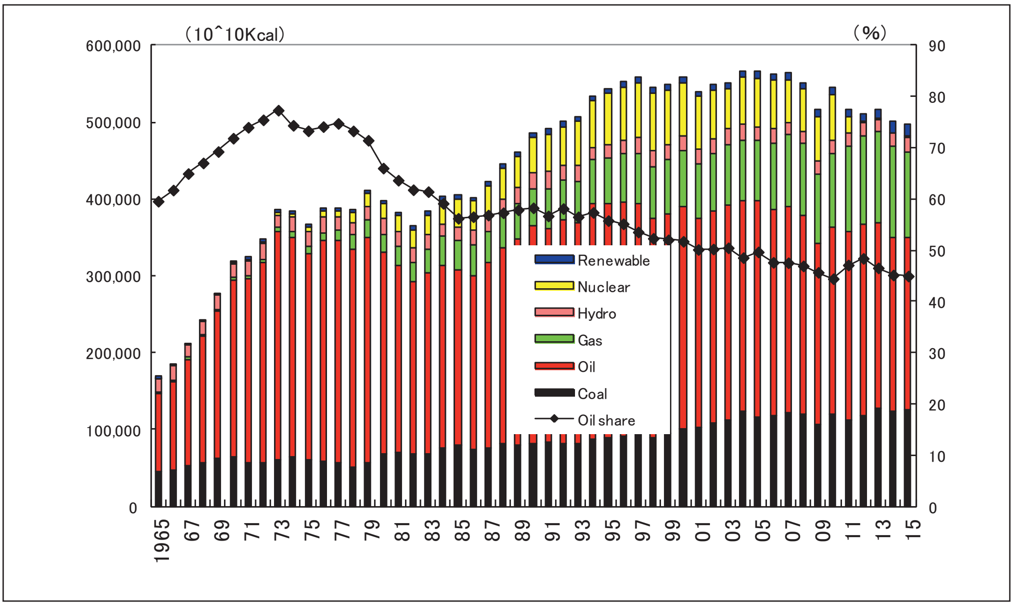
a) Reduce Oil Imports,
b) Diversify Oil Import Sources,
c) Strengthen Relations with Oil Producing Countries,
d) Enhance Emergency Preparedness, and
e) Strengthen Oil Industry in Japan.

Policy to Reduce Oil Imports

This policy approach can be broken down further into the following three policy categories, namely energy source diversification, energy efficiency/saving enhancement, and promotion of domestic oil production.

The Japanese government, spearheaded by the Ministry of International Trade and Industry (MITI), later renamed as the Ministry of Economy, Trade and Industry (METI), has implemented policy measures to promote alternative energy sources to oil such as nuclear power, natural gas, coal and renewable energy since the 1970s.[61] The energy supply from these alternative sources continued to increase and as a result, the share of oil in TPES in Japan continued to decline from the peak of 77.4 percent in JFY 1973 to 44.5 percent in JFY 2010 (Figure 1).

Figure 1: Trends in Japan's Primary Energy Supply



Source: IEEJ/EDMC, "Handbook of Japan's and World Energy and Economic Statistics"

The share of oil temporarily increased after JFY 2011 when the Great Eastern Japan Earthquake and Tsunami, and the Fukushima nuclear accident resulted in the shutdown of Japan's nuclear fleets in turn resulting in a substantial increase in use of fossil fuels, including oil in power generation, to offset the reduction in nuclear power generation. However, it is important to note that there still is a fundamental trend of a declining share of oil in TPES. The share of oil actually declined again from 48.4 percent in JFY 2012 to 45.0 percent in JFY 2015.

Energy efficiency improvement has played an important role behind the scene in the decline of oil dependency. MITI (METI) promoted policies to improve energy efficiency by introducing such measures as powerful energy saving laws, regulations,

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[61] Refer to the relevant chapters for a detailed discussion of each alternative energy source development.

and economic incentives.[62] Thanks to the success of these policies and efforts made by industry and Japanese citizens to improve energy efficiency, most of the world now regards Japan as the global "top-runner" of energy efficiency/saving. Fuel efficiency improvement in vehicle transportation sector especially resulted in a structural decline in oil consumption in Japan. Oil consumption in Japan actually peaked in JFY 2005 and since has continued to decline.

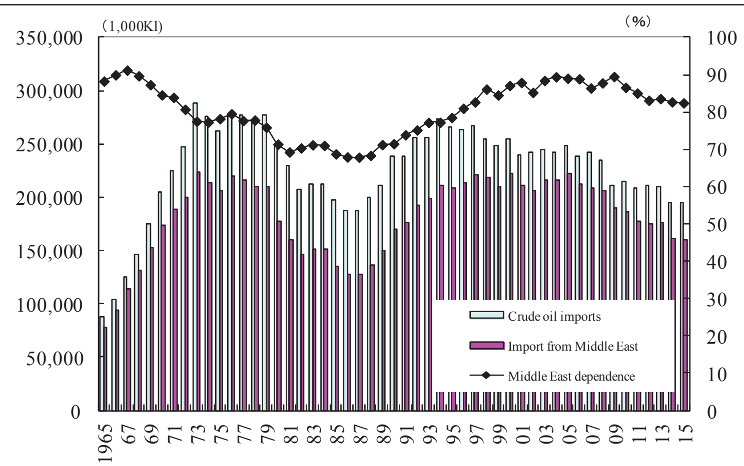
The policy to promote domestic oil production had very limited effects because of the lack of domestic oil resources in Japan. Given this situation, MITI/METI embarked on a policy to promote overseas oil development by Japanese companies by providing financial assistance through government related entities such as the Japan National Oil Corporation (JNOC), later renamed as the Japan Oil, Gas and Metals National Corporation (JOGMEC), details about which are in a later section of this chapter.

Policy to Diversify Oil Import Sources

As a high dependency on Middle East oil is a perceived source of concern, MITI/METI tried hard to diversify oil import sources and reduce Middle East dependency. In this regard, a typical example of the policy efforts is the promotion of crude oil imports from China, Indonesia and Mexico. The government promoted these imports under the umbrella of government-to-government (G-to-G) dialogues/negotiations between Japan and each of these respective countries.

Crude oil imports from the three countries temporarily increased in the 1980s, lowering Middle East dependency to 67.9 percent in JFY 1987 (Figure 2). Crude oil imports from the three countries then started to decline. For China and Indonesia, the availability of their crude oil for exports declined (as their domestic oil demand expanded) until finally they became net importers of oil. For Mexico, Japanese refiners did not find the economics of importing Mexican crude oil attractive enough.

Figure 2: Trends in Japan's Dependence on Middle East Crude Oil



Source: IEEJ/EDMC, "Handbook of Japan's and World Energy and Economic Statistics"

[62] Refer to the relevant chapters for a detailed discussion of energy efficiency policy.

Therefore, Middle East crude oil import dependence bottomed out and started to rise again, reaching as high as 89.5 percent in JFY 2009. While the recent development of Russian crude oil exports from its Sakhalin projects and the ESPO (Eastern Siberian Pacific Ocean) pipeline is contributing to lowered Middle East dependence, the fact remains that Japan continues to be highly dependent on Middle East oil supply.

Policy to Strengthen Relations with Oil Producing Countries

Despite its various efforts, Japan's status is unchanged as a highly oil import/Middle East dependent country. That is why the Japanese government regards the policy to strengthen relations with oil producing countries as very important with an expectation that it should contribute to Japan's oil supply security.

The government has employed a comprehensive approach to strengthen these relationships, promoting economic, industrial, investment and trade relations as well as promoting cooperation in the areas of economy, culture and human networking including capacity building. In order to carry out this approach, not only MITI/METI but also other government ministries such as the Ministry of Foreign Affairs, and even diplomacy at the highest levels of government all played their respective roles in strengthening relationships.

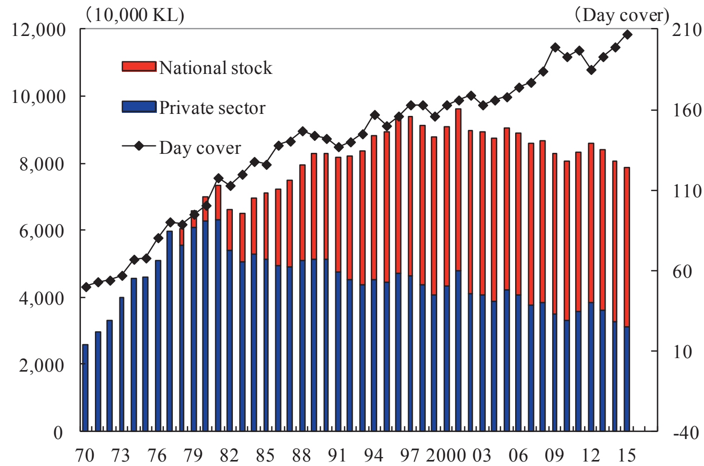
Policy to Enhance Emergency Preparedness

The severe experiences brought about by the oil crises in the 1970s taught Japan that it was extremely important to enhance its capability to deal with oil supply emergencies. With this recognition, MITI started to build an oil stockpile in Japan as a counter measure to oil supply emergencies.

Even before the first oil crisis in 1973, MITI introduced oil stockpile obligations for Japanese oil companies. Nevertheless, after the crisis, MITI decided to increase the day cover requirement for mandatory stockpiling to 90 days of consumption in Japan. Furthermore, the government decided to develop government-owned strategic stockpiles on top of the stockpiling obligation of the industry. JNOC/JOGMEC is the designated governmental entity responsible to manage the strategic stockpile. In recent days, Japan's oil stockpile covers more than 200 days of oil consumption in Japan (Figure 3), contributing to improvement of emergency preparedness for oil supply security.

Japan also regards international cooperation to prepare for, and deal with, supply emergencies as a critically important policy tool. In particular, participation as a founding member and cooperation with the International Energy Agency (IEA), established in 1974 to counter oil supply insecurity, is a centerpiece of Japan's policy. Japan has joined IEA-led coordinated response measures to deal with oil supply problems in the world market three times (the Gulf crisis in 1991, Hurricane Katrina in 2005 and the Libya crisis in 2011). In comparison with its capability before the 1973 oil crisis, Japan has improved its emergency preparedness substantially.

Figure 3: Trends in Japan's Oil Stockpile



Source: IEEJ/EDMC, "Handbook of Japan's and World Energy and Economic Statistics"

Policy to Strengthen Oil Industry in Japan

For upstream side of the industry, MITI/METI has continued to promote overseas oil (and gas) development by Japanese companies. This policy has been based on the perception that oil fields developed by Japanese oil companies (not foreign companies) can be regarded as "more secured sources of supply" because they are under control of Japan (Japanese companies). Another element behind this policy is the recognition that the promotion of Japanese upstream companies can help strengthen the international competitiveness of those companies as the upstream segment is an important source of revenue/profit for the oil industry.

JNOC/JOGMEC has provided financial assistance to overseas oil (and gas) exploration and development activities of Japanese companies as a tool to support the government policy. For example, METI has a target that oil and gas developed overseas by Japanese companies should account for more than 40 percent of total oil and gas imports by 2030.

For the downstream side of the industry, a very important policy approach taken so far is the deregulation/liberalization of the downstream market in a bid to streamline the industry and enhance its competitiveness. The oil industry in Japan was under strong and direct government control until the late 1980s when the process of deregulation/liberalization started. The process continued in the 1990s and completed in 2002 when the government abolished the Oil Industry Law, the basic law to regulate the industry.

Coupled with the severe competition that resulted from liberalization and declining domestic oil demand, oil companies in Japan came under strong pressure to streamline not only company operations and financial capabilities but also the industry structure itself. Mergers between companies continue in the Japanese downstream market. Most recently, JXTG group emerged from the merger between JX and Tonen General on April 2017 as the new dominant company with a domestic market share exceeding 50 percent in Japan.

Natural Gas

LNG as an Important Energy Source for Japan

Natural gas accounted for just around 1 percent in TPES in Japan during the 1960s and early 1970s because domestic gas production was very limited and there were no gas imports as a supply source. However, the first introduction of liquefied natural gas (LNG) imports from Alaska in 1969 by Tokyo Electric Power Company (TEPCO) and Tokyo Gas became an important milestone for gas market development in Japan. Since then, Japan's LNG imports have continued to expand, making Japan the world's largest LNG importer. LNG is now becoming a critical part of the country's energy market.

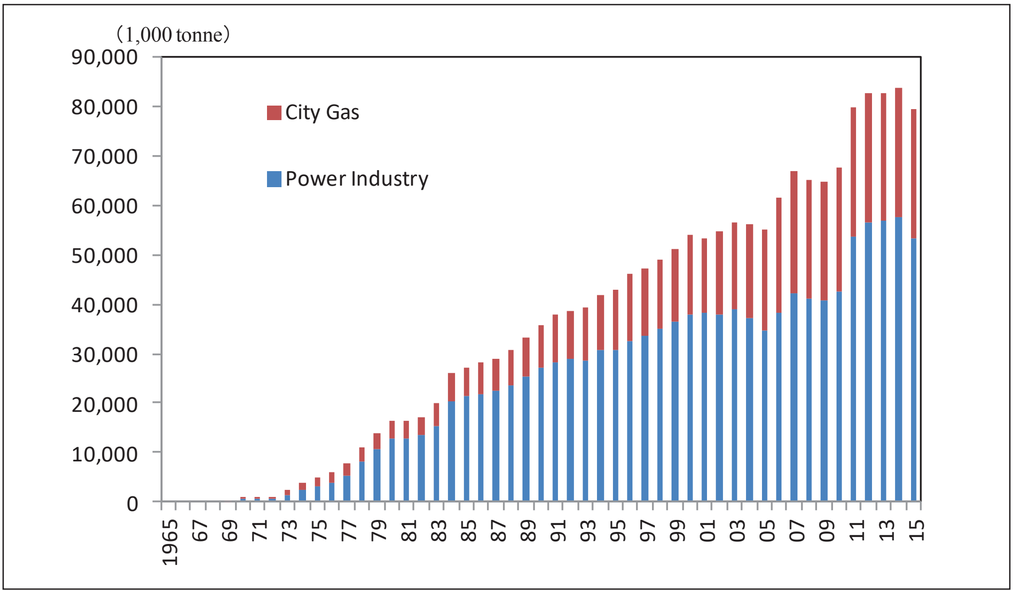
Japan promoted LNG use as an energy security measure in particular after the first oil crisis because LNG could reduce oil dependency, diversify the energy mix and thus reduce dependence on Middle East oil. Furthermore, the country regarded LNG supply itself as "stable and reliable" backed by its contractual characteristics of long-term supply guarantees with very close and stable relationships between sellers and buyers. In other words, LNG became a preferred option to contribute to Japan's energy security, which had become a national priority.

However, LNG's role as a clean fuel was arguably more important than its contribution to energy security when first introduced. During the 1960s and early 1970s when Japan's economy and energy consumption continued to grow rapidly, strong public concern emerged over local and regional environmental problems, such as air pollution and water pollution caused by emissions from factories. Rapid growth in fossil fuel (particularly oil) consumption also had created health-hazardous air pollution problems in many urban and industrial regions in Japan. Air and water pollution became national problems attracting very strong social and political attention. The introduction of LNG, a clean energy with far less SOx and NOx emissions than oil, as an energy option for urban and industrial areas made a significant contribution to improving air quality. This environmental situation was an important background factor influencing TEPCO and Tokyo Gas to introduce LNG. Other power and gas companies followed their example for similar reasons.

By the 1990s, climate change was recognized as a worldwide problem. The issue on how to manage or reduce CO2 as a main source of greenhouse gas (GHG) emissions became a serious energy and environment policy issue in many countries including Japan. Particularly after agreement on the Kyoto Protocol in 1997, which included concrete targets to reduce GHG emissions for the period 2008-2012 for Annex 1 countries (including Japan), de-carbonization of the primary energy supply structure became a priority in national energy policy. Given its advantage as the least CO2-intensive of fossil fuels, Japan expected that the expanded use of LNG would contribute to Japan's GHG reductions.

Given these advantages, LNG use both in power generation and in the city gas sector continued to increase (Figure 4). As of JFY 2015, power generation is the dominant use for LNG in Japan, accounting for 67 percent of sales with the other major use, city gas, holding a 33 percent share.

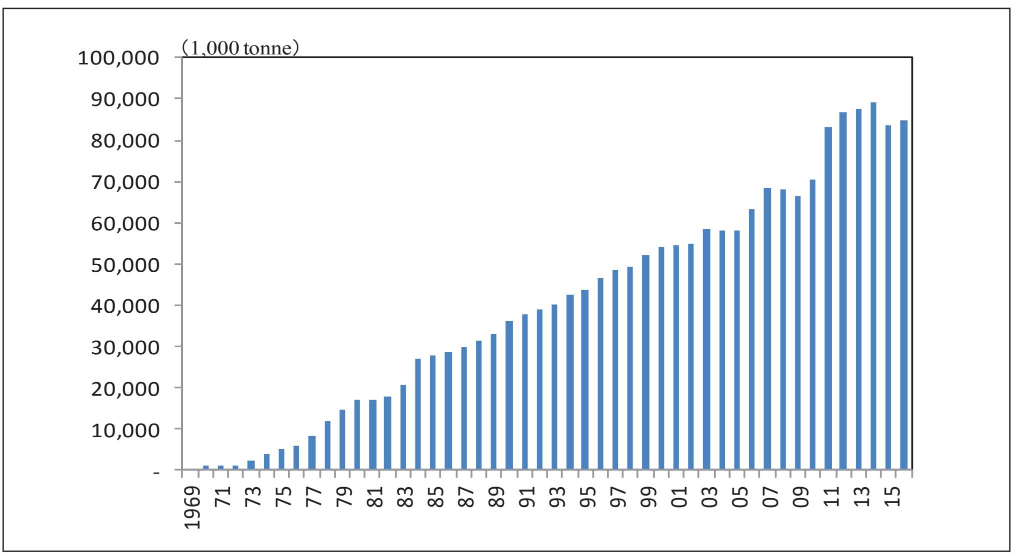
Figure 4: Trends in Japan's LNG Consumption



Source: IEEJ/EDMC, "Handbook of Japan's and World Energy and Economic Statistics"

These factors led to LNG imports expanding from 0.18 million tonnes/year (mtpa) in JFY 1969 to 70.6 mtpa in 2010 (Figure 5). In the early 1970s, the country became the world largest LNG importer, and by 2000, accounted for more than half of global LNG trade. The share of natural gas in Japan's primary supply increased from 1.0 percent in JFY 1969 to 17.5 percent in JFY 2010, contributing to diversification of energy supply in Japan as well as to environmental protection both in terms of air quality and climate change.

Figure 5: Trends in Japan's LNG Imports



Source: IEEJ/EDMC, "Handbook of Japan's and World Energy and Economic Statistics"

LNG/Natural Gas after Fukushima

The importance of LNG in Japan's energy portfolio further increased after JFY 2011 when the Fukushima nuclear accident on March 11, 2011 resulted in shutdown of Japan's nuclear fleet of power reactors. Actually all nuclear reactors in Japan stopped their operations in JFY 2014. No reactors could restart operation after the regular maintenance due to the widely held public concern about nuclear safety and social/political sensitivities.

Given this situation, use of all fossil fuels expanded to offset the decline in nuclear power generation with LNG playing the central role in offsetting the decline. LNG played the central role because Japan used LNG-fired power generation for middle-load power generation. Coal-fired power generation was base-load generation that, by definition, meant coal generation already was at almost full capacity until such time new coal power plants could be built.

LNG imports by Japan jumped up immediately after the nuclear accident. The import volume of LNG increased from 70.6 mtpa in JFY 2010 to 83.2 mtpa in JFY 2011 and increased further to 89.1 mtpa in JFY 2014. The share of natural gas in TPES in Japan reached at 24.0 percent in JFY 2014.

The recent development of nuclear restarts (five reactors as of November 2017) and continued improvement of energy efficiency finally resulted in a decline in LNG imports to 84.7 mtpa in JFY 2016. Despite the decline, the fact is LNG is still playing a very important role in Japan's energy mix. In particular, thanks to expanded use of LNG together with other fossil fuels in power generation, Japan has successfully up to now avoided any unplanned and large-scale blackouts after the Fukushima accident.

However, the timing of the surge in LNG imports in Japan coincided with that of higher LNG import prices. Higher LNG import prices happened because: a) almost all of LNG long-term contracts for Japanese buyers adopted crude oil indexation for LNG pricing; and b) the crude oil price continued to stay at around $100/barrel between 2011 and the first half of 2014.

The combination of the larger volume of LNG imports and higher LNG prices created serious economic problems for Japan. Japan's energy prices, in particular electricity prices, increased and affected citizens' daily lives and the economic competitiveness of industry. Furthermore, the substantially larger LNG import bill became an important factor forcing Japan to become a trade deficit country after JFY 2011.

Under these circumstances, how to procure LNG more competitively has become a national priority for Japan's LNG policy and a major corporate strategy for LNG importing companies. In this regard, METI established a very high-level international forum in 2012 for dialogue — the "LNG Producer-Consumer Conference" — with the objective that the dialogue could contribute to more competitive LNG procurement. METI also published its "LNG Market Strategy" in 2015 to highlight the importance of the price competitiveness of LNG compared to other competing fuels. It also highlighted the importance of improved LNG supply flexibility through such factors as the elimination of destination clauses that restrict reselling of cargoes.

After 2015, the global LNG market became a "buyer's market" because of the prevailing oversupplied situation in the global market. Large-scale LNG buyers in Japan, such as JERA (an alliance between TEPCO and Chubu Electric Company), Tokyo Gas, Kansai Electric Power Company and Osaka Gas, are now using this situation to negotiate with sellers to realize more competitive and flexible LNG procurement. Given this circumstance, Japanese companies regard LNG imports from United States as an important source of supply diversification as well as pricing diversification because U.S. LNG uses the Henry Hub price as a benchmark rather than an index to the oil price. Japanese buyers also view the flexible supply characteristics of U.S. LNG without any restriction on destination as valuable.

Japanese buyers who face uncertainty over future LNG requirements regard improvement of supply flexibility of LNG as crucially important. First, uncertainty over nuclear restarts will affect Japan's LNG demand. Second, recent substantial increases in renewable energy such as PV solar in Japan supported by feed-in-tariff (FIT) policies can also significantly affect future LNG demand. Last, but not least, electricity and gas market reform or liberalization can have significant impacts. The reforms will create uncertainty over the demand of LNG for individual market players in the future. With the uncertainty in mind, LNG market players will be required to continue to pursue more competitive and flexible LNG procurement for their survival.

Chapter Five

The Return of Coal

Jane NAKANO
Senior Fellow, Center for Strategic and International Studies

A Coal Renaissance

Coal is having a renaissance in Japan. The power supply concerns following the nuclear accident at the Fukushima Daiichi Power Station in March 2011 illuminated coal's strategic value in Japan's energy and economic security. Key numerical indicators, such as coal consumption volumes and share in the power mix, reflect the strong role of coal in Japan and distinguish the nation from the rest of developed economies, where coal power generation is receding. In fact, Japan's installed coal power capacity of 41 GW (gigawatt) appears to be on a growth trajectory. A closer examination reveals, however, that coal's future is in flux as the notion of de-carbonization begins to take hold in the Japanese society and challenge the fuel's value propositions. This chapter illustrates key drivers of the recent resurgence in coal power generation in Japan as well as the evolution of coal resource diplomacy and Japan's promotion of advanced coal power technology exports. It considers the future of coal power generation in light of Japan's transition to a lower-carbon future.

Energy and Economic Security Benefits Render Coal a Staying Power

The nuclear accident dealt a major shock to Japan's energy system. However, it also illustrated the value coal played in helping avert a major power supply shortage and thus in assuaging Japan's energy security concern in the accident's aftermath. By shattering public faith in the country's nuclear sector governance, the accident took the nation's 48 post-accident operable commercial nuclear reactor units[63] off-line by August 2015. It also negated Japan's planned transition away from fossil fuels as part of the nation's broader effort to heighten its energy security as well as manage carbon emissions. According to Japan's *Strategic Energy Plan of 2010*, the share of nuclear in the nation's 2030 power supply mix was to roughly double to 53 percent while that of coal was to be roughly halved to 11 percent.

In order to fill the void in power generation capacity left by the nuclear outage, Japanese electric utilities turned to fossil fuels to meet shortfalls. Between 2010 and 2015, the share of coal in the nation's power generation increased from 23 percent to 31 percent,[64] and the nation's coal consumption increased by about 20 percent.[65] Especially since 2013, coal power generation has been growing as coal capacity damaged by the

[63] Japan had 54 reactor units at the beginning of 2011. Four units were disabled following the tsunami and two units in the same plant became inaccessible due to plant contamination.
[64] U.S. Energy Information Administration. Country Analysis Brief, February 2, 2017.
[65] Stephen Stapczynski. "Japan Utilities Burn Record Coal Amid Minister's Call for Cuts," *The Bloomberg*, September 11, 2015, http://www.bloomberg.com/news/articles/2015-09-11/japan-utilities-burn-record-coal-amid-minister-s-call-for-cuts.

earthquake was restored and new coal capacity added.[66] By 2016, the nation's coal power supply had grown to 16 times the level in the mid-1970s when the oil embargos and Japan's attendant effort to reduce dependence on imported oil reversed the decline of coal's share in the nation's primary energy consumption.

Moreover, the post-accident energy situation underscored coal's strategic value in enhancing Japan's economic security. The aforementioned switch away from nuclear power generation prompted a greater use of gas power plants as well as coal power plants, and the share of gas in the national power generation mix grew from 30 percent to 42 percent between 2010 and 2015.[67] The increased reliance on gas power generation in turn led to a dramatic uptick in imports of liquefied natural gas (LNG). Increases in both the volume and the price of oil-linked LNG imports[68] caused the overall cost of LNG imports to roughly double, from $35 billion in 2010 to about $70 billion in 2013.[69,70] During this time, Japan's trade deficit steadily increased, and reached $115 billion in 2013.[71] In 2014, the LNG import expenditure accounted for nearly 9 percent of the total import expenditures (Figure 1).

In comparison, coal imports affected the trade balance more moderately. In 2015, when coal accounted for 25 percent less than gas in the total power supply mix, coal's share of import expenditure in total import expenditures was about 2.5 percent while that of gas import expenditure was 5.5 percent (Figures 1 and 2). Note that a more detailed data set is required to portray more precisely the scope of expenditure impact by the two power sources as the Figure 2 data on the shares of coal import expenditure (red line) does not differentiate thermal coal—used for power generation—from coking (metallurgical) coal—used for iron and steel making. Likewise, the Figure 1 data (bars and the green line) do not specify end-use. Natural gas usage in Japan includes not only power generation (61 percent), but also consumption as city gas (31 percent).[72] Yet, the graphs effectively portray how coal's impact on Japan's overall import expenditures has generally been smaller than that of LNG.

Coal's economic appeal goes beyond its effect on the current account. In Japan, coal has traditionally been the cheapest type of fossil fuel for electricity generation. Nuclear restarts thus far have mostly reduced oil-fired generation with the consumption of thermal coal remaining strong. Although slightly lower than the historic high of 59.9 million tons in 2013, the nation's thermal coal consumption in 2016 was 59.4 million tons.[73]

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66 Ministry of Economy, Trade and Industry of Japan, The Energy White Paper (平成28 年度 エネルギーに関する年次報告), June 2017, p.162.

67 U.S. Energy Information Administration, Country Analysis Brief, February 2, 2017.

68 The weaker Japanese yen against the U.S. dollar increased Japan's trade deficit levels in 2012 and 2013.

69 The exchange rate between the U.S. dollar and Japanese yen is set at US$1 = ¥100 throughout this chapter.

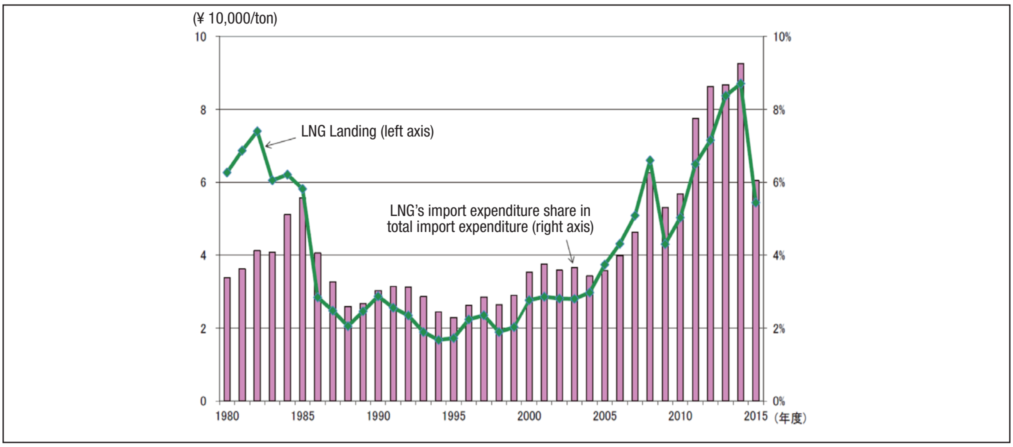
70 Ministry of Economy, Trade and Industry of Japan. "Japan's Energy Situation," April 2015, p. 36.

71 Ibid.

72 Ministry of Economy, Trade and Industry of Japan. *The Energy White Paper* (平成28 年度 エネルギーに関する年次報告), June 2017, http://www.enecho.meti.go.jp/about/whitepaper/2017pdf/, p.156.

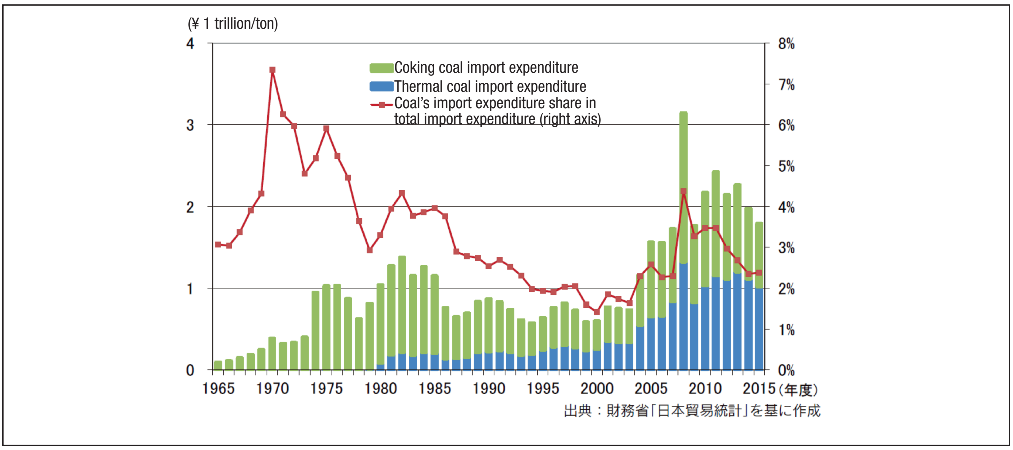
73 Coal-fired power output at the third highest level in history *(Sekitan Koh-suijun—Kako 3-banme)*, Denki Shimbun, May 8, 2017.

Figure 1: LNG Import Expenditures and their Shares in the Total Import Expenditures



Source: Energy White Paper 2017, p. 158.

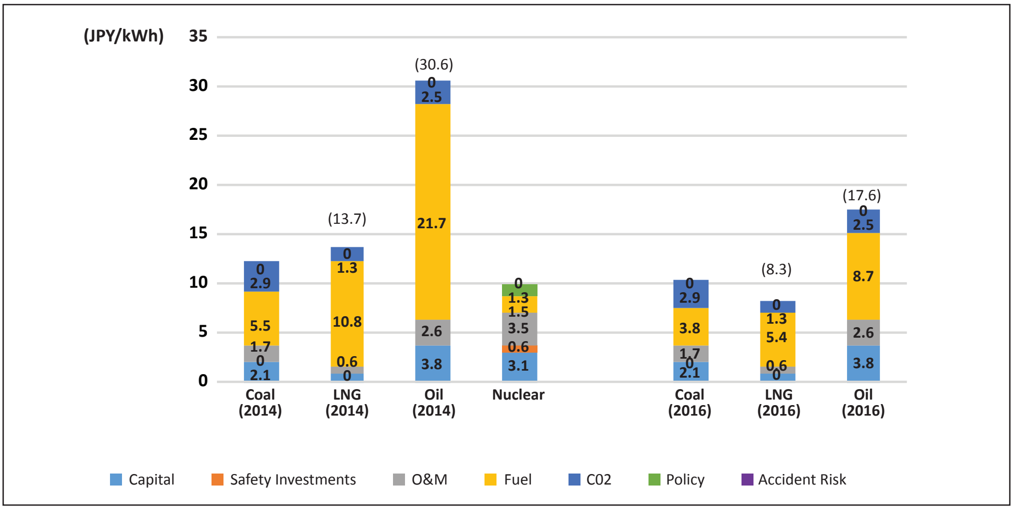
Figure 2: Coal Import Expenditures and their Shares in the Total Import Expenditures



Source: Energy White Paper 2017, p.163.

However, these economic value propositions are fluid as they are highly subject to fuel prices. Specifically, the cost competitiveness of coal power generation in Japan is highly subject to not only the price of thermal coal but also the price of LNG. In fact, the collapse of the oil price in the mid-2014 and the attendant reduction in the price of oil price-linked LNG led LNG power generation to be cheaper than coal power generation in Japan in JFY 2016 (Figure 3). In the context of power generation cost competitiveness, the history cannot be taken as a guide to future.

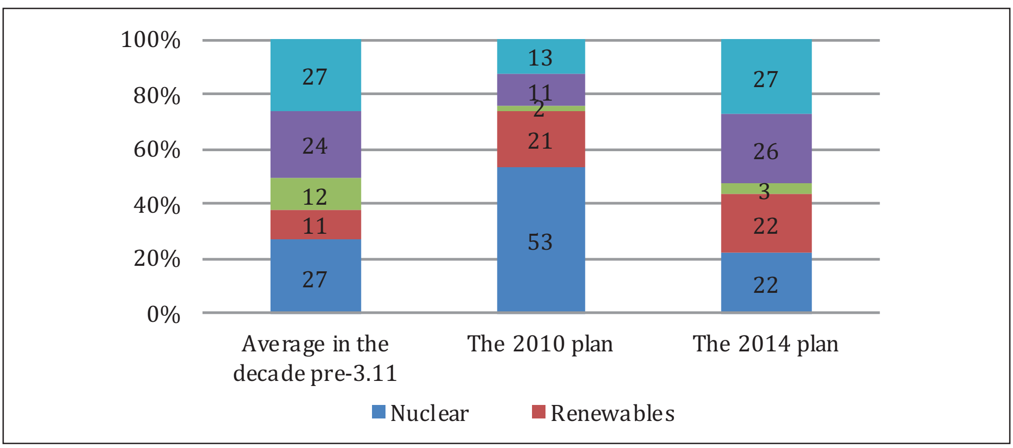
Figure 3: Comparison of Power Generation Costs in Japan by Fuel, JFY 2014 vs. JFY 2016



Source: Author's compilation, with the data from *Trade Statistics of Japan*, Ministry of Finance and *Cost Review Sheet,* by the Power Generation Cost Verification Working Group.[74]

The renewed focus on coal power generation reflected in the 2014 *Strategic Energy Plan* took into account major changes in the energy supply and demand conditions surrounding Japan since the last plan issued in 2010. The government's energy and electricity targets for Year 2030 per the 2014 document suggests near doubling of coal's share in the power supply from that in the 2010 version.[75] In fact, both the shares of coal and gas power generation are posited to revert back to their pre-earthquake 10-year average (Figure 4).

Figure 4: Japan's Electricity Supply Mix Outlooks for 2030



Source: Author's compilation, with data from the Agency for Natural Resources and Energy of Japan.

[74] The Cost Review Sheet (excel), by the Power Generation Cost Verification Working Group, Ministry of Economy, Trade and Industry can be found at the following link: http://www.enecho.meti.go.jp/committee/council/basic_policy_subcommittee/#cost_wg.

[75] Ministry of Economy, Trade and Industry of Japan. "Japan's Energy Situation," April 2015, p. 22.

The added momentum stems from power sector deregulation that is part of the three-step deregulation effort launched in 2013. Among other actions, the government most notably opened up the electricity retail market to new entrants and existing gas companies in order to generate competition in the power sector. Since April 2016 when the electricity retail sector was fully liberalized, about 380 enterprises—including existing gas companies—have joined 10 existing electric utility companies in the electricity retail business.[76] As they seek to survive the competition, many such new entrants have expressed interest in operating coal power plants over other fuels because coal is much cheaper than LNG although the capital cost of building a coal power plant is roughly double that of building a gas power plant (Figure 3).[77]

Coal Resource Diplomacy is Deepening and Widening

Japan is known for its high level of energy import dependence, but this was not always the case. Coal mining was fairly widespread across Japan in the 18th and 19th centuries, from Hokkaido to Fukushima, and to Ibaraki and Fukuoka. In the early Meiji period (the mid-1870s), Japan exported a little over half of its domestic output to various places, including China. Yet, declining competitiveness of indigenous coal has significantly shrunk mining operations in Japan. Consequently, Japan's energy import dependence has extended to coal as well. As of 2015, imports accounted for over 99 percent of Japanese coal consumption after the domestic production of coking coal ceased in 1990 while the mining for thermal coal has declined significantly.[78] Today, only half a dozen open-pit mines remain in operation in Hokkaido, producing about 100,000 tons of thermal coal each and the output is sold to regional power plants for electricity generation while a 500,000 ton scale underground mining operation also remains in Kushiro, Hokkaido. This underground mine serves not only to supply coal, but also to provide capacity-building training in extraction technology, operational management and safety practices to trainees from countries with coal power generation growth, such as China and Vietnam.[79]

Relations with coal supplier countries is therefore yet another area of focus in the Japanese government's "energy diplomacy." Australia is the leading coal supplier to Japan, accounting for about 75 percent of coking coal imports and 50 percent of thermal coal imports.[80] The quality of coal, reserve level, proximity, infrastructure availability, and government policy make Australia a superior supplier of coal to Japan. But, the Japanese government is mindful of rising environmental awareness among the Australian population and how sensitivity associated with fossil fuel extraction could generate some adversarial effect on the future of their coal industry. In an effort to diversify a pool of coal supplier countries, the Japanese government has held bilateral consultations on coal resource development and trade with Indonesia, Vietnam, and Mongolia. More recently, Tokyo has

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[76] Ministry of Economy, Trade and Industry of Japan. *The Energy White Paper* (平成28 年度 エネルギーに関する年次報告), June 2017, http://www.enecho.meti.go.jp/about/whitepaper/2017pdf/, p.107.

[77] Ministry of Economy, Trade and Industry of Japan. The Recent Status of Thermal Power Generation (火力発電に係る昨今の状況), October 10, 2017, www.meti.go.jp/committee/sougouenergy/shoene_shinene/sho_ene/karyoku/pdf/h29_01_04_00.pdf, p.9.

[78] Ministry of Economy, Trade and Industry of Japan, *The Energy White Paper* (平成28 年度 エネルギーに関する年次報告), June 2017, http://www.enecho.meti.go.jp/about/whitepaper/2017pdf/, p.161.

[79] Kushiro Coal Mine Co., Ltd., "On the Training," http://www.k-coal.co.jp/training.html.

[80] Ministry of Economy, Trade and Industry of Japan. *The Energy White Paper* (平成28 年度 エネルギーに関する年次報告), June 2017, p. 161.

begun eyeing closer ties with Russia, and the United States.[81] For example, when Russian President Vladimir Putin visited Japan in December 2016, Japan's Minister of Economy, Trade and Industry Hiroshige Seko and his Russian counterpart signed a Memorandum of Understanding that sought enhanced coal trade between the two countries.[82]

Most notably, coal has been among the topics of bilateral discussions between the governments of Japan and the United States, under President Trump. The Trump Administration sees the production and exportation of energy resources, such as coal, as a major driver of economic growth and job creation at home and a key avenue for improving U.S. trade deficit with Japan. Notwithstanding the lack of coal export facilities along the U.S. west coast, the Administration seeks to facilitate U.S. coal exports to Asia, including Japan. Following the U.S.-Japan Economic Dialogue, in Washington, on October 16, 2017, the two governments launched the Japan-United States Strategic Energy Partnership (JUSEP) and identified cooperation on the deployment of highly-efficient, low emission (HELE) and carbon capture and storage (CCS) technologies as one of the four near-term priorities.[83]

Additionally, as the Japanese government seeks to raise the ratio of coal supplies that are developed by Japanese entities or produced domestically ("*shigen jikyu-ritsu*") to over 60 percent by 2030,[84] the Japanese government supports private sector investment in coal production projects overseas through loan guarantee, investment finance and investment/export insurance through its financial institutions, such as the Japan Oil, Gas and Metals National Corporation (JOGMEC), the Japan Bank for International Cooperation (JBIC), and Nippon Export and Investment Insurance (NEXI). Some of the specific activities that the Japanese government supported in 2016 include coal exploration and infrastructure impact assessment activities (¥1.2 billion), and promotion of Japan's exploration technologies through technical training (¥1.41 billion).[85]

Coal Technology as a R&D and Export Focus

Japan is one of the leaders in advanced coal technology research and development (R&D), especially in the development of HELE coal technologies. The idea is to elevate the temperature and the pressure of steam higher and higher to improve the efficiency of the boilers and turbines that use steam as the working fluid, thus requiring less coal and producing less greenhouse gases. While R&D interest in HELE is virtually non-existent in the United States, mirroring the dearth of investment interest in coal power generation, the cost competitiveness of coal power generation and strong manufacture interests sustain R&D focus on HELE in countries like Japan, China and South Korea. The official R&D roadmap illustrates the push to improve power generation efficiency (Figure 6). Specifically, the current focus includes increasing the efficiency of Ultra-Super Critical (USC) units as well as developing integrated gasification combined cycle (IGCC) and integrated gasification fuel cell cycle (IGFC).

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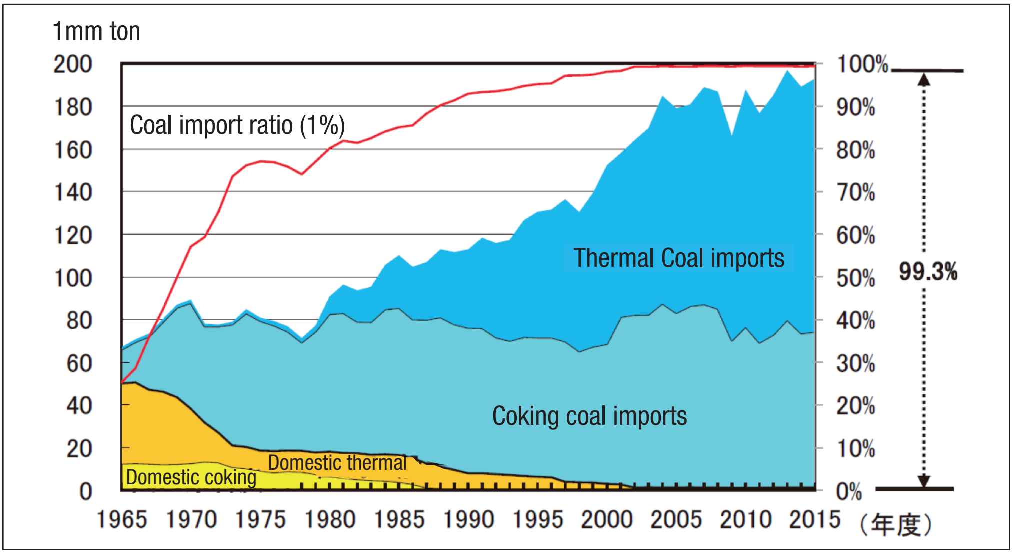
81 Ibid., p. 254.
82 Ibid., p. 255.
83 Ministry of Economy, Trade and Industry of Japan. *Japan-United States Strategic Energy Partnership*, November 7, 2017, http://www.meti.go.jp/english/press/2017/pdf/1107_001a.pdf.
84 "How to ensure secure supply of natural resources and fuels *(Shigen/Nenryo-no Anteikyukyuu-no-Kadai-to Kongo-no Taiou)*, http://www.enecho.meti.go.jp/committee/council/basic_problem_committee/027/pdf/27-4-2.pdf.
85 Ministry of Economy, Trade and Industry of Japan. *The Energy White Paper* (平成28 年度 エネルギーに関する年次報告), June 2017, p.257-258.

Figure 5: Japan's Coal Import Ratio



Source: Energy White Paper 2017, p.160.

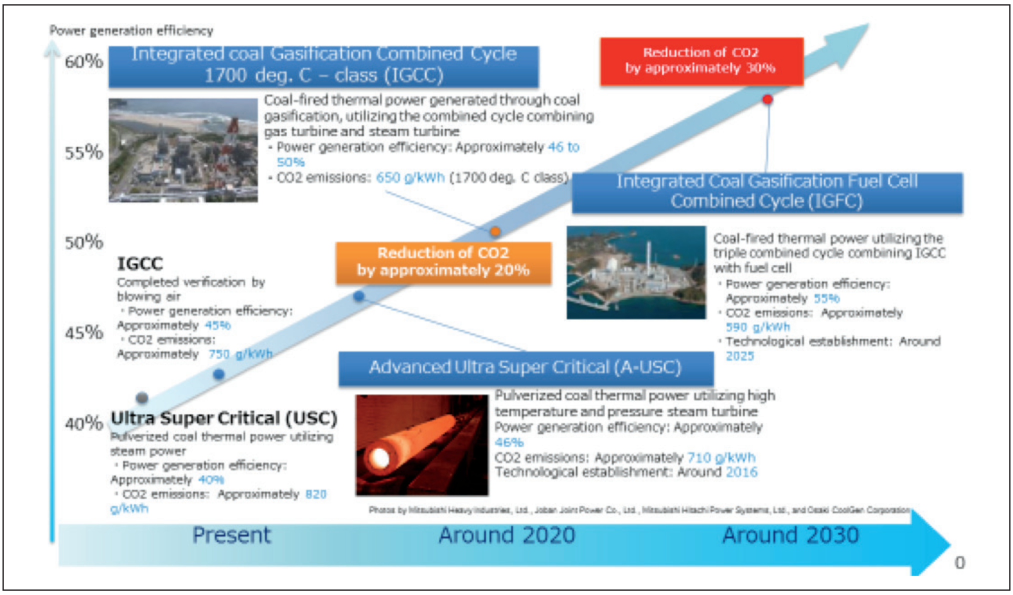
Playing a key role in advancing coal technologies is the New Energy and Industrial Technology Development Organization (NEDO), which is Japan's largest public management organization promoting R&D as well as deployment of industrial, energy and environmental technologies. For example, NEDO's ongoing coal related projects aim to improve the sustainable development of low quality coal resources (JFY 2016-2019, with the JFY 2017 budget of *¥440 million);*[86] demonstrate high efficiency turbine technologies and IGFC (JFY 2016-2021, with the JFY 2017 budget of ¥11.5 billion);[87] and carry out international collaboration to demonstrate high efficiency coal power technologies and development of advanced coal power generation system (JFY 2017-2021, with the JFY 2017 budget of ¥1.66 billion).[88]

Because HELE does not eliminate carbon emissions, CCS is another major focus of advanced coal R&D in the world today. Per the 2014 Strategic Energy Plan, Japan hopes to demonstrate and deploy CCS technologies around 2020.[89] Their R&D focus consists of a CCS technology demonstration project in Tomakomai, Hokkaido that has been under way since 2012; R&D on elemental technologies to reduce cost and improve operational efficiency; and survey to identify about three sites, each capable of storing 100 million tons of CO2 for geological storage by 2021.[90] In terms of international cooperation, the

[86] New Energy and Industrial Technology Development Organization. "Clean Coal Technology Development," last updated on July 14, 2017, http://www.nedo.go.jp/activities/ZZJP_100116.html.
[87] New Energy and Industrial Technology Development Organization. "Next-Generation Thermal Power Generation Technology Development," last updated on August 22, 2017, http://www.nedo.go.jp/activities/ZZJP_100115.html.
[88] New Energy and Industrial Technology Development Organization. "Operations for the global promote of advanced thermal power generation technology," last updated on June 23, 2017, http://www.nedo.go.jp/activities/ZZJP_100131.html.
[89] Ministry of Economy, Trade and Industry. "The Strategic Energy Plan (エネルギー基本計画)," April 2014, http://www.enecho.meti.go.jp/category/others/basic_plan/pdf/140411.pdf, p.45.
[90] Ministry of the Environment of Japan. Japan's CCS Projects *(Waga-kuni ni okeru CCS jigyo-ni tsuite)*, September 5, 2017, http://www.env.go.jp/council/06earth/y0618-17/ref01.pdf, p.12.

United States is a key partner to Japan. Based on the Memorandum of Cooperation, signed between METI and the U.S. Department of Energy in April 2015, the two countries look to have robust exchange of data, experts and equipment related to CCS.[91]

Figure 6: Roadmap for Development of Next-Generation Coal-Fired Power Technologies



Source: Council for Promoting the Early Achievement of Next-Generation Thermal Power Generation, June 2016

The advancement in coal power technologies is not meant only for the domestic market. In fact, the Japanese government sees coal as a key fuel to help enhance energy access in developing countries, and promotes the export of advanced coal power technologies that are developed and manufactured by Japanese companies—such as Mitsubishi Hitachi Power Systems, Ltd., Toshiba Corp. and IHI Corp.—as a cleaner alternative to dated power generation assets in these countries. For example, the Japanese government actively calls for the sustainable use of coal resources and promotes HELE technology—namely the Ultra Supercritical plants—at international forums, such as G20 and the Asia-Pacific Economic Cooperation (APEC), and through bilateral engagements with governments of Australia, India, Ukraine and Vietnam.[92]

Also, aiming to achieve Japan's emission reduction target while facilitating diffusion of Japan's low-carbon technologies, products and services, Japan has launched its own offset mechanism known as the Joint Crediting Mechanism (JCM). The JCM allows Japanese companies to invest in emission reduction projects in developing countries to earn offset credits. Since the first bilateral agreement was signed with Mongolia in 2013, 16 countries have become JCM partners.[93] While the JCM does not exclude coal power generation equipment and services, no HELE project appears to be under consideration.

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[91] Ministry of Economy, Trade and Industry of Japan. Japan's CCS Policies *(Waga-kuni no CCS porishi)*, December 2016, https://unit.aist.go.jp/georesenv/information/20170104/R_Matsumura.pdf, p.33.
[92] Ministry of Economy, Trade and Industry of Japan. The Energy White Paper (平成28 年度 エネルギーに関する年次報告), June 2017, p.339, 344-45.
[93] Ministry of Foreign Affairs of Japan. "Joint Crediting Mechanism," January 16, 2017, http://www.mofa.go.jp/ic/ch/page1we_000105.html.

The Japanese promotion of advanced coal power technologies has not been without setbacks. In fact, it was a source of tension in the relationship with the United States under the Administration of Barack Obama. Following a 2013 call by then President Obama to end the public financing for new coal power plants overseas, the United States and the like-minded governments from the United Kingdom and the Netherlands proposed to the OECD Export Credit Group a carbon emissions performance standard that limits export credit agency support of high-carbon power plants. Japan opposed such restrictions as its financial institutions were active in promoting HELE exports. The senior officials from Japan and the United States reportedly had a few intense exchanges on this matter. In the end, the two governments struck compromise and agreed in November 2015 to begin limiting the export credit financing available for new construction of inefficient coal-fired plants by instructing the use of Ultra-Supercritical technologies from January 2017.[94]

Notwithstanding the resolution of tension over OECD export credit financing issue, the Japanese stakeholders in HELE exports remain anxious, however. Their main concern for some years has been the unchecked expansion of coal power plants by China, which they view as the primary competitor in this sector. The Japanese are frustrated that coal plant exports by China, whose public financing accounted for approximately 40 percent of the total amount of public financing provided by major countries from 2007 to 2013,[95] remains unrestricted by such OECD policies and rules as China is not a member of OECD. Moreover, the Japanese believe that China's unchecked export of lower quality coal power technology could aggravate GHG emissions in non-OECD economies.

Partly in an effort to promote sustainable economic development in Asia through infrastructure development, but also to counter the robust export of Chinese infrastructure for example like coal plants, Japanese Prime Minister Shinzo Abe launched in May 2015 the *Partnership for Quality Infrastructure,* a framework by which the Japanese government would provide about $110 billion over 5 years—roughly a 30 percent increase from their overseas infrastructure spending in the past five years. More than $50 billion of this lending and investment would come from the Asia Development Bank, over $30 billion from the Japan International Cooperation Agency, and $20 billion from the Japan Bank for International Cooperation and the Japan Overseas Infrastructure Investment Corp. for Transport & Urban Development.[96] The scope of success will be subject to not only the pace of technology advancement by Chinese manufacturers but also the market preference; cost rather than lifecycle quality is often the overriding determinant for buyers in many developing country markets.

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[94] Organization for Economic Co-operation and Development. "Sector Understanding on Export Credits for Coal-Fired Electricity Generation Projects," November 27, 2015, www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=TAD/PG (2015)9/FINAL&docLanguage=En.

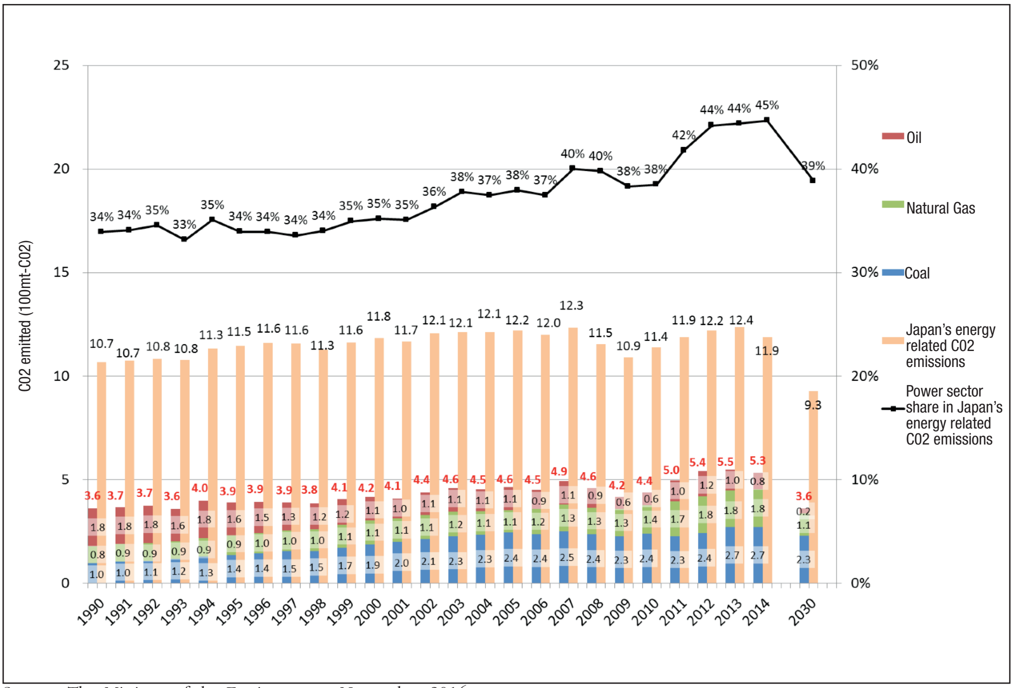
[95] Ueno, Yanagi and Nakano. "Quantifying Chinese Public Financing for Foreign Coal Power Plants," Tokyo University, November 2014, http://www.pp.u-tokyo.ac.jp/wp-content/uploads/2016/03/GraSPP-DP-E-14-003.pdf.

[96] "Abe focuses on 'quality' investment for Asia," May 22, 2015, https://asia.nikkei.com/Politics-Economy/International-Relations/Abe-focuses-on-quality-investment-for-Asia.

Climate Change Awareness Sharpens Public Scrutiny on Coal Power Use

Despite its strong economic value propositions, coal power generation comes with a significant challenge from the environmental and climate perspective. While a USC plant emits 0.81 to 0.84kg of CO2 per kWh of electricity generation, an existing LNG plant emits 0.415kg-CO2/kWh.[97] Since 1990, both the volume of CO2 emissions from coal power generation as well as the share of coal power generation as a source of CO2 emissions have generally been on a steady rise (Figure 7).

Figure 7: Changes in Power Sector C02 Emissions and Shares by Fuel



Source: The Ministry of the Environment, November 2016

Finding the right balance between reaping its economic benefits and minimizing emissions became a major agenda for the Japanese government. Some intense inter-agency work to find the right balance led to the revision in early 2016 of the *Act on Sophisticated Methods of Energy Supply Structures of 2009*.[98] Per the revision, electricity retailers are required to ensure that 44 percent of power supply comes from non-fossil fuel sources by 2030, corresponding to the energy mix targets per the 2014 Strategic Energy Plan. Also, pursuant to the *Energy Conservation Act of 1979*,[99] a *new* coal power plant is required to meet the generation efficiency of over 42 percent (a USC level)[100]

[97] Ministry of the Environment of Japan. *Measures for countering the global warming by the power sector*, November 9, 2016, p.4, https://www.env.go.jp/earth/ondanka/denryoku/jokyo_01/mat_ichi.pdf.
[98] The law is officially titledエネルギー供給事業者による非化石エネルギー源の利用及び化石エネルギー原料の有効な利用の促進に関する法律, and is generally referred asエネルギー供給構造高度化法.
[99] The law is officially titled エネルギーの使用の合理化に関する法律, and is generally referred as 省エネ法.
[100] The required generation efficiency for natural gas oil are 50.5 percent and 39 percent, respectively.

while each power generation company is required to meet the generation efficiency of 41 percent for its *existing* coal power fleet and 44.3 percent for its *existing* fossil fuel power fleet.[101]

The business community has taken a step, too, in the effort to address carbon emission from the power sector. The Electric Power Council for a Low Carbon Society, comprising of about 50 companies in the power business, has introduced voluntary measures to achieve an emission factor of approximately 0.37kg-CO2/kWh from fossil fuel power generation in JFY 2030, by "adopting the best available technology that is economically feasible when building new thermal power plants."[102]

With the successful enforcement of regulations and voluntary practices, Japan hopes to reduce CO2 emissions from the entire power sector by one-third, from 505 million tons in 2014[103] to 360 million tons of in 2030.[104] Specifically for coal, based on its power supply target of 26 percent from coal in 2030 (281 TWh), the government estimates 230 million tons of CO2 emissions from coal power generation that year,[105] which is 15 percent points lower than the 2014 level of 270 million tons.[106] (See Figure 7.) The power sector achievement would be crucial for Japan's ability to meet its pledge under the Paris Agreement to reduce GHG emissions by 26 percent by 2030 against the 2013 level as the sector is the largest emitter of GHG in Japan.

A key sign-post for the successful emissions reduction from coal power generation is how technologically advanced the future fleet can be. Currently, Japan's 41 GW installed coal capacity is comprised of 0.42 GW of IGCC, 20.46 GW of USC, 9.95 GW of SC, and 10.54 GW of Subcritical plants.[107,108] The 2030 target of 26 percent power supply from coal would translate into 47 GW of installed capacity (at the 80 percent utilization rate).[109] Assuming that one-third of 41 GW existing coal fleet would reach 40 years of life by 2030 and be ready to retire,[110] there could be a room for as much as 20 GW of new capacity. According to the government, Japan's future fleet is expected to be less carbon intensive, with new capacity additions of 15 GW from USC and 1.25 GW from IGCC.[111]

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[101] The required generation efficiency for each company's gas-fired fleet is 48 percent and oil-fired fleet is 39 percent.
[102] Federation of Electric Power Companies. "Establishment of the Electricity Business Council for a Low-Carbon Society," February 8, 2016, http://www.fepc.or.jp/about_us/pr/pdf/kaiken_s_e_20160219.pdf.
[103] Ministry of the Environment of Japan. "The Environmental White Paper (平成28年度　環境白書)," 2017, p.48.
[104] Ministry of the Environment of Japan. *Measures for countering the global warming by the power sector*, November 9, 2016, p.1, https://www.env.go.jp/earth/ondanka/denryoku/jokyo_01/mat_ichi.pdf.
[105] Ministry of the Environment of Japan. "The Environmental White Paper (平成28年度　環境白書)," 2017, p.48.
[106] Ministry of the Environment of Japan. *Measures for countering the global warming by the power sector*, November 9, 2016, p.1, https://www.env.go.jp/earth/ondanka/denryoku/jokyo_01/mat_ichi.pdf.
[107] Ministry of Economy, Trade and Industry of Japan. *The Recent Status of Thermal Power Generation* (火力発電に係る昨今の状況), October 10, 2017, www.meti.go.jp/committee/sougouenergy/shoene_shinene/sho_ene/karyoku/pdf/h29_01_04_00.pdf, p.6.
[108] In terms of actual coal power supply, of 223.8 TWh generated, 60 percent (134.6 TWh) came from USC plants, 27.8 percent (62.3 TWh) came from SC plants, and 12 percent (27 TWh) came from subcritical plants. Agency for Natural Resources and Energy, http://www.meti.go.jp/committee/sougouenergy/shoene_shinene/sho_ene/karyoku/pdf/003_01_00.pdf, November 17, 2016, p.15.
[109] Agency for Natural Resources and Energy, *On Power Generation Efficiency Standards to Improve the Efficiency of Thermal Power Generation,"* November 17, 2016, http://www.meti.go.jp/committee/sougouenergy/shoene_shinene/sho_ene/karyoku/pdf/003_01_00.pdf, p.5.
[110] Ibid. p. 3.
[111] Ibid. p. 4.

As noted above, Japan's 2030 coal power supply target might require as much as 20 GW of new capacity after retirements are offset. This number seems to roughly match the total capacity of projects that are planned, under environmental impact assessment or under construction as compiled by Japan's environmental nonprofit organization, Kikko Network.[112] However, the NGO list[113] reveals that a few of the planned plants have installed capacity of just under 112.5 MW—a threshold above which environmental impact assessment are warranted per the *Environmental Assessment Act of 1997*.[114] Notably, small capacity plants have a known tendency to deploy subcritical technologies. The planned capacity just below the threshold is likely motivated by interest in circumventing environmental impact assessment that ordinarily take a minimum of three years. Meanwhile, two of the planned projects that were cancelled since the beginning of 2017 were slated to deploy HELE. How the coal fleet will transition warrants close attention.

Conclusion

Coal has regained its prominence in terms of thermal coal consumption volume, coal power generation volume, and its share in the total power output. The electricity supply concern post-Fukushima underscored the economic competitiveness of coal generation and reversed the role of a once declining fuel in the government's power supply mix vision for 2030. Moreover, the deregulation of the power sector is elevating electricity retail market competition, fostering commercial interest in building new coal power capacity as the fuel is cheaper than natural gas. Additionally, high efficiency, low emission coal power technologies have become the nation's focus for both research and development as well as export as Japanese manufacturers observe strong market potential in developing countries, where population growth and modernization trends drive continued growth in power demand.

However, the sustainability of the renaissance is not a foregone conclusion for Japan. Absent a significant and permanent reduction in the global coal output or a debilitating level of levy on the use of coal in the future, coal power generation will likely remain economically viable in Japan although its cost competitiveness is highly subject to the price of thermal coal and competing fuels, particularly LNG. Meanwhile, the nation's stagnant electricity demand growth, due to slow economic growth and aging and declining population, may well serve as a cap on the margin of growth for new coal capacity. Furthermore, the growing awareness of climate change is only likely to sharpen the public scrutiny of the scope and type of coal power capacity in Japan. For example, in May 2017, the City of Sendai became the first municipality to eliminate exemptions completely from the environmental impact assessment that previously were enjoyed by small-scale coal power project applicants.[115] Therefore, both the outlook for electricity demand and climate change awareness will warrant close attention in order to ascertain whether and how the value propositions of coal power generation continue to evolve in Japan.

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[112] Kiko Network. "Japan Coal Plant Tracker," http://sekitan.jp/plant-map/en/v2.

[113] Kiko Network. "List of Proposed," http://sekitan.jp/plant-map/en/v2/table_en.

[114] The law is officially titled 環境影響評価法.

[115] "On the Abolishment of the Scale Thresholds in the Environmental Impact Assessment on Coal Power Plants," City of Sendai, last updated May 1, 2017, https://www.city.sendai.jp/kankyochose/kurashi/machi/kankyohozen/kurashi/kankyo/sekitan.html.

Chapter Six

Japan's Radical Incrementalism in Power Market Regulation and Renewable Energy

Dr. Llewelyn HUGHES
Associate Professor, Crawford School of Public Policy, Australian National University

Introduction

Major policy changes are occurring in Japan's power sector, centrally reforms to the regulation of competition, and the management of the integration of new sources of renewable energy. The Japanese government is implementing a series of reforms designed to increase efficiency in the power sector, while attempting to manage the fiscal and regulatory issues that have emerged as a result of the introduction of large amounts of power generated from renewable energy sources – primarily solar photovoltaics – to the grid. As in other countries, these policy changes have important distributional effects, making them inherently political in nature.[116,117]

I argue in this chapter that the changes implemented in order to drive greater efficiency in the power sector, and promote decarbonization through the introduction of renewable energy, imply a transformation of the regulations governing Japan's power sector. I also suggest that the negotiation of market redesign occurs through existing regulatory institutions, leading to important areas of continuity, as is the case across many national electricity markets.[118] Japan is thus engaged in a process of what I have term "radical incrementalism," defined as a substantial reordering of the policies used to achieve public policy goals, but with important areas of path dependence because of institutional constraints and the longevity of capital-intensive assets that are central to the power sector.[119]

Changing Approaches to Power Market Governance

For more than two decades, policymakers have negotiated a transformation of Japan's power market from a vertically-integrated monopoly to a system that identifies transmission and distribution as natural monopolies, but otherwise assumes competitive markets can more efficiently allocate capital, while enabling energy security and environmental goals to be met.

Efforts to transform Japan's power market reflect lessons learned from European and some U.S. power markets competitive principles into previously vertically integrated

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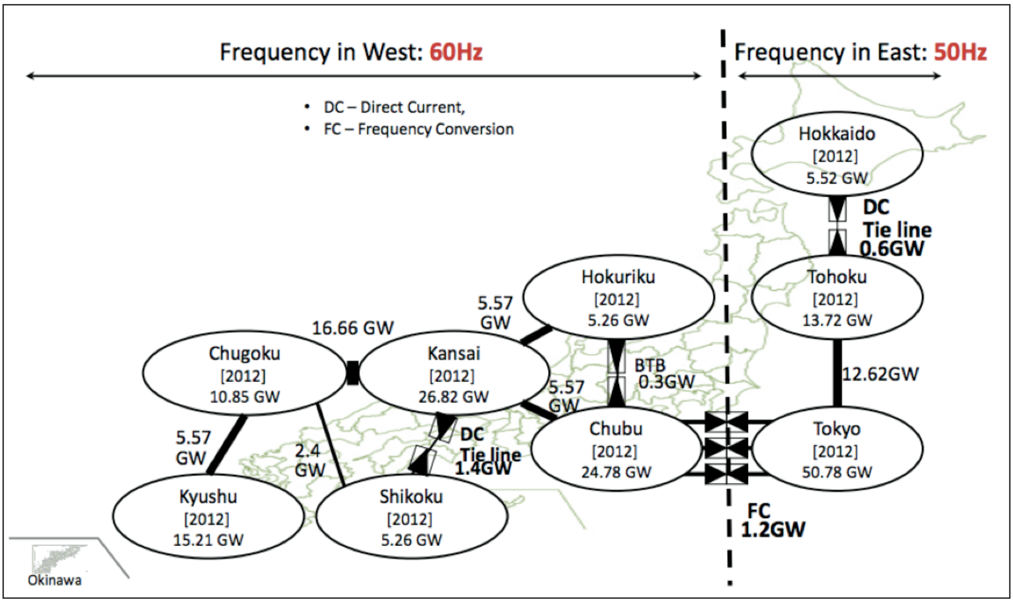
[116] Hughes, Ll., and Lipscy, P.Y. "The politics of energy," *Annual Review of Political Science*, 16, 2013, pp.449-469.
[117] Kominers, S.D., Teytelboym, A. and Crawford, V.P. "An invitation to market design," Oxford Review of Economic Policy, 33(4), 2017, pp.541-571.
[118] Nepal, R., Menezes, F. and Jamasb, T. "Network regulation and regulatory institutional reform: Revisiting the case of Australia," *Energy Policy*, 73, 2014, pp.259-268.
[119] Hughes, Ll. "Japan's Radical Incrementalism in Energy," In *East Asia Forum* (Vol. 25), 2013.

monopoly systems.[120] A key feature of Japanese markets is the continued existence of private companies – and not State Owned Enterprises (SOEs) – in delivering electricity. Reforming the power market has thus required negotiating with private regulated monopolies, in addition to new market entrants to the power market, and other actors.

A second key characteristic of Japan's power sector is its regional structure. Under the *Electricity Business Law*, ten power utilities – including Okinawa – were responsible for supplying power within designated regions, with limited capacity to supply electricity between these regions (See Figure 1). An additional constraint remains the divide between Eastern and Western parts of the main island of Honshu, which operate on different frequencies (50Hz vs. 60 Hz). Once again, there is limited capacity to redirect power between these regions, standing at 1.2 gigawatts (GW). (For comparison, the Tokyo region has over 50 GW of installed generating capacity.) The shift from a regional monopoly model of power market governance to a system centered on a national market enabling competition between suppliers, and between retailers of electricity, thus faces technical as well as political constraints.

Figure 1: Japan's Regionalized Power Structure



Source: Takuya Yamazaki, "Japan's Electricity Market Reform and Beyond," July 7, 2015, at https://www.iea.org/media/workshops/2015/esapplenaryjuly2015/Yamazaki.pdf

A second feature that requires overhauling is administrative oversight. The supply of electricity from one supply area to another under the regional monopoly system occurred on a bilateral, Over-The-Counter (OTC) basis, rather than through an exchange incorporating many buyers and sellers. The Ministry of Economy, Trade and Industry's (METI) Agency for Natural Resources and Energy (ANRE) regulated rates-of-return, with regional utilities allowed to adjust tariffs in response to changing fuel supply costs by applying to the regulator (ANRE).

[120] Scalise, P.J. "Who Controls Whom? Constraints, Challenges and Rival Policy Images" in Japan's Post-War Energy Restructuring. *Critical Issues in Contemporary Japan*, 2013, pp.92-106.

Initial changes include legal revisions enabling industrial and commercial consumers – representing about 62 percent of the retail market – to select their suppliers over time, with regulatory limits loosened on non-utility generators entering the market. Vertically-integrated utilities nevertheless continue to dominate power sales. Calculated by the amount of electricity supplied, for example, companies other than the power utilities captured just 4.2 percent of electricity in 2013 prior to the introduction of full competition at the household level, and 1.3 percent of total sales were traded on the Japan Electric Power Exchange (JAPX) wholesale power market.

The Fukushima Disaster as a Driver of Radical Incrementalism

The disaster of March 11, 2011 had important effects on the mix of fuels used to supply customers, as discussed elsewhere in this volume. In this section, I focus on the effect of the disaster on the ongoing changes to the power market designed to introduce competition to the generation and retail segments of the market. I posit that the disaster advanced the redesign of the power market forward more rapidly than it otherwise might have been the case in a process of what I term "radical incrementalism."

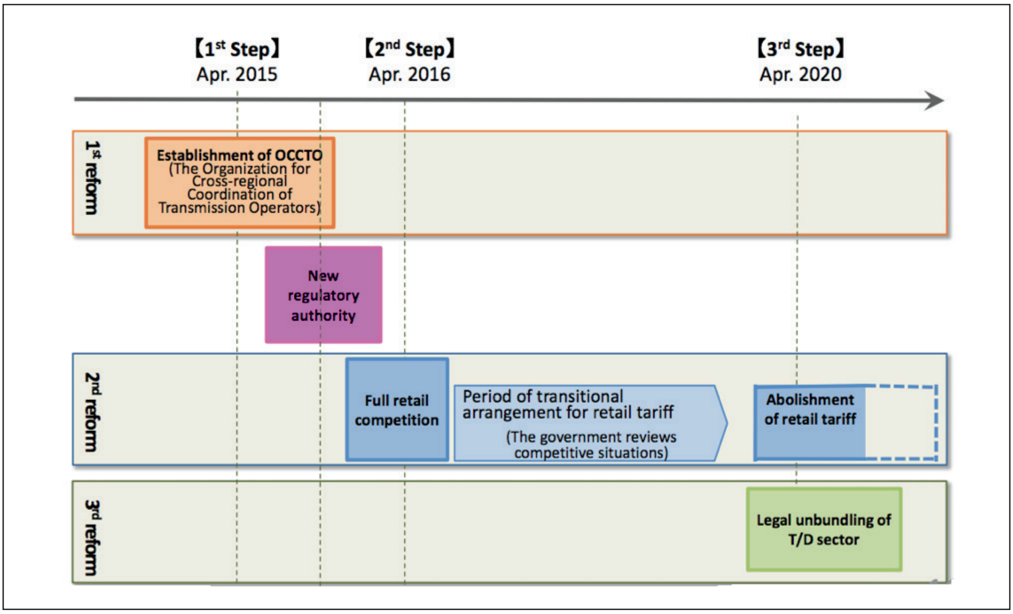
If we frame the changes to Japan's power market in terms of institutional change, the market retains substantial elements of continuity despite the effects of the Fukushima disaster on the role of nuclear power in electricity generation. This is consistent with Dr. Eleanor Westney's analysis, in which she finds important continuities in institutions adopted in post-Meiji Restoration across different public policy areas, despite the extraordinary upheavals of the era.[121] The changes are consistent with a theoretical framework that understands institutions have distributional effects that advantage some actors, whilst imposing costs on others.[122] Institutional stability thus requires the ongoing investment of resources by actors that benefit from their maintenance. In the case of the Fukushima disaster, the governing Liberal Democratic Party no longer had a strong incentive to favor a status-quo benefitting the incumbent power utilities.

The upshot was a series of changes to the *Electricity Business Law* that are progressively changing the rules governing competition in the power sector (Figure 2). A three-phased program first transferred greater responsibility to the regulator for managing electricity flows among Japan's regionalized power grids. This occurred through the creation of a new regulatory body – the Organization for Cross-regional Coordination of Transmission Operators (OCCTO). OCCTO was created in April 2015, partly in recognition of the problems faced in wheeling electricity across utility service areas in the wake of the Fukushima disaster, and is made up of personnel from the Electricity and Gas Group within METI, along with secondees from the utilities. (By convention, utility secondees do not work on interconnection decisions from their own utilities' service area.) OCCTO has the mission of monitoring and enhancing energy security by reviewing the supply-demand forecasts of the utility transmission operators, and planning for grid investments in order to maintain and enhance grid stability. This represents an expansion of the concept of energy security beyond securing the supply chain for fuel

[121] Westney, D. E. *Imitation and innovation.* Cambridge: Harvard University Press, 1986.
[122] Mahoney, J. and Thelen, K. eds. *Explaining institutional change: ambiguity, agency, and power.* Cambridge University Press, 2009.

inputs, which previously dominated Japan's approach to energy security.[123] It is a key change because it removes responsibility for some components of network operation from the vertically integrated utilities, and gives OCCTO some role in determining the costs for new generators to connect to the grid.

Figure 2: Phased Reform of Power Market Regulation



Source: Takuya Yamazaki, "Japan's Electricity Market Reform and Beyond," July 7, 2015, https://www.iea.org/media/workshops/2015/esapplenaryjuly2015/Yamazaki.pdf

An example of the effect of the creation of OCCTO on the power sector is the new process established for sharing the costs of connecting generators to the transmission grid in the Tohoku region. An important issue for Japan given its geography is that there is distance between locations with commercially attractive volumes of wind and solar resources, and the major demand centers of the Tokyo and Kansai regions. The Northern Tohoku and Hokkaido regions, in particular, have substantial wind resources, estimated to be in excess of demand within the Tohoku region itself.

It is OCCTO that has taken responsibility for developing rules governing the distribution of costs between generators in the Tohoku region wishing to newly connect to the high voltage line in Northern Tohoku. This stands in contrast to the previous system, in which negotiations over grid interconnection were carried out bilaterally between new market entrants and the relevant utility, as the network operator. The government designed the system to enable new market entrants to share the costs of building out network capacity enabling connection to the main high-voltage transmission line servicing the Tohoku region. While there remains some uncertainty with the process, the approach nevertheless represents a reduction in barriers to market entry as it implies that fixed investment costs will fall for individual developers as they pool the costs of

[123] Hughes, Ll. *Globalizing Oil: Firms and Oil Market Governance in France, Japan, and the United States*. New York: Cambridge University Press, 2014.

interconnection, relative to what would have occurred in bilateral negotiations with the utility.

The third, and arguably most crucial, stage of the reform process scheduled for implementation in 2020 will see the unbundling of transmission and distribution from the generation and retail segments of the power market. While details are yet to be negotiated within Japan's committee system, material from ANRE strongly suggest that the new legal structure will allow utilities to retain a holding company structure. A holding company structure is one in which network operations are managed by a company established as subsidiary to a company that participates in the competitive segments of generation and retail in the power market.

In preparation for this stage, Tokyo Electric Power Company (TEPCO) – which remains majority owned by the government in the wake of the Fukushima disaster – has already reorganized itself into a holding company structure made up of TEPCO Fuel and Power (generation and fuel procurement), TEPCO Power Grid (transmission and distribution), and TEPCO Energy Partner (retail). Interestingly, TEPCO is using the changing rules governing the power market within Japan as an opportunity as well as a risk, building an international strategy focused on the purchase and operation of generating assets outside Japan. TEPCO Fuel and Power also created JERA – a joint venture with Chubu Electric Power – to procure fuel, and President Toshihiro Sano has signaled an interest in integrating the thermal power operations of the two companies.[124] The important remaining question is the extent to which these changes undermine the problem of market power that continues to beleaguer the Japanese power market.

Challenges of Renewable Energy

As with reforms to the rules of competition in the power market, the Fukushima disaster accelerated change in the mix of energy sources used within the domestic market. The transfer of power to the Democratic Party of Japan (DPJ) between 2009 and 2012 also helped ensure the passing of a new subsidy – the Feed-in-Tariff (FIT) – modelled on Germany, to give Independent Power Producers (IPPs) an incentive to develop renewable energy projects. The FIT had a particularly powerful effect on promoting investments in solar photovoltaics, which made up the bulk of registered projects under the scheme.

The power mix among nuclear, thermal (coal and gas), and renewable energy is projected in the *Basic Energy Plan* (BEP; *enerugii kihon keikaku)*, which is calculated through a model-plant assessment of different generation sources, incorporating the costs of fuel, operating, capital, subsidies, and other factors to 2030, and released as the Long-term Supply Demand Projection (*enerugii choki jukyu mitoshi*). The government included these projections – and the implied Greenhouse Gas (GHG) emissions – in Japan's submission to the United Nations Framework Convention on Climate Change (UNFCCC) Paris Conference of the Parties (COP), as part of Japan's Intended Nationally Determined Contribution (INDC). The BEP is thus a crucial document that both reflects the current state of policy debate, and charts the contours of future policy change.

According to the April 2015 assessment used as the basis for the BEP, renewable energy is projected to double in terms of electricity generated, from 12 percent in JFY

[124] TEPCO. Annual Report 2016 *(Year ended March 31, 2016)*. Tokyo: TEPCO.

2013 to 22-24 percent in JFY 2030. The assessment projects that increased investment in renewable energy will make up for one wedge of the power lost because of the retirement of a significant number of older nuclear power plants. Within renewable energy, hydropower is expected to retain the bulk of electricity generated within the category of renewable energy, followed by solar PV, and then biomass. It projects wind power, in contrast to markets outside Japan, will retain a modest share of electricity generated, at 1.7 percent, although some experts contest this figure as overly conservative.

The increase in renewable electricity generation is another sign of radical incrementalism at work in the Japanese power market. Growth in capacity, and generated power, was anemic under the Renewable Portfolio Standard (RPS) that was the previous centerpiece of the government's efforts to promote renewable energy, with a mean annual growth rate in capacity of approximately five percent across all sources of renewable energy (solar PV, wind power, small-scale hydro, geothermal, and biomass) between JFY 2003 and JFY 2008. This increased to approximately nine percent between JFY 2009 and JFY 2012 with the introduction of net metering that allowed renewable energy producers to sell unused power to the utilities. Between JFY 2012 and JFY 2013, in contrast, there was a 32 percent increase in renewables generating capacity.[125] It also led to an increase in generated electricity, although renewable energy generated continues to represent a small share of Japan's overall electricity supply. Across JFY 2016, renewable energy excluding pumped hydro generated a mean of 56.78 terawatt hours (TWh) of electricity per quarter (JFY 2016 total renewable generation of 227 TWh), against 73.75 TWh/quarter for coal (JFY 2016: 295 TWh), and 100.5 TWh/quarter for natural gas (JFY 2016: 402 TWh).[126]

These changes in fiscal incentives increased investment in renewable energy capacity, and generated electricity. Continued growth of renewable energy is dependent, however, on the successful management of a series of secondary policy issues, specifically:

- Rebalancing the composition of renewable energy investment;
- Managing interconnection of large numbers of renewable energy capacity, and the allocation of the costs of upgrading transmission lines to manage new load; and
- Reducing the rising burden of the FIT on household electricity costs.

Central is the revision of the FIT that came into force on April 1, 2017. The bias of investments in renewable energy types has been identified as a central problem in the current design of the FIT; a large share of registered projects are solar photovoltaic (PV) projects, and many of these have not moved to the development stage, despite being registered under the FIT. A review within ANRE determined that a key reason for this lay in the relatively undemanding standards required for registering projects under the FIT, meaning projects were registered (and thus value created) that had little hope of ultimately reaching interconnection and generating electricity. In addition, the majority of registered projects were in large-scale solar PV, with other areas of potential investment comparatively neglected (Figure 3).

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125 See http://www.meti.go.jp/committee/sougouenergy/shoene_shinene/shin_ene/pdf/001_03_00.pdf.
126 REI, based on METI/ANRE "Monthly Report on Electricity Statistics."

Figure 3: Solar PV as Share of Total Renewables Investment as of March 2014

<Certification status of renewable energy generation facilities as of the end of January in 2016>

Certificated Capacity							
Types of Renewable Energy Generation Equipment	Before Introducing the Fixed Price Purchase System	After Introducing the Fixed Price Purchase System					
	Cumulative Introduction Capacity until the end of June 2012	Certificated Capacity in FY2012 (July ~ end of March)	Certificated Capacity in FY2013	Certificated Capacity in FY2014	Certificated Capacity in FY2015 (April ~ end of January)	**Total after the System Start**	
Solar Power (Housing)	**About 4.7 mil kW**	1.415 mil kW (323,243 cases)	1.268 mil kW (290,392 cases)	1.099 mil kW (234,325 cases)	0.735 mil kW (152,017 cases)	**4.518 mil kW (999,997 cases)**	5.2%
Solar Power (Non housing)	**About 0.9 mil kW**	16.052 mil kW (129,390 cases)	37.249 mil kW (423,919 cases)	17.991 mil kW (242, 189 cases)	3.504 mil kW (59,231 kW)	**74.796 mil kW (854,729 cases)**	87.4%
Wind Power	**About 2.6 mil kW**	0.761 mil kW (68 cases)	0.231 mil kW (41 cases)	1.273 mil kW (199 cases)	0.33 mil kW (309 cases)	**2.595 mil kW (617 cases)**	3.0%
Geothermal	**About 0.5 mil kW**	0.004 mil kW (6 cases)	0.01 mil kW (9 cases)	0.057 mil kW (25 cases)	0.005 mil kW (18 cases)	**0.074 mil kW (58 cases)**	0.1%
Small and Medium-Sized Hydroelectric	**About 9.6 mil kW**	0.076 mil kW (59 cases)	0.225 mil kW (111 cases)	0.356 mil kW (218 cases)	0.085 mil kW (84 cases)	**0.742 mil kW (472 cases)**	0.1%
Biomass	**About 2.3 mil kW**	0.119 mil kW (43 cases)	0.808 mil kW (115 cases)	1.012 kW (116 cases)	0.954 mil kW (58 cases)	**2.892 mil kW (334 cases)**	3.4%
Total	**About 20.6 mil kW**	18.426 mil kW (452,809 cases)	39.791 mil kW (714,587 cases)	21.788 mil kW (477,074 cases)	5.611 mil kW (477,074 cases)	**85.616 mil kW (1,856,187 cases)**	

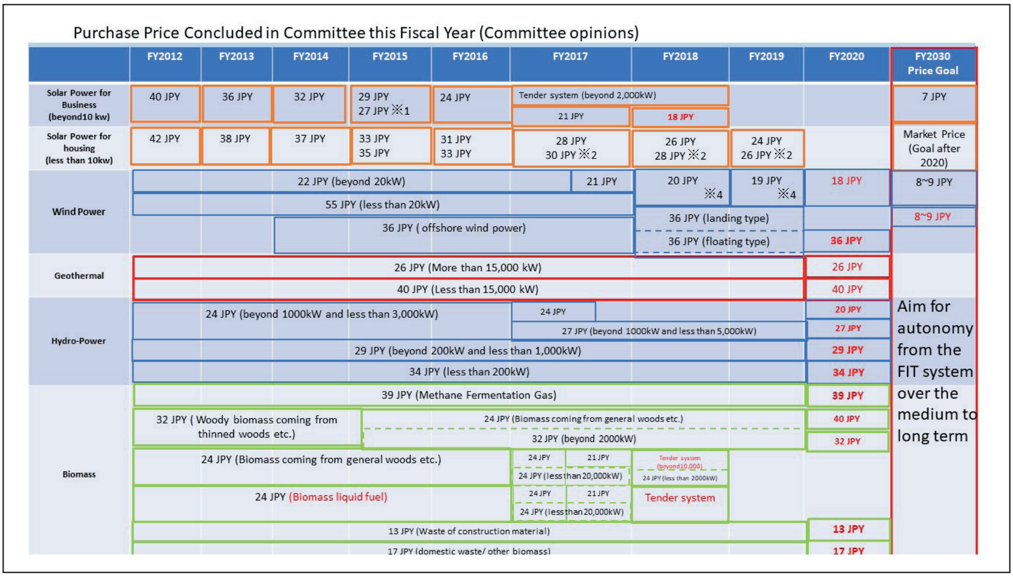
Source: http://www.enecho.meti.go.jp/category/saving_and_new/saiene/kaitori/dl/kaisei/0628tokyo.pdf

In response, ANRE negotiated a revision to the system for registering under the FIT, newly requiring an interconnection agreement to be in place with the network operator as part of the FIT registration process. This set a higher hurdle on developers hoping to gain registration under the FIT. Existing projects were given a grace period before also being required to meet the standards required of new developers. ANRE has also changed the rules to ensure registered projects are more likely to be developed, and projects deemed to have a low likelihood of being developed have been deregistered.

ANRE has also shifted the financial incentives in support of non-solar PV projects, in recognition of barriers that increased uncertainty for developers. Theoretically, the FIT should provide a rate of return sufficient to encourage investment, with incentives reduced as system costs fall due to scale economics, and other factors. A key issue has emerged, however, because of the comparatively long lead times required for certain renewable generation sources, in part because they are required to go through an environmental permitting process.

In response, revisions established a multi-year FIT, providing greater certainty for developers of wind power, biomass, geothermal, and small-scale hydropower. In contrast, the FIT has continued to fall annually for solar PV projects. Offshore wind power was also newly included in the FIT scheme. Taken together, the goal is to improve the quantity and quality of the financial incentives for renewable energy sources other than solar photovoltaics.

Figure 4: Multi-year Feed-in-Tariff Rates



Source: METI

The government also faced a difficult problem in that the number of projects registered under the FIT far exceeded load within the former utility service areas. Indeed, in 2015 Kyushu Electric unilaterally began refusing to accept applications for interconnection because of the size of the implied renewables capacity within its service area.[127] In order to manage this problem, ANRE developed rules governing curtailment, and developed a process for calculating the maximum theoretical capacity able to be connected in each of the utilities' former service areas. The most recent version of rules enable curtailment orders for wind and solar PV generators of up to 720 hours for wind, and 360 hours per year for solar PV, without compensation, and requiring developers to attach equipment enabling curtailment order to be carried out as a condition for grid interconnection.

A final important concern with the FIT is the burden that it is placing on households. Because it is financed in part by costs being transferred to consumers, the FIT is a financial transfer from consumers of electricity to investors in renewable energy. The government assesses that the FIT has already cost ¥2.3 trillion, implying a financial burden on households of an average of ¥675/month. The government projects the fiscal burden of the FIT will almost double by 2030, ¥3.7 and ¥4 trillion.

One response to this dilemma has been to adopt a reverse auction process for large-scale solar facilities, defined as those with a capacity of over 2MW. ANRE designed the reverse auction process to lower costs by giving qualified auction participants an incentive to win access to funds provided by the FIT through bidding lower costs into the auction. The first auction for 500MW, completed under the reverse auction process in November 2017, yielded a price by the successful bidder substantially lower than previous prices, with the lowest bid coming in at ¥17.2/kWh, almost 30 percent lower

[127] See https://spectrum.ieee.org/energywise/green-tech/solar/japan-crimps-solar-juggernaut.

than the FIT rate offered in the previous fiscal year although still far in excess of prices achieved in other markets.[128] A key issue is nevertheless that successful bids under the auction reached 140MW under the first bid, short of the 500MW initially anticipated. Further, a large number of the solar PV companies that competed successfully in the action were affiliates of non-Japanese firms, such as Canadian Solar and Hanwa Q-Cells.

The complex policy issues of rebalancing renewable energy sources, managing interconnection, and reducing the fiscal costs of renewables promotion emerged as a direct result of the success of the FIT in inducing increased investment into Japan's power system. While their resolution continues to be negotiated among policymakers in the LDP and Komeito parties, Japan's ministries and agencies, the incumbent power utilities, and new market entrants, the direction of change – in favor of greater competition and an increased share of renewable energy in the power mix – is fixed. The outcome of debate over the management of the nuclear fleet is a central, and additional, issue that will determine the pace of this change due to its implications for the particular mix of fuels used to generate power, capacity constraints in the transmission and distribution network, and the implications of the resolution of the nuclear issue for Japan's international climate commitments.

[128] Publicover, B. "Japan's METI awards 140 MW in first PV auction — report," PV Magazine. November 22, 2017. Available at: https://www.pv-magazine.com/2017/11/22/japans-meti-awards-140-mw-in-first-pv-auction-report/.

Chapter Seven

Nuclear Energy – Light Water Reactors at a Crossroad

Nobuo TANAKA
Chairman, Sasakawa Peace Foundation

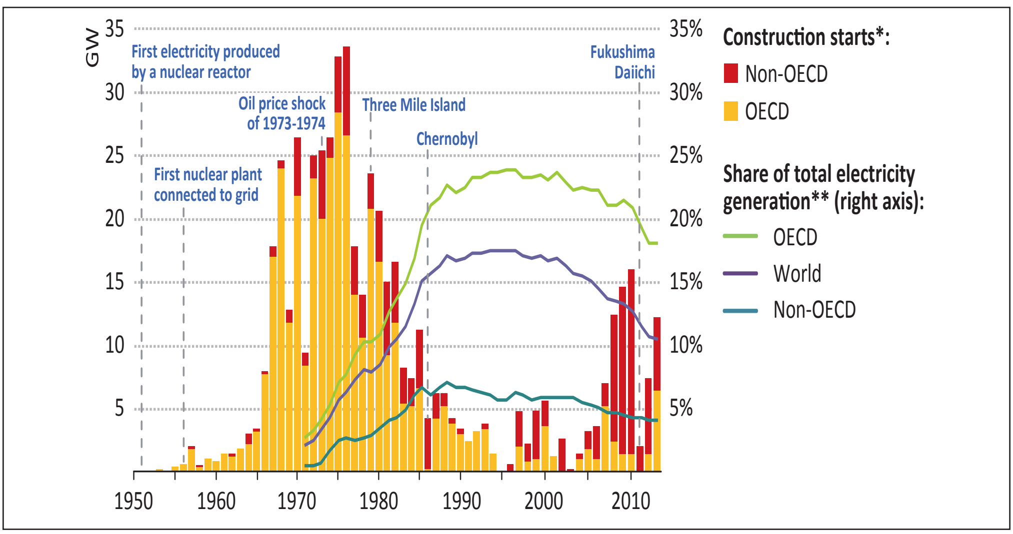
Introduction

Japan has a long history of using nuclear energy to enhance its energy security and fuel its economic growth. There is also a long history of U.S.-Japan bilateral collaboration on nuclear energy. The tragic accident at Fukushima after the Great Eastern Japan Earthquake and Tsunami March 11, 2011 brought the use of nuclear power into question. At the same time, global changes in the nuclear power industry are taking place amid broader developments in energy markets. This chapter looks at the role nuclear energy might play in light of all these developments and suggests a path forward.

Rise of the Light Water Reactor

U.S. President Dwight Eisenhower made nuclear fission technology, originally developed for bombs, available for commercial purposes in 1953 through his "Atoms for Peace" initiative. Since then, countries, including Japan, rushed to build commercial nuclear reactors during the 1960s and 1970s, construction reaching a peak after the first oil crisis in 1973 (Figure 1).

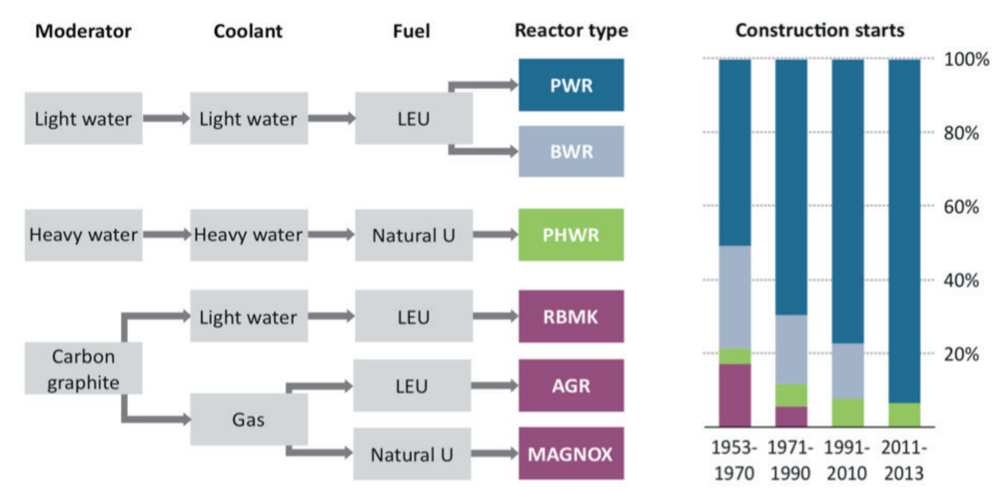
Figure 1: Reactor Construction Starts and Timeline of Events



Source: International Energy Agency, World Energy Outlook (WEO) 2014

There are 434 reactors operating in the world with a capacity of 392 gigawatts (GW), with an additional 76 GW under construction in 2013. They generated 2,478 terawatt hours (TWh) and accounted for approximately 11 percent of total electric power generation in 2013. This share of electricity production increased to 13 percent in 2016 according to the IEA's 2017 World Energy Outlook (WEO-2017). Light Water Reactors (LWRs) cooled and moderated with ordinary water account for almost 90 percent of capacity in operation. There are two types of LWRs: Pressurized Water Reactors (PWRs) that account for two thirds of installed nuclear capacity and Boiling Water Reactors (BWRs) that account for one-fifth (Figure 2).

Figure 2: Overview of Basic Nuclear Reactor Technologies



Notes: LEU = low-enriched uranium; Natural U = natural or slightly-enriched uranium; PWR = pressurised-water reactor; BWR = boiling-water reactor; PHWR = pressurised heavy-water reactor; RBMK = high power channel-type reactor; AGR = advanced gas-cooled reactor; MAGNOX = magnesium non-oxidising.

Source: IEA WEO-2014, using data from IAEA PRIS and IEA analysis

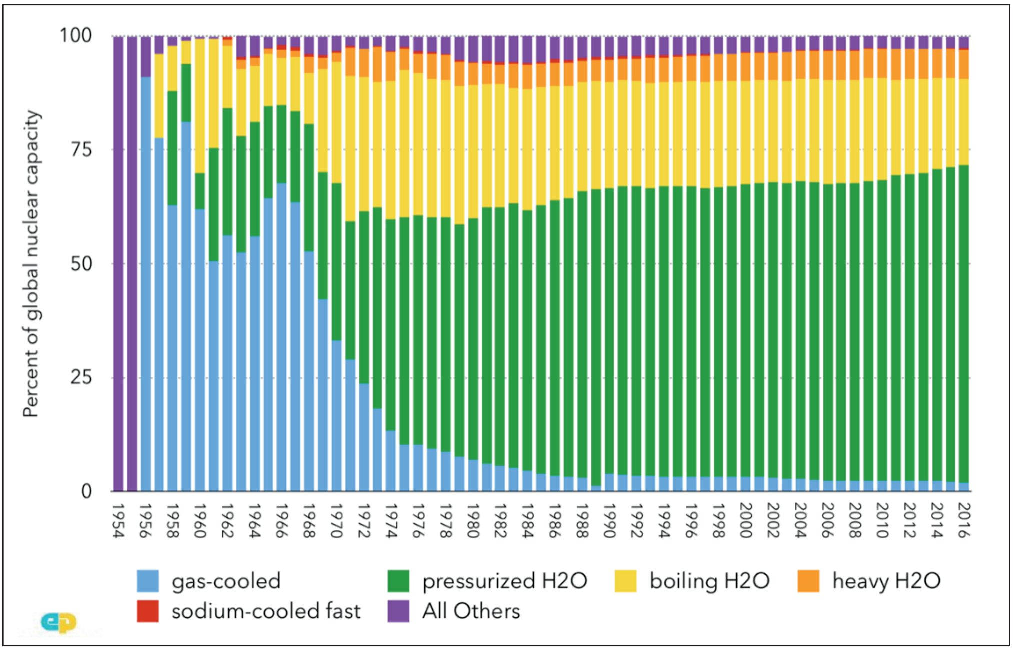
PWRs are the most prevalent type of commercial reactor. The United States originally developed PWRs for submarines. Admiral Hyman Rickover (1900-1986) was the father of the U.S. Navy's nuclear submarine fleet. He successfully established the necessary technology for nuclear submarines and the necessary discipline for the personnel operating them. He himself recruited and trained staff to maintain the safety of the reactors. He ejected staff who did not meet his standards right away. His relentless determination eventually resulted in the safest and most efficient nuclear submarine fleet in the world. Vendors, power plants and regulators recruited retired submarine staffers to help design, build, operate and regulate commercial nuclear power plants.[129]

The safety culture nurtured in the military spun off to civil nuclear engineering. Using regular water as coolant and moderator enables submarine applications to be passively safe. Using steam generators for heat exchange for PWRs enables control of

[129] Rear Admiral Dave Oliver's book "Against the Tide" published in 2014 by the Naval Press describes Admiral Rickover's tremendous efforts.

radioactive contamination. The spinoff of military technologies and experience enabled commercial LWRs, especially PWRs, to enjoy a reputation as a source of cheap, secured and safe electricity (Figure 3).

Figure 3: Reactor Types as Percent of Global Nuclear Capacity 1954-2016



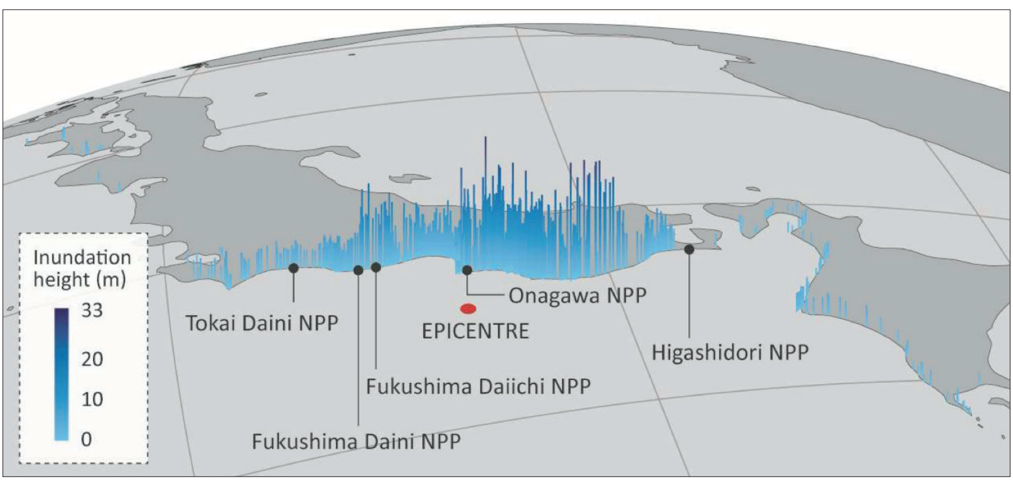
Source: Environmental Progress Tracker, 2017

Safety Risk of Reactors

The Three Mile Island (TMI) accident in Pennsylvania in 1979 was the first serious nuclear power plant safety accident. It triggered public opposition to nuclear power, and construction starts fell sharply. (See Figure 1.) Mechanical and human operational errors creating a shortage of cooling water caused the TMI accident, which resulted in the partial meltdown of the reactor core of Unit 2 and release of radioactive gases. It was a PWR reactor. A shortage of water is the critical safety risk for LWR reactors. A further slowdown of nuclear power occurred after the tragic accident in 1986 at the Chernobyl reactor in the Ukraine. The Chernobyl reactor is a Soviet designed RBMK-1000, a graphite moderated light water reactor. The accident happened because of a serious reactor design flaw, inadequately trained personnel, and the lack of safety culture in the Soviet nuclear community. Even though this reactor type is very different from LWRs, many European countries decreased nuclear deployment after the Chernobyl accident. At the same time, Japan, Korea and China continued building new nuclear power plants. China especially has kept a very ambitious plan for deploying nuclear energy, mainly PWRs.

On March 11, 2011, the Great Eastern Japan Earthquake hit Japan's northeast coast. Forty minutes later gigantic tsunami waves hit Japan's Pacific shores. All operating reactors in the region shut down automatically when the earthquake occurred. However, the tsunami affected nuclear power plant sites very differently. Figure 4 shows the location of the nuclear power plants on the northeast coast and the heights reached by the tsunami. Tokyo Electric Power Company's (TEPCO) Fukushima Daiichi (First) Nuclear Power Plant (1FNPP) experienced a total blackout as the quake cut all external power lines and the high tsunami wave destroyed the emergency diesel generators. The reactor at 1FNPP was a Boiling Water Reactor (BWR). As one type of LWR, it needs water for cooling. The 1FNPP plant lost the water supply essential for its cooling reactor cores due to the lack of power. The operators could not stop the meltdown of reactor cores at Units 1, 2 and 3. The designers had not foreseen the height of such a tsunami at the time of construction: a "Beyond Design (*Souteigai*)" situation happened. However, other power plants prevented accidents even though the tsunami also hit them. Onagawa Nuclear Power Plant of Tohoku Electric Power Company is located closer to the epicenter of the quake and experienced by even higher tsunami waves than Fukushima. However, Tohoku Electric saved the plant because it had built the reactors 10 meters higher than originally proposed. Tohoku Electric Power Company considered a risk of tsunami much more seriously than TEPCO. Moreover, nearby residents used the Onagawa plant site as a shelter at the time of the disaster. Fukushima Daini (Second) Nuclear Power Plant (2FNPP) of TEPCO, located 10 kilometers south of 1FNPP, escaped a similar accident. Because it had emergency diesel generators more robustly housed, some survived. Tokai Daini of Japan Atomic Power Company (JAPC) in Ibaraki prefecture avoided a similar accident just in time; they had increased the height and improved the water tightness of the walls surrounding the seawater pumps prior to the tsunami. The Governor of Ibaraki had demanded that JAPC raise the height of the wall so construction was already underway. These cases reveal that the real reason for the accident at TEPCO's 1FNPP was not the tsunami. The tsunami triggered the accident but if TEPCO had been sufficiently prepared, it could have avoided the catastrophic accident. The real reason for the accident was the lack of preparedness — human error.

Figure 4: Tsunami and Location of Nuclear Power Plants



Source: IAEA, "Fukushima Daiichi Accident Technical Volume 1," 2015.

The Japanese Diet established the independent Nuclear Regulatory Authority (NRA) in 2012 and it has developed and implemented the world's most stringent safety rules.

It took a rather long time for the utilities to meet the standards for restarting reactors shut down one after another for maintenance. As of March 2018, only six reactors were running out of the 48 operable reactors in Japan.

Even before the Fukushima accident, Japanese NPPs had very low capacity utilization rates compared to other countries. Japan's rate was about 70 percent while the rate was more than 90 percent in Korea and 85 percent in the United States. The reason provided is that Japanese regulations, due to cautious safety management, require more frequent checkups. In a sense, Japan had enforced higher standard safety rules relative to other countries. Then, how could an accident such as 1FNPP have happened? This has long been a mystery for me. Many investigatory reports on the accident revealed a lack of safety culture and the existence of a "myth of safety" or the "trap of the safety myth." It means that, since TEPCO believed its safety standard had been proven by its past performance, TEPCO, other utilities, vendors and regulators and the nuclear community as a whole did not think it necessity to prepare and make serious emergency rescue plans for an unthinkable situation like a total plant blackout.

There were missed opportunities that might have helped avoid the accident. After the September 11, 2001 terrorist attacks in the United States, the U.S. Nuclear Regulatory Commission (NRC) in 2002 ordered all nuclear licensees to prepare for a terrorist attack using aircraft. Section B.5.b of the Order demands a "defense in depth" approach for the specific risks. The NRC defines defense in depth as "an approach to designing and operating nuclear facilities that prevents and mitigates accidents that release radiation or hazardous materials. The key is creating multiple independent and redundant layers of defense to compensate for potential human and mechanical failures so that no single layer, no matter how robust, is exclusively relied upon. Defense in depth includes the use of access controls, physical barriers, redundant and diverse key safety functions, and emergency response measures."[130] The NRC is said to have recommended a similar approach to the Japanese regulator but it declined saying there would be no terrorist attacks in Japan and total plant blackouts were unthinkable. Taiwanese and Korean regulators accepted similar advice. If it had accepted the advice, Japan might have avoided the accident. Hence, the regulator made a human error.

TEPCO management also made mistakes allocating resources between two of its nuclear power plants, Fukushima and Niigata. TEPCO's largest and newest NPP is located in Kashiwazaki-Kariha in Niigata Prefecture. Restarting that plant after the Chuetsuoki earthquake in 2007 was an urgent matter for TEPCO's management. Their efforts consequently concentrated on measures to protect against future earthquakes in Niigata and they did not consider seriously the risk of a tsunami at Fukushima. TEPCO did everything to restart Kashiwazaki-Kariha while it operated Fukushima as a cash cow, compensating for the loss of revenue from Niigata. This, in fact, traded the *ANSHIN* (emotional security) of Niigata with the *ANZEN* (technical safety) of Fukushima. Politicians often cite *ANSHIN* and *ANZEN* together to emphasize complete safety and credibility. However, they are very different concepts and their treatment should be different. In order to raise the *ANZEN* (technical safety) level by additional measures in order to increase the *ANSHIN* (emotional security) level often results in unnecessary cost increases. For example, Governor of Niigata has not agreed to restart Kashiwazaki-Kariha because TEPCO cannot

[130] U.S. Nuclear Regulatory Commission. *Glossary*, https://www.nrc.gov/reading-rm/basic-ref/glossary/defense-in-depth.html.

obtain the *ANSHIN* of people in Niigata. If TEPCO should sell Kashiwazaki-Kariha, for example, to Kansai Electric Power Company (KEPCO), the Governor would agree to restart it. The NPP's *ANZEN* will not change by this sale but *ANSHIN* of the people would increase. TEPCO is no longer credible as a nuclear operator and can only survive by becoming a power transmission company in all of Japan and by giving up power generation. The establishment of JERA, the joint thermal power company by TEPCO and Chubu Electric Power Company, is the first step.

Economics of LWRs

Large scale LWRs are an economic base-load power source. Operators achieve an economy of scale by increasing the size of the reactors and their generation capacity. Reactors started out with 250 megawatts (MWe) in 1960s and then increased to 1,000 MWe in 1970s. Third Generation Advanced BWRs reached 1,350 MWe in 1990s. Westinghouse's Advanced PWR is 1,200-1,400 MWe while the European PWR (EPR) in Finland is 1,700 MWe. By introducing larger reactors, power companies theoretically could reduce the unit cost of electricity generation. The overnight construction cost of a new nuclear power plant today varies widely from $2,000/kW for Generation II model in China to $7,000/kW for new European Generation III models according to the IEA's 2004 *World Energy Outlook*. However, generally speaking, overnight costs are rising due to more and more stringent safety rules. China's overnight cost (the cost of a project as if no interest were incurred during its construction) has risen from $2,000 level to over $3,000/kW according to recent research by the Japan Electric Power Information Center, Inc. (JEPIC).

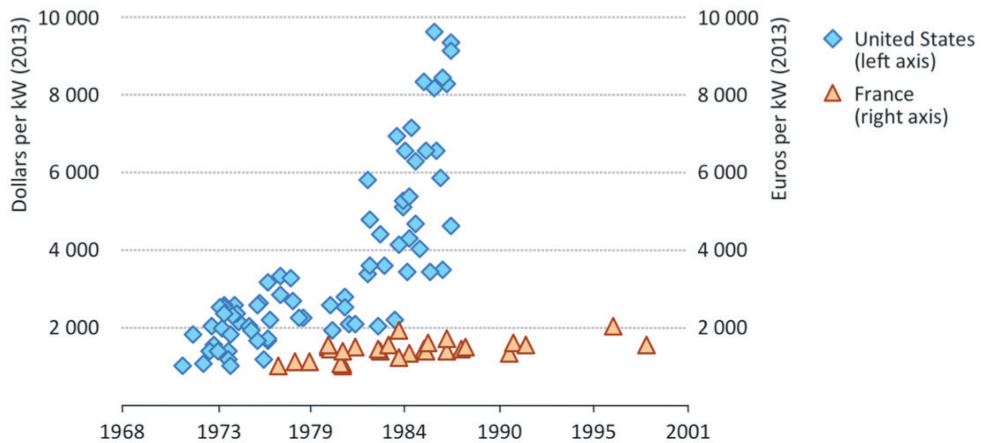
In March 2017, Westinghouse Electric Company filed for the Chapter 11 bankruptcy protection due to the enormous cost overruns in construction of its AP1000 reactors in Georgia and South Carolina. The U.S. Government is providing $8.3 billion of loan guarantees, but the construction costs would end up over $10 billion for these reactors.

The overnight costs of construction can be contained if reactors are deployed in a more standardized manner with limited models and designs. Historical data compiled by the IEA provides a clear comparison between the United States and France (Figure 5). While unit overnight costs in the United States have been rising quickly, France succeeded in suppressing overnight cost increases for years by limiting the reactor models and designs under a single operator, AREVA. The high cost of new French EPRs is because they are first-of-a-kind Generation III reactors. Korea, China and Russia also are successfully containing construction cost increases through standardized deployment. Japan as well as the United States did the opposite.

It is possible to group Japanese utilities by their reactor type. The PWR group is Kansai, Kyushu, Shikoku and Hokkaido. The BWR group is Tokyo, Chubu, Tohoku, Hokuriku and Chugoku. Japan Atomic Power operates both types. Even in the same group, detailed designs are each slightly different even by the same vendor. Deploying two different designs, PWRs and BWRs, also might have increased system costs and risks.

Developers of small modular reactors (SMRs) seek cost reduction through standardized fabrication in spite of possible higher unit costs incurred by giving up the economies of scale of large reactors. SMR developers also seek to reduce licensing costs by speeding up the licensing process by standardized designs. Will the SMR economic model work and by how much? We have to wait and see but whether it is automobiles or cameras, mass-produced and standardized designed goods have proven their safety, cost effectiveness and higher quality.

Figure 5: Trends in Overnight Construction Costs for U.S. and French Nuclear Power Plants



Note: Overnight costs are shown for the year in which plants came online.
Sources: Cour des Comptes (2012), US CBO (2008) and US DOE/EIA (1986).

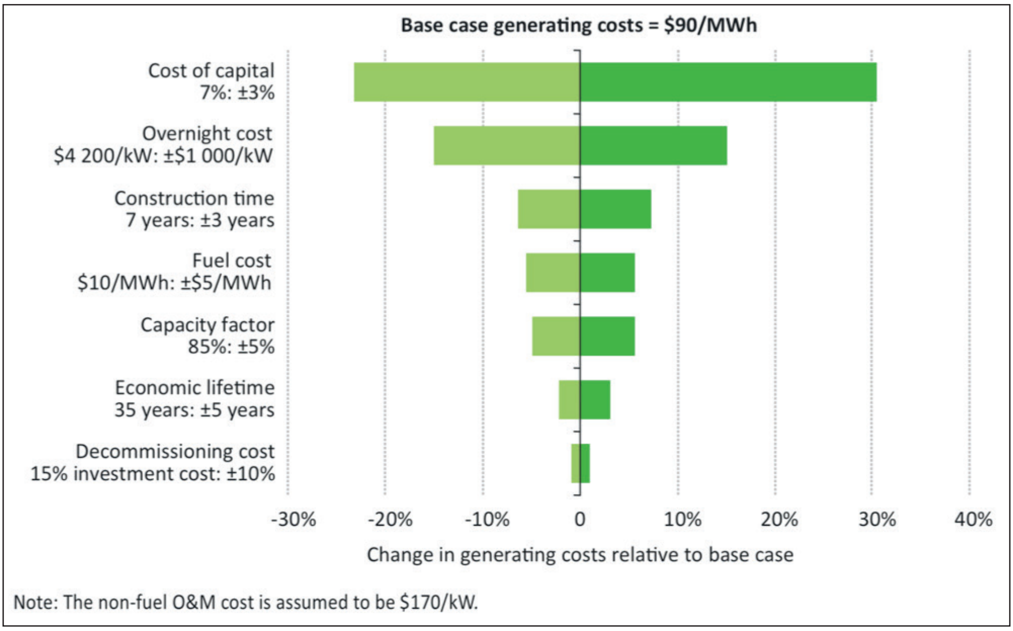
Source: IEA, WEO-2014

Overnight cost is an important element in determining the total financial cost of power plants. However, there are many other elements to consider. The levelized cost of electricity generation (LCOE) calculates the cost of generation for the total lifetime of a newly built plant. Nuclear power tends to face more stringent regulatory processes and political difficulties that result in a longer planning and construction period. Thus, the pay-off period needs to be longer to cover costs. The capacity utilization of power plants is another important factor that can shorten or lengthen the pay-off period. A lengthy process of licensing new technologies can increase costs and uncertainty. After the 9.11 terrorist attack and the Fukushima accident, regulatory authorities around the world established severer safety standards and licensing procedures. Japanese regulatory authorities set very stringent safety standards and even did not allow reactors shut down for maintenance to restart until they passed the new standards. Some other countries criticized these standards as too stringent and costly to implement relative to the global standards set by the International Atomic Energy Agency (IAEA). After the Fukushima accident, building new reactors faces much political uncertainty. LCOEs also have risen significantly. In addition, it is more and more evident that building large LWRs will be very difficult if not impossible in liberalized power markets.

The IEA compared different cost factors and analyzed their sensitivity to the total costs. The average generating cost for the base case is set at $90/MWh in 2014 (Figure 6). Cost of capital and overnight cost play relatively more important roles due to the long-term nature of the investment. On the other hand, decommissioning cost is smaller.

In the following sections, let me compare the cost of nuclear power with gas and coal, and then with renewables.

Figure 6: Sensitivity of Nuclear Generation Costs

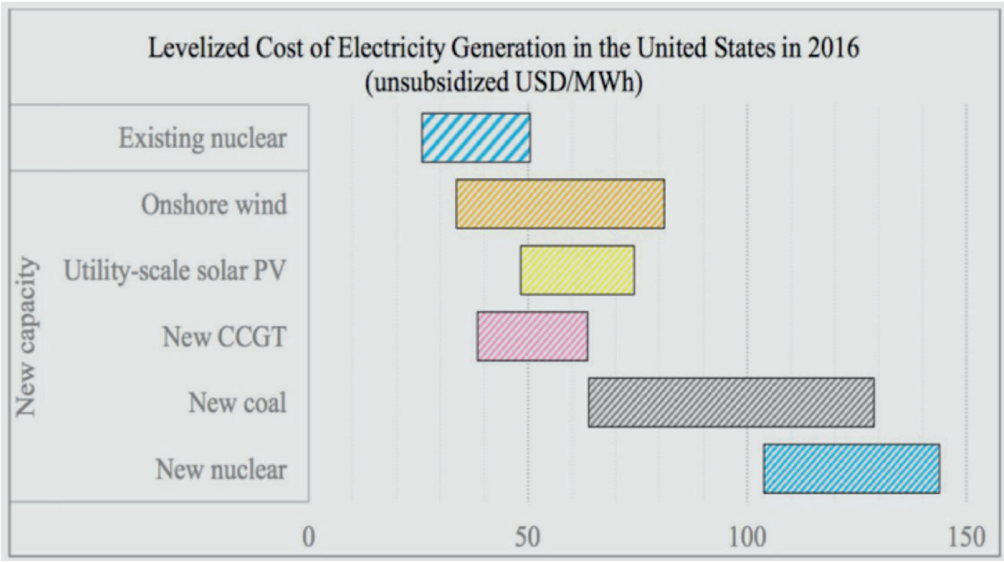


Source: IEA WEO-2014

Challenge of the Shale Gas Revolution

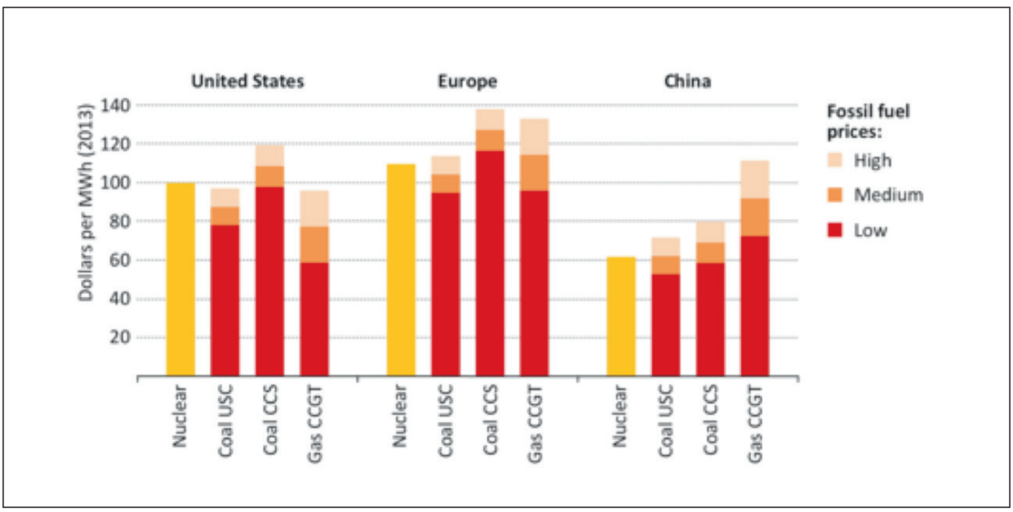
In the United States, there are many nuclear plants closing early before the end of their lifetimes because of very inexpensive natural gas. The "Shale Gas Revolution" in the United States in recent years created a very cost competitive environment for Combined Cycle Gas Turbines (CCGTs). The unit generation cost of existing nuclear plants in the United States is about $40-50/MWh and that of new nuclear plants is over $100/MWh. At the same time, CCGTs cost about $40-60/MWh. (See Figure 7.) New CCGT plants are the most competitive and, as a result, some existing costlier nuclear power plants are shutting down. In Japan, the natural gas price is at least double the U.S. price because Japan imports its natural gas as LNG and must pay the added liquefaction and transportation costs. Consequently, the existing Japanese nuclear power plants may still be competitive as a base-load power source when compared to gas thermal power. In China and Europe, the competitiveness of nuclear plants depends on coal and gas prices. In China, if coal is less than $90/ton, coal power without carbon capture and storage (CCS) is more competitive. In Europe, if gas is less than $13/MBtu (million British thermal units), CCGT is more competitive (Figure 8-1).

Figure 7: LCOE Generation Cost in the United States



Source: Clearpath

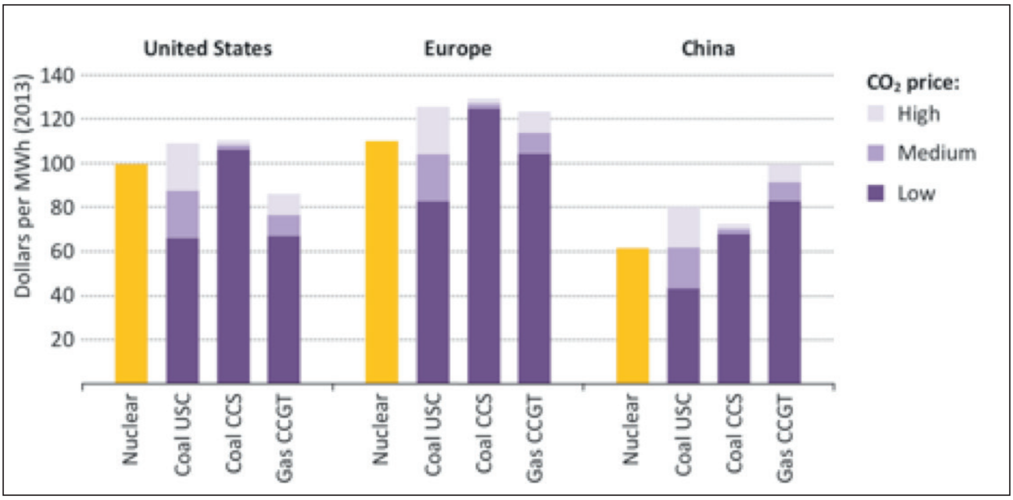
Figure 8-1: Electricity Price Sensitivity to Fuel Prices



Source: IEA WEO-2014
Note: IEA assumptions: U.S. Gas High (H) $10/MBtu, Medium (M) $7, Low (L) $4; U.S. Coal H $90/ton, M $60/ton, L $30/ton; EU Gas H $15/MBtu, M $12, L $9; EU Coal H $140/ton, M $110, L $80; China Gas H $14/MBtu, M $11, L $8; China Coal H $120/ton, M $90, L $60.

Carbon pricing is another important element to include in discussing the future competitiveness of different types of electricity generation. Global warming and sustainability awareness will gradually force countries to implement either explicit or implicit carbon pricing mechanisms. Nuclear and renewables are carbon free energy sources. Figure 8-2 shows IEA analysis of the effect of CO_2 pricing on the relative cost of nuclear to gas and coal. Even with a carbon price of $60/ton of CO_2, U.S. nuclear cannot compete with natural gas. New York and Illinois decided to provide support for nuclear power. Without significant support measures such as exist for renewables, nuclear power in the United States cannot compete with fossil fuels. On the other hand, nuclear could be competitive against coal and gas in Europe and China with carbon price levels estimated in the EU as $50/ton and in China as $25/ton. Governments can create a level playing field for nuclear power if they so wish.

Figure 8-2: Sensitivity to CO2 Prices



Source: IEA WEO-2014
Note: IEA Assumptions: U.S. High (H) $60/ton, Medium (M) $30, Low (L) $0; EU H $65, M $35, L $5; China H $50, M $25, L $0.

Challenge of the Renewables — the Solar Revolution

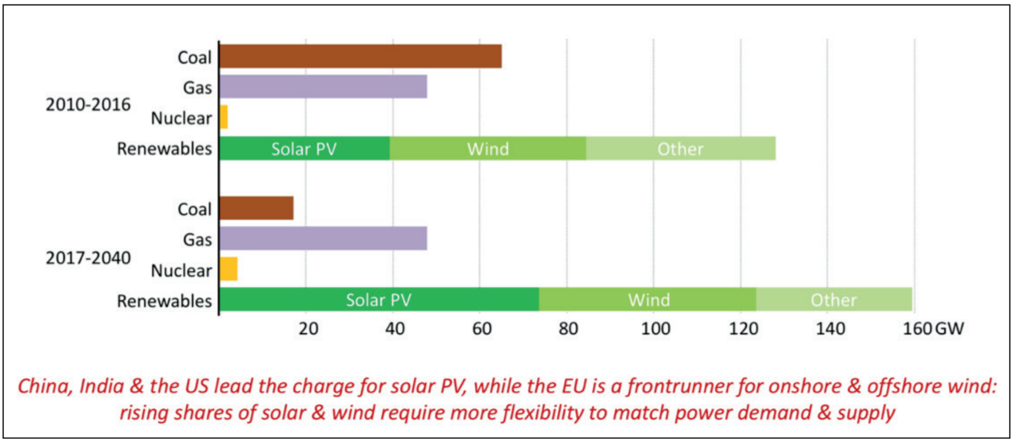
Challenges from renewables are getting tougher. One reason is that renewables benefit from clean energy support measures like feed-in-tariffs, renewable portfolio standards, etc. In addition, solar PV and wind technologies have progressed very rapidly driving down costs so that auctions for solar and wind power in some countries are yielding surprisingly inexpensive costs.

The IEA says in its World Energy Outlook 2017 that solar PV is on track to be the cheapest source of new electricity in many countries. Electrification will advance with electric vehicles (EVs) and the digitalization of economies resulting in radical structural change in the power sector.

In 2016, renewable power capacity additions exceeded that of all fossil fuels. This is a turning point for the power sector. Renewables will account for 60 percent of global capacity additions until 2040 in the New Policies Scenario in the IEA's WEO-2017. Solar is the clear winner among all energy sources (Figure 9). The IEA says that renewables are a global phenomenon and will represent the majority of capacity additions up to 2040 in most regions of the world. How then can nuclear power compete or co-exist with renewables?

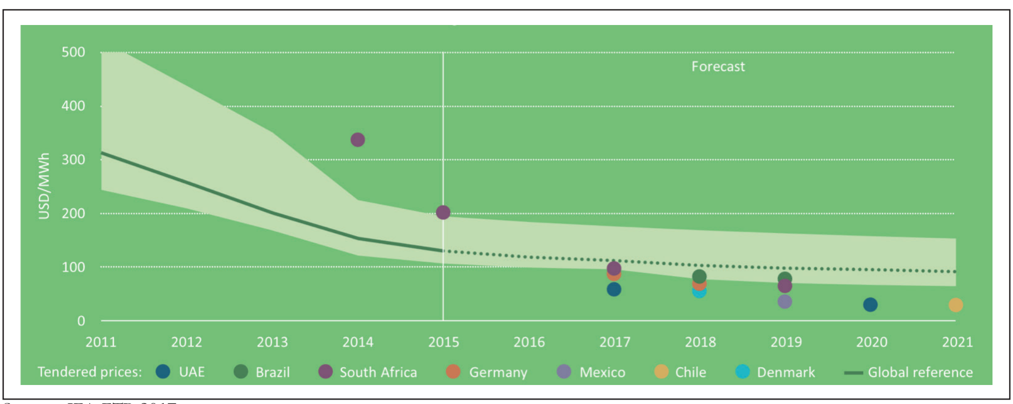
The IEA's Energy Technology Perspective (ETP) 2017 says that by 2016, almost 70 countries employed auction/tender schemes to determine support levels for renewables, compared with fewer than 20 in 2010. In Chile and the United Arab Emirates in 2016, solar PV developers signed contracts for projects at below $30/MWh, a global record low. In Mexico's energy auctions, winning bids ranged from $28/MWh to $55/MWh for both solar PV and onshore wind (Figure 10). In 2016, the global weighted average capital cost of solar PV fell by 20 percent, compared with 2015. Solar cost is changing day-to-day; a recent auction in the Middle East turned out to be less than $20/MWh. The solar revolution may change the game totally and globally. Cost of batteries and other power storage technologies also are likely to decline further, enabling renewables to be a base-load power in the near future. On the other hand, if LWR's LCOE is over $100/MWh and rises higher, it is very likely that LWRs can no longer compete with renewables without substantial public support. The IEA WEO-2014 says the United Kingdom's Hinkley Point C NPP (which would be the first new unit constructed since 1995) required government support called a "contract for difference" which guarantees a price of GBP £92.5/MWh ($145/MWh) for the electricity the plant produces over a period of 35 years. If subsidies have to expand further in the future, it could be politically very difficult to sustain the support.

Figure 9: Global Installed Power Capacity Additions by Type in the New Policies Scenario



Source: IEA WEO-2017

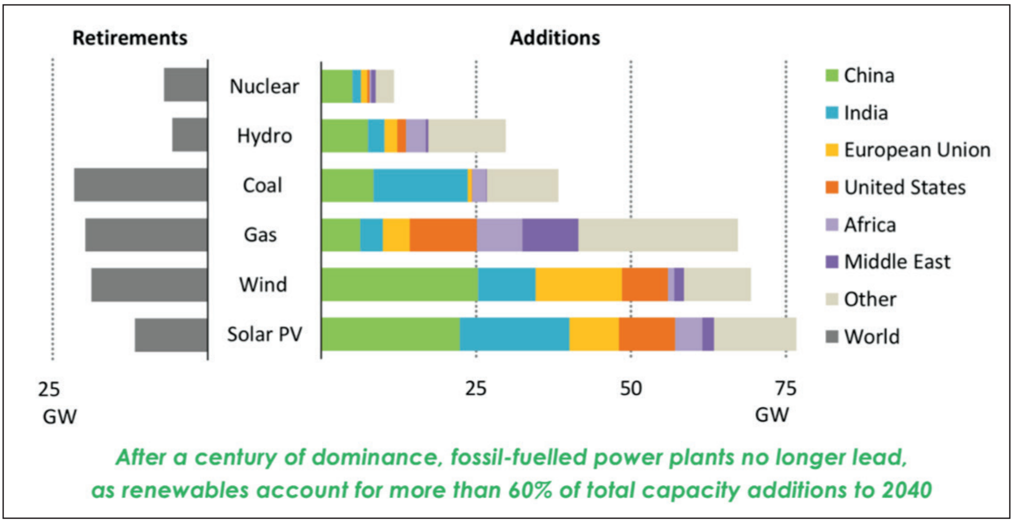
Figure 10: Solar PV LCOE and Contract Prices



Source: IEA ETP-2017

The IEA WEO-2017 predicts that nuclear capacity will grow from 413 GW in 2016 to 520 GW in 2040. Figure 11 shows that, while the nuclear capacity addition looks much more modest than other sources, it will be an additional 10 GW of capacity added every year until 2040.

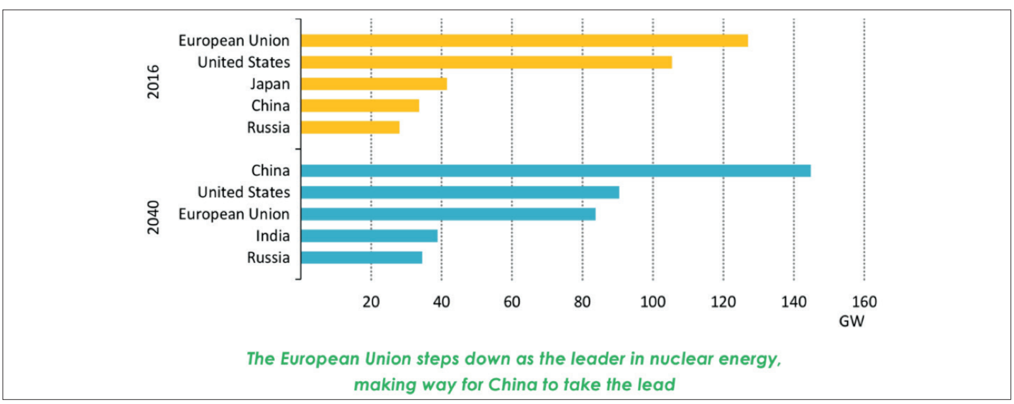
Figure 11: Global Annual Addition and Reduction of Power Capacities in New Policies Scenario



Source: IEA WEO-2017

The EU currently leads globally in nuclear capacity followed by the United States. The IEA's new policies scenario (the likely scenario), tells us that by 2030 China will triple its capacity and become the leader, India will be the fourth and OECD countries stagnate. The EU will lose a third of its capacity by 2040 due to policy changes in Germany, Belgium, France and Switzerland. The United States will stay at second but with much reduced capacity. Japan gradually will restart some of its shutdown reactors but can only recover to 30 GW, more than a third below the level prior to the Fukushima accident (Figure 12).

Figure 12: Top Five regions of Installed Nuclear Power Capacity in New Policies Scenario



Source: IEA WEO-2017

As part of its *13th Five Year Plan*, China has an ambitious goal to expand nuclear power from 34 GW in 2016 to 58 GW by 2020, and plans for up to 150 GW by 2030. China continues to complete its plants currently under construction but nuclear power seems to be getting less competitive even in China. WEO-2017, in fact, expects that investment in nuclear power will increase until 2030 but gradually decline thereafter. How long can China maintain its ambitious plan?

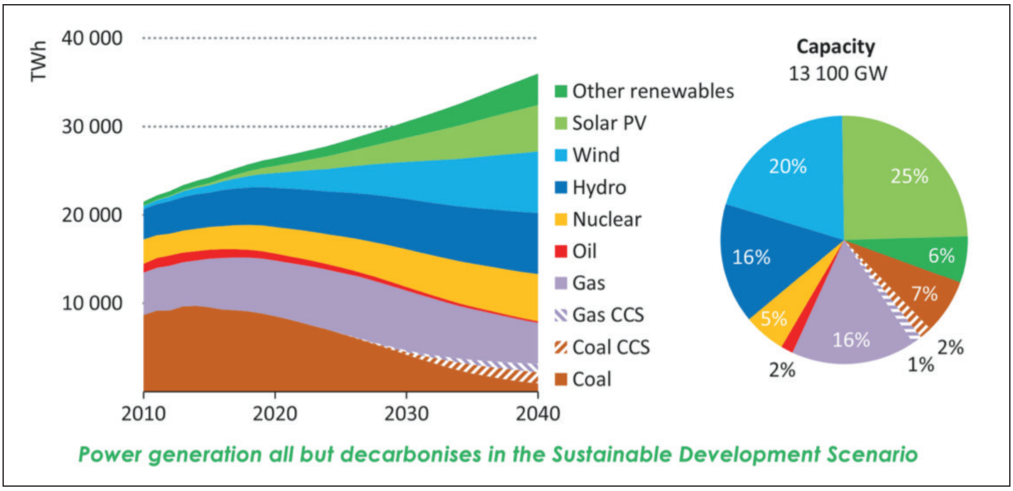
Challenge of the Sustainable Development Goals (SDGs): the Energy Revolution

In order to achieve a sustainable future, the world needs revolutionary changes in the energy sector. Globally, electrification will progress further and clean energy will grow much faster. The Sustainable Development Scenario of the IEA WEO-2017 tells us that to achieve two degree Celsius atmospheric temperature rise containment, less air pollution and universal energy access, we need to double today's energy efficiency, build more than 3,250 GW of solar power and put 875 million electric vehicles (EVs) on road by 2040. This means that 60 percent of electricity generation needs to come from renewables and 40 percent of car stock in 2040 is electric. Batteries on EVs will stabilize volatile renewables by providing a secondary storage system for electricity. (See the China case described in the next section.) Decentralized power systems will enable a much more efficient and effective role for renewables. Coal and oil demand will peak in 2020s.

As for nuclear, the IEA sets a challenging assumption: we need to increase the nuclear share of electricity generation from 13 percent in 2016 to 23 percent by 2040, reaching 655 GW, about a quarter more than in its New Policies Scenario (Figure 13). This means countries must build an additional 20 GW of nuclear power every year. In 1960s and 1970s, we did build more than twenty reactors a year. However, after the major accidents at TMI, Chernobyl and Fukushima, it will be very difficult to get public acceptance to build enough LWRs in OECD countries even to replace retiring reactors. The IEA calculated that globally 200 out of the 434 reactors could be retired by 2040. Retirements will happen mainly in Europe, the United States, Russia and Japan.

There are many questions to address before the Japanese public accepts such a future for nuclear power. After the Fukushima accident, safety is the primary concern of the public. However, passive safety features are not yet operational in LWRs. Operating LWRs are producing radioactive spent fuels but disposal sites are not yet determined in many countries. Addressing back-end issues of the nuclear fuel cycle such as decommissioning old reactors, including the destroyed Fukushima reactors, and how and where to dispose radioactive toxic waste is essential to recover the public confidence. Nuclear should also fit into an increasingly decentralized/distributed power supply. In order to achieve the IEA targets, we quickly need to make a paradigm change to Generation IV reactors in order to have "Sustainable Nuclear Power."

Figure 13: Power Generation and Capacity Share in the Sustainable Development Scenario



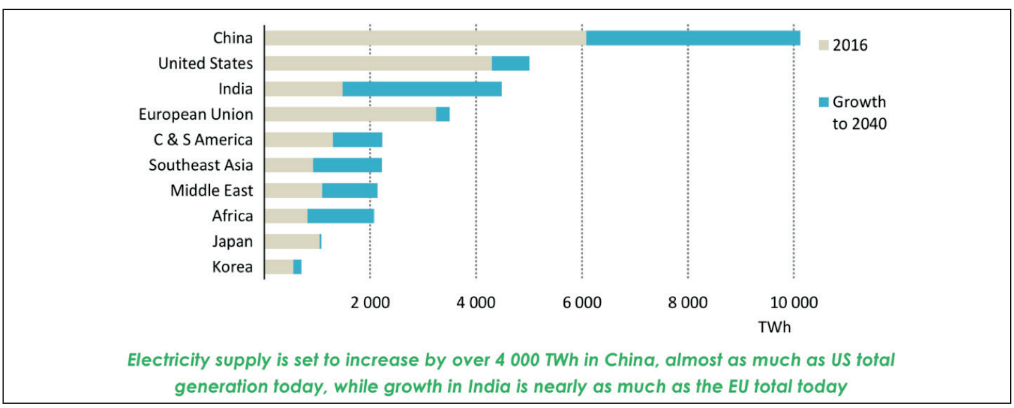
Source: IEA WEO-2017

Challenge of Electrification and Global Competition

Electrification will continue. The IEA's New Policies Scenario posits that electricity demand will grow 60 percent by 2040 and that over 85 percent of global demand growth will be in developing economies. India will add as much electricity consumption as total current European demand and China will add as much as total current U.S. demand (Figure 14). Digitalization, service sector-led growth, cooling for housing and EVs will drive the demand.

China is the game changer for the "Energy Revolution." Battery storage, particularly EV batteries, can play a role in China's electricity future as costs decline. For example in China, IEA's WEO-2017 New Policies Scenario says that, with annual sales of light-duty EVs projected to rapidly rise from 1.8 million in 2020 to 9.5 million by 2040, 35 GW of battery capacity could be available for grid applications by 2030 alone, and almost 70 GW by 2040. If the Sustainable Development Scenario happens, the number of EVs in China in 2040 would be 200 million.

Figure 14: Total Electricity Generation in 2016 and Growth to 2040 in New Policies Scenario

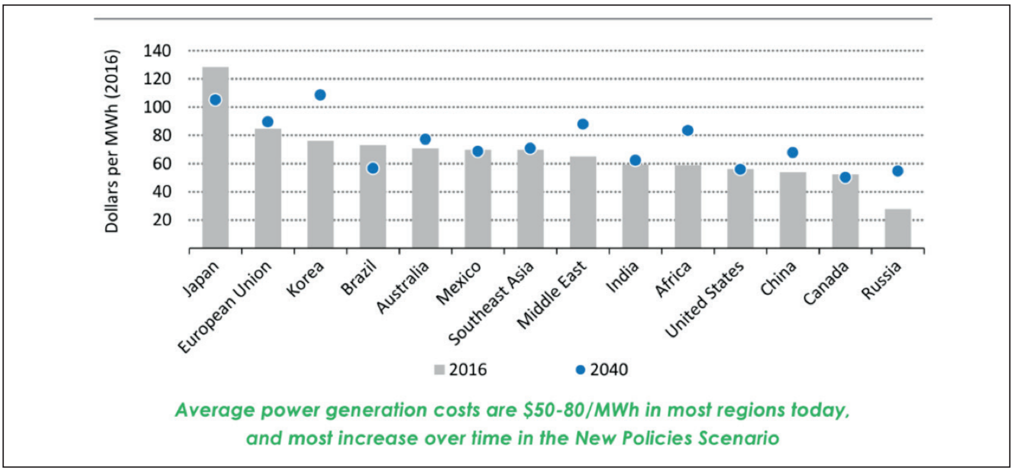


Source: IEA WEO-2017

Therefore, it is imperative for countries to have inexpensive electricity to survive global industrial competition. What matters is the total cost of electricity rather than the individual cost of different energy sources. Competition will drive high cost power sources out of the power mix. For example, in China, new coal and gas-fired power plants cost will increase due to fuel, labor and CO2 costs. The IEA's WEO-2017 says that the average LCOE from utility scale solar PV currently is over $100/MWh and not cost-competitive without subsidies. However, due to falling costs, the average solar PV project will become less expensive than both new and existing gas-fired power plants by 2020, and new coal-fired capacity and onshore wind by 2030. By 2040, solar PV will be the cheapest form of electricity generation in China.

There are significant differences in power generation costs across regions. Russia, Canada, China and the United States are at the lower end, while Japan, the EU and Korea are at the higher end because they are energy importers. The latter group's competitiveness may suffer in coming years if electricity costs continue to be higher. Europe seems to be withdrawing from nuclear. Can nuclear power survive in Japan or Korea? How about in China? (See Figure 15.)

Figure 15: Average Power Generation Costs by Region

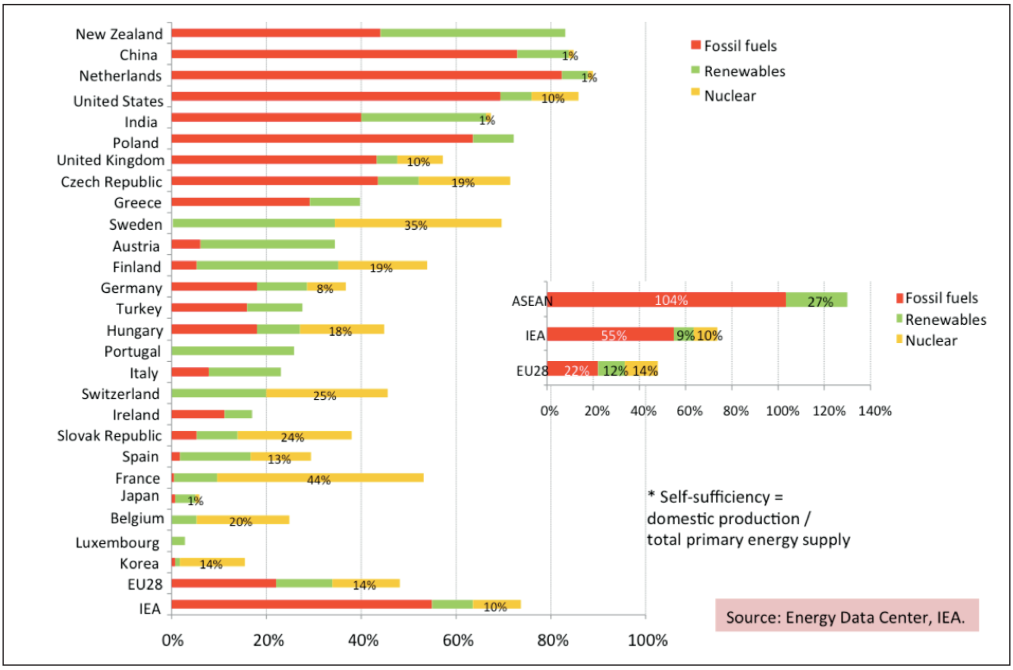


Source: IEA WEO-2017

Collective Energy Security and Sustainability

While the power mix is highly diverse country by country, the EU overall enjoys a self-sufficiency rate of 50 percent (Figure 16). Those countries without fossil fuels or many renewables such as France, Slovakia and Belgium use nuclear power. By connecting power lines and gas pipelines, the EU can achieve collective energy security and sustainability. The largest beneficiary is Germany as it located in the middle of Europe. After the Fukushima accident, the German government decided promptly to phase out nuclear power by 2022. However, Germany can import electricity generated by nuclear power from France and trade renewables with the neighboring countries to help reduce generation cost. Germany's geographic advantage enables it to phase out nuclear power and use more renewables. Japan and Korea do not have this advantage, as their electricity grids do not connect with neighbors. Nuclear therefore has a more important role to play.

Figure 16: Ranking of Countries by Energy Sufficiency by Fuels in 2013

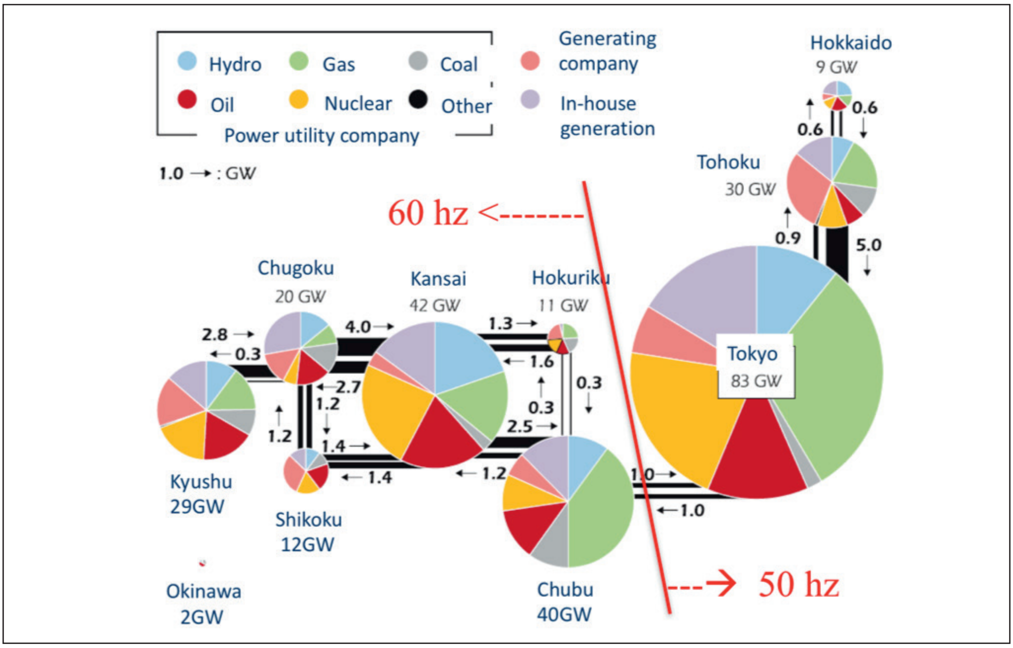


Source: IEA

Japan's situation is even more serious because grid connectivity between her two power systems is very weak. Japan for all practical purposes is separated into two frequency zones, 50 hertz in the east and 60 hertz in the west (Figure 17). The IEA has long recommended Japan unify the frequency zones and strengthen connectivity for the sake of both security and sustainability. However, the government has not followed that advice, which contributed to the Fukushima blackout. There was enough extra capacity in western Japan but those utilities could not transmit to the east where the accident occurred due to the weak connection. In addition, the lack of connectivity hampers the expansion of renewables. Japan introduced the ambitious feed-in-tariffs and the number of new solar PV projects has grown rapidly. Yet, actual solar generation has been limited because of the lack of physical connectivity as well as the unwillingness of utilities to use renewables. The unification of frequency zones has never happened because of power company opposition. The power companies, established as regional monopolies, did not want the tougher competition that would result from connecting with each other and from new market entrants. It remains to be seen how this issue plays out with Japan's deregulation of its electricity market.

After the Fukushima accident, Japan's energy market is undergoing revolutionary changes. The nuclear shutdown continues, compensated for by high cost imported gas and oil. A very favorable feed-in-tariff is encouraging renewables. Globally, the cost of renewables is declining rapidly. Japan nationalized its largest power company, TEPCO. Power market reform "unbundling transmission and generation" has occurred.

Figure 17: Lack of Grid Connectivity in Japan



Source: METI's Agency for Natural Resources and Energy, the Federation of Electric Power Companies of Japan, the Electric Power System Council of Japan, the International Energy Agency

The power system must still undergo further transformation. A window of opportunity for strengthening international connectivity exists. Several proposals to connect Japan's power grids with its neighbors have appeared. Among them, the proposals of Masayoshi Son of Softbank and Liu Zhenya of China's State Grid of China are worth mentioning. They respectively are the "Asia Super Ring" and the "Global Energy Interconnection." Softbank, State Grid, KEPCO of Korea and Rosseti of Russia established a joint venture that did a feasibility study on how to connect Japan with Russia-China-Korea by 2 GW high-voltage direct-current (HVDC) power lines and how to import solar generated electricity from Mongolia. Russian President Putin endorsed the project at the 2016 Vladivostok Far Eastern Economic Summit. Mr. Son declared that power lines should be connected by 2020. If it happens, it will be the first step towards "Collective Security and Sustainability in Asia" similar to the European model. If Japanese utilities have to compete in such large market, they may become much more competitive just as European utilities did under the new framework of European Energy Union.

Does Nuclear Matter?

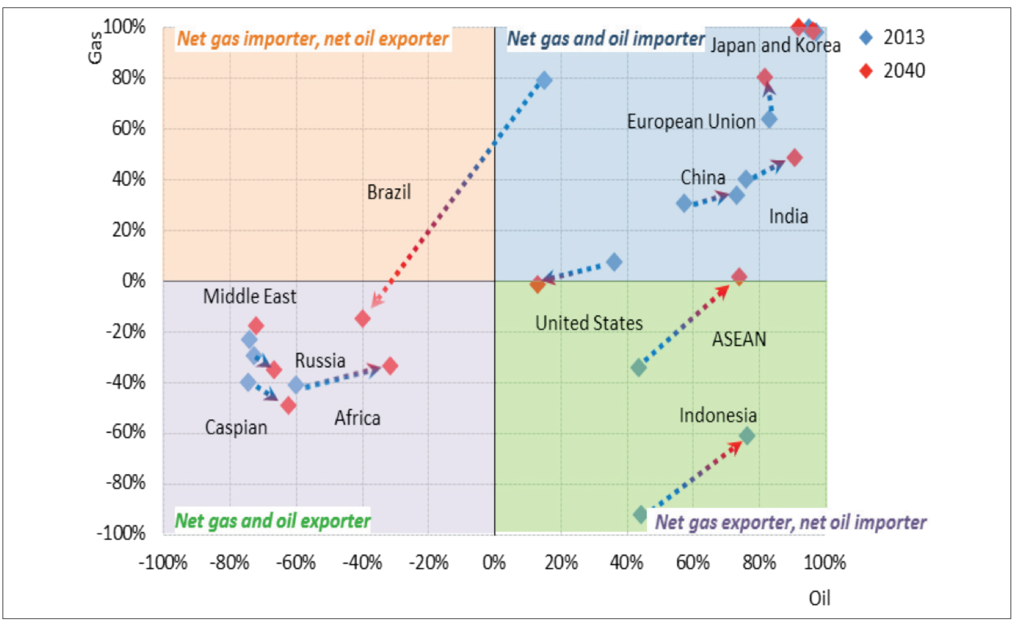
I suggest that yes, it does. Operating nuclear power plants does have risks associated with severe accidents such as radioactive contamination and resulting public health problems. However, the zero nuclear option also has risks.

First, if we use fossil fuels for power generation instead of nuclear, there will be more CO2, aggravating global climate change. Moreover, pollutants from some fossil sources carry public health risks, causing millions of deaths. Coal is the most dangerous energy source due to air pollution that causes premature deaths from respiratory illnesses. On the other hand, renewables with effective storage technologies can also play a role similar to nuclear creating a cleaner environment less expensively. However, until there can be full utilization of energy storage technologies, nuclear continues to be important. The effective stabilization of the power supply necessitates diversified sources and connectivity. The real question is what are the costs and benefits that would legitimize nuclear power?

Second, for countries such as Japan or Korea who are major importers of fossil fuels from the Middle East, the zero nuclear options put at risk a stable energy supply due to possible disruptions by geopolitical events and by natural disasters. Figure 18 shows oil and gas import dependency by country. The United States likely will achieve energy independence through the shale revolution. The IEA WEO-2017 says the United States will be a net exporter of oil by the end of the 2020s and the largest exporter of LNG by the middle of the 2020s. On the other hand, Japan and Korea are now and continue to be 100 percent import dependent for oil and gas. Therefore, it is suicidal for Japan and Korea to phase out nuclear power quickly. Nuclear power contributes to the diversity of energy supply and hence both countries' energy security. Restarting shutdown nuclear plants in Japan also is important to save significant imported fuel costs: the shutdown of reactors after the Fukushima accident cost Japan on average more than one trillion yen, about ten billion U.S. dollars, a year for additional fossil fuel imports.

Nuclear is certainly a quasi-indigenous source but renewables are indigenous. Japan can also import electricity and diversify by connecting grids. The question should be the cost and benefit of energy security provided by nuclear power.

Figure 18: Oil and Gas Import Dependency by Countries



Source: IEA

Third, China, India and other emerging countries will continue building new reactors whether or not Japan shuts down its nuclear power. Possible accidents in China or

Korea could send radioactive plumes over Japan. Japan's experience and the lessons of Fukushima will help safer operation in these countries. Rather than giving up nuclear power, Japan should improve the safety of its operations as well as ensure proper regulation. It also should keep advising nuclear newcomers as a global model of the peaceful and safe use of nuclear power. There are valid arguments in favor of maintaining LWRs in Japan as long as China or Korea continue the LWR paradigm.

Fourth, nuclear power has national security implications. Joseph Nye and Richard Armitage mentioned their serious concern that a nuclear-free Japan will drift toward being a tier-two nation with a negative affect on the U.S.-Japan alliance:[131]

> "For such an alliance to exist, the United States and Japan will need to come to it from the perspective, and as the embodiment, of tier-one nations. In our view, tier-one nations have significant economic weight, capable military forces, global vision, and demonstrated leadership on international concerns. Although there are areas in which the United States can better support the alliance, we have no doubt of the United States' continuing tier-one status. For Japan, however, there is a decision to be made. Does Japan desire to continue to be a tier-one nation, or is she content to drift into tier-two status?
>
> "While the people of Japan have demonstrated remarkable national unity in reducing energy consumption and setting the world's highest standards for energy efficiency, a lack of nuclear energy in the near term will have serious repercussions for Japan.
>
> "The 3-11 tragedy should not become the basis for a greater economic and environmental decline. Safe, clean, responsibly developed and utilized nuclear power constitutes an essential element in Japan's comprehensive security. In this regard, U.S.-Japan cooperation on nuclear research and development is essential."

After the Fukushima accident and the rapid deployment of inexpensive renewables, some may no longer consider LWRs a safe, clean and cheap electric power source. Yet, given recent geopolitical developments in Northeast Asia, eliminating Japan's nuclear capability could be very unwise. If so, whether and how we should maintain Japan's nuclear capability needs to include the national security perspective as part of a serious public discussion. Japan will never ever build nuclear weapons, and yet being suspected of doing so by some of its neighbors, is probably the strongest national security reason for Japan to continue to use nuclear power.

Small Modular Reactors: the Sustainable Nuclear Power Paradigm

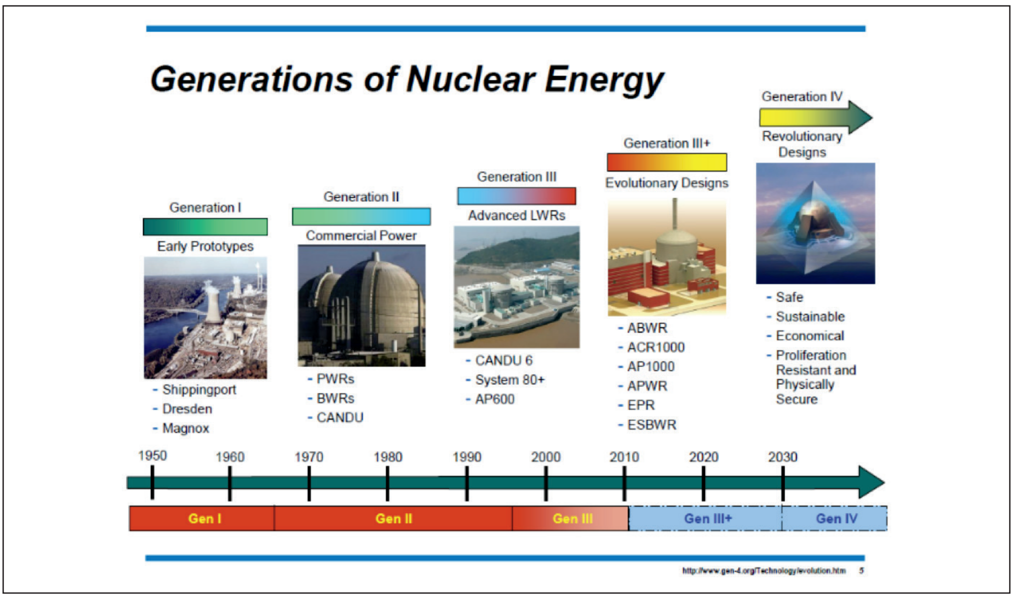
Small Modular Generation IV Reactors might be the alternative answer to LWRs. Since they built identically in factories, regulators could provide a single license for all reactors built in the same series. Reduced licensing transaction costs may offset their smaller economies of scale derived from their smaller sizes. Reduced financial burdens may facilitate smaller utilities, small localities and emerging countries to use standardized

[131] Joseph Nye and Richard Armitage. *The U.S.-Japan Alliance Report*, presentation at Center for Strategic and International Studies (CSIS), August 10, 2012.

SMRs in cases where they would not consider a LWR. Standardization is the key for higher safety and lower costs. SMRs may provide another valuable trait by enabling frequent changes in their load factor leading to a friendly co-existence with volatile renewables. SMRs also may offer a new paradigm of decentralized (distributed) nuclear power. A large reactor with high initial costs must operate as base-load power source. It is most efficient connected to, and supplying, a large grid, which was the LWR paradigm prior to Generation III reactors. China and India may continue this paradigm due to relatively lower construction costs and rapidly growing demand for carbon and pollutant free electricity by their urban areas. Nevertheless, it is time for OECD nations to move into a Generation IV advanced reactor paradigm.

Generation IV reactors have a variety of technologies but with common features of passive safety, modularity, proliferation resistance, easy management and less need for frequent replacement of spent fuels. (See Figure 19.) There are also many small venture companies in the pipeline developing various advanced Generation IV nuclear technologies varying in coolant, fuel type and modularity as depicted in Figure 20.

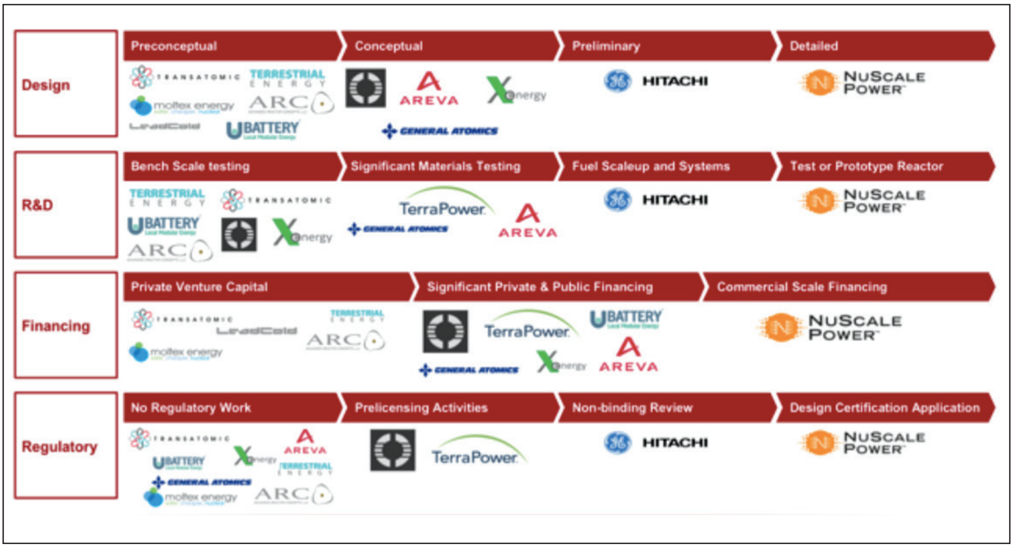
Figure 19: Generations of Nuclear Energy



Source: Generation IV International Forum

The biggest hurdle for these new technologies is the licensing process. Predictable licensing is therefore the first issue to be resolved. The process should be shortened and operate as an "enabling regulation" such as that which Canada is trying to implement. Many SMR nuclear venture companies are seeking a Canadian license, hoping for faster approval that could lead to demonstrations and perhaps facilitate faster licensing in other countries.

Figure 20: State of Play Among Nuclear Fission Innovators



Source: Clearpath

Conclusion

Dr. Takashi Nagai was a Professor at Nagasaki University in 1945 when the atomic bomb fell. He exemplifies the Japanese people's resilience, courage, and belief in science. Despite suffering a severed temporal artery from the bomb, he went to help other victims even before going home. Once he got home, he found his house destroyed and his wife dead. He spent weeks in the hospital where he nearly died from his injuries. However, just months after the atom bomb dropped, he said:[132]

> "Everything was finished. Our mother land was defeated. Our university had collapsed and classrooms were reduced to ashes. We, one by one, were wounded and fell. The houses we lived in were burned down, the clothes we wore were blown up, and our families were either dead or injured. What are we going to say? We only wish to never repeat this tragedy with the human race. *We should utilize the principle of the atomic bomb. Go forward in the research of atomic energy contributing to the progress of civilization. Devil will then be transformed to fortune (Wazawai tenjite Fukutonasu). The world civilization will change with the utilization of atomic energy. If a new and fortunate world can be made, the souls of so many victims will rest in peace."*

The Fukushima accident was a huge tragedy. The nuclear community and the Japanese government lost the public's trust. Japan lost the world's trust in her technological

---

[132] Quotation from Dr. Yoichi Fujii-e, Tokyo Institute of Technology, in *Nuclear Fission Energy Systems to be explored for the Future*, February 17, 2016 at https://www.jaea.go.jp/news/symposium/RRW2016/shiryo/e02.pdf.

capability. Yet, if we solve the remaining problems of the Fukushima by building a Generation IV Reactor as outlined in the special proposal found just after this chapter, I believe we may regain that trust and transform the devil to fortune just as Dr. Takashi Nagai said after the tragedy of Nagasaki.

A Special Proposal for U.S.-Japan Nuclear Cooperation

Nobuo TANAKA
Chairman, Sasakawa Peace Foundation

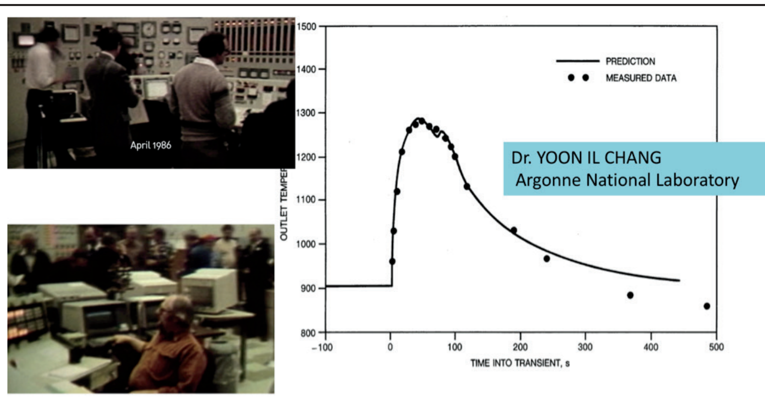
The Integral Fast Reactor

I propose we build a small Integral Fast Reactor (IFR) at the Fukushima Daini (Second) Nuclear Power Plant (NPP) located 10 kilometers south of the Fukushima Daiichi (First) NPP for experimental use to solve the debris issue. The Sasakawa Peace Foundation did a detailed feasibility study of this idea in 2016.[133] Total cost of construction of an IFR would be $2 to $3 billion and would reduce the transuranium (TRU) in the debris by a third in 25 years. How would this work?

The U.S. Department of Energy's Argonne National Laboratory developed a Generation IV technology called the Integral Fast Reactor (IFR). A commercial version is the S-PRISM of GE-Hitachi Nuclear Energy. The IFR is a fast reactor with a sodium coolant and metal fuel. Argonne National Laboratory built the prototype, the EBR-II in 1964.[134] Argonne also successfully used pyroprocessing to treat, recover and recycle uranium and plutonium to EBR-II.

The IFR features include an inexhaustible energy supply, inherent passive safety, a long-term waste management solution, proliferation resistance and economic fuel cycle closure. Scientists proved its passive safety in a 1986 experiment that had conditions very similar to the Fukushima accident, namely total plant blackout. Figure 1 depicts the test result. The reactor core temperature rose quickly at first but gradually came down without human intervention.

Figure 1: Loss-of-flow without Scram Test in EBR-II



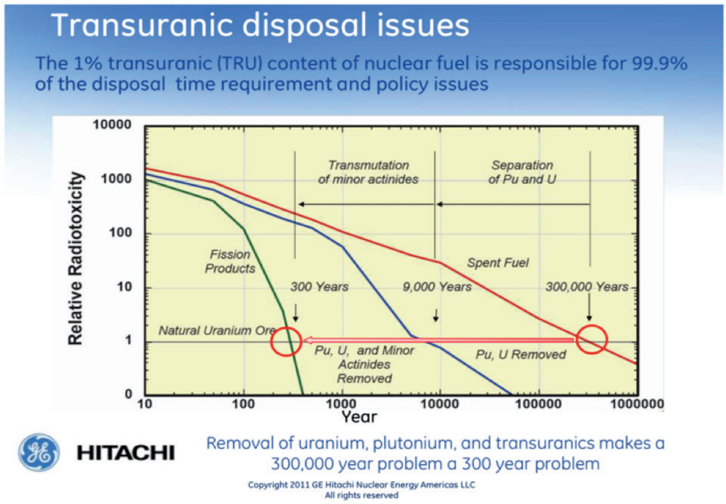
Source: Argonne National Laboratory

This process could reduce the radio toxicity of high-level spent fuel waste to the level of natural uranium level within 300 years compared to 300,000 years it would

[133] Sasakawa Peace Foundation. T*echnical Feasibility of an Integral Fast Reactor (IFR) as a Future Option for Fast Reactor Cycles – Integrate a Small Metal-Fueled Fast Reactor and Pyroprocessing Facilities,* November 30, 2106 at https://spfusa.org/research/technical-feasibility-integral-fast-reactor-ifr-future-option-fast-reactor-cycles/.
[134] More on the history of the EBR-II is at http://www.ne.anl.gov/About/reactors/EBR2-NN-2004-2-2.pdf.

take using pyroprocessing technology. Removal of uranium, plutonium and transuranics (Minor Actinides or MA) for burning in the fast reactor makes a 300,000-year problem a 300-year problem. Politically it is much easier to find a high-level waste disposal or storage site for 300 years rather than 300,000 years. (See Figure 2.)

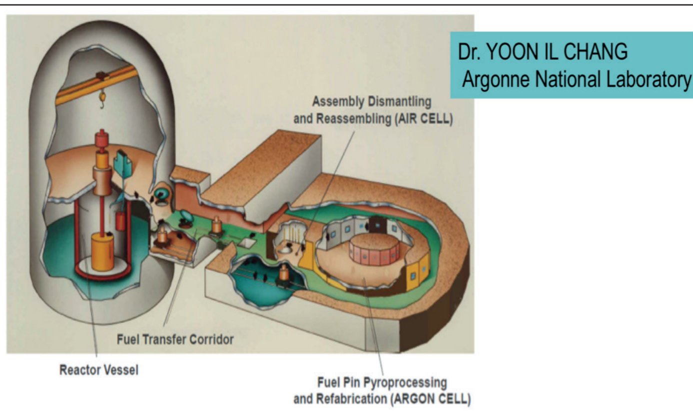
Figure 2: High Level Waste Disposal Issue



Source: Hitachi

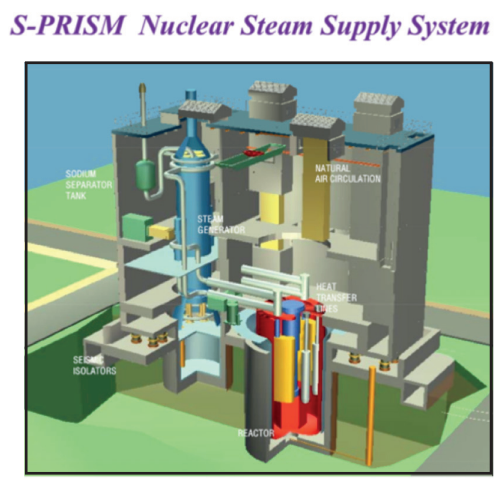
Figure 3 shows an image of this impressive technology. As the IFR is a closed system, plutonium will not have to move from the site. This also reduces the risk of seizure by a terrorist. In addition, pyroprocessing separates the MA and plutonium from other fission products. MA's high radio toxicity is more proliferation resistant than products from PUREX chemical plutonium separation technology, another separation technology used by all current reprocessing plants. Figure 4 shows the commercial version of IFR, the S-PRISM.

Figure 3: Image of Integral Fast Reactor



Source: Argonne National Laboratory

Figure 4: GE-Hitachi Nuclear Energy's S-PRISM



Source: GE-Hitachi

Argonne National Laboratory calculated the cost of building the pyroprocessing unit as one-fifth the cost of an aqueous reprocessing unit such as PUREX. Japan's Rokkasho Reprocessing plant used PUREX technology imported from France. Utilities spent tens of billions of dollars to build the facility but it is not yet completed.

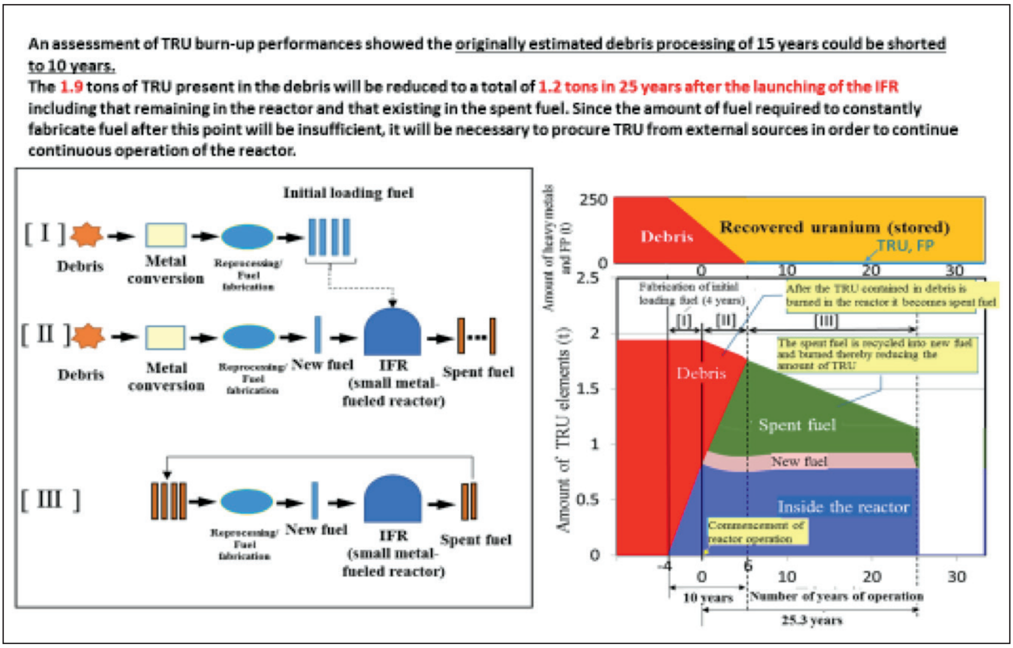
Another advantage of IFR is its possible application to Fukushima decommissioning. With current technology, workers must remove the melted down debris from the site rather than processing it on-site. No prefectures will accept the debris, so it must be treated in Fukushima. Pyroprocessing is the most promising technology to separate plutonium, uranium and MA from the debris. Then a small fast reactor will burn them to make 300-year waste. Figure 5 depicts the possible debris reduction scheme.

Successfully accomplishing this small IFR experiment in Fukushima would provide a model of sustainable nuclear power for Japan and the United States. In Japanese nuclear power plants, spent fuels accumulate in the cooling pools at reactor sites or in the dry casks waiting for disposal or reprocessing. The IFR would burn plutonium and MA from the spent fuels and reduce radio toxicity to 300 years at the nuclear sites. The concept is an "atomic incinerator." It burns the radioactive waste, and results in safer residuals and generates power.

The Japanese public will not easily accept the restart of shutdown LWRs without a clearly defined solution for the decommissioning and decontamination of Fukushima Daiichi Nuclear Power Plant and a real sustainable alternative to the LWR paradigm proposed. The IFR experiment in Fukushima would be the first step.

As the United States developed the IFR, we need to organize an international collaborative project between Japan and the United States. The U.S. Navy helped Japan after the Great Eastern Japan Earthquake and Tsunami through Operation "Tomodachi (Friendship)." We could call this project Operation "Tomodachi Part 2." The U.S.-Japan Nuclear 123 Agreement will come to the end of its original term in July 2018. Both governments have agreed to extend it automatically. U.S.-Japan cooperation on an IFR under the extended 123 Agreement would provide a great opportunity to showcase a new model for sustainable nuclear power. The Republic of Korea also is researching an advanced reactor using this technology. Korea is undertaking joint research with the United States to be completed in 2020 at the U.S. Department of Energy's Idaho National Laboratory, opening the possibility that eventually the bilateral IFR project could be trilateral. As the IFR has strong nuclear proliferation resistant characteristics, this coalition may open the gate for nuclear newcomers who wish to be peaceful and sustainable users of the nuclear power.

Figure 5: Debris Processing Scheme and TRU Reductions



Source: Sasakawa Peace Foundation, *Technical Feasibility of an Integral Fast Reactor (IFR) as a Future Option for Fast Reactor Cycles -Integrate a Small Metal-Fueled Fast Reactor and Pyroprocessing Facilities*, November 30, 2106.

PART 3:

INFLUENCE OF DEMAND AND PRODUCTIVITY

Chapter Eight

The Rise of Energy Efficiency

Yukari Niwa YAMASHITA
Board Member, The Institute of Energy Economics, Japan

Introduction

Japan has developed its energy efficiency and conservation[135] policies over time to one of the most advanced levels in the world. Even so, the quest for better and more effective energy efficiency policies and measures continues for Japan. Expected contribution from energy efficiency improvement to achieve the Paris Agreement target (i.e. Intended Nationally Determined Contribution or INDC) for Japan is as big as what was achieved during the post Oil Crises period; it is not an easy target. This chapter provides an overview of the development of Japan's energy efficiency and conservation policies. It also explores some of the implications for Japan-U.S. collaboration towards a low-carbon society.

Pre-History of Japan's Energy Conservation Act

Japan is known as the world's energy efficiency front-runner. The reason for this status is rather simple; the country is not well endowed with domestic energy resources. Consequently, it must watch its energy use because most of it must be imported from abroad.

The history of energy efficiency and conservation (shortened to "energy saving" in the rest of this chapter) goes back to the World War I (WWI) period. Thus, it has a century of history in Japan. Because of a coal price hike in the late 1910s, the shortage of domestic coal supply encouraged boiler experts to start a movement to share know-how on "heat management" in the Osaka area. The objective was not only to improve boilers' efficiencies to save coal use, but also to reduce or prevent particulate emissions, as many of the factories were located near downtown Osaka (a big commercial city that is Japan's second largest urban city, even now). There was a recognition that the air quality was deteriorating. This century old situation is very similar to the issues facing today's emerging and newly industrialized countries, such as China, Indonesia and India.

The sharing of know-how included several activities that are still suitable today for the development of good energy management practices in the manufacturing industries. For example, study groups formed to share experiences and good practices, the Osaka local government founded and financed a public research institute on industrial efficiency, and officials conducted a thorough data survey to provide a solid database for analyses. The database covered boiler ownership, stock efficiencies and documentation on the sources of lower efficiencies. They discovered that a variety of factors caused lower efficiencies (or insufficient burning). These groups identified the factors for each

[135] In this chapter, "energy saving" is frequently used to represent concepts such as "energy efficiency," "energy efficiency and conservation" and" energy efficiency improvement."

category of industries and size of boilers. These factors included the following: too short length of chimneys, under capacity of burning facilities and equipment, unskilled labor, and malfunction of boilers. The unskilled laborers were recognized as the biggest factor contributing to inefficiencies.

The *Osaka-furitsu Sangyou Nouritsu Kenkyuusho* (Osaka Public Research Institute of Industrial Efficiency) spread the boiler management movement to other parts of Japan, mainly in urban areas similar to Osaka, through the dispatch of lecturers. Tokyo and Yokohama soon also were actively involved in the movement. As it sought to address the shortage of coal during WWI, the level of activities was limited to a certain extent and it did not yet reach as far as the management of steam or waste heat. On the other hand, the energy saving movement induced the rapid deployment of meters (such as Orsat gas analysis meter, CO2 meters, thermometers and ventilation meters) and the introduction of newer models of boilers. It also created an atmosphere of collaboration within each factory and among local associations; it induced the creation of regional expert groups and introduced an award scheme to recognize skilled experts.

In 1920, the Ministry of Agriculture and Commerce founded a national research institute on fuel. In 1932, certification systems for boiler experts were introduced in Osaka and Tokyo, and scholars have identified at least 40 such individual groups in industrial journals. Many kinds of seminars, lectures, site visits and expositions took place during the period from 1931 to 1937.[136]

Thus far, the industrial need for the efficient use of coal and for better air quality in urban areas induced the energy saving movement. We cannot ignore the fact that conditions resulting from WWI and later WWII also heavily influenced it. The most crucial reason for the rapid spread of the energy saving movement has been (and remains) the lack of sufficient domestic energy resources. With the accelerated transition from solid to liquid fuels and without any domestic oil resources, Japan encountered even bigger challenges to save energy.

In 1937, a newly established Department of Fuel in the Ministry of Commerce and Manufacturing started a national fuel coaching activity. The conflict between Japan and China also began in 1937 and continued into early 1940s. By the time Japan was engaged in WWII, it was already suffering economic damage and was facing serious shortages of both coal and oil. Therefore, some scholars consider the energy shortage to be one of the main reasons Japan confronted and invaded energy rich colonial states in Southeast Asia. It is a bitter reminder for all countries never to underestimate the need for energy security.

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[136] S. Kobori (2007). *Japan's Heat Management Movement and Heat Management Policies during and after the World War* (Japanese only), Osaka University Knowledge Archive. https://ir.library.osaka-u.ac.jp/repo/ouka/all/16325/oep056_2_040.pdf.

Oil Crises in the 1970s and the Establishment of the Energy Conservation Act[137]

After WWII and in the course of Japan's economic recovery, the Ministry of Commerce and Manufacturing established the "Heat Management Rule" in 1947; it became the *Heat Management Act* in 1951. The *Heat Management Act* succeeded all the fundamental schemes and systems developed through the boiler management movements. After the two oil crises, the Ministry of International Trade and Industry (MITI)[138] established the *Energy Conservation Act* in 1979 to succeed the *Heat Management Act* which, in fact, was the legacy of the boiler management activities that started almost 70 years earlier as a local activity in the Osaka region.

In addition to the energy management schemes that began in Japan as early as the 1910s, quality control and industrial engineering also found their way into the Japanese manufacturing in the 1950s. Just like energy management schemes, and typically through group activities, companies incorporated these production management methods and techniques into the manufacturing process to improve productivity while maintaining the required quality of products. While first introduced to the manufacturing sector, they then spread to the commercial sector, such as offices and hospitals. The basic concept was first developed and exercised in U.S. industries as early as the 1910s, starting at the Ford Motor Company. Because of the requirement for energy saving in Japan, group activities continue and have been taken up by both energy and production management as they work closely with each other on manufacturing and on factory floors.

The Energy Conservation Act first targeted large-scale manufacturing[139] factories and, over time, slowly widened its coverage to the commercial, transport and residential sectors. The Act has two distinctive approaches: energy management and efficiency improvement of appliances and materials. Figure 1 shows the evolution of the Act as coverage widened from 1979 to 2008. Continuing from these changes, there were revisions in 2010, 2013 and then almost every year ever since. For example, every year the government summons together a working group to discuss the details of energy management revision, targeting a further widening of the coverage in the commercial sector (e.g. the building sector).

The spirit behind the energy management part of the Act is to help industries and building owners to identify efficiency improvement potential and systematically realize such potential. Thus, experts actively utilize the energy management scheme to promote data collection to address wasteful energy use and to prioritize those suitable for financial support.[140] Based on the historical development of boiler and heat management, energy management in Japan took the bottom-up form, with group activities for productivity improvement as well as the collection and dissemination of data and best practices for an industrial level approach to improve each industry's average energy efficiency. Over time, the government broadened the coverage of the Act both in terms of the number of designated entities and in terms of the energy types. The most recent revision goes as far as distinguishing peak electricity demand from the total electricity consumption.

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[137] *The Act on the Rational Use of Energy* (commonly referred to in English as the "Energy Conservation Act").

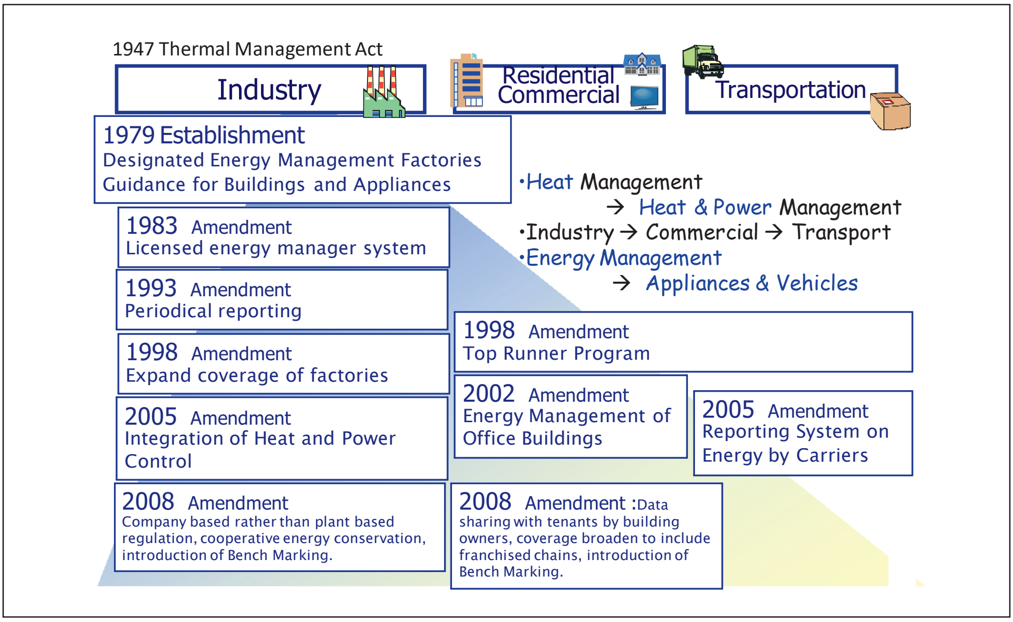
[138] In 1947, the Ministry of Commerce and Manufacturing changed to the Ministry of International Trade and Industry (MITI). MITI, then, changed to the Ministry of Economy, Trade and Industry (METI) in 2001.

[139] Japan's energy statistics and balance tables define manufacturing sector to include energy-intensive industries as well as other manufacturing sectors such as assembling, food, printing, etc.

[140] Many forms of financial support are available under the energy management scheme including financial subsidies, tax reduction, interest support and free energy saving advice.

This way it is possible to recognize the performance of individual companies in meeting electricity saving requirements under power shortage situations such as that related to the Fukushima incident.

Figure 1: Transition of the Energy Conservation Act in Japan (1973-2008)



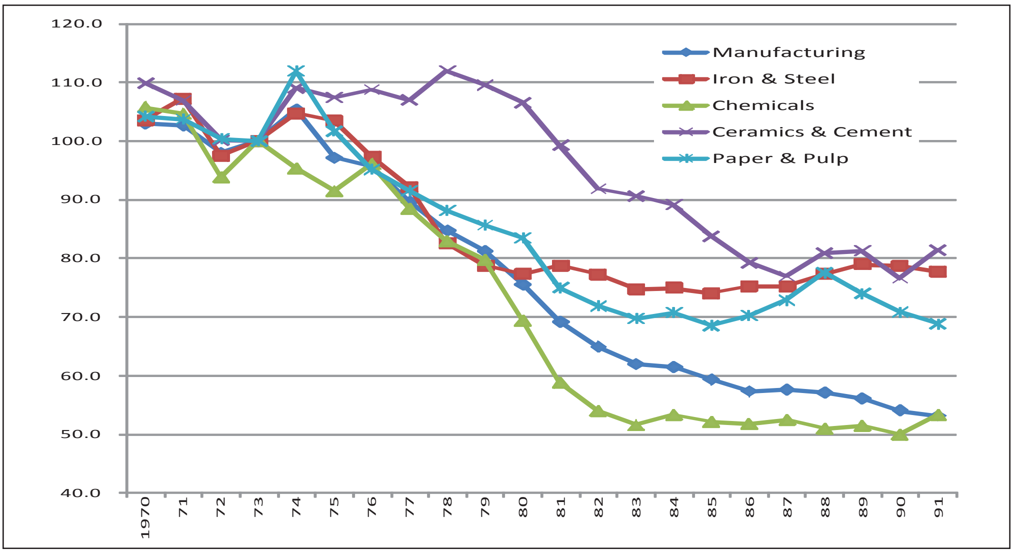
Source: Compiled by the author based on information from METI's Agency for Natural Resources and Energy.[141]

Industrial associations contributed greatly to the improvement of energy efficiency for appliances as well as fuel economy for vehicles. The "Top Runner" program, the very renowned appliance efficiency scheme, would not have been as successful without the detailed technical data collected via such associations and collaboration from their member companies. The "Top Runner" program is a unique initiative where policymakers and industries explore together and mutually agree to higher efficiency improvement targets. The meeting participants arrive at future efficiency standards through a series of meetings held over a period often exceeding twelve months and they ground their decisions on technical data. If manufacturers negotiate for lower target levels or longer adjustment periods, the meeting participants invite them to explain their technical difficulties to achieve a higher efficiency target.

[141] See for example Agency for Natural Resources and Energy. *About Revision of Energy Conservation Act* ("Shou Energi Hou no Kaisei ni tsuiste"), April 2014, http://www.enecho.meti.go.jp/category/saving_and_new/saving/summary/pdf/140401_syouenehoukaisei.pdf. (Japanese only) and ANRE (2015), documents for "Long-term Energy Outlook Sub Committee," 10th Session (1st June 2015). http://www.meti.go.jp/english/press/2015/0716_01.html.

In the energy management scheme, the Act requires all the designated industries to report on their annual intensity improvement as well as on their 5-year investment plans for energy savings. The government provides financial incentives to encourage investment in more efficient machinery. Because of widely utilized energy management planning, energy intensities drastically improved during and after the two oil crises, especially in energy intensive industries such as iron and steel, chemical, cement, and paper and pulp.[142] Figure 2 shows such achievement over the two decades following the first oil crisis. On average, the energy intensity of the manufacturing sector improved by almost 50 percent over these periods.[143]

Figure 2: Manufacturing Average and Major Industries' Energy Intensity Improvement in Japan (1973-1990)



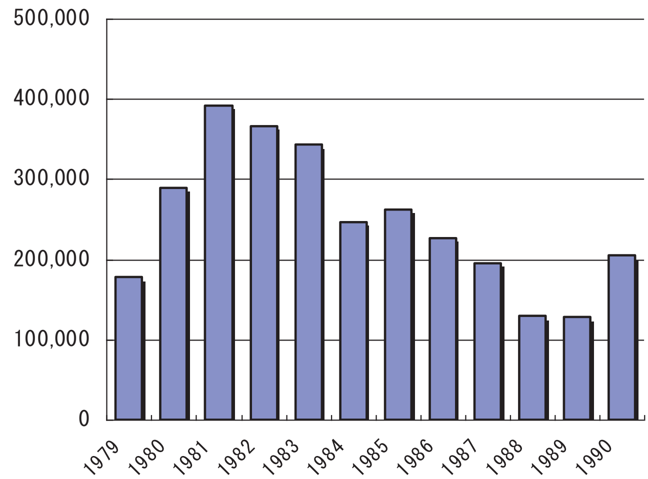
Source: IEEJ, *Energy Saving in Manufacturing Sector in Japan: Examples from Oil Crises Period*, (2005).

During the first decade of the Act that followed the two oil crises, investments in energy efficiency increased rapidly in the manufacturing sector. With the support of financial schemes, investment continued to remain robust until the late 1980s. After the first round of robust investments, industries enjoyed a much lower energy bill from the mid-1980s to the 1990s. The investment trend slowed eventually, in part due to lower energy prices.

[142] See The Institute of Energy Economics, Japan. E*nergy Saving in Manufacturing Sector in Japan: Examples from Oil Crises Period*, April 2005.

[143] To estimate an average of overall manufacturing sector intensity, we used IIP (i.e. Index of Industrial Production) as a devisor for the Figure 2. On the other hand, for energy intensive industries, physical production (tons of paper & pulp, ethylene, steel and cement production) is the devisor. Thus, Figure 2 sets the year 1973 at 100 for the comparison. Therefore, Figure 2 only compares the historical improvement of intensity for each individual category.

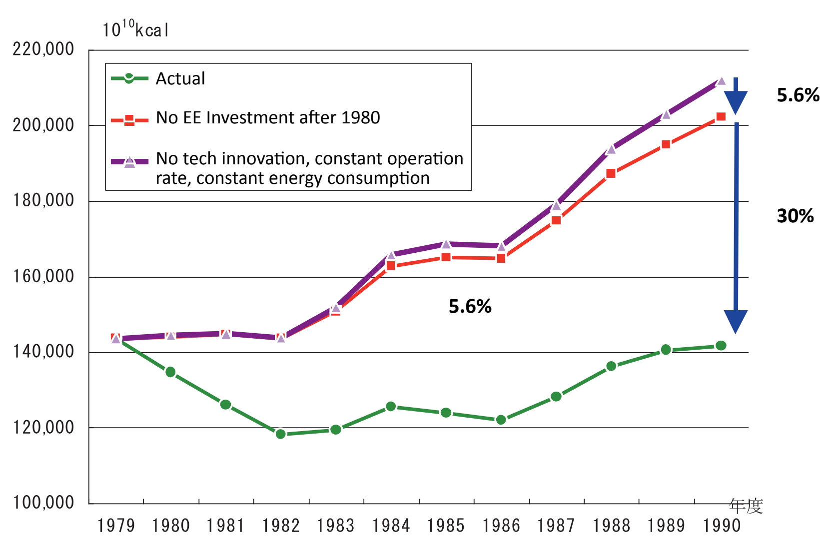
Figure 3: Manufacturing Sector's Energy Efficiency Investment in Japan (1979-1990) (Installation and construction base, million yen)



Source: IEEJ, *Energy Saving in Manufacturing Sector in Japan: Examples from Oil Crises Period*, (2005)

For the period of 1980 to 1990, the estimated outcome of energy efficiency investment in achieving energy intensity improvements is 30 percent of the overall improvement of 35.6 percent. The other portion of improvement (i.e. 5.6 percent) came mainly from structural change. This means that the structural change of the manufacturing sector, itself, had some effect on energy intensity improvement but the energy savings efforts accounted for the majority of the improvement.

Figure 4: Estimated Impact of Energy Efficiency Improvement (Manufacturing Sector, 1980-1990)



Source: IEEJ, *Energy Saving in Manufacturing Sector in Japan: Examples from Oil Crises Period*, (2005) By 2010, designated factories in the manufacturing sector started struggling to meet the annual one percent intensity improvement target, especially energy intensive industries such as iron and steel, petrochemicals, cement, and paper and pulp. The struggles were because either their energy efficiency improvement was reaching its theoretical limit, or their business model had to shift towards higher value-added products facing international competition, with more energy use. The government introduced a few changes to address such challenges in order for the manufacturing sector to keep contributing to energy efficiency improvement for the country as a whole.

The first change made was with regard to the designated base unit. The base unit changed from by factory to by company. This change meant not only factory floor but also the office spaces of manufacturing companies were covered. The second change was to designate the headquarters of franchise chains (such as convenience stores and restaurants) as a participant. This change meant that even if each store or restaurant does not consume the threshold level of energy consumption required for designation, the whole chain of shops or restaurants was required to follow their headquarters' policy to improve energy efficiency. The expected result is that eventually massive improvements of the energy intensity as a group (i.e. franchise chain) would occur while also improving the coverage of the Act.

The third change was to introduce a "benchmark" system to the manufacturing sector. The system defines the boundary of operation and sets a universal energy intensity indicator for each sub-sector. Universally defined common intensity indicators enabled comparison among different companies within the same sub-sector. Those companies (and factories) which face a technological limit of efficiency improvement can prove the difference from others with indicators. The coverage of the benchmark system first was limited to energy intensive manufacturing industries and then gradually widened to cover the commercial sector's sub-sector, namely convenience stores, in 2016. Discussions on widening coverage to additional industries continue.

The coverage of office buildings and convenience stores as well as restaurant chains (which are categorised into the commercial sector under Japan's *Energy Conservation Act*) widened tremendously. As a result, the commercial sector coverage of the Act after the 2010 revision widened from 30 percent to 50 percent of the total energy consumption for the sector.

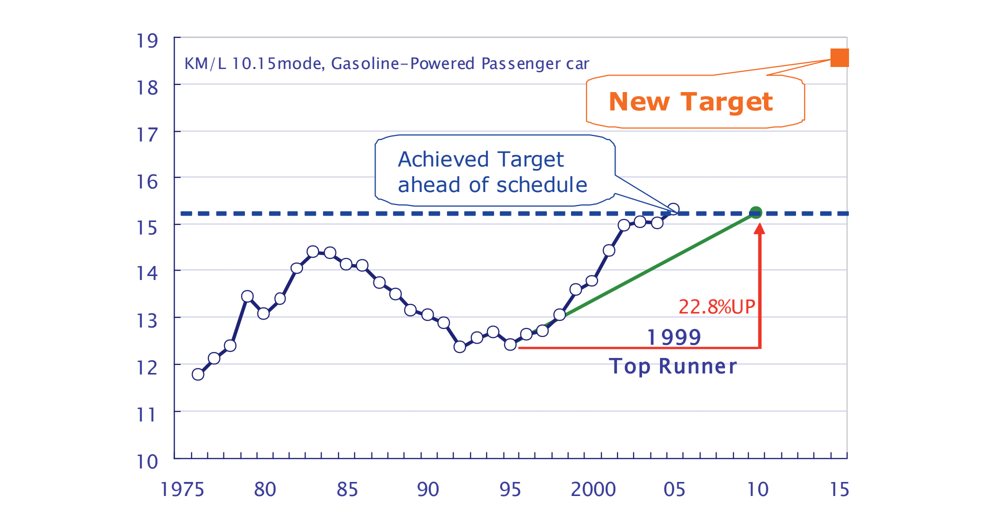
The appliance energy efficiency standard scheme now covers 28 products[144] including building materials (e.g., insulation and windows). The government typically establishes the efficiency target for appliances for a future target year and sets it at a level slightly higher than the currently available best products. For existing products, the target year established is usually for 5 years in the future. For newly targeted products, the first target year for efficiency improvement is very often set for 10 years in the future, taking into consideration the time required to adjust product lines, etc.

Because of the way the efficiency standard target is set for the future, this scheme is called the "Top Runner Program." All the manufacturers will eventually meet the higher

[144] Products designated under the Top Runner Program as of 2017 are: air conditioners, lighting, LED lamps, TVs, copying machines, computer, magnetic discs, passenger cars, freight cars, video tape recorders, refrigerators, freezers, stoves, gas cookers, gas water heaters, oil water heaters, electric toilet seat heaters, vending machines, transformer, rice cookers, microwaves, DVD recorders, routing equipment, switching equipment, MFPs, printers, electric water heaters (heat-pumps) and AC motors.

efficiency of the "top-runner" by the target year and thus all the designated products will eventually catch up with "Top Runner" products.

Figure 5: Fuel Efficiency Improvement Trend (Shipment Base, 1980-90)



Source: Energy Saving in Manufacturing Sector in Japan: Examples from Oil Crises Period, The Institute of Energy Economics, Japan (2005)

Because of the fierce competition among manufacturers, the Top Runner Program often achieves its targets earlier than anticipated. For example, as Figure 5 shows, companies achieved the Top Runner fuel efficiency standard, introduced in April 1999 with the target year of JFY 2010, six years ahead of time. Approximately 80 percent (shipment base) of gasoline passenger vehicles achieved the 2010 standard by 2004.

Combined with the labeling scheme and the retail shop recognition award, Japan's Top Runner Program has been proven effective in improving the stock efficiency of appliances widely in the country. Thus, it has silently but steadily changed the way electricity is used.

Role of Energy Saving after Fukushima

The actions taken during and after the two Oil Crises included not only energy management but also "energy conservation." Society uses terminology such as "energy efficiency," "energy conservation," and "energy saving" rather freely and loosely. A consensus among energy policymakers is as follows: "energy efficiency" refers to the physical improvement of efficiency in machines, processes, appliances, and so on, and "energy conservation" mainly refers to actions that achieve reductions in energy use, including the introduction of regulations, energy management systems, or changes in human behaviour. Energy conservation is achieved through changing life-styles or through people's efforts to use less energy while possibly sacrificing some of their comfort. "Energy saving" is used in a more relaxed way to refer to all the above.

Thus, during and immediately after the two oil crises, "energy conservation" was very much relevant to Japan because the country desperately had to look for and find ways to save energy, as quickly as possible and as much as possible. The government and experts informed the citizens of Japan of the seriousness of the Oil Crises and requested them to cooperate in daily activities at home, in offices, factories, public transport systems, shops, schools, hospitals, etc. The government issued "energy conservation advice" about most of the required activities. Some activities also had an amplified impact due to how the information reached the public – the so-called "announcement effect." For example, many of us still recall that TV programs finished early and that commercial and business areas became dark with roof top advertisements and neon lights shutting off by midnight. These actions made us aware of the severity of the situation.

Society never expected, though, that 35 years later the country would face a similar situation that required us to undertake and achieve similar energy saving efforts. This time the actions were more to save electricity than oil. Success required more information sharing with the consumers as the campaign specifically targeted the saving during "peak" demand of electricity, "in a hurry."[145] These actions were required to avoid huge and sudden blackouts during the period immediately after the Great Eastern Japan Earthquake and Tsunami and in the following summer.

After the Fukushima incident, the immediate challenge in the Kanto and Tohoku areas was to share enough information on how to reduce very quickly peak electricity demand throughout the different clusters of customers. The government requested relevant parties to make contingency plans for "rolling blackouts," in parallel, in order to avoid a sudden big-scale blackout caused by a power supply shortage. For example, officials divided TEPCO's entire service area into five groups and asked each group to be ready for scheduled three-hour blackouts. The government scheduled such rolling blackouts to start as early as 6:20 a.m. on Monday, March 14, 2011, three days after the Great Eastern Japan Earthquake.

On Monday morning March 14th, office workers left their homes earlier than usual and still faced tough situations as trains either were not on schedule, not coming at all or coming already fully packed with passengers. While train operators might have felt the potential chaos of miss-located trains ahead of time, commuters did not. The chaos continued until mid-afternoon that day. Companies and industries quickly chose the option of refraining from coming to the office. The effort, time and cost required to prepare for the "rolling blackout" exercise was enormous, but it took place only a few times and for a limited number of groups. TEPCO and related parties did their best to avoid this exercise as they considered it as a last option planned only for emergencies.[146] Yet the exercises caused a lot of confusion and incurred extra costs that would not have occurred without a plan for rolling blackouts. A very tough call for the utility and authorities back then, though.

Taskforce teams arose to tackle every challenge. Nobody had ever experienced or prepared for the big challenge of addressing the potential of shortages of electricity supply in Tokyo, one of the biggest cities in the world. Figure 6 shows the summer

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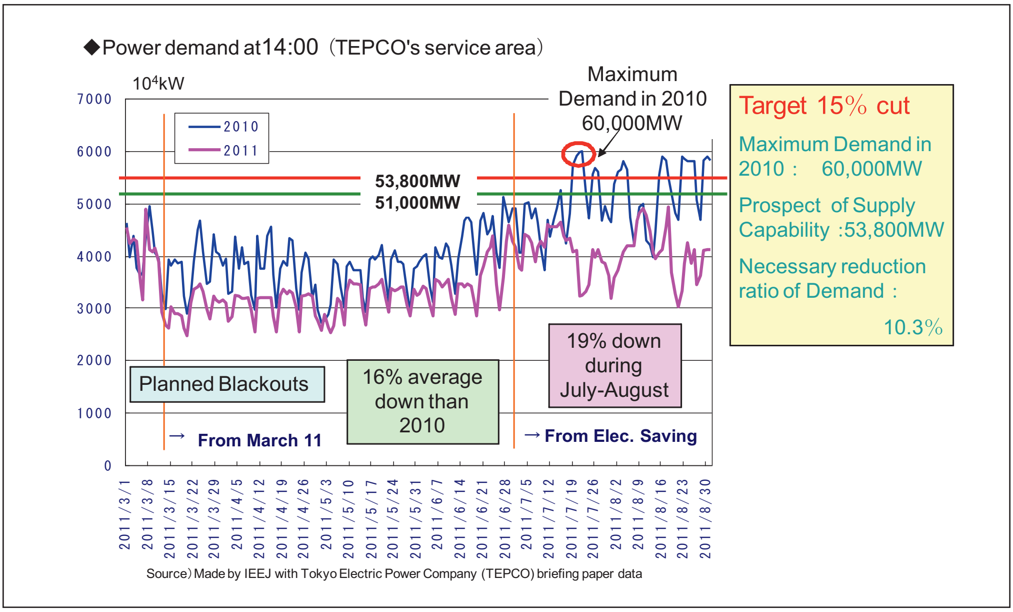
[145] Yamashita, Y. "Japan 2011," in *Comparative Case Studies for Saving Electricity in a Hurry: Update* (IEA, June 2011) https://www.iea.org/publications/freepublications/publication/Saving_Electricity.pdf.
[146] On April 8, 2011, policymakers decided that a basic rule is not to use rolling blackouts.

peak-cut target of 15 percent for TEPCO's service area.[147] It also shows that they met the target and shaved 19 percent of the peak through efforts made by every sector. This achievement would not have occurred if there had been no information sharing and appropriate advertisements. The most challenging part of this target was that it was about peak demand and ordinary consumers of households, commercial sectors or small and medium-sized enterprises (SMEs) were not accustomed to energy management based on their own load curve data. They were not even aware of the magnitude and timing of their peak demand.

Figure 6: Electricity Saving Target for the TEPCO Area (Peak Demand, Summer 2011)



Source: Compiled by IEEJ and TEPCO

The areas neighboring Tokyo and within the TEPCO service region include industrial districts with large-scale manufacturing industries. Those industries possess a huge cumulative experience of energy management with experienced skilled engineers and are equipped with sophisticated "on-time" energy management data systems. On the other hand, in the downtown Tokyo area, the main large-scale customers are office buildings and the remaining customers are small and medium-sized enterprises (SMEs), the commercial sector and finally ordinary households. The challenge was to guide the latter group to save their peak electricity demand.

One of the taskforce teams was responsible for estimating the different daily load curves for each category of TEPCO's customers. The purpose of such an estimation was to identify the peak demand for each category of business and household type,

[147] Tohoku Electric Power Company and Kansai Electric Power Company also had electricity saving targets for Summer 2011. The targets were for 15 percent and 10 percent cuts, respectively. The TEPCO area target of 15 percent was set to cover the minimum required saving of 10.3 percent and additional room to address any happening such as an aftershock or risks of stoppage of old thermal power plants which were operated under urgent circumstances.

and prepare a list of prioritized actions to cut peak demand based on data. Officials expected such up-to-date advice would supply enough information on the electricity peak demand reduction of each category thus providing a clearer view of how much each should do under the national emergency electricity saving action plan. A series of seminars took place in every part of the service area targeting the different categories of business types (e.g., small-scale manufacturing factories, offices, shops, restaurants, other services). The Energy Conservation Center, Japan (ECCJ) prepared lists of prioritized electricity saving actions for the different sectors and shared power saving potential based on the load curves estimated by the Institute of Energy Economics, Japan under guidance from METI's Agency for Natural Resources and Energy (ANRE) and the data supplied by TEPCO.

Information service providers supplied daily and hourly power supply-demand balances via their websites as well as data displays installed in public spaces including train stations, commercial buildings and shopping malls. TEPCO announced the daily power balance forecast and informed their customers of the level of power saving actions required for the following day.

All these efforts combined[148] resulted in the achievement of the 2011 summer target and the targets for winters and summers of the following seasons until 2013. Starting 2013, no target was set but requests for electricity peak-demand saving continued. The Government of Japan reformed its Electricity Supply-Demand Emergency Response Headquarters[149] into the Study Group on the Power Supply and Demand. Ministers continued to meet twice a year to analyze the electricity supply-demand situations ahead of summer peak and winter peak seasons. In 2016, the government did not issue a request for summer electricity saving exercises for the first time since the 2011 earthquake. It has not issued winter and summer electricity saving requests since then.

METI released its revised *Basic Energy Strategy* in 2014 and the supporting *Long-term Energy Demand and Supply Outlook* in 2015. Because Japan is heavily dependent on imported energy, the revised Strategy re-emphasized the importance of balancing the three Es (i.e. Energy Security, Economic Efficiency and Environment) with "Safety" (i.e. safe use of nuclear energy) as its basis. Three concrete policy targets were set: 1) improve self-sufficiency from 20 percent (before the earthquake) to 25 percent by 2030; 2) lower electricity cost from the current level; and 3) set a GHG reduction target which is compatible with those of the United States and the European Union. With these three policy goals in mind, the Strategy set the 2030 target for power generation mix (the so-called "energy mix") with the aim to balance the sources of power generation for Japan (at 20-22 percent from nuclear, 22-24 percent from renewables (solar, wind, etc.) and the remaining 56 percent from fossil fuels).

An important basic assumption in the above mentioned "energy mix" is a huge electricity and energy saving. The Strategy assumes a 35 percent improvement of the energy intensity (i.e. final energy consumption/real GDP). As the dotted red line in Figure 7

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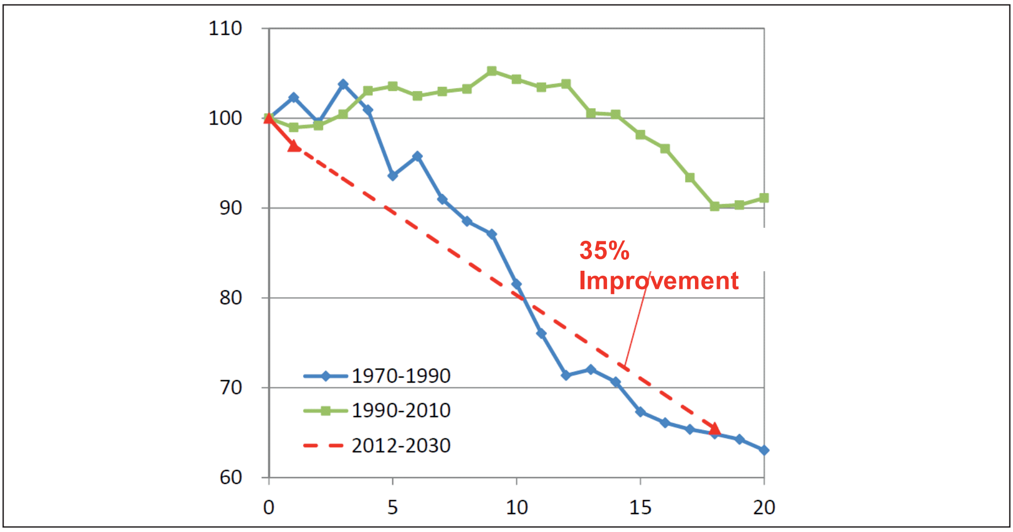
[148] The energy management scheme of the *Energy Conservation Act* also has been amended to introduce a rule where designated companies will gain scores if they introduce schemes to reduce peak consumption of electricity. Energy Conservation Award is a new prize for electricity saving.

[149] The first meeting of the Electricity Supply-Demand Emergency Response Headquarters took place on 13 March 2011 in the evening followed by the second meeting which took place on 14 March in the morning. It consisted of all Cabinet members. Because of the expected 10 GW of power supply shortage at that stage, TEPCO decided to exercise a rolling blackout as early as March 13.

shows, the anticipated improvement is very similar to the energy saving achieved during the period of oil crises (blue line). Without a doubt, achieving this target will be a huge challenge for Japan.

Figure 7: Comparison of Energy Efficiency Improvement (Final Demand/Real GDP)



Source: Documents discussed at the "Long-term Energy Outlook Sub Committee," 10th Session (June 1, 2015).

Related committees and working groups resumed their discussions to revise existing regulations while new working groups started to introduce additional new policies and measures under the *Energy Conservation Act*. The two major areas newly targeted are buildings and the commercial sector. For buildings, the Ministry of Land, Infrastructure and Transport and METI collaborate in introducing energy efficiency standards to the building code. New buildings must now comply with the energy efficiency standards when applying for a building permit. As for the commercial sector, convenience stores (2017), hotels and department stores (2018) have already introduced or are scheduled to introduce benchmarks while supermarkets, shopping centers and office buildings are currently discussing how energy efficiency improvement could be assessed equally and effectively.

Towards Low Carbon Society

Japan will keep striving to widen the coverage of the *Energy Conservation Act* and strengthen the effectiveness of its energy saving policies and measures. Since Japan is actively involved in relevant international or regional cooperation groups such as the Energy Efficiency Working Party (EEWP) of the International Energy Agency (IEA) and the Expert Group on Energy Efficiency and Conservation (EGEEC) under the Asia-Pacific Economic Cooperation Forum (APEC), it can contribute to promoting energy efficiency technologies worldwide by actively sharing its expertise with other countries.

The latest world IEEJ Outlook[150] estimates the emission reduction potential for the year 2050 with robust climate change policies and advanced technologies at 14.4 gigatons (Gt) of CO2. The analysis attributes about half of the CO2 emission reduction to energy efficiency improvements and energy conservation. The IEA recognizes "energy efficiency" as a "hidden fuel" or the "first fuel" of the global energy system nowadays.[151] Energy efficiency improvement has become an essential target of opportunity in many countries' policy making because saving energy feels like a new form of energy that requires less net investment and fewer costs. Energy saving policies and measures are introduced to address different national issues and are not limited to combating climate change. For energy importing countries, energy security is one of the main purposes while for emerging countries with rapidly growing urban cities and related issues, air pollution is becoming the main issue.

Recognizing such needs, governments established the first international collaboration framework beyond the OECD or APEC in 2009. The International Partnership for Energy Efficiency Cooperation (IPEEC) is a framework to connect countries in order to share best practices and foster development of policies and measures to improve energy efficiency in participating countries.[152] It is also a forum for IEA member and non-member economies to share information about various bilateral and multilateral initiatives.

The Clean Energy Ministerial (CEM) is a forum that combines the leadership of energy ministers and the engagement from the private sector and other international partners with year-round initiatives and campaigns to drive faster deployment of clean energy policies and technologies worldwide. The U.S. Government launched the CEM in 2010 and hosted the first meeting of Ministers. CEM's objective is to address climate change through a rapid dissemination of clean energy technologies including those for energy efficiency improvement. Currently, CEM consists of 24 member countries and the European Commission. The IEA hosts the CEM secretariat at its Paris headquarters.

The G7 (or G8) and the G20 often highlight energy efficiency as a part of their energy and climate policy agenda. The Gleneagles Plan of Action[153] (2005) and Action Plan for Voluntary Collaboration on Energy Efficiency (2014)[154] are good examples. In 2016, the G20 adopted the Energy Efficiency Leading Programme that is the G20's first long-term plan for energy efficiency.

Furthermore, energy saving is widely recognized as an essential tool for sustainable development, addressing both energy poverty and environmental issues. The United Nations' global 17 Sustainable Development Goals include several energy-related goals and Goal 12 (Responsible Consumption and Production) refers to energy saving as one effective means to reduce ecological footprints.

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[150] The Institute of Energy Economics, Japan. IEEJ Outlook 2018, October 2017, http://eneken.ieej.or.jp/en/whatsnew/427.html.

[151] See International Energy Agency. *Energy Efficiency Market Report 2013*, https://www.iea.org/publications/freepublications/publication/EEMR2013_free.pdf; IEA. *Energy Efficiency Market Report 2016*, https://www.iea.org/eemr16/files/medium-term-energy-efficiency-2016_WEB.PDF.

[152] IPEEC was founded in 2009 by the G8 (Group of 8) to serve the world's major economies. It now includes 17 of the 20 members of the G20 (Group of 20), covering both developed and emerging economies. Among its founding members are Brazil, Canada, China, France, Germany, Italy, Japan, Korea, Mexico, Russia, the United Kingdom, and the United States. Since its creation, Argentina, Australia, the European Union, India, and South Africa have also become members of IPEEC. Turkey is currently in the process of joining the partnership.

[153] The G8 Summit issued a plan addressing climate change called "Gleneagles Plan of Action" on July 8, 2005.

[154] The G20 tasked IPEEC to coordinate the voluntary implementation of the G20 Energy Efficiency Action Plan in 2015.

Japan participates in all such major initiatives both regionally and internationally. Japan's longstanding experience in energy efficiency and conservation has put it at the forefront of this policy area and, as such, Japan considers joining the global efforts as essential. With increasing recognition of the effectiveness of energy saving, more and more countries are starting to introduce energy efficiency policies and measures including energy-rich countries such as Russia and Saudi Arabia. Some countries introduced energy efficiency policies primarily as an important part of climate change or of local environmental measures while others do so for energy security reasons. As the coverage of policies widen, new and different policies and measures are developing. These new policies and measures include such things as white certificates (tradable documents certifying attainment of a certain reduction of energy consumption), demand side management, benchmarking schemes, and energy saving certificates trading schemes (e.g. India's ESCerts).

Countries share new schemes and studies on technical details through international or regional cooperation as well as bilateral cooperation. Many countries have now introduced a similar variety of energy efficiency and conservation regulations and measures as those of Japan. Unfortunately, the level of implementation and enforcement vary, and thus there is wide difference in achievement among even similar policies. Therefore, there is still a lot to do in these countries. Learning from those that have been successful is an effective shortcut to successful implementation.

Shortly before COP21, the Paris Agreement entered into force with ratification announcements by the United States and China that brought the agreement over the threshold (55 countries representing 55 percent of the world's greenhouse gas emissions) needed to take effect. It is an epoch-making agreement because over 190 countries are on board together to address climate change for the first time. On the other hand, there is still a big gap in the estimated sum of the national pledges[155] and the required level of emission reduction (mitigation) in meeting the 2°C target.

New and innovative technologies are essential and further cost reductions of advanced technologies are required for deeper emissions reductions. Even more importantly, energy efficiency improvement remains essential for all the countries in the world and there are still many *low hanging fruits* to harvest. If we are to introduce more intermittent renewables into our power transmission systems while avoiding astronomical investment requirements, reducing the total requirement for electricity will remain an effective and economic tactic. International, regional and bilateral cooperation accelerate the dissemination of existing energy efficiency technologies and the development and diffusion of new technologies. Japan and the United States are leaders among countries with such technologies, including those within their private sectors.

The United States consists of 50 states, all with different characteristics in energy. Some are coal/oil/gas rich traditional energy producers. California is well known for its aggressive energy and environment policies. Some states are connected with other states and neighboring countries by pipelines or power grids. The electricity market in some states has been deregulated while in others it is not. The United States offers rich

[155] As each country makes its national pledge keeping in consideration its own national priorities, target years and target-setting methods vary greatly. Thus, estimates are necessary to understand the magnitude and scope of the global total of these pledges.

examples from which others can learn because of the large variety of new business models and new policy frameworks, and the way in which they are introduced.

Both state level and federal level experiences in the United States are informative and useful for the rest of the world, including for Japan. After the Fukushima incident, Japan learnt a lot from the U.S. experience on how to save electricity in a hurry. The Californian experience taught Japan the importance of public relations activities designed to share information with the public. Japan also learned a lot from the United States on nuclear safety regulations and from the experience of the utilities that, through independent safety schemes, it is possible to re-construct self-confidence and regain the public trust, both essential for the efficient operation of nuclear power stations.

Japan's cumulative knowledge and experiences in the area of energy efficiency improvement combined with the United States' advanced expertise in energy saving and the incorporation of variable/intermittent renewable electricity, form an ideal blend to enhance the advancement of clean energy diffusion in the world. As members of the many international, regional and bilateral collaboration schemes and as long-standing partners in the international arena, Japan and the United States have a lot to contribute individually and by acting together.

Moreover, it is important that both Japan and the United States highly value energy security as one of the basic building blocks of energy and climate change policy. While the recent uncertainties surrounding the geopolitical situation in the Middle East and North Africa (MENA) region may not catch the full attention of many climate change activists and environmentalists, Japan and the United States fully understand energy security is a very important key issue for the world. With cost-effective and sound approaches and a variety of expertise, Japan and the United States can work together to greatly contribute to the advancement of a global low-carbon society.

Chapter Nine

Transforming Transportation

Dr. Michael SMITKA
Professor of Economics, Washington and Lee University

Introduction

Visitors to Tokyo encounter roads jammed with vehicles, many of which are SUVs or minivans. The buildings they enter are air conditioned and adorned with neon lights. It does not feel like a society that places a high priority on energy efficiency.

Cars have long been central for rural residents, but in suburban Japan, they are now also part of daily life. For those living outside of central Tokyo, the neighborhood streets lined with mom-and-pop stores are gone, replaced by malls located as often as not on former industrial sites. Instead of daily trips on foot or by bicycle to pick up fish and vegetables for dinner, there is now the weekend trip to get food to stock the freezer for the coming week.

Energy data reflect this new reality even as overall domestic energy consumption remained flat. In 2015 total consumption was roughly at the level of 1990 and only 20 percent greater than in 1973. However, that hides structural change in energy use. Since 1973 demand by the transport sector rose 70 percent and that by the household sector 90 percent. Together they now account for one-third of energy consumption. Half of that, or one-sixth of Japan's total energy usage, is used to power vehicles.

Much of this book focuses on energy supply and energy policy, domestic and international. In contrast, this chapter looks at energy demand for transportation. It is not that other sectors are unimportant. For example, energy use by commerce, rose 2.4x during 1973-2015. On the flip side, industry's share dropped by 20 percentage points, from 64 percent to 43 percent. In contrast to commerce, which ranges from retail to hospitals, transport is less diverse, which facilitates analysis. While it uses only 42 percent of imported hydrocarbons, the auto industry is almost unique in its salience to consumers and to policymakers. A case study is thus useful.[156]

[156] Sources for Statistics in Chapter Nine: Data on sales and registrations are from the Japan Automobile Manufacturers Association, *Motor Industry of Japan* (annual) and the 自動車統計月報 (Monthly Automotive Statistics). Data on energy utilization are drawn from the 2017 Institute of Energy Economics, Japan, *EDMC Handbook of Japan's and World Energy Economic Statistics*. Its data are drawn from standard Japanese government sources, but are available in long time series. Other economic data are drawn from the 75th Edition (2017/18) of the Yano Foundation's statistics compendium *Nihon Kokusei Zue*（矢野恒太記念会, 日本国勢図会、第７５版). Fuel efficiency data are from https://e-nenpi.com/enenpi/. See the Japanese-language Wikipedia on Tokyo ring roads (entries on 首都高速中央環状線 and 東京外郭環状道路), for the Chinese EV market see the presentation by Tomasso Pardi at the June 2017 GERPISA conference in Paris, and for data on battery costs see the post by John Anderson, *SeekingAlpha.com*, February 14, 2018.

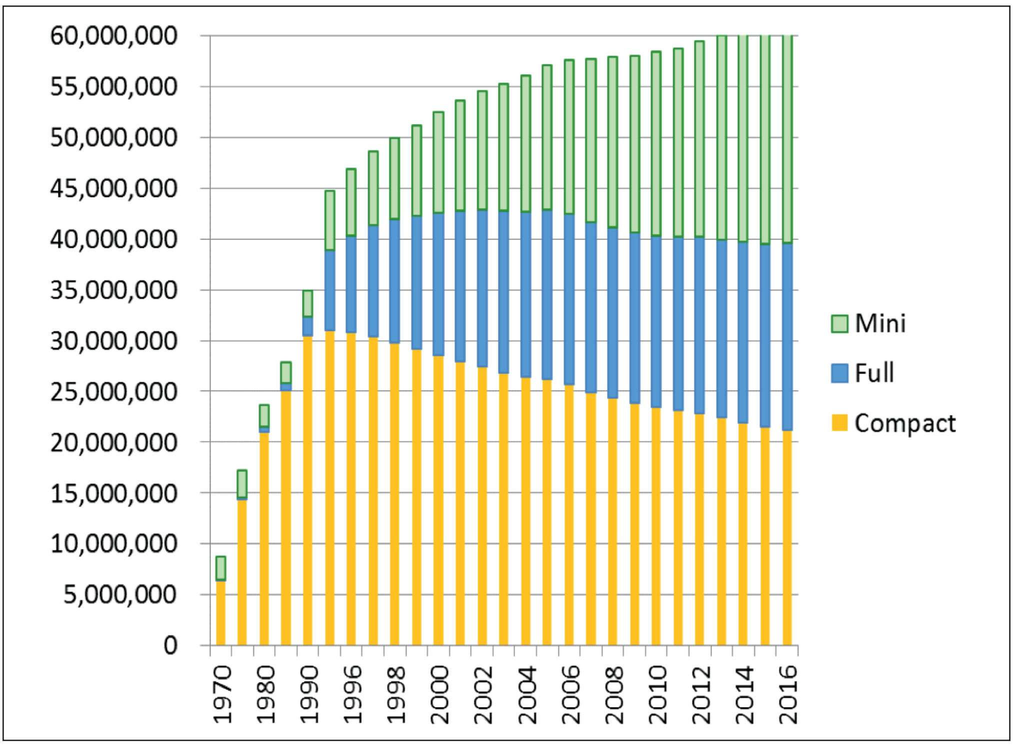
Changes in Vehicle Ownership

Numbers

Most domestic auto production in Japan ended in 1936, and it took two decades – 1957 – for output to recover. Vehicles meant trucks, and often very small ones – in 1960 a third of those on the road were three-wheelers. For personal transport, the other option was a scooter or (for deliveries) a small motorbike. In 1965, over half of all motorized vehicles were 3-wheelers or scooters. The market expanded rapidly in the 1960s, but only in 1969 did the sales of new cars exceed that of trucks. It was not until 1970 that Japan registered more cars than trucks, and only in 1992 that the number of cars exceeded that of scooters, motorbikes, buses and trucks.

Sales surged in the late 1980s, during the ascending phase of Japan's real estate bubble. At the same time both agriculture and the textile industry declined, and that cut into the demand for small trucks. By 1990, sales of cars were almost double those of trucks. Similarly, the number of registered scooters and motorbikes peaked in 1986. The number of trucks on the road peaked in 1991 at 21.3 million, and since 2008 cars outsell trucks by 5:1.

Figure 1: Vehicle Stock in Japan



Source: Japan Automobile Manufacturers Association

The mass consumer market for cars faced a dilemma: as long as demand remained low, retailers and restaurants, and real estate developers provided no parking. By the 1970s, as developers turned fields into suburban housing developments, single-family dwellings came with a parking space, while retailers and suburban restaurants slowly added parking spaces. With a few rural exceptions, however, shopping malls developed only after 1994, when the government lifted restrictions on retail entry. Thereafter owning a car gradually became a necessity for dwellers in suburban areas and small towns. In newer suburbs shopping streets, accessible on foot or by bicycle, never developed. In smaller cities, they disappeared. For example, in 2015 two-thirds of the retail space in the once-busy central shopping area in Karatsu in Kyushu, a city of 100,000, were shuttered and the for-lease signs in the stores that had bothered to put one up were yellowed. Even in Chiba, a city of just under 1 million that marks the easternmost end of suburban Tokyo, almost all stores were either immediately adjacent to commuter train stations, or in shopping malls. Elsewhere rows of shuttered storefronts dominate.

Composition

The accompanying graphs show the change in the composition of vehicles since 1970. Two key points are that the total number of vehicles expanded by 50 million between the first oil crisis of 1973 and 2016, with the increase dominated by the rise in passenger car ownership. The second is that within the car segment, the composition of vehicles shifted from compact cars to an almost equal mix of minicars, compact cars and full-sized cars.

Minicars or "kei" cars correspond to A-class cars in Europe, though the specifications differ. Their popularity stems from favorable treatment for parking and license plates, purchase-related taxes and fees and annual taxes. Japan put the basic framework for cars in place in 1949, but few were sold until the rules were amended in 1955 to allow a 360cc engine. This change was in conjunction with the never-implemented plans for a national champion "people's car," seeking to create the Japanese equivalent of the Volkswagen Beetle. The Japanese government raised the ceiling on "kei" engine size to 550cc in 1976 and 660cc in 1990, with gradual increases in a maximum of 3.4m in length and 1.48m in width. To give a sense of this, the Daimler-Benz Smart Fortwo has a 1,000cc engine and is 1.51m wide, so fails the criteria in terms of both engine displacement and size. GM's smallest U.S. offering, the Korean-made Spark, is 3.6m long and 1.6m wide and sports a 1,400cc engine, failing under all three criteria.

Indirect benefits are multiple, from not needing to prove the owner has a parking spot to lower taxes. For example, the annual "kei" road tax is about ¥15,000 for the first two years, whereas that for a small car runs ¥20,000. The "kei" sales tax was 3 percent instead of 5 percent, or about ¥20,000 less on a typical car. Insurance costs less, and the annual use tax is ¥10,800 for a "kei" versus ¥34,500 for a compact car. All of this means that a "kei" car costs about ¥45,000 a year or $400 less to own. All of this has helped increase the share of "kei" vehicles, at the expense of compact cars. Families are still likely to opt for a regular minivan, which is a full-sized vehicle, and as elsewhere SUVs and crossovers are highly popular. Even "kei" cars come in wagon versions, now that they can be as tall as a regular car. Of course adding weight lowers fuel efficiency; the top-selling vehicles are boxy van-like models that do no better than fuel-efficient "regular" sedans. The top-10-selling "kei" cars in 2017 averaged 41 miles per gallon, once weighted by sales. Again weighted for sales, the top 10 regular cars averaged 48 mpg, inclusive of the Prius, the only hybrid in the list.

Figure 2: Fuel Efficiency of Top Ten "Kei" Cars

Rank	Firm	Model	Sales 9 months 2017	Rated Fuel efficiency l/km	eNenpi user data	miles/gal
1	Honda	N-BOX	157,795	27	15	35.4
2	Nissan	Dayz	113,641	26.8	16	37.8
3	Daihatsu	Tanto	112,696	28	16	37.8
4	Daihatsu	Move	105,037	31	18	42.5
5	Suzuki	Wagon R	88,385	33.4	19	44.8
6	Suzuki	Spacia	82,208	32	18	42.5
7	Daihatsu	Mira	74,054	35.2	18	42.5
8	Suzuki	Alto	71,128	37	21	49.6
9	Honda	N-WGN	60,666	29.4	18	42.5
10	Suzuki	Hustler	58,546	32	19	44.8
Total / Average			924,156	31.18	17.8	42.0

Source: Japan Automobile Manufacturers Association and eNenpi

Figure 3: Fuel Efficiency of Top Ten Regular Cars

Rank	Firm	Model	Sales 6 months 2017	Rated Fuel efficiency l/km	eNenpi userdata	miles/gal
1	Toyota	Prius	78,707	40.8	25	59
2	Nissan	Note	68,441	37.2	20	47
3	Toyota	Aqua	62,537	38	23	54
4	Toyota	C-HR	60,627	30.2	21	50
5	Honda	Freed	51,652	27.2	18	42
6	Honda	Fit	48,488	37.2	23	54
7	Toyota	Vitz	44,005	34.4	16	38
8	Toyota	Sienta	42,837	27.2	18	42
9	Toyota	Voxy	39,988	23.8	17	40
10	Nissan	Serena	37,503	17.2	15	35
Total / Average			534,785	31.3	20	46

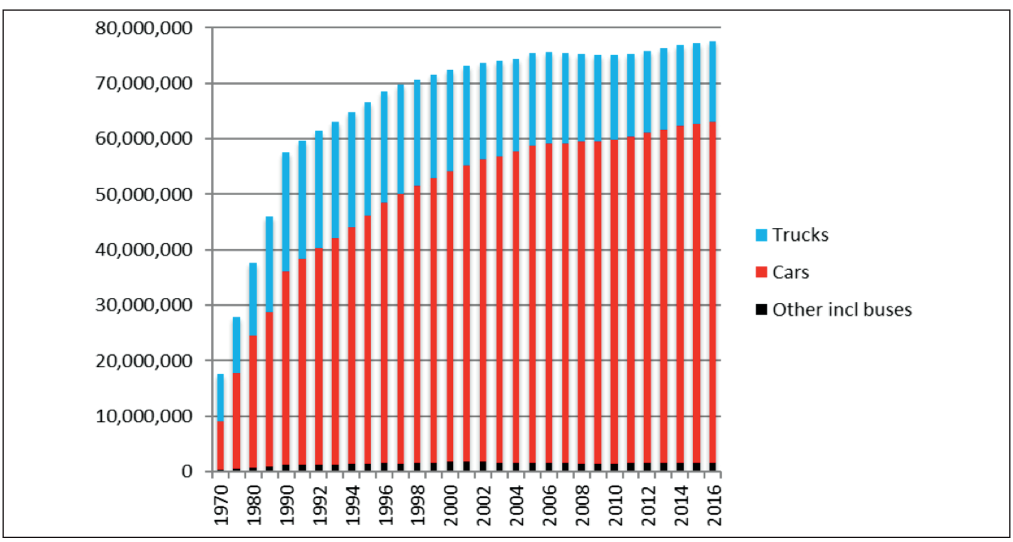
Source: Japan Automobile Manufacturers Association and eNenpi.

According to eNenpi survey data, the actual fuel efficiency drivers realize is about 70 percent that of the official test cycle. The average also reflects vehicle age. While the *shaken* (vehicle inspection system) once meant owners scrapped cars at the end of their 10th year, a simplification of the regulations and the licensing of independent inspection firms drove down the *shaken* price. Owners now keep cars (and trucks) much longer. In 1975, the average car was kept in service for only 6.7 years and, once the sales of new cars was factored in, the average car on the road was only 3.3 years old. Twenty years later those figures rose to 9.4 years and 4.9 years, respectively. In 2016, the levels were 12.8 and 8.4 years. Therefore, even though the average officially rated fuel efficiency of new vehicles rose from 30 miles per gallon in (fiscal) 2000 to 52 mpg in 2015, the actual fleet lags current standards. An aggressive policy to improve fuel efficiency that raises the price of new cars would lead consumers to hold off on purchasing a new vehicle and hence an even further increase in vehicle age, muting the impact of such policies.

Passenger Miles Traveled

The diffusion of personal vehicles came late in Japan's urbanization process. By the time ownership became widespread, commuter rail and subway systems were already in place. On the opposite side, the lack of a workable eminent domain process and, until the late 1990s, the comparatively high price of land meant that key pieces of the middle and outer ring road system around Tokyo will only be completed in 2018. Expressways remain two lanes even in urban areas. They have maximum speed limits of 100 km/hour (60 miles per hour) which are enforced often enough that drivers watch their speed. Most limited access roads charge tolls; in rural Niigata, where I lived in 1997, they were high enough that truck drivers stuck to the congested 2-lane national road rather than taking the expressway that paralleled it. In urban centers many roads remain one-lane and one-way. Parking is scarce and in city centers expensive. In other words, moving around by car is time consuming, and for those who work in city centers, commuting by car is out of the question.

Figure 4: Total Vehicle Stock in Japan



Source: Japan Automobile Manufacturers Association

Fuel prices add to the calculation of the mode of travel. Taxes are comparatively high, at ¥53.8 per liter plus the 8 percent consumption tax. As a result, the after-tax price of unleaded gasoline in Japan in September 2017 averaged $5.09, high enough to encourage buying fuel-efficient vehicles. At the same time, it reinforces the disadvantages of driving. Outside of rural areas, where service has been cut back due to demographics, it is thus standard to take a bus from a housing development or condominium complex to a suburban train station, and then transfer to a subway before the "last mile" of walking a few minutes to one's final destination. Most trains are air conditioned in summer and heated in winter, which was not the case 40 years ago, and while those during peak rush hour are crowded, cell phones (and internet connectivity on many trains) have made the time less unpleasant. Furthermore, a standard "perk" for full-time employees is a monthly rail pass. Those driving receive no such subsidy.

As a consequence, average vehicle miles traveled (VMT) in Japan averaged 3,900 kilometers (2,440 miles) per capita in Japan versus 13,000 km (8,100 miles) in the United States in 2007, over a three-fold differential. In Japan 36 percent of the population uses public transport, but only 15 percent in the United States. Between fewer miles traveled and more efficient vehicles, per capita fuel consumption is less than 1/3rd that of the United States. Public transport dominates: in 2014, in Japan total kilometers traveled averaged 72,579 for vehicles, 413,970 for trains, and 86,763 for air transport (apparently including international flights).

This also applies to freight. Despite the omnipresence of "Black Cat" small package delivery trucks handling internet shopping on Rakuten and Amazon, total freight shipments are falling. Total vehicular kilometer-metric tons of freight peaked in 1990 at 5.9 billion, and since fell 27 percent to 4.4 billion. Bus and taxi ridership is also down, from 101 billion passenger-kilometers in 1970 to 70 billion in 2016, a 30 percent drop. Meanwhile trains and subways accounted for 427 billion passenger-kilometers, six-fold more than automotive transport. Furthermore, that level of train ridership is 10 percent above the level of 1990, and 6 percent above that of 2012. The shift of the economy away from manufacturing and agriculture, and towards densely settled urban services, has shifted the average commute away from vehicles and towards trains.

That hints at another key issue: Japan's labor force is falling as its baby boomers retire, and the overall population is shrinking, down 2 percent from a peak of 128 million in 2007 to 125 million in April 2017. While that may not affect the role of energy in proportion to the economy, it will lead to declines in absolute levels of consumption, independent of changes in fuel efficiency and the mix of transportation. Retirement however does not mean inactivity. While in Japan it becomes increasingly difficult to maintain a driver's license after age 70, rural residential densities are low and rural areas are older than cities. (While the total number of licensed drivers rose 3.3 million during 2007-2016, that was entirely due to a rise in the number of women with licenses, as the number of men with licenses actually fell.)

That retirees no longer commute does not eliminate the need for shopping, but direct expenditures on transportation fall by 50 percent. However, older Japanese do consume transportation indirectly through the national old age care system (*kaigo hoken*, which complements the national health care system). Under it, for example, older residents may qualify for twice-daily visits to get in and out of bed, or daily trips to a senior center. In addition, relative to working households expenditures on utilities, particularly heating and cooling, rise by about 30 percent, albeit from a base well below that of transportation. On net, an aging society will lower energy consumption, but the patchwork of data do not allow even a back-of-the-envelope calculation.

Policy

Three avenues are open to lessen the consumption of imported energy by the transportation sector. One is to shift utilization even further towards public transport. The 60 percent of personal travel in cars accounted for 87 percent of energy consumption, while the 28 percent on trains accounted for just 3.6 percent. Even more skewed was freight: 52 percent moved by truck, but that consumed 86 percent of all energy. Any policy that moves people and goods off trucks and onto trains, buses and (for freight) ships improves energy efficiency. To my knowledge, there are no major initiatives in Japan that specifically seek to shift the mix of transportation. If anything, the financial difficulties of regional rail operators are pushing in the opposite direction of cutbacks in service.

The second avenue is to move towards use of renewables. Diesel vehicles comprise a small share of the Japanese vehicle "parque," at about 1.5 percent of cars and 27 percent of trucks. Research continues on biodiesel, but it is less important for Japan than Europe or the United States. It also is not politically salient – there is no equivalent of the U.S. corn lobby that can push for an ethanol mandate. Should cellulose-based processes develop, the climate of western Japan might make the growth of fast-maturing trees and other sources commercially attractive. That however would be more likely in an environment of expensive petroleum. (Other chapters of this book examine solar, wind and nuclear sources.)

The third is to make vehicles more efficient. That is technically challenging. First, while policymakers focus on battery electric vehicles (BEVs), the commercial case is at present non-existent: consumers do not buy BEVs without subsidies so large that they will not be fiscally viable at a large level of sales. Here China provides a good base case: even with a national subsidy of approximately $8,000 per vehicle, in 2016 sales were under 5,000 units in 19 of the country's 30 provinces and provincial-level cities for which data were available. In contrast, 70 percent of BEV sales (but only 30 percent of car sales) were in the eight provinces and cities that topped off the national subsidy with additional local ones. Japan is no different: despite favorable taxes and much publicity for Nissan's Leaf, there were only 15,000 on the road at the end of 2016. Indeed, even hybrids sell poorly. In 2016, there were 1.275 million on the road. Almost all are Toyota Priuses. As a car it was a hit; as cars hybrids other than the Prius are not. As long as consumers face a significant price premium, they shun electric vehicles and even hybrids.

One narrow challenge for BEVs is that electricity prices are high. In 2014, household electricity cost about ¥27 per kilowatt-hour while in the United States, the cost is about ¥13/kWh, albeit with wide regional variation. Commercial rates vary even more, at ¥20/kWh in Japan versus ¥7/kWh in the United States. High rates encourage users in general to economize, but relative energy costs do not favor BEVs over vehicles powered by gasoline internal combustion engines (ICEs). In the past several years, BEVs have benefited from excess capacity. That arose due to investment during the Great Recession, when a wave of enthusiasm over BEVs led to the expansion of capacity for making cathode and anode powders and for the assembly of cells and packs. That capacity overhang is ending, and supplies of cobalt in particular are tight, with prices rising $8 per kWh during 2017, or $600 per car for the Tesla Model 3. In the interim, none of the potential breakthroughs in battery chemistry have made it past test-of-concept. Experience suggests that it will be at least 10 years before learning curve cost reduction can make any such processes commercially viable, and another 5 years to add capacity commensurate to the scale of global automotive production. Capacity and cost constraints will limit BEVs to a small slice of the market at least into the mid-2020s. The cost penalty for fuel cell vehicles (FCVs) and the costs for fueling infrastructure are even greater. FCVs are potentially a good mesh for buses and other fixed-base vehicles where compact packaging is not a constraint and there is shared infrastructure. Making public transit more fuel-efficient has little effect on overall fuel consumption. Fuel cell use as the main power source for passenger vehicles lies in the distant future.

The second challenge is that in Japan the share of renewables in electricity generation remains low. Increasing the use of BEVs may shrink imports of petroleum but will increase those of coal and LNG. That is useful if the goal of policy is to diversify the sources of energy away from petroleum, but will do little to the overall cost of energy imports. To the extent that incremental power comes from coal, it is likely worse for Japan's GHG emissions than powering cars with gasoline. The production of batteries is energy intensive, while recycling them is technically challenging, so overall BEVs are not particularly good for Japan's environmental footprint.

Nighttime charging can improve grid efficiency as it evens out demand over the course of a day. Such off-peak charging also lessens the bottleneck of local grid capacity. While the U.S. Department of Energy has test studies, those studies need verification in the context of Japan's electricity market. Such indirect benefits are premised on home charging. BEVs make less sense with daytime recharging at a public station, both from the perspective of the opportunity cost of time and the relative expense of supply power during periods of peak demand. While many car owners have parking at their residence, a greater share of the population in Japan lives in apartment complexes and condominiums than in the United States, in older neighborhoods owners must use commercial parking lots some distance from their residence. Infrastructure costs will thus be higher than in the United States, where garages are the norm.

BEVs face one final obstacle: the steady improvement of the efficiency of ICEs. The biggest gains are from the lightweighting of vehicle architectures and the reduction in the weight of engines and transmissions. The former, of course, also benefits BEVs, but the biggest gains have come from the replacement of large engines (V-8s in the United States) with smaller ones (V-4s and for compact cars, I-3s). Electric motors are replacing hydraulic and chain/belt driven accessories, cutting parasitic losses for water pumps, and enabling more efficient transmissions. Light electrification from start-stop systems and power-boost alternator-generators come at a low cost increment. Modest hybrid systems, such as using electric motors to provide on-demand four-wheel drive but not primary motive power, come next in expense. Full hybrids follow, and then plug-in hybrid electric vehicles. The fuel efficiency ratings in Figure 5 give a sense of how much is possible with ICEs. To be a good consumer proposition, battery costs not only have to fall, they have to fall much faster than the cost of these alternatives. For at least the next decade, policy should focus as much on improving ICEs as on developing better batteries.

Figure 5: Fuel Efficiency – Top Ten Regular Cars

Rank	Firm	Model	Sales 6 months 2017	Rated fuel efficiency l/km	eNenpi userdata	miles/gal
1	Toyota	Prius	78,707	40.8	25	59
2	Nissan	Note	68,441	37.2	20	47
3	Toyota	Aqua	62,537	38	23	54
4	Toyota	C-HR	60,627	30.2	21	50
5	Honda	Freed	51,652	27.2	18	42
6	Honda	Fit	48,488	37.2	23	54
7	Toyota	Vitz	44,005	34.4	16	38
8	Toyota	Sienta	42,837	27.2	18	42
9	Toyota	Voxy	39,988	23.8	17	40
10	Nissan	Serena	37,503	17.2	15	35
Total / Average			534,785	31.3	20	46

Source: Japan Automobile Manufacturers' Association

The Japanese government has nevertheless put forth a wide array of tax breaks and other policies aimed at encouraging greater fuel efficiency in transportation. Rather than list those here, interested readers should refer to the extended coverage (11+ pages) in JAMA's annual *Motor Industry of Japan Yearbook*. These include stair-step tax reductions for meeting various emissions and fuel-efficiency thresholds, as well as tax reductions for vehicles using specific technologies. It is too soon to evaluate whether significant numbers of vehicles will qualify for any of these measures.

Conclusion

Automotive transport is a large end-user of energy, which in Japan means imported petroleum. Thanks to high energy taxes, the cars and trucks on the road are already smaller and more fuel efficient than those in the United States. Technology already in early commercialization will lead to further improvement. Despite the hype over the efficiency of battery electric vehicles (BEVs), in Japan electric power is generated using imported fuels, while their efficiency is less once power-plant-to-battery losses are considered. A wholesale move away from the internal combustion engine (ICE) would barely move the needle on energy imports. Bigger benefits would instead come from encouraging consumers to choose public over private transport, and small vehicles over large. The trend for both though is in the opposite direction. Unless policy is willing to push back against these two trends, for example by taxing gasoline more heavily and using that to subsidize public transport, per capita fuel consumption will be little different.

Chapter Ten

Demand-Side Management in Japan: Moving Beyond Gaman and Pilot Programs

Dr. Ken HAIG
Research Associate, Graduate School of Public Policy, Hokkaido University

Introduction

In the aftermath of the March 11, 2011 (3.11) Great Eastern Japan Earthquake and subsequent tsunami and nuclear disaster, the Tokyo Electric Power Company (TEPCO) was forced to shutter several of its larger nuclear and thermal power stations for an extended period. Especially given heating needs during the colder mid-March weather when the earthquake struck, electricity supply suddenly fell short of demand. TEPCO responded by implementing rolling blackouts, dividing its service area into five sections and cutting power for a few hours per day across each section. While TEPCO tried to put in place a reliable schedule for the planned blackouts, these rarely occurred at designated hours or for predictable lengths of time, creating uncertainty and disruption in industry, the economy, and transportation services.[157] Voluntary energy-saving measures eventually replaced forced outages, but these measures never developed into a dependable mechanism for encouraging energy users to flexibly adjust consumption—a practice known as "demand-side management," or DSM—in lieu of having to increase supply.

Japan's electric power system has long prioritized reliability over flexibility. Throughout the post-World War II period, government and industry struck an implicit bargain with Japanese electric power companies,[158] granting regional monopolies in exchange for ensuring a consistently reliable, stable supply of electricity.[159] The consequence of this implicit bargain was that, in addition to under-investing in inter-regional transmission links—which proved to be a problem after 3.11, when different frequencies used across the eastern and western halves of Japan meant that available power in western Japan could not be transmitted to the east, due to the limited number of inter-regional frequency conversion facilities—Japanese utilities also over-invested in generation

[157] Murakoshi, Chiharu, Hidetoshi Nakagami, and Sho Hirayama (2012). *Electricity Crisis and Behavior Change in the Residential Sector: Tokyo Before and After the Great East Japan Earthquake*. Washington, D.C.: American Council for an Energy-Efficient Economy.

[158] Throughout much of the early post-WWII period there were nine vertically integrated electric power companies with regional monopolies, though this number increased to ten with the addition of Okinawa Electric Power Company after the reversion of Okinawa to Japan in 1971.

[159] This was particularly true of power to the industrial and commercial sectors, the largest consumers of electricity in Japan and the key drivers of post-WWII economic growth, but also to the residential sector, from whom Japanese utilities derived the bulk of their revenue, and upon whom political parties were dependent for votes. See Samuels, Richard J. (1987), *The Business of the Japanese State: Energy Markets in Comparative and Historical Perspective,* Ithaca: Cornell University Press.

capacity.[160] For much of the post-WWII period, essentially free from cost constraints and guaranteed a rate of return on just about anything they built under their regional monopolies, Japan's electric power companies historically built capacity to meet the highest peak demand.[161] In other words, Japan's electric power system was set up in such a way that it incentivized the generation of excess power year-round, just to serve a relatively small number of peak demand hours during the hottest summer and coldest winter months.

Building Japan's baseload power supply to support maximum peak demand meant that Japan's electric power system was well over capacity for much of the rest of the year. This accounts in part for Japan's higher electricity rates relative to other OECD countries.[162] Nevertheless, this was considered an acceptable trade-off as part of the post-WWII implicit bargain with Japanese utilities: regional monopolies meant higher costs for consumers, but also more localized accountability and dependability in electric power delivery.[163] While economically inefficient, localized monopolies did prove remarkably successful in ensuring reliability. One anecdotal measure of this success was the fact that many Tokyo-area residents experienced blackouts for the first time in their lives on 3.11, something unimaginable in many other parts of the developed world.[164]

From what began as temporary/emergency measures in the immediate aftermath of 3.11, policymakers are now considering how to make DSM a permanent part of Japan's energy mix. So far, however, the focus has been more on promoting adoption of particular DSM-enabling technologies than on market design to encourage acceptance of DSM as an energy resource. Systematic changes are required to realign utilities' and consumers' incentives to look beyond Japan's traditional supply-side-centric approach and take DSM from an exercise in "*gaman*" (suffering stoically through hardship, as in post-3.11 Japan) to a marketable, flexible *and* reliable energy resource going forward.

Defining Demand-Side Management

DSM represents a change in the traditional energy delivery model. In Japan as well as the rest of the world, investment in supply-side resources and increased power supply historically provided the means by which utilities and their shareholders were able to earn a steady rate of return from ratepayers. Energy providers thus traditionally have been incentivized to generate power in excess, rather than attempt to flexibly adjust demand. Utilities built peaking power plants, which can be ramped up quickly to provide additional power on top of baseload generation to meet short-term spikes in demand,

[160] The amount of electricity that can be sent to eastern Japan is limited to 1 GW because of a difference in electrical frequencies between regions. Japan is one of the few industrialized countries with essentially two separate power grids—one that runs at 50 Hz in eastern Japan, with another that runs at 60 Hz in western Japan. This was the result of Tokyo's adopting German-manufactured generators in the initial days of electrification, while Osaka adopted U.S. equipment. See Kikkawa, Takeo (2004). *Nihon Denryokugyo Hatten no Dainamizumu* [The Dynamism of Development in the Japanese Electric Power Industry]. Nagoya: Nagoya University Press.

[161] See Takeuchi, Keiji (2013). *Denryoku no Shakai-shi: Nani ga Tokyo Denryoku wo Unda no ka* [A Social History of Electricity: What Gave Rise to TEPCO], Tokyo: Asahi Shimbun Shuppan.

[162] OECD (2015). "Electricity Prices by International Comparison," in *OECD Economic Surveys*. Paris: OECD Publishing.

[163] Kikkawa, Takeo (2013). *Nihon-no Enerugi Mondai* [Japan's Energy Problem]. Tokyo: NTT Shuppan.

[164] Yagita, Yoshie, Yumiko Iwafune, Miyuki Ogiwara, and Goshi Fujimoto (2012). "Household Electricity Saving Behavior after the Great East Japan Earthquake." *Journal of Japan Society of Energy and Resources*. Vol. 33, No. 4, pp. 7-10.

while they met predicted long-term growth in demand through the construction of more power generation and transmission infrastructure, and/or upgrades to existing infrastructure. DSM turns this traditional supply-side logic on its head, encouraging investment in ways to use already available power more flexibly and efficiently, rather than increasing supply.

When scaled effectively, energy savings from DSM programs can replace retiring power plants, or displace or defer the need for new generation and transmission investments altogether.[165] In Japan in particular, where imported fossil fuels accounted for nearly 90 percent of the electricity supply after 3.11, policymakers increasingly recognize that DSM would reduce dependence on imported fuel, reduce Japan's negative balance of payments, and increase economic competitiveness.[166]

In many countries, DSM plays a central part in efforts to reduce greenhouse gas emissions associated energy production and consumption. Whether by promoting longer-term improvements in energy efficiency, or by making more power available when supply is constrained through shorter-term "demand response" programs, fostering markets for DSM can also have widespread economic benefits, including job creation and investment in innovative new clean technologies and services.[167]

Across much of the advanced industrialized world (outside of Japan), DSM is considered an energy resource unto itself, one that competes effectively with other supply-side resources in energy and power markets.[168] One good example of this is how DSM is treated within the PJM Interconnection, the regional transmission organization that oversees grid operations and the electric transmission system across much of the eastern United States. Delivering power to over 60 million people across 14 U.S. states, PJM operates one of the world's largest competitive wholesale electricity markets. Power is purchased based on auctions of various types, including payments for "capacity," or commitments to provide enough power to meet future demand. The idea here is to direct investment a few years ahead of delivery, creating an ongoing, flexible market for whatever resources will best meet future energy needs.

Since there is no functional difference between a megawatt of power from a power plant and a megawatt of power saved (avoided capacity) in PJM's capacity auctions, the auctions encourage investment in—and create long-term price signals for—a wide variety of energy resources. Whether generated power (supply-side resources) or demand-side resources like energy efficiency or demand response, every resource bids into the auction at its total cost of operation (capital costs plus operational costs). Bids are

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[165] See Billingsley, Megan A., Ian M. Hoffman, Elizabeth Stuart, Steven R. Schiller, Charles A. Goldman, and Kristina LaCommare (2014). *The Program Administrator Cost of Saved Energy for Utility Customer-Funded Energy Efficiency Programs.* Berkeley, CA: Ernest Orlando Lawrence Berkeley National Laboratory/U.S. Department of Energy Office of Electricity Delivery and Energy Reliability.

[166] After 3.11, the increased use of thermal plants to make up for the loss of nuclear generation caused higher fuel import costs, borne by Japanese consumers and industries, which led to Japan's first trade deficit since 1980 (Kikkawa 2013, p. 9).

[167] In the United States, for example, the American Council for an Energy Efficient Economy (ACEEE) forecasts that by 2030, in addition to 600 million tons of CO2 savings, the market for DSM will yield USD 47 billion in new investment, 610,000 new jobs, and a $95 billion reduction in household energy expenditures—savings that can be reinvested in other parts of the economy. See Hayes, Sara, Garrett Herndon, James P. Barrett, Joanna Mauer, Maggie Molina, Max Neubauer, Daniel Trombley, and Lowell Ungar (2014). *Change Is in the Air: How States Can Harness Energy Efficiency to Strengthen the Economy and Reduce Pollution.* Washington, DC; American Council for an Energy Efficient Economy.

[168] Molina, Maggie (2014). *The Best Value for America's Energy Dollar: A National Review of the Cost of Utility Energy Efficiency Programs.* Washington, DC; American Council for an Energy Efficient Economy.

collected from lowest to highest cost, until enough capacity has been acquired to meet demand.[169]

Compare this to Japan's *Basic Energy Plan*, last updated in 2014, which does not count DSM as an energy resource, even while upholding supply-side resource targets that are clearly out of step with what is feasible in post-3.11 Japan.[170] For example, the *Basic Energy Plan* describes an energy mix in 2030 in which nuclear power will account for 20 to 22 percent of the country's electricity, as well as the development of an additional 27 GW of new coal capacity.[171] Market predictions, however, are increasingly at odds with this vision. With respect to nuclear power, more stringent stress tests—in addition to the requirement that local governments must approve the restart of each of Japan's idled nuclear reactors (a high hurdle, given strong continued public opposition due to concerns over nuclear safety) and the more than two dozen lawsuits against nuclear restarts still making their way through Japanese courts—have all made nuclear restarts more difficult than hoped for by Japanese utilities, who have faced a heavy financial burden from having to import fuel to run thermal power plants in place of their nuclear reactors. Of the 26 nuclear power plants targeted for restarts, only six had actually come back online by March 2018. Analysts argue that at this rate, the assumption that nuclear power will account for more than 10 percent of Japan's electricity output by 2030 is highly improbable.[172] Calls for more coal-fired power plants are similarly impractical, given that high costs and competition from other forms of generation capacity with lower marginal costs and greenhouse gas emissions (e.g. natural gas and renewables) ensure that any new coal generation infrastructure will quickly become stranded assets.[173]

3.11 showed the need to restructure Japan's power sector—including the need to create incentives for adjusting demand rather than relying on an overabundance of supply—even as it highlighted the challenges in shifting a system set up to promote fixed and reliable electric power supply towards accommodating more flexible approaches.[174]

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[169] The most expensive capacity commitments (those that do not meet the clearing price) are rejected. At 2016's auction (at which payments for 2019–2020 capacity commitments amounted to $6.9 billion), over 10 gigawatts (GW) of demand response cleared the auction, in addition to 1.5 GW of energy efficiency. At the same time, 2,600 MW of coal commitments and 1,500 MW of nuclear commitments failed to clear the auction, with a number of aging coal-fired and nuclear power plants now likely to be shut down as a result. For more details, see http://www.pjm.com/~/media/markets-ops/rpm/rpm-auction-info/2019-2020-base-residual-auction-report.ashx.

[170] See Duffield, John S., and Brian Woodall (2011). "Japan's New Basic Energy Plan." *Energy Policy*. 39(6), pp. 3741–3749.

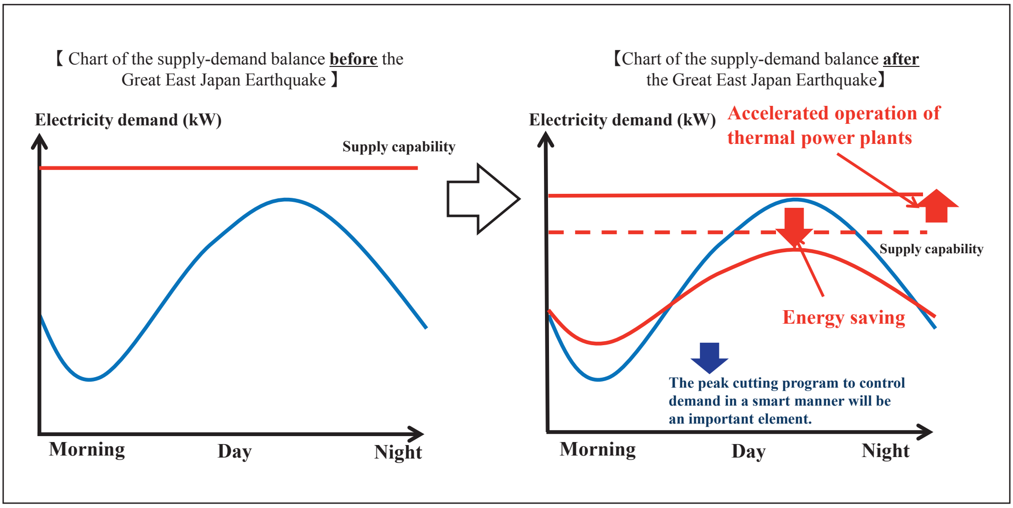
[171] For more details, see http://www.enecho.meti.go.jp/en/category/brochures/pdf/energy_plan_2015.pdf.

[172] BNEF (2014). *Japan's Approach to Demand-Side Management*. Bloomberg New Energy Finance, October 26, 2014.

[173] Caldecott, Ben, Gerard Dericks, Daniel J. Tulloch, Lucas Kruitwagen, Irem Kok (2016). "Stranded Assets and Thermal Coal in Japan: An Analysis of Environment-Related Risk Exposure." Oxford: Stranded Assets Programme, SSEE, University of Oxford, 2016.

[174] See, for example, Wolak, Frank (2012). "Restructuring the Japanese Electricity Supply Industry in the Aftermath of Fukushima," in *One Year After Japan's 3/11 Disaster: Reforming Japan's Energy Sector, Governance, and Economy* (Stanford, CA: Walter H. Shorenstein Asia- Pacific Research Center, 2012).

Figure 1: METI/ANRE Vision for Demand Response Programs after 3.11



Source: Ministry of Economy, Trade & Industry (METI)/Agency for Natural Resources & Energy (ANRE), Policy Planning Division, Energy Conservation and Renewable Energy Department

Japan's Post-3.11 Turn Towards DSM

After 3.11, in addition to waiving the normal approval process for restarting mothballed thermal generators, officials at the Cabinet Office and the Ministry of Economy, Trade & Industry's (METI) Agency for Natural Resources & Energy (ANRE) sought to implement a sustainable energy-saving strategy before peak consumption during the hottest summer months outstripped available electricity supply. This time, in order to ensure better demand forecasting and avoid the difficulties that arose from TEPCO's rolling blackouts after 3.11, a group of researchers, government officials, and utility employees convened to estimate sector-specific load curves and energy-saving potential, as well as to develop specific recommendations for saving electricity for each sector.[175] The result was calls for mandatory rationing by large commercial and industrial customers (utility customers with contracts of at least 500kW), and voluntary savings aided by information campaigns and technical energy-saving assistance for all others.

On the commercial and industrial side, METI invoked Article 27 of the *Electricity Business Act* (for the first time in more than 40 years, since the Oil Shocks of the early 1970s), requiring customers with contracts of at least 500kW to reduce their demand during weekdays by 15 percent relative to the previous year's consumption.[176] Japanese utilities also eased the requirements for large end-users to enter "adjusted supply and demand" contracts, under which end-users receive discounted rates during normal conditions in exchange for the obligation to reduce usage when electricity supply is constrained. Time-of-use (TOU) rates—which offer a cheaper tariff for off-peak consumption and a higher charge for peak usage—also were recommended for residential

[175] Demand forecast estimates were made for eight commercial subsectors, including office buildings, wholesale and retail outlets, supermarkets, hospitals/clinics, hotels, restaurants, schools, and factories. Estimates also were made for the residential sector using assumptions about occupancy, electronics / appliance diffusion, and household usage. See Yagita et al (2012).

[176] Kushida, Kenji E. (2012). "Japan's Fukushima Nuclear Disaster: Narrative, Analysis, and Recommendations." *Shorenstein APARC Working Paper.*

customers, though adoption remained low, in part because there was no mechanism for timely feedback on consumption data without widespread smart meter deployment.[177]

Smaller commercial and industrial as well as residential customers (those with contracts under 500kW) also were encouraged to reach 15 percent savings through voluntary measures. The government promoted a "Super Cool Biz" campaign, asking businesses to adopt a relaxed dress code (open collars and short-sleeved shirts, in lieu of suits) during the summer months, and to set thermostats above 26 degrees Celsius.[178] Forecasts of supply and demand were updated hourly via multiple communication platforms: on television, via government Twitter feeds and Websites, and on displays at train and subway stations. Trains slowed, and billboards called upon citizens to save energy for the sake of the nation.[179] METI/ANRE publicized electricity-saving tips, established energy-saving contests, and offered rewards to residential and commercial customers for meeting or exceeding voluntary targets.

Commercial and industry groups responded with various voluntary initiatives of their own. After environmental and noise regulations were relaxed during the summer months, factories shifted operations to nights and weekends where they could, and retailers and commercial building operators adjusted operating hours, reduced lighting, and decreased the number of elevators and escalators in operation. Employers extended summer holidays, and tried to create incentives for employees to take vacation during the summer months.

Ultimately, voluntary curtailment resulted in 18 percent savings during the summer months of 2011.[180] While the summer of 2011 was milder than expected, this was still an impressive achievement. But Japanese policymakers struggled with how to make these temporary/emergency measures permanent, especially as disaster fatigue set in. What was needed was a shift in emphasis from energy *conservation*—which carried with it the image of *gaman*, or suffering stoically through hardship, especially as calls to conserve came during the hottest summer months—to an emphasis on ongoing investment in energy *efficiency*, or efforts to cut waste where it makes sense to do so, without negatively impacting workplace productivity or lifestyle comfort.[181] Much as had happened with making the Top Runner program for electronic appliances the centerpiece of residential energy efficiency efforts in the late 1990s, METI/ANRE took a hardware-based approach to towards enabling DSM initiatives, beginning with promoting the standardization and widespread deployment of smart meters.

[177] OpCit. BNEF (2014).

[178] See Tanabe, Shinichi, Yuko Iwahashi, Sayana Tsushima and Naoe Nishihara (2013). "Thermal Comfort and Productivity in Offices under Mandatory Electricity Savings after the Great East Japan Earthquake." *Architectural Science Review*. Volume 56, Issue 1, 2013.

[179] Public awareness campaigns tended to emphasize *kizuna*, or "connections" to the disaster-affected areas, and phrases like *minna de ganbarou*, or "we're all in this together."

[180] OpCit. Murakoshi, Chiharu, Hidetoshi Nakagami, and Sho Hirayama (2012), pg. 38.

[181] OpCit. See Tanabe, Shinichi, Yuko Iwahashi, Sayana Tsushima and Naoe Nishihara (2013).

Smart Meter Deployment and DSM Pilot Programs

Whereas traditional (analogue) electricity meters require in-person manual meter reads, "smart" meters automatically record electricity consumption data and send this information wirelessly back to the energy provider in regular intervals. Energy providers thus tend to see the value of smart meters in terms of operational savings (i.e. lower costs associated with meter reads due to automation). But there greater is value to end-use customers in the DSM-enabling capabilities of smart meters. For example, smart meters make it possible for consumers to choose the tariff that best suits their usage profile from a menu of time-of-use (TOU) rates, as well as to take part in paid demand response programs. Smart meters also can be connected to in-home monitors to display energy consumption in real time, or to IOT-enabled homes or building energy management systems (HEMS/BEMS) and smart thermostats that can automatically adjust room temperature and appliance settings, supporting automated demand response (ADR) programs.

U.S. and European utilities already had started large-scale deployment of smart meters before 2011, but Japanese utilities (with the exception of Kansai Electric Power Company, which got an early start) were only conducting limited smart meter demonstration projects before 3.11. At the time, smart grid investment in Japan—exemplified by the launch of four smart community projects in 2010—was primarily focused on developing energy-management technologies for export, rather than testing DSM solutions for widespread adoption in Japan.

All of this changed after 2011, when poor demand forecasting and shifts in Japanese utilities' political fortunes after 3.11 stirred METI/ANRE to induce utilities to both speed up nation-wide smart meter deployments and conduct competitive tenders to lower procurement costs (rather than pursue the traditional sole-sourced, preferred-vendor contracting approach).[182] In addition, the government used its effective majority control over TEPCO (via the Nuclear Damage Compensation and Decommissioning Facilitation Corporation) to use TEPCO as a model for smart meter deployment and use. Also on the hardware front, METI provided subsidies for lithium-ion batteries for energy storage by smaller-scale commercial and industrial (C&I) and residential customers, as well as for the installation of HEMS/BEMS, and construction of "smart" and "zero-emission" houses and buildings (ZEH/ZEB).

Unlike the Feed-in-Tariff (FIT) program for renewable energy a few years earlier, rather than move quickly to create long-term regulatory or market incentives for utilities to employ DSM programs, METI/ANRE started first by using their budgetary discretion to fund new grant and subsidy programs as well as tests of markets for DSM technologies. METI/ANRE supported three waves of new pilot programs: 1) a direct-to-consumer residential DSM model, 2) an aggregator-led C&I DSM model, and 3) the virtual power plant model.

[182] All smart meter equipment in Japan must comply with the ECHONET Lite standard as the common consumer application interface and an ECHONET Lite compliant "B route" to facilitate communication between electric devices/home appliances and HEMS/BEMS and access by third parties, such as demand response providers, further down the road.

Direct-to-Consumer Residential DSM: Testing the Efficacy of Behavioral Approaches and Demand-Based Pricing

In 2010, the then-DPJ-led government approved a New Growth Strategy emphasizing green innovation. This included funding for "smart communities" that would serve as a showcase and export platform for Japanese smart technologies, from mobility and healthcare services to ICT-enabled DSM and renewable energy integration.[183] Under this program, four regions across Japan—Yokohama City, Toyota City, Kitakyushu City, and Keihanna Science City (an unincorporated city located in the border region between Kyoto, Osaka, and Nara Prefectures)—were selected as smart city demonstration sites. Funded and administered by METI/ANRE in collaboration with the private sector, after 3.11 these smart cities became test sites for demand response programs in HEMS-installed households and BEMS-installed buildings.

In contrast to the C&I sectors, where the bottom-line value of energy efficiency (in terms of operational cost savings) is clear, and where employment of full-time professional energy managers is common, ordinary households have fewer incentives and face higher hurdles to managing energy consumption.[184] Researchers working in Japan's smart city demonstration sites set out to test whether using HEMS/BEMS as a platform for demand-based pricing would motivate residential customers to reduce peak demand. The thought was that, by charging higher rates when demand spikes (similar to "surge pricing" for ride-hailing services), demand-based pricing would send price signals significant enough to motivate residential customers to either reduce usage outright during peak demand periods (e.g. by turning down the air conditioning) or shift usage to off-peak hours (e.g. waiting to run the dishwasher or washing machine until after-peak hours).[185]

Demand-based pricing in these smart city experiments, conducted from JFY 2011 to JFY 2015, yielded an average of 10-20 percent savings in residential peak demand.[186] While noting challenges to the generalizability of these findings (including the small sample sizes, opt-in program design, and selection bias associated with inclusion of HEMS-enabled households only), researchers on these projects have conducted cost-benefit simulations to evaluate—and advocate—the nationwide expansion of demand-based pricing as an effective means of enlisting residential and smaller commercial and industrial end-users in DSM programs.[187]

Despite this research-supported effort, widespread use of institutionalized demand-based pricing seems unlikely for the foreseeable future in Japan. Uptake of the TOU rates already offered by Japanese utilities remains low, and Japanese policymakers are not about to take the step that places like the U.S. State of California have, mandating a

[183] DeWit, Andrew (2014). "Japan's Resilient, Decarbonizing and Democratic Smart Communities." *The Asia-Pacific Journal.* Volume 12, Issue 50, Number 3. December 2014.

[184] These include higher transaction costs associated with lack of access to information, as well as lack of financing for DSM technologies and services.

[185] For example, in Kitakyushu City, electricity was supplied at ¥15/kWh during normal hours and ¥6/kWh during night/off-peak hours (more attractive than average Japanese electricity rates, which were around ¥23/kWh), while peak pricing rose to a maximum of ¥150/kWh, depending on forecasting for the following day's demand (BNEF 2016).

[186] BNEF (2016). *Economics of Residential Demand Response in Japan*. Bloomberg New Energy Finance, February 29, 2016.

[187] See, for example, Ito, Koichiro, Takanori Ida, and Makoto Tanaka (2015). "The Persistence of Moral Suasion and Economic Incentives: Field Experimental Evidence from Energy Demand." NBER Working Paper No. 20910. January 2015.

transition to demand-based pricing as the default offering for all electricity customers.[188] Moreover, current proposals for expanding demand-based pricing as a mechanism for residential DSM tend assume universal adoption of HEMS as a platform for sharing real-time feedback on usage and cost. While Japanese homebuilders have continued to promote HEMS-installed smart homes as a part of their tech-enabled home branding strategies, these still comprise only a very small percentage of new home sales, especially after the conclusion of METI's HEMS subsidy program in 2013.[189]

The value of residential DSM in terms of grid management is in the aggregation of relatively small individual household energy savings. However, reaching out to millions of households individually—let alone installing HEMS in every home—is cost prohibitive. As a result, proponents of residential DSM in Japan have increasingly looked to incentivize the cooperation of energy providers as the quickest route to scaling up residential DSM programs. The logic here is that recruiting utilities and energy retailers—who already have trusted relationships with, data on, and communications channels reaching every household—significantly reduces the costs and logistical challenges associated with promoting residential DSM.[190]

The first major test of this approach was a pilot program run by METI/ANRE in 2015-2016, which for the first time enlisted utilities' cooperation in sending and measuring the impact of personalized energy efficiency communications across their residential customer base. In this pilot, 20,000 households in Hokuriku Electric Power Company's service territory were sent paper home energy reports (HERs) employing "nudge"-based communication strategies, such as comparing and ranking each household's energy consumption relative to that of nearby similar homes, throughout the winter of 2015-2016.[191] In addition to being Japan's largest residential DSM pilot program to that point, this was also Japan's first "no price, no device," or 100 percent "behavioral energy efficiency" program—described as such for the fact that it used behavioral science-inspired approaches to encourage consumers to adopt more energy-efficient behaviors, without the use of any new hardware or price signals.[192]

In contrast to METI/ANRE's previous pilot programs, this HER pilot was not limited to households with smart devices, increasing the potential for scalability.[193] Given the relatively small per-household impact of HER programs, scalability is crucial to ensure meaningful aggregate savings. After two HERs, the Hokuriku pilot yielded an average of 1.2 percent energy savings (treatment vs control) per household. While this sounds small, the METI/ANRE report from this pilot estimates that, if HER programs were scaled

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[188] See, for example: http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB1090.
[189] OpCit. BNEF (2014), pg. 10.
[190] This logic also forms the basis for utility-led residential energy efficiency programs in the United States as well. See, for example, https://www4.eere.energy.gov/seeaction/system/files/documents/ratepayer_efficiency_customersatisfaction.pdf.
[191] For more on this pilot program, see METI's project report here: http://www.meti.go.jp/meti_lib/report/2016fy/000233.pdf.
[192] http://web.iss.u-tokyo.ac.jp/cjg/lecture/2016/06/untapped-potential-results-and-policy-implications-from-japans-first-large-scale-behavioral-energy-e.html.
[193] http://www.meti.go.jp/meti_lib/report/2016fy/000233.pdf. Indeed, the personalized HERs generated and sent to each recipient in this case used no HEMS or smart meter data; monthly meter read data were used instead, enabling communications with all of Hokuriku Electric's residential customers.

to reach all Japanese households, it would yield the equivalent of most of Japan's HEMS/ BEMS-enabled DSM targets for 2030 in just one year.[194]

Another key difference was the randomized control trial (RCT) and opt-out program design, which ensured a high degree of confidence in the research findings and their generalizability.[195] This has become progressively more important as Japanese policymakers have increasingly turned their attention to evidence-based policymaking to justify public spending, and the need for precise measurement to employ DSM as a reliable energy resource.[196]

Based on these findings, METI/ANRE has since used the Hokuriku pilot results as the basis for new guidelines for energy providers to encourage efficiency-promoting communications.[197] Also, as part of the government's goal of reducing residential-sector greenhouse gas (GHG) emissions by 40 percent by 2030 (relative to 2013 levels) as per Japan's Paris Agreement commitments, the Ministry of Environment (MOE) has since supported the expansion of utility-led behavioral energy efficiency programs across all of Japan with a five-year (JFY 2017-JFY 2022) nation-wide HER pilot program.[198]

While these efforts do not yet go as far in requiring utilities to promote residential DSM programs as the Energy Efficiency Resource Standards (EERSs) seen in many of the world's advanced industrial economies,[199] they are an indication of Japanese policymakers' understanding that creating scalable and cost-effective residential DSM programs requires reaching residential consumers through their energy providers.

Aggregator-Led Commercial and Industrial (C&I) DSM: Negawatt Trading

By contrast, the vision for DSM for large C&I end-users in Japan is one enabled by aggregators, who act as intermediaries in getting C&I customers to reduce energy consumption in response to requests from power companies. Aggregators bundle and are paid for this unused power, and compensate participating end-users according to the amount by which they reduce their demand. METI/ANRE first tested this model in a demand response pilot with C&I customers that ran initially from December 2013 to March 2015, and then was extended from August 2015 to January 2016.

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[194] Ibid. Note: projections from the Hokuriku pilot show an expected impact in the 2-3 percent range after a year-plus of HER treatment, the global average for Opower HER programs at the time.

[195] Both the 20,000 households receiving HERs in this case - the treatment group- and the similarly sized control group (those not receiving communications from the utility, against whom monthly usage of those in the treatment group was compared before and after receiving HERs) were randomly selected. This, combined with the fact that the treatment group received HERs on opt-out basis (i.e. no sign-up, purchase, or prior interest was required), helped ensure that the results of this pilot were reasonably representative of what could be expected from the average Hokuriku Electric residential customer.

[196] Scrutiny of Japan's traditional behavioral energy efficiency approaches, such as MOE's "Cool Choice" and "Cool Biz" programs, has increased in the absence of evidence of precise measurement of program impact. For more on this, see the Japanese government's Behavioral Sciences Team (BEST) Website: http://www.env.go.jp/earth/ondanka/nudge.html.

[197] See proceedings of METI/ANRE's Energy Efficiency Guidelines Working Group: http://www.meti.go.jp/report/whitepaper/data/pdf/20170331002.pdf.

[198] For more, see http://www.env.go.jp/earth/ondanka/nudge/renrakukai01/mat02.pdf, http://www.env.go.jp/press/104736.html.

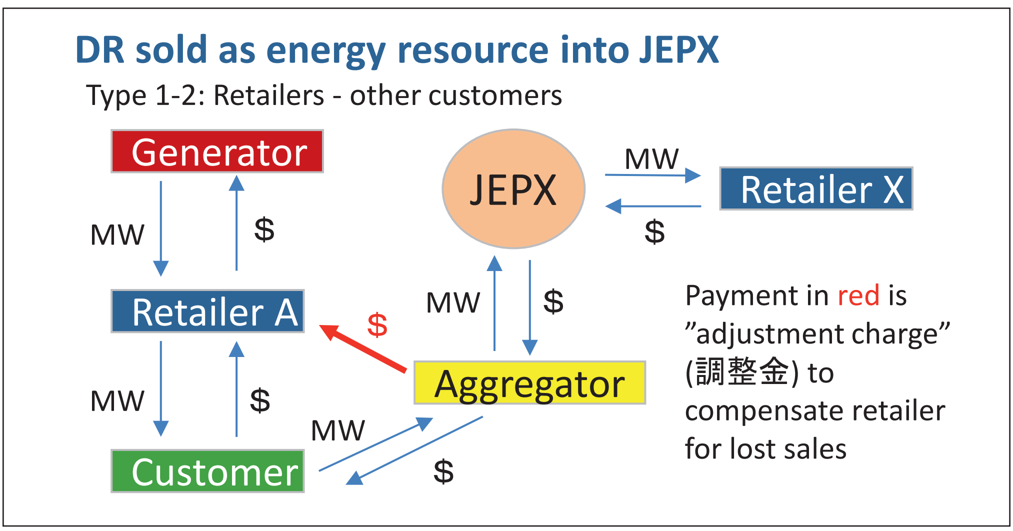
[199] See IEA (2017), *Market-Based Instruments for Energy Efficiency: Policy Choice and Design*. Paris: OECD/International Energy Agency. https://www.iea.org/publications/insights/insightpublications/MarketBased_Instruments_for_Energy_Efficiency.pdf. An EERS is a performance-based policy mechanism that obliges energy providers to reach a certain percentage of energy savings over a specific timeframe (usually relative to the previous year's total energy sales), and compensates providers for these efforts via a regulator-approved tariff. EERSs are similar conceptually to renewable portfolio standards (which require utilities to purchase a certain percentage of power from renewable energy sources, to support market development), only applied to the demand side.

In this pilot project, utilities in three regions, Tokyo (TEPCO), Kansai (KEPCO), and Chubu (CEPCO), called three different types of demand response events: day-ahead, one-hour, and 10-minute advanced notifications, in mornings and evenings during the peak winter and summer months, and afternoons during the fall. About 2,000 C&I customers participated; based on their predetermined contracted capacity versus the capacity supplied, it was determined that C&I demand response had the potential for almost 14 GW of peak load reduction (or about 9 percent of national peak load) during the summer, as well as steady demand response potential in the winter and fall.[200]

Based on these results, METI/ANRE drew up guidelines for Japan's version of C&I demand response, including baseline calculation standards, and started a market in April 2017 for "negawatt trading" in which aggregators pay consumers to curb their electricity use, and then sell the resulting spare capacity back to the grid. Japan's fledgling negawatt market cleared 1 GW of bids upon completion of its first auction in December 2017, in the Kyushu Electric Power Company service territory in addition to the TEPCO, KEPCO, and CEPCO service territories already covered in the initial pilot program.[201]

Japan's negawatt trading market works as follows: utilities pay an annual rate of ¥3,000-5,000 per kilowatt of power saving to negawatt aggregators, who use a portion of the revenue to pay rewards to factories and offices for the amount of usage they commit to curb on hot summer days and other peak-demand periods.[202] Through negawatt trading, the Japanese government aims to reduce peak demand by 6 percent by 2030.[203] The assumption is that utilities will be willing to pay for demand response because they would save considerable sums of money by forgoing capital investments to maintain surplus power-generating capacities.

Figure 2: Diagram of Japan's Market for Negawatt Trading



Source: Ministry of Economy, Trade & Industry (METI)/Agency for Natural Resources & Energy (ANRE)

[200] For more details, see the JFY 2014 final report: http://www.nepc.or.jp/topics/2016/0330_1.html. 10-minute advanced notification provided incentives of JPY 6,500/kW per year and JPY20/kWh, one-hour ahead notification provided JPY 5,000/kW per year and JPY 20/kWh; and day-ahead notification provided JPY 30/kWh.
[201] For more, see http://www.meti.go.jp/press/2016/12/20161228004/20161228004-1.pdf.
[202] Ibid.
[203] Ibid.

Moving from Negawatts to Flexiwatts: Flexibility as the Key to Energy Reliability and Resiliency

American physicist Amory Lovins adopted the term "negawatts," used to describe power saved through energy conservation or efficiency measures, as a part of his argument that producing negawatts (rather than more megawatts) was the cleanest and most economical way to meet future power needs.[204] Since then, Lovins and the research institute he heads, the Rocky Mountain Institute, have shifted their focus to "flexiwatts," or how to manage power supply variability by adjusting flexibly between supply-side and demand-side resources—both of which have become progressively more decentralized, and in need of better aggregation—depending on which resource is more plentiful at different times of the day.[205]

Imagine if end-use consumers could be tapped as a resource not only for reducing demand when power supply is short, but also for collectively storing and supplying power on a community-wide basis. With the appropriate configuration, electric vehicles and plug-in hybrid automobiles could be used not only as a means for storing energy to meet individual households' energy needs, but also for storage in aggregate to help manage community-wide peak demand. Put together, these would form a "virtual power plant" (VPP), a collection of distributed energy resources—including both supply-side and demand-side resources—that could eventually replace centralized generation altogether.

This is precisely where Japan's most recent METI/ANRE-funded pilot programs are headed. Starting with a budget of ¥3 billion (roughly $28.7 million) in subsidies in fiscal 2016, METI/ANRE began funding efforts to link together and remotely control networks of independent batteries (and in some cases, hydrogen storage facilities), solar panels, and electrical equipment/appliances/building heating and cooling systems via a centralized data center and common software platforms.[206] After committing to support the development of a number of public-private VPP initiatives over the next few years, METI/ANRE's aim is to somehow find a means of commercializing these systems by 2020. From there, the thought is that the wider use of VPP systems should enable flexible supply and demand adjustment, making it easier to integrate and store more distributed energy resources—both as a means of meeting future energy demand, as well as avoiding another energy crisis of the sort that followed 3.11.

Conclusion: Pinning DSM Hopes on Regulatory and Market Reforms in Japan

The heroic response of Japanese households and businesses to public calls to voluntarily reduce their electricity usage after the March 11, 2011 disaster showed that DSM resources could contribute effectively to energy management goals in Japan, and that building new power plants (or restarting/updating older ones) was no longer the

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[204] Lovins (1990): https://www.rmi.org/wp-content/uploads/2017/06/RMI_Negawatt_Revolution_1990.pdf and see Bronski, Peter, Mark Dyson, Matt Lehrman, James Mandel, Jesse Morris, Titiaan Palazzi, Sam Ramirez, and Herve Touati (2015). The Economics of Demand Flexibility: How "Flexiwatts" Create Quantifiable Value for Customers and the Grid. CO: Rocky Mountain Institute, August 2015.
[205] Dyson et al (2015): https://www.rmi.org/wp-content/uploads/2017/03/RMI-TheEconomicsofDemandFlexibilityFullReport.pdf.
[206] For more, see http://www.enecho.meti.go.jp/about/special/johoteikyo/vpp.html.

only way to keep up with society's shifting energy needs. In addition to diversifying supply-side resources (e.g. with distributed generation and more renewable energy options), Japan is increasingly seeking to promote investment in various means of adjusting demand itself. However, Japan needs smarter policies to harness the potential of DSM on an ongoing basis, as more than just an emergency resource.

In the United States, widespread DSM programs (both short-term peak demand response as well as long-term improvements in energy efficiency) gained momentum after the energy crisis of the 1970s. Demand response in particular started as an emergency resource, with the spread of interruptible/direct load control (DLC) utility programs. As the value of DSM as an ongoing, flexibly dispatchable grid resource became clear, DSM shifted to wholesale markets. This was enabled by the restructuring of regional wholesale markets and the emergence of capacity markets, as well as Federal Energy Regulatory Commission (FERC) rulings (e.g. the *Energy Policy Act of 2005* and later Orders 719 and 745) that further removed hurdles to the participation of demand-side resources alongside supply-side energy resources in wholesale markets.

DSM in Japan appears to be following a similar path. There is a growing consensus around the idea that DSM could be more than just an emergency resource, one that helps bolster flexibility and resilience year-round. Nevertheless Japanese policymakers' focus so far has been on providing grants and subsidies to promote DSM-enabling technologies, rather than fostering markets where demand-side energy resources can compete effectively with supply-side resources.

In some respects, Japan's focus on technology infrastructure has been remarkably successful. With respect to smart meter deployment, for example, Japan has quickly gone from being a global laggard to a global leader. Moreover, a nation-wide network of smart meters provides unprecedented opportunities for Japanese utilities to engage end-use customers in DSM programs.

However, Japanese utilities' incentives remain essentially unchanged from before 3.11. Energy providers still are invested in selling more kWh than fewer. Especially as constraints on electricity supply have diminished since 3.11, Japanese utilities' incentives are less aligned with those of policymakers who seek to promote DSM both for its individual-level benefits (e.g. reduced energy bills for consumers) and its system-wide benefits (e.g. increased flexibility from shifting energy consumption from peak to non-peak hours).

While the government has liberalized and opened retail sales of electricity to competition,[207] transmission and distribution assets remain the sole property of vertically integrated utilities who have historically used this monopoly to block access to the grid and markets for non-utility-generated resources. METI's planned unbundling of Japanese utilities (separating the regulated transmission and distribution part of the utility business from competitive generation and retail operations) in 2020 may go some way to address this. Moreover, the planned creation of a variety of new markets—including "non-fossil value" markets, ancillary services, and capacity markets, also intended to begin by 2020—may yet provide opportunities for new distributed energy resources, including DSM, to compete. However, starting new markets is no guarantee that they will be open,

[207] This began with high-voltage customers (2000kW and above, high-rise buildings, factories, etc.) in 2000, mid-voltage (50kW ~2000kW, medium-rise buildings, retail/chain stores, etc.) in 2004, and low-voltage (50kW and below, residential, small businesses, etc.) in 2016.

liquid, and competitive. The amount of electricity sold on Japan's wholesale power market, the Japan Electric Power Exchange (JEPX), is still less than 3 percent of the total electricity generated, 15 years after its inception.

Outside of Japan, costs of electricity from low-carbon energy sources are declining faster than expected due to rapid, market-driven technological advances and accelerated economies of scale. By sticking to politically determined rather than market-determined energy targets, Japan risks shackling itself to high-carbon, overly expensive, and ultimately stranded-asset investments that are not in line with global market trends. Japan could save its citizens money, promote domestic energy innovation, and reduce energy imports by adopting a market-based approach to integrating DSM resources alongside supply-side resources.

PART 4:

COOPERATION GOING FORWARD

Chapter Eleven

Japan's Energy and Climate Quadlemma and U.S.-Japan Cooperation

Jun ARIMA
Professor, GrasPP, Tokyo University

Complexity of Climate Change

Global warming is a global negative externality and, therefore, needs to be addressed at the global level. It would be ideal if a global carbon price were set equalizing marginal abatement cost across countries. However, in reality, such a policy is inconceivable politically and economically for the foreseeable future. Therefore, each country needs to address global warming issues based on its national circumstances.

In addition, internalizing climate-related externalities is much more complicated compared to environmental externalities (e.g., air and water pollution) where the calculation of damages is relatively easy and the benefits of mitigation measures are regional. On the other hand, Greenhouse Gas (GHG) emissions derive from almost all economic activities and, *ceteris paribus,* GHG mitigation measures inevitably results in regional economic costs while the benefit of GHG mitigation is spread all over the world. In other words, GHG mitigation costs occur locally, but mitigation benefits are global, which inevitably creates incentives for countries to attempt "free riding." If GHG mitigation measures did not entail any economic cost, global warming issues would not have become as hotly contested and the United Nation's (UN) negotiations would have been much easier.

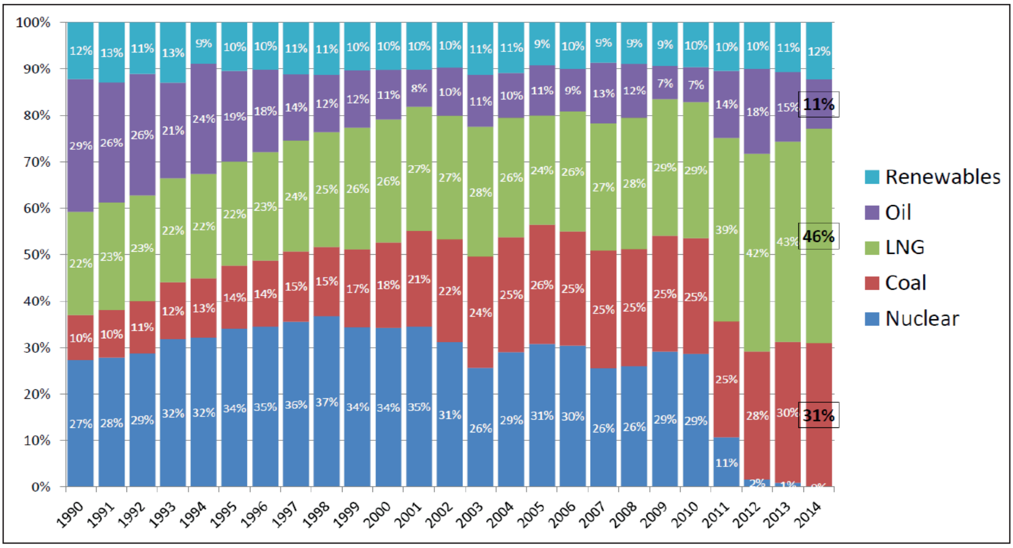
Agreeing on international burden sharing under a structure where free riding has economic rewards is extremely challenging since mitigation costs will affect each country's international competitiveness, employment and economic growth. This is precisely the reason why the UN climate negotiations faced rough going. This basic structure is unchanged even after agreement of the Paris Climate Accord at COP21 in 2015. Ironically, the biggest reason for the success at the COP21 was that the Parties gave up negotiating national targets, leaving them up to each country's bottom-up (local) decision.

Japan's Energy and Climate Quadlemma

In Japan's case, it has traditionally addressed the climate change issue as an integral part of ensuring balance among "3Es," namely, economic growth or economic efficiency, energy security and environmental protection. This balance is particularly challenging for Japan since it does not have domestic fossil resources or international grid/pipeline connections with neighboring countries.

After the Fukushima Daiichi nuclear accident resulting from the Great Eastern Japan Earthquake and Tsunami in 2011, all Japanese nuclear power plants stopped operation. Japan compensated for the loss of nuclear power by increased burning of fossil fuels, namely, LNG and coal. This resulted in a "quadlemma," or a four-fold predicament in Japan.

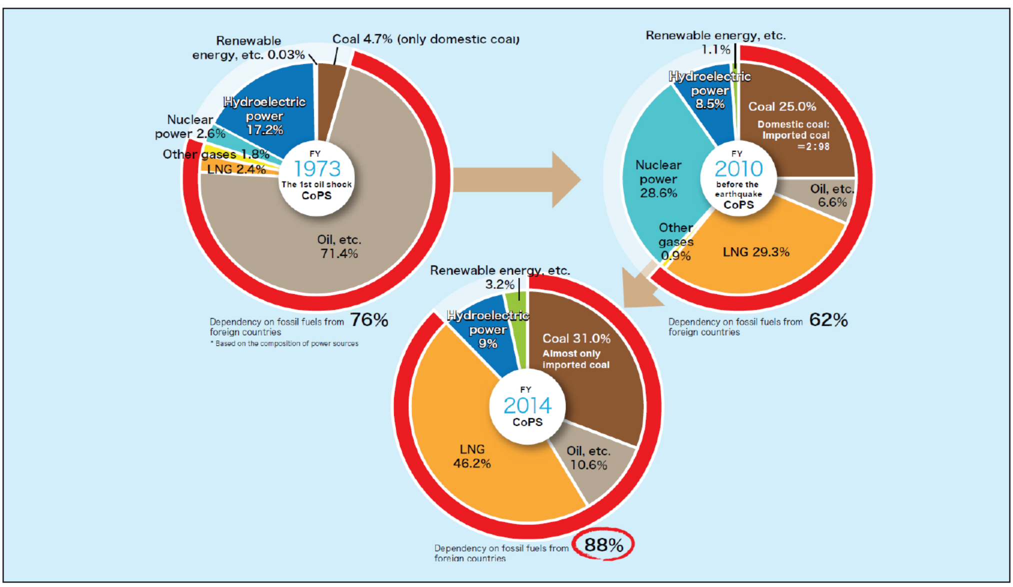
Figure 1: Japan's Power Generation Mix



Source: Japanese Ministry of Economy, Trade and Industry (METI)

First, Japan's dependence on imported fossil fuels had been decreasing steadily from 76 percent in 1973 to 61 percent in 2010 thanks to the constant energy diversification efforts after the first oil crisis. However, due to the stoppage of its nuclear power plants, Japan's dependence became even higher than it was in 1973.

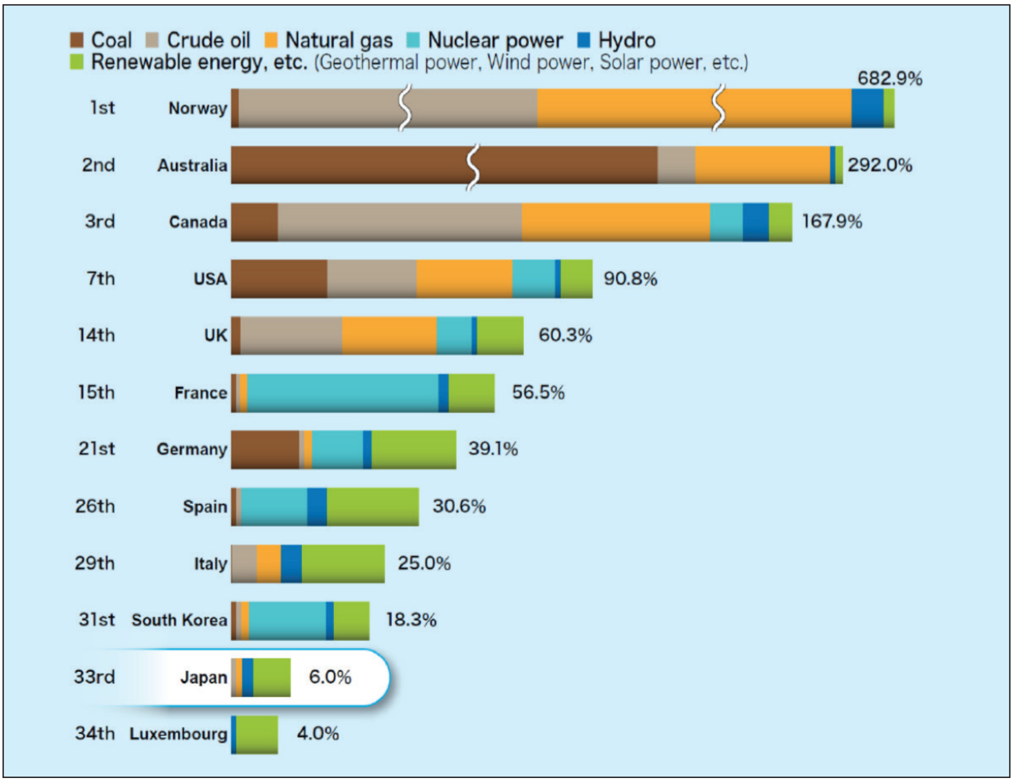
Figure 2: Dependence on Imported Fossil Fuel in Japan's Power Sector



Source: METI

Accordingly, Japan's energy self-sufficiency dropped from 19.9 percent in 2010 to 6.0 percent in 2014, the 2nd lowest level among OECD (Organization for Economic Co-operation and Development) countries.

Figure 3: Energy Self-Sufficiency of OECD Countries



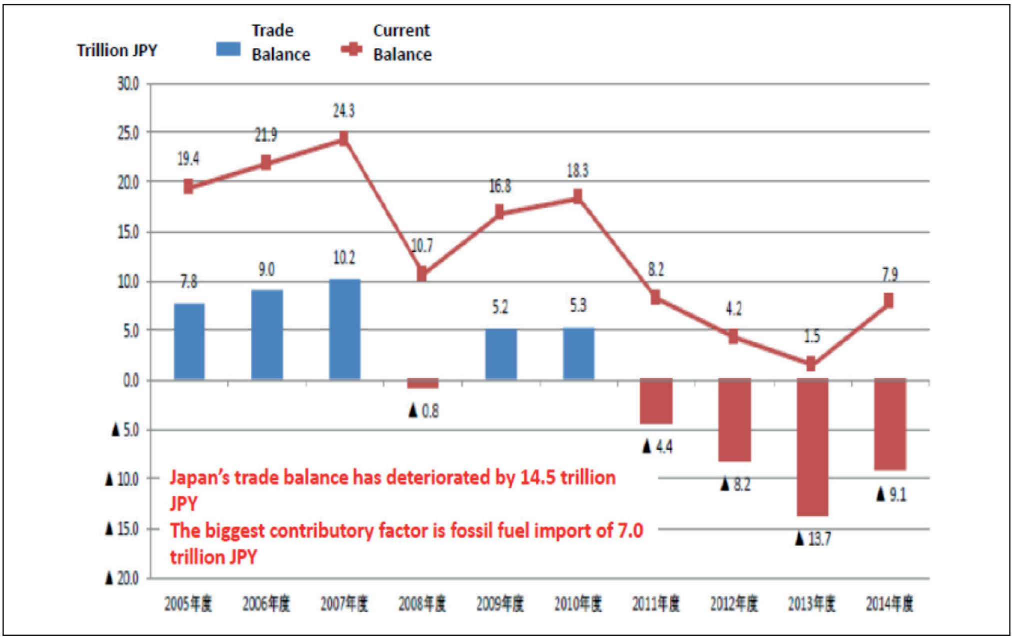
Source: METI

Second, due to increased imports of fossil fuels, Japan's trade balance deteriorated by ¥14.5 trillion between JFY 2010 and JFY 2014, out of which ¥7.0 trillion could be attributed to increased burning of imported fossil fuels compensating for the loss of nuclear.

Third, due to surging fossil fuel imports, yen depreciation and feed-in-tariff (FIT) surcharges, Japanese electricity tariffs (prices) have risen by 25-39 percent since the 2011 Great Eastern Japan Earthquake and Tsunami. These high prices are causing a heavy burden to people's daily lives, industrial activity, international competitiveness and the macro economy.

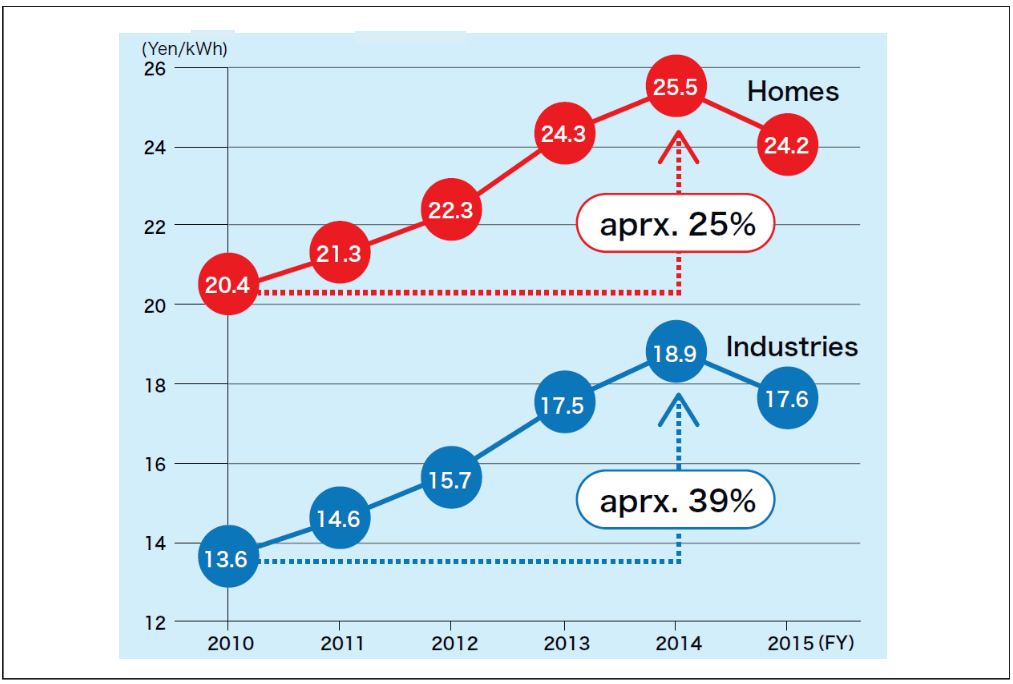
Fourth, Japan's CO2 emissions increased by 6 percent and by 83 million tons from 2010 to 2014. This increase can be attributed entirely to the increased CO2 emissions caused by the increased consumption of fossil fuels as a substitute for nuclear energy in the power sector. These four factors indeed constituted an energy and climate "quadlemma," which no other country has ever experienced. The United States is experiencing the complete opposite in its energy sector: higher exports, higher self-sufficiency, lower electricity tariffs and lower CO2 emissions.

Figure 4: Japan's Trade Balance



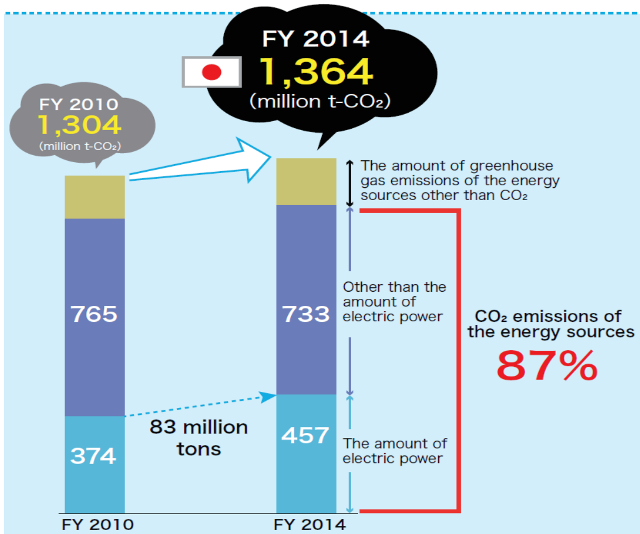
Source: METI

Figure 5: Changes in Electricity Prices



Source: Japan Federation of Electricity Power Companies (FEPC)

Figure 6: Japan's CO2 Emissions



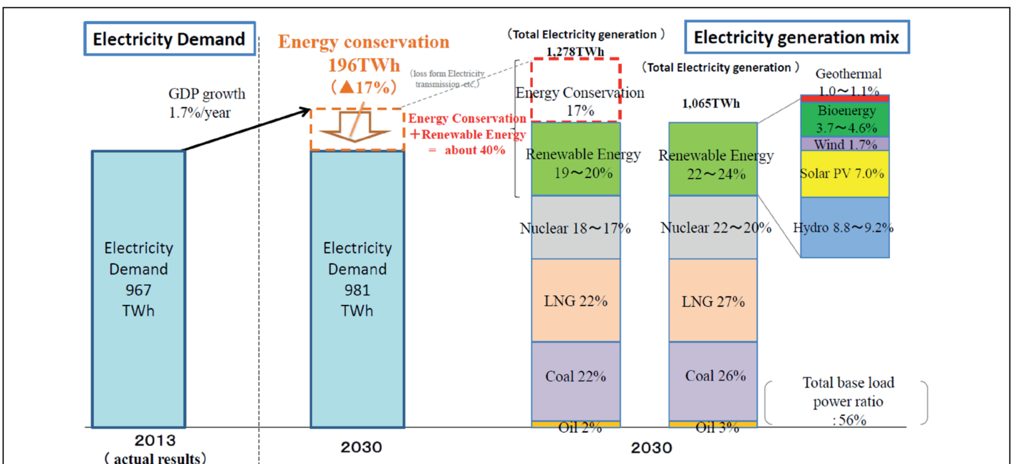
Source: METI

Japan's Intended Nationally Determined Contribution (INDC)

Japan's INDC was underpinned by the assumption of a future energy mix based on three requirements, namely, 1) restoring energy self-sufficiency to around 25 percent surpassing the pre-Earthquake level, 2) lowering the electricity costs below those of today, and 3) setting GHG reduction goal comparable with other developed countries.

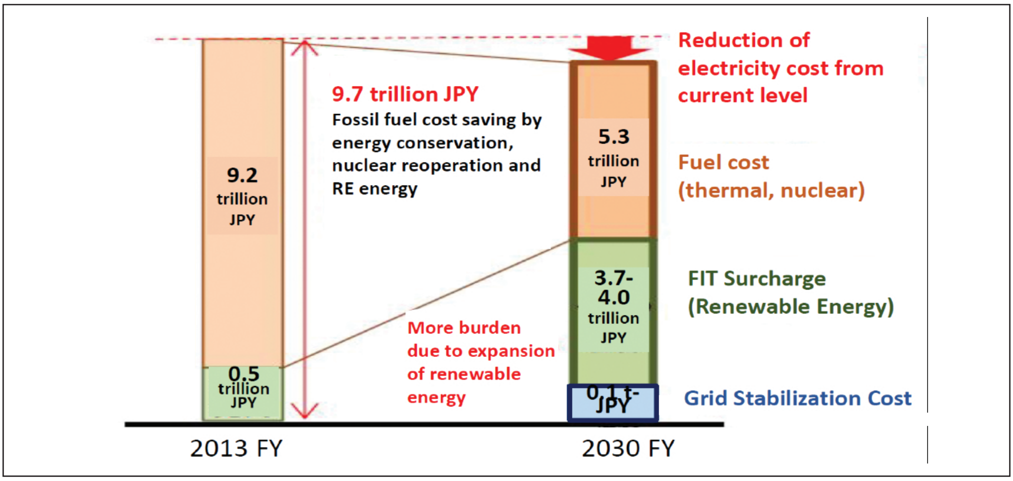
This energy mix aims to absorb the cost increase caused by the expansion of renewable energy (higher costs seem inevitable due to the feed-in tariff system) with the cost savings from reduced fossil fuel imports due to the restart of nuclear power plants as well as reductions due to energy conservation and increased use of renewables.

Figure 7: Japan's New Energy Mix



Source: METI

Figure 8: Forecast of Electricity Cost



Source: METI

In defining the energy mix, METI also conducted a sensitivity analysis to calculate the impact on economic cost and CO2 emissions when one percent of the share allocated to nuclear is substituted by coal, LNG or renewables. For example, if all of the 22-20 percent share for nuclear is substituted by renewables, electricity costs will be ¥4.8-4.3 trillion ($40-36 billion) higher per annum than the forecast for the INDC. As a result, instead of fulfilling the second requirement to reduce costs, such a future would result in even higher electricity costs.

Figure 9: Sensitivity Analysis about the Change of Power Mix

	Coal ▲1%	LNG▲1%	Nuclear ▲1%	RE ▲1%
Coal +1%		+4.4 mt-CO2 ▲64 billion JPY	+8.4 mt-CO2 +34 billion JPY	+8.4 mt-CO2 ▲184 billion JPY
LNG +1%	▲4.4 mt-CO2 +64 billion JPY		+4.0 mt-CO2 +98 billion JPY	+4.0 mt-CO2 ▲120 billion JPY
Nuclear +1%	▲8.4 mt-CO2 +34 billion JPY	▲4.0 mt-CO2 ▲98 billion JPY		±0 ▲218 billion JPY
RE+1%	▲8.4 mt-CO2 +184 billion JPY	▲4.0 mt-CO2 +120 billion JPY	±0 +218 billion JPY	

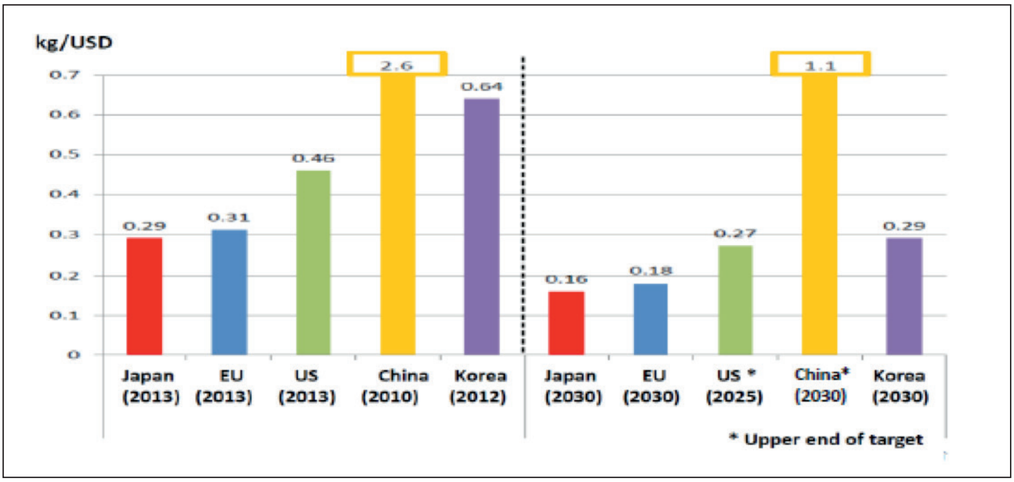
※ All approximate figures

Source: METI

Ambition Level of Japan's INDC

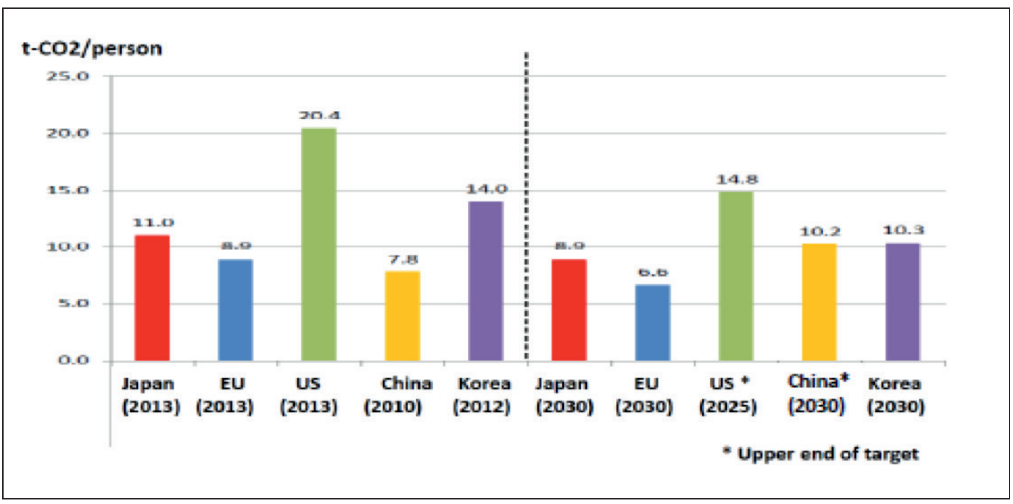
There has been some criticism of Japan's INDC and its underpinning energy mix on the grounds that its percentage figure reduction rate from 1990 or 2005 is lower than those of European Union (EU) and the United States. However, what matters is not a comparison between percentage figures but the comparability of efforts. For example, levels of GHG emissions per GDP or GHG emissions per capita for the present and for 2030 clearly show that Japan's INDC is sufficiently ambitious compared with the EU and the United States. The criticism does not take into account the changes in approach on how best to move forward on climate change that have taken place in the twenty years since the Kyoto Protocol.

Figure 10: GHG Intensity of Major Countries (Present and 2030)



Source: METI based on IEA and UN Statistics

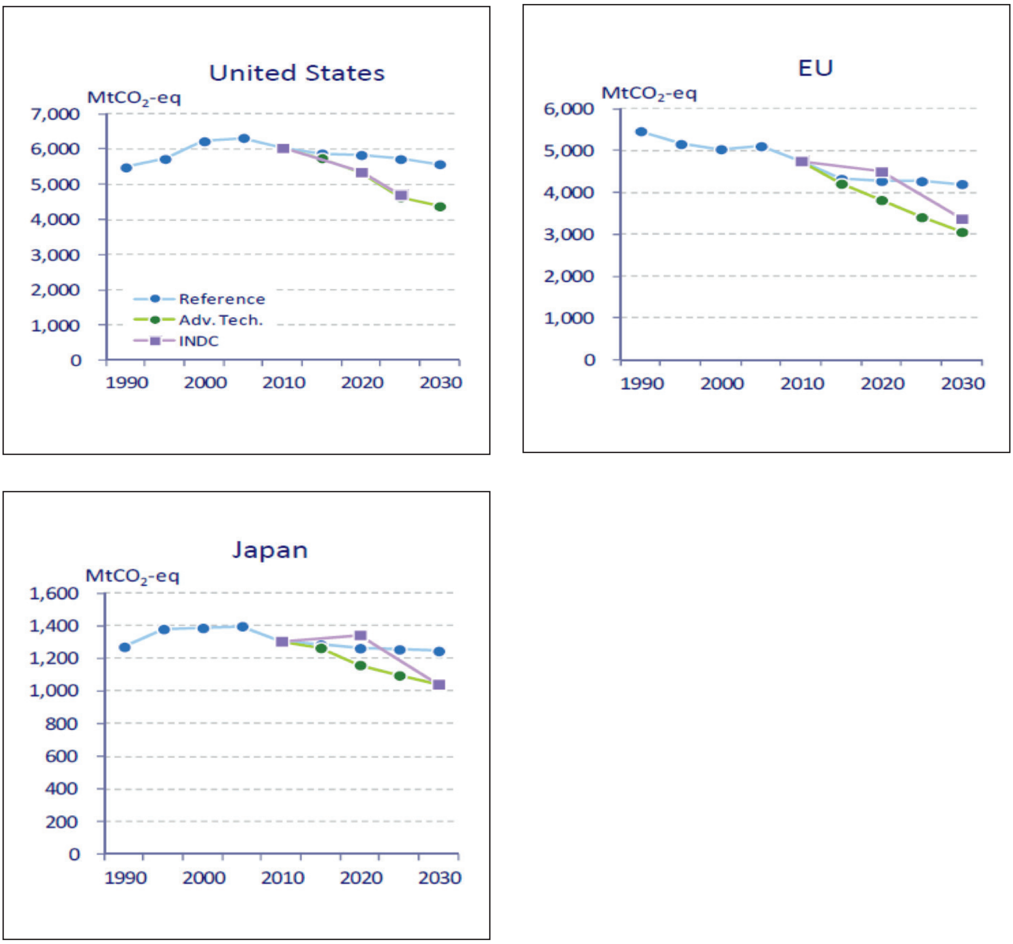
Figure 11: GHG per Capita of Major Countries (Present and 2030)



Source: METI based on IEA and UN Statistics
Note: The above data is a rough best guess estimate due to the different underlying assumptions (e.g. for GDP growth) across countries and lack of published data (especially for China).

The Asia/World Energy Outlook 2015 by the Institute of Energy Economics, Japan (IEEJ) (Figure 12) shows that Japan's INDC is as ambitious as the ATS (Advanced Technology Scenario), which assumes maximum introduction of energy efficiency and low carbon technologies.[208]

Figure 12: Comparison of INDC, Reference Case and Advanced Technology Scenario

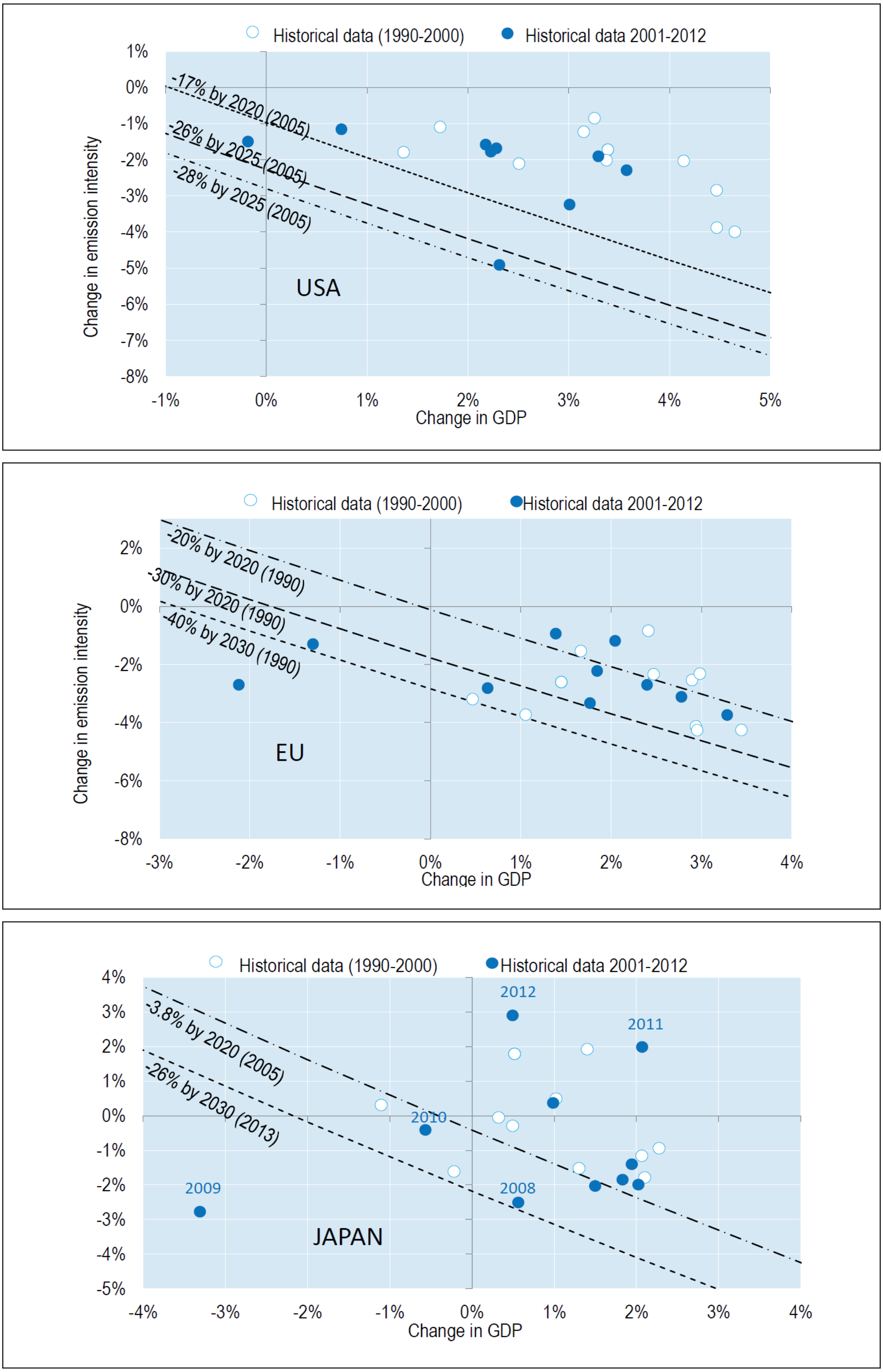


Source: Institute of Energy Economics of Japan

Recent OECD analysis[209] shows that the targets of the United States, EU and Japan all require large deviations from their historical trends of correlation between GDP growth and emissions intensity improvement. Among them, it is clear that Japan needs to achieve a particularly large shift from its 2011 and 2012 performance to put itself on track for the 26 percent target.

[208] Japan's 2020 target does not count nuclear.
[209] See https://www1.oecd.org/publications/climate-change-mitigation-9789264238787-en.htm.

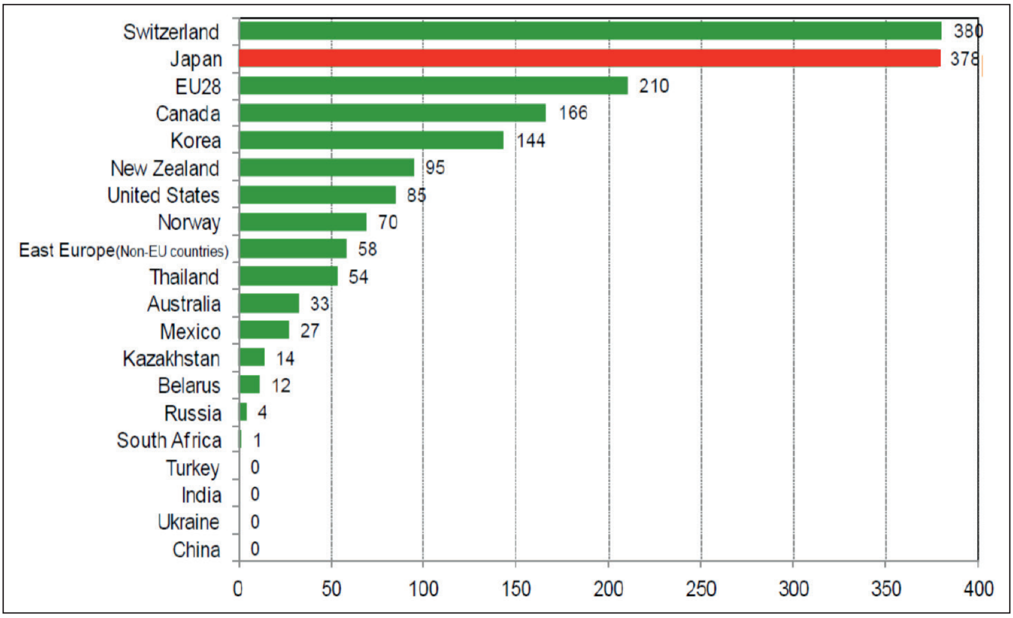
Figure 13: Emission Intensity and GDP Scatter Plots of U.S., EU and Japan



Source: Organization for Economic Co-operation and Development (OECD) "Climate Change Mitigation – Policies and Progress" (October 2015).

Furthermore, according to the Research Institute of Innovative Technology for the Earth's (RITE) model analysis,[210] Japan's marginal abatement cost (MAC) is higher than those of the United States and the EU. In fact, the Government of Japan could have conducted a more detailed cost analysis in defining its energy mix. Its MAC seems to have been dominated by a pre-determined conclusion that Japan's INDC must be "20 percent plus" with a view to presenting comparability with the EU and the United States, which could be called a "Kyoto era obsession."

Figure 14: Comparison of Marginal Abatement Cost Curves of Major Countries (2030)



Source: Research Institute of Innovative Technology for the Earth (RITE)

It should be borne in mind that the MAC analysis by RITE assumes the steady restart of nuclear power plants, of which the marginal cost is very low due to the depreciation to date. The higher level of MAC compared to those of the EU and the United States mainly derives from the extremely ambitious energy efficiency target. If the restart of nuclear plants does not proceed as expected and the efficiency and renewable energy targets are further "enhanced," the MAC will skyrocket and potentially have a devastating impact on the Japanese economy.

Risk Scenarios related to 26 Percent Target

As is obvious from the above, the steady reoperation of nuclear power plants is the prerequisite for simultaneously achieving GHG emissions reductions, energy security and cost reductions.

However, it is still highly uncertain whether a 20-22 percent share of nuclear can be achieved in 2030. In the opinion polls, there is still a strong "nuclear-phobia." Lacking a

[210] See http://www.rite.or.jp/Japanese/labo/sysken/about-global-warming/download-data/EEnergymix_IN-DCs_20150818.pdf.

comprehensive perspective on energy security and climate change mitigation, the public tends to consider that there is no need for nuclear so long as there are no blackouts and no rapid upsurge in electricity tariffs. Stagnant oil and natural gas prices in recent years have further reduced the sense of urgency.

Since nuclear power is still politically controversial, the ruling Parties tend avert and postpone difficult debates on nuclear such as the replacement of existing nuclear power plants after their operational lifetime. However, Japan needs to discuss the nuclear question seriously if it is really committed to long-term GHG mitigation.

The regulatory environment is also far from ideal. The Nuclear Regulatory Authority (NRA) tends to react excessively to "zero-risk" demand, which is scientifically and technically impossible. The NRA tends to avoid even close communication with power industry based on its erroneous interpretation of "neutrality." This is a deviation from a regulator's original mission, namely, ensuring safe operation of nuclear power plants. In addition, due to insufficient staffing, there is still a long queue for safety checks, which is further delaying reoperation.

Lawsuit risk is still rampant. While it is encouraging the Osaka High Court overturned an injunction issued against the restart of Kansai Electric Power Co.'s No. 3 and No. 4 reactors at its Takahama facility in Fukui Prefecture, the recent ruling of the Hiroshima High Court ordering the suspension of a nuclear reactor at Shikoku Electric Power Co.'s Ikata power plant in Ehime Prefecture is a serious blow to the government and utilities that are aiming to bring more reactors back online.

Furthermore, on-going electricity market liberalization is making the business environment for nuclear more unpredictable. In particular, replacement of existing nuclear power plants and new construction would be extremely challenging due to the high upfront cost, a difficult financing environment, and regulatory and political uncertainties.

Under such a situation, the possibility of reaching the 26 percent target is also uncertain as it depends on the prospects for nuclear restart. There are four possible scenarios going forward.

Scenario 1: The proposed energy mix could be achieved as planned by the steady reoperation of nuclear power plants and the extension of their lifetimes. While this is the ideal situation, the big "if" is whether nuclear power restarts can occur as envisioned.

Scenario 2: Due to slow progress in safety checks by the NRA and roadblocks by the anti-nuclear movement, nuclear restarts do not occur as expected. In order to ensure security of electricity supply, fossil fuels, renewables and energy efficiency will fill the gap while minimizing the upward impact of electricity tariffs. This could make it difficult to achieve the 26 percent target.

Scenario 3: Despite slow progress in nuclear restarts (like Scenario 2), the gap in achieving the 26 percent target would be filled by just renewables and energy efficiency. In this case, electricity tariffs could soar, damaging international competitiveness and the economy.

Scenario 4: While sticking to the 26 percent target, this scenario assumes emissions credits purchased from overseas. Its cost is lower than Scenario 3, but it will cause the outflow of national wealth for purchasing fossil fuel and "air," repeating the 1st Kyoto period when Japan spent ¥600-800 billion purchasing Kyoto credits.

These scenarios pose significant challenges as Japan considers its future INDCs. In particular, the Trump Administration's announcement to terminate implementation of the U.S. INDC (26-28 percent reduction from 2005 by 2025) completely changes the underlying assumption used by Japan when it defined its 26 percent target.

Figure 15: World Trading Matrix (2015)

63% of EU export goes to the EU region. 65% of EU import comes from EU region

71% of Japan's import comes from APEC region

77% of Japan's export goes to APEC region

Million USD

Export to: / Export from:	World	NAFTA	U.S.	EU28	Japan	East Asia	RCEP	China	ASEAN	APEC
World	16,481,400	2,925,152	2,137,300	5,246,380	591,763	3,22[illegible],287	4,212,387	1,420,900	1,173,301	7,859,419
NAFTA	2,293,607	1,154,041	621,967	321,633	73,111	2[illegible]3,239	399,267	136,870	81,447	1,629,5[illegible]6
U.S.	1,504,570	516,394	-	274,073	62,472	258,492	347,436	116,186	75,077	934,[illegible]53
EU28	5,387,170	487,788	411,23[illegible]	3,395,830	62,707	355,015	479,804	189,300	92,137	1,079,[illegible]68
Japan	624,801	144,585	126,372	66,011	-	283,043	271,316	109,216	95,010	483,856
East Asia	4,276,798	753,037	647,370	555,945	279,327	1,295,351	1,715,374	368,789	689,621	2,939,457
RCEP	5,127,018	921,858	795,440	657,036	299,194	1,602,288	2,040,491	487,349	785,440	3,488,294
China	2,280,540	474,000	410,783	356,595	135,89[illegible]	420,045	619,786	-	278,900	1,448,987
ASEAN	1,199,820	156,695	134,535	128,673	100,9[illegible]8	518,804	677,627	160,578	286,188	882,715
APEC	8,216,946	2,133,457	1,464,151	1,167,623	418,564	2,280,298	2,896,555	916,629	923,017	5,639,264

Source: JETRO World Trade and Investment Report 2016

As presented above, 71 percent of Japan's imports come from the APEC region (including the United States) while 77 percent of Japan's exports go to the APEC region. This means policy developments in the APEC region will have significant implications for Japan's relative international competitiveness. Accordingly, in considering Japan's future course of action in response to the slow restarting of nuclear power plants, such elements as the crucial status of the United States as Japan's trading partner, its pursuit of further lower energy costs putting its national interest first, and the implication of that on Japan's economy and international competitiveness needs to be carefully taken into account.

Long-term Goal and Its Implication

The Plan for Global Warming Countermeasures (13 May 2016) defines not only the mid-term 2030 target but also a long-term goal for 2050:

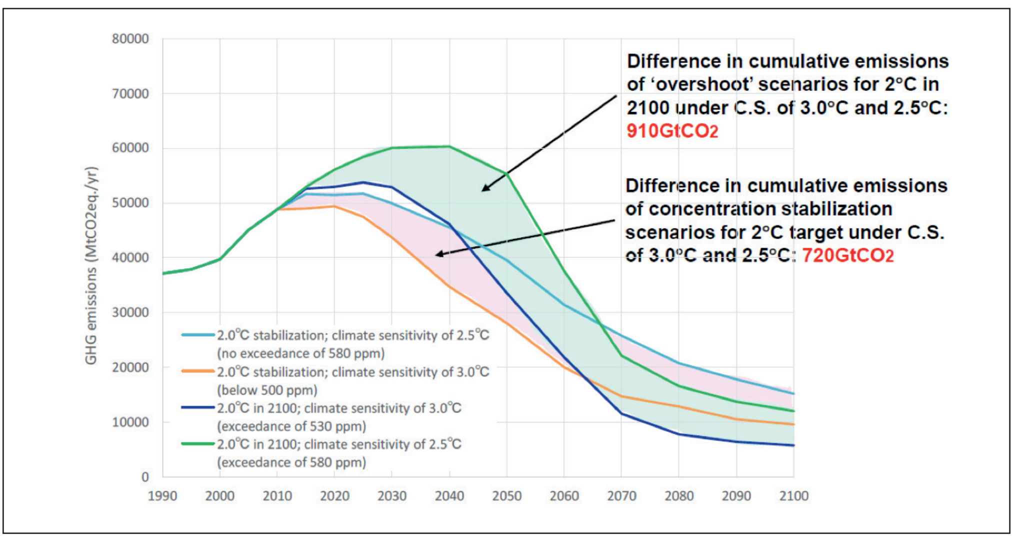
> "Based on the Paris Agreement, under a fair and effective international framework applicable to all major Parties, Japan leads the international community so that major emitters undertake emission reduction in accordance with their capacities, and, aims to reduce greenhouse gas emissions by 80% by 2050 as its long-term goal, while pursuing the global warming countermeasures and the economic growth at the same time. Such a deep cut in emissions is difficult to achieve through the

> extension of existing measures so far. Therefore, Japan pursues solution through innovation such as development and deployment of innovative technologies which enables drastic emission reductions, and, while promoting domestic investment, enhancing the international competitiveness, and asking citizens for their opinion, aims to achieve a deep cut in emissions through long-term, strategic actions, and contributes to global GHG emission reductions."

However, the author has many reservations about 80 percent goal. The figure "80%" originates from the developed countries' proposal in the UN climate negotiation in 2009 to reduce global GHG emissions by 50 percent by 2050 while developed countries take the lead by reducing their emissions by 80 percent. In other words, a 50 percent reduction of global GHG emissions by 2050 and 80 percent reduction in developed countries formed a package. However, the developing countries have never accepted this proposal. While developed countries proposed a 40-70 percent reduction of global GHG emissions by 2050 together with the temperature target of 1.5-2.0 degrees at the time of COP21, it did not fly. So long as there is no consensus on a global GHG emissions reduction goal, this package deal should be regarded as invalid.

Furthermore, while the proposed global GHG emissions reduction goal of 50 percent or 40-70 percent derives from a specific level of climate sensitivity (3.0 degrees), there is a range of views about climate sensitivity that run from 1.5 to 4.5 degrees without any consensus on which is correct. With a difference of only 0.5 degrees, the shape of global GHG emissions for achieving 2.0 degrees target greatly changes,[211] putting the rational for "50% globally and 80% for developed countries" into question.

Figure 16: GHG Emissions Paths to 2100 for 2°C Target with Climate Sensitivity of 3.0 and 2.5°C



Source: RITE

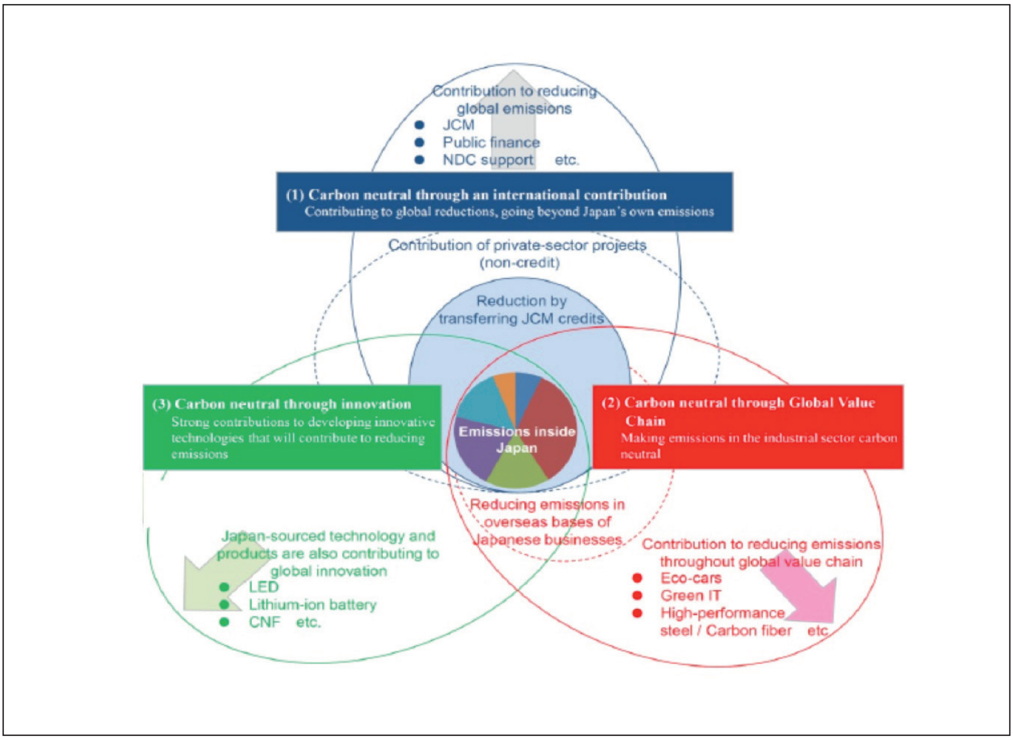
[211] See http://www.rite.or.jp/system/latestanalysis/pdf/E-Climatesensitivity_2degrees_INDCs.pdf.

In addition, U.S. withdrawal from the Paris Agreement means that the preconditions of the long-term goal, namely, "a fair and effective international framework applicable to all major Parties" and "major emitters' undertaking emission reductions in accordance with their capacities" are not fulfilled.

Japan's Contribution to Global GHG Emissions Reductions

More fundamentally, the author seriously doubts the current UN approach that just focuses on production level GHG emissions reductions in each country will work. As suggested in the Long-Term Climate Change Policy Platform,[212] Japan rather should implement the "three arrows" game changers as countermeasures against global warming: (1) international contribution through dissemination of Japan's efficient and environmentally friendly technologies to developing countries; (2) global value chain-based reductions by industries and companies through such technologies as Green IT and high-performance steel with a view to reducing GHG emissions at utilization stage; and (3) development of innovative technologies.

Figure 17: Three Arrows Beyond National Border



Source: METI Long-Term Climate Change Policy Platform

[212] See http://www.meti.go.jp/english/press/2017/pdf/0414_001a.pdf.

Based on these three-arrows, the government, industries and companies should all proactively engage in efforts to reduce carbon emissions by an amount greater than that emitted by themselves, i.e., eventually carbon neutralizing Japan as a whole while assisting emission-reduction efforts by other countries.

U.S.-Japan Cooperation

On 1 June 2017, President Trump announced his intention to withdraw from the Paris Agreement. It is regrettable that the United States turns its back on the Agreement given its decisive role in ironing out this historic document. If there are serious concerns about the previous administration's announced INDC's negative impact on U.S. business and people's lives, the INDC could be revised downward, which is not legally prohibited under the Paris Agreement.

Having said that, the author is convinced that the United States and Japan as the closest of allies can do a lot together to combat climate change. On 4 August 2017, the U.S. Department of State issued a media note on the U.S. communication to the UN regarding its intention to withdraw from the Paris Agreement.[213] While many had anticipated the decision announced in the media note, it is encouraging that the United States will continue to participate in international climate change negotiations including ongoing ones related to guidance for implementing the Paris Agreement and COP23 to protect U.S. interests and ensure all future policy options remain open. Such participation will include ongoing negotiations related to guidance for implementing the Paris Agreement. The effectiveness of the Paris Agreement highly depends on to what extent we can overcome the dichotomous structure enshrined in the framework to date. It is true that both developed and developing countries will participate in a common transparency framework under the Paris Agreement, but some developing countries are still insisting on institutionally differentiated treatment between developed and developing countries based on "common but differentiated responsibilities." Differentiated treatment would substantially water down the spirit of the Paris Agreement. The United States and Japan have always been strong advocates of a "common framework" and should continue to work together. An effectively differentiated framework would make it more difficult for the United States to reconsider its position on withdrawing from the Paris Agreement.

Outside the UN arena, there are even greater opportunities for bilateral cooperation whatever the U.S. course of action on the Paris Agreement. The immediate candidate is natural gas trade. U.S. liquefied natural gas (LNG) will certainly diversify Japan's gas procurement, could reduce Japan's energy costs, and have a positive impact by increasing flexibilities in the LNG trade not only for Japan but also for all of East Asia.

It is very encouraging that the U.S. Department of State media note mentioned above clearly confirms the United States' strong support of "a balanced approach to climate policy that lowers emissions while promoting economic growth and ensuring energy security." It also encouragingly states the United States' intention to "continue to reduce (our) greenhouse gas emissions through innovation and technology breakthroughs, and work with other countries to help them access and use fossil fuels more cleanly and efficiently and deploy renewable and other clean energy sources, given the importance

[213] See https://www.state.gov/r/pa/prs/ps/2017/08/273050.htm

of energy access and security in many nationally determined contributions." These approaches are identical to Japan's approaches on climate change delineated above in this chapter despite Japan's and the United States' different positions on the Paris Agreement. These approaches provide ample opportunities for bilateral cooperation.

The ultimate solution to climate change challenges requires disruptive innovation. As the leading countries on innovation in the field of energy and environment technologies, the United States and Japan should expand existing and explore additional possible areas for technology collaboration. Developing technologies allowing clean use of fossil fuels including carbon capture and sequestration (CCS) is an obvious choice since the world, in particular, developing countries, still will use fossil fuels to support their economic growth. Both countries should also consider collaborative demonstration projects (e.g. CCS, distributed energy) in third countries. Enabling the clean use of fossil fuels through innovation also would be beneficial for the United States' goal of "energy dominance" through export of its ample energy resources and related technologies. From this perspective, the author strongly expects that the U.S. energy RD&D budget will not suffer as deep a cut as first proposed by the current administration. It is encouraging that Congressional discussion appears to support reversing the proposed RD&D budget cut for the sake of the future competitiveness of the U.S. economy.

Another area for possible cooperation is nuclear energy since both the United States and Japan are determined to utilize nuclear as part of their road plans for energy security and climate change. They could exchange their views and experiences as to how to ensure competitiveness of existing nuclear power plants and enable new investment in Japan's liberalized electricity market. They could also cooperate in developing safer and more advanced nuclear power technologies.

Conclusion

Climate change is a daunting challenge for the entire world. Its unique characteristic, namely, "mitigation benefit is global, but mitigation cost is local" makes global action quite challenging and complicated. Japan is experiencing a unique "quadlemma" in terms of energy security, energy cost and climate mitigation due to its almost entire loss of nuclear power. 3E + S (safety) is the crucial guiding principle governing Japan's course of action. While Japan and the United States differ in their positions on the Paris Agreement, there are many commonalities in their approaches on climate change, namely, strong emphasis on a balanced approach among economic growth, energy security and climate change mitigation, high priority on technology and innovation, and intention to spread clean environmental technologies to developing countries. This indeed warrants a closer examination of, and embarking on, these ample opportunities for U.S.-Japan cooperation.

Chapter Twelve

U.S.-Japan Energy Trade and Investment

Tom CUTLER
President, Cutler International LLC

Common Cause

The story of energy trade and investment between Japan and the United States is a classic case of how two allies can find common cause and collaborate on energy security and commerce despite the fact that they face significantly different energy trade and investment scenarios. In spite of some challenges, going forward there will be expanded opportunities for U.S.-Japan energy trade and investment as well as for collaboration on energy in the global arena.

Foreign trade and investment is essential to Japan. Japan faces daunting energy supply challenges due to its dependence upon imports for over 90 percent of its overall energy requirements. The sheer magnitude of its requirements as the world's largest importer of liquefied natural gas (LNG), 3rd largest coal importer, and 3rd largest net oil importer, all of which is delivered by ship with LNG and oil coming mostly from the Middle East, is daunting.[214] By comparison, the United States has a deep base of indigenous energy resources that is enabling it to become increasingly self-sufficient in energy. It also enjoys secure cross-border energy trade and investment linkages, and substantial over-land energy infrastructure with neighbors Canada and Mexico. Accordingly, investment in energy supply in the United States dwarfs that of Japan by a factor of almost eight to one. In 2016, there was some $227 billion invested in U.S. energy supply while the figure for energy supply investment in Japan was only $36 billion.[215]

By virtue of their strategic relationship, the two allies have been able to navigate the conundrums of meeting major energy import challenges and alleviating frustrating non-energy trade imbalances. This relationship provides the basis for the premise that Japan's import dependence and the emerging growth in U.S. exports of fossil fuels, notably oil and gas, has the potential to take the U.S.-Japan economic partnership to a new level in terms of trade, investment and strategic solidarity.

Close Partners in Commercial Trade and Investment

The United States and Japan are the first and third largest economies in the world, respectively. Accounting for about 30 percent of global GNP, they are major drivers of the world economy, generating 29 percent of global outward foreign direct investment

[214] See U.S. Energy Information Administration (EIA). *Country Analysis of Japan*, updated February 2, 2017, https://www.eia.gov/beta/international/analysis.cfm?iso=JPN.
[215] See International Energy Agency (IEA). "Energy Investment by Fuel and Region," Table 1.1, in "World Energy Investment 2017."

(FDI) stock, 21 percent of inward FDI stock, and 16 percent of world trade.[216] The two nations also are major partners in trade, investment and commerce.

The United States is Japan's largest investment partner by several measurements. It is the largest foreign investor in Japan, accounting for 30 percent of inward direct investment equivalent to $52 billion in 2015.[217] The United States is also the largest destination of overseas Japanese FDI, accounting for 34 percent of outward direct investment equivalent to $413 billion. From the perspective of cumulative foreign investment into the United States, Japan ranks second behind only the United Kingdom holding $373 billion of FDI assets through 2014, equivalent to a 13 percent share overall.

Japan was the largest investor into the United States between 2012 and 2014 before dropping slightly in 2015 to $30 billion.[218] This compares to the $280 billion invested in the U.S. energy sector overall.[219] In the same year, 2015, Japanese investment also reportedly created new 5,029 jobs in the United States, second only to Germany at 6,646 jobs.[220] (Exports to Japan support more than 710,000 U.S. jobs while Japan's foreign direct investment in the United States accounts for an estimated 719,000 jobs.)[221]

The United States and Japan also are major trading partners. Japan is the United States' fourth largest trading partner, just ahead of Germany and trailing only China, Canada and Mexico. In 2016, Japan accounted for 6.0 percent of U.S. imports, 4.3 percent of U.S. exports, and 5.4 percent of total U.S. foreign trade.[222]

Meanwhile, the United States was the top export destination for Japan with a 20 percent share, followed by China and Korea. The United States was the source of 10

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[216] East-West Center and Sasakawa Peace Foundation. "Japan Matters for America Matters for Japan," http://www.asiamattersforamerica.org/sites/default/files/pdfs/Japan%20Matters%20for%20America%202015.pdf. Also, see "Trade with Japan is Hugely Beneficial to the U.S. and Pennsylvania," by Dr. Satu Limaye and Admiral Dennis Blair, Philadelphia Inquirer, October 20, 2016, https://spfusa.org/research/trade-japan-hugely-beneficial-u-s-pennsylvania/.

[217] "The discrepancy between Japan's accounting of U.S. foreign direct investment (FDI) into Japan, and U.S. accounting of that FDI is attributed to methodological differences, especially with regard to indirect investors, profits generated from reinvested earnings, and differing standards for which companies must report FDI." In any scenario, the United States also dominates in terms of Japanese portfolio investment, including debt and equity securities. See U.S. Department of State. "Investment Climate Statement for 2017 – Japan," https://www.state.gov/e/eb/rls/othr/ics/investmentclimatestatements/index.htm#wrapper. For example, in 2015, the United States accounted for 36 percent of all FDI into Japan at $810 billion, with the next biggest share going to Singapore at 13 percent. Also see "Japan: Foreign Investment, Santander Trade Portal," https://en.portal.santandertrade.com/establish overseas/japan/foreign-investment.

[218] See U.S. Department of Commerce, International Trade Administration. "Japan - Market Overview," Japan Country Commercial Guide, February 22, 2017, https://www.export.gov/apex/article2?id=Japan-Market-Overview. Please note that another source has Japan ranked fifth in 2015 in terms of "announced" investment into the United States at $2.8 billion. The difference is probably definitional. (See Ernst & Young. "2016 U.S. Investment Monitor," at http://www.ey.com/Publication/vwLUAssets/ey-2016-us-investment-monitor/$FILE/ey-2016-us-investment-monitor.pdf.

[219] See SELECT USA, International Trade Administration, U.S. Department of Commerce. "Energy Industry Spotlight: The Energy Industry of the United States," https://www.selectusa.gov/energy-industry-united-states.

[220] See Ernst & Young. "2016 U.S. Investment Monitor," at http://www.ey.com/Publication/vwLUAssets/ey-2016-us-investment-monitor/$FILE/ey-2016-us-investment-monitor.pdf. Also, see "Foreign Direct Investment in the United States 2016 Report," http://ofii.org/sites/default/files/Foreign%20Direct%20Investment%20in%20the%20United%20States%202016%20Report.pdf.

[221] See "Trade with Japan is Hugely Beneficial to the U.S. and Pennsylvania," by Dr. Satu Limaye and Adm. Dennis Blair, Philadelphia Inquirer, October 20, 2016, reproduced by the Sasakawa Peace Foundation USA, https://spfusa.org/research/trade-japan-hugely-beneficial-u-s-pennsylvania.

[222] Data is from the U.S. Census Bureau, at https://www.census.gov/foreign-trade/statistics/highlights/top/top1612yr.html. Please note year-to-date totals are available at https://www.census.gov/foreign-trade/statistics/highlights/top/top1612yr.html.

percent of Japan's imports.[223] In terms of exports to Japan, the United States at $64 billion was second to China's $152 billion and followed by Australia at $31 billion.

In 2016, the second largest U.S. trade deficit after China was with Japan, estimated to be $68.9 billion. This amount is considerably less than the deficit with China at $347 billion and just ahead of the U.S. trade deficit with Germany at $64.9 billion. The overall U.S. trade deficit in 2016 was $734 billion while, according to the U.S. Census Bureau, Japan had an overall trade surplus of $82 billion.[224]

The value of U.S. energy exports to Japan, $4.3 billion in 2016, accounted for almost 7 percent of overall U.S.-Japan trade. About half of the trade in terms of value falls under categories of "nuclear fuel," "oil field equipment," "electric power generators and equipment," and "mining & excavating machinery" as shown in Figure 1. Three fossil fuels (oil, coal and gas) account for the other half.

Figure 1: Composition of U.S. Energy Related Exports to Japan
(million dollars)

Item	2014		2015		2016	
	Amt.	% Share	Amt.	% Share	Amt.	% Share
Coal (mostly metallurgical)	558	1	470	1	488	1
Oil	2,185	3	1,477	2	2,082	3
Natural Gas	217	nil	103	nil	73	nil
Nuclear Fuel	51	nil	33	nil	37	nil
Electric power generators & equipment	1,427	2	1,980	3	1,511	2
Oil field equipment	15	nil	13	nil	16	nil
Mining & excavating machinery	136	nil	123	nil	84	nil
Sub-total of Energy Trade	4619	7	4199	7	4291	7
Sub-total of Non-energy Trade	62,257	93	58,244	93	58,973	93
Total U.S. Exports to Japan	66,876	100	62,443	100	63,264	100

Source: Calculated from U.S. Census Bureau statistics at https://www.census.gov/foreign-trade/statistics/product/enduse/exports/c5880.html. Definitions: Coal includes metallurgical (met) coal, steam coal and other fuels. Coal trade is mostly met coal. Oil includes crude, fuel oil, other petroleum products and natural gas liquids (NGL).

[223] Ibid., see SELECT USA, International Trade Administration, U.S. Department of Commerce. "Energy Industry Spotlight: The Energy Industry of the United States," https://www.selectusa.gov/energy-industry-united-states. Also, see Ernst & Young. "2016 U.S. Investment Monitor," http://www.ey.com/Publication/vwLUAssets/ey-2016-us-investment-monitor/$FILE/ey-2016-us-investment-monitor.pdf.

[224] Op Cit, the data is from the U.S. Census Bureau for which the link is https://www.census.gov/foreign-trade/statistics/highlights/top/top1612yr.html. Please note year-to-date totals are available at https://www.census.gov/foreign-trade/statistics/highlights/top/top1612yr.html.

About one percent of U.S. imports from Japan, $705 million, were energy-related according to the U.S. Census Bureau, as shown in Figure 2.[225] Meanwhile, Japan's top export to the United States is automobiles valued at $94 billion.[226]

Figure 2: U.S. Energy Related Imports from Japan
(millions of dollars)

Item	2014		2015		2016	
	Amt.	% Share	Amt.	% Share	Amt.	% Share
Coal	1	nil	1	nil	1	nil
Oil (almost all product)	998	1	947	1	703	1
Nuclear fuel materials	17	nil	1	nil	1	nil
Sub-total of Energy Trade	1016	1	949	1	703	1
Sub-total of Non-energy Trade	133,488	99	130,415	99	131,498	99
Total U.S. Imports from Japan	134, 504	100	131,364	100	132,201	100

Source: Census Bureau, https://www.census.gov/foreign-trade/statistics/product/enduse/imports/c5880.html. Definitions: Coal includes related fuels. Oil includes crude, fuel oil, other petroleum products and natural gas liquids (NGL).

Energy accounts for a 20 percent share of Japan's overall imports. In 2015, Japan imported $151 billion in mineral fuels, $99 billion in electrical machinery (including $9 million in power generating machines), as well as $64 billion in chemicals.[227] Petroleum and natural gas specifically accounted for the largest share of overall Japanese imports, valued at $47.3 billion and $40.5 billion, respectively. Price decreases in these commodities provided great savings compared to earlier years. Similarly, the roughly $15 billion in coal imports in 2016 was down 31 percent from the prior year.[228]

In sum, although Japan is not a currently a major market for U.S. oil, gas and coal, and the United States is not yet a major energy supplier for Japan, the energy trade relationship has great strategic significance. Japanese companies are increasing their investments in the United States to expand U.S. capacity to be a reliable source of the fossil fuels oil, gas and coal as part of Japan's energy security to diversify its sources of supply. By comparison, opportunities for U.S. firms in Japan's domestic energy sector

[225] Calculated from statistics from the Census Bureau. The link is https://www.census.gov/foreign-trade/statistics/product/enduse/exports/c5880.html.
[226] See Ernst & Young. "2016 U.S. Investment Monitor." The link is http://www.ey.com/Publication/vwLUAssets/ey-2016-us-investment-monitor/$FILE/ey-2016-us-investment-monitor.pdf. Also, see Op Cit., MIT Media Lab OEC, Japan, http://atlas.media.mit.edu/en/profile/country/jpn/.
[227] See U.S. Department of Commerce, International Trade Administration. "Japan - Market Opportunities," Japan Country Commercial Guide, February 22, 2017. The link is https://www.export.gov/apex/article2?id=Japan-Market-Opportunities.
[228] See by Daniel Workman. "Japan's top 10 imports," February 8, 2017. The link is http://www.worldstopexports.com/japans-top-10-imports/.

are relatively limited by comparison and mostly in the power, energy efficiency and renewable sectors.[229]

Conundrums of Energy Security, Trade and Investment

The energy supply gap caused by the Great Eastern Japan Earthquake and Tsunami on March 11, 2011 greatly exacerbated Japan's reliance upon imported fossil fuels. According to the U.S. Energy Information Administration (EIA), Japan's trade balance flipped from having enjoyed a trade surplus for thirty years that topped $65 billion in 2010 to a trade deficit that reached a record $116 billion (¥12.8 trillion) in 2014. The reversal was due primarily to increased fossil fuel import costs that ballooned by an annual average of $30 billion in the three years after the nuclear accident at Fukushima. The depreciation of the yen and high oil prices also exacerbated the deficit. The softening in international fossil fuel prices starting in late 2014 helped reduce Japan's trade deficit to $22 billion (¥2.8 trillion) in 2015.[230] Japan returned to trade surplus in 2016 mainly due to declining oil and gas prices but saw that surplus soften in 2017, down approximately 25 percent from 2016.

U.S.-origin coal, gas and oil played a key role by partially filling the lost capacity in Japan's power generation. These increased imports marked a new phase in the U.S.-Japan relationship, i.e., a new calculus of Japanese energy security relying more closely upon the United States to play an expanded role as a supplier of fossil fuels.

Growing Potential for Trade in Petroleum

Japan is the world's third-largest net importer of crude oil and petroleum products with total net imports of 3.8 million barrels per day (b/d). The United States is not a major supplier of oil to Japan at this time, accounting for only 8 percent of crude imports in 2016.[231] Inasmuch as oil security is an important issue for Japan, it is significant that U.S. exports of petroleum products (e.g., natural gas liquids, liquefied petroleum gas and oxygenates) more than doubled from 2010 to 2016. With the lifting of the ban on U.S. crude oil exports on December 18, 2015 by the U.S. Congress due to booming oil shale production, there is good potential for exports of crude oil and petroleum products to grow.[232] In addition, the expansion of the Panama Canal will facilitate increased exports by allowing larger ships to transit its locks and reducing the transit time to Japan from the U.S. Gulf Coast to 20 days, compared to 31 days via the Suez Canal or 34 days around the southern tip of Africa.[233]

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[229] See, Op Cit., International Energy Agency. "Energy Investment by Fuel and Region," Table 1.1, page 22 in "World Energy Investment 2017.

[230] Op Cit., EIA *Country Analysis of Japan*, February 2, 2017 at https:/www.eia.gov/beta/international/analysis.cfm?iso=japan.

[231] Ibid., see EIA *Country Analysis of Japan.*

[232] In 2016, the United States supplied less than 1 percent of Japan's gasoline imports and just over 1 percent of naphtha imports. See Petroleum Institute of Japan, *Oil Statistics, Oil Product Import by Countries and by Source* (accessed January 2017) (via Japan›s Ministry of Economy, Trade, and Industry data), http://www.paj.gr.jp/english/statis/.

[233] See EIA. "Expanded Panama Canal reduces travel time for shipments of U.S. LNG to Asian Markets," *Today in Energy*, June 30, 2016, at https://www.eia.gov/todayinenergy/detail.php?id=26892.

Even though the United States instituted an oil export ban in 1975, Japan was able to take advantage of a small exception for Alaska crude.[234] Thus, during the ban, trade in crude oil between the United States and Japan was limited to intermittent supplies from Alaska. But when the ban was lifted in December 2015, trade rebounded with Japan importing 8,000 b/d of U.S. crude in 2016. In the first ten months of 2017, U.S. crude oil exports to Japan have ranged from 5,000 to 62,000 b/d on a monthly basis. Meanwhile, export trade in petroleum products, primarily liquefied petroleum gas (LPG), has been growing from 54,000 b/d in 2008 to 240,000 b/d in 2016, and in the first five months of 2017 ranging up to 452,000 b/d on a monthly basis. Despite this growth, Japan is not yet a major market for U.S. petroleum exports, accounting for about 2 percent of U.S. crude exports in 2016, and 5 percent of product exports (including 19 percent of U.S. exports of propane/LPG in 2016). However, the trend is clearly trending upward with considerable growth potential.[235]

Figure 3: U.S. Oil Exports to Japan
(thousand barrels per day)

Item	2014		2015		2016	
	Amount	Japan Share of	Amount	Japan Share of	Amount	Japan Share of
Crude Exports to Japan	0		0		8	0%
Total US. Crude Exports	351	0%	465	0%	591	1%
Product exports to Japan	150		166		242	
Total U.S. Product Exports	3,824	4%	4,273	4%	4,670	5%
Total U.S. Oil (crude & product) Exports to Japan	150	0%	166	0%	2505	0%
Total U.S. Oil Exports	4,176	4%	4,738	4%	5,261	5%

Source: See series of data tables in EIA, "Petroleum & Other Liquids – Exports by Destination" at https://www.eia.gov/dnav/pet/pet_move_expc_a_EP00_EEX_mbblpd_a.htm. Totals may not add due to rounding.

The Government of Japan encourages Japanese companies to invest in exploration and production projects overseas as part of its energy security strategy. The Japan

[234] Although the United States banned crude oil exports in 1975, President Regan allowed the export of Alaska Cook Inlet oil in 1985/1986 and ten years later President Clinton made a "national interest determination" in 1996 that authorized exports of Alaskan North Slope crude. Japan was a natural destination being only 12 days steaming time away by oil tanker. The United States shipped between 1996 and 2000 about 25 million barrels of Alaskan North Slope crude oil to Japan.

[235] See series of data tables in EIA, "Petroleum & Other Liquids – Exports by Destination" accessed in August 2017, https://www.eia.gov/dnav/pet/pet_move_expc_a_EP00_EEX_mbblpd_a.htm. Also, see EIA. "U.S. Exports of Crude Oil and Petroleum Products Have More Than Doubled Since 2010," *Today in Energy*, June 27, 2017, https://www.eia.gov/todayinenergy/detail.php?id=31812. Also, see Reuters. "Japan to import U.S. crude in May, second cargo since export ban lifted," March 16, 2016.

Oil, Gas and Metals National Corporation (JOGMEC), an independent governmental organization, plays a key role in promoting Japanese investment. With a global oil and gas budget of $5.2 billion, it provides equity capital and liability guarantees for Japanese special purpose companies (SPCs) to promote oil and gas exploration and production as well as mining of nonferrous metals and other minerals. JOGMEC offers equity investments in the development stage of resource projects, including oil, gas, coal and geothermal energy. In addition, the Japan Bank for International Cooperation (JBIC) helps secure strategic natural resources overseas for private Japanese business interests by offering loans at favorable rates.

Because of the pressing need to secure energy supplies following the Great Eastern Japan Earthquake and Tsunami of 2011, Japanese companies stepped up the pace of their investment. By 2014, they were participating in more than 140 oil and gas projects worldwide.[236] These projects included shale oil and oil sands projects in the United States and Canada involving Japanese firms such as Inpex, Cosmo Oil, Idemitsu Kosan Company, Japan Energy Development Corporation, Japex, Mitsubishi, Mitsui, Nippon Oil, and others. Many of these companies are involved in small-scale projects originally set up by the Japan National Oil Company prior to 2004 or since then by its successor JOGMEC while other investments are in high-profile overseas upstream projects.[237]

In one deal, Mitsui & Co. announced in 2016 that it would buy a 20 percent working interest in four blocks in the Gulf of Mexico owned by Shell estimated to hold 100 million barrels in reserves. On-shore, Tokyo Gas acquired a 25 percent interest in the Eagle Ford shale gas play in 2016 following-up on the estimated $1 billion each invested by Mitsui & Co. and Marubeni Corporation in the Eagle Ford basin in 2011-2012. Mitsui & Co. also has investments in over 1,100 wells in the Marcellus shale gas region.[238]

Of the foreign investors who committed around $112 billion in the U.S. oil and gas industry between 2008 and 2013, mostly in shale gas ventures, Japan ranked second at $16.4 billion behind Australia at $20.1 billion. This was a win-win scenario. Japanese funding provided much needed capital to U.S. firms and Japanese investors got a first-hand opportunity to learn about shale gas production techniques.[239]

In June 2017, the Trump Administration announced its energy policy priority to remove "unnecessary roadblocks that will unleash America's energy potential" and to achieve "energy dominance" which could lead to more U.S. production.[240] This policy, focused on fossil fuels, aspires to make the United States a major energy exporter to "markets around the world." Actions taken in 2017 include authorizing languishing pipeline projects, such as the Keystone XL and Dakota Access pipeline projects, and

[236] See Reuters. "Japan's JOGMEC says could accelerate investment in oil, gas," June 19, 2014 and Petroleum Association of Japan. "Petroleum Industry in Japan 2015," page 25.

[237] See Op Cit, EIA. *Country Analysis of Japan*, updated February 2, 2017.

[238] See Paraskova, Tsvetana. "Japan Continues Acquisition of U.S. Oil and Gas Assets," *Oil Price*, December 5, 2016, http://oilprice.com/Latest-Energy-News/World-News/Japan-Continues-Acquisition-Of-US-Oil-And-Gas-Assets.html.

[239] See attributed to Ernst & Young in "Foreign Investors U.S. Power Play," by Susan Caminiti, special to CNBC. com at https://www.cnbc.com/2014/03/05/foreign-investors-us-power-play.html.

[240] See White House Press Release, "Perry, Zinke and Pruitt: Paving the path to U.S. energy dominance," June 27, 2017, https://www.whitehouse.gov/the-press-office/2017/06/27/perry-zinke-and-pruitt-paving-path-us-energy-dominance, and "Trump Seeks to Project Global Power Through Energy Exports," Reuters, June 29, 2017, https://www.reuters.com/article/us-usa-trump-energy/trump-seeks-to-project-global-power-through-energy-exports-idUSKBN19K2VY. Also, see "Trump to Call for U.S. Dominance in World Energy Production," by Jennifer Dlouhy, Bloomberg Politics, January 25, 2017, https://www.bloomberg.com/news/articles/2017-06-25/trump-to-call-for-u-s-dominance-in-global-energy-production.

speeding up approvals of oil production on federal lands by the U.S. Department of Interior. These and other actions could help enhance the supply of oil the United States can make available to world markets, including Japan. Of course, even if U.S. oil does not go directly to Japan, it still has a beneficial impact for Japan in terms of global market supply availability and price.

Coal Trade Poised for Continued Growth

The United States has the largest coal reserves in the world, including major deposits in the Powder River Basin in Wyoming and in Montana, while Japan continues to be a driver for the utilization of coal for baseload power generation. The outlook for Japanese demand for coal imports, which jumped after the 2011 Fukushima-Daiichi accident, is still robust as Tokyo seeks to diversify and lower the cost of its energy mix. In 2015, Japanese thermal coal imports hit a record 113 million tons before dropping back to 110 million tons in 2016.[241]

The United States is a major coal exporter, the fourth largest in the world, and a growing supplier to Japan. Although Japan has accounted for 5 to 6 percent of U.S. coal exports recently as shown on Figure 4, in the first half of 2017 U.S. coal exports to Japan more than doubled from whole-year levels in 2016. They rose from 1.8 million short tons in 2016 to almost 4 million short tons in 2017 through June. In 2017, Japan accounted for almost nine percent of total U.S. coal exports.[242]

Figure 4: Total U.S. Coal Exports to Japan

(thousand short tons)

Item	2014		2015		2016		2017 Jan-June	
	Amount	Japan Share %	Amount	Japan Share %	Amount	Japan Share %	Amount	Japan Share %
U.S. Coal exports to Japan	4,898		4,657		1,839		3,993	
Total U.S. Coal exports	97,257	5	73,958	6	28,376	6	44,103	9

Source: Includes both steam and met coal. Coal data is from EIA "Quarterly Coal Report," August 2016 and October 2, 2017, as derived from Census Bureau "Monthly Report EM 545."

Following several down years after record high exports in 2012 of 125 million tons (mt), overall U.S. coal exports jumped 58 percent in the first quarter of 2017. Although there are several export projects proposed for the Pacific Northwest that could enlarge capacity to ship more coal to Japan, most have stalled.[243] Softness in global coal markets

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[241] See Reuters Update, January 25, 2017, http://uk.reuters.com/article/energy-japan-imports-idUKL4N1FF1X1.

[242] See EIA, "U.S. Coal Exports," accessed September 2017, https://www.eia.gov/coal/production/quarterly/pdf/t7p01p1.pdf.

[243] See EIA. "Today in Energy," July 18, 2017, https://www.eia.gov/todayinenergy/detail.php?id=32092.

and the dominant role played by Australia and Indonesia in supplying coal to Japan constrain the outlook for increased U.S. coal exports to Japan, or for significant additional investment in export infrastructure in the Pacific Northwest as an outlet for Powder River Basin coal.

All of Japan's coal supply is imported. Often times, the imported coal comes from mines developed by Japanese companies. Japan's coal policy includes government financial support for overseas exploration through geological surveys and planning new mine infrastructure.[244] In addition, Japan is a world leader in developing and deploying lower-emission coal technologies. It also is developing technologies to facilitate the efficient use of low-quality coal. A key government policy priority is to support exports of Japanese-origin low-carbon technologies and power plants.

The United States stands as a natural collaborator in the achievement of these policy goals but the two countries have at times differed in their support for the development of coal-fired power plants overseas. For example, official Japanese government support for investment in coal arose as an issue of financial coal diplomacy during the Obama Administration. Japan is the largest provider of coal project finance, investing $20 billion in coal finance between 2007 and 2014.[245] However, in 2015 it adjusted its policy in response to a request by the United States to modify its policy toward government funded credit support programs in order to reduce increase greenhouse gas emissions globally from coal-fired power plants.

The United States supported ending public export financing for coal-fired power plants unless they deployed carbon capture and storage (CCS) technology with limited exceptions for the poorest countries. Japan's position was to support the global deployment of the most efficient coal-fired power technologies in countries that will continue to use coal. In November 2015, Japan and the United States reconciled and agreed to an Organization for Economic Co-operation and Development (OECD) position that its members limit export credit financing for coal-fired power projects to those with ultra-supercritical technologies, supercritical plants in countries facing energy poverty challenges and small sub-critical plants in poorer, developing nations.[246] This decision led to major Japanese trading houses such as Mitsubishi to sell coal assets and cut their exposure to thermal coal in a strategic move towards a greener portfolio and to focus on new priorities such as coking coal and LNG.[247]

Natural Gas Trade a Key Target for Japanese Investment

The United States is an established supplier of LNG to Japan, averaging over 50,000 million cubic feet (Mcf) of LNG per year from the mid-1970s through 2007 from Alaska.

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[244] See IEA. *Country Review Japan 2016*, https://www.iea.org/publications/freepublications/publication/EnergyPoliciesofIEACountriesJapan2016.pdf.

[245] See Samantha Page. "The U.S. and Japan are Close to reaching a Major Agreement on Coal," https://thinkprogress.org/the-u-s-and-japan-are-close-to-reaching-a-major-agreement-on-coal-4ffa738aa031/.

[246] The agreement limited investment in low-efficiency power plants but allows continued investment in high-efficiency combustion technologies. More broadly, it intended to align export credit policies with climate change objectives to achieve lower emissions. See OECD. "Statement from the Participants on the Arrangement on Officially Supported Export Credits," Paris, November 18, 2015, http://www.oecd.org/newsroom/statement-from-participants-to-the-arrangement-on-officially-supported-export-credits.htm.

[247] See Reuters. "Japan's Trading Houses Off-Load Thermal Assets Among Climate Concerns," June 13, 2017, https://www.reuters.com/article/japan-coal-traders/japans-trading-houses-offload-thermal-coal-assets-amid-climate-concerns-idUSL3N1JA36T.

Trade then dropped off for a few years until the advent of the shale gas revolution. The emergence of shale-based LNG drove the expansion of U.S. LNG export capacity. Despite initial uncertainty about the U.S. regulatory process to approve LNG project proposals to export to non-FTA (free trade agreement) countries, Japanese companies invested in, and contracted for, U.S. LNG despite Japan not having an FTA with the United States.[248]

Japanese companies such as Inpex, JX Nippon group and Mitsubishi have long invested in natural gas exploration and production projects overseas tied to export facilities, including projects in Australia, Southeast Asia and the Middle East. Thus, with the arrival of the shale gas boom, it was natural for Japanese firms to seek similar opportunities in North America, particularly the United States. Investors included Japanese utilities, the eventual wholesale customers of the gas, acquiring equity stakes in upstream projects and LNG export terminals to ensure their access to LNG. JERA, Tokyo Gas, Mitsui & Company all signed long-term contracts with the U.S. LNG exporters including the Freeport, Cameron, Cove Point, and Jordan Cove projects.

The issue of access to U.S. LNG is a classic case study of Japanese diplomacy in energy trade and investment. In February 2013 when Prime Minister Abe met with President Obama, he asked for approval of LNG exports to Japan. He also announced $11 billion in credit guarantees to fund Japanese investment in U.S. shale gas projects.[249] In addition, at that same meeting, perhaps as part of a quid pro quo, the United States asked, and Japan later agreed, to join negotiations on the Trans-Pacific Partnership (TPP). Later, in July 2013, Prime Minister Abe sent Ministry of Economy and International Trade (METI) Minister Toshimitsu Motegi to Washington to request access to U.S. LNG exports and to exempt Japan from the U.S. regulatory requirement that LNG export customers had to be FTA partners in order to get automatic approval.[250]

Meanwhile, JOGMEC announced in June 2013 that it would guarantee 75 percent of the bank loans to Japanese companies involved in developing LNG projects that help reduce Japan's import fuel cost.[251] This action helped Japanese companies become significant investors in large scale upstream and downstream shale gas projects including LNG export infrastructure in Texas, Louisiana and Maryland.

Upstream, Mitsubishi and Inpex participated in oil and shale gas ventures in western Canada. Mitsui and Sumitomo, large Japanese trading companies, are also involved in large upstream shale gas ventures in the United States.[252] Downstream, Japanese trading companies Mitsubishi and Mitsui jointly acquired a 33 percent equity share in the Cameron LNG project in 2013, securing two-thirds of the terminal's export capacity.

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[248] See Cutler, Tom. "The Trans-Pacific Partnership as a Pathway for U.S. Energy Exports to Japan," National Bureau of Asian Research (NBR), January 28, 2015, http://www.nbr.org/downloads/pdfs/eta/ES_essay_cutler_012815.pdf.

[249] See "Japan wakes up to the U.S. Shale Revolution" by Emiko Terazono and Guy Chazen, *Financial Times*, February 26, 2013, https://www.ft.com/content/20b40574-8007-11e2-96ba-00144feabdc0.

[250] See Cutler, Tom. "The Trans-Pacific Partnership as a Pathway for U.S. Energy Exports to Japan," National Bureau of Asian Research (NBR), January 28, 2015, http://www.nbr.org/downloads/pdfs/eta/ES_essay_cutler_012815.pdf. Also, see "Impact of Trade Policy on Japanese Trade and Investment" by Roger Farrell in *The Political Economy of Japanese Trade Policy* edited by Aurelia George Mulgan, and Masayoshi Honma, Palgrave Macmillan, 2015, p. 166.

[251] See S&P Global Platts. "Jogmec to guarantee 75% of loans to LNG projects that lower Japan's import costs," June 21, 2013, https://www.platts.com/latest-news/natural-gas/tokyo/jogmec-to-guarantee-75-of-loans-to-lng-projects-27108982.

[252] See Op Cit, See EIA. *Country Analysis of Japan*, updated February 2, 2017, https://www.eia.gov/beta/international/analysis.cfm?iso=JPN.

At the Cove Point project in Maryland, an arm of Sumitomo bought half of its output that it then re-sold to Tokyo Gas and Kansai Electric. Osaka Gas and Chubu Electric Power each invested a reported $600 million for 25 percent equity stakes in the Freeport LNG project.[253] These investments all happened after 2010 when for five straight years the largest individual capital investment announcements in the United States were for LNG facilities. In 2015, the six largest projects all were LNG and chemical manufacturing facilities, many of which use natural gas as a feedstock.[254]

In December 2016, Japan imported 11,137 Mcf out of the Sabine Pass LNG terminal whereas in the preceding two years it had received shipments of U.S. LNG only from Alaska. Japan accounted for 29 percent of total U.S. LNG exports in 2015 but due to a number of new customers for U.S. LNG, this share dropped to 6 percent in 2016 even though the actual volume of Japanese imports grew by one-third. These figures reflect the rather erratic trend in Japanese imports of U.S. LNG, including re-exports, dating back to 2011 when imports reached a peak of 18,012 Mcf and then eased to 14,379 Mcf in 2012 before dropping to zero in 2013 and back up to 13, 310 Mcf in 2014 and 8,262 Mcf in 2015.[255]

Figure 5: U.S. Natural Gas and LNG Exports
(billion cubic feet)

Item	2014		2015		2016	
	Amount	Japan Share %	Amount	Japan Share %	Amount	Japan Share %
U.S. LNG Exports to Japan	13.3	n/a	8.3	n/a	11.1	n/a
Total U.S. LNG Exports	16.3	82	28.4	29	186.8	6
Total U.S. Natural Gas Exports (pipeline; e-export)	1,514	1	1,784	nil	2,335	nil

Source: Energy Information Agency, "U.S. Natural Gas Exports and Re-Exports by Country," https://www.eia.gov/dnav/ng/ng_move_expc_s1_a.htm.

Although a steadier and growing volume of Japanese imports of U.S. LNG can be expected once the projects Japan has invested in come on line, the global gas market's

253 As reported in Reuters, "Interview with Chubu Electric," by Jacob Gronholt-Pedersen, February 28, 2014, http://uk.reuters.com/article/chubu-lng/interview-japans-u-s-lng-imports-to-reach-10-mln-t-yr-chubu-electric-idUKL3N0LW13V20140228.

254 See Ernst & Young. "2016 U.S. Investment Monitor," http://www.ey.com/Publication/vwLUAssets/ey-2016-us-investment-monitor/$FILE/ey-2016-us-investment-monitor.pdf.

255 See EIA. "Natural Gas: U.S. LNG Exports and Re-Exports by Point of Exit," https://www.eia.gov/dnav/ng/ng_move_poe2_a_EPG0_ENG_Mmcf_a.htm.

plentiful supply and lower cost brought about by the U.S. shale gas revolution also makes the option of importing U.S. LNG less commercially compelling. Nevertheless, energy security remains a major driver of the continuing strong interest in access to U.S. LNG. In the short-term, some Japanese companies are likely to continue to acquire energy resource assets while others will be more hesitant to invest in new projects as long as there is a soft LNG market.[256]

Japanese Investment in Nuclear Power Facing Uncertain Future

Japan was the first country to join President Eisenhower's "Atoms for Peace" program and signed its first nuclear cooperation agreement with the United States in November 1955.[257] This led to decades of close cooperation between government and industry. It resulted in U.S. companies selling billions of dollars of equipment, technology, and fuel to Japan while Japan made the largest foreign contribution—at least $150 million in the 1960s— to U.S. nuclear R&D programs and paid substantial license fees to the U.S. Atomic Energy Commission and its successors for nuclear fuel services. In fact, one of the biggest, if not the biggest, Japanese energy investment in the United States was in the nuclear power sector. In 2006, Toshiba outbid Mitsubishi Heavy Industries and General Electric in a major strategic move to purchase Westinghouse from British Nuclear Fuels PLC for $5.4 billion.

Since Toshiba built boiling water reactors and it appeared some major markets such as China preferred Westinghouse pressurized reactors, Toshiba envisioned that this acquisition would enable it to triple its nuclear business by 2015.[258] Meanwhile, in the next year in June 2007, Hitachi and GE announced a new partnership for commercial nuclear power.

In 2011, the Great Eastern Japan Earthquake and Tsunami upended the global outlook for nuclear power especially in Japan, drastically changing the industry's prospects. Japan shut down all of its nuclear plants pending safety reviews. Then, in March 2017, Westinghouse filed for bankruptcy following billions of dollars in cost overruns at nuclear power plants it designed and is constructing in Georgia and South Carolina.[259] The bankruptcy caused Toshiba significant financial hardship and it has announced its decision to divest itself of its Westinghouse assets in 2018.[260]

The enormous upfront cost to build new nuclear reactors combined with the fallout from the events of 2011 results in an uncertain outlook for nuclear energy in Japan and the United States. In turn, this uncertainty affects the potential for future bilateral trade and investment in this sector.

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[256] See Canadian Trade Commissioner Service. "Mining Sector Overview 2016 – Japan," http://tradecommissioner.gc.ca/japan-japon/market-reports-etudes-de-marches/0001460.aspx?lang=eng.

[257] See Zwigenberg, Ran. "The Coming of a Second Sun: The 1956 Atoms for Peace Exhibit in Hiroshima and Japan's Embrace of Nuclear Power," *The Asia Pacific Journal*, February 4, 2012, http://apjjf.org/2012/10/6/Ran-Zwigenberg/3685/article.html.

[258] See Timmons, Heather. "Toshiba Agrees to Buy Westinghouse for $5.4 Billion," *New York Times*, February 6, 2006, http://www.nytimes.com/2006/02/06/business/toshiba-agrees-to-buy-westinghouse-for-54-billion.html?mcubz=0. Also see Wald, Matthew. "GE and Hitachi will Merge their Nuclear Power Units," *New York Times*, November 14, 2006, http://www.nytimes.com/2006/11/14/business/worldbusiness/14nuke.html?mcubz=0.

[259] See Mufson, Steven. "Things Go South at Westinghouse," *Washington Post*, March 30, 2017, p. A-12. Also Mufson, Steven. "Work Stops on S.C. Nuclear Reactors," *Washington Post*, August 1, 2017, page A-10, and Hals, Tom. "Westinghouse Reaches Deal for $800 Million U.S. Bankruptcy Loan," *Reuters*, May 23, 2017, http://www.reuters.com/article/us-toshiba-accounting-westinghouse/westinghouse-reaches-deal-for-800-million-u-s-bankruptcy-loan-idUSKBN18J2M2.

[260] See Clenfield, Jason et al. "How Toshiba Lost $6 Billion," *Bloomberg*, https://www.bloomberg.com/news/articles/2017-02-17/how-toshiba-lost-6-billion.

Japan has restarted six nuclear power plants as of March 2018. The Trump Administration has expanded federal financing for the two Westinghouse reactors in Georgia and is looking favorably upon nuclear energy as a source of baseload power. The revitalization and expansion of the U.S.-Japan relationship in nuclear power though likely rests with their ability to successfully commercialize new forms of civil nuclear energy, such as small modular reactors.

New Opportunities in Renewables and Clean Energy

U.S.-Japan trade and investment in renewable energy is not on a scale sufficient to be a major feature of their energy/economic relationship. However, Japanese and American corporations are both looking for attractive commercial opportunities bilaterally and overseas to invest and construct renewable energy projects, including wind, solar and other technologies.[261]

The U.S. Department of Commerce in 2016 ranked Japan as a top potential market for renewable energy products because, with the shutdown of Japan's nuclear fleet and electricity market deregulation, the Japanese renewable market is growing. U.S. exporters have the potential to enlarge their renewable energy presence especially in solar, wind and geothermal in the Japanese market in the future, primarily as suppliers to domestic Japanese producers.[262] For example, Goldman Sachs established a portfolio company, Japan Renewable Energy, to help address Japan's need for renewable energy post-Fukushima.[263] Japan has been expanding its overseas presence in the renewables market but has not been particularly active in the U.S. market.

Although difficult to quantify, there also is increasing bilateral investment and trade in other clean energy technologies. Japanese automotive companies have invested heavily in the United States in advanced hybrid and electric vehicles, and related parts and equipment, in addition to their exports to the United States. In terms of joint investment in clean energy R&D for buildings, one success story is the 2016 partnership between SUNY Polytechnic Institute in Albany, New York and Japan's New Energy and Industrial Development Organization (NEDO). NEDO invested $25 million in the partnership to add energy-efficient technologies to SUNY Polytechnic Institute's ZEN building (i.e. Zero Energy Nanotechnology) which will become the largest zero energy-capable, mixed-use building in the United States.[264] These technologies included lighting, fuel cells and smart building energy management systems.

[261] See Buckley, Tim and Nicholas, Simon. "IEEFA Update: Japan is Investing Heavily in Overseas Renewables," March 28, 2017, http://ieefa.org/ieefa-update-japan-investing-heavily-overseas-renewables/.
[262] U.S. International Trade Administration, "2016 Top Markets Report Renewable Energy, Japan Country Case Study," 2016.
[263] Goldman Sachs, "Environmental Market Opportunities Clean Energy," http://www.goldmansachs.com/citizenship/environmental-stewardship/market-opportunities/clean-energy/.
[264] See the link for the ZEN building at https://www.eypae.com/client/suny-polytechnic-institute/zen-zero-energy-nanotechnology-building.

Energy Trade and Investment Central to Japan-U.S. Economic Security

Japan's lack, and the United States' wealth, of energy resources create opportunities for energy trade and direct foreign investment. These opportunities can advance Japan's energy security strategy, ameliorate non-energy trade imbalances, and deepen the U.S.-Japan strategic alliance. However, challenges remain. Thus, close attention needs to be paid to seizing opportunities and overcoming obstacles to strengthen the bilateral energy relationship and to enhance cooperation and coordination in multilateral forums.

Starting with President Trump's action on his first day in office to withdraw from the Trans-Pacific Partnership (TPP), trade and investment issues are playing out at the highest levels in the bilateral relationship. In response to President Trump's action on TPP and his expressed concerns over the U.S. trade deficit with Japan, the Japanese government is considering ways to increase energy imports from the United States. Prime Minister Abe adopted the posture of "not accommodating, not opposing" as part of a strategy to address President Trump's broader concerns over Japan's trade surplus. He has proposed launching job-creating investment programs in U.S. infrastructure as well as importing more U.S. LNG.[265] When he met with President Trump in February 2017 as part of his golf cart diplomacy, Prime Minister Abe pitched a $450 billion infrastructure investment plan. These investments would include power plants and U.S. energy export facilities, and create 700,000 U.S. jobs over a ten-year period.[266]

It appears that Japanese companies' longer-term strategic investment into U.S. energy assets has started to pay off. In December 2016, the Sabine Pass terminal shipped the first cargo of LNG to Japan. Overall, Japan's energy imports from the United States more than doubled from the previous year.[267] Thus, even though the United States accounted for less than 5 percent of Japan's total energy imports, this jump in bilateral energy trade helped the Abe Administration ease the rhetoric of a trade war.

Although the Japanese government cannot dictate from where private sector utility companies import their energy supplies, it can still exert strong influence. According to one observer, "pressuring utility companies to import more energy from the U.S. must also be a politically easier option than opening up the domestic beef market to U.S. It will be interesting to see how an increase in energy imports from the U.S. could help reduce Japan's trade surplus with the U.S."[268]

Trade also was on the agenda when U.S. Vice President Pence travelled to Japan in April 2017. Prime Minister Abe stated the Trans-Pacific Partnership (TPP) without the United States would be "meaningless" and that Japan has still not completely given up

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[265] See Uetake, Tomo and Kubo, Nobuhiro. "Japan Considers Buying More U.S. Energy as Abe Prepares to Meet Trump," *Reuters*, February 2, 2017 at http://www.reuters.com/article/us-usa-trump-japan-lng-exclusive/exclusive-japan-considers-buying-more-u-s-energy-as-abe-prepares-to-meet-trump-idUSKBN15H0NJ.

[266] See Francis, David. "Abe-Trump Meeting Might Yield Clues on Trump's Trade Vision," *Foreign Policy*, February 10, 2017, http://foreignpolicy.com/2017/02/10/abe-trump-meeting-may-yield-clues-on-trumps-trade-vision/. Also, see East Asia Forum. "Mr. Abe Goes to Washington," February 13, 2017, http://www.eastasiaforum.org/2017/02/13/mr-abe-goes-to-washington/.

[267] See Okubo, Takuji. "Japan Doubled Energy Imports from the U.S.," Japan Macro Advisors, February 20, 2017, https://www.japanmacroadvisors.com/reports/view/breaking-news/japan-doubled-energy-imports-from-us.

[268] See Uetake, Tomo and Kubo, Nobuhiro. "Exclusive: Japan Considers Buying More U.S. Energy as Abe Prepares to Meet Trump," *Reuters*, February 2, 2107, https://www.reuters.com/article/us-usa-trump-japan-lng-exclusive/exclusive-japan-considers-buying-more-u-s-energy-as-abe-prepares-to-meet-trump-idUSKBN15H0NJ.

on the TPP.[269] Since then however, Japan has since moved ahead with the other TPP countries minus the United States to negotiate and signed in March 2018 a "TPP 11," the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP).

Nevertheless, despite these entreaties, in May 2017 U.S. Secretary of Commerce Wilbur Ross stated that the U.S. trade deficit with Japan grew at an "alarming rate" in the early months of 2017, and that "the United States can no longer sustain this inflated trade deficit with our closest trading partners. The Trump Administration is committed to rebalancing our trade relationships in order to protect American workers and businesses from lopsided trade relationships."[270] Thus, speculation remains about the need to codify opportunities to increase bilateral energy trade.

In reality, Japan and the United States do not need a bilateral FTA for energy trade and investment to flourish. Given that the United States and Japan are heavily invested in each other, an energy trade and investment partnership already exists. Markets can trend to what is the optimal commercial balance with scope remaining for government policy actions to apply more precision and accelerate activity. Thus, the robust energy trade and investment connection will remain one of the key foundational links between the United States.

[269] See Fifield, Anna. "U.S. Trade Winds Blowing Toward Japan and South Korea," *Washington Post*, April 19, 2017, p. A-12.
[270] See U.S. Department of Commerce Press Release, May 4, 2017, https://www.commerce.gov/news/press-releases/2017/05/trade-deficit-mexico-and-japan-continues-grow-unsustainable-rate.

Chapter Thirteen

Considerations for the 2020s and Beyond

Dr. Phyllis Genther Yoshida
Senior Fellow, Sasakawa Peace Foundation USA

Introduction

Japan's energy conundrum – how to provide an affordable and environmentally friendly energy supply resilient to the unexpected – persists. Many countries have the same conundrum, but Japan is unique because of its size and lack of domestic fossil fuel resources, and because it suffered the extraordinary Great Eastern Japan Earthquake and Tsunami on March 11, 2011. Japan must find a new politically achievable solution to mitigate its energy conundrum that can be achieved at reasonable cost, provides energy security and promotes economic growth. It is a tall order.

That singular, extraordinary event on March 11, 2011 challenged and necessitated a change in Japan's prior preferred solution (nuclear energy and demand reduction) to its energy conundrum. It also silenced opposition to regulatory reform of electricity and gas markets, and to expansion of renewables. Unlike earlier challenges, the crisis affected not just the type of supply, like oil in the 1970s, but also the power generation and distribution system itself.

In the short term following the crisis, an activist international policy ensued to encourage a flexible, lower cost liquefied natural gas (LNG) supply. It also sought to expand the export market for the advanced, highly-efficient, low emission (HELE) coal technologies Japan increasingly needed for itself. Policies to constrain energy demand continued. Most importantly, the crisis created a highly impassioned conversation around domestic supply—nuclear energy and renewables—that is yet to be settled, and sped up regulatory reform of the electricity and gas markets.

As a result, Japan faces a major transformation in its energy market in order to maintain its energy security. A question still unanswered is whether the transition to a new energy market in a quickly evolving world will be rapid and deep enough to maintain Japan's global economic position and fulfill its social and environmental goals. What will the transformation entail? This chapter includes recommendations on how Japan can manage its energy conundrum going forward and how U.S.-Japan cooperation can play an important role in that process.

Our authors argue that the transformation must introduce competition into the energy sector, promote decarbonization, lower demand, and build a new stable secure energy supply to replace the lost nuclear power. The transformed energy system will include securing supplies of fossil fuels (oil, gas, and coal), developing domestic alternatives (advanced nuclear energy, renewables), and advancing associated technologies (e.g., energy storage, digital technologies, distributed energy and hydrogen systems). It also will include lowering demand through enhanced energy management, and international collaboration. These elements all will be part of a transformed energy market that will reflect the deregulation of electricity and natural gas as well as the outcome of the jockeying underway on the energy mix.

A Singular Extraordinary Event

While we tend to model changes in energy markets as incremental and taking place over several years, singular events as well as breakthrough technologies can have immediate and long-lasting ramifications. The Great Eastern Japan Earthquake and Tsunami dramatically challenged Japan's energy security and revealed shortcomings in its previous approach, as highlighted repeatedly by our authors. It was a challenge that no one expected. It forced Japanese policymakers and energy companies to scramble in crisis mode to find alternatives to nuclear energy, resulting in increased reliance on fossil fuels and more constraints on energy demand. Japan spent $286 billion on net imports of fossil fuels in 2012, more than any other country in the world.[271] As Japan's dependence on imported fossil fuels ballooned, it pushed Japan's 32 years of trade surpluses into deficits that lasted from 2011 until 2016, recovering only with the fall in global energy prices. In the long-term, the disaster is forcing policymakers to rethink Japan's energy mix and the structure of Japan's energy market. It was just the most recent episode in Japan's frustratingly persistent and familiar energy conundrum. It also was the most complicated episode to date due to climate concerns, population decline, and flat economic growth in Japan as well as the global unconventional oil and gas revolution and the growth of world energy demand.

The impact of March 11, 2011, goes far beyond the question of nuclear energy. The Great Eastern Japan Earthquake and Tsunami also revealed Japan's remarkable resilience. Japan dealt successfully with the sudden loss of the almost 30 percent of its electricity supply provided by nuclear energy and with subsequent skyrocketing energy costs caused by importing expensive alternatives such as LNG. March 11, 2011 added urgency and accelerated changes already underway needed to maintain and increase resiliency. These changes included energy market deregulation, the uptake of renewables, diversification of fossil fuel sources, and expansion of energy management targets. The disaster also added to concerns about Japan's ability to meet its climate goals, and increased Japan's global engagement on energy security issues.

The Nuclear Question

Everyone's first image of Japan's latest energy challenge is the devastated Fukushima Daiichi nuclear power plant. In addition to the tragedy it created for the residents of Fukushima, it upended Japan's long-term solution for its energy security. Nuclear energy was the heart of Japan's answer to energy security after the oil crises of the 1970s. It enabled Japan to cut back on the imported fossil fuels needed to power economic growth. Policymakers considered nuclear energy a domestic energy source and felt that it would contribute even more when and if Japan uses domestically reprocessed nuclear spent fuel. In Japan's 2010 *Third Energy Plan*, nuclear energy was slated to grow from 30 percent to 50 percent by 2020 and 70 percent by 2030.

[271] McCracken, Ross. *The burden Japan is facing in its higher energy costs.* Platts Energy Economist, January 24, 2014, http://blogs.platts.com/2014/01/24/japan-energy/.

In 2014, after the Fukushima catastrophe, Japan's policymakers scaled back the nuclear energy goal but kept it at a still substantial 22 percent by 2030 and 30 percent by 2050. They also accelerated plans for grid modernization and deregulation of Japan's electricity and gas markets. A new plan, expected in the second half of 2018, likely will retain a sizeable role for nuclear energy given the part it has played in strengthening energy security since the oil crises of the 1970s and in lowering CO2 emissions. Japan must first restore social trust in nuclear energy. Nuclear energy will likely play a smaller role in the longer-term solution to Japan's energy conundrum in conjunction with renewable energy, LNG, coal, demand management and a deregulated more competitive energy market.

What remains unaddressed is if social trust is rebuilt, can nuclear energy remain a major domestic energy source? It will likely take a transition to the next generation of advanced nuclear power plants for that to happen. If so, will Japan be ready and able to play a major role in that transition globally? Nobuo Tanaka took up this transition and presented his special proposal for U.S.-Japan advanced nuclear cooperation. The need for Japan to maintain a civil nuclear energy industry can be, and is, debated. It is difficult, however, to see how Japan can meet its energy security goals and, as Jun Arima detailed, its goals related to climate change without any nuclear energy. The United States and Japan are the world's longest-standing partners in the field of civil nuclear energy, and U.S.-Japan cooperation could play a major role in enabling such a discussion.

A second consideration in determining the future of nuclear energy in both Japan and the United States is the critical linkage between national security and nuclear governance. The existence of a strong community of civil nuclear power stakeholder countries helps ensure international norms, including safety and nonproliferation concerns, are not compromised.[272] Achieving these objectives will be easier and more effective if countries such as the United States and Japan maintain civil nuclear programs and continue active engagement with international partners on technology and regulatory development.

Japan's energy mix is changing. With only about a fourth of existing nuclear power plants likely to come back on line, Japan needs new domestic energy sources including renewables. Further diversification of types and sources of imported fossil fuels can support Japan's energy security. Growing domestic energy supplies and continued reduction of energy demand need to complement that diversification. The energy system needs to become more competitive. In the midst of this change, the future of nuclear energy in Japan remains clouded. Nuclear energy can be part of a serious answer to Japan's energy conundrum and climate needs especially if the country transitions to advanced fast reactors and small modular reactors that can be more efficient, proliferation-resistant, safe and socially acceptable.

Fossil Fuels Still Rule

Japan remains heavily dependent upon fossil fuels and therefore, for the foreseeable future, impacted by the geopolitics that surround these fuels. Dennis Blair underscored energy supplies come from international markets, and the nature of these energy markets

[272] Global Nexus Initiative, *Nuclear Power for the Next Century: Addressing Energy, Security and Climate Challenges*, 2017 at https://www.nei.org/CorporateSite/media/filefolder/resources/reports-and-briefs/global-nexus-initiative-nuclear-power-next-generation-2017.pdf.

heavily influences the geopolitics of energy. He posited the weight of evidence predicts the future of energy geopolitics in Asia will be more cooperative than confrontational, and cooperative energy relations have a chance of being shielded from the great power rivalries of the region. In 2017, China became the world's largest oil importer, passing the United States, and the second largest importer of LNG, passing Korea. Another major power in the region, India, is now the third largest energy consumer in the world, after China and the United States. It is the fourth largest consumer of oil and importer of LNG. In 2015 and 2017 respectively, China and India became Association partners of the International Energy Agency, an organization created after the 1973 oil crisis for collective energy security and of which Japan and the United States are founding members. China and India increasingly share many of the same energy security concerns as Japan, including clear national and economic interest in preserving access to imported fossil fuels, diversifying fuels and sources of supply, and increasing energy efficiency. As always, unexpected developments could upset this prediction of cooperation. The global energy world has seen more than its share of change in the last decade.

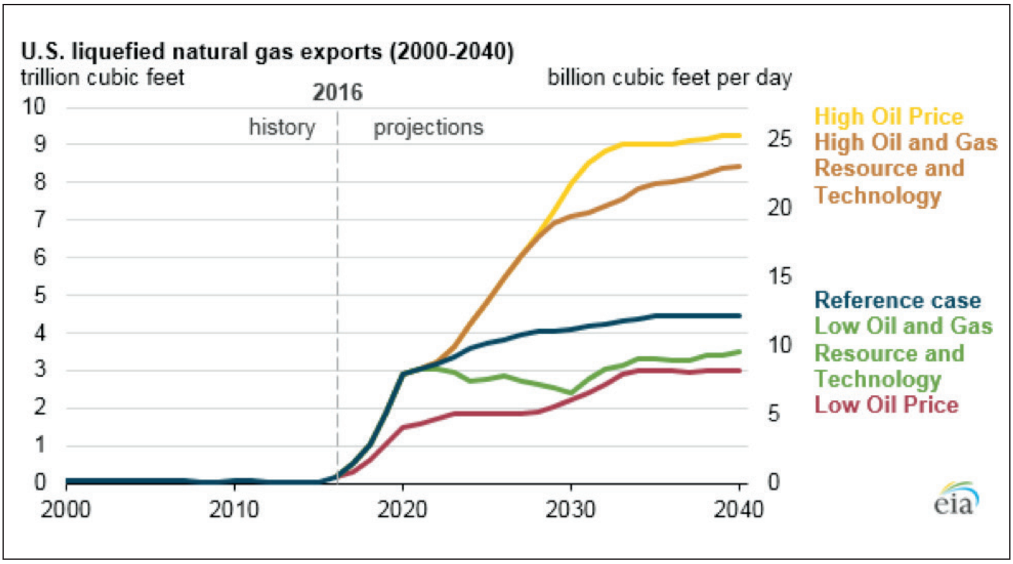
Japan's oil consumption grew after the events of March 11, 2011. Consumption peaked in JFY 2015 and continues to decline. However, oil remains 45 percent of Japan's total primary energy supply, with the Middle East still the dominant source. The transportation and industrial sectors remain highly dependent on oil. Ken Koyama detailed Japan's continuing dependence on Middle Eastern oil and its energy security ramifications.

At the same time despite the decline in oil consumption, Japan is no less dependent on fossil fuels. In fact, Japan's dependence on imported fossil fuels for its primary energy supply (90 percent) is now even higher than it was at the time of the first oil crisis in 1973 (76 percent). With nuclear energy largely offline and renewable energy production small, there is a huge reliance on imported natural gas and coal due to Japan's lack of resources. Japan's only other potential domestic fossil fuel is deposits of methane hydrates located deep offshore of its southeast coast that remain impossible to tap safely and economically, and whose potential use raises climate concerns.

LNG played a particularly strategic role after the Great Eastern Japan Earthquake and Tsunami shut down nuclear energy production. It continues to be essential for Japan's economy. LNG's high cost caused Japan to take on an activist leadership role in rewriting the international rubric of LNG trade, pushing for flexibility by ending oil-linked prices and restrictive destination clauses. It is essential to note changes in the international rubic of LNG trade were possible only because new technologies enabled the North American shale revolution that in turn increased competition in the global energy market and provided a different pricing model. Koyama noted that as Japan debates the role of nuclear energy in its future energy mix, Japanese buyers facing uncertainty over future LNG requirements still regard improved LNG supply flexibility as crucially important. In addition, several authors argued that compared to its role in energy security and fuel diversification, LNG has in fact been as or more important for achieving Japan's climate goals. Therefore, continued use of LNG with its lower CO2 emissions than coal or petroleum will be important going forward at least in the short- and medium-term with little nuclear energy back on-line or much production of renewable energy.

As Tom Cutler discussed, Japan's lack—and the United States' wealth—of fossil energy resources creates opportunities for energy trade and direct foreign investment that can advance Japan's energy security strategy, ameliorate non-energy trade imbalances, and deepen the U.S.-Japan strategic alliance. The United States became the world's top producer of natural gas in 2011 and is jockeying with Saudi Arabia and Russia to be the top oil producer. With the U.S. growth in production, the advent of LNG and oil exports from the United States to Japan, while still small, represent an opportunity for Japan to increase its energy security by diversifying its sources of supply. Japanese companies also are investing in U.S. energy production and infrastructure. For example, the first shipments from the U.S. Cove Point LNG export terminal in April 2018 went to India's gas utility Gail and to a Japanese joint venture of Sumitomo and Tokyo Gas. Both have 20-year contracts.

Figure 1: U.S. LNG Export Trends



Source: U.S. Energy Information Administration

Jane Nakano spoke to the return of coal as a major energy source. She pointed out that key numerical indicators, such as coal consumption volumes and share in the power mix, reflect coal's importance in Japan and distinguish Japan from other developed economies where coal power generation is receding. Between 2010 and 2015, the share of coal in the nation's power generation increased from 23 percent to 31 percent, a trend that has been underreported. What is different from earlier periods is imported coal is substituting for exhausted domestic coal reserves. Although imported, coal is appealing as it is less expensive than oil or LNG and contributes to the economic growth "E" in Japan's three "3Es" plus "S" energy policy. It also contributes to the energy security "E" as it is procured from a diverse group of reliable suppliers including Australia, Indonesia, Canada and the United States. Many new entrants into Japan's deregulated electricity market also favor coal due to its low cost and the ease with which coal power plants fit into the existing energy system. On the other hand, there is great sensitivity to coal's negative impact on the environment due to its higher CO2 emissions. As a result, Nakano spoke to how coal has become an important factor in Japan's activist energy diplomacy to secure sources of supply, promote exports of HELE coal technologies, and support international collaboration in carbon capture and storage (CCS).

Energy Demand Hurdles

Increasing energy efficiency, i.e. decreasing demand and increasing productivity, is an important element of Japan's energy security and policy. Japan is a recognized world leader and an active participant in international energy efficiency efforts. Yukari Niwa Yamashita discussed how Japan developed its energy efficiency and conservation policies over time to become one of the most efficient countries in the world. Japan became highly efficient because it had to import much of its energy and increase manufacturing productivity to compete globally. Energy data reflect this success as overall domestic energy consumption is flat.

It is ironic Japan's very success with energy efficiency will make it harder to achieve reductions in energy demand at the same pace as in the past. There are fewer high value targets and it is harder to get rid of the next joule, BTU, watt, or therm than it was the first. The same is true for the next gram of CO2 and other greenhouse gases. Policies to reduce energy demand thus remain important but have greater hurdles to overcome to achieve significant reductions. Japanese efficiency efforts continue to push into more areas, for example targeting buildings by introducing energy efficiency standards into the building code and expanding to additional parts of the commercial sector such as supermarkets and shopping centers.

Japan's main targets for energy demand reduction are less about oil and more about electricity in general in the aftermath of the Great Eastern Japan Earthquake and Tsunami. Ken Haig detailed how Japan needs to change how it has approached electricity to make progress on this target. Japan's electric power system has long prioritized reliability over flexibility, granting regional utilities monopolies in exchange for ensuring a consistently stable supply of electricity. This led utilities to opt to focus on increasing supply within their own regions. The national grid was not improved to handle transfers of power between regions. As a result, Japan found in 2011 it was unable to move enough electricity to where it was needed. It had insufficient inter-regional transmission links and inter-regional frequency conversion facilities between its two different frequency areas (50 Herz in eastern Japan and 60 Herz in western Japan). It also had critically underinvested in renewable energy generation, an important domestic energy source due to perceived cost, local opposition (e.g. hot springs owners to geothermal, fishermen to offshore wind), grid access issues, and the oligopolistic market structure.

The disaster weakened the opposition to energy deregulation, but it remains challenging to change the utility-centric model. Deregulation is starting to open the market to renewables and expand competition by creating new players. Deregulation also is bringing demand-side management practices that focus on reducing electricity use rather than increasing national grid flexibility and supply. Japan is undertaking pilot projects in demand supply management (DSM), an area where the United States already is much more experienced and where additional U.S.-Japan cooperation and information exchange is important.

The main target for reducing oil demand in both Japan and the United States is the transportation sector. Policies promote fuel efficiency and alternative fuels (electricity, hydrogen) in Japan and the United States as well as biofuels in the United States. Michael Smitka pointed out the differences between the two countries. Compared to the United States, in Japan vehicles are more fuel efficient and smaller, and mass transit more widely used, especially in dense urban environments. However, personal vehicle ownership and use is increasing due to lifestyle changes, including increases in suburban living with big box stores and a growing number of licensed drivers. He noted that, since 1973, energy demand by the transport sector rose 70 percent and that by the household sector 90 percent. Together they now account for one-third of energy consumption. Half of that, or one-sixth of Japan's total energy usage, is used to power vehicles.

Transportation oil use is also the largest energy security demand issue in the United States. Increased domestic energy supply and weakening of fuel economy regulations could slow purchases of more energy efficient vehicles even though oil prices still are set on an unfree global market and recent low prices are surging upwards. Unless and until electric (battery and fuel cell) and autonomous vehicles become mainstream through technology advances and/or regulatory policies, and car use starts to decline, it will be difficult to reduce oil demand in the transportation sector significantly in either country.

Japan's success in reducing energy demand and in developing solutions to the challenges it now faces makes it even more important for it to continue to share best practices and expertise, and to expand joint research with international partners. For example, Japan, with the United States, is a founding member of the International Partnership for Energy Efficiency Cooperation (IPEEC)[273] established in 2009 to promote collaboration on energy efficiency. It also is active in energy efficiency projects with the Asia-Pacific Economic Cooperation (APEC) forum and other regional organizations.

The Renewable Energy Option

The escalating interest in renewables post-2011 as a domestic alternative to nuclear energy deserves special attention. As spelled out by Llewelyn Hughes, there was interest in renewables in Japan pre-2011, particularly after the oil crises of the 1970s. However, apart from investment by the utilities in large conventional hydropower power plants and by some companies in photovoltaics and related components for solar energy subsidized by the government until 2006, interest was anemic and costs high. Social acceptance was an issue for some types of renewables. This has started to change. For the first time, as mentioned by Hughes and other authors, many Japanese see renewables as a viable alternative to nuclear energy, resulting in the current vibrant debate over Japan's energy mix.

Renewables did not fit easily into Japan's utility-centric and oligopolistic model; nuclear energy did fit and, as climate issues increased in importance, had the added advantage of being low carbon. In the International Energy Agency's 1999 review of Japan's energy policies, renewable energy merited only a brief mention under ongoing research.[274] It constituted only 4.4 percent of total primary energy supply and about 10 percent of the electricity supply. In the IEA's 2016 review, renewable energy merited its own chapter.[275] It had grown to 5.7 percent of total primary energy supply and 16.9

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[273] IPEEC's founding members are Brazil, Canada, China, France, Germany, Italy, Japan, Korea, Mexico, Russia, the United Kingdom, and the United States.

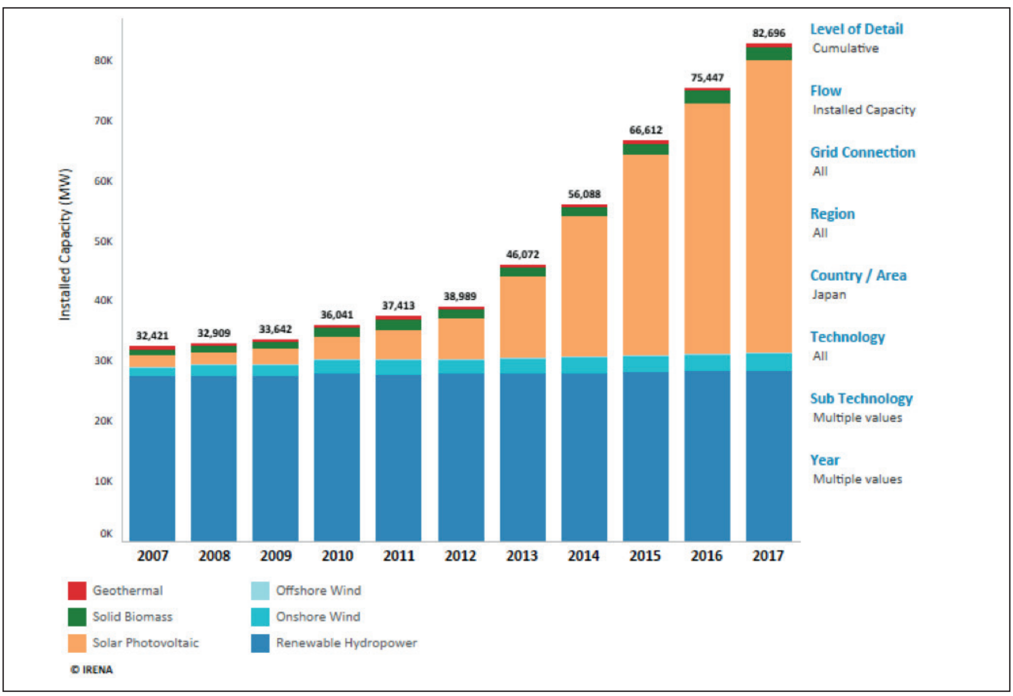
[274] International Energy Agency. *Energy Policies of IEA Countries, Japan 1999 Review.* OECD/IEA, Paris, 1999.

[275] International Energy Agency. *Energy Policies of IEA Countries, Japan 2016 Review.* OECD/IEA, Paris, 2016.

percent of electricity. Illustrative of the new push for renewables was the change in its mean annual growth rate from 5 percent between JFY 2003 and JFY 2008 before the Great Eastern Japan Earthquake and Tsunami to a 32 percent growth rate between JFY 2012 and JFY 2013. Japan's energy policies became more actively supportive of renewables, including the introduction of net metering and a feed-in-tariff. In late 2013, METI began a "Green Power Project" aimed at creating a new green industry and market in Japan. METI's Agency for Industrial Science and Technology (AIST) established for the first time a research institute dedicated to renewable energy, the Fukushima Renewable Energy Institute (FREA), in April 2014. It should be noted that dramatic global progress particularly in the United States and Europe in lowering the cost and increasing the efficiency of renewables, especially wind, solar and geothermal, makes renewables a much stronger contender in Japan and globally than previously.

Solar, as shown in Figure 2, so far has been the favorite renewable in the energy mix debate. Offshore wind and geothermal have strong potential and have started to take off since the events of 2011. Much like the opposition to deregulation, opposition to renewables diminished after the Great Eastern Japan Earthquake and Tsunami. Some long-standing regulations inhibiting the deployment of renewables have changed or weakened. For example, Japan has the world's third largest geothermal reserves that prior to 2011 were largely untapped. In 2012, the Ministry of Environment relaxed regulations on production in national parks and protected hot springs. Together, with the feed-in-tariff, new technology with a smaller footprint and new research programs, this action spurred renewed interest. The first new geothermal plant since 1999 opened in 2014 and METI expects 380-850 MW of newly installed capacity by 2030.

Figure 2: Trends in Japan's Renewable Energy



Source: International Renewable Energy Agency

In the aftermath of the events of 2011, renewables became a viable option. Can renewables play the same role as nuclear energy in lowering Japan's dependence on imported fossil fuels? It is unlikely that renewables by themselves will be the answer, but they can be a large part of it. Indeed, the government itself has not settled yet on the potential of renewables or the role of nuclear energy, and makes two projections of the energy mix in 2050, one of which suggests 30 percent nuclear, 40 percent renewables and 30 percent fossil fuels, and the other 50 percent renewables and 50 percent fossil fuels. Either will be difficult to meet. The challenges, as discussed by the authors, are rebalancing renewable energy sources, modifying additional unnecessary regulations (e.g. agricultural water use restrictions that inhibit micro-hydro installations), managing interconnection, overcoming local opposition to projects, and reducing the fiscal costs of renewables promotion.

The Miracles and Beginning of Transformation

Progress toward reaching climate goals suffered after the Great Eastern Japan Earthquake and Tsunami but not as much as expected. Given Japan's history of coping effectively with energy challenges and its skill at reducing CO2 levels, few other countries, if any, could do as well. Japan's "energy miracles" post-Fukushima described by Robert Feldman were real. The first miracle was the stunning improvement of energy intensity in GDP, which fell by 2.79%/year–a bit more than CO2 intensity worsened. The second miracle was that the transformation of energy supply restrained the growth of CO2. This miracle is primarily due to the greater use of natural gas, which emits about half of the CO2 per unit of energy that petroleum or coal do. For Feldman, the concern is that while Japan's energy accomplishments in the wake of the Fukushima accident are praiseworthy, they also raise a difficult and central question for Japan's energy transformation of whether these accomplishments are harbinger or artifact. Will the transformed energy system be as resilient?

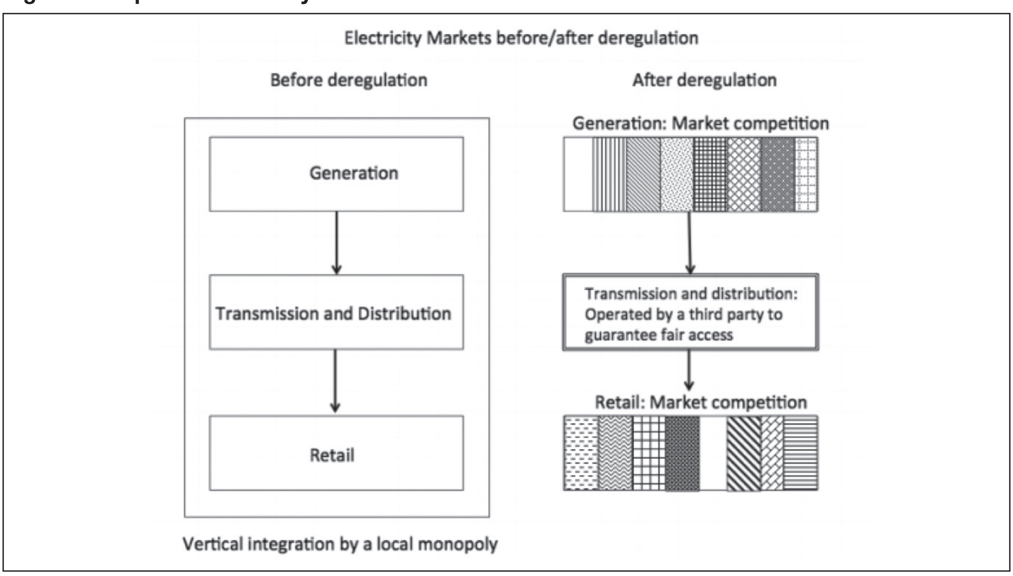
Indeed, the singular extraordinary event of the Great Eastern Japan Earthquake and Tsunami portended a profound transformation, bringing with it an expansion of opportunities for U.S.-Japan collaboration. The fact that Japan has proved remarkably resilient to its latest energy challenge is providing a stable foundation on which the transition to a new transformed energy system is building. The scale of the transformation, however, is easy to overlook because the conversation about change is incremental in its approach. The possibilities, however, are radical.

Hughes characterized and defined change in Japan's power markets as "radical incrementalism." This concept is useful in understanding how the energy policy transformation is occurring. The concept harkens back to a long running debate in the United States and Japan about the best way to innovate. Is it better to approach innovation through incremental improvements or through a radical shake-up? In practice, either can be transformative. The profound transformation of Japan's energy system is being implemented through a step by step approach of perfecting policies and adopting new market tools and practices while remaining cognizant of existing institutions. It can seem frustratingly slow. Is a focus on improvements apt to miss an opening to innovate? It is possible to take the burden of risk aversion so far as to close off new ideas and methods, a potentially devastating error in an increasingly rapidly changing world. On the other hand, is a focus on a radical shake-up more likely to fail because of entrenched interests? Would a radical shake-up dismiss those aspects of the current system such as nuclear energy and energy management that still might be used to great advantage?

Change in the energy sector globally in the past has been difficult due to the heavy investments required for upstream production, generation and transmission. The advent of new technologies and practices ranging from the production of unconventional gas and oil to the decentralized and often off-grid nature of renewables is starting to change that paradigm. Can Japan change and keep up?

The transformation is playing out most clearly in the deregulation of the electricity and natural gas markets along with the change in the energy mix. While some of these changes had already been under consideration or started, Japan greatly sped them up after March 11, 2011. More importantly, the crisis silenced the opposition. Deregulation started with the electricity sector and then moved to the natural gas sector. (Note: Japan deregulated the petroleum market in April 1996.) For electricity, deregulation has opened the generation and retail markets to competition, eliminating the vertical monopolies and enabling new entrants as shown in Figure 3. Nakano pointed out that since April 2016 when the ¥7.5 trillion electricity retail sector was fully liberalized, about 380 enterprises—including existing gas companies, oil wholesalers and telecommunications companies—have joined 10 existing electric utility companies in the electricity retail business. New entrants have gained about a 9.2 percent market share. As expected, new entrants are expressing interest in increasing renewable energy generation, but many are focusing on coal power plants because of the relatively low cost of imported coal compared to LNG. Unbundling the transmission and distribution sector will happen in 2020. The new entrants also are bringing new business practices to the market. Deregulation, however, is still playing out and it is difficult to overstate the scale and potential impact of the challenge for existing utilities and new entrants, and challenge of integrating the two types of players in a manner seamless to ultimate consumers.

Figure 3: Japan's Electricity Market Structure



Source: Koichiro Ito, Energy Policy Institute, University of Chicago

As with electricity, gas market reform started as early as 1995 but proceeded slowly. The events of March 2011 sped it up. In April 2017, Japan deregulated the retail gas market except for existing regulated tariffs for small users that will phase out if possible. Greater third party access to LNG import terminals also occurred. The gas pipeline network will be deregulated (unbundled) in April 2022. This will be difficult as there is no national gas transmission system in Japan; instead, a rather fragmented regional structure exists. In addition, the demand for gas could change depending on the success of renewables and/or the number of nuclear restarts. It is hoped deregulation of gas, as with electricity, will increase competition, lower consumer prices, encourage the development and deployment of new technologies, and increase investment in infrastructure.

As deregulation and reform play out, as the relative roles of renewables and nuclear are defined, and as the extent of transportation electrification and autonomy are clarified, the magnitude and timing of Japan's energy transformation will become clearer. However, the transformation, in reality, has already begun.

Global Leadership and Bilateral Implications

The singular extraordinary event of March 11, 2011 also holds a message for the United States and global energy markets. Japan's experience sounds a note of caution that extraordinary singular events can and do happen. Preparation, flexibility, and a diversified portfolio of energy supply and demand options are necessary ingredients to create the sufficient underlying resiliency that is needed for a successful response. In the midst of the dizzying unconventional hydrocarbons revolution, the United States finds it is easy to be complacent about energy security, but doing so entails risks that a singular event would uncover. Japan was resilient enough to contain and mitigate the immediate challenge to its physical infrastructure but experienced an immense political and psychological jolt over the role of nuclear energy, causing its commercial oligopolistic market tempered by a persistent government presence to change and evolve.

The geopolitics of fossil fuels of course affects not just Japan's but energy security globally. For example, U.S. energy security is tied intrinsically to geopolitics despite the United States' large and growing domestic energy supply sources. The United States should become the world's largest crude oil producer by 2023 according to the International Energy Agency (IEA). However, the United States still relies on the Organization of Petroleum Exporting Countries (OPEC) for 30 percent of its oil imports. The severity of the 2017/2018 winter in the northeastern United States increased demand for expensive fuel oil and brought shortages of natural gas. It even led to imports of Russian LNG for the first time, partly due to the lack of sufficient pipelines and Jones Act restrictions on coastal shipping (e.g., there are no U.S. flagged LNG carriers). In the coming years, this situation could repeat with more severe winters and other weather events (hurricanes, floods) predicted in the United States due to climate change. The United States also expends tremendous military and other resources on preserving its and the world's access to fossil fuels to maintain global energy security. Thus, imported fossil fuel dependence remains the most critical obstacle globally and in both countries' efforts to increase energy security.

In addition, fossil fuel dependence contributes to Arima's "quadlemma": decreased energy self-sufficiency, a deteriorating trade balance, high electricity tariffs, and increased

CO2 emissions. Increased CO2 emissions in particular are a global energy security issue. Resilience of energy infrastructure to natural events such as tsunamis and increasingly intense weather phenomena as well as to man-made incidents such as cyber-attacks are an increasingly integral component of energy security policy that nations should recognize and address. The authors in this book pointed out that supply and demand for fossil fuels, increasingly global coal and natural gas markets and climate change are not the only areas of shared energy security concerns and interests. The future of nuclear energy, electrification, deregulation of energy markets, and the development of new technologies are all also areas of common interest.

Japan's global leadership has been critical in the past to global energy security and will be in the future as it navigates its energy transformation and shares what it has learned. Japan must maintain its international leadership role in developing and disseminating technologies and methods to increase energy efficiency. Japan also should continue the international activism it demonstrated with natural gas markets. Its leadership in multilateral fora like the IEA and APEC can continue to contribute to global and regional energy security and thus that of itself and the United States. Finally, Japan should actively cooperate with the United States and other like-minded countries in the development and deployment of the next generation of advanced nuclear reactors.

Greater U.S.-Japan cooperation also can advance both countries' energy security strategies, ameliorate non-energy trade imbalances, and deepen the U.S.-Japan strategic alliance. Japan's lack, and the United States' wealth, of energy resources creates opportunities for additional energy trade and direct foreign investment in both directions in fossil fuels and renewable energy that should be developed to a greater extent. Joint research, development, and demonstrations should expand to accelerate technological innovation. This work should include advanced nuclear energy, hydrogen, highly efficient, low-emission coal technologies, carbon capture and storage, digital technologies, renewable energy, distributed energy, and energy storage systems. The United States and Japan also must continue to share experiences and lessons learned with energy deregulation, infrastructure resilience, climate change, intermittent and variable renewable electricity, and energy demand reduction including DSM with each other and multilaterally.

Recommendations for Transformation

Japan's energy transformation offers a plethora of opportunities to increase Japan's energy security, strengthen Japan's global leadership, and expand U.S.-Japan cooperation. Overall, Japan should pursue an "all fuel" and "all technology" approach to energy policy for energy security and resilience as proposed by the International Energy Agency Executive Director in February 2018 and elaborated in the IEA's Energy Policies of IEA Countries, Japan 2016 Review.[276]

In addition to the IEA's recommendations, METI's Roundtable for Studying the Energy Situation (エネルギー情勢懇談会) released its report in April 2018.[277] The report

[276] Dr. Fatih Birol, Executive Director of the International Energy Agency, *Presentation at The Round Table for Studying Energy Situations*, METI, Tokyo, 27 February 2018.
[277] METI Roundtable for Studying the Energy Situation, *April 25, 2018 Committee Report at* http://www.enecho.meti.go.jp/committee/studygroup/ene_situation/009/pdf/009_006.pdf.

sets out five policy problem areas and made broad suggestions to address the challenges in each. The five areas are: renewable energy, nuclear power generation, thermal generation, heat and transportation, and energy conservation and decentralized energy. In general, the report places a strong emphasis on renewable energy and leaves open the question of nuclear energy use until the restoration of social trust. It points out an immediate need to strengthen human resources, develop technology and decarbonize. It also noted the continued use of fossil fuels during the transition, including responding to geopolitical risks.

Authors in this book pointed out opportunities to pursue an "all fuel" and "all technology" approach and offered recommendations for Japan's policymakers and people to consider going forward, the most important of which are highlighted below. The recommendations are consistent with those of the IEA and the METI Roundtable for Studying the Energy Situation but contain a stronger emphasis on utilizing distributed energy systems, finding the role for nuclear energy, and ensuring transparency in deregulation and market function. In short, Japan's successful transformation of its energy system requires a profound change to ensure an affordable and environmentally friendly energy system resilient to the unexpected.

Recommendations

1. Policymakers must ensure electricity and natural gas market deregulation and reform is transparent, increases competition, and creates opportunities for new Japanese and international actors, and for new technologies and practices.
2. Japan must reverse its underinvestment in and underutilization of renewables as a major source of domestic supply to enhance energy security and environmental sustainability. U.S. and other foreign companies could play a larger role in accelerating renewables deployment in Japan with sufficient opportunities.
3. Japan must give special attention to mass transportation in smart-urban and -suburban environments, vehicle electrification, hydrogen-fuel vehicles, and autonomous-drive technologies to mitigate oil consumption.
4. Japan must actively explore the next generation of advanced nuclear reactors to determine how they can play a role in Japan's energy future and energy security. Such reactors could provide carbon-free power with safety features that passively cool reactor cores and lower cost through mass production with fewer components, smaller sizes, proliferation resistance technology, and small land footprints.
5. Adequate system flexibility, especially the expansion of transmission interconnections, must play a role in lowering energy demand and achieving Japan's goal of cutting greenhouse gas emissions from 2013 levels by 80 percent by 2050.
6. Japan must limit investment in the fossil fuel power plants to generators with the highest operational efficiency to support environmental and climate goals for security, health, and resiliency.
7. Advances in energy storage systems, digital technologies and hydrogen technologies have been numerous but Japan must push these technologies considerably harder and faster.
8. Japan must maintain momentum in energy demand reduction by continuously expanding coverage of products, sectors, and parts of sectors, such as recent

expansion of energy efficiency standards for the new buildings. Practices like demand supply management (DSM) should be widely implemented.

9. Japan must continue to find and pursue opportunities to collaborate with the United States and other global partners to support global energy security.

Conclusion

For the imaginable future, Japan's energy conundrum that developed at the beginning of the last century will continue. Japan's three "3Es" plus "S" (e.g., energy security, economic growth, environment, and safety) concept remains valid as an organizing framework for its energy policy.

Japan's energy transformation is underway. Greater competition, new investment, renewable energy growth, international activism, and a low-carbon environment are all trends that will continue. The challenge of access to imported fossil fuels will remain. The transportation sector will run on oil until there is success in the mass deployment of battery electric vehicles and/or fuel cell vehicles. Deregulation will strengthen Japan's energy security through increased competition and new entrants, and result in more efficiency, flexibility, and innovation. Increased domestic production of renewables and a possible new model of nuclear power will strengthen energy security and help Japan meet its climate goals.

Opportunities will abound in the energy sector for U.S.-Japan collaboration, including increased trade, investment, research, and cooperation in multilateral forums. Japan and the United States will have to prepare to be as resilient as possible for those unexpected singular extraordinary events that can and will change their paths and international energy markets going forward.

Japan has proven remarkably resilient so far in navigating its energy conundrum. Challenges remain, including adapting to population aging, lifestyle changes, flat energy growth, and changing geopolitics – all of which also apply to the United States. Inertia and existing stakeholders will slow its energy transformation. So far, it is transitioning with its focus on solutions. Japan cannot escape its energy conundrum in the foreseeable future but can mitigate it through a competitive energy market, diversification of fuels and supply sources, close attention to lowering demand, and enhanced U.S.-Japan cooperation bilaterally and in multilateral fora.

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SASAKAWA USA
Sasakawa Peace Foundation USA

1819 L Street NW #300
Washington, DC 20036
info@spfusa.org

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