Chapter 3

Japan's Electricity System: Reform After Fukushima

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Introduction

Following the Fukushima Daiichi nuclear power plant incident of March 2011 (hereafter referred to as "Fukushima"), Japan's energy policy is in need of a radical overhaul. The first issue is the mid- to long-term discussion regarding Japan's energy mix, specifically what to do with the country's nuclear power plants. In September 2012, the Democratic Party of Japan put forth the "Innovative Energy and Environment Strategy," which included abandoning nuclear power, but with the change of administrations at the end of December of the same year that strategy was scrapped. Subsequently, in April of 2014, the Cabinet of Prime Minister Shinzo Abe approved the "Basic Energy Plan 2014," thereby reopening the way towards a return to nuclear power, but the contents of that plan are broad and give little in the way of direction.

The second issue, and the main topic of this paper, is the reform of the electricity system. This would involve unbundling transmission grids from vertically integrated utilities and completely liberalizing the retail market in order to allow the large-scale deployment of renewable energy sources (RES) and give consumers more choices. This endeavor has continued even after the change of administration, with the Abe Cabinet steadily pushing forward with amending the Electricity Business Act. Reforming the regulations surround-

ing the current monopolistic electricity industry will provide new business opportunities, and many companies are preparing to enter the market.

When it comes to electricity reform, the key phrase is distributed energy sources (DES). In the past, most electricity systems around the world have been comprised of large-scale power companies, which combine power generation and transmission, developing nuclear and large-scale coal power plants (i.e., centralized power generators), and long-distance transmission grids built systematically from those locations. In contrast to such centralized systems, a new system is appearing around the world—a distributed electricity system in which various new market entrants develop RES, companies install co-generators in order to supply their own energy needs, and demand response (DR) aggregators stimulate so-called "negawatts" from customers.[1]

For a long time it was believed around the world that centralized electricity systems were superior, but from the 1990s on, distributed systems began to be revisited by Western countries. The reason: A changing environment due to electricity market liberalization and a call for lower carbon emissions. Japan's electricity system reform is an attempt to reassess the overly centralized system in response to the historic incident at Fukushima. A shift towards a distributed system would make it difficult to maintain or develop nuclear power, affecting Japan's electricity structure and energy security as a result. And if such reforms become the global norm, then Japan's efforts will no doubt have a ripple effect on the rest of Asia as well.

The purpose of this paper is first to understand Japan's electricity system reform before considering the effects on a distributed elec-

1. "Negawatts" is a notion advocated by Amory Lovins. If consumers could save electricity effectively in response to supply shortage, the "minus supply" would be an equivalent to costly additional power generation. See Amory B. Lovins, "The Negawatt Revolution," *Across the Board* XXVII, no. 9, September 1990, available from https://www.rmi.org/wp-content/uploads/2017/06/RMI_Negawatt_Revolution_1990.pdf.

tricity system, and finally providing an outlook of the future. The first section examines Japan's electricity crisis following Fukushima and lays out the details of electricity system reform. The second section first defines DES before identifying the need to shift to such an electricity system and concomitant challenges. The third section introduces the current state of DES in Japan and its future potential, after which it examines the effects of Japan's energy policy, including electricity system reform. The final section gives an outlook on DES in East Asia.

Electricity Crisis After Fukushima and Electricity System Reform in Japan

Centralized Electricity System and Electricity Liberalization

Before 1990, most countries had electricity systems with legal monopolies and vertical integration from power generation to transmission and retail. Because the economy of scale works in such a system, the power company with monopoly was able to invest heavily in centralized power sources like nuclear and large-scale hydroelectric plants and long-distance transmission grids, and recoup its investment through regulated prices. As a result, self-generated power was uncommon, other than for in-house or emergency use, and the introduction of renewable energies was severely limited. In a centralized electricity system, it was very difficult and uneconomical for anyone but the monopoly-holder to own power plants and sell the electricity generated there.

From the 1990s onward, however, electricity liberalization became a strong trend among developed nations. While small gas turbines became more economical, it also became easier to integrate and control diverse power generators as information technology (IT) advanced. Consequently, opening up the generation and retail markets and having consumers behave based on price indices allowed

the resources of the whole system to be distributed more efficiently. These were the underlying factors of electricity liberalization.

In Great Britain, as the administration of Prime Minister Margaret Thatcher pushed through new liberal reforms in rapid succession, the Central Electricity Generating Board had its transmission separated from other businesses,[2] and was taken private in 1990, and the generation and retail markets were liberalized. Norway and Sweden took similar methods in 1992 and 1996, respectively. The United States' electricity system varies by state, but such large states as New York, Texas, and Pennsylvania are making progress in liberalization. As the economy of self-generation increased, owners of such generators sought entry into the generation market, and retail was also liberalized not long thereafter.

In contrast, Japan has been the wariest of all developed countries when it comes to electricity liberalization. The system of ten regional companies with vertical integration and legal monopolies, formed following World War Two (WWII), was able to cope with the ravenous demand for power during Japan's period of high economic growth. After 1995, liberalization took several steps forward, but the incumbent power companies' opposition was strong and competition policy was not exercised thoroughly. The number one reason for the power companies' opposition to liberalization was stable power supply. They claimed that grid unbundling for the sake of competition would make it difficult to coordinate between the two and would lead to power outages. Their second reason was nuclear power. They asserted that liberalization would lead to the prioritizing of short-term profits, and that power sources which benefitted

2. There are three forms of grid unbundling. Ownership unbundling, generally used in Europe, involves cutting off the transmission section of the integrated power company in terms of capital. Functional unbundling, commonly used in the United States, involves surrendering the operations rights to an independent system operations body, regardless of who owns the transmission grid. Legal unbundling, used in France and some parts of Germany, involves designating the power company as a holding company and the transmission section as its subsidiary. The strongest structural measure is ownership unbundling.

the public, such as nuclear power, would become unsustainable.[3]

In 2003, when the attempt at unbundling failed in the so-called "third-stage liberalization" as outlined above, electricity liberalization faded from the forum of serious discussion in Japan. As a result, almost 40% of all demand was still filled by legal monopolies in the small retail market, and even in the liberalized bulk market, which filled more than 60% of demand, the share of new entrants was no more than 3.5% in 2011 according to the Agency for Natural Resources and Energy's (ANRE) Electricity Survey Statistics.[4] Japan's effective monopolies from before Fukushima had continued until April 2016, when the entire retail market was liberalized.

Fukushima Daiichi Nuclear Incident and the Electricity Crisis

The Great East Japan Earthquake of March 11, 2011, not only caused a hydrogen explosion at the Fukushima Daiichi nuclear power plant and the resulting radiation contamination of the environs, it also brought about an electricity crisis, in which supply fell to critical levels. The magnitude 9.0 earthquake and 10-plus meter-high tsunami rendered utterly inoperable not only Fukushima Daiichi (six reactors totaling 4.7 gigawatts [GW]), but also other centralized installations arrayed along Japan's Pacific coast, including the Fukushima Daini nuclear power plant (four reactors totaling 4.4GW), the Hirono thermal power plant (five generators totaling 3.8GW), and the Kashima thermal power plant (six generators to-

3. In the Agency for Natural Resources and Energy's (ANRE) Electricity Business Subcommittee Meeting report which discusses unbundling, it states: "In order to advance large-scale power generation businesses such as nuclear power, they must be combined with transmission businesses," and that "even if retail liberalization progresses further, we must create an environment in which nuclear power can be pushed forward." See, Agency for Natural Resources and Energy, "On the Future Desirable Framework of the Electricity Business," February 18, 2003.

4. Agency for Natural Resources and Energy, "Electricity Survey Statistics," March 31, 2014.

taling 4.4GW). The Tokyo Electric Power Company (TEPCO), Japan's largest electrical company, had more than 60GW of installed capacity, but three days after Fukushima, on Monday, March 14, it could muster no more than 31GW.

TEPCO called for the aid of its counterparts across Japan, but the transmission grid connecting TEPCO's region with that of Chubu Electric Power has a capacity of only 1GW—a drop in the bucket. Although western Japan had not been severely affected by the disaster and had tens of gigawatts of electricity to spare, eastern Japan could not make use of the power.

Consequently, TEPCO enacted rolling blackouts on March 14, 2011, for the first time since WWII. By subdividing its supply regions and stopping electricity to each area in a set order and by time period, TEPCO avoided large-scale, unpredictable power outages. However, because there was little time to prepare for and publicize these rolling blackouts, many people were irked by the unilateral and across-the-board measures taken by TEPCO.[5] Much criticism suggested that if pricing plan menus, which encouraged peak shifting, had been widespread, and if smart meters had been installed in homes, then energy would have been saved more effectively based on price mechanisms, and the effects of the rolling blackouts would have been ameliorated.

As thermal power plants were brought back online and the cold winter temperatures started to rise, power consumption dropped and the rolling blackouts ended on March 28, 2011. However, with the annual record-high demand peaks of Japan's hot summer fast approaching, there were still concerns about supply shortages within TEPCO's region. To alleviate this concern, the government enacted an Electricity Usage Limitation Ordinance based on the Electricity Business Act, which required large consumers to cut peak demand by 15% of the previous year's. As a result, during the summer of 2011, peak demand in TEPCO's region fell 18% from 59.99GW

5. On March 17, 1.8 million households suffered rolling blackouts.

the year before to 49.22GW, with a large reduction of 20.7% in the daily average peak demand (between July 1 and September 9) from 51.44GW the year before to 40.8GW.

With such enormous peak cuts, TEPCO was able to avoid both unexpected and planned power outages. However, using an Electricity Usage Limitation Ordinance, which carries penalties for transgressions, had severe effects on the production plans of factories, and criticism of TEPCO increased. With across-the-board peak cuts of 15%, TEPCO had again failed to use a method that allowed flexibility in energy savings between companies which found it easy and those which found it difficult to abide by the ordinance.

Move Towards Electricity System Reform after Fukushima

Policy-makers and power companies were given a shock by many factors related to the fallout from Fukushima: Over-reliance on centralized power generation had caused a supply shortage following the disaster; the transmission system connecting the entire country had not functioned effectively, and they had been unable to adjust supply to meet demand flexibly through market mechanisms. This was because the very same region-based monopoly system, which they had protected under the argument of stable supply being paramount, had inhibited the all-important stable supply of electricity. With the nuclear power plant incident and the criticism of the power companies by the Japanese people weighing on them, the ruling Democratic Party of Japan set about reforming the electricity system.

In February 2012, the Agency for Natural Resources and Energy established the Electricity System Reform Expert Subcommittee and began discussing reform proposals. Normally, executives of several power companies would be present, but this time they were excluded; the majority of committee members were economists and other reformists. The midterm report, delivered in July 2012, included an idea from 10 years earlier: Grid unbundling. Thereaf-

ter, the committee continued discussions, and following the change of administrations in December, it delivered the final report to the Abe administration in February 2013.

The goals of the reform outlined at the beginning of the report were fourfold: (1) To expand introduction of renewable energies, which had been severely lacking in the past; (2) to promote cross-regional supply-demand adjustment; (3) to give households and other consumers choice in power companies and services; and (4) to make use of demand response. To summarize, the goal was to account for variable power sources and widely changing power structures while building a stable power supply system that makes use of market mechanisms.

The committee's detailed plan can be summarized in three points. First is the establishment of the Organization for Nationwide Coordination of Transmission Operators. After reflecting on the electricity crisis, the committee decided to establish a national organization (incorporated body) which would coordinate system operations and grid development plans among power companies across the country, thereby promoting a flexible electricity supply between regions. In 2013, the Electricity Business Act was amended, with the establishment of this organization planned for 2015. Once this is accomplished, large wind-farms can be built in Hokkaido, which has an excellent wind environment, and the resulting power can be sent to Japan's main island of Honshu, where supply-demand coordination can be carried out with ease.

Point number two is the complete liberalization of the retail market. The June 2014 amendment to the Electricity Business Act has completely opened all retail markets, including the households market that had been under monopoly until April 2016, providing consumers with the ability to choose. Not only will the new competition drive down prices, but a greater variety in price plans will allow expanded smart demand response, and new services in combination with electric vehicles and fuel cells will become available.

Finally, the committee set forth grid unbundling as a structural competition policy. The proposal is to make the original vertically integrated power company into a holding company and name the transmission section as a subsidiary or separate company. This legal unbundling would take effect no later than 2020 according to the amendment to the Electricity Business Act. This would effectively render the transmission company neutral and remove the issues of renewable energies and new market entrants connecting their generation facilities to the power grid. At the same time, a real-time balancing market would be created and supply-demand would be coordinated efficiently based on market principles.

These reforms would not simply stop at liberalization, but may open the way to the distribution of the entire system. Here let us switch focus and look at the DES of developed countries and how Japan's electricity system reform relates to them.

Distributed Energy Sources and Electricity System Reform

What Are Distributed Energy Sources?[6]

There are many possible definitions of DES or distributed generation.[7] European Union (EU) Directive 2003/54/EC concerning

6. For previous comprehensive research on DES, see, Amory B. Lovins, *Small is Profitable*, Snowmass, CO: Rocky Mountain Institute, 2002; Jeremi Martin, *Distributed vs. centralized electricity generation: are we witnessing a change of paradigm?* Paris: HEC Paris, 2009; and John P. Banks, et al., *Assessing the Role of Distributed Power Systems in the U.S. Power Sector,* Washington, DC: Brookings Institution Energy Security Initiative and Stanford, CA: the Hoover Institution Shultz-Stephenson Task Force on Energy Policy, 2011.

7. For previous discussion on definition of DES, see, Thomas Ackermann, Goran Andersson, and Lennart Soder, "Distributed Generation: a definition," *Electric Power Systems Research* 57, no. 3, April 2001, pp. 195-204; and Guido Pepermans, Johan Driesen, Dries Haeseldonckx, Ronnie Belmans, and William D'haeseleer, "Distributed generation: definition, benefits and issues," *Energy*

common rules for the internal market in electricity defines them as "generation plants connected to the distribution system."[8] On the other hand, a 1999 report from the International Conference on Electricity Distribution (known by its French acronym CIRED) focuses on generation capacity up to 50MW or 100MW at most.[9]

In this paper, we will use the following four categories. First, historically speaking, the term "DES" has referred to electricity self-generation. In contrast to the large-scale generators of power companies, businesses will sometimes install small or mid-sized thermal generators in their factories to supply their own inexpensive power. Called "customer-owned power generators" by big power companies, these setups experience almost no power loss due to transmission or distribution because the generator is on-site; they allow for cogeneration and they are excellent for facilitating business continuity in emergency situations. The falling prices of small gas turbines and innovations in cogeneration technology spurred private generators usage and from the 1990s onward they have gained in popularity.

The second category are renewable energy sources (RES). The falling prices of wind turbines and solar panels from the 1990s resulted in RES becoming a global trend (Figure 1). Global warming and the introduction of policies prioritizing and subsidizing renewable energies in many countries also contributed to this trend. In addition to highly variable power sources such as wind and solar, biomass, geothermal, solar thermal and small hydroelectric energies currently in use, there is hope that we will be able to use wave and tidal energies in the future with the necessary technological advances.

Policy 33, no. 6, April 2005, pp. 787-798.

8. European Union, "Directive 2003/54/EC of the European Parliament and of the Council," *Official Journal of the European Union*, L 176/42, Luxembourg: Publications Office of the European Union, June 26, 2003, available from https://eur-lex.europa.eu/legal-content/ENG/TXT/PDF/?uri=OJ:L:2013:176:FULL.

9. N. Jenkins, et al., "CIRED Working Group 4 on Dispersed Generation," preliminary report prepared for CIRED 1999, the 15th Annual International Conference and Exhibition on Electricity Distribution, Nice, France, June 1-4, 1999.

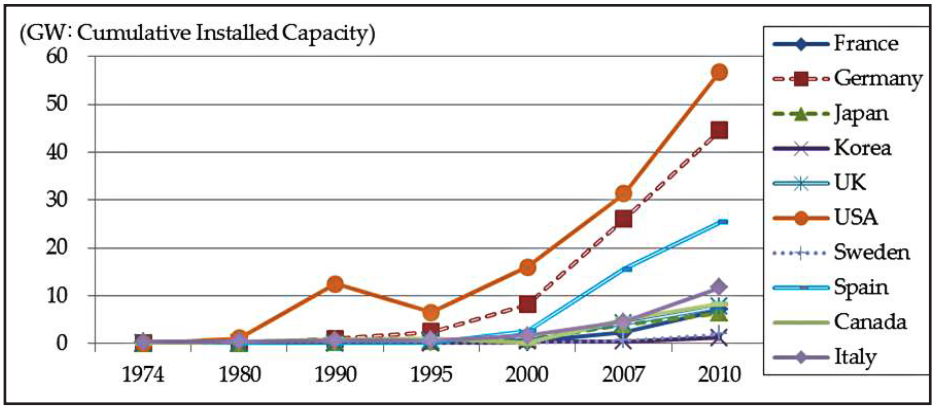

Figure 1. Renewable Energy (Except Hydroelectric) Installed Capacity of Leading Countries.[10]

The third possible category is fuel cells and storage batteries, a recent technological innovation expected to spread in the future. Fuel cells produce electricity by taking natural gas, reforming it into hydrogen gas and causing a chemical reaction. The advantages of fuel cells are that they can be used in cogeneration, their energy efficiency can be increased, and they produce relatively little carbon dioxide (CO_2). Furthermore, batteries that store energy but do not generate electricity can also be considered as part of DES. In the past, storing electric energy was very difficult, but if large capacity lithium-ion batteries and sodium-sulfur (NaS) batteries continue to become less expensive, they will become ubiquitous in the electricity system and play a large role in supply-demand adjustment.

The fourth and final possible interpretation of DES is demand-side coordination, or demand response (DR). For example, if consumers cut peak usage by a certain amount when supply-demand is tight, that is of equivalent value to the expensive extra power generation that would have been required to meet that demand. This concept, called "negawatts" by Amory Lovins, could provide a valuable

10. International Energy Agency, *Electricity Information*, 2012 edition, Paris: Organization for Economic Cooperation and Development/International Energy Agency, 2012, p. III.8.

source of energy by borrowing the power of IT to effectively control consumer behavior. Furthermore, negawatts don't simply have zero carbon emissions, they reduce energy consumption and increase energy efficiency and self-sufficiency. Because the source of negawatts lies in each and every consumer, it is the most extreme form of DES.

To summarize the above, while there are many types of DES, they all have the characteristics of being small-scale, consumer-side, and owned by those other than incumbent power companies. As a result, in the existing centralized electricity system, DES have been limited to little more than a supplementary role, and power companies have not actively pursued their development. However, recent changes in the power generation environment, such as cost reduction through technological innovation, increased economic value due to liberalization, and the call for lower carbon emissions, have caused many to revisit DES as a possibility for the future.

Distributed Electricity System for Distributed Energy Sources

The biggest reason that monopolistic power companies have not pursued DES is that it threatens to alter their existing business model and would require a new distributed electricity system.

First, grid unbundling would be essential. During the period of centralized energy dominance, only monopolistic power companies were able to develop large-scale power generation plants and there was no need to allow others to use the transmission grid. However, if various new entrants were to sell their self-generated power, or if RES were introduced into the system, the transmission grid would have to be made open to all. In Western countries, the structural measure generally used to achieve this is unbundling, but the vertically integrated power companies are obviously opposed to this.

Second, the transmission and distribution grid would need to be expanded and upgraded. A centralized energy system has a relatively limited number of large-scale power sources, and as such monopo-

listic power companies are able to plan out the transmission grid with one eye on the locations of those plants. In other words, the existing grid is optimized for the existing centralized electricity system. However, a distributed electricity system is spread out geographically, and so the transmission grid would have to be expanded into areas it was not previously needed, such as northern Hokkaido. Additionally, with the recent advances in IT, grid operators have become able to directly control dispersed wind generator outputs and DR has become very effective through the use of smart meters. The question of who will take the responsibility and burden for investing in such technologies will become a significant issue.

Third, how the grid is operated will have to change. For example, Germany's renewable energy law stipulates that renewables are prioritized for connection and dispatching. Also, with the increase in the number of variable power sources, the use of adjusting power supplies will change, too. Not only will grid operators face new challenges to provide a stable power supply, but power generation businesses will face the issues of falling use rates for gas thermal power and the need for output-adjusted operation of nuclear and coal thermal plants as well.

Finally, the design of the market would change. Grid unbundling would mean that grid operators would no longer have generation facilities, so any supply-demand adjustment would in principle be done through the market. Supply and demand would be roughly matched based on the previous day's spot market, with final adjustments being made on today's real-time balancing market. Such markets would need to be created and the setups of both grid operators and power generation businesses would change. New players, such as traders and DR aggregators, would need to be involved in these markets. There is also discussion of the need for a capacity mechanism for thermal generation plants, which are seeing reduced capacity factors.

As we have seen, the expansion of DES calls for the distribution of the electricity system and calls for a radical shift in existing busi-

ness models. In Germany, the government's policy shifts away from nuclear power and towards renewables and electricity liberalization have led not only to the corporate breakup of incumbent utilities, but to their falling behind in investing in renewables and the falling capacity factor of gas thermal generation.[11] In order to give DES a policy advantage, large and systematic policy change is necessary.

Issues with Distributed Energy Sources

DES are being re-evaluated in more and more leading developed countries, with European countries in particular, such as Germany, Denmark, and Spain, steadily making progress by giving it policy priority. Whether from the standpoint of energy self-sufficiency, climate change, safety against terrible disasters, next generation technologies, or international competition, there is hope that distributed will replace centralized energy systems in the future. However, there are many uncertainties and obstacles along that path.

The first obstacle is economic. DES are still less economical than centralized power sources because they do not follow the rule of economies of scale. Among RES, wind power has fallen in price significantly, but fuel cells still lack competitiveness. While DR is being applied practically in the United States, a structure for effectively gathering negawatts has yet to be established. Until we see further technological innovation and volume efficiency, it will be economically unfeasible to depend on DES.

Second is the technological uncertainty of system reform. As mentioned above, in order to reform towards a mainly distributed electricity system, one must first provide effective measures to stabilize variable power sources and come up with a DR program using market mechanisms. Variable power sources account for approximately 30% or more of Germany's and Denmark's power mix and

11. E.g., "How to lose half a trillion euros," *The Economist*, October 12, 2013, available from https://www.economist.com/briefing/2013/10/15/how-to-lose-half-a-trillion-euros.

they have yet to experience any significant operation problems, but there is no guarantee that this will hold true at 80%. Furthermore, expanding the transmission grid and establishing hydrogen infrastructure for a distributed system would require enormous investment. Who would take such risks, and how? What would the timeline of reforms look like? These issues are still being discussed in many countries.

Third is the issue of what to do with existing power companies after such a momentous structural shift. In other words, how can the opposition of the incumbent power companies be restrained and how can they be made to step down peacefully? The reason Japan was not able to achieve unbundling was because the opposition of the power companies was just too strong. Additionally, giving favor to distributed power sources means that centralized power will become disadvantaged. After electricity began to be liberalized in the 1990s, many developed countries saw a plateau in the number of new nuclear power plants being built (Figure 2). In response to this, the British government introduced "Contracts for Difference" for new nuclear plants. It will be difficult to develop DES without finding such a balance of policies.[12]

12. "Contracts for Difference" (CfD) is a policy instrument to support low-carbon power sources by guaranteeing the selling price of such electricity for 15 years for RES and for 35 years for nuclear. See Department of Energy and Climate Change, "Electricity Market Reform: Delivering UK Investment," Cm 8674, London: The Stationary Office Ltd., June 2013, available from www.gov.uk/government/uploads/system/uploads/attachment_data/file/209276/EMR_Spending_Review_Announcement_-_FINAL_PDF.pdf.

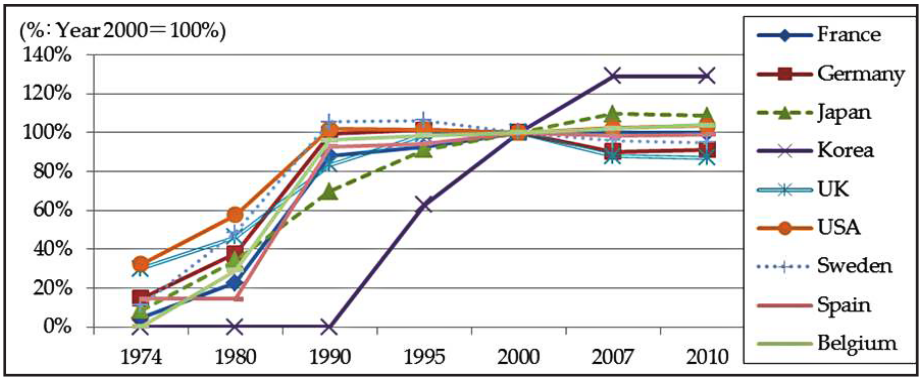

Figure 2. Installed Capacity of Nuclear Power Plants in Leading Countries.[13]

Potential of Distributed Energy Sources in Japan

State of Distributed Energy Sources in Japan and Related Industrial Infrastructure

There is no clear agreement in Japan on whether the country can make the shift to DES and a distributed electricity system as outlined above. Japan has not introduced very much renewable energy (Figure 1) and electricity liberalization has made no headway. Nevertheless, the electricity system reform that the Japanese government is currently pursuing seems to be aiming towards a distributed system. If so, does Japan, in fact, have the necessary technological and industrial wherewithal to actually make use of DES?

First of all, Japan boasts the most electricity self-generation in the world, with 3,963 facilities producing 57.70 GW (Figure 3). This number is greater even than the installed capacity of domestic nuclear plants and has been growing steadily over the past several years. While many of the generators are thermal ones, this number is likely

13. International Energy Agency, *Electricity Information*, 2012 edition.

to continue growing as the memory of the rolling blackouts after Fukushima is still fresh in people's minds. Approximately half of self-generation capacity is consumed in-house, while the remaining half is sold off. Self-generated electricity has been an important power source for new power companies to date, and as liberalization makes inroads, the increase in self-generation will help with the growth of the distributed system as well.

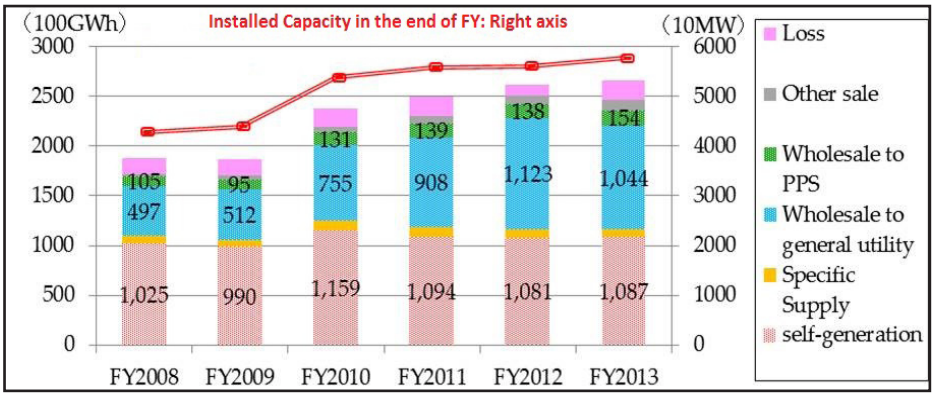

Figure 3. Generated Electricity and Installed Capacity of Self-Generation in Japan.[14]

Second, Japan still has not introduced very much RES at all. If large-scale hydro-electric generators are excepted, RES account for only 1.7% of Japan's electricity generated,[15] well behind most other developed countries. Two of the largest contributing factors are the fact that renewables received a very low policy priority and the fact that it is very difficult for them to connect to the grid under the vertically integrated system. However, Japan possesses even greater resource potential than Germany,[16] one of the leading

14. Total installed capacity of Japan's 10 general electric companies is 209.32GW. Agency for Natural Resources and Energy, "Electricity Survey Statistics," March 31, 2014.

15. Renewable energy electricity generation was 16.94TWh (Ibid).

16. According to a 2011 report of a government cost verification committee, under certain developmental conditions, Japan's renewable energies were estimat-

countries in renewables in the world. Japan also has many leading manufacturers of solar panels, wind turbines, and geothermal generators. Accordingly, a large introduction of renewables would have a significant impact in terms of Japan's industrial policy, as well.

Third, although fuel cells and large capacity storage batteries are still in their initial stages globally, Japan is positioned at the forefront of the field. Japan's sales of household-use fuel cells have expanded annually, from 24,517 in 2012 to 40,447 in 2015.[17] One must not overlook Toyota Motor Corporation, who introduced the first ever fuel cell vehicle on the market in December 2014.[18] Japan is also a world leader when it comes to large capacity storage batteries, with advanced lithium ion battery technologies in its hybrid and electric vehicles.[19] Finally, Japanese companies are some of the world's leading storage battery manufacturers, with NEC, Panasonic, and Sony all hailing from the island country.

Fourth and finally, while Japan's market is still too small for DR to have a significant impact, Japan may have some of the most conscientious consumers in the world. When supply-demand was tight

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ed as follows: Solar 91GW, on-shore wind 150GW, geothermal 4.3GW. National Policy Unit, Energy and Environmental Council, "Cost Verification Committee Report," presented at the Energy and Environment Conference, December 19, 2011, Japanese version available from www.cas.go.jp/jp/seisaku/npu/policy09/pdf/20111221/hokoku.pdf.

17. Third, although fuel cells and large capacity storage batteries are still in their initial stages globally, Japan is positioned at the forefront of the field. Japan's sales of household-use fuel cells have expanded annually, from 24,517 in 2012 to 40,447 in 2015.

18. Toyota, "Toyota Opens the Door and Invites the Industry to the Hydrogen Future," *Toyota-USA Newsroom*, January 5, 2015, available from corporatenews.pressroom.toyota.com/releases/toyota+fuel+cell+patents+ces+2015.htm.

19. According to the Next Generation Vehicle Promotion Center website, vehicle retention numbers in 2012 were: PHV 17,281; EV 38,707; and hybrid 2,852,105. See "Number of Electric Vehicles Owned (Point Estimate)," Next Generation Vehicle Promotion Center, available from http://www.cev-pc.or.jp/english/archive/whitepapers/owned.html.

following Fukushima, DR was thought to be an important solution, and DR aggregators such as NTT Facilities and Eneres worked together with power companies to roll out a program. Foreign companies such as America's EnerNOC and France's Energy Pool have also entered Japan's market. Unfortunately, under the current vertically integrated system, market mechanisms don't work and there are still no real-time balancing or capacity markets; electricity system reform is needed before these things can happen.

Energy Policy after Fukushima and Future of Distributed Energy

As we have seen above, Japan has plenty of potential for developing the distributed electricity system. However, DES has received very little policy backing to date and consequently has remained ineffective, and Japan's centralized electricity system of the past remains firmly sustained. The fate of DES in Japan therefore hangs on an array of policies. As the title of this paper implies, I will now examine whether or not the electricity system reform after Fukushima and other energy policies are truly aiming for DES.

First of all, Japan's policy position on DES remains unclear. In April 2014, the Abe administration published the first Basic Energy Plan since Fukushima, but it was very broad and difficult to understand. RES are described as "an important domestic low-carbon source of energy,"[20] but at the same time the document says of the future of the feed-in tariff program begun in 2012 that it would be "generally reviewed" from the viewpoint of "minimizing the burden on citizens."[21] Based on this plan, the tariff to purchase electricity produced from RES was continuously reduced, and the Feed-in Law was revised in 2016 so that auction to large-scale solar photovoltaic (PV) would be introduced in 2017.

20. In the original proposal in December 2013, renewable energy was not described by the adjective "important" and was not highly evaluated. The adjective was added later, following a party conference.

21. Government of Japan, *Basic Energy Plan*, April, 2014.

Second, the Basic Energy Plan still assigns a key role to centralized power sources. Nuclear power plants, which had all been shut down by September 2013, are described as "important base load power sources." Because it is difficult for nuclear power plants to maintain their businesses due to stricter safety standards put in place after the Fukushima nuclear disaster, the government is considering new ways of supporting them, such as limiting liability in the case of a severe accident, covering the costs of decommissioning reactors, and the implementation of a Contracts for Difference program as in Great Britain. Coal is also given a place as "an important fuel for base load power sources." After Fukushima, the environmental assessment standards for coal-fired thermal power plants were relaxed, and 5GW worth of new facilities is planned for the early 2020s.

As it happens, the Basic Energy Plan has a section titled "Expanding the Distributed Energy System." However, no clear definition is given, and judging from the context, it seems to mean "distributed energies such as renewables and cogeneration" will be managed "in communities of a certain size" "using IT and storage battery technologies."[22] Essentially, this means that the centralized electricity system will be preserved and a distributed system will be used in a supplementary role in certain areas, thereby absorbing the variability of RES.

Third and finally, although DES requires electricity reform, the detailed reform plan has many compromises as stated above, and it will not be implemented quickly. For example, not only was the grid unbundling watered down to a very weak structural measure, i.e., legal unbundling, but it is set to be implemented no later than 2020. Competition policy in power generation is also not getting the reforms it needs. Power generation facilities will not be bought back as they were in the United States, nor will dominant generation companies be forced to sell their wares on the wholesale market. Furthermore, it is general practice to establish an independent regulatory body when liberalizing the electricity market, but the gov-

22. Ibid.

ernment seems set to establish a minimally independent body, the so-called article-8 council, within the Ministry of Economy, Trade, and Industry. While the government touts electricity system reform as one of the pillars of its growth strategy, it seems to be taking pity on the financially struggling power companies and moving forward very slowly and with many compromises.

Outlook on Distributed Energy Sources in East Asia

Industrial Infrastructure for Distributed Energy Sources in Non-Western Countries

In Western developed countries, there has been a trend from centralized energy to distributed energy, from centralized electricity systems to distributed ones. Conversely, rapidly growing developing countries still rely heavily on coal-fired thermal and nuclear power generation. Many of these countries have not liberalized their electricity markets and still have state-run power companies with vertical integration. Without a shift in their energy policies and electricity systems, it is doubtful that DES will spread.

Another possibility for accelerating DES is the precipitous drop in costs brought about by a disruptive technological innovation. For example, in the 1990s developing countries did not have many landline telephones, but the IT revolution led to the sudden prevalence of cellular telephones. The more complete a country's centralized electricity system is, the more difficult it is to realize structural reform; by this measure, it is entirely possible for the so-called "leap frogging phenomenon" to occur in the electricity field in developing countries.

Japan's neighboring countries also have no small amount of potential when it comes to DES. China has the most installed capacity for wind power in the world (Figure 4), and in 2013 set a record

for the most solar panel capacity installed in a single year (11.3GW) and jumped to number two in the world in terms of cumulative capacity (18.3GW).[23] In terms of industrial infrastructure, China has world-leading solar panel manufacturers, and 60% of all photovoltaic (PV) cells made in 2012 globally were made in China.[24] South Korea is lacking in renewable energy resources, but its storage battery industry rivals even Japan's.

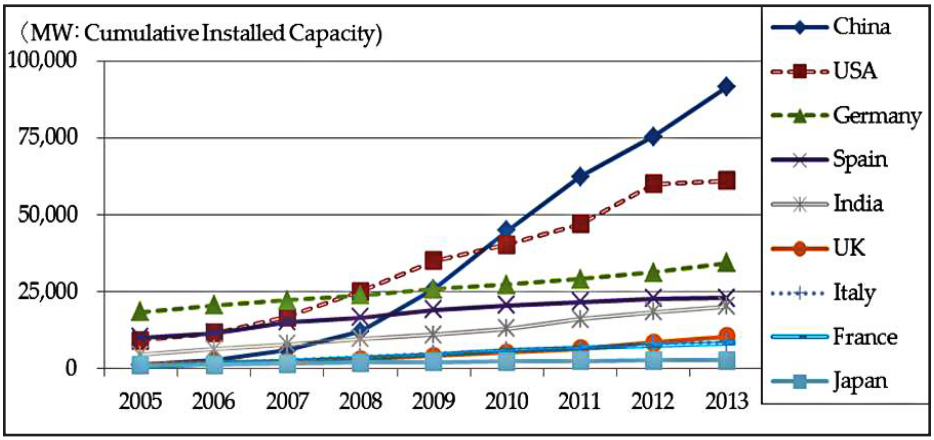

Figure 4. Installed Capacity of Wind Power Generation in Leading Countries.[25]

The industrial infrastructure of related products in East Asia therefore has plenty of potential, but those countries are lagging behind in terms of policy. First of all, electricity liberalization has made little progress, and Japan and South Korea have had only limited success in introducing renewable energies due in part to issues with opening

23. #1 was Germany with 35.5GW. Japan was #4 with 13.6GW. See, Gaëtan Masson, *PVPS Report: Snapshot of Global PV 1992-2013*, Report IEA-PVPS T1-24:2014, Paris, International Energy Agency Photovoltaics Power System Program, 2014.

24. Ibid.

25. The chart shows the Top 8 countries in 2013, and Japan, which was #16. Global Wind Energy Council, *Global Wind Report: Annual Market Update 2013*, available from www.gwec.net/wp-content/uploads/2014/04/GWEC-Global-Wind-Report_9-April-2014.pdf.

up the transmission grid. An inability to use market mechanisms means that DR cannot be used effectively either. On the other hand, because liberalization is at a standstill, nuclear power is in a very advantageous position. In fact, China and South Korea have stuck to their plans to build many new nuclear power plants even after Fukushima. The fact that China still relies on coal-fired thermal generation for 70% of its power generation tells us that DES still has a long way to go in these countries.

Will East Asia Forge International Grid Linkages?

When it comes to electricity systems, there are also significant obstacles in terms of grid operation. Both Japan and South Korea have independent grids with no international linkages. This means that there is a limit to the range of their grid operations, which presents a problem when it comes to counteracting the variability of electricity provided by RES. These countries contrast starkly with European nations, which have deeply integrated their transmission grids and electricity markets and are standardizing their energy policies, including those regarding renewables.

Is there no hope, then, for international linkages between grids in East Asia? The author believes there to be ample potential, both technologically and economically. For example, Fukuoka city in Japan and Busan city in South Korea are separated by approximately 220km of sea. The longest undersea transmission line in the world, NorNed, which connects Norway to the Netherlands, is 580km long. Hokkaido and Sakhalin, Russia are only 40km apart. Japan could most certainly form international grid linkages with other East Asian countries.

If grids were internationally linked, differences in electricity prices would likely result in brokerages engaging in much export and import of electricity. Japan's price for electricity is more than twice South Korea's; with such a large disparity, brokerages would thrive. Furthermore, if both countries were to introduce large amounts of

renewable energy, electricity import and export would play a large role in ensuring the stability of both grids. If South Korea's grid were further linked to North Korea, China, and even Mongolia, the stabilizing effect would be even greater.

Softbank, one of Japan's leading telecommunications companies, proposed the idea to connect all of Asia with an ultra-high-voltage transmission grid, build enormous wind and solar farms in Mongolia, and thereby supply electricity to Japan, designating it the "Asia Super Grid Initiative." This is not a mere daydream, however, as Softbank is working together with Mitsui & Co., a large trading company, and Inter RAO, a large Russian power company, to investigate the business feasibility of importing electricity from Sakhalin to Japan.[26]

While the private sector has begun moving to create international grid linkages, the Japanese government's reaction has been slow due to the souring diplomatic relations with neighboring countries. Relying on each other for energy requires a certain level of trust between two countries, and unfortunately, such trust is not being developed in East Asia, particularly between Japan and other leading countries such as China and South Korea. In order to build an international transmission grid and make proper use of it, market integration policies must also be in alignment, but the current state of things in East Asia does not allow very much room at all for cooperation on policy or anything else.

26. "Power imported from Russia concept Softbank and Mitsui & Co. Ltd." Nihon Keizai Shimbun, February 24, 2013, Japanese version available from www.nikkei.com/article/DGXNASDD2302L_T20C13A2MM8000/.

Conclusion

In conclusion, the outlook for DES in Japan is not very bright. The government asserts that it will decisively undertake electricity system reform, but its progress is incremental, the order of priority among renewables, cogeneration, nuclear, and coal as power sources is unclear, and the energy policy seems directionless. To give things a more favorable interpretation, one might say that the government is trying to give itself policy flexibility to respond to the present unclear energy environment, but their hemming and hawing is doing nothing more than to put off the difficult decisions, and there is a distinct possibility that Japan will be stuck on the fence for good. The uncertain policy environment may cost the energy industry a lot of yen in private sector investment.

Even within the larger framework of East Asia, DES's lot does not change all that much. Japan, China, and South Korea all have the physical and industrial potential to implement DES, but they all assign it a very low policy priority. Cross-border competition, and sometimes cooperation, helped spur the development of a distributed electricity system in Europe, but East Asia is far from being able to follow that example.

If any momentum towards DES is to be had, it will be from the direction of market movements and innovative developments. Market trends are much better able to cross international borders than policies. Additionally, East Asian countries are susceptible to the policies and market trends of Western countries. If Western energy companies enter East Asian markets, they may shift momentum towards DES. The future will reveal whether the potential for DES in East Asia will be realized or not.