Is Japan Prepared to Accept Post-3.11 Energy Policy Change?
Future of Renewable Energy

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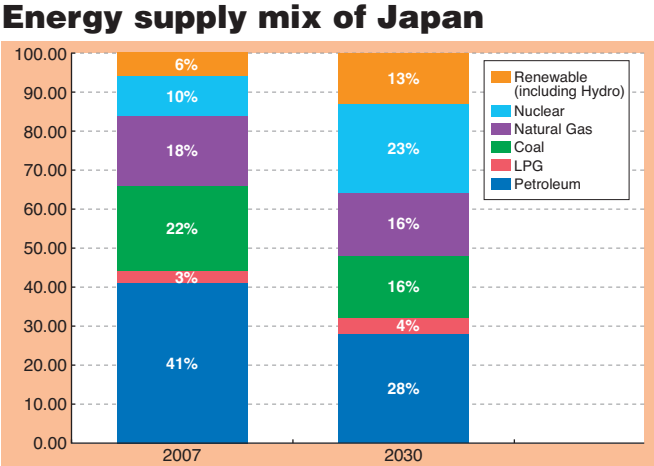
What's There on the Ground?

Japan's energy sector is traditionally monopolised by a conventional fuel mix that includes a large share of fossil and nuclear power. Being an island country with no significant domestic fossil fuel reserves, hydrocarbon fuel sources are mostly imported (around 98%). It is currently the third-largest oil consumer in the world and the third-largest crude importer. In terms of quantity, oil is the most-consumed fossil fuel followed by coal and natural gas. Nuclear power contributes about 13% of the total primary energy consumption and close to 30% of the total electricity supply. However, other sources like hydro and renewable energy contribute only a meagre 4% and 1% of the total primary energy consumption in the country, respectively.

So far the energy sector in Japan has been guided by the three principles mentioned in the Basic Energy Policy Act 2002, which are: 1) securing a stable energy supply, 2) assuring environmental compliance, and 3) utilizing market mechanisms with due consideration accorded to energy supply stability and environmental compliance. At the UN Climate Summit in 2009, then prime minister Yukio Hatoyama also announced Japan's commitment towards a 25% CO_2 emission-reduction by 2020 compared to 1990 levels. Nevertheless, the Basic Energy Plan was further revised in 2010 to add the perspectives of sustainable energy-based economic growth and structural reform of the energy industry, as well as detailing goals for 2030 to revitalize the slumping Japanese economy. This revised policy gave significant importance to increasing the share of nuclear energy in the energy supply mix, mainly to reduce the import burden of high-cost fossil fuels, but also to give international competitiveness to Japanese exporting companies by lowering production costs. As a matter of fact, 14 additional plants were planned to be added to the existing fleet of nuclear reactors. Projections of the energy mix for 2030 showed a noticeable difference in the supply pattern from that in 2007. This can be seen in *Chart 1* showing the 2007 and 2030 energy supply mix in Japan developed prior to the disastrous earthquake that struck the northeast of the country in March 2011.

CHART 1
Energy supply mix of Japan



Source: Ministry of Economy and Trade (METI), Japan, 2010

Unfortunately, the situation brought about by the Great East Japan Earthquake, followed by the Fukushima nuclear accident, all of a sudden compelled a paradigm shift in the fundamentals of Japan's future energy policy. The severity of nuclear accidents and the vulnerability of nuclear power plants in the wake of massive earthquakes became apparent to the people of Japan, conditions which were not clear until March 2011. Japanese policymakers are now compelled to think of alternatives to avoid a massive nuclear energy expansion plan, which has been found to be risky due to Japan's geological position in a very active seismic zone of the earth. It could also be said that the expansion plan is unnecessary, in the context of having a significant amount of untapped indigenous renewable energy potential. Nuclear is no longer a sustainable option in Japan since alone it cannot satiate the increasing energy voracity engendered by the continuous modernization of lifestyles.

Japan is now at the crossroads of its future energy policy direction, with limited options and several constraints to achieving the targets set under the basic energy plan such as energy security, reliability and environmental quality, and finally the sustainability of the energy supply. Japan is a net energy importer, and so it is indeed an uncertain and costly option for the country to adopt a more fossil fuel-based energy alternative path under a condition of "no-nuclear." Renewable energy is, therefore, an option that can play a catalytic role in this situation and can strike a balance between the security of the domestic and international energy supply; a safer, cleaner energy supply, and keeping to the country's GHG emission-reduction commitments.

Scope of Renewable Energy in Japan

Amidst the complexity of redevelopment of the national energy policy, Japan's indigenous renewable energy is to play a pivotal role. Having a total potential of 2000 giga-watts (GW), Japan is considered to have one of the highest potentials in the world for renewable energy utilization. Unfortunately, however, owing to adverse political, technical and market conditions, Japan has so far been using only a fraction of its potential and thus huge untapped resources are lying idle in the country. Among the major sources of renewable energy, solar, wind, small hydro and geothermal are the most promising in terms of potential and Japan's technical capabilities to harness them at a relatively competitive price. *Table 1*

TABLE 1

Renewable energy potential of Japan

Technologies	Types	Installation capacity (GW)	
		Existing facilities	Installation potential (include existing facilities)
Solar	Non-residential	2.63	150
Wind	Land	2.19	280
	Offshore	0	1600
Mid-small hydro		9.55	14
Geothermal	Hydrothermal resources development	0.53	14
	Hot springs	0	0

Source: Estimated by author using data from Ministry of Environment, Japan and NEDO, 2010

TABLE 2

Japan's ranking in renewable energy development index

Index description	Ranking (total countries, 30)
All renewable energy index	15
Long-term wind index	18
Near-term wind index	30
Solar index	7

Source: Ernst & Young, 2010

shows the installation potential compared to the existing installed capacities of renewable energy in Japan, which indicates severe under-utilization of its immense potential.

The slight progress that has been made in terms of renewable energy generation is mainly due to governmental intervention in the market with various fiscal incentives including subsidies and tax rebates. However, the existing scenarios of the different sources on hand are summarised as follows:

Solar

Government subsidies for solar installations were the key factor that helped the development of the solar industry in Japan. The unit price of solar power was brought down from 250 yen/kWh in 1993 to 46 yen/kWh in 2004, a figure that was reported in the *Japan Times* this year ("Despite Headwinds, Solar Energy Making Progress, Advocates Say," *Japan Times,* accessed: September 24, 2011, http://search.japantimes.co.jp/cgi-bin/nn20110924f1.html). Although solar power is estimated to be the most expensive of all renewable energy sources, its provision for large-scale commercial generation can significantly help the fledgling solar industry to survive market competition against low-cost fossil fuel technologies in coming years.

Wind

Wind energy potential in Japan is one of the largest in Asia including the huge offshore potential available along the country's coastline. So far, wind energy development has been painfully slow and it has been developed only in the on-shore sector. There is 1600 GW of offshore potential that is still completely untapped. Ironically, in spite of having the technological and financial capacities, Japan is seriously lagging behind other developed countries in terms of renewable energy development and utilization. Indices on the attractiveness of countries with regards to renewable energy were prepared by Ernst & Young (2010) and these show Japan's poor performance in this area. The Global Wind Energy Council further ranked Japan at the dismal level of 14th in terms of yearly growth of wind capacity. Even in the US, the total wind capacity calculated for 2007 is 38 times more than Japan's *(Table 2)*.

Geothermal

Geothermal energy is another indigenous source of significant energy supply in Japan. The country is situated on one of the most active seismic belts on Earth and has more than 200 active volcanoes. As a result, geothermal energy is abundant in nature with about 24 GW of potential (14 GW is a conservative estimate of the government). One GW is equivalent to the capacity of one standard reactor of the current nuclear facilities in Japan. Thus, harnessing every GW of geothermal energy could potentially avoid the installation of even one nuclear reactor in the country. So far there are only around 600 mega-watts (MW) of installed capacity available in the country, ranking it sixth in the world.

Biomass

Biomass is another potential source of steady energy supply for Japan, provided that proper arrangements are made. Municipal Solid Waste (MSW) converted into energy is not a new concept in Japan. The country has 1900 incinerators; 190 are running on MSW and generating urban heating-gas. However, biomass production is limited due to lack of space, but there is still growth potential with a capacity of 35 million tons of annual wood residual generation out of logging, forestry and construction activities. Furthermore, biomass energy is important for Japan, especially in the context of avoiding a nuclear energy supply that is of base-load character.

At present Japan's total electricity generation is approximately 1 tera-watt hour (Twh), which is around one fifth (20%) of the total potential of renewable energy available in the country. This gives a silver lining of hope to the energy policymakers and shows that renewable energy could play an important role in the future energy mix of Japan, if an enabling environment were in place. The Fukushima nuclear accident has, in some way, been the compulsion for a paradigm shift in thinking.

Economics of Renewable Energy

Given the situation and working towards a positive goal, the two major barriers for renewable energy to enter the mainstream energy supply mix are cost of generation and supply intermittency. Compared to conventional energy technologies, renewable technologies are 10 to 20 times more expensive, mainly because of the low level of capacity utilization (the low capacity factor turns into higher cost of per-unit generation). Capacity utilization determines what percentage of full capacity is being used. Nuclear technologies are as costly as other fossil fuels like coal and natural gas and with no GHG emissions, and thus become the strongest competitors against renewable energy technologies. However, after the Fukushima nuclear accident, the power sector in Japan has been exposed to tremendous market uncertainty, especially for future investments in nuclear energy technology, one of the key technologies for Japan to strike a balance between the cost of the energy supply, meeting energy demand and achieving GHG emissions targets. Nuclear energy is found to be cost-competitive

only when compared without considering any long-term damage costs that might occur in the case of an accident like at Fukushima. It is now apparent that such long-term damage costs could run into trillions of dollars, if not more. In fact, there is now every possibility that nuclear energy will lose its economic competitiveness relative to other technologies when such damage costs are accounted for. The renewable energy market in Japan now has a golden opportunity to compete with nuclear and other fossil fuel technologies by demonstrating the triple benefits of (a) long-term risk hedging against fossil fuel price volatility, (b) environmentally-benign power generation, and (c) a sustainable risk-free energy supply.

The power-sector investment cycle is another important factor for intervening changes in the technology option. The power sector is conventionally characterized with a prolonged technology and investment lock-in period of around 30 years. This prevents investors from making drastic and rapid changes in the investment pattern. But as a matter of fact, Japan is now facing a very high rate of retirement of power plants, with several ageing power plants in the fleet that are more than 30 years old. On one hand, this further disturbs the balance of energy supply and demand in the markets, and on the other hand it brings a new opportunity for renewable technologies to penetrate the market. It is an opportunity for policymakers and investors to decide on the direction of the next-generation energy supply mix and its corresponding investment portfolio. In its current situation, Japan cannot afford to miss this opportunity to turn around the future energy supply mix towards more sustainable options.

Japan's electricity supply portfolio is inherently skewed towards high investment risks due to its high fossil fuel dependency. In a systematic manner, the power companies pay risk premiums mainly to avoid international fuel price fluctuations, and these costs are passed on to the consumers. This system effectively protects the companies from taking a hit to their profit margins. Ten major power companies dominate the entire Japanese electricity market in a vertically-integrated system and these companies have enjoyed a market monopoly from the beginning. Nevertheless, it seems that the Fukushima nuclear accident has meant a multi-fold increase in the importance of explicit investment risk analysis, at least in the planning process for setting up new power plants. Such risk analysis is especially important for nuclear and thermal power plants, mainly due to the anticipated incremental costs for additional nuclear safety measures and also to increasing fossil fuel imports to manage the current and future power supply shortages from nuclear power plants.

As a result, there is a high possibility that renewable energy will get favourable consideration from investors in Japan to hedge the risk of fossil fuel import costs and an uncertain nuclear power supply. Due to the sudden increase in market demand of fossil fuels like LNG, oil and coal, it is envisaged that power companies will need to buy such additional fuels in their respective spot markets at much higher prices. It has been estimated that, in such a case, if the investors (including power companies) give priority to the overall energy supply portfolio risk mitigation rather than just following conventional least-cost planning techniques, Japan could see the renewable energy supply going up to 9% of the total electricity supply compared to its current dismal level of only 2%. Such levels of renewable energy penetration also have the potential to replace the 14 ageing nuclear reactors that are more than 30 years old. Nuclear power plant life extension can thus be avoided by making investment risks explicit in all future power-plant investment planning. Amidst the high risk of conventional power plant operation, if the risks are appropriately converted into costs, there is a high possibility that renewable energy will become cost-competitive. Solar and wind technologies are the most likely candidates in such a situation.

Energy Systems of Japan

Whilst Japan is planning for national-scale changes in its energy supply mix, it is perhaps becoming an issue of energy systems as a whole. From the perspective of energy systems analysis, Japan needs to find a way to avoid nuclear power by introducing more sustainable energy supply options including renewable energy and low-emission-intensity fuels like Liquefied Natural Gas (LNG) and Natural Gas (mainly pipeline gas). This could be achieved with a massive overhauling of the entire energy supply system including infrastructural development. The current problem in Japan is more like an energy systems problem than anything else. Japan's total nuclear power supply to the grids was around 250 Twh up to March 2011. Such a massive amount of nuclear energy supply (mostly supplied as base load to the grids) is not so easy to replace with renewables, nor by any single fuel option. Increasing the supply of renewable energy in the system will also increase the probability of grid instability due to an intermittent supply of renewable energy. This is a critical technical challenge when looking at how to manage grid instability engendered by renewable energy. Not only that, but if there were to be an increase in the use of other fuels such as natural gas, LNG or even coal, then Japan would need to have sufficient fuel-handling capacity to manage the sudden influx of such fuels into the backyards of power plants. For example, an immediate alternative for nuclear energy is to use more LNG for power generation. Japan imports LNG by ship so stepping up imports of LNG will immediately demand more storage capacity at LNG ports and bigger pipelines to carry the gas. Without such upgrades to infrastructure, Japan cannot just import more LNG as a substitute for the nuclear energy supply. Similarly, coal-handling plants also need to be recapitalized by additional infrastructure, which will incur significant fixed costs for the power companies. Additionally, Japan does not have a unified national grid as its supply backbone. Japan is also divided into two different supply frequency (50 and 60 Hz) zones, which are critical for grid expansion and energy system harmonization with massive changes in the supply mix such as those now envisaged.

Overall, Japan has a variety of constraints that prevent it from optimizing the national energy system to achieve the targets set under the basic energy plan for sustainable development in all aspects. To deal with an intermittent supply of renewable energy, the addition of more storage facilities like battery arrays and pump-storage in the system are good options but very expensive in nature and can make renewable energy even more uncompetitive. Moreover, geothermal energy, which is one of the most promising indigenous

sources of energy in Japan, is facing serious forestry-related regulatory control that prevents the geothermal option from being explored to its full capacity. It also faces severe opposition from the hot-spring business lobbies.

These energy resources characterised by their natural base load are the key to stabilising Japan's energy system in the course of developing a changing supply mix. Increasing LNG port capacity and pipeline facilities, or expanding coal-handling capacity to generate more fossil fuel-based electricity are all very expensive propositions. Moreover, as Japan is an energy importer, it is basically the price-taker in the international market of energy trade and thus has very limited control over the supply. This threatens to push the country further towards supply limitation in case of any failure in energy trade negotiations. As the global primary energy supply is increasing only at a rate of 4-5% per annum, it is indeed a challenging task for Japan to secure an additional long-term energy supply in the case of a no-nuclear scenario. Moreover, Japan needs to compete with other Asian giants like China and India, whose incremental energy demands are much higher than those of Japan.

As a result, investment in energy supply infrastructure development also has a huge uncontrolled risk of securing long-term supply contracts. Japan may have to depend on spot market trading of energy in a more regular manner, which will obviously increase the overall generation cost of electricity and supply of other types of energy on the domestic market. Apart from the external risk of the energy supply, the domestic infrastructure of the energy supply would also be put in a vulnerable condition if it had to cope with such massive changes in the supply mix. Currently Japan does not have a unified backbone electricity supply grid that can carry electricity from north to south and east to west across the country. Fragmented grids are localized into service areas determined by the power-supplying companies, which created a huge vacuum of power supply in the face of demand and supply in the east Japan area after the March 11 disaster. Complications were further intensified due to the frequency differences between east and west Japan, which prevented the power companies from trading electricity during peak hours amidst a supply shortage. There are in fact three high-voltage frequency converters located in three different places of Japan, but in total the installed capacity of frequency conversion is only around 1.2 GW, which is far below the requirement.

In the context of planning for such massive changes in the electricity supply mix in Japan (with more renewable energy), it is imperative to have a well-structured national electricity grid that can pick up all the possible potential (including renewable supplies) of the non-nuclear category from any part of the country without any trouble. The importance of a power grid is magnified for cases where renewable energy dependency is envisaged. One major reason is the scattered availability of renewable energies across the country. Unless the power grid reaches to every possible corner of the country with a uniform characteristic, it would not be possible for developers to harness the renewable potential in a commercial manner. Renewable energy is already expensive and, if any additional investment is required for its supply to the grid, it would never be commercially viable unless supported by regular subsidies.

Secondly, to overcome the intermittency problem of renewable energy, the power grid should have flexibility to act on a real-time basis. Although the power companies in Japan are now trying to increase grid supply flexibility by introducing more frequency converters, the costs are also expected to be increased significantly. At present, 1 GW of FC capacity addition costs approximately $2 billion and it takes around two to three years of installation time (without any litigation settlement time for acquiring the right-of-way for transmission lines). In the process of implementing a supply mix change, Japan might need hundreds of GW capacity of such frequency converters, which would cost hundreds of billions of dollars. It is a daunting task for the country to estimate a cost-effective way to revamp its national power supply network either by installing new sets of transmission lines or by a combination of new lines with additional FC capacity. In any case, what Japan needs to do now is introduce a standardized national grid system.

Japan's New Energy Planning

Japan's future energy system depends primarily on how the current policymakers of the country see the future. Under the existing framework of basic energy plans and following the Fukushima nuclear accident, nuclear energy is not a sustainable option for Japan. However, without nuclear energy it will be a challenge to meet national emission-reduction targets, which have been set at around 25% of 1990 levels by 2020, while at the same time meeting the massive energy demand to lift this mammoth economy to the desired level of economic growth. Amidst the options left for Japan to deal with this bottleneck, some are listed below:

1. Upgrading the national energy system to a unified standard by amalgamation of sub-national prefectural energy system harmonization. This envisages national grid expansion and harmonization, and the creation of a situation enabling a technical environment for third-party wheeling of power to the national grid.
2. Reducing energy consumption and demand as much as possible without hampering growth. This is possible via tightening energy conservation, efficiency improvement and switching fuel from a high-emission intensity to a lower one.
3. Upgrading the electricity supply principle from regional planning to national-scale planning. It has been a tradition in Japan to plan an electricity supply system on a regional demand and supply basis (based on the service area of the power company) rather than from a national perspective. This hinders the national synchronization of energy systems that could be the backbone of a new energy mix with less or no nuclear energy supply.
4. Removing regulatory drawbacks in Japan to promote small-scale third-party generation of renewable energy from every possible source and place in the country. Due to the rigid, vertically-integrated system of power generation, transmission and distribution, it is a great challenge for non-power companies to generate power and to wheel it back into the national grid. JS

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