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Japanese wind energy development policy: Grand plan or group think?

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ABSTRACT

This paper analyzes Japan's national power generation strategy with a view to explaining Japan's phlegmatic approach to wind energy development. The analysis concludes that Japan's current power generation strategy is not optimized to achieve the government's three strategic energy objectives of simultaneously enhancing economic security, national energy security and environmental security (3Es). To achieve long-run energy sustainability, Japan needs to strive to phase out nuclear power, which is the centerpiece of its current power generation strategy. The analysis concludes by offering four suggestions for a sustainable 3E power generation strategy: (1) internalize all external costs associated with power generation technologies in order to level the economic playing field, (2) increase feed-in mandates for renewable energy to 20%, (3) fully liberalize the power generation industry and (4) intensify R&D in energy storage technologies to support intermittent renewable technologies.

1. Introduction

There is a historical reverence for wind in Japan. Twice, in 1274 and 1281, the Mongol leader Kubilai Khan dispatched massive military forces to invade Japan. Both times, the invasions were thwarted by great storms which unexpectedly arose, breaking up the invasion fleets. The Japanese characterised these storms as "divine winds", or in Japanese *kamikaze*. Although the term is better-known internationally to describe Japan's suicide bombers during the World War II, etymologically, the origins date back to the Mongol invasions.

Popular accounts of the defeat of the Mongol fleets tend to aggrandize the role of the divine winds and downplay the contributions of Japanese strategy. After repelling the smaller first invasion (40,000 Mongol troops), the crippled Japanese military enlisted the community support to construct and safeguard a long defensive wall along the coast of Hakata Bay in Kyushu. The fortification was a ruse intended to fool the Mongol leadership into thinking that Japanese forces were vigilant and anticipating an impending attack. The reality was, if the ruse did not deter a Mongol landing, defeat of the depleted Japanese forces would be inevitable. Fortunately for the Japanese, the fortifications served their purpose when the Mongol armada of 140,000 troops arrived in Kyushu. Mongol leaders delayed the intended landing in order to assess the situation. Reportedly, the invasion fleet stayed afloat for over a month while waiting for scouts to sneak ashore in order to assess the situation and identify a less fortified landing spot for the troops. It was during the interim that a huge tropical storm hit the fleet. The Mongol boats were ill-prepared to withstand the pounding caused by high waves driven by gale-force winds (Hall, 1990).

Today, in the energy world, the omnipotent properties of wind are once again being felt. Increasingly, energy policy makers are coming to understand that once all the environmental and social costs associated with the various energy technologies have been fully internalized, wind energy represents an economically appealing option (see Fig. 1). Moreover, the CO_2 lifecycle footprint of wind energy is amongst the lowest of all renewable energy technologies (Sovacool, 2008b).

Alternatively, for readers who are uncomfortable with the use of social cost projections to argue a case for the economic merits of wind energy, Fig. 2 presents more straightforward cost projections incorporating only direct costs associated with three power generation technologies. The insight that both graphics attempt to convey is that national energy policy makers would be remiss to ignore wind energy as an economically viable component of any low-carbon energy strategy.

The observation that wind energy can help national energy planners facilitate a transition away from CO_2 emitting technologies has not been lost on energy planners in many nations. As a result, installed global wind capacity has increased from 7636 MW in 1997 to 94,122 MW in 2007—a 12-fold increase. Accordingly, one might surmise that Japan which boasts an envious record for spearheading technological trends would be one of the vanguard nations with respect to the diffusion of wind energy. However, as this paper will illustrate, this is not the case. Wind energy is clearly relegated to a subsidiary role in Japan's national energy strategy.

The intent of this paper is to analyze Japan's national power generation strategy in order to explicate why wind energy is failing to achieve the diffusion rates found in vanguard nations.

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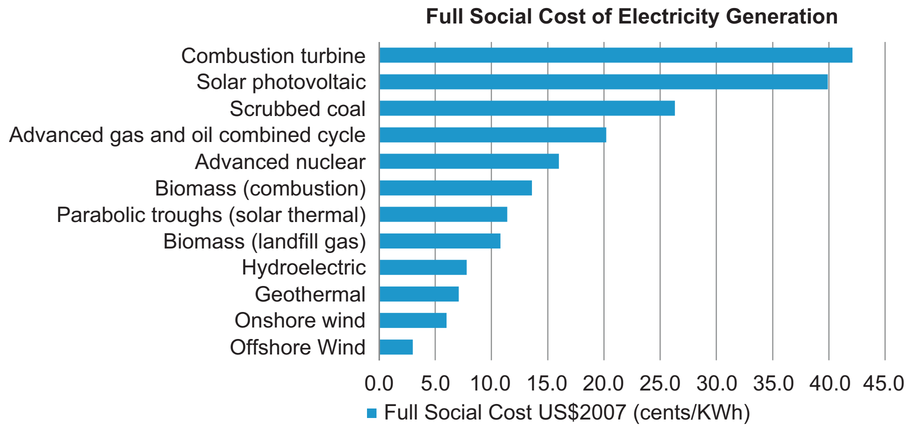

Fig. 1. Full social cost comparison of electricity generation technologies. *Source of data*: Sovacool (2008a).

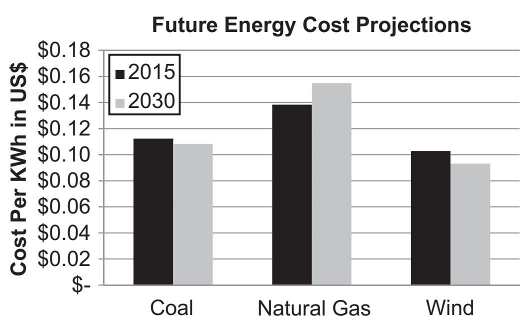

Fig. 2. Projected electricity costs in the EU in 2015 and 2030. *Source*: IEA World Energy Outlook 2008.

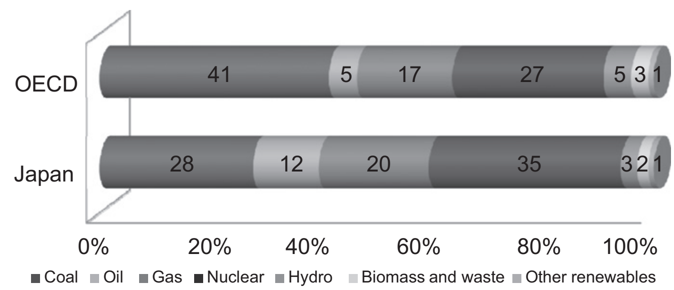

Fig. 3. Power generation in Japan and the OECD. *Source of data*: International Energy Agency (2008b).

Specifically, this study attempts to establish whether Japan's phlegmatic commitment to wind energy development is because a grander power generation strategy exists, which incorporates better options or because Japan's energy policy network lacks the sufficient diversity to avoid misguided strategic decisions. As the analysis will demonstrate, there are indications that the latter is a more likely interpretation.

In addition to providing a thorough analysis of the energy strategy of the world's second largest economy, this paper hopes to contribute to the growing body of knowledge on effective and ineffective elements of applied energy policy. In particular, this Japan case study demonstrates the need for proactive government intervention in energy markets that are dominated by large, vertically integrated utilities if a shift from status quo is desired.

The foundation of the study stems from a series of interviews and academic conferences attended during a one-year attachment to the University of Tokyo's Graduate School of Public Policy. Where possible, government publications or existing research have been referenced to support assertions or verify data gleaned through discussions with energy experts in Japan.

This paper is organized in the following manner. Section 2 launches the journey by briefly examining the overall energy profile in Japan. Section 3 describes the principles upon which Japanese energy strategy is founded. This includes an analysis of the core policy programs within Japan's national power generation strategy. Section 4 examines the impact that Japan's power generation strategy has had on wind energy diffusion and Section 5 attempts to explain the factors that discourage Japan's energy utilities from purchasing greater quantities of wind power. Section 6 summarizes the short-comings Japan's power generation strategy and Section 7 offers recommendations for redressing these short-comings.

2. Japan's energy situation

Fig. 3 contrasts Japan's power generation mix with the average power generation mix found in OECD countries (International Energy Agency, 2008b). Comparing the differences provides useful insight into Japan's power industry. Firstly, it is apparent that Japan has a comparatively heavy reliance on oil. In fact, in 2007, nearly 5 million barrels of oil were consumed daily in Japan. In absolute terms, Japan has become the third largest national consumer of oil in the world behind the United States and China. Secondly, the dominant source of electricity in Japan is nuclear power. In quantitative terms, Japan is the third largest national consumer of nuclear power in the world after the United States and France. Thirdly, renewable energy plays an inconsequential role in Japan's electricity mix.

One other critical element of Japan's power generation mix is not conveyed in Fig. 3—Japan imports 59% of its power generation feed-stocks. Virtually all coal, oil and gas feed-stocks are imported (Energy Information Administration, 2008). Moreover, it imports these feed-stocks in vast quantities. In 2005, Japan consumed 226 million tons of oil equivalent (Mtoe) energy for power generation (International Energy Agency, 2008b). Japan's 127 million people (1.9% of the global population) consume 5.3% of the energy used for power generation in the world.

Japan's dependence on imported energy has a pervasive influence on strategic energy planning. As Fig. 4 indicates, with the exception of Italy (which is securely linked into the EU energy network), no other industrialized nation has such a precarious dependence on other nations for energy supply. Any global disruption to energy supplies would have a greater impact on Japan than any other nation (ANRE, 2006). Consequently, in order to safeguard supply, Japan maintains massive strategic oil and gas reserve inventories. To illustrate, at the end of April 2008, Japan

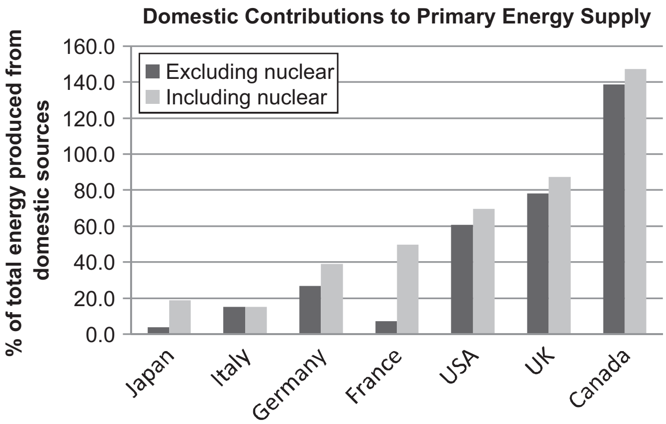

Fig. 4. Japan's energy self-sufficiency compared to other OECD nations. *Source of data*: The Federation of Electric Power Companies of Japan (2008).

held 328 million barrels of oil in strategic reserves (Energy Information Administration, 2008). Assuming a cost of $60 US per barrel, this amounts to approximately US$16 billion in sunken investment. Cognizant of the risks that high levels of energy imports pose, a consistent tenet of Japan's national energy planners has been to wean itself from this high level of dependence on foreign energy.

Before turning to the specifics of Japanese energy policy, the structure of Japan's electric utility industry merits description because, as will be seen in Section 5, how the industry is structured influences the diffusion of renewable energy technologies. Up until World War II, a state run monopoly was responsible for the generation and transmission of power in Japan and nine private firms were responsible for distribution. At the end of the war, the industry was privatized and nine private companies were given regional monopolies to generate, transmit and distribute electricity within their assigned territories (The Federation of Electric Power Companies of Japan, 2008).[1] As will be demonstrated later in the paper, the vertical integration of Japan's utilities into all levels of the electricity supply chain is a key hurdle to the diffusion of wind energy.

3. Japanese energy policy

3.1. Setting the agenda

Japan is a risk-averse society. Mechanisms for mitigating risk are embedded in many of the nation's most distinctive cultural artefacts. A rigid vertical hierarchy (in Japanese *tateshakai*) based primarily around seniority adds a degree of stability to interpersonal relationships. Japan's famous lifetime employment contracts mitigate career risk. Even the infamous inscrutable nature of the Japanese can be considered to be a manifestation of risk-aversion. Candour is discouraged in Japanese society because conflicting opinions run the risk of disrupting group harmony. A unique Japanese expression conveys this sentiment—*the nail that sticks up, gets hammered down*.

Given the Japanese aversion to risk, it should come as no surprise that "security" is a prominent theme in Japan's national energy strategy. The government endeavours to enhance *economic security* by minimizing energy costs, *national energy security* by reducing dependence on imported energy, and *environmental security* by supporting sustainable energy solutions which will not adversely impact the environment (METI, 2006). However, not all forms of security are considered equal in energy policy planning.

Economic security is accorded top priority in Japan because the nation has learned through experience that economic prosperity can capacitate security in all other forms. During the 1960s and 1970s, Japan's natural environment was significantly degraded as a result of insufficient environmental governance in the face of unfettered industrial activity (Tsuru, 2000). Economic prosperity of the 1980s provided the financial means for environmental restoration. Similarly, from a national energy security perspective, corporate prosperity enhanced tax revenues and enabled the government to finance the development of the nuclear energy industry. Japan's nuclear energy plants have greatly enhanced domestic power generation capabilities (comprising 35% of power generation).

There is a degree of symbiotic interplay between economic security and national energy security policy objectives. A healthy economy can finance national energy security initiatives. Conversely, bolstering national energy security helps stabilize energy costs, which enhance economic security. Consequently, a synthesis is achieved by seeking policies that will facilitate a long-term stabilization of energy costs at the lowest possible level. One approach to stabilizing energy costs is to endeavour to replace technologies that use feed-stocks that are imported from politically unstable nations with technologies which use feed-stocks that are imported from stable nations. One other approach is to improve domestic generation capacities (nuclear, renewables, etc.). As Section 3.3 will describe, policies exist which exemplify both approaches.

Although the attainment of environmental security is not as exigent as nurturing economic and national energy security, environmental concerns still bear weight in energy planning. Japanese national planners understand that climate change has the potential to seriously derail global economic development; and in the process, attenuate prospects for domestic economic prosperity. Accordingly, the Japanese government is currently intent on achieving its goal of reducing greenhouse gas (GHG) emissions to 6% below 1990 levels by 2012 and recently, new Japanese Prime Minister Yukio Hatoyama announced that Japan will seek to reduce GHG emissions by 25 percent below 1990 levels by 2020. To achieve the initial 2012 goal, the Japanese government aims to reduce CO_2 omissions related to energy generation by (i) sustaining the current transition from oil to gas power, (ii) enhancing nuclear power capacity, (iii) expanding energy efficiency programs and (iv) promoting greater inclusion of renewable energy into Japan's electricity grid (Government of Japan, 2005; METI, 2006).

However, the greatest flaw of Japan's national energy strategy relates to environmental security. One of the government's energy policy goals prior to PM Hatoyama's announcement was to extend nuclear energy capacity to deliver 40% of the nation's electricity needs by 2030 (Amari, 2006). Under the current emission reduction strategy, the announcement of more ambitious GHG reduction targets will likely further fuel plans to expand Japan's nuclear capacity. Although this will help mitigate CO_2 emissions, it will also tax national capabilities to manage the effective disposal of nuclear waste. Due to a shortage of viable landfill sites, municipal and industrial waste management have already reached a crisis state in Japan (Barrett, 2005). Accordingly, it seems improbable that the Japanese government will be able to effectively identify suitable locations to safely sequester ever-increasing amounts of nuclear waste.

[1] There are now 10 private regional electric utilities in Japan. The 10th region was created in 1972 when Okinawa rejoined Japan. The Federation of Electric Power Companies of Japan, 2008. Electricity Review Japan: 2008.

3.2. Formulating policy

Japan's energy strategy has not changed substantively over the past two decades. In the late 1990s, Japanese government energy policy objectives were: (1) to improve energy utilization efficiency, (2) to restructure the national energy mix to incorporate renewable energy sources and (3) to positively promote and pursue international cooperation in the energy field (Ushiyama, 1999). In 2004, these energy policies were conceptually recast as the 3E's: (i) economic growth, (2) energy security and (3) environmental protection (International Energy Agency, 2004a).

More recently, the Japanese Ministry of Economy, Trade and Industry (METI) revealed a "*New Energy Strategy*" that identified three "new" primary objectives (METI, 2006):

- Establishment of energy security measures that our people can trust and rely on.
- Establishment of the foundation for sustainable development through a comprehensive approach for (sic) energy issues and environmental issues altogether.
- Commitment to assist Asian and world nations in addressing energy problems.

Although this latest manifestation of Japan's energy strategy is more loquacious, the 3E's are still clearly evident in the first two objectives. Moreover, the third "new" objective is evocative of the international cooperation objective instituted in the 1990s.

3.3. Power generation policy programs

The penchant for prioritizing economic security explains why certain energy initiatives in Japan have received more government support than others. In this section, Japan's five policy program areas related to power generation are analyzed in the context Japan's strategic energy objectives.

3.3.1. Conservation programs

Energy conservation initiatives took root in Japanese energy policy following the oil crises in the 1970s. Japan's *Energy Conservation Law* was passed in 1979 and has subsequently undergone four revisions. The revisions set progressively rigorous standards to encourage energy efficiency in industry. Also in 1979, the Japanese Energy Conservation Center (ECCJ) was founded in order to spearhead comprehensive outreach efforts in energy conservation. Since then, a significant number of conservation programs have been established. Appendix 1 summarizes some of the more notable programs.

There are at least three ways in which conservation programs support economic security objectives. Firstly, conservation efforts obviate capital investment to facilitate energy efficiency (Sovacool, 2008a). Accordingly, the fiscal impact of such programs is comparably light. Secondly, waste alleviation associated with conservation improves corporate profitability (Reinhardt, 1999). Consequently, industry resistance to conservation programs has been negligible. Thirdly, conservation initiatives typically exhibit the highest benefit-to-cost ratios (Komor, 2004). In short, successful conservation programs enjoy a synergic relationship with the 3E's. They enhance corporate performance, reduce energy import dependency and lessen the impact of power generation (per kWh) on the environment.

As of 2005, per capita energy consumption in Japan was 4.2 tons of oil equivalent energy per year. This is significantly lower than consumption levels in Canada (8.4 tons) and the United States (7.9 tons) but similar to per capita energy consumption levels in France (4.4 tons), Germany (4.2 tons) and the UK (3.9 tons) (OECD, 2007). The Japanese government believes that conservation programs in conjunction with programs to develop energy efficient technologies (discussed next) can catalyze a reduction in per capita energy consumption by a further 50% (ANRE, 2008). This ambition is reflected in the government's Guideline of Measures to Prevent Global Warming, which establishes progress in energy efficiency as a critical objective for achieving its emission reduction target under the Kyoto Protocol (Government of Japan, 2005; Japan Ministry of the Environment, 1998).

3.3.2. Energy efficiency through technological development

The Japanese government has sponsored a plethora of initiatives to encourage the development of energy-efficient technologies. A selection of some of the more prominent initiatives is provided in Appendix 2. Encouraging development of energy efficient technologies supports Japanese industrial development strategy in at least three ways. Firstly, industries, which use resources (like energy) more efficiently, establish competitive advantage over foreign competitors (Porter, 1990; Porter and Van der Linde, 1995). Secondly, the implementation of energy-efficient technologies hones engineering prowess which is a core competency in large-scale construction activities. Thirdly, subsidizing the innovation and development of devices and equipment for improving energy efficiency, nurtures the growth of specialized businesses.

A number of examples stand out as testament to the success of these initiatives. Japan has become one of the leading exporters of products and services to support energy-efficiency in engineering and construction projects (Energy Information Administration, 2008). The 1500 °C class gas turbines that have been developed in Japan boast the most efficient generation efficiency ratios in the world (52%). Similarly, Japan's 600 °C class supercritical pressure power generation technology for coal-fired power generation exhibits the highest level of thermal efficiency of the world (45%). Japan also boasts three companies that are world leaders in nuclear power generation technology (Toshiba, Hitachi and Mitsubishi) (ANRE, 2008). In terms of the manufacture and sale of energy-efficient equipment, Japanese firms such as Ebara, Mitsubishi and Toshiba produce some of the broadest arrays of energy-saving devices in the world.

In terms of policy approach, incentives have tended to precede regulations. For example, when targeting industrial energy-efficiency improvements, the government tasked the Japanese Business Council (*Keidanren*) with the responsibility for encouraging industry-led initiatives. The result was the *Voluntary Action Plan on the Environment* which covered 36 industries and involved 137 firms (International Energy Agency, 2004b). However, in industries where self-governance is difficult to coordinate (i.e. the building industry which has thousands of private contractors), or in cases where voluntary efforts are unsuccessful (i.e. improving energy efficiency in appliances), the government legislates targets. The revisions to the Japanese Energy Conservation Law illustrate this approach (see Appendix 1).

3.3.3. Nuclear energy support programs

For decades, the lion's share of government funding for energy research has gone into nuclear energy research. As Fig. 5 illustrates, over US$2 billion were annually allocated to nuclear research between 1981 and 2001. According to the Japanese Atomic Energy Commission (www.aec.go.jp), over US$2.5 billion have been committed to annual nuclear research activities since 2001.

This consistent commitment to nuclear energy research has yielded remarkable results. According to METI, nuclear power has

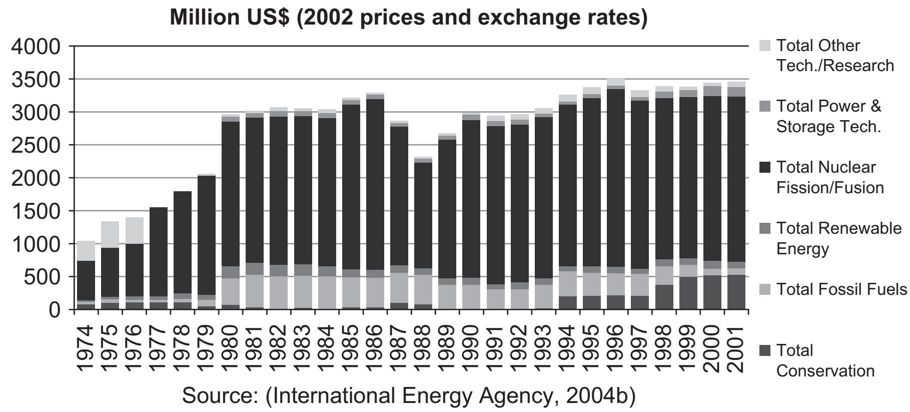

Fig. 5. Japan government R&D expenditure. *Source*: International Energy Agency (2004b).

surpassed coal-fired power as the cheapest energy technology in Japan. It is nearly 20% cheaper than LNG-fired power, over 40% cheaper than hydropower had over 50% cheaper than wind power (ANRE, 2008).[2] Japan's dependence on imported oil has lessened considerably due to the expansion of nuclear power. Furthermore, three world-class competitors have emerged from Japan in the nuclear energy manufacturing field (Hitachi, Toshiba and Mitsubishi).

The ascendance of nuclear power in Japan has occurred despite intense public opposition. Such uncharacteristic resolve of the part of the government to defy public opinion underscores the extant political consensus that nuclear energy represents the only cost-effective approach for significantly reducing CO_2 emissions associated with power generation. During numerous discussions with energy industry experts in Japan over the past year, the phrase *shikata ga nai* ("there is nothing else we can do") was heard frequently in reference to nuclear energy development.

The aforementioned concern over management of ever-accumulating volumes of nuclear waste has not gone unnoticed by government policymakers. Between 1998 and 2008, an estimated US$13 billion was invested into research to develop approaches for minimizing and securely sequestering nuclear waste (Japanese Atomic Energy Commission, 2009). A cornerstone project is the development of Japan's first reprocessing plant which was slated to open in 2000, but has been delayed by technical problems. The plant is intended to enable the recovery of plutonium and reusable uranium from spent fuel. These recovery processes will help extend fuel resources and reduce the amount of high-level radioactive waste produced. Another key project is the commissioning of a uranium–plutonium mixed oxide (MOX) fuel fabrication plant that is slated to begin operation in 2012 (The Federation of Electric Power Companies of Japan, 2008). When these projects are completed, they will exemplify progress made toward more efficient use of nuclear feed-stocks. However, these technologies will not resolve the dilemma of safely storing ever-increasing quantities of nuclear waste in a densely populated country.

Perhaps due to public sensitivity regarding nuclear power, the government tends to be less forthcoming about nuclear program challenges. For example, the waste storage dilemma is seldom elaborated upon in government communications. Moreover, safety concerns are significantly downplayed. For example, in 2007, Japan released a White Paper on nuclear energy which summarized the safety of the technology in the following manner.

In recent years, the world's nuclear facilities have been stably operated without any serious incidents involving a massive release of radioactive material. The international community has criteria in place for nuclear facility (operators) (Japan Atomic Energy Commission, 2008).

It is not until later in the report, in a section on "trends in nuclear energy" that "recent nuclear energy community setbacks" are touched upon. These "trends" include falsification of safety reports which led to the closure of a number of nuclear facilities in March 2007 and closure of the Kashiwazaki-Kariwa Nuclear Power Plant after design concerns arose following inspections after the Niigata earthquake in July 2007 (Japan Atomic Energy Commission, 2008). In fact, the Japanese nuclear energy industry has experienced a number of "setbacks" in the past including a sodium leak in a reactor in Fukui Prefecture in 1995, an explosion at the Tokai reprocessing plant in 1997, a uranium mismanagement mishap in 1999 at a Tokai plant where over 100 workers were exposed to high doses of radiation, a 2002 scandal involving the falsification of safety records which led to the temporary shutdown of 17 plants, and a steam leak at the Mihama plant in 2004 which killed five workers.

Another concern that has been the subject of political "spin" concerns access to uranium supplies. The government has justified the ongoing transition from oil-fired power to nuclear power by reasoning that "uranium can be considered a domestic energy source in view of the fact that it can be utilized for some years after importation" (ANRE, 2006). Under this logic, imported automobiles would be domestic forms of transportation.

3.3.4. *Initiatives to minimize supply risk*

Japan's precarious dependence on foreign energy supplies has shaped public policy for over 100 years. An ambition to gain access to Korea's ample coal reserves was a causal factor of the Sino-Japanese War of 1894–1895 (Paine, 2003). In the early 20th century, as the Japanese economy grew and its overseas military presence expanded, access to fuel-stocks became central to continued prosperity. Ultimately, Japan's military defeat was expedited when American forces cut-off access to Japan's Indonesian oil supply (Yergin, 1993). Accordingly, although economic justifications have superseded military justifications for enhancing national energy security, the Japanese policy ambition to improve national energy security has deep roots.

Under Japan's current national energy strategy, three strategic goals guide fortification of national energy security. The first goal is to gain preferential access to international energy supplies by supporting international energy exploration activities and infrastructure development. The second goal is to minimize dependence on energy imports from unstable nations. The third goal is

[2] It should be noted that the estimate pertaining to the cost of nuclear power does not include the long-term cost of storing nuclear waste. As this article will describe, this artificially inflates the attractiveness of nuclear energy.

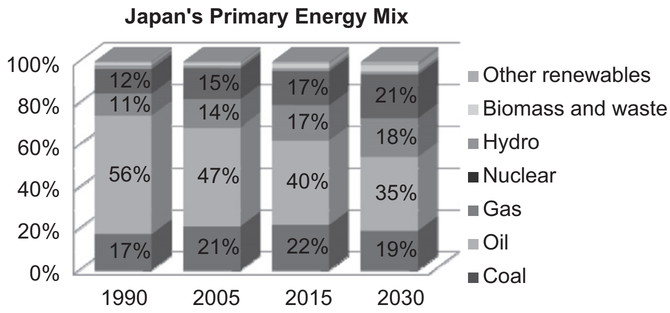

Fig. 6. The changing face of Japan's primary energy mix (power+transport). *Source of data*: International Energy Agency (2008b).

to diversify the national energy mix in order to mitigate risks associated with overdependence on one energy resource.

Over the past two decades, the Japanese government has aggressively pursued the first goal of engaging in cooperative international energy ventures. A public body, the Japan National Oil Corporation (JNOC), spearheads Japanese efforts to finance overseas oil exploration and production (E&P) activities in return for a share in the finds (Energy Information Administration, 2008; Toichi, 2002). Between 1967 and 1997, the JNOC financially supported 359 E&P projects managed by foreign companies (Koike, 2008). Of recent note, the Japanese government helped coordinate private Japanese investment to support the development of the Sakhalin 2 project in Russia which will provide up to 1.1 million tons of LNG annually to Japan (Sakhalin Energy, 2003).

The goal of minimizing dependence on energy imports from unstable nations centers on reducing dependence on Middle Eastern oil, which accounts for 90% of Japan's oil imports (ANRE, 2006). As Fig. 6 illustrates, the transition will be facilitated primarily through increased reliance on natural gas energy and nuclear power. Japan imports the majority of its natural gas from Indonesia (26.9%), Malaysia (22.8%), and Australia (14.8%) (ANRE, 2006). Therefore, a transition to natural gas helps avert reliance on Middle Eastern energy. Similarly, the majority of uranium is imported from Australia (33%) and Canada (27%) (ANRE, 2006). Consequently, substituting uranium for oil improves supply stability.

Fig. 6 also highlights Japan's progress toward achieving the third goal of diversifying its energy mix. In 1973, 77% of the nation's primary energy requirements were met through oil (ANRE, 2006). By 2005, the role of oil had diminished to 47% (International Energy Agency, 2008b). By 2030, Japan aims to establish a diversified energy mix with the bulk of reliance spread over four energy sources-coal, oil, natural gas and nuclear power. Conspicuously, renewable energy is not expected to make a major contribution to energy diversification. The remainder of this paper examines why.

3.3.5. *New energy support programs*

Renewable energy is not completely neglected in Japan. In fact, there have been, and still are, two policy approaches for promoting renewable energy diffusion. The first approach involves government sponsored research initiatives which are aimed at improving the commercial viability of renewable technologies. The second approach centers on legislation designed to create markets for renewable energy. Both policy approaches will be examined below.

Government funding for renewable energy tends to target-specific technologies. For example, as Fig. 7 indicates, in response to the oil crises in the 1970s, solar thermal energy received an enormous boost in funding as the government sought to develop domestic energy sources. In the same period, funding for geothermal energy research also escalated as the government sought to expediently exploit Japan's abundance of geothermal sites. By the mid-1990s, geothermal and solar thermal research waned as the technologies approached maturity. Throughout the 1980s and 1990s, the most consistent funding initiative was in solar photovoltaic (PV) research. Annual government grants for solar PV research have exceeded US$50 million since 1981.

By international standards, government-sponsored renewable energy R&D programs in Japan are well-funded (International Energy Agency, 2008a). However, the targeted funding approach applied over the past 30 years tends to produce winners and losers. Solar PV research has been by far the biggest winner. Although the cost of solar photovoltaic electricity is still commercially unviable (about three times as expensive as wind energy), consistent funding has produced world-leading solar energy manufacturers. On the other hand, government funding in support of wind energy technology has been negligible (see Fig. 7). Aside from wind turbine prototype testing in 1992–1993 (Inoue and Miyazaki, 2008), wind energy research has been largely ceded to private R&D initiatives.

Fig. 8 outlines the current and expected contributions of "new" energy in Japan. It should be noted that geothermal energy and hydropower are not considered to be "new" energy. The data in Fig. 8 shows where the majority of government renewable energy funding has been channelled since 2000. The research focus has primarily been on technologies to improve energy efficiency (i.e. waste power, underutilized energy, waste heat and wood chip waste). These research areas have received a considerable amount of funding because the governments renewable energy research fund has increased considerably over the past few years. By 2006, Japan's renewable energy budget had reached US$1 billion (Maruyama et al., 2007).

In addition to R&D support, the Japanese government also endeavours to promote renewable energy diffusion through legislative means. In 2003, the government introduced Renewable Portfolio Standard (RPS) legislation. Under this legislation, Japan's utilities are required to purchase a specified amount of renewable energy each year. The utilities are free to choose amongst small and medium-sized hydropower, geothermal power, solar PV, wind and biomass. The price they are obliged to pay for purchasing this energy is equal to the price paid by the end-consumer. In carrying out purchase obligations, the utility can either generate the renewable electricity itself, purchase the electricity from another provider or purchase new energy certificates from another utility which has surpassed its RPS quota (International Energy Agency, 2009). The Japanese RPS also has a "banking" mechanism which allows utilities to store credits for any renewable energy acquired that exceeds quota (Japan Agency for Natural Resources and Energy, 2008). Annual RPS quotas in terawatts hours are as follows (International Energy Agency, 2009):

2003	2004	2005	2006	2007	2008
7.32	7.66	8.00	8.34	8.67	9.27
2009	2010	2011	2012	2013	2014
10.33	12.20	13.15	14.10	15.05	16.00

The RPS quota for 2010 is projected to equal 1.35% of the total annual amount of electricity generated nationally. By 2014, the RPS quota will have inched up to comprise 1.63% of national electricity generation (Englander, 2008). With a number of renewable energy technologies competing for this small allocation, competition is heated. Toshio Hori, president of Green Power Investment Corporation in Tokyo sums up the situation by pointing out that the targets provide no incentive for renewable energy providers to undertake the investments necessary to grow (Englander, 2008).

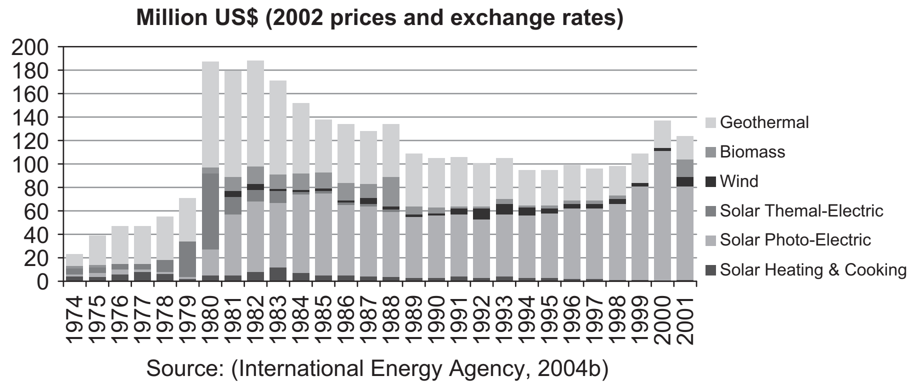

Fig. 7. Government funding for renewable energy. *Source*: International Energy Agency (2004b).

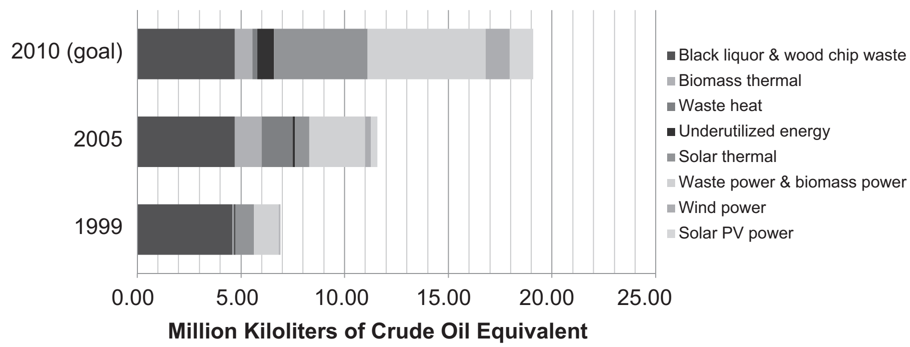

Fig. 8. The dynamics of "New" energy in Japan. *Source of data*: Report of Coordination Committee and Energy Supply and Demand Subcommittee of the Advisory Committee for Natural Resources and Energy, August 2007.

Given the prioritization of enhancing economic security in energy policy planning, one perhaps should not be too surprised by the government's apathy toward renewable energy. Currently, all forms of renewable energy are considerably more expensive than nuclear and coal-fired power in Japan. However, at current levels, the RPS legislation has negligible impact on the overall cost of electricity. Research indicates that the RPS legislation results in a premium of ¥0.1 per kWh (US 0.1¢ per kWh) on electricity produced (Nishio and Asano, 2003). If the research estimate is accurate, the government could significantly increase the RPS quota and still preserve economic security, which it values so dearly.

In concluding this summary on Japan's RPS program, it is worthwhile to note that solar photovoltaic energy is accorded special treatment under this program. Each kilowatt hour of solar PV electricity that is purchased equates to 2 kWh generated by other renewable energy technologies (International Energy Agency, 2009). Although this policy provides much-needed support for Japan's solar PV manufacturers, it is a regressive policy in terms of climate change mitigation initiatives. A utility that purchases its entire RPS quota from solar PV generators would offset 50% less CO_2 emissions than if the RPS quota were filled entirely through other forms of clean energy.

3.4. Policy benchmarks

Initiatives within the five program areas outlined above are expected to contribute to achievement of the following energy goals for 2030 (Amari, 2006):

1. improve energy efficiency by at least 30%.;
2. reduce oil dependence by 40% or lower;
3. reduce oil dependence in the transport sector to 80%;
4. target the share of nuclear power in electricity generation to 30–40%;
5. increase the share of crude oil owned by Japanese companies to 40%.

The fact that nuclear power is the only technology that is accorded a specific benchmark for top-level energy goals highlights the central role that nuclear power plays in Japan's national power generation strategy.

4. Wind power in Japan: the numbers

When considering the potential for wind power in Japan one must recognise that Japan faces the same hurdles that confront most heavily populated, developed nations. Onshore, competition for land use force wind sites to more remote, less urbanized areas which gives rise to increased transmission costs (Wizelius, 2007). Offshore, wind power potential in Japan is high but has yet to be aggressively exploited due to the higher costs associated with offshore wind power development (cf. Dong et al., 2008). Yet, geographic constraints notwithstanding, technical wind potential in Japan is still significantly higher than current installed wind power capacity, which amounted to 1880 MW as of December 2008 (World Wind Energy Association, 2009). Data compiled by the Geographical Survey Institute in Japan indicate that a mid-range estimate of 70,000 turbines could be situated at 964 prospective onshore and offshore sites (Ushiyama, 1999). Assuming a turbine power rating of 2 MW, this implies that there is 140,000 MW of wind power potential in Japan, almost 75 times current installed capacity. In the short run, the New Energy and Industrial Technology Development Organization (NEDO), which is a government research agency, foresees at least 10,000 MW of installed wind capacity as being a feasible target by 2020 (Inoue and Miyazaki, 2008). In short, despite Japan's geographical constraints, there is evidence of significant amounts of untapped wind power potential in Japan.

As Fig. 9 depicts, compared to other major economies, Japan clearly lags behind in wind power development. Comparing the three largest economies, installed wind power capacities in the USA and Germany wind power are over 12 times that of Japan. Italy, which shares Japan's heavy reliance on imported energy, boasts twice as much installed wind power capacity as Japan. In short, the Japanese government's subordination of renewable energy has had predictable consequences for wind power development in Japan.

Fig. 10 shows the growth of wind power capacity from 1992 to 2008 and presents the government's target for 2010 (ANRE, 2006). In order to reach this very modest target of 3000 MW of installed capacity by 2010, existing wind power capacity Japan would have to increase by 60% over the next 2 years. As the trend line of Fig. 10 demonstrates, if the pace of growth remains unchanged, Japan will likely fall short of its 2010 target.

The apathy that underpins the government's wind capacity target for 2010 of 3000 MW is clear when viewed from the bigger picture. If the 3000 MW target is reached, the annual contribution to Japan's electricity supply will amount to 1% (International Energy Agency, 2008b). Although, reaching this target would bring the wind power capacity up to the same level as geothermal power capacity, it will still pale in comparison to other renewable energy sources. Solar PV and biomass power generation will be 2.5 times greater than the power supplied by wind energy (ANRE, 2006). Moreover, hydropower will exceed the power supplied by wind energy by a factor of 10 (International Energy Agency, 2008b). In short, even within the context of Japan's uninspired renewable energy programs, wind power underperforms. The next section examines why.

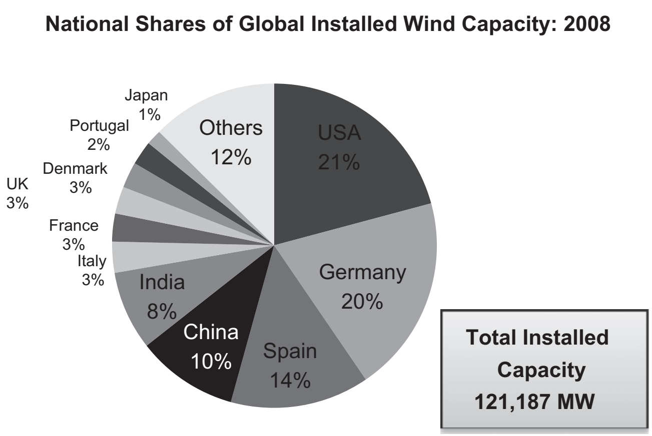

Fig. 9. Wind power capacity in Japan—a global comparison. *Source of data*: World Wind Energy Association (2009).

5. Barriers to wind power development

The ten regional utility monopolies in Japan are the gate-keepers of Japan's electricity market. Understanding the factors that discourage the utilities from purchasing wind power illuminates the challenge ahead for wind power diffusion efforts. Essentially, three dominant themes epitomize the nature of utility resistance: (i) cost disincentives, (ii) operational inconveniences and (iii) strategic conflicts. In this section, these themes will be examined in turn.

5.1. Cost disincentives

In Japan, electricity is sold to the end-consumer at a fixed price regardless of the technology used to generate electricity. The government assumes a regulatory role in ensuring that the retail price is established at a level that will not exact undue hardship on energy consumers. This system precludes Japan's utilities from strategically managing retail energy costs. With fixed retail prices, profitability for Japan's utilities comes down to cost control—minimizing the cost of power generation, maximizes gross margins.

Given the importance of cost control for profitability, utilities are incentivized to favour the cheapest technologies. Table 1 has been extracted from the Japanese government's Annual Energy Report for 2007. According to this government data, nuclear power, coal-fired power and LNG-fired power represent the cheapest sources of electricity in Japan. Accordingly, it should

Table 1
Comparative electricity generation costs in Japan.
Source: ANRE (2008).

Power source	Generation cost (¥ per kWh)	Capacity factor (%)
Hydroelectric	¥8.2–13.3	45
Oil-fired	¥10.0–17.3	30–80
LNG-fired	¥5.8–7.1	60–80
Coal-fired	¥5.0–6.5	70–80
Nuclear	¥4.8–6.2	70–85
Photovoltaic	¥46.0	12
Wind	¥10.0–14.0	20

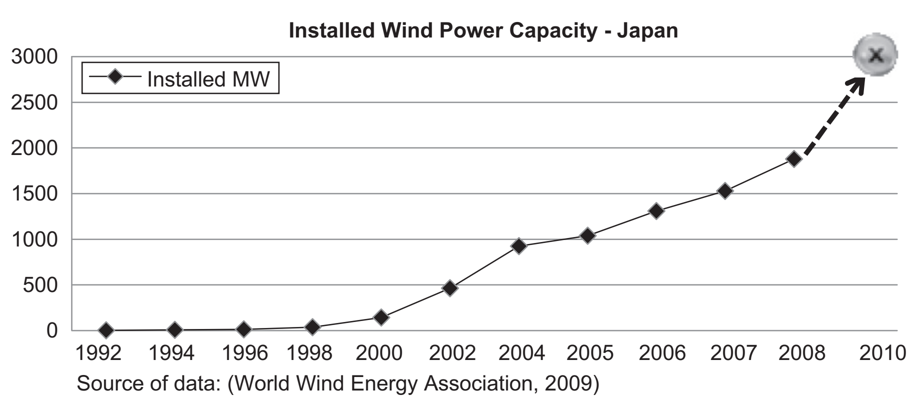

Fig. 10. The past and future of wind energy in Japan. *Source of data*: World Wind Energy Association (2009).

come as no surprise that these three technologies supply over 80% of Japan's electricity (International Energy Agency, 2008b). The cost comparisons also highlight why utilities are reluctant to purchase more wind power than is mandated by the government and why the government is hesitant to mandate higher purchases of wind power—it appears to be comparatively costly.

There is, however, reason to question the accuracy of the data presented in Table 1. As the table indicates, the cost of generating wind power in Japan (including the cost of grid connection) is estimated to be ¥10–14 per kWh (approx. US$0.10–0.14). In comparison, a study by the European Wind Energy Association (EWEA) estimates the cost of wind power (including grid connection costs and incorporating a 7.5% discount rate) in Europe for comparable medium speed wind sites (2100–2500 load hours per year) to be ¥8.2–9.7 per kWh (Morthorst and Awerbuch, 2009). The disparity between Japanese and European wind energy costs is particularly noteworthy given that the cost of capital in Japan is lower than in Europe and this would justify application of a lower discount rate, causing wind generation costs to be lower in Japan. Although the higher cost of wind in Japan is partly explained by Japan's higher cost base for key materials (such as steel), higher land lease costs and higher labour costs, two other less obvious factors exacerbate the inflation of wind cost estimates in Japan—use of a highly conservative capacity load factor for the cost calculation and demands placed on wind developers to fully mitigate the challenges posed by intermittency.

5.1.1. The capacity load factor question

The cost estimate for wind is based on a capacity load factor (CLF) of 20%. Such a low CLF is typically associated with low wind areas that are borderline financially viable. In Japan's case, the majority of sites chosen for wind power developments are medium wind areas (Ushiyama, 1999; Yamaguchi and Ishihara, 2007). In such areas, achieving a CLF of 24–26% is common (Morthorst and Awerbuch, 2009). If the cost of wind power was recalculated using a capacity load factor of 25%, the costs would be approximately 25% lower (i.e. ¥7.5–¥10.5).

Nevertheless, under the current costing regime where external costs are ignored, even if the cost of wind power were 25% lower, the costs of nuclear, coal and LNG power would still be cheaper. However, a narrower cost differential implies that incorporating more wind energy would have a less dramatic impact on the bottom line of Japan's utilities than implied by the data presented in Table 1. Furthermore, the adoption of a US$20 per ton tax on CO_2 emissions or a similar tax on nuclear waste disposal would make wind energy commercially competitive (Boyle, 2004).

5.1.2. The intermittency question

The intermittency of wind is widely regarded as the biggest hurdle facing wind energy diffusion today (Ackerman, 2005; Boyle, 2004; DeCarolis and Keith, 2006). The current technological consensus appears to be that wind energy can contribute up to 20% of a large scale electricity grid's power without requiring additional backup systems to cover power fluctuations associated with wind intermittency (DeCarolis and Keith, 2006; EWEA, 2009). This is made possible by more effectively utilizing surplus capacity that is already built into the system (Boyle, 2004).

In Japan, the utilities contend that the intermittency of wind power poses unacceptable risks to grid stability. Accordingly, there are reported cases of electric utilities forcing wind energy providers to assume the cost of storing the energy generated in order to sell it to the utility in consistent flows. According to one report, this requirement increases the cost of wind energy by as much as 50%, severely curtails profit margins for wind energy providers and dampens market development (Englander, 2008).

The demands that Japan's utilities place on wind energy providers seem unreasonable when considering that Japan's current wind power capacity amounts to a little over 1% of the total power supply. NEDO, Japan's largest public research and development organization, has concluded that the national electricity grid could accommodate wind power contributions of 10–20% before additional backup capacity is needed to address intermittency concerns (Nagai et al., 1995).

To summarize the verity of cost disincentives, in the absence of carbon taxes or nuclear waste management fees, wind energy is approximately 50% more expensive than the dominant electricity sources; however, resistance to wind energy based on concerns over managing intermittency are unfounded at current capacity levels.

5.2. Operational inconveniences

Even if the cost gap between wind energy and Japan's dominant electricity sources could be narrowed, there is a prevailing sense amongst members of Japan's wind energy community that utilities resist wind energy because the technology is an operational bother. The aforementioned intermittency challenge exemplifies an operational drawback. Although higher amounts of wind power can be incorporated into existing electricity grids without necessitating increases to reserve capacity, the inherent power fluctuations complicate the dynamics of electricity supply planning and require system adjustments. Without incentivization, incorporating more wind capacity is an added inconvenience that monopolies can do without.

Another operational bother is the added work involved in integrating a plethora of wind turbines into the electric grid. If a utility wishes to add 1 GW of generating capacity by constructing a nuclear power plant, grid planners would have at least 3 years lead time to plan a grid connection to the site (Sovacool, 2008a). Conversely, to generate an equivalent amount of power (inclusive of load factor differences) through wind energy, over 1000 2-MW turbines would be required. Grid planners would have to coordinate grid connections to a number of sites within construction lead time intervals that can be as short as 4–6 months (Wizelius, 2007).

5.3. Strategic conflict

For over 50 years, Japan's utilities have enjoyed monopoly control over the power generation supply chain from resource acquisition to power generation to transmission and distribution (The Federation of Electric Power Companies of Japan, 2008). Under the existing system, the utility business plan is straightforward: (1) strive to negotiate the best possible retail energy prices with government regulators, and (2) seek to reduce operating costs by simultaneously utilizing the least expensive energy generation technology and investing in cost minimization research. Wind energy (and other renewable energy options) threatens to upset this business model.

Incorporating wind energy into the electricity grid poses a dilemma for utility strategists. On the one hand, a utility could decide to develop wind energy projects itself; thereby, incurring the time-consuming obligations associated with site selection, project planning, community relations, environmental impact assessments, project management, etc. On the other hand, the utility could decide to avoid the logistical bother and purchase wind energy from private providers. However, delegating responsibilities for generation will result in profits and control leaking from the monopolized supply chain. Moreover, under either option, lower margin wind energy would displace profitable energy generated by conventional technologies. Clearly, neither of the alternatives holds much appeal.

In summary, the comparatively high cost of wind energy, the operational inconveniences associated with incorporating wind energy into existing electricity grids and the destabilizing impact that wind energy diffusion can have on the existing utility business model incentivize utilities to resist wind energy adoption (Inoue and Miyazaki, 2008). Espousing unfounded concerns over technical hurdles or exaggerating cost disparities exemplify such resistance.

6. Grand plan or group think?

The analysis presented in this paper has attempted to explain the phlegmatic approach to wind energy development in Japan. The specific goal of the analysis was to qualitatively evaluate two opposing hypotheses. The first hypothesis was that wind power has been deemphasized because amidst Japan's grand power generation plan, there are better strategic alternatives available. The second hypothesis was that wind power is viewed as extraneous by a homogenous policy culture, which is fixated on an alternative strategic approach to power generation despite indications that the current strategy is sub-optimal.

Results of the analysis indicate that the latter hypothesis appears more credible. As discussed, the current strategy will fail to achieve the 3E objectives in the long run. In terms of enhancing environmental security, expanding the nuclear energy program should help reduce CO_2 emissions; however, it will also sire critical new environmental challenges related to the disposal of hazardous waste. Moreover, regardless of the confidence of energy planners in the safety of the technology, Japan is still a nation that is prone to earthquakes. An earthquake centered on a nuclear power plant or a nuclear waste storage facility would put this confidence to a test.

In terms of long-term enhancement to economic well-being and national energy security, the decision to support the expansion of Japan's nuclear power program shifts Japan's dependence on overseas resources from one commodity to another. Although uranium is currently an inexpensive commodity, Japan is not alone in its pursuit of nuclear power program expansion. The inevitable acceleration of demand is certain to have an inflationary influence on the price of uranium.

Japan's national energy strategy can be summed up as a "Hail Mary pass". It is a high risk strategy that delivers short-term economic benefits at the expense of long-term sustainability. Future generations in Japan will be saddled with the dual challenges of managing enormous stockpiles of nuclear waste and facilitating the development of new technologies for generating electricity when uranium supplies dwindle and the cost of uranium escalates. As the Federation of Electric Power Companies of Japan concedes, there are 85 years of commercially viable uranium stores left on the planet.

Finally, it is ironic given the prioritization of nuclear energy in Japan that one of the goals of Japan's "New Energy Strategy" is to "*assist Asian and world nations in addressing energy problems*". While some Japanese bureaucrats labour to achieve this goal, others are actively pursuing negotiations with foreign governments to try and purchase the right to sequester nuclear waste somewhere other than Japan. This is not the type of "assistance in addressing energy problems" that will engender positive overseas relationships.

Toward a better plan

There are a host of initiatives that the Japanese government could implement to redress the unsustainable approach to national power generation planning that currently exists. In this concluding section, four policy initiatives are introduced as requisite first steps toward a more sustainable power generation strategy that more effectively meets the 3E objectives.

Firstly, the more significant external costs associated with each power generation technology should be internalized to reflect the true cost of power generation. For example, assuming the cost of carbon credits to be US$20 per ton, the Japanese government is currently subsidizing coal-fired energy with approximately 2¢US per kWh, oil-fired energy with approximately 1.5¢US per kWh and LNG-fired energy with approximately 0.6¢US per kWh (Sovacool, 2008a). This subsidy is in the form of requisite government purchases of carbon credits in order to offset excessive national CO_2 emissions (in order to meet its Kyoto Protocol obligations) (Japan Ministry of the Environment, 1998). Similarly, costs related to the sequestration of nuclear waste are not currently included in the cost of nuclear power generation. This artificially inflates the commercial attractiveness of nuclear power. In contrast, wind power providers are required to absorb all external costs associated with their projects, including costs associated with grid connection, transmission sub-stations, environmental damage mitigation and in many cases, the cost of electricity storage (Englander, 2008). Enforcing a full accounting of any significant costs associated with power generated through fossil fuel and nuclear plants will allow policy makers to make economically optimized decisions based on a balanced playing field.

This does not necessarily mean that retail electricity prices have to increase. Subsidizing retail electricity prices to allay the threat that higher electricity costs will dampen economic growth prospects is an industrial policy decision that would be justifiable if the subsidies could not be used more effectively elsewhere. However, the current practice of subsidizing the costs of specific inefficient energy technologies is economically sub-optimal. It makes inferior technologies appear better on paper.

Secondly, bolder RPS quotas are necessary. As explained earlier, research suggests that up to 20% of Japan's electricity could be generated through intermittent renewable sources (i.e. solar PV, wind, wave or tidal power) without requiring additional storage or generator backup. Even under the current electricity costing system (in which wind energy is 50% more expensive than conventional energy sources because externalities are not internalized), a 20% contribution of wind power would have a low impact on aggregate energy prices and even a lower impact on corporate profitability. A 20% contribution from wind would result in an aggregate electricity cost increase of about 10%. In firms where energy costs represent 10% of overall operating costs, this increase would amount to a 1% increase in operating costs.

Increasing RPS quotas is important because expanding the scale of wind power deployment would force utilities to amend their grid management systems in order to efficiently accommodate higher levels of intermittent energy inputs. These upgrades would cultivate the competencies necessary for incorporating higher contributions in the future. Given the impending perils of climate change, the 20% target should receive short-term priority. A 20% wind power target for 2020 would not be unreasonable.

Thirdly, the electricity generation industry should be fully liberalized. Currently a form of "Japanese" liberalization exists whereby utilities have monopoly control over all but small specialised segments of the national energy supply chain (The Federation of Electric Power Companies of Japan, 2008). Operation of the electricity grid should be clearly separated from the energy generation function. While it is widely accepted that electricity distribution constitutes a natural monopoly (Harris, 2006), power generation should be open to competition in order to ensure that generation costs are minimized.

Serendipitously, increasing the RPS quota (recommendation one) will partially catalyze market liberalization. A higher RPS quota will encourage heated competition for a lucrative revenue pool and result in lower renewable energy costs. However, in a well-managed feed-in tariff system – which is what the RPS system is – the subsidized purchase price should be decreased over time to encourage cost minimization behaviour on the part of renewable energy providers (Komor, 2004). Consequently, in the absence of mainstream market liberalization, renewable energy providers will eventually be forced to compete with the energy generation arms of the utilities. Under such competitive circumstances, renewable energy providers would be hard-pressed to defeat the competition. This implies that steps toward full market liberalization should be taken in conjunction with the recommended increase in the RPS quota.

Lastly, the Japanese government should provide more R&D funding for research aimed at making electricity storage systems more cost effective. Efficient energy storage technologies would allow intermittent renewable energy technologies to play an unlimited role in national electricity generation. In the absence of cost effective energy storage, wind energy contributions over 20–30% will incur additional costs associated with added back-up requirements to smooth power intermittency (Ackerman, 2005). Although research is already under way in Japan in this regard, the scale of funding pales in comparison to funding set aside for nuclear power research. Funding for energy storage technologies on a scale similar to nuclear power funding could yield technological breakthroughs which would facilitate electricity grids comprised of 100% intermittent renewable energy. Not only would improved power storage synthesize Japan's objectives of achieving economic well-being, national energy security and environmental security (3Es), it would also nurture the emergence of a new power storage industry.

In concluding this review of Japan's wind power policy, it should be apparent from the analysis provided herein that Japan is in a precarious position in regard to developing a sustainable national electricity generation system. Wind power can be only part of the solution. If the technical potential of 140,000 MW of installed wind power capacity projected by the Geographical Survey Institute in Japan were achievable, wind power could conceivably provide approximately 430 TWh of electricity annually (assuming a capacity load factor of 35%). This amount of electricity would satisfy only about 48% of Japan's current electricity needs (FEPC, 2008). Including the 5% contribution currently made by hydro and biomass, there is still a shortfall of 47% that must be accommodated through a combination of fossil fuel power, nuclear power and/or energy-efficiency measures. In short, given current technical and economic constraints, it is highly probable that a decarbonized electricity mix in Japan would have to incorporate a degree of nuclear energy at least in the short run to help cover the 47% shortfall; and even then, it is probable that a high amount of installed gas-fired electricity capacity would be required to provide the necessary peaking capacity to accommodate such high levels of wind power.

This predicament underlines the importance of both intensifying research into cost-effective, utility-scale storage systems and continuing to champion energy-efficiency initiatives in all sectors of the Japanese economy. Advances in storage technology and progress in improving energy efficiency from both the demand and supply sides will reduce the amount of fossil fuel and nuclear power needed to cover energy supply shortfalls.

Ultimately, the dilemma that Japan faces epitomizes the quandary faced by most large industrialized nations. Until new technologies emerge, electricity needed to preserve the current economic status quo will likely have to come partially from either nuclear power (inducing waste management problems) or fossil fuel combustion (inducing carbon storage problems). However, regardless of the decisions made in regard to satisfying electricity supply shortfalls after all renewable energy options have been exploited to full capacity, exploiting the potential of renewable energy in general and wind power in particular should be accorded top priority if Japan wishes to minimize the externalities that reliance on fossil fuels and nuclear power cause.

In the 13th century, divine winds came to the assistance of the Japanese nation; however, without the strategy that the Japanese implemented to deter the Mongol forces from landing, the arrival of the "divine winds" would have been too late to have saved the nation. Similarly today, if Japanese policy makers accept the challenge of laying the policy foundation necessary for wind to play a role in Japan's energy transformation, it may very well be that once again wind will prove to be ambrosial.

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Appendix 1. Significant energy conservation developments in Japan

1978 Establishment of the Energy Conservation Center, Japan (ECC J.)
- A government-sponsored foundation responsible for promoting the efficient use of energy.

1978 Introduction of ECCJ Energy Audits Program
- Free energy audits provided for small and medium-sized companies. To date, approximately 5600 assessments have been carried out. Target companies are those with capital of less than ¥100 million or less than 300 employees.

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1979 Energy Conservation Law (AKA. The Law Concerning the Rational Use of Energy)
- Mandated energy management programs in approximately 3500 large factories.

1980 Publication of enhanced building standards for housing developments

1983 Revision to the 1979 Energy Conservation Law
- Regulatory and structural revisions to streamline the licensing and audit processes.

1992 Building Standards Upgrade
- All standards for housing developments were upgraded to meet benchmarks established for colder regions of Europe and North America.

1993 Further Revision to the 1979 Energy Conservation Law
- Tightened energy efficiency standards in factories and applied new standards to office buildings.
- Established energy efficiency standards for air-conditioners, fluorescent lamps, televisions, copying machines, computers and magnetic disk units.

1993 Introduction of Law for Energy Conservation and Recycling Support
- Introduced to financially assist business operators who voluntarily tackle such activities as rationalization of energy use and utilization of energy efficient technology.

1997 Establishment of the Headquarters of Measures to Arrest Global Warming
- Tasked with the responsibility of identifying comprehensive energy conservation measures to control CO_2 emissions.

1998 Further Revision to the 1979 Energy Conservation Law
- Expanded the number of “designated energy management factories” to include medium-sized factories. Over 9000 medium-sized factories and businesses affected by new standards.
- Introduction of the Top Runner Program which established best practice efficiency targets for 12 categories of products: passenger cars, diesel passenger cars, trucks, diesel trucks, air-conditioners, fluorescent lights, electric refrigerators, TV sets, computers, VCRs, magnetic disk units and copying machines.

2000 Establishment of eEnergy Conservation Labelling System
- Featuring the introduction of energy standards and a labelling system for household appliances.

2006 Further Revision to the 1979 Energy Conservation Law
- Tightened energy efficiency standards in affected factories and businesses.
- Introduced new standards to encourage energy efficiency in the transportation sector.

Appendix 2. Significant energy efficiency technology development policies Japan

1995 The Energy Star Program
- A labelling program which provides energy-saving criteria for office equipment.

1996 Voluntary Action Plan on the Environment
- A voluntary industry effort organized by the Japan Business Federation (Keidanren) involving 36 industries and 137 organizations. Each industry voluntarily sets energy efficiency targets and publicizes results on an annual basis.

1998 Financial Support Program for Combined Heat and Power
- 15% assistance toward the equipment cost for large-scale cogeneration projects.
- Debt guarantees provided by the New Energy and Industrial Technology Development Organization (NEDO).

1999 Regional Subsidies
- Initiatives include local government support for the introduction of advanced energy-saving equipment, community energy-saving activities, the creation of energy-saving models, development of practical energy-saving techniques, development of techniques for electrical loss reduction and optimum device control in operating equipment, medium and small businesses energy conservation programs, development of energy efficient equipment businesses, promotion of field tests for the introduction of high performance industrial furnaces, and the promotion of energy-saving development of housing and office buildings.

2000 METI Committee on Advanced Demand Side Management
- Committee which seeks to influence consumption patterns through the creation of policies for the promotion of businesses which provided energy-saving goods and services and policies that will encourage users to invest in energy saving equipment.

2000 The Green Procurement Law
- Promotes the purchase of equipment that reduce environmental impact.

2001 Introduction of Solar Power in Government Office Buildings
- Aiming to install 410 kWh of solar power capacity in 13 government offices. This program is designed to serve as a model project in order to encourage other institutions and companies to introduce solar power.

2008 Creation of Green Energy Partnership

The aim of the partnership is to bring together manufacturers, retailers, green power generation companies, green power certificate issuers and community stakeholders to join forces to promote the adoption and use of green energy at the national level.

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