TOWARDS BETTER DEVELOPMENT POLICY: UNDERSTANDING THE SOCIO-POLITICAL ECONOMY OF WIND POWER

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Wind power has the potential to play a leading role in the exigent challenge to facilitate a global transition away from fossil fuel electricity generation. Unfortunately, it is still a comparatively costly form of electricity generation when external costs associated with electricity generation technologies are ignored, as they historically have been in all advanced nations. Accordingly, a great deal of attention is given to evaluating the effectiveness of economic policy instruments to help close the cost disparity between wind power and coal-fired power, which is the preferred source of electricity generation technology in many nations around the world. Although such attention is certainly warranted, this thesis demonstrates that there is a growing body of evidence to suggest that non-economic impediments to wind power development also exist and can threaten the efficacy of even the most suitable economic instruments in terms of catalyzing expedient development of wind power.

The focus of this thesis is on examining STEP (social, technical, economic and political) impediments to wind power development both at a project level and at a national planning level. It will be demonstrated that these forces interact to form a web of impediments. If wind power development policies are to be designed and implemented for optimum impact, policymakers cannot afford to neglect non-economic impediments.

Part 1 of the thesis examines STEP impediments at the micro (regional or project) policy level. For policymakers who are tasked with the responsibility for either creating regional wind power development support policy or overseeing the development of public wind power projects, part 1 of the thesis provides insights in cost control, community relation management, environmental planning, wind power potential analysis, project tender design and CO_2 emission evaluation that are deemed necessary to optimize policy decisions at the micro-level.

Part 2 of the thesis examines STEP impediments at the macro (national) policy level. This part introduces detailed case studies of wind power development in four advanced nations (Australia, Canada, Japan and Taiwan) which have track records of phlegmatic wind power development. The intent of the case studies is to extract insights into impediments that cause such stilted progress. Therefore, part 2 concludes by tying all four case studies into a STEP framework which explicates the social, technical, economic and political barriers that hinder adoption of effective national wind power development policies.

For energy policy practitioners, this thesis represents a necessary consolidation of requisite knowledge to improve the efficacy of wind power development policy. From an academic perspective, this work remedies a major lacuna in wind energy policy by explicating the impediments to effective wind power development from a policymaking perspective.

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ACRONYMS

3E's	economic growth, energy security and environmental protection
ATSE	Australian Academy of Technological Sciences and Engineering
CCS	carbon capture and sequestration
CDM	Kyoto Protocol Clean Development Mechanism
CEPA	Canadian Environmental Protection Act
CER	certified emission reduction
CLF	capacity load factor
CO2	carbon dioxide
COP15	15th Conference of the Parties
CPRS	Carbon Pollution Renewable Scheme
ECCJ	Japanese Energy Conservation Center
EIA	United States Energy Information Administration
EIAs	environmental impact assessments
EWEA	European Wind Energy Association
GDP	gross domestic product
GHG	greenhouse gas
GW	gigawatt
GWh	gigawatt hours
HFC	hydrofluorocarbon
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPP	independent power producers
JNOC	Japan National Oil Corporation
kW	kilowatt
kWh	kilowatt hour
LCOE	levelized cost of electricity
LNG	liquid natural gas
METI	Japanese Ministry of Economy, Trade and Industry
m/s	meters per second
Mt	million tons
Mtoe	million tons of oil equivalent

MW	megawatt
MWh	megawatt hours
NAFTA	North American Free Trade Agreement
NEDO	Japan New Energy and Industrial Technology Development Organization
NEM	national energy market
NIAMBY	mot in anyone's backyard
NIMBY	mot in my backyard
NFFO	Non-Fossil Fuel Obligation
PEI	Prince Edward Island
ppm	parts per million
OECD	Organisation for Economic Co-operation and Development
OPEC	Organization of the Petroleum Exporting Countries
PFC	perfluorocarbons
PPA	power purchase agreements
ppm	parts per million
PV	photovoltaic
R&D	research and development
REC	renewable energy credits
RET	Renewable Energy Target
RFP	request for proposal
RPS	Renewable Portfolio Standard
SF6	sulfur hexafluoride
STEP	social, technical, economic, political
T&D	transmission and distribution
Taipower	Taiwan Power Company
TBOE	Taiwan Bureau of Energy
TWh	terawatt hours
WCMG	waste coal mine gas
WDI	World Development Indicators
WPP	wind power potential
WPPI	Wind Power Production Initiative

CHAPTER 1

INTRODUCTION: WHY WIND?

The climate centres around the world, which are the equivalent of the pathology lab of a hospital, have reported the Earth's physical condition, and the climate specialists see it as seriously ill, and soon to pass into a morbid fever that may last as long as 100,000 years. I have to tell you, as members of the Earth's family and an intimate part of it, that you and especially civilisation are in grave danger.

- James Lovelock 2006[1]

Climate change presents a unique challenge for economics: it is the greatest and widest-ranging market failure ever seen… Our actions over the coming few decades could create risks of major disruption to economic and social activity, later in this century and in the next, on a scale similar to those associated with the great wars and the economic depression of the first half of the 20th century. And it will be difficult or impossible to reverse these changes.

– Sir Nicholas Stern, 2006[2]

1. 1 THE GLOBAL IMPERATIVE

The year 2006 represented an intellectual tipping point for climate change advocacy. It was a year which saw the beginning of a general convergence of understanding between many environmentalists and economists on the perilous threat posed by climate change.

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[1] Source: The Independent (Lovelock, 2006)

[2] Source: The Stern Review- Executive Summary (Stern, 2006)

In the summer of 2006, the release of Al Gore’s *An Inconvenient Truth* brought the issues associated with climate change to the general public, eventually becoming the third-highest grossing documentary in United States’ history.

In October 2006, a comprehensive independent study called the *Stern Review* commissioned by the Chancellor of the Exchequer in the UK, presented an assessment of the anticipated impacts of climate change. As a foreboding sign of the content which would follow, the report began by describing climate change as “*the greatest and widest ranging market failure ever seen*” (Stern, 2006, p. i). The report concluded that the long-term costs of climate change are expected to be so great, that early action to abate global warming is the most cost-effective alternative. It estimated that the net benefits (benefits less costs) from reducing greenhouse gas (GHG) emissions to achieve a stabilization level of 550 parts per million (ppm) by 2050 would be in the neighbourhood of US$2.5 trillion (Stern, 2006).

In February 2007, the first of four reports that comprise the Fourth Assessment Report of the United Nation’s Intergovernmental Panel on Climate Change (IPCC) was released. The goal of this first report was to “*describe progress in understanding of the human and natural drivers of climate change, observed climate change, climate processes and attribution, and estimates of projected future climate change*” (IPCC, 2007b, p. 2). Overall, the report upgraded international agreement on the likelihood of human activities being responsible for global warming from *likely* (66% or greater probability) to *very likely* (90% or greater probability). The data presented in the report was unexceptional in the sense that it mirrored data already available in the public domain; however, the report was significant in that it represented a consensus view of UN member nations. Symbolically, it represented the juncture in which humanity formally accepted culpability for causing climate change.

In April 2007, the second of four reports that comprise the Fourth Assessment Report of the IPCC was released. This second report focused on "*current scientific understanding of impacts of climate change on natural, managed and human systems, the capacity of these systems to adapt and their vulnerability*" (IPCC, 2007c, p. 1). Comparatively, the report was less comprehensive than the Stern Review in its assessment of the current and anticipated economic impacts of global warming on humanity and global ecosystems. However, it did serve to solidify the emergent consensus that climate change was significantly harming hydrological, terrestrial and biological systems (IPCC, 2007c).

Given the emergent international consensus that climate change is an immediate threat to both the social and economic well-being of humanity, the intuitive international response should be to cast vested national interests aside, hoist the sails of initiative and embark on rigorous greenhouse gas (GHG) abatement programs. However, such departures have not materialized. In fact, one is tempted to glibly question whether members of the international policy community have misconstrued Stern Review's admonition – "*delay in taking action on climate change would make it necessary to accept both more climate change and, eventually, higher mitigation costs*" (Stern, 2006, p. xv) – as a policy recommendation.

1. 2 ENERGY AND THE GLOBAL IMPERATIVE

Of the six greenhouse gases covered under the Kyoto Protocol (carbon dioxide, methane, nitrous oxide, and 3 fluorine gases- HFCs, PFCs and SF6), CO_2 emissions represent by far the largest anthropocentric threat to our atmosphere due to the sheer volume of annual CO_2 emissions. To illustrate this point, in 2004, CO_2 emissions (combined fossil fuel combustion and deforestation activities) accounted for 75% of all GHG emitted (on a comparative CO_2 basis[3]) (Netherlands Environmental Assessment Agency, 2006). In the same year, methane emissions (CH_4) accounted for approximately 16% of total GHG emissions and nitrous oxide accounted for approximately 9% of the total GHG emissions. As Figure 1.1 outlines, the remaining three fluorine gases represent a very small proportion of greenhouse gas emissions.

Figure 1.1: Global Greenhouse Gas Emissions from 1970-2004

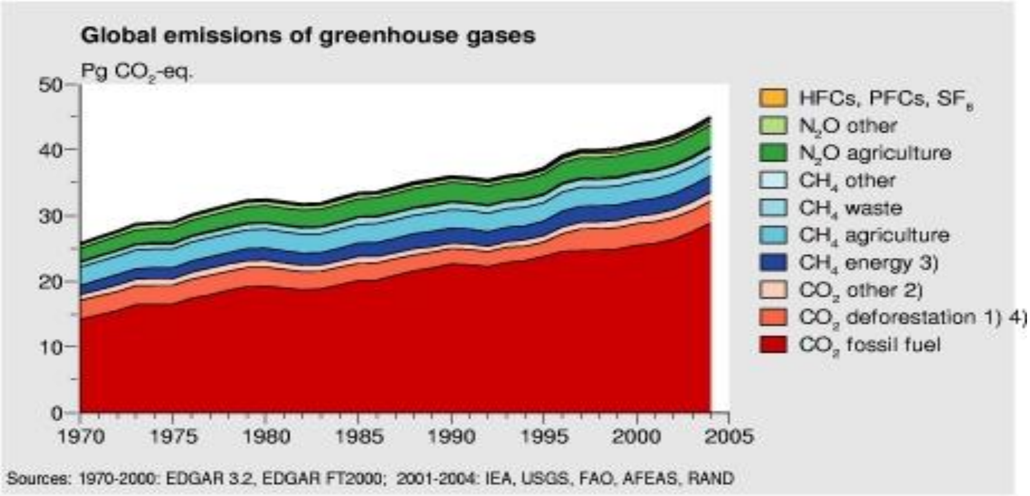

Chart Source: (Netherlands Environmental Assessment Agency, 2006)

The main hurdle stymieing international efforts to reduce CO_2 emissions appears to be difficulty that all countries are having breaking free from a dependence on fossil fuel

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[3] Greenhouse gases exhibit different global warming potentials so aggregate impact is often compared by translating global warming potential to a common metric- CO_2 equivalent.

energy. As UN Secretary General, Ban Ki Moon pointed out in his 2008 World Environment Day Message:

> "*Addiction is a terrible thing. It consumes and controls us, makes us deny important truths and blinds us to the consequences of our actions. Our world is in the grip of a dangerous carbon habit…The environmental, economic and political implications of global warming are profound. Ecosystems -- from mountain to ocean, from the poles to the tropics -- are undergoing rapid change. Low-lying cities face inundation, fertile lands are turning to desert, and weather patterns are becoming ever more unpredictable*." (Ban, 2008)

As Figure 1.1 indicates, CO_2 emissions from fossil fuel *combustion* accounted for approximately 60% of all GHG emissions in 2005. Clearly, if humanity is to avoid the worst effects of global warming alluded to by the Stern Review and the IPCC 4th Assessment Report, progress in terms of reducing emissions related to fossil fuel combustion is essential. Unfortunately, data points to increasing – not decreasing – trends in combustion-related CO_2 emissions. Globally, total combustion-related CO_2 emissions increased by 28% between 1990 and 2005 (Netherlands Environmental Assessment Agency, 2006). Although the main catalyst of this unsettling trend was a 75% increase of CO_2 emissions in developing countries, industrialized countries have also failed to reduce CO_2 emissions despite commitments made under the Kyoto Protocol to do so. As of 2006, Annex B nations (industrialized nations committing to reduction targets) had recorded an aggregate annual increase in CO_2 emissions of 4% compared to 1990 levels.

Looking forward, the US Energy Information Administration projects that under a scenario whereby current laws and policies remain unchanged, global energy consumption will increase by 50% between 2005 and 2030 (EIA, 2008c). Furthermore, the *proportion* of energy generated through fossil fuel sources will remain virtually unchanged. Thus, despite indications that CO_2 emission reductions of up to 80% are needed to abate the worst impacts of global warming (Stern, 2006), CO_2 emission projections indicate that emissions will increase rather than decrease.

It is notable that a great deal of global interest has arisen regarding the prospects of carbon capture and sequestration technology (CCS technology). The premise behind CCS technology is to capture CO_2 emissions from a point source (i.e. a coal-fired power plant) and then store the emissions either aquatically (deep sea injection), biologically (biological assimilation) or geologically (in natural geological storage chambers), thereby preventing CO_2 from dispersing directly into the atmosphere. Unfortunately, the volume of CO_2 which must be sequestered each year to abate global warming is of such magnitude that the management of captured CO_2 would likely present insurmountable hurdles, thereby rendering discussions about how to safely sequester such volumes to be moot.

CCS technology as it stands today requires a liquid storage vehicle (i.e. water) for the CO_2 (Hefner, 2008). How much liquid is required? If the CO_2 generated from all the coal-fired power plants in the United States were captured, approximately 50 million barrels per day of CO_2 infused fluid would be generated (Victor, 2008). This volume is four times greater than the daily oil production in the US (Hefner, 2008). In fact, on an annual basis, 90 million barrels of oil per day are distributed globally by a network that has taken decades to form (Victor, 2008). Accordingly, not only would enormous distribution networks be required to transport the effluent associated with CCS technology, the potential for environmental disaster caused by injecting so much effluent into geological or aquatic storage sites is almost unfathomable. In short, CCS technology may be somewhat viable as part of a short-term solution to abate the worst effects of global warming; but in its current technological manifestation, it is far from a responsible solution to the global GHG management challenge.

1. 3 ELECTRICITY AND THE GLOBAL IMPERATIVE

> *Over the next 25 years, the world will become increasingly dependent on electricity to meet its energy needs. Electricity is expected to remain the fastest growing form of end use energy worldwide through 2030, as it has been over the past several decades. Nearly 1/2 of the projected increase in energy consumption worldwide from 2005 to 2030 is attributed to electricity generation.* (EIA, 2008b, p. 61)

1.3.1 Electricity Generation Technologies

Given the dominant role that the electricity generation sector plays in global energy consumption, it is insightful to examine the pattern of technological development in the sector in order to assess the progress that can be expected in terms of CO_2 emission reductions.

Table 1.1: Global Electricity Use by Source

(data in trillion kilowatt hours)	2005	2030	Annual growth %
Liquids and other petroleum	1.0	0.8	-0.9
Natural Gas	3.4	8.4	3.7
Coal	7.2	15.4	3.1
Nuclear	2.6	3.8	1.4
Renewables	3.2	5.0	1.8
TOTAL	17.3	33.3	2.6

Source: (EIA, 2008b)

Table 1.1 tells a bleak tale. It is the Energy Information Administration's (EIA) 2030 global electricity use forecast from 2008 broken down by fuel source. The role of renewable energy technologies in global electricity generation is expected to continue to be minor despite a consensus that climate change presents an immediate, perilous threat to humanity (Stern, 2006), and despite expectations that costs of fossil fuels will rise (EIA, 2008b) while the costs of wind power and other renewable power will continue to decline (Brown & Escobar, 2007; Celik, Muneer, & Clarke, 2007; DeCarolis & Keith, 2006). By 2030, renewable technologies are expected to contribute a mere 15% to global electricity generation (down from 18.5% in 2005).

1.3.2 The Dynamics of Electricity Prices

Historically, the sluggish diffusion of renewable energy has been rationalised in economic terms. Until recently, the cost disparity between fossil fuel power options (specifically coal and natural gas) and renewable energy alternatives has been capacious enough to discourage transition to alternative energy. However, fossil fuel prices have edged significantly higher in recent years, substantially eroding this historical competitive cost advantage.

High grade US Appalachian Coal exemplifies the volatility of fossil fuel prices. From a trading range of US$40-45 per short ton between December 2005 and December 2007, the cost of this commodity swelled to US$150 per short ton in September 2008. Although, the cost retreated to approximately US$60 per ton in response to the fall 2008 global economic slowdown which quashed demand for coal, the cost is still higher than historic levels (US$51.60 as of November 25, 2009).[4]

Estimating the kilowatt hour (kWh) cost of energy generated by coal depends significantly on the grade of coal used and the generation technology employed; however, broadly speaking, the cost of the feedstock for generating 1 kWh can be estimated to be approximately US 3.25¢, assuming that i) Northern Appalachian coal has a thermal energy content of approximately 6,150 kWh/ton, ii) the coal sells for US$80 per short ton, and iii) the combustion technology employed exhibits a moderate 40% electricity conversion ratio. When the price was US$150 per short ton in September of 2008, the cost of feedstock to generate 1 kWh of electricity would have been approximately US 6¢. Note, however, that neither estimate includes capitalisation costs or operation costs.

The case for renewable technologies is strengthened when upward price pressure on fossil fuel feed-stocks are factored into the decision. For example, the EIA estimates that global coal consumption will increase by 65% between 2006 and 2030 (EIA, 2008b). Many analysts believe that such levels of consumption will dangerously deplete already degraded coal reserves. In a study for the European Commission,

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[4] Source: The Energy Information Administration, Accessed on January 3, 2010 at http://www.eia.doe.gov/cneaf/coal/page/coalnews/coalmar.html

Kavalov and Peteves (2007, pp. 4-5) provide a succinct overview of trends in the coal industry:

- (Due mostly to accelerated consumption), *from 2000 to 2005, the world's proven reserves-to-production ratio of coal in fact dropped by almost a third, from 277 to 155 years.*
- *Coal production costs are steadily rising all over the world due to the need to develop new fields, increasingly difficult geological conditions and additional infrastructure costs associated with the exploitation of new fields.*
- *The USA and China — former large net exporters — are gradually turning into large net importers with an enormous potential demand, together with India.*
- *These trends suggest a likely significant increase of world coal prices in the coming decades.*

Recently, the costs of other fossil fuel stocks have not fared much better than coal. Throughout the 20th century, the price of oil averaged US$24.98 per barrel with major price fluctuations occurring only during times of major global economic disruption.[5] However, as Figure 1.2 illustrates, since mid-1990, oil prices have sharply escalated, topping US$140 per barrel in July 2008.

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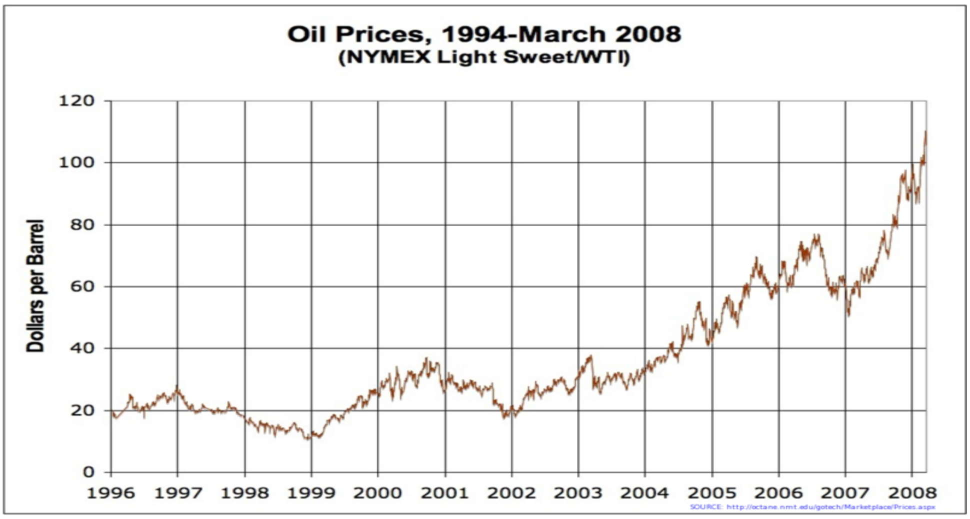
[5] Source: WTRG Economics web-site: "Oil Price History and Analysis" Accessed on June 27, 2008 at http://www.wtrg.com/prices.htm

Figure 1.2: The Price Trend of Light Sweet Crude Oil



Source of graph: Go-tech Website (http://octane.nmt.edu/gotech/Marketplace/Prices.aspx)

It may be tempting to attempt to draw a parallel between the recent inflation of oil prices and the sudden price increases in oil during the 1970s. After all, if the circumstances are analogous, the world can expect oil prices to fall back to pre-inflationary levels as it did between 1985 and 1998. Unfortunately the circumstances are not analogous. The escalation of oil prices in the 1970s was due to a supply shock. Specifically, oil-producing nations in the Middle East curtailed supplies. The current episode of escalating oil prices is caused by demand-side pressure. Simply put, the emergence of new economic powerhouses such as China and India along with unabated increases in oil consumption in established industrialized countries are taxing the ability of oil-producing nations to meet demand (Yergin, 2008). Not only are there concerns that oil capacity expansion initiatives will continue to lag demand for the next few decades, there are a growing number of experts within the oil industry who acknowledge that the global supply of oil may have peaked (Deffeyes, 2005). The Japanese government which is a major importer of oil estimates that commercially recoverable reserves of oil will be exhausted in 40 years (ANRE, 2006).

If oil has indeed peaked, it will become increasingly scarce and more costly to procure as rampant demand continues to deplete available supplies (EIA, 2008b).

For over 50 years, major oil-producing countries have been in the driver’s seat in terms of controlling the price of oil. The Saudis in particular, which still boast over one quarter of the world’s proven oil reserves, have played an active role in ensuring stable oil prices by controlling supply and pressuring other OPEC nations to follow their lead. Leaders in Saudi Arabia have astutely recognized that high oil prices provide incentives for nations to consider adopting other energy technologies (Ross, 2008). The fallout from the oil crisis of the 1970s taught this lesson. In response to high oil prices, nations such as the United States adopted more aggressive renewable energy promotion policies (Sovacool, 2008a). On the other hand, if oil prices are too low, oil producers squander profit opportunities because the demand for oil is relatively inelastic between the $30-$60 per barrel range (Deffeyes, 2005). Typically, then the oil producing nations have sought to maintain a balance that optimizes profitability without precipitating a shift to alternative energy forms. However, the demand for oil has escalated over the past decade to the point where oil producers have lost control of the market (Yergin, 2008). Opening the supply taps in order to maintain low enough oil prices to discourage adoption of alternative energy sources has simply accelerated depletion of oil reserves (Deffeyes, 2005).

Robert Hefner, the founder of The GHK Company which specializes in the development of natural gas projects sums up the coal and oil situation thusly:

> *Unfortunately, our existing energy infrastructure and its principal fuels of coal and oil are basically 18th, 19th and 20th century technologies that have not changed that much and can no longer meet our 21st century needs.* (Hefner, 2008, p. 152)

Natural gas is increasingly viewed as an attractive substitute for oil in many energy applications due to superior combustion efficiency and lower CO_2 emissions. On average, in comparison to electricity generated from coal, natural gas emits less than half the CO_2 for every kilowatt hour generated (Hefner, 2008). Over the next six years, the market for liquefied natural gas (LNG) is expected to double (Yergin, 2008). The EIA anticipates that by 2030, 35% of the world's total natural gas consumption will be utilized in electricity generation.

Unfortunately, the supply of natural gas exhibits the same undesirable characteristics as the supply of oil does. For starters, the nations that have rich reserves of natural gas are almost as unstable as the oil-producing nations. In fact, in many cases, they are one and the same in that natural gas and oil are frequently found in combination with one another (Deffeyes, 2005). For example, Russia which is the number one producer of oil in the world is also the number one producer of natural gas. It possesses 26% of global natural gas reserves and has demonstrated a propensity to use this resource for political gain and to exploit periods of high demand to gouge consumers (Stent, 2008). For example, a week prior to the conclusion of negotiations on the Black Sea Fleet in 1993, Russia cut natural gas supplies to the Ukraine by 25%. In 1998, it threatened to curtail natural gas provisions to Moldova unless Russia was permitted to retain troops in a breakaway region of the country. Moreover, in 2006 and 2008, Russia cut-off gas supplies to the Ukraine in the middle of winter when the Ukraine refused to renegotiate a favourable contract that they had in place for Russian natural gas. Russia exhibited similar behaviour in January 2007 by curtailing delivery of oil to Belarus amidst purchase price negotiations (Stent, 2008).

Moreover, like oil and coal, natural gas is a finite resource. Currently, the global reserves-to-production ratio of natural gas is estimated at 63 to 66 years (ANRE, 2006; EIA, 2008b). Although history has demonstrated that fossil fuel reserves tend to grow as exploration activities expand, it is becoming more evident that the projected demand boom for natural gas will significantly outpace the expansion of supply (Deffeyes, 2005). In short, like the prices of coal and oil, an upward escalation in the price of natural gas is likely.

While the costs of fossil fuels are on a decidedly upward trend, the costs of most mainstream alternative energy technologies continue to fall significantly as higher volumes of installed capacity lead to improved economies of scale and technological innovations improve generation efficiency. Table 1.2 provides an overview of the cost of electricity per kilowatt hour for the mainstream renewable energy technologies contrasted against the cost of electricity per kilowatt hour for the cheapest fossil fuel - coal. As the comparison in the 2001 column indicates, most renewable sources – wind energy, hydropower, geothermal power, and biomass energy – if produced in the most effective manner possible can generate electricity at costs that are already competitive with coal-fired power.

Table 1.2: Comparative Prices of Fuel Technologies and Future Trends

	2001 energy costs	***Emergent cost trends***
Coal (comparison) [6]	3-6 ¢/kWh	5-20 ¢/kWh
Wind	4–8 ¢/kWh	3–10 ¢/kWh
Solar photovoltaic	25–160 ¢/kWh	5–25 ¢/kWh
Solar thermal	12–34 ¢/kWh	4–20 ¢/kWh
Large hydropower	2–10 ¢/kWh	2–10 ¢/kWh
Small hydropower	2–12 ¢/kWh	2–10 ¢/kWh
Geothermal	2–10 ¢/kWh	1–8 ¢/kWh
Biomass	3–12 ¢/kWh	4–10 ¢/kWh

* All costs are in 2001 US$-cent per kilowatt-hour.
Source: World Energy Assessment, 2004 update (Johansson & Goldemberg, 2004)

The column on the right estimates an average cost of electricity over the next few decades given current trends. As the estimate indicates, the conflation of escalating coal costs and declining renewable energy costs has significantly improved the commercial competitiveness of all renewable energy technologies. This trend is expected to continue in coming decades.

Critics of this assessment could make the argument that maximizing the efficiency of coal combustion is largely dependent on the choice of technology; and as such, producing electricity at the lower-cost range for coal-fired power (i.e. 3¢/kWh) is simply a matter of technology selection while producing electricity at the lower-cost range for geothermal, biomass and wind power is largely dependent on geographic attributes, which are not a controllable. In other words, although it may be achievable for most countries to produce coal-fired electricity at US3¢/kWh, it is more likely that for most countries, the cost of generating wind power is closer to US6¢/kWh (the median value) because wind power cost is heavily influenced by geographical wind conditions. In fact, there are numerous estimates for wind power that either meet or

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[6] This range for coal is my estimate based on market trends. All other estimates are from the 2004 World Energy Assessment (Johansson & Goldemberg, 2004).

exceed the US6¢/kWh median value (cf. BWEA, 2005; Celik, et al., 2007; Dismukes, Miller, Solocha, Jagani, & Bers, 2007; Morthorst & Awerbuch, 2009)

On the other hand, such criticism could be countered with the argument that fossil fuel generated electricity has historically enjoyed a significant level of government subsidy support. Consequently, historical cost data rarely incorporates the full cost of fossil fuel generation. Nor does such criticism take into consideration the prospects of fossil fuel costs rising in the future. For the cost of fossil fuel generated electricity to be equitably compared to the cost of electricity generated by alternative technologies, it is necessary to compare the levelized cost of electricity (LCOE). LCOE is calculated by summing up all current capital costs, future fuel costs, future operation and maintenance costs and decommissioning costs. This total is then divided by the number of kilowatt hours of expected production over the lifetime of the equipment. When LCOE is used, it yields an interesting profile of costs.

Table 1.3: Nominal LCOE for the United States

Technology	*Nominal LCOE, US ¢/kWh ($2007)*
Offshore wind	2.6
Hydroelectric	2.8
Landfill Gas	4.1
Advanced Nuclear	4.9
Onshore wind	5.6
Geothermal	6.4
Integrated Gasification Combined Cycle (IGCC)	6.7
Biomass (combustion)	6.9
Scrubbed Coal	7.2
Advanced Gas and Oil Combined Cycle (AGOCC)	8.2
IGCC with Carbon Capture	8.8
AGOCC with Carbon Capture	12.8
Solar Photovoltaic	39.0

Source: Sovacool, 2008

Sovacool, in preparing an LCOE comparison for the United States based on data from the IEA, Cornell University, the National Renewable Energy Laboratory and the Virginia Centre for Coal and Energy Reserve, arrived at the estimates presented in Table 1.3 (Sovacool, 2008a).

As Table 1.3 indicates, fossil fuel sources of electricity are no longer the most economical options for electricity generation when subsidies are removed and the cost of building new plants incorporate best available estimates of future fuel stock costs. In fact, Sovacool argues that "nominal" LCOE should just be a starting point for electricity cost comparisons. He logically contends that social and environmental costs associated with each energy source (i.e. the cost of coal-fired power plant pollution abatement) should also be factored into the cost of electricity. Table 1.4 illustrates the impact that internalizing these external costs has on electricity source cost profiles (refer to the "adjusted LCOE" column) (Sovacool, 2008a).

Table 1.4: Nominal and Adjusted LCOE for the United States

Technology	***Nominal LCOE, US ¢/kWh ($2007)***	***Adjusted LCOE, US ¢/kWh ($2007)***
Offshore wind	2.6	3.0
Onshore wind	5.6	6.0
Geothermal	6.4	7.1
Hydroelectric	2.8	7.8
Landfill Gas	4.1	10.8
Biomass (combustion)	6.9	13.6
Advanced Nuclear	4.9	16.0
Advanced Gas and Oil Combined Cycle (AGOCC)	8.2	20.2
AGOCC with Carbon Capture	12.8	24.8
Integrated Gasification Combined Cycle (IGCC)	6.7	25.9
Scrubbed Coal	7.2	26.3
IGCC with Carbon Capture	8.8	27.9
Solar Photovoltaic	39.0	39.9

Source: Sovacool, 2008

As Table 1.4 illustrates, based on Sovacool's estimates for electricity costs in the United States, wind power, geothermal power and hydroelectric power emerge as decisively the most economical when all of the external costs are internalized. It should be noted that any such comparison of electricity costs comes with inherent biases which influence the results. For example, the "nominal" data presented in Table 1.4 is contingent on assumptions made regarding the future cost of fossil fuel resources. Furthermore, the "adjusted" data presented in Table 1.4 is appurtenant to assumptions made regarding costing of dominant negative externalities such as CO_2 emissions.

Accordingly, for the purposes of this paper, the data presented is not intended to support definitive quantitative proclamations regarding the comparative cost of electricity technologies; rather, it is intended to lend general support to the assertion that commercially viable alternative electricity generation technology is available today. A bounty of studies investigating the cost of externalities associated with fossil fuel electricity generation have all arrived at the same conclusion that even if conservative estimates regarding the cost of externalities (i.e. using the current price of carbon credits as a proxy for "all external costs") are employed, fossil fuel electricity sources become more expensive than hydropower and wind power (cf. ATSE, 2009; Morthorst & Awerbuch, 2009; Stern, 2006; Tester, Drake, Driscoll, Golay, & Peters, 2005; Wizelius, 2007). While the specific cost data may be at odds, the general conclusion is not.

Electricity sector market dynamics are changing due to international concerns over global warming and the progressive narrowing of the cost differential between fossil fuel electricity generation and alternative generation sources. From a policy perspective, a transition away from fossil fuel electricity generation technologies presents new opportunities and new threats. Accordingly, the next two sections examine the potential impact of such a transition on national interests. Section 1.4 examines opportunities and threats from the perspective of industrialized nations, while Section 1.5 takes a developing nation perspective. As will be demonstrated, after weighing the opportunities and threats associated with such a transition, there is a strong argument to be made for adopting aggressive policies to expedite such a transition.

1.4 ENERGY MARKET CHANGE & INDUSTRIALIZED NATIONS

For industrialized nations, energy has played a largely unheralded role in wealth creation and the cultivation of military might. Energy drives the high-tech production processes that provide industrialized nations with technological advantage over developing nations. It also fuels machines of war and supports military production processes that provide industrialized countries with international clout and domestic defence capabilities. Accordingly, any changes in energy market dynamics that alter the comparative cost structure of the nation's energy mix can potentially undermine national competitive advantage and destabilize national security. Overall, there is an ineluctable connection between energy policy, environmental policy, economic policy, national security policy and foreign-policy (Rothkopf, 2008). As the allure of fossil fuel energy technology continues to diminish, the once disparate objectives within these policy realms are exhibiting convergence (Biegan, 2008).

1.4.1 Convergence and Alternative Energy

It can be argued that a common "created" competency exists for all industrialized nations – effective strategic management of energy resources for the purposes of supporting industrial mechanization (Yergin, 1993). The top economies have learned how to create core competencies at different stages in the energy value chain. Canada (in oil and natural gas) and Australia (in coal) have exploited abundant reserves of fossil fuels to become global suppliers. The United Kingdom (British Petroleum), Holland (Shell) and the United States (Exxon) created national competitive advantages in wholesaling by nurturing the development of multinational energy firms (Yergin, 1993). Singapore established a core competency as an Asian hub for the refinement of fossil fuels. Japan leads the world in energy utilization efficiency and nuclear technology development (Campbell & Price, 2008b). In short, many countries that have achieved economic prosperity have done so by developing strategic strengths in one or more links of the energy supply chain.

As a global transition to alternative energy technologies materializes, new opportunities will emerge for nations to establish entrenched positions of leadership in the stages associated with these new energy value chains. Nations which are successful in assuming leadership roles will develop core competencies that will facilitate national competitive advantage. Viewed from a defensive perspective, industrialized nations that fail to make the transition in a strategic manner, may find their historical advantages usurped by developing nations. This is increasingly so in recent times, as the technological advantages that have been enjoyed by firms in industrialized nations are increasingly eroded. As Wizelius (2007, p. 133) summarizes for wind power, "*Even if the economic subsidies for wind power during its early stage* *of development are relatively expensive for the economy, politicians have calculated that in the longer run it will generate economic benefits.*"

In national defence, the strategic disadvantages of fossil fuels are becoming increasingly evident. Fossil fuels are largely imported (using tankers, barges, lorries, or pipelines that make easy military targets), scarce (thus, increasingly expensive) and subject to high degrees of international competition (Campbell & Price, 2008a). As Daniel Yergin points out, domestic energy supply limitations restrict a nation's capabilities to sustain lengthy military operations. In fact, insufficient access to oil at strategic stages of warfare contributed significantly to the downfall of both the German and the Japanese armies during the 1940s (Yergin, 1993). In recent times, the world witnessed the perils associated with foreign energy dependency when Russia curtailed access to liquid natural gas supplies to the Ukraine (Campbell & Price, 2008a). Clearly, establishing a national energy portfolio that focuses on encouraging the cultivation of domestic energy supplies represents a prudent initiative in the context of national security. Although very few countries can boast fossil fuel production that exceeds annual demand, all countries can bolster domestic energy security to some extent by harnessing alternative energy sources (geothermal, wind, hydro, solar PV, biofuels etc.).

This should not be misconstrued to imply that "complete independence" in energy is a goal that all nations should strive to achieve (Yergin, 2008). Clearly for many nations, there will be resource barriers which inhibit such a goal (Farrell & Bozon, 2008). Moreover, the economic theory of comparative advantage suggests that complete energy independence may in fact be economically sub-optimal (Mankiw, 1997).

However, it is clear that for many nations, the current reliance on fossil fuel supplies provided by unstable foreign countries subverts national security.

The influence that energy has on other aspects of global stability was summed up succinctly by Kurt Campbell and Jonathon Price in the context of US national security:

> *Every major issue confronting the United States today - including climate change, the rise of China and India, jihadist financing, an increasingly bellicose Russia, worrisome trends in Latin America, and endemic hostilities in the Middle East - is either inextricably linked to or exacerbated by decisions associated with energy policy. (Campbell & Price, 2008a, p. 11)*

1.4.2 The Need for Speed

There is strategic value in policies which encourage expedience in regard to facilitating a transition to domestically cultivated alternative energy supplies. Effective transition policies in deregulated markets enhance market opportunities and encourage intensified competition. This expedites competitive “shakeout” whereby the most efficient competitors leverage growth opportunities to stimulate growth and attain competitive advantage through economies of scale. Eventually the market consolidates to a pool of highly proficient market leaders (Porter, 1998). Applied to the electricity sector, policies which effectively support alternative electricity generation technology development will eventually create a market that produces electricity that is economically superior and not subject to fuel stock price fluctuations. This ensures that nations can preserve a competitive edge in this important factor endowment.

Another national benefit to be derived from nurturing competitively resilient alternative energy firms stems from employment and tax revenue enhancements as the firms grow first domestically and then internationally. It is worth exploring how this occurs. In order to achieve a dominant position in a given market, a firm must develop the core competencies that allow it to produce and deliver goods and services that meet market requirements in a competitively superior manner (Porter, 1985). Many of these core competencies can only be honed through experience. In short, market pioneers can gain a competitive advantage over slow market entrants by learning from early experiences and adopting better practices (Grant, 2005). Firms that succeed in highly competitive domestic markets often find that lessons learned domestically are often transferable to competitive forays into foreign alternative energy markets (Bartlett, Ghoshal, & Birkinshaw, 2003).

Firms which establish advanced competencies in competitively critical areas can use this competitive edge to establish unassailable market positions in foreign energy markets. This is because first-movers can establish defensive beach-heads in markets to more effectively counter market entry attempts by competing firms (Bartlett, et al., 2003). They can establish early brand recognition and early market share leads that make it difficult for competitors to usurp (Doyle, 1998). As all this unfolds, governments which have helped nurture the development of such industry leaders begin to benefit through enhanced tax revenues and job creation. The Dutch firm, Vestas, which is the world’s largest wind turbine manufacturer, is a testament to the capacity of domestic energy policy to nurture firms that are capable of competing successfully in global markets.

It is ironic how reluctant many leaders of industrialized nations have been to provide leadership in facilitating a transition away from fossil fuel dependence given the increased threats that fossil fuel reliance poses to economic well-being and national security. Islamic extremism, unrest in the Middle East, the rise of nationalism in countries such as Russia, Venezuela and Iran, global warming, the international drug trade and global financial instability all have roots stemming from this global addiction to fossil fuel energy (Rothkopf, 2008). The often heard laments espoused by leaders of industrialized countries that moving away from fossil fuel energy will increase the cost of doing business for domestic firms and impinge upon economic growth prospects is a false belief predicated on a misperception that fossil fuel energy technology is actually cheaper than other forms of energy. As outlined earlier, excluding external costs, wind energy for example is now cost competitive with fossil fuels. Including external costs, fossil fuel energy is economically inferior to any alternative energy form (Sovacool, 2008a).

1.5 ENERGY MARKET CHANGE & DEVELOPING NATIONS

Unsurprisingly, strategic energy mix planning has extensive economic, security and social repercussions in developing countries also.

1.5.1 Economic Considerations

For firms from developing nations that compete in international markets, a key competitive advantage is the ability to tap into a cost base that is significantly lower than that found in industrialized nations (Bartlett, et al., 2003). Accordingly, if the energy trends outlined earlier continue and alternative energy become less expensive than fossil fuel energy, exporting firms from developing countries will be at a strategic disadvantage if they must continue to pay higher prices for electricity produced by fossil fuel sources.

1.5.2 Economic Security Considerations

Volatile electricity costs are of particular concern in developing countries. This is because developing countries are frequently characterized by both low per capita rates of saving and low levels of government savings (Perkins, Radelet, & Lindauer, 2006). Consequently, unanticipated increases in the cost of a resource, that is as important to economic well-being as energy is, can significantly influence the economic well-being of firms and citizens. Clearly, anything that can be done by policymakers in developing countries to encourage price stability should be done.

Alternative energy technology represents an avenue for enhancing electricity price stability. As demonstrated earlier, fossil fuel prices have fluctuated considerably while inching higher over the past few years and are expected to lurch higher in the decades to come (EIA, 2008c). On the other hand, the costs of many alternative sources of energy have been declining consistently over the past decade. The only degree of volatility that exists for many alternative energy technologies lies in uncertainty over the timing and degree to which costs will decline (Neuhoff, 2005). In short, renewable energy represents an opportunity to inject a degree of cost stability into a nation's energy mix.

1.5.3 Economic Empowerment

The technological diversity of alternative energy options allows policymakers in developing nations to target and support technologies which mesh most effectively with the existing economic infrastructure. Governments in developing nations that attempt to fast track economic development by importing advanced technology often experience sub-optimal results because the existing economic infrastructure fails to support the technology (Perkins, et al., 2006). Todaro and Smith (2003) contend that a more effective national economic development strategy is to identify strategies to support the development of forward and backward linkages associated with existing industries. In the alternative energy industry, there are biofuel options which can be integrated with agricultural activities, there are solar options that can provide electricity to areas where electricity grid infrastructure is insufficient and there are biomass energy options that can add-value to industries which produce biomass as waste by-products. Clearly, the diversity of technical options in alternative energy allows developing countries to match strategic energy mixes with national competencies.

1.5.4 Social Considerations

In developing countries, abatement of climate change is just one benefit associated with a transition away from fossil fuel energy. Economic growth overwhelms environmental governance in many developing countries. Consequently, lax environmental regulations governing electricity generation and transportation emissions give rise to significant environmental and social problems. For example, air pollution in China is so bad that it is now the leading cause of death in the country (Fairley, 2007). Worldwide, 16 of the 20 cities with the worst air pollution are found in China (Bader, 2008). If a transition to cleaner forms of energy could be facilitated in an economically effective manner, citizens in developing countries could enjoy the benefits of enhanced affluence without also having to suffer the negative externalities associated with economic growth.

1.5.5 The Need for Speed

Previously, an assertion was made that industrialized nations that embrace more proactive policies for expediting a transition to alternative energy can nurture the development of internationally competitive, domestic alternative energy firms. This justification for expedience also applies in developing nations. An example of how government support for alternative energy in developing nations can also sire domestic firms that are capable of competing successfully internationally is the wind power firm Suzulon which was formed in 1995 in India and has since grown to become the 3rd leading manufacturer of wind power equipment.

There is another benefit to proactive alternative energy development policies that applies solely to developing nations. Currently, there are a number of financial mechanisms (the Clean Development Mechanism-CDM, the Global Environmental Facility, the World Bank Clean Energy Fund, and a number of other Overseas Development Assistance funds) that developing nations can tap into to help finance a transition away from fossil fuel energy. However, these financial support funds will not last forever. As more nations adopt alternative energy expansion policies, competition for these funds will heat up. Donor agencies will be faced with difficult choices in regard to allocation. If history is any indicator, this in turn will result in more conditions being placed on the funds (Perkins, et al., 2006). Furthermore, a stage will inevitably be reached where international willingness to finance such energy projects will wane. Forebodingly, a number of CDM projects are already being rejected for not meeting the CDM condition of “additionality” (that the project would not have been carried out without support from the CDM program) (Castro & Michaelowa, 2008). It appears that the market for funds is already tightening.

Developing nations that move quickly to take advantage of these financial mechanisms will gain a leg up on their developing country rivals by procuring alternative energy generation capacity at subsidized rates.

1.6 WHEN FORCES FOR SPEED MEET THE NEED FOR SPEED

The analysis presented to this point indicates that energy market dynamics are gradually shifting in favour of alternative energy technologies; and indeed, for industrialized and developing countries alike, there are strong emergent incentives for political leaders to embrace aggressive policies to facilitate expedient transition. Fortuitously, the benefits associated with such a transition mesh seamlessly with the need to respond assertively to abate global warming.

In the oft quoted economic assessment of climate change known widely as the Stern Review, climate change was called, "*the greatest and widest-ranging market failure ever seen*." The review concluded that "*the benefits of strong, early action* (to abate global warming) *considerably outweigh the costs*". In emphasizing the importance of expedience in facilitating a transition away from fossil fuel dependence, the report declared:

> *The effects of our actions now on future changes in the climate have long lead times. What we do now can have only a limited effect on the climate over the next 40 or 50 years. On the other hand, what we do in the next 10 or 20 years can have a profound effect on the climate in the second half of this century and in the next*. (Stern, 2006, pp. i-ii).

The Intergovernmental Panel on Climate Change's Fourth Assessment Report on Climate Change also echoed the appeal made in the Stern Review that expediency in developing and implementing mitigation measures is of utmost importance. The report stated:

> *Many impacts can be reduced, delayed or avoided by mitigation. Mitigation efforts and investments over the next two to three decades will have a large impact on opportunities to achieve lower stabilisation levels. Delayed emission reductions significantly constrain the opportunities to achieve lower stabilisation levels and increase the risk of more severe climate change impacts (IPCC, 2007a).*

It is promising that the forces to justify an expedient transition to alternative energy are amassing during a period of time when such an expedient transition is required.

1.7 THE DICHOTOMY OF ALTERNATIVE ENERGY

Despite emergent levelized cost data such as the data presented in Table 1.4 which indicate wind power, hydro power, geothermal power and biomass combustion are all economically superior to all forms of fossil fuel power (with or without carbon capture and sequestration); despite the potential benefits accruing to nations (both industrialized and developing) that undertake a transition to these alternative energy forms in an expedient manner; and despite the global warming imperative to ensure nations cooperate to reduce CO_2 emissions, the pace of alternative energy development is phlegmatic.

Most certainly the growth rates attributed to some of the more commercially attractive alternative energy technologies are impressive when considered in isolation. For example, the World Wind Energy Association reports that installed wind power capacity has grown more than 10-fold since 1999 (WWEA, 2009). Less impressive but still laudable, the International Geothermal Association reports that installed geothermal power capacity for electricity generation increased 55% between 1990 and 2005.[7] However, in absolute terms, the inroads that these two commercially viable energy forms have made into the electricity generation sector have been minor. Total global installed wind power capacity at the end of 2008 amounted to approximately 121,188 MW. Electricity output from these turbines amounted to only 1.5% of global electricity consumption (WWEA, 2009). Even less significant was the total amount of installed geothermal electricity generation capacity which, as of 2005, totalled only 9,064 MW.[8] Overall, it would be accurate to conclude that these two promising forms of renewable energy are indeed diffusing but nowhere near the level of penetration necessary to make significant contributions to global warming abatement.

This then is the emergent dichotomy involving renewable energy; although strong environmental, economic and political justifications exist for nations to adopt aggressive programs for supporting a transition to renewable energy, the nations of the world remain highly committed to fossil fuel electricity generation. In the lead up to the 15th Conference of the Parties in Copenhagen (COP15), there were indications that the commitments to be undertaken by developed countries would be in the neighbourhood of 8-12% below 1990 levels by 2020 after accounting for forestry

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[7] International Geothermal Association web-site: http://www.geothermal-energy.org/226,installed_generating_capacity.html. Accessed on 29 November 2009.
[8] Ibid.

credits.[9] This lies in stark contrast to the 25-40% reduction level described as necessary by the Intergovernmental Panel on Climate Change (IPCC). Yet even these modest targets failed to gain acceptance at COP15. Meanwhile, developed countries lag far behind the industrialized countries in terms of GHG emission reduction targets with most still resisting the concept of making formal commitments (IGES, 2005).

Clearly a degree of dynamic tension exists within the electricity sectors in all nations. On one hand, all of the 192 nations that have ratified the Kyoto Protocol (as of December 1, 2009) have introduced initiatives to support the development of renewable energy. Many of the top economies of the world now have specific renewable energy targets supported by policy instruments such as feed-in tariffs, production tax credits, mandatory renewable energy quotas and production subsidies, all intended to encourage a greater uptake of renewable energy. Best practices in policy development have been internationally disseminated and policymakers that are intent on pursuing aggressive renewable energy development strategies can access numerous accounts of how countries such as Germany, Spain and Denmark have recorded successes in encouraging development of renewable energy through various policy instruments (cf. Komor, 2004; Mallon, 2006; Wizelius, 2007). However, with the exception of a few smaller nations such as Denmark, Norway, Portugal and the Netherlands, the contribution of renewable energy source to the national electricity mix is trivial in most advanced nations. Given the justifications outlined to this point for supporting renewable energy development and the existence of policies for catalyzing such a transition, the phlegmatic results in advanced nations are perplexing.

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[9] Climate Tracker web-site: http://www.climateactiontracker.org accessed on November 30, 2009. This site is created to allow members of the general public to keep track of political commitments made by nations.

Simply put, what is preventing a more robust diffusion of renewable energy in the electricity sector?

1.8 OBJECTIVES OF THE RESEARCH THESIS

This thesis seeks to make a contribution to the broader challenge of identifying what is preventing a more robust diffusion of renewable energy in the electricity sector by better understanding the factors that impact the effectiveness of the policy making process and influence the diffusion of wind power in advanced economies.

A decision was made to focus on one renewable energy technology because each technology is characterized by its own set of socio-technical political challenges that must be overcome in order for the technology to proliferate (Mallon, 2006). For example, concerning social hurdles, there are perceptions that wind power technology is noisy and poses a threat to avian communities (Boyle, 2004). Conversely, solar PV is not audibly invasive but a transition to solar PV electricity at the household or industry level would require a massive conceptual shift in architectural design that amplifies the economic barriers solar PV firms face. Similarly, each alternative technology faces different technical hurdles. For wind power, a major technical hurdle lies in effectively managing the stochastic flow of power generated from wind (Ackerman, 2005). For geothermal power, a huge challenge stems from logistical complications of delivering power from the geothermal site to where it is needed (Boyle, Everett, & Ramage, 2004). Each technology also faces different political and economic barriers because each technology has its own profile in terms of generation costs, infrastructure requirements and economic impacts. Moreover, the diffusion of each technology is influenced by different stakeholder groups all exerting varying degrees of influence on the diffusion process. Because each alternative technology faces unique challenges, one technology was chosen as the focus to ensure a suitable level of depth for the purposes of this study.

When considering which technology to select as the focal technology for this study, wind power stood out for a number of reasons; but three are worth highlighting. First and foremost, because wind power is a commercially competitive energy source, the majority of advanced nations around the world have initiatives in place specifically designed to encourage the development of wind power. This attribute was attractive from a research perspective because it implies a much larger and richer research universe from which to draw research insights. Second, for virtually every advanced nation, wind power can, to certain degrees, be incorporated into existing grids without any significant physical alterations to the electricity grid structure. The allure of this attribute is that research insights to improve the effectiveness of wind power development policy could be immediately useful to policymakers worldwide. As Whetton (1989) points out in an article clarifying what constitutes a worthy academic contribution, choosing topics which are of contemporary interest helps to ensure that emerging research provides the "*so what*" factor that is characteristic of a significant contribution to any given field. Third, as was pointed out earlier, the need for an expedient transition to carbon-free forms of electricity generation is imperative if humanity is to have any chance of avoiding severe ecological impacts associated with global warming. As will be detailed later in this thesis, wind power could conceivably provide at least 20% of humanity's electricity demand within months if the political will and economic commitment existed. In short, research into how to improve wind power development policy in advanced nations represents the type of social contribution that applied public policy research should endeavour to achieve (O'Sullivan, Rassel, & Berner, 2003).

The study focuses specifically barriers to wind power development in *advanced* economies for three specific reasons. First, it is probable that per capita level of affluence has paramount influence over wind power development policy in a given nation. When nations reach high levels of per capita affluence, national development policies tend to shift from a prevailing emphasis on fostering economic growth to a more balanced development portfolio that also incorporates the enhancement of environmental and social welfare (Perkins, et al., 2006; Todaro & Smith, 2003). The result is a convergence of socio-political economic aspirations. For example, although cultural nuances differ, socio-political economic aspirations in Japan and the United Kingdom exhibit more similarities than socio-political economic aspirations in Japan and Malaysia. Second, with the exception of China, India and Russia, advanced economies dominate the list of nations with the highest levels of energy related CO_2 emissions. In 2006, over 40% of all CO_2 emissions came from 10 advanced economies.[10] Consequently, an improved understanding of wind power development in advanced nations will provide insights into how CO_2 emissions can be reduced in nations which are having the highest per capita impact on global warming. Third, advanced economies have superior financial capacity to support wind power development initiatives and as such deserve a degree of prioritization given the global imperative to expediently initiate such transition away from carbon-intensive

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[10] Source: World Bank, World Development Indicators 2006, www.worldbank.org. The 10 advanced economies with the most emissions include: USA (21.2%), Japan (4.5%), Germany (2.9%), Canada (2.1%), UK (2%), South Korea (1.7%), Italy (1.6%), France (1.4%), Australia (1.3%), and Spain (1.1%). Data from Taiwan is not included in WDI data but in 2006, per capita CO2 emissions in Taiwan were the third highest in the world which would place Taiwan in the top 5 advanced nations in terms of aggregate emissions (Tchii, 2009).

electricity technologies and the reluctance that developing countries have demonstrated toward facilitating such a transition without advanced nations acting first (Prins & Rayner, 2007).

The boundaries implied by these conceptual choices produce a refined version of the paradox alluded to earlier and gives rise to the predominant research question guiding this study: *if forces in support of a transition to alternative energy are currently amassing and wind energy is currently a viable, readily implementable solution, why is the diffusion of wind energy technology plodding along in many advanced nations when it should be escalating at breakneck speed?* In the next chapter, the methodology used to guide the search for answers to this important question is explicated.

CHAPTER 2

RESEARCH DESIGN AND METHODOLOGY

2.1 RESEARCH QUESTION AND CONCEPTUAL LENS

2.1.1 Primary Research Question

If forces in support of a transition to alternative energy are currently amassing and wind energy is a currently viable solution, why is the diffusion of wind energy technology plodding along in many advanced nations when it should be escalating at breakneck speed?

2.1.2 Theoretical Perspective

It would be a gross oversimplification of the policy process to contend that successful policymaking depends solely on the successful development and implementation of appropriate policy instruments. Clearly in regard to wind power development, the development and implementation of effective policy instruments can influence market behaviour; however, there are a great many exogenous factors which are not typically considered part of the traditional policy cycle (cf. Howlett & Ramesh, 1995) which have the capacity to undermine the effectiveness of any given policy instrument.

Broadly, exogenous impediments to the policy process can be conceptualized on two levels, a micro-level and a macro-level. Micro-level exogenous impediments include forces in play at the municipal or project level that can either derail the completion of projects or cause projects to be developed in sub-optimal fashion. For example, in the UK during the 1990s, the policy instrument for promoting renewable electricity capacity development was known as the Non-Fossil Fuel Obligation (NFFO) which was essentially a supply-side subsidy. One of the problems with the NFFO was that wind power development projects were awarded through a national bidding process to developers who then faced inflated zoning hurdles erected by municipal governments who felt that community development was being impinged upon by the national government. Projects without local participation often wound up approved nationally but undeveloped locally, a good illustration of micro-level exogenous forces impeding the policy process (Komor, 2004). Macro-level exogenous impediments refer to elements which influence policy at the national level. For example, James Hansen makes the charge that fossil fuel special interest groups in the United States have been primarily responsible for undermining development of renewable energy despite economic and ecological advantages attributed to some of the mature renewable energy technologies (Hansen, 2008).

A key premise of this research study is that micro and macro-level exogenous impediments are not well understood; nor have any attempts been made in respect to wind power development policy to explicate the nature and characteristics of these exogenous obstacles in a manner that would allow policymakers to develop counter-strategies to minimize these impediments. Therefore, the study seeks to achieve two goals: i) contribute to a better understanding of these peripheral influences on the policy process, and ii) begin the process of “bringing order” to the study of these forces by developing cognitive taxonomies to map these forces (cf. Lowi, 1972). The phrase “socio-political economy” has been used in the title of this research project to highlight that the study seeks to examine a broad spectrum of social, technical, political and economic influences which impede wind power development.

The study is operationalized on both the micro and macro-levels. The first part of the study – the micro-analysis – examines impediments to wind power development at the *project level*. A micro-level analysis serves two functions for this research study. First, for policymakers who are tasked with the responsibility of supporting project development at the community or regional level, it is essential to understand the types of barriers that can cause a well-designed policy instrument to be ineffective at the implementation stage. Second, an in-depth examination of concerns faced by wind power developers will provide the reader with the background knowledge necessary to better understand the social, technical, political and economic forces that impinge on effective national wind power development policy, which is the theme of the second part of the study – the macro-analysis. Although a lot has been written about us how to design effective national wind power development policy, very little research exists in regard to exogenous obstacles which tend to either undermine national policy design or derail policy diffusion efforts.

2.2 PART 1 METHODOLOGY (MICRO-LEVEL POLICY INSIGHTS)

There are numerous examples of national wind power development stimulus measures being undermined by failed projects due to community resistance, environmental concerns or technical issues that result in unexpected financial burdens goals for the developer, the utility, the affected community or transmission and distribution (T&D) companies (cf. Ackerman, 2005; Firestone & Kempton, 2007; Wizelius, 2007). Many of these project level problems occur because of inadequate knowledge on the part of policymakers who create policies to oversee such projects. Decisions made by local or regional governments in areas such as spatial planning (zoning decisions), regulatory control, infrastructure investment and environmental impact governance significantly influence the viability of individual wind energy projects (Komor, 2004).

The complexity of wind power technologies combined with the intrusive nature of community wind power projects implies that effective micro-level policy decisions must consider issues related to engineering (mechanical, electrical and aeronautical), finance, geography, spatial planning, environmental management, meteorology, law and industrial ecology, to name but a few (Wizelius, 2007). Very few individuals, in government policy roles or otherwise, possess the depth and breadth of knowledge necessary to ensure such projects are overseen in economically optimal, environmentally sustainable manners. In the policy profession, enlisting specialist advice on complex issues is a common approach for improving decision-making effectiveness. However, a modicum of discernment is necessary in order to avoid making poor decisions through flawed expert judgement. In short, a degree of scholastic aptitude must be an acquired in order to evaluate the advice given by specialists.

Regrettably, even though there is a great deal of extant literature which could help better inform policymakers, it is fragmented and frequently highly specialized. Technical knowledge on wind power projects that hold relevance to policymakers frequently wind up embedded in engineering journals and trade publications. Insights related to environmental impact typically must be unearthed from environmental management journals or other ecological publications. Actual experiences from project implementation are often embedded in an array of sources ranging from textbooks to trade publications to applied energy journals. This puts regional or municipal policymakers in the unenviable position of having to vet numerous data sources to gain the insights necessary to effectively design wind power project support strategies. Policymakers seldom have the time to conduct such research; yet when they do, time pressures accentuate the possibility of vital insights being overlooked.

With this in mind, the main goal of Part 1 of this study is to conduct a meta-analysis of issues which can influence the success of wind power project implementation and to communicate the insights in a manner that is relevant to policymakers who are tasked with the responsibility of designing and implementing policies to support development of such projects.

The main research question which guides research efforts in Part 1 is:

> *What do policymakers need to know about utility-scale wind power projects to produce development support strategies that are socially, technically, economically and politically effective?*

2.2.1 Research and Sampling Approach

Construction of the research design for Part 1 began with the fundamental premise that the task of identifying a comprehensive collection of policy relevant insights in regard to wind energy projects would benefit from a formalized approach to searching extant literature, extracting insights and cataloguing the insights into categories that will be intuitively understandable for policymakers. The basic processes associated with this challenge – extracting and ordering insights from scientific observations – suggested that an inductive model would be most suitable.

In regard to identifying the research universe from which observations would be gathered, the desired objective was to achieve depth and breadth of insights. Conducting field research was initially entertained because primary field research tends to yield the type of fresh insights that contribute to the advancement of academic understanding. However, field research was eventually obviated by a realization that with time and budget limitations, conducting the extent of interviews necessary to acquire comprehensive knowledge would be infeasible. After rejecting field research as a method for operationalizing Part 1, efforts turned to identifying a “proxy” for interviews that would yield valuable insights. Extant literature was a logical choice in this regard.

There are numerous benefits to using existing research literature to provide insights into what policymakers need to know about wind power development. As opposed to field interviews where subjects may be less punctilious regarding the quality of information given, the peer review process associated with academic journals encourages academic rigor and ensures a degree of precision regarding the information published (Bryman, 2007). Moreover, the academic research process encourages the supplementation or refutation of previous articles (Locke & Golden-Biddle, 1997). Consequently, the collection of insights found in academic journals tend to reflect an emergent consensus of knowledge regarding any one issue or area, which is a form of external validation (Cook & Campbell, 1979). Finally, the process of drawing insights from extent literature enables the extraction of knowledge from disparate research fields and from various cultural contexts. This last benefit is highly relevant to the challenge of addressing micro-level wind power development policy challenges in different nations.

2.2.2 Contribution of Part 1: The Microanalysis

A prime concern related to the decision to rely on extant literature for source data was that the conclusions would not represent a significant contribution which is the goal of PhD research. However, it is contended that the contribution of this study does not lie in the freshness of the data; but rather, the freshness of the interpretative insights. Essentially, the goals of Part 1 are to i) gather vital research insights from various disciplines related to wind energy development, ii) interpret these insights in terms of how they impact the policy process and iii) convey these insights through a cognitive framework that policymakers can comprehend. Therefore, much like quantitative research that manipulates extant data (i.e. World Bank statistics) in order to identify relevant trends or relationships, this research study attempts to do the same thing using a pool of extant quantitative and qualitative research data.

2.2.3 The Value of an Interpretative, Qualitative Model

The dominant processes in Part 1 of this research project (extracting and ordering insights from scientific observations) and the diversity of the data pool (both quantitative and qualitative sources) render an interpretative, qualitative model appropriate. Such a model allows data from disparate sources to be conflated and moulded into a cognitive framework.

2.2.4 The Fit with Grounded Theory

Given these background considerations, grounded theory was identified as a promising methodology to apply in Part 1 because it is widely accepted inductive, qualitative research methodology (Glaser & Strauss, 1967). However, it is most commonly used in ethnographic studies where subjects are observed in field settings and inductive conclusions are drawn from these observations (Charmaz, 2006). In order to apply grounded theory in the context of Part 1, the methodology needed to be adapted to draw observations from extant literature analysis. To the author's knowledge, although there are precedents where grounded theory has been adapted for non-ethnographic research (cf. Figueroa, 2008), adopting this methodology to facilitate the analysis and coding of insights from extant literature is a new application of this methodology.

Four stages were necessary to adopt grounded theory methodology to Part 1. Each stage is outlined next.

2.2.5 Stage 1: Orientation

As Strauss and Corbin (1990) point out, a certain degree of knowledge is necessary in regard to a phenomenon being studied in order to guide the "discovery" process of grounded theory. Accordingly, the first step in operationalizing Part 1 involved a review of foundational literature pertaining to wind power development and energy policy. Having a previous background in energy policy research, step one was limited to a two-month orientation period focusing on scopic monographs (Including: Ackerman, 2005; Boyle, 2004; Boyle, et al., 2004; Campbell & Price, 2008b; Deffeyes, 2005; Komor, 2004; Mallon, 2006; Sovacool, 2008a; Tester, et al., 2005; Wizelius, 2007; Yergin, 1993)

2.2.6 Stage 2: Defining the Research Universe

Choices made regarding the boundaries of the research universe greatly influence the breadth and depth of research conclusions (Babbie, 2004). The pursuit of internally valid, externally applicable research findings requires a balance to be established between acquiring sufficient data to validate conclusions and time availability (Cook & Campbell, 1979). Choosing research boundaries for Part 1 posed just such a challenge. Fortunately, the process of identifying the research pool was aided by the background readings undertaken in stage 1. The preparatory readings provided insights into the types of multidisciplinary issues that were relevant to researchers in wind power development. Knowing the types of issues of relevance helped to define the databases that would yield the greatest diversity of relevant literature.

Four academic databases were chosen for the search process – ProQuest, Science Direct, EconLit and Engineering Village. These four databases were selected because they include coverage of key journals in the fields of public policy, energy policy, project management, alternative energy financing, environmental management, environmental science, environmental engineering, wind power research and development and applied wind energy research. During the preparatory reading, issues related to these areas emerged as most prominent.

The terms “wind power” and “wind energy” were used as keywords to conduct a search within each database. Returns were limited to articles written after 1999 because the relevance of issues related to wind energy development is time sensitive. Additionally, the search parameters were set to extract full text articles of a “scholarly” nature (whenever the option was available) in order to benefit from the rigor associated with the peer review process. Articles containing the keywords in article titles, citations or abstracts were retrieved.

Contrary to concerns that the choice of databases may limit the amount and type of research relating to wind power development, hundreds of diverse articles were uncovered in the search process. Clearly, it would have posed extreme time management challenges to read the hundreds of articles in order to define salient issues which impact wind energy development policy. Fortunately, one of the cornerstones of qualitative data collection methodology rendered an exhaustive analysis of all materials unnecessary. Kathleen Eisenhardt in an analytical piece on how to define boundaries in qualitative data collection makes the point that quality of insight stems from reaching a “saturation” point in information collected. When further observations reveal no further significant insights, that is the time to stop the collection process (Eisenhardt, 1989). Eisenhardt’s perspective echoes a fundamental tenet of grounded theory which is to record and categorize observations until there are no more significant observations left to include (Strauss & Corbin, 1990).

Eisenhardt’s principle of knowledge saturation was operationalised in a straight-forward manner. A determination was made to begin with the database with the smallest number of hits and progressively read and extract insights from each full text article until reaching a point where three articles read in sequence revealed no further insights of significance (“significance” was defined for this purpose as “initiating the creation of a new coding category”). Once a saturation point in one database was realised, the analysis moved on to articles from the next database.

2.2.7 Stage 3: Coding

In grounded theory, “scoping” questions are used to guide the search for insights. A scoping question (or questions) is essentially an ontological tool that helps to ensure that the research objectives guide how data is interpreted (Charmaz, 2006). For Part 1, a compounded scoping question was used: "*What information in this article would be considered relevant by policymakers who were charged with designing wind power development policy and what do the authors of the article conclude about the issue?*" Insights deemed to be of relevance to this scoping question were extracted from each paper in the data set and then transferred to a master coding sheet.

The master coding sheet is a draft document that combines insights from the literature review into thematic groups that can be conceptually delineated from each other. In grounded theory methodology, coding represents the "grounding" of the emergent theory (Glaser & Strauss, 1967). Essentially, coding is a process of seeking out similarities and differences in a data set that is being analyzed. Part of the process is creative (defining new categories) and part of the process is comparative (establishing rationales for differentiating one category from another) (ref. Charmaz, 2006). As policy relevant insights from each new article are added to the master coding sheet, the number of thematic categories begins to expand and the information contained within the categories begins to grow in volume. Periodically, the thematic categories are reviewed and attempts are made to consolidate categories if justifiable relationships can be identified. At the same time, information *within* each category is reviewed and attempts are made to consolidate these insights if justifiable relationships can be identified. In short, throughout the coding process, new thematic categories are emerging, existing thematic categories are synthesizing, and relationships are continuously being refined.

An illustration of how this methodology was applied in Part 1 of the research serves to clarify how this process works. One of the first articles under evaluation presented an analysis of variables that influence the cost of wind energy (ref. Ackermann & Soder, 2002). Many insights were extracted from this paper and assigned to a thematic category labelled, “the current cost of wind power”. In a subsequent article, different authors discussed criteria influencing the future cost of wind energy. Insights relating to this theme were extracted and placed into a thematic category entitled, “future costs of wind power”. Subsequent papers led to the creation of three other thematic categories associated with the cost of wind power. These new categories included “the cost of competing alternative energy sources”, “the current cost of fossil fuels”, and “the future cost of fossil fuels”. As the literature review progressed, more and more insights were inserted into these categories. However, as research progressed, the thematic categories increased in number until it was feared that they were becoming unwieldy. At this stage, an analysis of the thematic categories was carried out with the aim of identifying categories that could be synthesized based on conceptual synergies. As a consequence, it was decided that consolidating the five thematic categories under one generic umbrella labelled “understanding costs of wind power” would allow inter-relationships between the five themes to be better examined.

2.2.8 Stage 4: Identifying Relationships

The final stage in operationalizing the grounded theory methodology of Part 1 is the stage at which structure and theory begin to congeal. As outlined earlier, during the data collection process, insights were extracted and coded into thematic categories. Within each thematic category, insights accumulate and patterns begin to emerge. Moreover, between each thematic category relationships begin to emerge. In aggregate, the crystallization of these relationships leads to the emergence of a conceptual framework that presents a systematically generated response to the scoping question: "*What information in these articles would be considered relevant by policymakers who were charged with designing wind power development policy and what do the authors of the article conclude about the issue?*"

The collection of insights from this process provides a response to the research question formulated to guide Part 1 research:

> *What do policymakers need to know about utility-scale wind power projects to produce development support strategies that are socially, technically, economically and politically effective?*

The response to the research question formulated to guide Part 1 research in turn feeds into the overarching research question for the study by providing a project level (micro) perspective:

> *If forces in support of a transition to alternative energy are currently amassing and wind energy is a currently viable solution, why is the diffusion of wind energy technology plodding along in many advanced nations when it should be escalating at breakneck speed?*

2.3 PART 2 METHODOLOGY (MACRO-LEVEL POLICY INSIGHTS)

Part 1 of the research study examines impediments that can result in specific wind power developments projects failing to meet desired objectives. Part 2 of the research study broadens the perspective by aiming to identify socio-political factors which adversely impact the effectiveness of national wind power development policy. The underlying implication of searching for broader socio-political factors is that policy instruments that have worked successfully in other nations are not necessarily guaranteed to succeed in a different national context. As Lee Kuan Yew points out, albeit in a broader context, policymakers should be cautious to avoid “foisting (a system) indiscriminately on societies in which it will not work” (Zakaria, 1994, p. 110).

A number of laudable publications analyze national experiences with wind development policy and extract best practice (cf. Komor, 2004; Mallon, 2006; Wizelius, 2007) for future policymakers to refer to when developing indigenous renewable energy policy. However, failure to understand the influence that exogenous factors have on wind power development policy design and implementation is a recipe for disaster, too often exhibited in electricity sectors around the world. Accordingly, the unique contribution that the research presented in Part 2 of this paper aims to make is to generate insight into the broader spectrum of socio-political obstacles that have undermined development programs in select advanced nations. It is hoped that identifying common barriers will highlight points of caution that policymakers in advanced countries should be attuned to when developing national wind power development policy.

The main question which guides research efforts in Part 2 is:

> *What elements adversely influence the design and implementation of effective national wind power development policy?*

2.3.1 Research Approach

To the best of the author's knowledge, no consolidated studies exist which investigate broader socio-political factors that impinge upon the efficacy of the policy cycle associated with wind power development initiatives. Consequently, a decision was made to adopt a case study approach under the premise that a case study approach represents a highly effective way to achieve richness of understanding when investigating phenomenon for which extensive understanding does not yet exist (Yin, 1984).

Since the goal of Part 2 is to identify factors which adversely impinge upon the efficacy of the policy cycle associated with national wind power development initiatives in advanced nations, it was decided that the case studies should focus on a critical analysis of wind power development policy in advanced nations that up until 2008 exhibited sub-standard performance in wind power development. In contrast to most of the extant literature which focuses on identifying best practice in effective policy instrument design and implementation, Part 2 of this research study focuses on identifying confounding practices.

2.3.2 Choice of Nations

It was decided that the case study analysis would be limited to four nations in order to facilitate a higher degree of analysis given time constraints associated with this project. The nations chosen were Japan, Taiwan, Canada and Australia. For each of these nations, there are strong justifications for supporting wind power development and yet, wind power development continues to stagnate. In Japan's case, enhancing wind power capacity could enhance domestic energy security, facilitate achievement of international CO_2 emission reduction commitments and insulate the nation from adverse effects associated with fossil fuel price fluctuation. Yet, the nation has opted to embrace a nuclear power development strategy despite serious concerns over the viability of domestic large-scale nuclear waste storage. The benefits associated with enhanced wind power capacity in Taiwan are similar to the benefits associated with enhanced wind power capacity in Japan. Yet, despite these benefits, the Taiwanese government has opted for a strategy that favours enhanced natural gas-fired electricity generation capacity and largely neglects wind power development. Canada and Australia were chosen for case studies because they are two nations which are rich in both fossil fuel energy resources and wind power potential. In both nations, wind power capacity falls significantly short of wind power potential. Consequently, explicating the rationale for phlegmatic wind power development policies in these two nations should provide insight into the factors that support rather apathetic government support for wind power development in high potential nations.

The absence of existing theory to explain hurdles to wind power development suggested that an inductive approach would be most appropriate for guiding the search for commonalities. The “scoping” question guiding the analysis of each nation in regard to wind power development policy was: *"What factors appear to be responsible for sub- performance of wind power development in these nations?"*

2.3.3 Research Universe

The basic approach to investigating wind power development policy in each of the nations was to amass as much extant literature as possible and use the insights from each of the studies to compile an overall picture of the electricity regime in each country. Four academic databases were selected as targets for the search process. The databases included ProQuest, Science Direct, EconLit and Engineering Village. These four databases were selected because they include coverage of key journals in fields that are influential to wind power development: public policy, project management, alternative energy financing, environmental management, environmental science, environmental engineering, wind power research and development and applied alternative energy research. It was felt that such broad coverage would facilitate more comprehensive understanding of the hurdles affecting wind power development. In preparing each case study, the terms "wind power" and "wind energy" and the nation name were used as keywords to conduct the search within each database. Returns were limited to articles written after 1999.

2.3.4 Contribution of Part Two, The Macro-analysis

It is acknowledged that conducting case study analyses with only four nations will not yield the level of comprehensive, triangulated data necessary for the development of an exhaustive conceptual framework to describe the impediments to national wind power development policy efficacy. However, the chosen approach succeeds in achieving a level of research introspection necessary to reveal new insights that contribute to the cumulative, progressive development of such a conceptual framework. In summary, while Part 2 of this study falls short of developing a definitive framework to explain impediments to national wind power development policy, it does succeed in developing a rough high-level framework that can accommodate future contributions from other researchers and eventually lead to the emergence of a comprehensive framework.

The collection of insights from this process provides a response to the research question formulated to guide Part 2 research:

> *What elements adversely influence the design and implementation of effective national wind power development policy?*

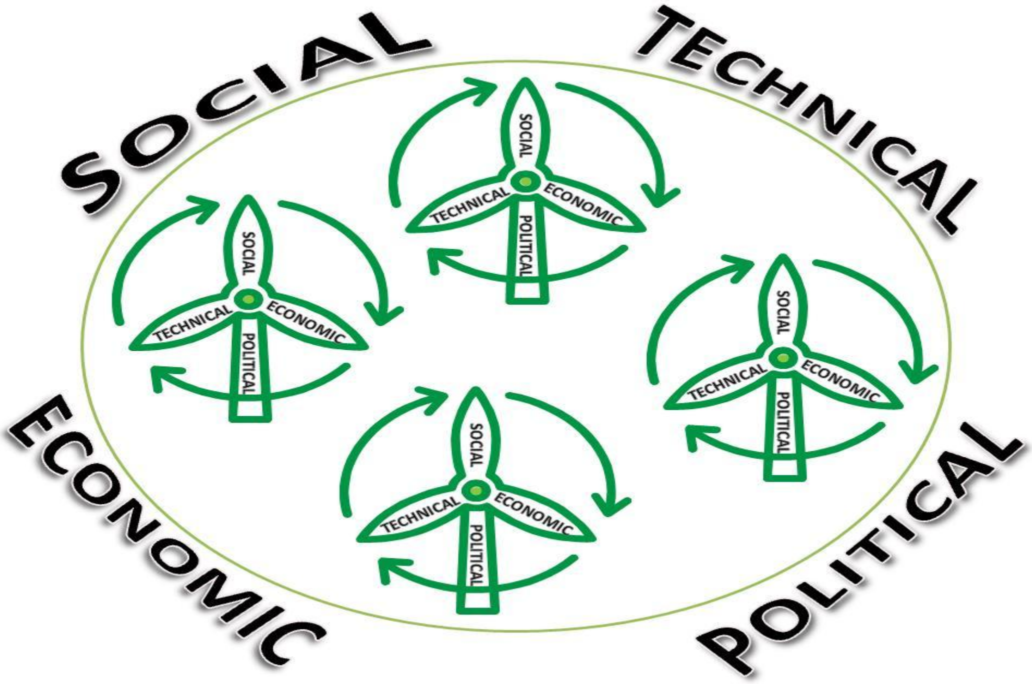
The response to the research question formulated to guide Part 2 research also feeds into the overarching research question for the study by providing a national level (macro) perspective on:

> *If forces in support of a transition to alternative energy are currently amassing and wind energy is a currently viable solution, why is the diffusion of wind energy technology plodding along in many advanced nations when it should be escalating at breakneck speed?*

2.4 DISSERTATION FORMAT

Figure 2.1 on the next page, provides a graphic conceptualization of this dissertation. Part 1 of the study focuses on social, technical, economic and political barriers to effective development of wind power projects and this is illustrated in Figure 2.1 by the individual wind turbines. The research findings from Part 1 of this research study are presented in Chapters 3 to 7. Chapter 3 provides an introduction to global wind power trends and provides more detailed information on research design and presentation for Part 1 of the research study. Chapter 4 examines impediments to an adequate economic analysis of adding wind power to a regional electrical grid. Chapter 5 investigates the technical challenges associated with strategic regional wind power planning. Chapter 6 explores social hurdles to wind power project development and Chapter 7 examines political forces which can render wind power development policy ineffective at the regional or project level. Part 2 of this research study is presented from Chapter 8 onward. Chapters 8 to 11 present the four case studies examining national wind power development hurdles in Australia, Canada, Japan and Taiwan respectively. Chapter 12 collates the insights gleaned from the four case studies into a STEP (social, technical, economic and political) framework that summarised generic hurdles to wind power development at a national policy level, which is depicted by the four STEP forces which encircle the illustration in Figure 2.1.

Figure 2.1: STEP Forces at the Project and the National Planning Levels



PART 1: MICRO-LEVEL POLICY INSIGHTS

"DEVELOPING WIND ENERGY PROJECTS"

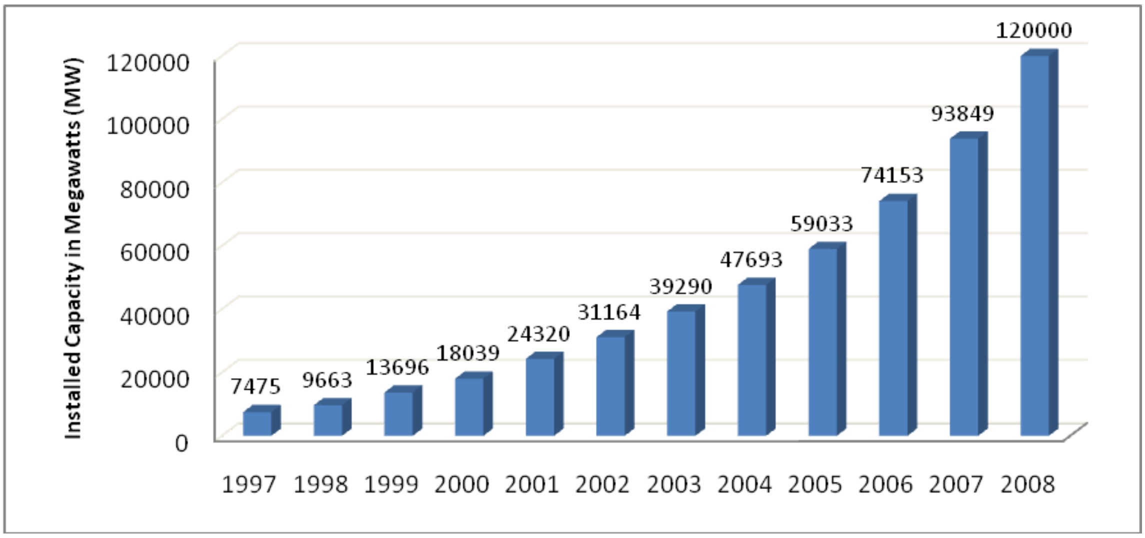
CHAPTER 3

INTRODUCTION TO MICRO-LEVEL POLICY HURDLES

This chapter opens with a summary of global wind power development trends and introduces the exigency of enhancing policymaker comfort levels with wind power in order to help expedite the pace of wind power development. The chapter concludes with a more detailed explanation of the data collection and interpretation approaches that yielded the insights presented in Part 1 of this study (Chapters 4-8). Lastly, the rationale behind the format chosen for presenting the finding is also discussed.

3.1 WIND ENERGY TRENDS

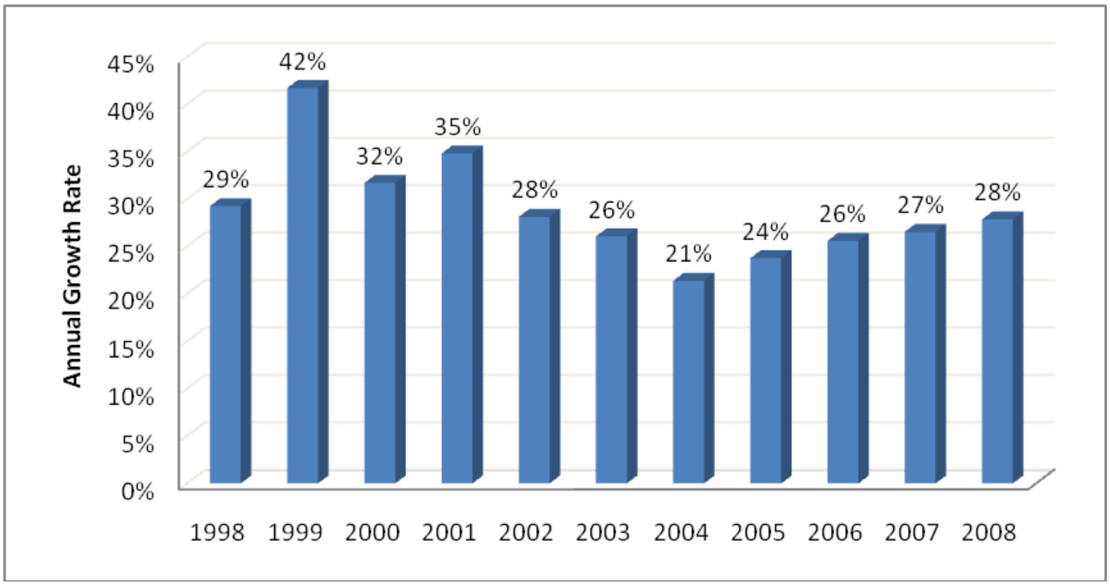
Figure 3.1: Global Installed Capacity of Wind Energy



Source: World Wind Energy Association (WWEA, 2008)

Currently, the wind energy sector is a rising star within the alternative energy industry. As Figure 3.1 indicates, since 1997 installed wind energy capacity around the world has grown by over 1600%, topping 120,000 MW in December 2008. Unfortunately, the 200 TWh of electricity generated in 2008 by wind turbines amounted to only 1.5% of global electricity production (WWEA, 2008).

Figure 3.2: Annual Growth Rate of Global Wind Energy Capacity



Source: World Wind Energy Association (WWEA, 2008)

Promisingly, evidence that wind power capacity continues to grow at a brisk pace raises hopes that the role that wind power plays in global electricity markets will broaden. Figure 3.2 charts annual growth in the wind energy industry over the past decade. As the data indicate, the wind capacity growth rate which accelerated on the heels of the Kyoto Protocol in 1997, tapered off somewhat between 2001 and 2004 but remained over 20% per annum. Since 2004, the growth rate of installed wind capacity has accelerated; and despite a decade of growth, there are no signs of growth abating. However, with wind power accounting for only 1.5% of global electricity generation, it would take almost 15 years of 20% compound annual growth just to reach 20% electricity supply contribution levels. The potential perils associated with global warming warrant a faster rate of transition.

3.2 ENHANCING WIND POWER COMFORT LEVELS

In terms of utility-scale energy planning, wind energy is somewhat of technological wild card and this tends to impede the pace of adoption. Most countries have less than thirty year’s experience with wind project developments and integrating wind energy into national electricity grids (Komor, 2004). Moreover, over the same 30-year period, advances in wind energy technology have rendered early experiences irrelevant. The early 1980s can be considered as an “exploratory technology” phase. During that period, rated output capacities of wind turbines ranged between 20 - 30 kW. Today, rated output capacities range between 5000 - 6000 kW (Dismukes, et al., 2007). In the 1980’s, incorporating electricity from a wind farm consisting of one hundred 20 kW wind turbines posed a minor load management challenge which was compensated for by the positive environmental PR these projects garnered. Today, adding one hundred 5000 kW turbines represents a large-scale infrastructure investment that is highly visible in the community and potentially disruptive to electricity grid stability (DONG Energy, 2008). In short, both the risks and the rewards associated with wind power projects have intensified.

The complexity of modern wind power projects gives rise to an array of project challenges (Dismukes, et al., 2007). Managing modern wind power projects requires interdisciplinary knowledge and comfort in the face of complexity because each wind project exhibits unique social, technical, economic and political challenges (Ackermann & Soder, 2002). Policymakers who sponsor such projects either directly (through active management) or indirectly (through policy support) need to be able to anticipate project disruptions, minimize planning pitfalls, mitigate political opposition and avert implementation inefficiencies.

Policymakers are generally risk-averse (Salamon, 2002). Consequently, in the absence of certainty regarding the impact of a given initiative, policymakers will tend to adopt an incremental approach to strategic implementation (Pierson, 2004). This is particularly salient in regard to changing the dynamics of an industry that has widespread impact on national interests, such as energy (Campbell & Price, 2008b)). Unfortunately, to reiterate, given the immediacy of the climate change dilemma, an incremental transition is highly undesirable (Aitkenhead, 2008).

Given this background, the applied intent of Part 1 of this research project is to help policymakers become better acquainted with issues that tend to undermine the efficiency of wind power projects and become more comfortable with this promising power technology.

3.3 RESEARCH DESIGN AND PRESENTATION

As outlined in Chapter 2, insights into impediments that impair effective wind power project development presented in Part 1 (Chapters 4-8) have been gleaned from extant literature employing a systematic grounded theory approach to identify as many hurdles as possible. The reader is directed to Chapter 2 for further details on fundamental aspects of the methodology.

Abstracts of academic articles listed in popular online databases were searched using the keywords “wind energy” and “wind power” to identify relevant research studies. This keyword search identified 28 relevant papers in ProQuest, 2,102 papers in Science Direct, 1 paper in EconLit and over 40,000 papers in Engineering Village (though this included articles that were not available in full text). The review began by analyzing all 28 ProQuest papers and the one EconLit paper. It then moved on to the Engineering Village papers and finally the Science Direct papers. Insights from each article were extracted and coded as the process progressed. In keeping with the methodology outlined in the previous chapter, whenever a review of three consecutive papers failed to produce new insights, the search process shifted to the next database in sequence. In aggregate, well over 100 research studies were reviewed.

Part 1 of the research study essentially sought responses to the following question:

> *What do policymakers need to know about utility-scale wind power projects to produce development support strategies that are socially, technically, economically and politically effective?*

Insights from the research studies were extracted, coded and categorized into thematic areas judged relevant to policymakers. These thematic areas are examined in detail in chapters 4 to 8. Chapter 4 begins with an examination of elements related to wind power costs that impair economic evaluation. Chapter 5 focuses on the technical challenges associated with regional strategic wind power site planning. Chapter 6 investigates social hurdles related to wind power projects with an emphasis on NIMBY opposition and ecosystem impact. Chapter 7 concludes part one by examining political elements which can undermine the efficacy of regional or municipal wind power project planning. The emphasis of Chapter 7 is on improving "request for tender" policies and enhancing understanding of the role that wind power can play in helping to reduce CO_2 emissions. With many municipalities adopting CO_2 emission reduction strategies when national governments fail to do so, understanding the potential contribution that wind power can make to a CO_2 emission abatement strategy is now as much a micro-policy issue as it is a macro-policy issue.

The findings from the grounded theory study are presented in a STEP format wherein each thematic category has been assigned to an appropriate chapter dedicated to **S**ocial (Chapter 6), **T**echnical (Chapter 5), **E**conomic (Chapter 4) and **P**olitical (Chapter 7) factors that impinge on wind power project development. In strategic management, a STEP analysis is a common tool for assessing exogenous influences on market development prospects (Grant, 2005); and as such, it was deemed a transferrable tool for evaluating wind power project development prospects. As the chapter order indicates, the sequential presentation of the STEP categories has been altered (ETSP) to provide more fluid transitions between the chapters.

CHAPTER 4

ECONOMIC INSIGHTS FOR BETTER MICRO- LEVEL POLICY

Strategic planning of electricity generation technologies is done at a sub-national level in most nations. Typically, regional or municipal policymakers who are contemplating wind power development initiatives (or other electricity generation technologies) begin with a cost-benefit analysis of development under consideration. Unfortunately, economic analysis of electricity generation in general and wind power in particular are contentious and complicated areas. This chapter endeavours to provide policymakers with the knowledge to make better informed decisions on development support programs by clarifying the direct and indirect costs associated with wind power and the factors which can alter the cost profiles of specific wind power projects.

4.1 AN OVERVIEW OF WIND COSTS

With the cheapest fossil fuel feedstock (coal) trading at between US$50-$70 per short ton (see Chapter 1), the cost divide between wind power and coal-fired power is progressively narrowing (McKinsey, 2007; Neuhoff, 2005; L. Thompson, 2006; Wizelius, 2007). In fact, some researchers assert that wind power is now cheaper than coal-fired or nuclear-powered energy (Wong, 2005); though absolute assertions of this kind are hard to defend unless full environmental costing were included in the calculation (Sovacool, 2008a).

The cost of wind power is contingent on a number of factors such as wind conditions, type of wind power systems used, grid connection costs, access to subsidies and geographic features of the site (Komor, 2004). Overall, a review of cost literature (see examples in Table 4.1) points to a cost range for wind power of between US4 to 7¢ per kWh. By these estimates, wind power indeed appears to be cost competitive with coal-fired power (the least expensive fossil fuel) under certain circumstances.

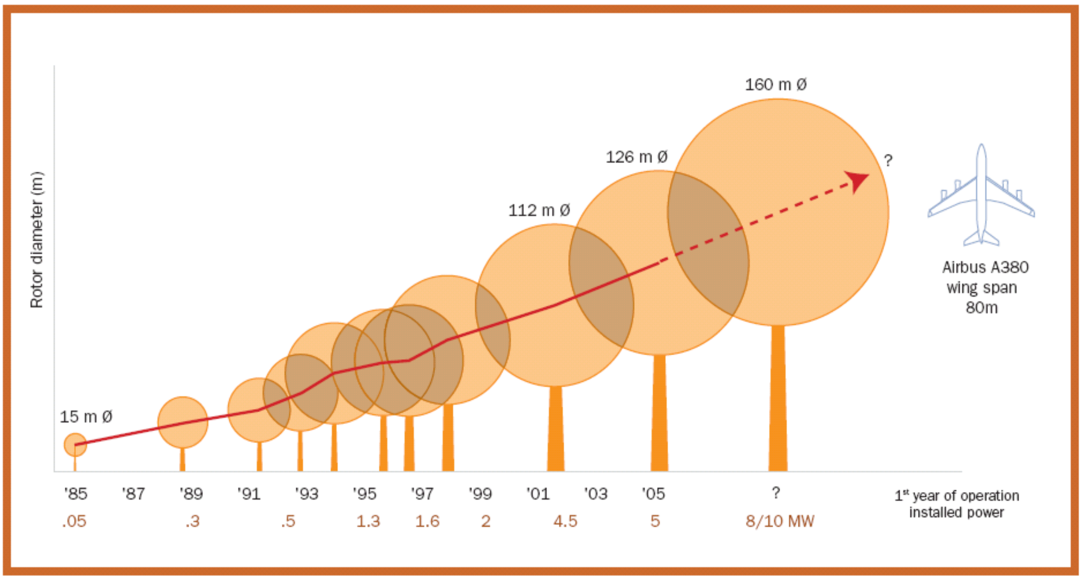
Table 4.1: A Sampling of Wind Cost Studies

Characteristics of data	KWh Cost (US¢)	Base Year	Researchers
Onshore installations with high winds	6.5-8.5¢	2009	(Morthorst & Awerbuch, 2009)
Onshore installations with med. winds	9¢	2009	(Morthorst & Awerbuch, 2009)
Onshore installations with low winds	9-13¢	2009	(Morthorst & Awerbuch, 2009)
Wind farm in Denmark	4.0¢	2008	(DONG Energy, 2008)
Average cost of onshore wind energy in Sweden	5.0¢	2007	(Wizelius, 2007)
Average cost of wind power	4.0¢	2006	(DeCarolis & Keith, 2006)
Remote wind system	2.6¢	2006	(DeCarolis & Keith, 2006)
Onshore wind in general (excluding subsidies)	7.0¢	2005	(Dismukes, et al., 2007)
Large scale onshore systems in general	5.5¢	2005	(Celik, et al., 2007)
Onshore wind installations in UK	4.7¢	2005	(British Wind Energy Association, 2005)
Offshore wind installations	8.1¢	2005	(British Wind Energy Association, 2005)
Large scale wind in general	4.0-5.0¢	2004	(Komor, 2004)
Large-scale, onshore systems in Japan	9-1-14¢	2001	(ANRE, 2006)
Bids for wind energy in UK	3.5-4.5¢	1998	(Ackermann & Soder, 2002)

4.1.1 Wind Energy Cost Trends

The cost of wind has declined from US28¢ to US4-7¢ per kWh over the past 30 years (Celik, et al., 2007) and both the US Department of Energy and UK government authorities project that costs will likely continue to decline over the next 30 years (Wizelius, 2007). Advances in generation technology fuel this trend. As Figure 4.1 indicates, the rated capacities of wind turbines have increased significantly since the early 1980s. State of the art 20 kW wind turbines of the 1980s now seem like school science projects in comparison to the 6000 kW turbines that are being erected today.

Figure 4.1: The Progressively Improving State Of Wind Turbine Technology



Source: (DONG Energy, 2008)

The relationship between turbine generation capacity and generation cost stems partly from technical economies of scale. The main components of wind systems are the nacelle components (blade, gears and generator), the tower, the foundation and the balance of plant components (including transformer and transmission cables) (Ackermann & Soder, 2002). All of these components have declining cost profiles in relation to increased scale. For example, a turbine with twice the power capacity of another does not require twice the tower height, nor does it require twice the foundation materials or twice the resource inputs for balance of plant components.

However, there are diminishing returns in regard to technical economies of scale. One wind expert contends that in the near future, technical economies of scale may be obviated by amplified increases in the cost of larger wind turbines (Wizelius, 2007). Furthermore, energy generated from wind turbines depends on the size of the area swept by the rotor blade. It is believed that the weight of the rotor blade may eventually limit the extent to which the size of the swept area can be expanded

(Wizelius, 2007). Yet, despite these concerns, technical economies of scale continue to be realized. Advances in turbine technology, lighter component materials, and improvements in wind capture engineering continue to drive down generation costs.

In addition to technical economies of scale, there are production economies of scale that reduce the cost of wind power. Ackerman and Soder (2002) estimated that in the 1990s, wind power cost declined by 20% every time the aggregate amount of global installed wind power capacity doubled. DONG Energy (2008) provides a forward perspective on this phenomenon estimating that the cost of wind power can be expected to decrease by 4-10% each time the aggregate market capacity doubles. Although further market growth will likely provide diminishing returns regarding production economies of scale, the consensus appears to be that over the next few decades, as the wind power market expands, production economies of scale will place downward pressure on generation costs and this will fuel further market expansion because market growth and cost enjoy a symbiotic relationship.

Overall, progressive cost savings through these economies of scale helps explain why many experts believe wind power costs will decrease substantially in coming decades (Ackermann & Soder, 2002; Dismukes, et al., 2007; DONG Energy, 2008; Wizelius, 2007). Some estimate the cost of wind power will fall to approximately US2¢ per kWh within the next three decades (Brown & Escobar, 2007; DeCarolis & Keith, 2006). However, this does not guarantee that a *specific* wind project will generate power at this cost level. The capacity to attain minimal cost levels depends on a number of other factors that are worth examining.

4.2 WIND QUALITY AND COST

There are three characteristics of wind quality that significantly influence wind power costs – overall wind speeds, consistency of wind speeds and consistency of wind speed direction. Firstly, absolute wind speed affects rotor speed; therefore, wind speed dictates the optimal size of wind turbines that can be employed. As a rule of thumb, a 10% wind speed increase can result in a 30% increase in energy production (Ackerman, 2005). This is because "*the power of the wind is proportional to the cube of the wind speed*" (Wizelius, 2007, p. 48). Secondly, actual wind speeds often fluctuate significantly around the mean. During some periods there may not be enough wind to generate power. At other times, wind speeds may be too high necessitating turbine lock down. Wind variances occur annually, seasonally, daily, diurnally (day versus night) or even by the second (Ackermann & Soder, 2002). Consequently, feasibility studies based on "average" wind speeds in a given area (for example see: Markevicius, Katinas, & Marciukaitis, 2007) should be supplemented by studies investigating wind speed fluctuations. Lastly, consistency in terms of wind direction can also impact the amount of wind power generated. Although most modern wind turbine systems have a yaw motor which aligns the nacelle to maximize wind collection, the yaw motor is typically set to respond to prolonged directional changes, not to sudden directional fluctuations (Wizelius, 2007).

These insights convey an important lesson to policymakers. Whether evaluating the feasibility of individual wind power projects or assessing sites for wind energy potential, estimates based on "average wind speeds" are inadequate. Reliable wind speed estimates should be based on comprehensive temporal analysis of wind patterns (yearly, seasonally, daily and diurnally) that incorporate data on both wind speed fluctuations and directional variances of wind gusts.

Due to the historical nature of wind speed data, even accurate data will not accurately predict future wind patterns. An error margin should always be built into wind quality estimates prior to preparing a financial assessment of the viability of a given site. The caveat for any policymaker who is making decisions based on such estimates is to confirm whether or not an error margin has been built into the calculations; and if so, how much of a margin has been included. One wind expert recommends that an error margin of 10% be used (Wizelius, 2007).

4.3 LOCATION AND COST

Given the importance of wind speed for wind power generation, it should come as no surprise that offshore wind energy is viewed with significant promise. Offshore winds are usually of higher quality. Unfortunately, constructing offshore wind farms is also more expensive.

The present consensus appears to be that although there may be some offshore sites where the increased power generated offsets higher construction costs (Wizelius, 2007), offshore wind energy is still more expensive than onshore wind energy on a kWh basis (DONG Energy, 2008; Dunlop, 2006). In 2005, the British Wind Energy Association (British Wind Energy Association, 2005) estimated that the current cost differential was US4.7¢ per kWh for onshore wind power and US8.1¢ per kWh for offshore wind power. However, this economic disparity may be reversed in the near future. Numerous studies point to costs of offshore wind power declining faster than onshore costs as offshore technologies improve (DONG Energy, 2008). As offshore costs approach parity with onshore costs, offshore options may become comparably attractive because offshore sites do not have to contend with as many competing land uses.

4.4 SYSTEM FEATURES AND COST

Over the past 30 years, a diverse array of wind system innovations have emerged to improve performance under varied conditions (Ackerman, 2005). For example, many nacelles now house a small motor which automatically adjusts the pitch of the blades in response to wind speed variance (Boyle, 2004). In a location which is characterized by inconsistent winds, adjustable rotor blades will, ceteris paribus, improve power output and generation consistency at a cost that is a fraction of the added revenue earned through improved power generation (Ackermann & Soder, 2002). As another example, higher towers make it possible for turbines to capture geostrophic wind which is less influenced by ground friction; and therefore, a more consistent source of wind power (Wizelius, 2007). Similarly, strategic choices made in regard to transmission infrastructure (i.e. buried underground vs. erecting transmission cable towers) can significantly influence the cost of wind power (Denny & O’Malley, 2006).

Although specific advice concerning how to minimize project costs through optimized technical planning is beyond the scope of this chapter, the lesson that policymakers should extract from the examples put forth is that each decision made in regard to wind power systems have cost implications. Therefore, for policymakers who are commissioning wind power projects through public funds, forcing the developers to justify the technical choices they have made in preparing a project proposal will enhance cost control.

4.5 GRID CONNECTION AND COSTS

Inauspiciously, wind farms are often sited in remote areas to take advantage of land availability and obviate social opposition (DeCarolis & Keith, 2006). The distance from the site to the electricity grid influences connection costs in two ways. Firstly, spatial separation from power grids means that longer transmission networks and access roads need to be built. This can add as much as US$80 per metre to the cost of a wind power project (Wizelius, 2007). Secondly, energy dissipates as it travels along transmission lines. Power leakage increases as distance to the electricity grid increases.

Although policymakers are frequently aware of the physical costs that arise due to distance from electricity grids, the phenomenon of leakage is less widely understood. It has been estimated that leakage can reach as high as 10% of energy produced (Wizelius, 2007). Two factors have the most influence on leakage – distance and the type of electricity conduit used – and knowledge of these two factors will allow engineers to estimate leakage (Blakeway & White, 2005).

One other grid connection factor that influences generation cost is the voltage capacity of power lines installed to carry power to the grid. The voltage level limits the amount of power that can be delivered to the grid (Wizelius, 2007). Consequently, power line capacity can influence the size of wind farms or necessitate investment in sub-stations to regulate voltage.

4.6 CLIMATE AND WIND ENERGY COSTS

Adverse climates frequently inflate maintenance costs. Consider for example, wind turbines erected in marine environments. Component parts that are made of steel are prone to corrosion in such environments and must be replaced more frequently. Although less corrosive materials can be substituted for some of these steel parts, using substitute materials frequently increases the overall cost of materials.

Adverse climates can also affect power production. For example, ice on wind turbine blades jeopardizes system operation. Ice can snap rotor blades and bend rotor drive shafts (Ackermann & Soder, 2002). Even a light coating of ice on rotor blades can adversely affect aerodynamic properties. There is also a safety risk associated with ice detaching from spinning rotor blades. Historically, in icy conditions, wind turbines were shut down. Consequently, wind farms in colder climates had fewer productive days. Nowadays, wind turbines erected in cold climates typically have blade de-icing features. Nevertheless, even with a blade de-icer, turbines frequently need to be shut down (albeit for shorter periods) to clear the ice off the blades (Wizelius, 2007).

Projects in regions exhibiting extreme temperatures or extreme wind speeds can also exhibit higher cost profiles. For example, siting wind turbines in regions that experience prolonged periods with temperatures below -20°C can be problematic because lubrication oils become more viscous and steel becomes more brittle. Costly, specialized heaters may be required to minimize problems associated with extreme cold. Conversely, turbines that are installed in regions characterised by extreme heat may require costly cooling systems. Costs may also be higher at sites which are prone to extreme wind episodes such as typhoons or hurricanes because specialized wind systems are required (Wizelius, 2007).

There are two policy-relevant lessons stemming from research into climatic influence on wind power system performance. Firstly, government authorities who are overseeing public wind farm developments should ensure that project bids specifically address climatic threats. Secondly, as the example concerning ice on the rotor blades implied, there may be a need for policymakers to develop safety standards for wind power projects.

4.7 CARBON CREDITS AND WIND ENERGY COSTS

Another climatic influence which significantly influences the cost of wind power is the availability and quantity of carbon credits attached to a given project. For example, under the Kyoto Protocol's Clean Development Mechanism, wind project developers can claim certified emission reduction (CER) credits for the CO_2 that is offset by a given wind project (UN, 1998). If a wind energy project offsets a CO_2 intensive technology such as coal-fired power, carbon credits amounting to as much as US2¢ per kWh can be secured over a 15-year period (DONG Energy, 2008). The European Union's Emission Trading Scheme (EU-ETS) offers similar carbon credit acquisition opportunities for wind project developers.

A caveat for policymakers in regard to carbon credit management is to ascertain the availability of carbon credits prior to initiating discussions with project developers. In this way, responsibility for managing the carbon credit acquisition process and ownership over the credits can be explicated in offers to tender. This injects a degree of financial certainty into a given project and ensures that misunderstandings over ownership of these credits do not arise (Brown & Escobar, 2007).

4.8 INDIRECT WIND ENERGY COSTS AND SAVINGS

Any cost-benefit analysis related to the siting of a wind power development in a community should attempt to estimate the financial impact the development will have on the economic fortunes of the community. Research indicates that one source of opposition to wind power developments stems from concerns over the potential adverse economic impact the development might have on property values and in some cases, tourism revenue (Firestone & Kempton, 2007). Financial impact assessments can be approximated by using hedonic pricing which is an environmental impact estimation technique that uses experience in one community to estimate impact in another community (Turner, Pearce, & Bateman, 1994). The scant research that does exist in regard to the impact of wind power projects on property prices and tourism indicate that any adverse impact that does exist is likely short lived (Firestone & Kempton, 2007). Property values have been shown to bounce back after wind farms become operational (Wolsink, 1988) and research indicates that wind turbines can actually be a boon to tourism in some cases (Maruyama, Nishikido, & Iida, 2007). However, the limited amount of research in this area suggest that formal financial impact studies might be warranted in sensitive communities.

If indirect costs associated with a wind energy project are to be estimated, indirect savings associated with the same project should also be estimated. In fossil fuel dominant societies, electricity generated by wind energy projects would otherwise likely come from fossil fuel power sources which inflict both health and environmental damages on communities. High concentrations of sulphur dioxide associated with coal combustion have been linked to the degradation of buildings and monuments as well as the acidification of lakes and waterways (Miller, 2004). CO_2 from fossil fuel combustion is the main anthropocentric contributor to global warming (IPCC, 2007a). Furthermore, pollution from coal-fired power plants has been linked to respiratory diseases. To put the damage into perspective, the Ontario Medical Association estimated that health problems in the late 1990's stemming from pollution attributed primarily to fossil fuel-fired power generation annually cost Ontario over C$1 billion in health costs and contributed to over 1900 pre-mature deaths (Rowlands, 2007).

Although health costs averted can be estimated by accessing scientific studies, estimating the savings from mitigating the environmental damage caused by fossil fuel combustion can be a complicated and contentious exercise. There are a number of economic techniques for estimating macro environmental impacts (or in this case, environmental enhancements) such as hedonic pricing (using real estate valuation techniques), contingent value (assessing societal willingness to pay for a given environmental outcome), replacement cost estimates (useful for man-made structures), dose-response estimates (useful for mediation of waterways) and opportunity cost valuation techniques (Turner, et al., 1994). A detailed review of these methods is beyond the scope of this paper; therefore, the interested reader is directed to environmental economics texts (Thampapillai, 2002; Tietenberg, 2003).

Although most environmental economists would be quick to point out that all environmental valuation methods suffer from method-specific weaknesses, making the effort to assign some value to environmental degradation is arguably better than not making the effort at all (Costanza, Cumberland, Daly, Goodland, & Norgaard, 1997). Currently, the norm appears to be to avoid integrating environmental costs (and benefits) in energy analysis (Lenzen & Munksgaard, 2002). Unfortunately, continuing to ignore environmental costs (and benefits) artificially depresses the cost of fossil fuel power (ATSE, 2009). If environmental costs were added to the operational costs associated with fossil fuel technologies, these technologies would not be able to compete economically with alternative energy technologies (Lenzen & Munksgaard, 2002; Sovacool, 2008a; Wong, 2005)

4.9 THE ADDED COST OF STOCHASTIC FLOWS

Even in ideal situations, electricity load management is complicated by demand-side variances. Demand for electricity varies by season, by week, by time of day and even by the second. An electricity supply system must be able to respond promptly to all these demand variations (Wizelius, 2007). The stochastic nature of wind further complicates the load management due to supply-side fluctuations because the amount of energy generated from a wind turbine can vary significantly from minute to minute, hour to hour, day to day, week to week and year to year.

Technically, there are two technological approaches to improving management of wind generated electricity and both pose costs that increase the cost of electricity generated. The first approach is to store wind energy that has been generated but not yet utilized. For utility-scale storage popular current options include advanced battery storage, pumped hydro, and compressed air energy storage (Denholm, Kulcinski, & Holloway, 2005). Compressed air energy storage systems are purportedly the most efficient of the current storage technologies; however, the systems are expensive to construct, require fuel to drive the compressor and "leak" energy (only a fraction of the energy gets stored) (Denholm, et al., 2005). In short, although storage is a feasible solution, it adds to the cost of electricity generated.

The other approach is to increase generation capacity of peak-load support systems such as hydropower or natural gas-fired power plants. Ensuring higher capacity in highly responsive electricity generation technologies allows load engineers to compensate for fluctuations in wind power by altering output of the reserve generators. The obvious downside to this solution is that it costs money to purchase back-up systems and the investment is not fully exploited due to the downtime (and combustion inefficiencies) that is common to reserve generators (Boyle, et al., 2004).

Although the added cost of adding storage or reserve back-up is frequently raised by wind critics as a reason to avoid amplified levels of wind power capacity, many of these cost concerns are exaggerated. For example, a report by the Australia Institute contends that adding approximately 5% wind power to the existing grid would only cost consumers AU$15-$25 per year extra (Macintosh & Downie, 2006). Another study, indicates that the additional cost of backup generation (i.e. gas-fired generators) necessary to allow wind power to reach high contribution levels (i.e. 40%) in Australia would increase the cost of wind power by approximately 25% (Diesendorf, 2003). This amounts to roughly AU1-2¢ per kWh.

Moreover, insinuations that significant contributions from wind power will unfailingly destabilize electricity grids are largely exaggerated. Research indicates that strategic site planning, geographic dispersal of wind power facilities and technical decisions made when selecting turbines (i.e. adjustable rotors, variable speed gearboxes, computerized yaw controls etc.) can significantly attenuate wind power fluctuations (Boyle, 2004). Furthermore, there are increasing indications that spare capacity already embedded in the average electricity grid is capable to accommodating significant amounts of wind power before further back-up is required (Ackerman, 2005; Karki & Billinton, 2001).

Currently, the consensus appears to be that depending on the electricity grid base-load profile, 10% to 40% wind energy can be integrated into an electricity grid without having to add storage or additional spare capacity. For grids that are dominated by coal-fired power stations, a 10 to 20% contribution from wind power represents the norm beyond which additional storage or capacity additions become necessary (Denholm, et al., 2005; Holttinen, 2008; Komor, 2004). For grids that are dominated by hydropower, a 30 to 40% contribution from wind power may be achievable. There are already examples of nations which rely on wind energy for up to 40% of total electricity demand (WWEA, 2008). Denmark has set a goal of producing 50% of its electrical power through wind energy by 2030 (Wizelius, 2007). In fact, some studies go as far as to conclude that even in systems with inflexible base-load energy sources such as nuclear power, the potential contribution of wind energy (without incurring additional storage or reserve capacity) may reach as high as 50% in coming decades through better dispersion of wind resources, improved generation technologies (Ackermann & Soder, 2002) and new energy storage technologies (DeCarolis & Keith, 2006; Denholm, et al., 2005). It remains to be seen whether or not a system that is supported by such high levels of wind energy is resilient enough to survive the loss the largest generation unit (Karki & Billinton, 2001)

The relevant insight for policymakers in regard to this research is that the intermittent property of wind can indeed pose logistical problems for managing regional electricity grids but not at the current levels that exist in most countries. At low levels of wind power integration (i.e. 5-10%) existing generation capacity may be able to support additional wind power contribution without any additional costs. At higher levels (i.e. 20%+) adding spare capacity or energy storage systems will increase the cost of wind power, but only by approximately 25%.

4.10 FRONT-END COSTS

There has been criticism that high front-end capital costs associated with wind energy projects deters the pace of wind power capacity expansion (Dunlop, 2006). Initial capital costs are estimated to account for approximately 70% of the total cost of wind energy (DONG Energy, 2008). However, such criticism fails to recognise the strategic advantage to a front-end heavy capital profile – reduced operational risk. Once the front-end investment has been committed, further costs are negligible with wind power operating and maintenance costs estimated at approximately US1.2¢ per kWh (DONG Energy, 2008). Contrast this to the investment scenario faced by fossil fuel power plant developers. The front-end investment for fossil fuel plants may be slightly lower compared to wind power facilities of similar output capacity; however, the highest cost element (the fossil fuel resource) is still prone to inflationary forces. The implication is that guaranteeing capital loans supported by claims on future revenue flows may be a viable policy tool to help wind power developers raise the capital necessary to accelerate the pace of development.

4.11 CONCLUDING THOUGHTS

This chapter has conveyed some insights into why private wind power project developers make the decisions they do regarding site selection and choice of wind power systems. For policymakers who are leading publically funded initiatives to expand wind power capacity, these insights can be referenced to guide the development of economically optimised wind power projects. Moreover, for policymakers who aspire to level the competitive playing field by developing and implementing policy instruments to de-carbonize regional electricity mix profiles, the two sections which examined “carbon credits” and “indirect wind energy costs and savings” highlight important issues to be addressed when designing policy instruments to influence market behaviour. Finally, it is worth re-iterating the observation that concern over the stochastic nature of wind power is over-exaggerated at low levels of wind power contribution. Putting all these insights together, one is left with an understanding that well-planned wind power projects carried out in conjunction with policies designed to internalise all external costs cultivates the necessary conditions for wind power project developments that are economically benign additions to the electricity mix. However, economics are but one aspect of successful project development. As the next chapter will illustrate, there are numerous examples of wind power projects that have been either delayed or derailed due to social opposition.

CHAPTER 5

SOCIAL INSIGHTS FOR BETTER MICRO- LEVEL POLICY

Social opposition can turn an economically beneficial wind power project into a political hot potato that can undermine completion of the project in question and influence prospects for future developments. Research indicates that social impediments to wind power development fall under two broad themes – concerns over impairment of existing community endowments and concerns over impairment of existing ecosystems. Both will be examined in this chapter.

5.1 IMPAIRMENT OF EXISTING COMMUNITY ENDOWMENTS

Community opposition to wind power projects is widely known by the acronym NIMBY (not in my back yard). Reasons for opposing wind projects are varied. For example, in a survey related to a proposed wind energy project in Cape Cod in the United States, eight justifications for opposition were uncovered. Respondents were concerned about adverse impacts on aesthetics, community harmony, the local fishing industry, pleasure boating, property values, bird life, marine life and tourism (Firestone & Kempton, 2007).

Accordingly, developing effective mitigation strategies requires awareness of the varied motivations for opposition to a given project (Zamot, O'Neill-Carrillo, & Irizarry-Rivera, 2005). A starting point for enhanced understanding of community concerns is through public outreach initiatives (surveys, town hall meetings etc.).

5.1.1 Separating Perception from Fact

Community concerns regarding wind energy projects have been shown to be based more on perception than fact (R. Thompson, 2005). For example, tourist areas, there is a misperception that the erection of wind turbines will adversely affect tourism. Surveys conducted in tourist areas in Germany, Belgium and Scotland indicate that such concerns are unfounded (Wizelius, 2007). Similarly, concerns over turbine noise, shadow flicker and threats to birdlife are not supported by actual data (NWCC, 2001; Wizelius, 2007; Zamot, et al., 2005).

The trouble is that the general public rarely has ready access to information necessary to assess the pros and cons of wind power projects. Media reports tends to emphasize storylines that have popular appeal (i.e. famous figures who are opposed to a development, accusations of scandalous behaviour etc.) (R. Thompson, 2005). Consequently, media coverage often fails to communicate the full information that the public needs to effectively evaluate the merits of a project (R. Thompson, 2005). Moreover, as one wind expert points out, a great deal of misinformation about wind power has been propagated by fossil fuel and nuclear power special interest groups (Wizelius, 2007).

The lesson for policymakers is that some types of opposition can be mitigated by providing community members with complete information on a given project. In fact, not only will a more proactive media management strategy help mitigating opposition, it may actually engender enhanced support.

5.1.2 Perceptions Improve

Public perceptions generally improve after wind projects become operational (Rodman & Meentemeyer, 2006). Polls conducted with residents from communities that host wind energy developments in the UK, Scotland, France, the US and Finland have all demonstrated that wind farms which are properly planned and sited can foster positive project perceptions (Wizelius, 2007). In fact, completed wind energy projects, which have been planned to minimise adverse social and environmental impacts, have been shown to positively influence perceptions of wind energy in general (Wolsink, 1988). From a policy perspective, it is noteworthy that positive perceptions are particularly strengthened when community members are offered opportunities to invest in the development (Wizelius, 2007).

5.1.3 Aesthetic Concerns Overshadow All Others

Research indicates that local concerns trump global concerns and aesthetic impacts trump ecological impacts when community members evaluate the pros and cons of a wind energy project. Research by Thompson (2005) found that a wind energy project’s contribution to global warming abatement will fail to mitigate project resistance associated with concerns that the project will adversely impact the aesthetics of a community. Moreover, a number of studies have found that the cause of public disenchantment over a given wind project is frequently centered on concerns over erosion of aesthetic values rather than concerns over degradation of ecosystems (Komor, 2004; R. Thompson, 2005; Wolsink, 2000). A caveat with these studies is that they were done in the US and may not be representative of other advanced nations. However, it is highly likely that in any community, the perception that wind turbines will be aesthetic eyesores must be addressed either through technical solutions (improved siting, camouflaging turbine towers etc.) or through better marketing of the community benefits associated with such projects.

5.1.4 Beyond NIMBY Opposition

Research shows that NIMBY resistance to wind energy projects is not the only type of resistance. In attempting to understand opposing factions in greater depth, Wolsink (2000, p. 574) identified four types of resistance:

- **Type A:** Individuals who support wind energy but are opposed to developing a specific site (this is the classic NIMBY group).
- **Type B:** Individuals who are generally opposed to all wind power developments (NIAMBY - not in any back yard).
- **Type C:** Individuals who were initially positive toward a specific project, but develop negative feelings as a project develops.
- **Type D:** Individuals who are opposed to a specific project due to poor planning or other technical reasons.

The importance of delineating opposition across the four typologies stems from the observation that each type of opposition demands a different strategic mitigation approach. As mentioned earlier, mitigating opposition from NIMBY opponents (Type A) involves a process that begins by seeking to understand the nature of the NIMBY concerns. Once the sources of concerns are identified, strategies can be developed to i) correct misperceptions, ii) negotiate solutions to appease any paramount concerns or iii) attempt to dilute opposition by highlighting benefits that offset the areas of concern.

On the other hand, it is unlikely that Type B opposition can be fully eliminated because such opposition frequently stem from misperception caused by entrenched ideologies. Although NIAMBY factions are typically small (Wizelius, 2007), involvement in project opposition activities by such factions can fuel opposition from other groups (such as Type 3 groups described in the next paragraph). Fortunately, as opposed to nuclear energy, NIAMBY opposition to wind power is rarely manifested in public protest (Wolsink, 2000). With that said, in some countries there are well-organized, vocal groups in opposition to wind power, such as the Country Guardians in the UK, the Association for Protection of the Landscape in Sweden and Windkraftgegner in Germany (Wizelius, 2007). Negotiation is typically the only way to mitigate opposition from such groups.

Opposition from Type C factions occurs when new information emerges which alters perceptions of a project. In some cases, negative perceptions are based on misinformation. Consequently, improved information dissemination may restore positive support. In other cases, negative perceptions are based on justifiable concerns which have emerged. In these cases, revisions to the project may appease outstanding concerns. In yet other cases, the source of negative perception may be both well-founded and irresolvable. In these cases, mediation efforts may at least help to dilute the strength of opposition. Any effective strategy for restoring support from Type C opponents is to first identify why negative perceptions have emerged and craft solutions accordingly.

Opposition from Type D factions can stem from either real or perceived problems. Therefore, mitigating opposition from Type D factions can be approached in a similar manner to mitigating opposition from Type C factions: i) correct misperceptions that fuel opposition, ii) amend real problems that can be viably resolved, and iii) employ mediation to defuse emotions when full resolutions are not possible.

5.1.5 Overall Lessons in Regard to Community Opposition

Overall, improved communication can temper emotions and attenuate local opposition (Wizelius, 2007). Public forums, community mailings, media management strategies and opinion surveys present opportunities for creative dialogues to take place. Often interaction with stakeholders generates creative solutions (Neely, Adams, & Kennerley, 2002). Even when full resolutions are not possible, public interaction allows citizens to vent and express their opposition. While this may not fully appease dissatisfied factions, research indicates that allowing dissenters to voice concerns diminishes the excessive emotional response that often underlies public protest (Wizelius, 2007).

In addition to ongoing discourse with community stakeholders, applying five other principles can help mitigate opposition to wind energy projects. First, sufficient distance between the project site and residential areas should be preserved in order to minimize disruption caused by noise and shadow flicker. Second, in inhabited areas, turbines with noise dampening devices should be mandated. Third, a project which financially benefits the local community garners improved support. Therefore, initiatives to encourage project participation from local firms and to entice community ownership over wind power projects can help endear projects within communities (Komor, 2004). Fourth, if the developer has social ties to the area, the propensity for community opposition diminishes. Last, providing avenues for ongoing community feedback purportedly diminishes extreme forms of resistance that can cause project delays (Wizelius, 2007).

5.1.6 Government Agency Opposition

One final form of opposition that can derail a proposed wind project comes from government agencies that have project veto power. Two illustrative areas of conflict are concerns over disruptions to military installation operations and airport communications (Wizelius, 2007).

Military agencies, airport authorities and telecommunication authorities may block wind power projects due to concerns that wind turbines can adversely influence radar surveillance and communication systems. Although studies show that interference is negligible, misperceptions can pose intractable barriers for project developers (Wizelius, 2007) because often, these bodies have veto power over neighbouring developments. With adequate buffer zones, such threats can be entirely negated. For planning reference, guidelines regulating minimum distance and maximum heights of wind turbines are often available through national civil aviation authorities (Wizelius, 2007).

Mitigating opposition from government agencies shares the same basic precepts as mitigating public opposition. The threat of opposition can be minimized by seeking to understand concerns, rectifying misperceptions, working with stakeholders to develop agreeable mitigation measures when necessary and engaging proactively with officials from government agencies who may be concerned about the impact of a proposed wind energy project.

As wind power projects expand in scale and scope, managing public perception will become increasingly important (McKinsey, 2007; Wolsink, 2000). Wind power projects will increasingly encroach upon locations that communities value for aesthetic or environmental reasons. A degree of public resistance is unavoidable because scenic spots such as hill tops, ocean bluffs and wide sweeping plains are often ideal locations for wind power projects (Komor, 2004). Accordingly, a degree of re-education may also be required in many communities in order to entrench understanding that a transition away from carbon-based electricity generation requires a degree of community commitment to accepting necessary trade-offs. As Dismukes and colleagues point out, "*success of radical innovation (such as wide scale wind adoption) requires much of the community it affects: resolution of technical debates about approach, write-down of existing investments, unlearning and relearning of organisational behaviours and practices, creation of new businesses or even industries, perhaps even cultural change. These processes can take years*" (Dismukes, et al., 2007, p. 777).

5.2 IMPAIRMENT OF EXISTING ECOSYSTEMS

Although the concerns over impairment of existing community endowments outlined to this point in the chapter are typically the strongest impediment to wind power development, there are cases when concerns over impairment of existing ecosystems can result in similar high levels of social opposition to wind power developments.

Many attractive wind power sites are located in ecologically sensitive areas (Wolsink, 2000). Rural sites which are often richer in biodiversity appeal to wind project developers thanks to lower land costs and lower risks of public opposition (Firestone

& Kempton, 2007). Although coastal areas, mountain ridges and mountain passes all present attractive siting options due to superior wind quality (Zamot, et al., 2005), they are often amongst the most ecologically precious. In many countries, coastal areas are extensively developed and few undeveloped sites remain. Erecting wind farms in such areas can close off important migration corridors for keystone species that bridge coastal and inland habitats (Miller, 2004). Similarly, mountain passes are often attractive wind sites due to wind channels found in such passes; unfortunately, wind channels also serve as avian flight paths (Zamot, et al., 2005).

5.2.1 Bird Mortality

Bird mortality is perhaps the most notorious of the ecological threats that wind farms pose. It is not uncommon for wind project developers to be confronted with public concern or even active protest over threats to the avian population (Firestone & Kempton, 2007).

Statistically, as Table 5.1 illustrates, pollution from fossil fuel electricity generation and collisions with cars or buildings cause far more bird deaths than do collisions with wind turbines (Firestone & Kempton, 2007; McKinsey, 2007). A study in 2001 conducted by the US National Wind Coordinating Committee estimated that there were 6400 bird fatalities associated with 3500 wind turbines covered by the study (Wizelius, 2007). Generally, research indicates that it is not the absolute number of bird kills; but rather, the rarity or ecological sensitivity of specific avian species that fuels the staunchest opposition to wind energy projects.

Table 5.1: Bird Mortality from Anthropocentric Causes in the US

Object	Mortality (birds per year)
Power Grid	130-174 Million
Cars and Trucks	60-80 Million
Buildings	100-1000 Million
Telecom Towers	40-50 Million
Pesticides	67 Million
Wind Turbines	6400

Source: (Wizelius, 2007)

Despite low avian mortality rates, misperceptions fuelled by planning flaws associated with wind farms of the 1970s and 1980s can still fan the flames of protest. Early turbine models were erected on lattice towers which provided an ideal nesting ground for birds (Boyle, 2004). However, newer turbine models are mounted on pylon-style towers which are not conducive to nesting (Wizelius, 2007). Unfortunately, although the primary causes of avian fatalities have been technologically mitigated, the stigma that wind turbines threaten avian populations remains. Community engagement supported by avian impact assessments can help diffuse community dissonance.

5.2.2 The Challenge of Estimating Bird Mortality

One common method for assessing the impact of a wind energy project on the avian population is to estimate "bird mortality" which is often expressed as number of birds killed in a given area (i.e. bird kills per square kilometre per year). Separate bird mortality estimates are often calculated for any endangered species inhabiting an area.

When evaluating bird mortality studies, policymakers should be aware that data can be misleading or altogether inaccurate due to a number of confounding factors. Firstly, many bird mortality estimates use data from other "proxy" wind power sites to generate rough estimates of bird kills. However, species, migration and scavenging behaviour of birds as well as the characteristics of each wind farm differ. Accordingly, estimates that are based on benchmark data from other sites will never be directly transferrable. Secondly, bird mortality is usually calculated by counting the number of bird carcasses found within the proxy site area. However, the number of carcasses found is dependent on the number of birds migrating through an area. Studies which fail to account for seasonal migration variations are unrepresentative. Thirdly, counting bird carcasses found within a site boundary produces underestimates of true mortality. Birds that are injured by wind turbines can fly off to other areas where they perish. Furthermore, bird carcasses that fall to the ground are frequently carried off by scavengers (Miller, 2004). In fact, bird mortality statistics are only truly liable when they are conducted at the site in question over at least a full year. Unfortunately, post-project completion bird mortality studies undermine the value of this tool for planning mitigation strategies.

Even when bird mortality estimates are relatively representative, absolute mortality numbers tell only part of the story. A thousand birds killed per year within the boundary of a wind site represents a significant mortality statistic if ten thousand birds pass through the site each year. However, if ten million birds pass through the site each year, the mortality rate is less significant. In order to evaluate the bigger picture, a statistic known as *bird risk* is commonly used. Bird risk is defined as the number of bird fatalities as a percentage of the total number of birds observed in the area (Zamot, et al., 2005).

Unfortunately this metric exhibits all of the potential problems associated with estimating bird mortality plus a host of other confounding threats associated with estimating the number of birds passing through an area. Firstly, birds migrate into and out of habitats. Accordingly, bird numbers are rarely consistent throughout the day, month or year. Secondly, some birds are nocturnal. This poses obvious enumeration challenges. Thirdly, different birds fly at different heights and so the threat posed is not the same for all species. Finally, as stated earlier, avoiding fatalities of endangered birds should take priority. Therefore, enumeration activities should ideally endeavour to separate endangered species from commonly found species. In practice, this is hard to accomplish (de Lucas, Janss, & Ferrer, 2007).

5.2.3 Lessons for Policymakers

There are two useful lessons that merit attention. Firstly, mortality studies can provide insight into the potential for public opposition from groups that are concerned about avian welfare. However, such studies are only useful if they avoid the threats to validity outlined earlier. Secondly, policymakers who reference avian mortality studies in order to gain insight into the threat that a wind energy project poses to the avian population should do so with a critical mindset. The methodology supporting the data should be clearly understood in order to ascertain the limitations associated with the study's conclusions.

5.2.4 Degradation of Animal Habitat

Disruptions to animal habitats associated with construction and operation of a wind facility can significantly influence foraging patterns and undermine the continued viability of the area to support resident species (Magoha, 2002). As the next few paragraphs demonstrate, more effective planning can significantly mitigate threats to ecosystem integrity at the site preparation, construction and operation stages.

Site Preparation Issues

Ecosystem-friendly site design requires a reassessment of the traditional approach to site development, which typically begins by clearing all vegetation from a site and levelling the site with bulldozers. Clearing a site in this manner creates ecologically barren wastelands that uproot animal habitats, disrupt foraging patterns and fragment animal populations (Ackermann & Soder, 2002). This is true even if new vegetation is planted once construction is completed. The level of comfort that an animal has with its habitat is dependent on the familiarity it establishes with its environs. Changes to physical features of the environment or even to scent patterns attached to flora can severely disrupt foraging patterns (Begon, Townsend, & Harper, 2006). A better way of developing sites is to clear only those areas of land which will be built upon. This will leave some of the original flora in place and provide a level of familiarity that will induce animals to return to the area after construction is completed. Moreover, careful attention should be given to selection of any vegetation to be replanted. Efforts should be made to ensure that new vegetation mirrors the type of vegetation lost (Harrop & Nixon, 1999). Furthermore, the ecological intrusiveness of wind tower foundations can be significantly reduced by recovering foundations with soil and vegetation (Wizelius, 2007).

Another flaw with traditional site development concerns fencing which is often erected around a site, often in adherence to public safety regulations. However, utilizing traditional chain-link fencing prevents larger species from returning to the site. Construction standards that require access holes to be installed at various intervals along the fence to facilitate animal migration can resolve this problem (Harrop & Nixon, 1999).

It’s worth noting that ecologically sensitive site design should not stop at site boundaries. One of the greatest threats associated with wind energy developments stems from the clearing of pristine lands for access roads and transmission line towers (Denholm, et al., 2005). Not only do such developments potentially hinder animal migration, they also facilitate human access to ecologically sensitive areas. Again, the process of designing the project with these threats in mind can produce cost effective solutions. Migration corridors can facilitate improved animal migration and entry gates at the mouth of service roads can help regulate unauthorized access.

Construction Phase Issues

Different species of animals respond differently to external commotion. During the construction stage, noise and commotion from construction activities can either scare off predators or prey; and in doing so, unintentionally upset the ecological balance (Begon, et al., 2006). Identifying the types of animals native to a site and developing impact assessment and mitigation strategies for the identified species can help minimize the disruptive impact of construction activities. It is particularly important in the development of “resident animal profiles” that endangered species and keystone species are prioritized to ensure a given project does not cause irreparable ecological damage (Harrop & Nixon, 1999).

Operational Phase Issues

Unfortunately, ecological disruption cause by wind farms does not entirely disappear upon completion of construction (Ackermann & Soder, 2002; Ardente, Beccali, Cellura, & Brano, 2008). Rotor noise which was a problem with older wind systems has been more or less attenuated through technological advances (Magoha, 2002;

Zamot, et al., 2005). However, the impacts that the continual “swishing” of modern rotors and shadow flicker caused by the oscillating blades have on wildlife are not yet fully understood. In the absence of better understanding, wind development planners should avoid developments in areas that are inhabited by endangered species.

5.2.5 Offshore Wind Farms and Ecological Concerns

Threats to habitat viability apply to offshore wind power developments as well. Moreover, the contention that ecologically sensitive site planning can avert many ecological problems is true for offshore wind developments as well (Ardente, et al., 2008; Magoha, 2002; McKinsey, 2007).

Mitigation measures should be designed to avoid damaging the health of reefs, marine breeding grounds and aquatic foraging areas. With that said, the marine habitat can be highly resilient. For example, research indicates that although the noise emitted and the turbidity caused during the process of tower construction can scare off marine mammals; post-construction, mammals tend to return to the area (DONG Energy, 2008). Research also indicates that the base of wind turbine towers can potentially act as artificial reefs for benthic fauna; and as such, positively contribute to the marine habitat (DONG Energy, 2008).

Overall, extant research in regard to ecosystem management of offshore wind energy developments generally indicates that informed environmental planning can avert most threats to the marine habitat. However, as is the case with onshore developments and animal habitats, more research still needs to be done on the effect of operational noise and vibrations on aquatic creatures.

5.2.6 The Importance of Environmental Impact Assessments

Ecological threats and appropriate mitigation measures are site-specific because flora and fauna profiles vary. Accordingly, to fully anticipate the impact of wind power projects on a given ecosystem, environmental impact assessments (EIAs) should be undertaken.

EIAs are detailed assessments of ecological impacts associated with specific projects. The first step of an EIA is to establish the baseline. The baseline represents the state of the ecosystem prior to any development. The next step is to conflate ecological and engineering principles to predict and evaluate impacts that will occur at the site preparation, construction and operation stages. Finally, the EIA typically concludes by recommending mitigation measures that will minimize the impact of the project on the ecosystem (Harrop & Nixon, 1999). In short, EIAs are site-specific blueprints for mitigating ecological damage associated with wind energy projects.

If the intention is to ensure ecological damage is minimized, it is imperative for the EIA to be a part of the project approval process (Brown & Escobar, 2007). Furthermore, the development of standardized EIA templates helps to ensure every project site is evaluated according to the same criteria and the same depth of study (Magoha, 2002). Almost counter-intuitively, research indicates that regulatory standardization of EIA criteria is greatly appreciated by environmental and corporate stakeholders alike (McKinsey, 2007). This is because standardization allows environmental watchdog groups to influence what goes into an EIA through political lobbying and more effectively evaluate EIA submissions from project developers.

Standardization also insulates project development firms from public criticism that the EIAs they carry out lack an acceptable standard of rigor (McKinsey, 2007).

Caveats Associated With EIA Legislation

There are three caveats associated with the management of EIA policy. Firstly, projects which have been planned in an ecologically sensitive matter should not be delayed by red tape associated with an inefficient EIA review process because inconsistent processing practices deters investment (McKinsey, 2007). This implies that authorities that are responsible for vetting the assessments and granting approval must be have the resources, competencies and operational obligation to expediently carry out effective, timely evaluation of submissions (Lawrence, 2003).

Secondly, a degree of flexibility should be built into the EIA process in order to allow amendments to be made to EIAs as characteristics of projects change, new technology emerges and project finances fluctuate (McKinsey, 2007; Wizelius, 2007). Mechanisms should exist to allow project developers to make minor amendments to project designs and have these amendments approved in a fast track manner without the entire EIA being resubmitted. An EIA should be an advisory tool which helps to make wind energy projects more environmentally sound; it should not be used to delay or derail projects that are beneficial to the community (Lawrence, 2003). In order to achieve economic and environmental balance, many nations draw a distinction between small and large wind energy developments. Larger developments require more detailed EIAs. In Germany, projects involving 20 turbines and more require significantly more due diligence and preparation of a mandatory EIA. In Sweden, any installation over 25 MW requires a comprehensive EIA (Wizelius, 2007).

Thirdly, mandatory EIA standards should ensure that EIAs are prepared and disseminated for stakeholder evaluation and input well before project approval is given (Wizelius, 2007). For wind energy project developers and civic sponsors, one of the main purposes of preparing an EIA is to minimize the threat of public protest caused by poor planning. Without giving stakeholders a voice, EIAs created with even the best intentions may still fuel protest (de Lucas, et al., 2007). This caveat may seem like a trite observation; however, all too often EIAs are prepared in isolation from stakeholders and appended to projects as afterthoughts (Lawrence, 2003).

5.3 CONCLUDING THOUGHTS

It is perhaps no exaggeration to say that the realizable potential of wind power depends on how well developers manage social and environmental issues (McKinsey, 2007). As more wind farms are developed, threats to both social and ecological endowments will increase (DONG Energy, 2008). As available sites become more scarce, the impetus to build wind farms on socially and ecologically sensitive areas will also increase (Markevicius, et al., 2007). However, by developing and overseeing improved standards for managing threats to social and ecological endowments, policymakers can play a role in ensuring that the benefits derived from wind energy are not realized at the expense of a community’s natural habitat.

CHAPTER 6

TECHNICAL INSIGHTS FOR BETTER MICRO- LEVEL POLICY

Chapter 4 outlined how factors such as wind quality, site location, and distance to the grid influence the cost profile of wind power and Chapter 5 explained how ineffective site management can sire social opposition that can derail even the most economically attractive wind power projects. Consequently, it is not a great stretch to conclude that site selection is the single most important activity in wind power development. This is true at both the regional planning level and the individual project level. Unfortunately, the processes of assessing wind power potential in a given planning region and then prioritising high potential sites for development are fraught with technical complications. This chapter examines some of the more prominent technical considerations and endeavours to provide some guidance to policymakers on how to prepare effective regional development strategies.

6.1 WIND POWER POTENTIAL INVENTORIES

A "Wind Power Potential" (WPP) inventory is essentially a catalogue of potential wind sites within a planning area. It identifies prospective sites and assesses the sites according to wind quality, environmental conditions and social considerations. In aggregate, the WPP estimates (recorded in megawatts of potential capacity) together represent the maximum "technical" capacity for wind energy in the planning region.

The least contentious way to develop a WPP inventory employs a negative planning approach. On a map of the planning area, sites where wind turbines should not be erected are blocked off. Prohibited areas can include areas of historical or cultural importance, ecologically sensitive sites, sensitive marine habitats, tourist or recreation areas, population centres, military installations and sites where strong public opposition can be expected (i.e. scenic vistas).

It should be intuitively obvious that a bottom-up approach enlisting public participation in identifying prohibited sites minimizes the prospect of future public opposition to proposed developments (Zamot, et al., 2005). A bottom-up strategy also effectively taps local knowledge. For example, local environmental groups are often best equipped with the knowledge necessary to identify ecologically sensitive sites (de Lucas, et al., 2007). For an illustration on how negative planning has been used for identifying feasible wind energy sites see Wizelius (2007) on Sweden.

Once prohibited areas have been blocked off, a map of possible sites remain. Therefore, the next step is to assess the suitability of the remaining sites (Wizelius, 2007). A suitability analysis typically begins with an assessment of relative wind speed and consistency because, as outlined in Chapter 4, these qualities of wind influence the economics of wind power. In areas where wind quality is deficient, wind turbines may not even be viable. For example, planners who were developing a suitability analysis for the Mecklenburg-Western Pomerania region of Germany rejected areas with average wind speeds below 5 m/s as being economically unviable (Wizelius, 2007).

In most nations, national meteorological agencies produce wind resource maps which provide a broad overview of the energy content of prevailing winds. The Risoe laboratory in Denmark provides links to wind resource maps for over 50 countries (www.windatlas.dk). Wind resource maps use wind data gathered from measuring masts in various locations to connect points with the same energy content, forming isovents (Wizelius, 2007). Isovents are conceptually similar to iso-lines on weather maps that illustrate areas of high and low pressure. Although wind resource maps are not always detailed enough to allow specific sites to be analyzed, they do provide planners with insight into which general locations typically have the highest wind energy potential and which should be ruled out (Wizelius, 2007). For example, the use of wind resource maps in Taiwan point to the island of Penghu as an attractive area for wind power development (Chang, Wu, Hsu, Chu, & Liao, 2003).

Identifying suitable sites within a region of high wind quality requires a detailed location analysis examining characteristics such as roughness of terrain, hills and obstacles. There are a number of commercial software programs that combine data from wind resource maps with data on site characteristics in order to identify the most attractive wind energy sites. Examples of software include WAsP, WindPRO, WindFarm, WindFarmer and Greenius. In fact, many of these programs boast additional features which allow noise, shadow and visual impact to be analyzed for each site. Prior to development of such software, developing comprehensive regional strategies for wind energy developments would have been extremely time-consuming. Now, entire countries can be fully evaluated in terms of wind energy potential within a month or two (Wizelius, 2007). The end result is an estimate of technical wind potential in a given planning region that incorporates predominant social and ecological concerns.

This then allows planners to estimate the maximum role that wind energy could play in nation's electricity portfolio:

$$\text{Maximum Role for Wind Energy} = \frac{\text{Aggregate WPP capacity}}{\text{Total amount of electricity generated}}$$

Keeping in mind the earlier discussion on constraints posed by wind intermittency on grid integration, defining the maximum role for wind energy in the manner just described improves the policy planning process in at least three significant ways. Firstly, estimating maximum technical wind power potential gives policymakers insight into how much additional storage or reserve generation capacity would be needed to fully exploit technical potential. Secondly, by estimating maximum technical wind power potential, planners can begin to evaluate which other alternative energy technologies need to be supported and to what degree in order to contribute to carbon-free electricity generation. Thirdly, the existence of government wind power potential studies signifies strategic intent (Hamel & Prahalad, 1989), giving wind power developers insight into the level of development that might be politically supported in a given region.

Denmark which employs a strategic approach for domestic energy planning exemplifies the usefulness of comprehensive strategic planning. The Danish government has determined that a domestic wind power target of 50% of electric power consumed is achievable by 2030. This target was arrived at by assessing the national potential for further wind energy development and considering the logistics of feeding such a high proportion of wind energy into Denmark's electricity grid. With overall targets established and desirable locations earmarked for development, wind energy project developers in Denmark can shift attention away from site selection politics to project development (Wizelius, 2007).

There is one policy caveat associated with the initiation of strategic regional plans for wind energy development. Leading up to the implementation of such a plan, new project activity typically slows down as municipal planning authorities and wind developers alike alter behaviour to mesh with the emergent strategy. Since projects can take up to a year for planning approval, a developmental lull can extend from one year prior to one year beyond implementation of the strategy. Indeed, this was the case in Denmark were development slowed down considerably between 1992 and 1994 as a national development strategy was being hammered out. However, post-1994, project activities intensified (Wizelius, 2007). A similar phenomenon occurred in the Gotland area of Sweden in 2002 (Wizelius, 2007).

6.2 RATIONALIZING DECISIONS WITH THE WPP INVENTORY

In addition to providing insights on technical wind power potential, WPP inventories can also help to ensure that development decisions are based on analytically consistent evaluation criteria. Formalized strategic planning of this type helps to uncover flaws in ad hoc development proposals. Lee and Tzeng (2008) for example, demonstrated through the creation of a WPP inventory how the Taiwanese government will be unable to meet announced targets for wind power without initiating costly offshore wind projects that it has not budgeted for. In recognition of the benefits of formalized strategic planning, the Danish Wind Turbines Act of 1992 requires municipal and regional authorities to submit strategic plans for wind turbines siting (Wizelius, 2007).

One caveat to working with WPP inventories is that there is a degree of subjectivity involved in their creation (Karki & Billinton, 2001). For example, a common approach to estimating the wind quality at a given site is to use historical data to estimate wind speeds and variances in a subsequent year. Unfortunately, annual wind variances also exist; therefore, even the most detailed historical analysis can be unrepresentative (Ackermann & Soder, 2002). The lesson for policymakers is that all wind energy estimates associated with a given site should have best case, worse case and median estimates. While it is acceptable to use median estimates for budgeting purposes, it may be more prudent to rely on worst case output scenarios for regional electricity mix planning to ensure enough aggregate capacity is commissioned to fulfil anticipated supply requirements.

6.3 PUBLIC VS PRIVATE SITES

Public and private lands should be clearly demarcated within a WPP inventory because land ownership can influence the nature of government involvement in a particular project (Ferlie, Lynn (Jr), & Pollitt, 2005), which in turn, shapes the types of policy tools adopted to facilitate wind power development. For example, coveted sites are on public land, the simplest approach to developing the sites may be for the civic authority to adopt a bidding system similar to that undertaken in the UK (Komor, 2004) wherein wind energy firms that most effectively meet the bid criteria win an operating concession. In this type of lease arrangement, private firms do not have to assume the risks of purchasing land or leasing land from unreliable private parties.

On the other hand, if sites with the highest wind potential are on privately held land, the planning authority may wish to consider adopting policies to encourage collaboration between private land owners and wind project developers. Policy instruments such as wind power production subsidies, tax rebates or power purchase guarantees have been employed globally for such purposes (Komor, 2004). Moreover, governments may wish to create regulatory guidelines to ensure that leases made between these private parties are structured in a way to ensure that the energy supply from the site is not adversely affected by legal disagreements over features of the lease.

Counter-intuitively, the control that government planners have over public land does not necessarily make public land a more attractive siting option. Developing public land for wind energy can fuel resistance from community groups that feel the government does not have the right to tender publicly-held endowments to commercial interests (Firestone & Kempton, 2007; R. Thompson, 2005). Conversely, privately held land has frequently already undergone a degree of development by owners who are seeking financial return on their investment. Consequently, except for developments that significantly and adversely affect a neighbouring community, developing wind farms on private land can be less contentious because it is seldom pristine land that is targeted. This is especially true of privately held agricultural land (Rodman & Meentemeyer, 2006). Farm owners are often supportive of hosting wind power developments because many view such developments as a way to supplement farming income (Komor, 2004).

Regardless of land ownership, careful attention needs to be given to the impact that wind power developments might have on neighbouring communities and the ecosystems within which they are situated. The next section explores this in further detail.

6.4 PRIORITISING SITES: ENVIRONMENTAL AND SOCIAL SENSITIVITY

Sites of equal technical wind power potential are not equal in terms of attractiveness of development. As Rodman and Meentemeyer (2006) point out, within WPP inventories, technical analyses of potential wind sites need to be supplemented with social and environmental impact studies. In their study of potential wind sites in California, inclusion of environmental and social impact considerations reduced the amount of technically superior wind sites by 61%.

The trouble with environmental and social impact studies is that measurement of environmental and social impacts is highly subjective. Determining the monetary worth of a bird's life or a scenic vista is contentious (McKinsey, 2007). As mentioned earlier, although there are economic methods for estimating environmental costs, each method has its share of critics and supporters (Costanza, et al., 1997; Thampapillai, 2002; Tietenberg, 2003). In regard to social estimates, objective measurement is equally difficult because survey results used to ascertain community support do not always mesh with actual community reaction (Babbie, 2004). Zamot and colleagues (2005) make the point that when undertaking social assessments of prospective wind projects, perhaps rather than inquiring "*What percentage of the community is intellectually opposed to the project?*", a more relevant line of inquiry may be "*What percentage would be likely to actively protest such developments?*".

In addition to the contentious nature of assigning monetary values to environmental or social degradation, prioritizing acceptable degrees of degradation can also sire controversy. For example, imagine a scenario wherein situating a wind farm at Site A will adversely impact a popular scenic vista that is highly valued by the community but will have negligible ecological impact on the area. Meanwhile, situating the wind farm at Site B will significantly degrade a natural ecosystem but it will not impair enjoyment of the cherished vista. Either site option will have supporters and opponents.

One way to avoid controversy over methodology used for weighting social or ecological endowments is to identify an attractive pool of sites based on generic criteria and then allow market forces to decide the sequence of sites to be developed. For example, one approach is to list sites as *excellent* (sites with superior wind conditions and no significant adverse ecological or social impacts), *good* (sites with either superior wind conditions and minor ecological-social impacts; or sites with fair wind conditions and no significant adverse ecological-social impacts), *fair* (sites that may be problematic due to highly variable wind conditions or ecological or social impacts which will have to be mitigated), and *poor* (sites with significant ecological or social impacts) (Rodman & Meentemeyer, 2006). After the sites have been assigned to these four categories, the excellent sites become the targets for private developmental bids or public development initiatives.

In summary, the discussion to this point has shown that an effective WPP inventory: i) decouples public and private sites, ii) includes technical (wind quality), environmental and social impact assessments and iii) prioritizes the sites to guide development sequencing. However, there is one other element of strategic regional wind planning that policymakers should consider geographic dispersion of wind power developments.

6.5 GEOGRAPHIC DISPERSION

As discussed in Chapter 4, geographically dispersed wind power facilities attenuate stochastic wind power flows because frequently when wind is not blowing in one area, it is blowing in another (DeCarolis & Keith, 2006). Consequently, prioritising site development should ideally seek to encourage dispersed development.

In liberalized electricity markets, geographic dispersal can be encouraged through the use of special “siting subsidies” which reward developments that are sited beyond minimum pre-established distances from existing wind farms. In centrally planned electricity markets, geographic dispersal can be planned by separating a planning region into square developmental grids and assigning one project per grid. Although this approach arguably results in some projects of lower energy potential being developed over more attractive projects, the aggregate result is a more optimally tuned wind power supply network.

6.6 SUMMARIZING THE VALUE OF WPP INVENTORIES

The insights extracted from literature and presented in this chapter, demonstrate how policymakers can optimize wind energy development strategies by preparing effective WPP inventories. In premise, a WPP inventory is similar to a blueprint that a construction company uses for guiding the construction of a building. While one would be hard-pressed to find a quality construction company that does not utilize blueprints, it is surprising how often strategic planning in regard to electricity portfolios is carried out without adequate national, regional or municipal plans.

CHAPTER 7

POLITICAL INSIGHTS FOR BETTER MICRO- LEVEL POLICY

This chapter concludes Part 1 of this research paper by examining two issues of political nature that confront project level policymakers. The first part of the chapter explores ways to improve the tendering process for wind power developments in order to operationalize regional wind development strategies that have been formulated through the activities outlined in Chapter 6. The second part of the chapter examines the challenges to estimating CO_2 emission reductions associated with wind power projects. Although estimating CO_2 emissions is an economic issue in the context of applying for carbon credits, it is also a political issue because CO_2 emission abatement can be an important cog in any campaign to generate public support for wind power development projects.

7.1 WIND POWER TENDERING POLICY

7.1.1 An Equitable Tendering Policy

In most democratic economies, energy planning authorities that adopt deregulation strategies (i.e. privatization, PPP relationships etc.) employ a tendering process to procure energy for the electricity grid. Unfortunately, rigid tendering requirements that seek guarantees of fixed amounts of energy generation each year put wind project developers in a disadvantageous competitive position (Blakeway & White, 2005). Due to the stochastic nature of wind power, it is costly for wind project developers to contractually commit to exact generation targets. In order to meet such a requirement, wind project developers must either incorporate over-capacity into the bid to ensure that the contracted amount of energy will be delivered, pay to store a portion of the electricity generated or risk submitting a competitive bid which will under-perform if wind forecasts are overestimated.

One way to ensure technological equity in a tendering system is to create a technologically divided tendering system. Under such circumstances, wind power providers would compete only with each other for a fixed annual purchase quota. The quotas allocated to wind power, solar PV, hydropower, coal-fired power and other generation technologies would add up to the total amount of electricity supply required. The obvious benefit to such a system is that it allows policymakers to micromanage a transition from fossil fuel technology to alternative energy technologies, thereby giving planners better control over the pace of development.

On the other hand, controlling market development to the extent implied by a technologically divided tendering system may be ideologically unacceptable in some national or regional contexts. Free-market purists may wish to ensure that each bidding exercise is open to all prospective suppliers. Under such a system, the playing field can be levelled by replacing contractual requirements to supply specific quantities of energy with requirements to supply energy within a range that intermittent energy providers could realistically meet without incurring storage costs.

7.1.2 Using Specialists to Define Criteria and Vet Bids

A degree of specialized knowledge is needed when i) defining the criteria to include in wind power requests for tender and ii) evaluating subsequent bids (Ackermann & Soder, 2002). One strategy for addressing the need for specialized knowledge is to form expert panels to carry out these duties. Panels should at the very least include a wind power engineer, an environmental impact assessment professional, a technical representative from the organizational entity that oversees electrical grid load management, an urban planner, an energy policy expert and a person representing community interests. All these stakeholders bring requisite knowledge to the process in order to avert scenarios where wind power development contracts are awarded to socially or ecologically undesirable project proposals. To consolidate the planning process, the WPP inventory process described in Chapter 6 should define what sites should be prioritised for public tender.

7.1.3 Manage Centrally, Consult Locally

A rule of thumb for managing the tendering process is to manage centrally but consult locally. In a UK study of alternative energy projects that were awarded to developers but failed to come to fruition, one of the main conclusions was that opposition from local interests stymied project implementation (Wong, 2005). While the study acknowledged that energy planning needs to be centrally managed in order to ensure supply stability, failure to include local stakeholders in a local development was identified as a recipe for disaster. Engaging local stakeholders reduces project opposition and may produce local economic benefits if local firms become involved in support roles (Komor, 2004). It may be worth noting that in Germany, wind farms are often owned and operated by farmers and farm cooperatives. Thanks to local ownership, German wind farms generally enjoy positive support in the communities in which they are sited (Wong, 2005).

7.2 CO_2 EMISSIONS ASSESSMENT

7.2.1 Lifecycle Analysis

One key motivation for incorporating wind energy into an electricity grid is to reduce CO_2 emissions associated with fossil fuel combustion. However, contrary to media hype, wind energy is not CO_2 emission-free (Lenzen & Munksgaard, 2002). Although CO_2 emissions are not produced during the operation of wind turbines, CO_2 emissions are produced when manufacturing wind energy components and constructing wind farms. Therefore, when evaluating how much CO_2 is offset by a given wind project, the entire lifecycle of the wind system must be evaluated and compared to the entire lifecycle of the system that it is displacing (Graedel & Allenby, 2001).

There are numerous lifecycle studies which attempt to estimate CO_2 emissions associated with both offshore and onshore wind power systems. Schleisner (2000) in a lifecycle study for a 9 MW offshore wind facility in Denmark concluded that CO_2 emissions over the lifecycle translated to 16.5 g of CO_2 per kWh generated by the facility over its lifespan. A more recent German study using technical data describing a hypothetical offshore 5 MW system arrived at a slightly higher estimate of 22 g of CO_2 per kWh (Pehnt, Oeser, & Swider, 2008).

Regarding onshore wind facilities, Schleisner (2000) estimated that CO_2 emissions over the lifecycle of a 5 MW onshore wind facility amount to just over half of the emissions of a similar sized offshore facility (9.7 g of CO_2 per kWh generated by the facility). Other lifecycle studies have produced estimates which fall on either side of Schleisner's estimates. Notably, Lenzen and Munksgaard (2002) conducted a metastudy which summarized research on lifecycle CO_2 emission estimates for 29 globally dispersed wind power developments. They found that CO_2 emission estimates on a per kWh basis ranged from 8.1 g per kWh at a German site to 123.7 g per kWh at a Japanese site. The average for all sites was 33 g per kWh.

Generally, reputable researchers have arrived at such disparate estimates due to differences in critical assumptions made concerning i) project boundaries, ii) wind power system components and iii) the nature of production processes. In subsequent sections, energy intensive stages along the lifecycle of a wind power system will be examined in closer detail to demonstrate the complexities of estimating CO_2 emissions. Additionally, recommendations will be proffered to help policymakers utilize this knowledge to effectively interpret lifecycle data.

7.2.2 Boundary Choices

Defining the boundary of a system has perhaps the greatest influence on CO_2 emission estimates (Lenzen & Munksgaard, 2002). For example, many studies begin the lifecycle analysis of a wind facility at the component manufacturing stage. This implies that the first source of CO_2 emissions will likely pertain to materials processing (i.e. when ore is converted into the steel moulds) (cf. Pehnt, et al., 2008). Choosing this stage to be the starting point implicitly ignores CO_2 emissions that are emitted when the ores are extracted during the mining process (Sovacool, 2008a). Accordingly, policymakers who are presented with lifecycle data on CO_2 emissions should endeavour to ascertain the comprehensiveness of the “lifecycle” data.

7.2.3 Aggregating Emissions from Disaggregated Processes

The source of energy generation can be just as important as the amount of energy consumed in a process. CO_2 emissions associated with wind farm components manufactured in a country where hydropower dominates the electricity mix will be significantly less than CO_2 emissions associated with components manufactured in a country where coal-powered electricity dominates. Unfortunately, in today's global economy, component parts of a typical wind turbine are manufactured at plants around the world (Bartlett, et al., 2003). Efforts to estimate the amount of CO_2 associated with the electricity used to produce each component part would require data on national electricity profiles and data on electricity used to produce each part (Schleisner, 2000). Even if this could be accomplished in a cost effective manner, the data would only be valid for turbines of the same type. Therefore, policymakers who are presented with CO_2 emission estimates should regard such estimates with a degree of healthy scepticism unless the assumptions underlying these estimates are made clear.

7.2.4 Recycled Materials and Carbon Footprints

Due to the dominance of CO_2 emissions associated with component manufacturing, employing recycled materials can significantly reduce the carbon footprint associated with a wind energy system (Ardente, et al., 2008). Specifically, wind energy systems made from recycled materials use up to 80% less energy in the component manufacturing stage when compared to systems which use virgin materials (Lenzen & Munksgaard, 2002).

This has implications regarding the accuracy of lifecycle analyses. A lifecycle analysis which estimates emissions based on an assumption that virgin materials are used could derive estimates for the production of component materials that are 5 times greater than studies which assume recycled components are used. Accordingly, requests for tender that require a certain percentage of the materials to be from recycled sources will positively support national CO_2 emission reduction plans.

7.2.5 Type of Materials and Carbon Footprints

The type of material used for the construction of turbine towers can play a significant role in terms of energy used in production and erection of components (Lenzen & Wachsmann, 2004). If a steel tower is used, up to half the energy attributed to a wind project goes into manufacturing the steel for the tower. On the other hand, if concrete is used in place of steel for the tower, approximately 50% less energy will go into the construction of the tower (Lenzen & Munksgaard, 2002). In short, mandating the use of concrete over steel can reduce aggregate CO_2 emissions by 25%.

One final research insight related to material choice is that the process of manufacturing larger turbines uses less energy and proportionately less CO_2 per megawatt hour (Lenzen & Munksgaard, 2002). This insight should be intuitively obvious given the observation in the last paragraph that 25% - 50% of CO_2 emissions are attributed to tower construction. A turbine that has twice as much generating capacity as another turbine will not require a tower that uses twice as much material to construct. Simply put, there is an exponentially declining relationship between tower size and turbine size.

7.2.6 Transport Emissions

One study estimates that liquid fuel combusted during the transportation and construction stage of a wind project represents approximately 5% of all energy used on project (Lenzen & Munksgaard, 2002). Yet another study points out that component parts for some facilities may come from overseas plants which would amplify the CO_2 emissions associated with transporting components (Ardente, et al., 2008). Obviously, vehicles and power generators that use biofuel instead of fossil fuels can significantly reduce transport-related CO_2 emissions.

7.2.7 Life Cycle Analysis in a Nutshell

The overarching lesson for policymakers is to view lifecycle CO_2 emission estimates with a sceptical eye and seek to identify the underlying assumptions upon which the estimates are founded. For policymakers who are intent on commissioning a comprehensive estimate of CO_2 emissions associated with a wind energy project, attention must be given to ensuring that the estimation process begins with raw resource extraction and ends with the disposal of the components after their useful life (i.e. delivery to a recycler or salvage yard).

PART 2: MACRO-LEVEL POLICY INSIGHTS

"CASE STUDIES OF NATIONAL WIND ENERGY DEVELOPMENT POLICIES"

PART 2

OVERVIEW

Part 2 of this research study endeavours to understand and explicate impediments to national wind power development policy. It approaches this challenge by first presenting case studies which describe wind power development in four advanced nations that are characterised by phlegmatic track records in wind power development – Australia (Chapter 8), Canada (Chapter 9), Japan (Chapter 10) and Taiwan (Chapter 11). Chapter 12 then draws the insights from the four case studies into a STEP (social, technical, economic and political) framework to help policymakers better conceptualise macro-level challenges to improved wind power development policy.

CHAPTER 8

WIND POWER DEVELOPMENT IN AUSTRALIA

Abstract
This chapter provides a critical evaluation of Australia's new Renewable Energy Target (RET) program in respect to its capacity to support wind power development. Five structural flaws associated with the RET which undermine its effectiveness as a catalyst for technological change in the electricity sector are discussed: i) failure to prioritise technologies which sires diffused, less effective financial support, ii) the inclusion of waste coal mine gas (WCMG) as an eligible fuel source which acts as an indirect coal industry subsidy, iii) program duration which is too short and ill-structured, iv) a multiplier that is well-intended to support small-scale renewable technologies but which creates "phantom capacity", and v) the capped target of 45,000 GW hours which will stymie long-term wind power market investment. The chapter concludes with recommendations which stress the importance of passing the Carbon Pollution Renewable Scheme (CPRS) legislation to offset the weaknesses associated with the RET. If the CPRS cannot be implemented, the chapter recommends that amendments be made to the RET to i) remove WCMG from the list of approved alternative energy sources and ii) extend the RET targets to reach 120,000 GW hours by 2030.

8.1 INTRODUCTION

December 3, 2007 was a watershed day for Australian politics; a new government was sworn into power under the Labor Prime Minister, Kevin Rudd. One of the regime's first acts was to ratify the Kyoto Protocol, and in so doing, committed Australia to meeting a greenhouse gas (GHG) abatement target amounting to 8% above 1990 levels for the period 2008-2012. Although Australia will likely meet this liberal target for the first Kyoto Protocol emissions reduction period thanks to favourable changes in land-use and forestry, any subsequent reductions will require radical structural changes to how the nation uses energy, which even the government realises is of a magnitude that few other industrialised nations face (Government of Australia, 2009h).

Given that nearly 50% of the GHG emitted in Australia comes from power generation (Government of Australia, 2008a), it should come as no surprise that one of the first policy initiatives directed at mitigating GHG emissions was a fortified program to encourage enhanced development of renewable energy capacity in the electricity generation sector.

The flagship program of these enhanced efforts is the Renewable Energy Target (RET) which consolidates all state-level Renewable Energy Target programs and legally requires Australia's electricity utilities to ensure that 45,000 GWh of electricity purchases (approximately 20% of total electricity generated) will be from renewable energy technologies by 2020. On the surface, the new RET brings Australia's renewable energy development program in line with EU targets (Hindmarsh & Matthews, 2008) and gives Australian renewable energy development firms the requisite market window to establish stronger market presence, thereby enhancing economies of scale and reducing the cost of renewable-sourced electricity.

For wind power developers in particular, the RET potentially represents an opportunity to establish a strategic beachhead in Australia’s electricity sector by capturing the economies of scale necessary to close the commercially corrosive cost gap that exists between wind power and fossil fuel-powered electricity. Actual cost differentials are hard to pin down for electricity sources due to technological, operational and regional factors which cause costs to vary; and peer reviewed sources on this topic for Australia are somewhat dated. However, as a general indicator of the current cost disparity, data from the Australia Institute in 2006 estimated that the cost range of coal-fired power was AU$31-40 per MWh (megawatt hour) while the wind power cost range was AU$60-80 per MWh (Macintosh & Downie, 2006). As of December 2009, the cost of coal had increased by over 25% from December 2005 levels[11]. Moreover, wind power generation costs, which improved 4-7 fold from 1981 to 2006 (Celik, et al., 2007), are widely expected to continue to improve (DONG Energy, 2008; Wizelius, 2007). Accordingly, it is possible to argue that the cost disparity has narrowed in the three years since this report was released. Moreover, a recent study by the Australian Academy of Technological Sciences and Engineering (ATSE) estimates externalities associated with coal range between AU$42 and AU$52 per MWh while the cost of externalities associated with wind power amount to only $1.5 per MWh (ATSE, 2009). Taking into account these externalities, the cost of wind power is actually much closer to the cost of coal-fired power than market prices indicate and might in some cases be less expensive. As the RET commences in 2010, wind power prospects are positive because wind power has the advantage of being close to commercially competitive and capable of immediate adoption (Kann, 2009).

Of other promising alternative energy technologies, engineered geothermal, solar PV and solar thermal technologies hold promise given Australia’s abundance of these resources; however, these technologies are not yet commercially viable for wide-scale application (Hindmarsh & Matthews, 2008). Geothermal hot rock technology possesses massive appeal in terms of scale potential. Geoscience Australia contends that tapping just one percent of the energy from hot rocks located within five kilometres of the earth's surface would be enough to supply 26,000 times Australia's annual power consumption on a perpetual basis for 2.6 million years (Clean Energy Council, 2009). However, it is still at an early developmental stage with only one

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[11] Source: The Energy Information Administration, Accessed on January 3, 2010 at http://www.eia.doe.gov/cneaf/coal/page/coalnews/coalmar.html

operational site as of 2009 (Government of Australia, 2009c). Overall, geothermal is not anticipated to contribute to Australia's electricity supply until at least 2015 and even then only at a marginal level due to cost (Government of Australia, 2009f). Solar PV technology is still 3-4 times the cost of gas-fired electricity (Gurney et al., 2007). Consequently, recent projections optimistically estimate solar PV reaching a maximum capacity of only 30MW by 2020 (CME, 2009). Utility-scale solar thermal technology is also at a developmental stage, albeit closer to commercialisation with a 10 MW demonstration plant planned in Queensland for 2010 (Government of Australia, 2009c). As a stand-alone technology, large-scale solar thermal remains an expensive proposition thereby limiting commercial diffusion to subsidised programs such as the Solar Flagships program which earmarks AU$1.6 billion over 6-years to support construction and demonstration of large-scale solar power stations, with an ultimate target of 1000 MW (Government of Australia, 2009a).

Other prominent alternative energy technologies face non-commercial barriers that are equally as formidable. Waste to energy biomass is currently cost effective but growth is limited by the capacity of Australia's sparse population to generate and more effectively manage waste. Although on the surface, agricultural biomass and combustible materials (i.e. wood and wood by-products) appear promising thanks to surplus land to support such initiatives, wide-scale adoption of these technologies is impeded by environmental factors which include extreme water shortages, environmental impacts associated with wide-scale harvesting of energy crops, seasonal harvests which produce a feast-famine supply profile and competing agricultural interests (Gerardi, Nsair, Falcon, & Ott, 2007; IEA, 2005; MacGill, Outhred, & Nolles, 2006). Growth potential for hydropower is limited by a dwindling number of exploitable water sources and severe regulation of water utilization (Government of Australia, 2009f; Hindmarsh & Matthews, 2008).

Meanwhile, research into carbon capture and sequestration (CCS) technology to render fossil fuel technologies as alternative “clean” energy sources is still at the developmental stage (Gurney, et al., 2007). As of April 2009, no functional CCS and power plant integration exists at an industrial scale anywhere in the world (Government of Australia, 2009h). Furthermore, it was estimated as recently as 2007 that utility-scale implementation of CCS technology would increase generation costs by 38-44% for new natural gas combined cycle plants and 44-65% for new pulverised coal plants, thereby rendering both technologies competitively uneconomical (Gurney, et al., 2007).

Finally, despite indications of increasing pressure to revisit existing nuclear policy, Australia is a nation in staunch opposition to the development of nuclear power. Any policy changes in support of nuclear power will likely face vociferous opposition. Moreover, there is evidence that the cost of nuclear power in Australia would exceed the cost of wind power and even if the cost disparity were negligible, further evidence indicates that CO_2 associated with the entire nuclear fuel cycle is comparative in volume to emissions from gas-fired power stations (Saddler, Diesendorf, & Denniss, 2007; Sovacool, 2008b).

In summary, although all of the alternative energy technologies listed can and likely will have a role to play in Australia’s transition away from carbon-intensive electricity generation, wind power developers in Australia face an unprecedented opportunity to snap up the majority of business generated by the January 1, 2010 commencement of the RET, provided the RET is structured in a way to support progressive wind power development.

In order to effectively support progressive development of wind power, two elements must be integrated into a policy instrument. The first element is that support policies must be designed to simultaneously encourage utilities to make the investments necessary to operationally support enhanced levels of wind power. For example, in Japan, despite the existence of government subsidies to encourage wind power development, utilities purportedly place undue storage demands on wind power developers due to concerns that the existing grid will be destabilized due to the fluctuating nature of wind power (Englander, 2008). Although wind developers are keen to take advantage of government inducements to sell wind power into the existing system, Japanese utilities are not making the investments necessary to support a progressive presence of wind power (Valentine, 2009). The second element is that any support policies must encourage wind power developers to commit the investment necessary to render wind power commercially competitive when the support policy is removed. For example, in Taiwan, the feed-in subsidies provided to wind power developers are viewed as insufficient for encouraging in-land wind farm development; and as a result, a situation is emerging wherein wind power developers are exploiting only the most financially attractive sites in Taiwan before moving on to other countries. Once all the financially attractive sites have been exploited, it is highly likely that wind power development in Taiwan will stall (Valentine, 2010b).

This chapter first aims to evaluate Australia's new RET on the basis of these two elements in order to evaluate the efficacy of this new program to support progressive wind power development. The analysis highlights a number of flaws in the RET which may significantly undermine progressive development of wind power; therefore, this chapter also seeks to put forth recommendations on how to improve the RET.

The layout of this chapter is as follows. Section 8.2 presents a profile of the Australian electricity industry and discusses recent developments and trends in regard to wind power development. Section 8.3 evaluates the new RET in the context of supporting progressive wind power development. Section 8.4 provides some concluding thoughts on how to improve effectiveness of the RET.

8.2 WIND POWER & AUSTRALIA’S ELECTRICITY INDUSTRY

With the exception of the Northern Territory and Western Australia, Australia boasts an integrated national energy market (NEM) which was established in 1998 to enhance electricity grid security and provide a more competitive market for the supply of electricity (NEMMCO, 2005). The NEM which serves about 90% of Australia’s population (MacGill, et al., 2006) is a "compulsory gross pool market" in which bids to sell electricity are collected en masse and electricity dispatches are sequenced according to the price (Owen, 2009). Australia is the only major economy to have introduced and maintained this type of mandatory wholesale electricity trading market (Chester, 2007).

Australia is blessed with massive stores of coal, laying claim to 24.1% of the world's economic demonstrated reserves of brown coal and 5.4% of the world’s economic demonstrated reserves of black coal (ABARE, 2009). Consequently, it should come as no surprise that coal plays a dominant role in the Australian electricity generation industry. Table 8.1 provides an overview of fuel inputs into electricity generation from 2003 to 2007. In 2006-07, brown and black coal accounted for 83.8% of Australia's electricity generation.

Table 8.1: Australia's Fuel Inputs into Electricity Generation

(in Petajoules- PJ)	2003-04	%	2004-05	%	2005-06	%	2006-07	%
Thermal								
Black coal	1296	56%	1297	55%	1357	56%	1379	56%
Brown coal	674	29%	683	29%	701	29%	671	27%
Oil	22	1%	25	1%	26	1%	25	1%
Gas	264	11%	267	11%	263	11%	284	12%
Total thermal	2256	97%	2272	97%	2347	97%	2359	96%
Renewables								
Hydro	58	2%	56	2%	58	2%	52	2%
Wind	0	0%	3	0%	6	0%	23	1%
Biomass	5	0%	5	0%	5	0%	5	0%
Biogas	8	0%	7	0%	7	0%	7	0%
Total renewables	71	3%	71	3%	76	3%	87	4%
TOTAL ELECTRICITY	**2327**	**100%**	**2343**	**100%**	**2423**	**100%**	**2446**	**100%**

Source: ABARE, 2009

One energy technology that is conspicuously absent from Australia's electricity generation mix is nuclear power. Although national uranium reserves account for 40% of total economically accessible uranium stocks (Wesley, 2007), Australia does not produce any electricity through nuclear power. Although there is considerable public opposition to the prospects of nuclear power (Falk, Green, & Mudd, 2006), there has been renewed political discussion over nuclear power development as a possible solution to CO_2 emission abatement (Schlapfer, 2009).

Table 8.1 also highlights how important it is for the Australian government to facilitate a transition away from coal. Per capita emissions of CO_2 from fuel combustion in Australia are amongst the highest in the world and 43% above the average for International Energy Agency countries (IEA, 2005). Of the 576 Mt (CO_2 equivalent) of GHG that Australia emitted in 2006, 47% was from electricity generation (Government of Australia, 2008a) and the vast majority of that was from coal combustion (IEA, 2005). Moreover, under “business as usual” practices, Australia’s greenhouse gas emissions from electricity generation are expected to increase 37% between 2004 and 2050 (Gurney, et al., 2007). Clearly if the new Labor government is to achieve marked progress in reducing domestic CO_2 emissions, a radical realignment of Australia's electricity industry will be required. The trouble is that the low price of coal in Australia along with the apparent security that huge stores of this resource provide portends a rocky road for a transition to renewable energy.

Wind energy, as the most commercially viable utility-scale renewable technology, is expected to be the largest contributor to Australia's new RET targets (Government of Australia, 2009f). As Table 8.1 confirms, wind power is rapidly expanding in Australia thanks in large part to former national and state-level initiatives to encourage enhanced uptake of renewable energy by Australia's utilities. According to the World Wind Energy Association, Australia possessed 1494 MW of installed wind power capacity at the end of 2008, which represents the 14th highest level of installed capacity in the world. In 2008, Australia's installed wind power capacity grew by 83% which was the third-highest growth rate in the world (WWEA, 2009). A study commissioned by the Australian government in 2005 projected an increase in installed wind power capacity in Australia of at least 7360 MW by 2029/30 (Akmal & Riwoe, 2005). This would represent a five-fold increase over current levels. However, statistics pointing to the success of wind power development in Australia can be misleading because when Australia's total installed wind power capacity is compared to the wind power potential which exists in the country, it becomes evident that a significant opportunity to abate the national dependency on coal is being missed.

With the exception of Australia's northern coast, coastal areas throughout Australia boast average annual wind speeds in excess of 8 m/s (at 10 metres) and are considered to be excellent locations for wind turbine placement (Coppin, Ayotte, & Steggel, 2003). Furthermore, there are huge tracts of land in the southern portion of Western Australia and throughout the states of Southern Australia and Victoria with average annual wind speeds in excess of 7 m/s (at 10 metres) which would constitute “good” wind conditions for wind turbine sites (Coppin, et al., 2003). Mark Diesendorf estimates that long-term wind power potential in Australia may be as high as 20,000 MW (Diesendorf, 2003, , 2007). Assuming a capacity factor of 35%, harnessing this potential would generate 60,000 GWh of electricity annually, which represents about 28% of Australia’s projected supply of electricity in 2020.

Although the theoretical potential of wind power in Australia is sufficient to provide all of Australia's current electricity requirements, there are technical constraints that dampen the prospects of a virtually carbon-free electricity system. The stochastic nature of wind power makes it necessary at higher levels of electricity grid integration for wind power to be integrated with storage or back-up reserve in order to avoid destabilizing electricity grid operational security (Ackerman, 2005). As Saddler and colleagues (2007, p. 1254) point out, “currently, the limitation is not the wind resource, but rather the transmission infrastructure, which has evolved for large centralised power stations”. Nevertheless, the Australia Institute, drawing from international experience with wind power integration into electricity grids, has estimated that spare capacity in Australia's existing electricity grid can accommodate up to 20% wind power before the stochastic nature of wind power begins to pose a technical threat to grid security (Macintosh & Downie, 2006).

It might be tempting for critics to argue that the Australia Institute's estimate may be overly optimistic given the dominant role that coal plays in the national energy mix and the relatively low levels of installed capacity in hydropower and gas-fired power plants which are essential technologies for responding effectively to the type of load fluctuations associated with wind power. However, there is also a counter-argument to such criticism that the addition of electricity storage technologies or enhanced reserve peak-load generation capacity could enable the integration of wind power levels that extend well-beyond the 20% benchmark (Diesendorf, 2007). As a testament to the technological feasibility of incorporating high levels of wind power with enhanced back-up support, electricity grids in two towns in Western Australia (Denham and Hopetoun) incorporate as much as 70% electricity from wind energy (supported by diesel generation), with an average wind power contribution of approximately 40%.

Enhancing reserve capacity comes at a cost. One study estimates that the additional cost of backup generation (i.e. gas fired power plants) necessary to allow wind power to reach high contribution levels (i.e. 40%) in Australia would increase the cost of wind generated power by approximately 25% on top of existing wind power generation costs (Diesendorf, 2003), constituting a premium of only 1-2¢ per kilowatt hour. Aside from these technical costs of supporting high levels of installed wind power capacity, there are grid connection costs that need to be considered in order for

Australia's wind power potential to be better exploited. In many cases, grid connections would need to be extended into remote areas where the absence of competing land uses enhances the commercial viability of wind farms. One estimate of the cost of new transmission and distribution infrastructure is at least AU$50 per meter for laying the cabling and AU$35 per meter for any necessary access roads (Wizelius, 2007). This can amount to a 10% or higher premium on wind power project costs (Wizelius, 2007).

Although in aggregate the economic costs associated with additional reserve capacity and grid connection significantly increase wind power generation costs at high levels of installed capacity, there are also economic savings associated with CO_2 reductions that offset these additional costs. The external costs referred to earlier (AU$42 to AU$52 per MWh (ATSE, 2009)) represent real costs that the government is currently paying for, albeit in an unreconciled manner.

Irrespective of the barriers to full exploitation of Australia's technical wind power potential, evidence presented to this point in the chapter suggests that achieving a target of 20% or greater contribution from wind power is both technically feasible and less economically damaging than critics contend. A study by the Australia Institute estimates that adding approximately 5% of wind power to the existing grid by 2010 would only cost consumers AU$15-$25 per year extra (Macintosh & Downie, 2006). The study further points out that if the costs of pollution associated with fossil fuel power generation were fully internalized, the additional costs (including generation cost disparity) to the homeowner would be fully offset (Macintosh & Downie, 2006).

These conclusions are supported by the ATSE study into the externalities associated with coal, referred to earlier (ATSE, 2009).

In terms of assessing the impact that a 20% or greater electricity supply contribution from wind power would make to CO_2 abatement in Australia, the New South Wales government estimates that each MWh of power produced by wind farms can displace 0.929 tons of CO_2 which would otherwise be generated through coal-fired generators (Macintosh & Downie, 2006). Employing this metric, if wind were to supply the 45,000 GWh of electricity which is projected to account for 20% of the electricity supply in 2020, wind power would displace approximately 42 million tonnes of CO_2, which represents a 16% percent reduction of 2006 national CO_2 emissions attributed to electricity generation.

In symbiotic fashion, three notable developments have appeared in the policy sphere to indicate that a path is being created for encouraging greater uptake of wind power in Australia. First, over the past decade, Australia's state-owned electricity grids have been integrated to form a national grid (the NEM). Now, all regions except for the state of Western Australia and the Northern Territory have interconnected electricity grids (Owen, 2009). For wind energy, grid inter-connectivity delivers a number of notable benefits. For example, an interconnected electricity grid allows states to integrate higher levels of wind power without the risk of stochastic flows destabilizing the grid (Ackerman, 2005). It also allows wind farms to be geographically dispersed which further dampens the adverse effect of wind intermittency (Coppin, et al., 2003). Second, the market liberalization initiatives that accompanied grid inter-connection have significantly improved the prospects for wind energy developers to sell energy into the grid (Owen, 2009). Third, the RET artificially enhances market prospects by mandating enhanced purchases of electricity generated from renewable technologies. Given that a bill for a new CO_2 emission trading scheme – the CPRS (Carbon Pollution Reduction Scheme) – which the government sought to implement in conjunction with the RET was defeated in Parliament, the RET is currently the centerpiece of the government strategy to facilitate a transition to renewable energy. Accordingly, assessing the pros and cons of this legislation warrants further attention.

8.3 EVALUATING THE RENEWABLE ENERGY TARGET

The Renewable Energy Target (RET) announced in August 2009 builds on the Mandatory Renewable Energy Target (MRET) program of 2001 which aimed to encourage 9,500 GWh of electricity generation from renewable energy sources by 2010 (Government of Australia, 2009e). This MRET target was pre-maturely achieved in 2006 (Kann, 2009). As mentioned earlier, the new RET aims to encourage 45,000 GWh of electricity generation from renewable sources by 2020 and consolidates all existing state and territory renewable energy schemes into a single national scheme which significantly simplifies the planning process for renewable energy developers (COAG, 2009). Moreover, the 2009 amendment increases the penalty levied on electricity retailers who fail to reach their 20% quota of renewable electricity sales from AU$40 to AU$65 per MWh (Government of Australia, 2009g). This penalty is not tax deductible (Gerardi, et al., 2007); therefore, the punitive value of this penalty to the firm is approximately AU$90 per MWh (Government of Australia, 2009d), which serves as a robust incentive for electricity providers to meet their quotas. On the surface, the RET appears to be a bold initiative that places Australia's climate change response efforts on equal footing as that of the EU, both aiming to ensure that 20% of electricity generated will be delivered via renewable energy technologies by 2020 (Hindmarsh & Matthews, 2008). However, there are five specific features of the RET that indicate it may under-deliver both in terms of meeting its intended goal of facilitating 45,000 GWh of renewable energy generation and encouraging enhanced commercial viability of wind power.

The first feature of concern is that the Electricity Act of 2000, upon which the RET is based, identifies hydro, wave, tidal, solar, geothermal, all forms of biomass and biofuels, landfill gas and "any other energy source prescribed by the regulations" as permissible sources of alternative energy (Government of Australia, 2000). The main reason why this is a problem for wind power developers relates to diminished opportunities for government support. The penultimate goal for wind power developers is to achieve wind power cost reductions of a magnitude that will render wind power to be an economically viable alternative when compared to coal-fired power. Although meeting this challenge will partly depend on R&D investments made by wind power systems manufacturers and operational improvements made by project developers, some of the requisite improvements involve innovations that can be considered to be public goods and should be supported by government funding. One prominent example is storage technology which, if improved, could eliminate concerns associated with stochastic wind power flows. Unfortunately, the formal process of listing so many permitted renewable energy technologies portends government intent to financially support all these technologies to a certain extent and with relatively fixed budgets this consequently implies diffused, less effective support programs. As a testament to the verity of this assertion, consider the AU$465 million in funding announced in 2009 under “Renewables Australia” as part of the government's Clean Energy Initiative. The stated focus of the program is on supporting emergent large-scale technologies, geothermal drilling and second generation biofuels R&D (Government of Australia, 2009a). Electricity storage research will likely receive very little support under this program. Meanwhile, carbon capture and sequestration research received commitments for AU$2 billion in new funding beginning in 2009 (Government of Australia, 2009a). When one considers that coal-fired power is the main technology that wind power needs to displace to enhance market presence and the funding disparity is approximately AU$2 billion between these two technologies, it is pretty clear which technology stands the best chance to post the greatest gains in technological innovation. If the RET prioritised two or three main utility-scale technologies, it is likely that funding support for wind power would be significantly higher than it is under the current RET scheme.

A second feature of concern relates to the treatment of waste coal mine gas. When the government was designing the RET program, it did so under the assumption that the CPRS would also be passed and the RET would gradually be phased out. Under this assumption, the government agreed to a political concession to allow waste coal mine gas (WCMG) to be included in the RET as an "eligible energy source" to differentiate it from the "renewable energy sources". The concession allows WCMG-fired power plants to apply to obtain renewable energy credits (REC) for electricity generated using this fuel source. The government capped the number of RECs available to WCMG projects (at 425 gigawatt-hours (GWh) in 2011 and 850 GWh every year from 2012-2020) and increased the aggregate RET by these amounts to avoid eroding the market for RECs attached to renewable energy projects (Government of Australia, 2009b). Unfortunately, there is a flaw with this treatment of WCMG in the absence of a CPRS. WCMG is a by-product of the coal mining process. Accordingly, any wholesale price of captured WCMG that is above the marginal cost of capture represents additional profits to coal mining firms. In short, the policy as it now stands is a form of subsidy to coal mining firms which if passed on through the coal value chain represents an added incentive to enhance coal-fired power generation over another fuel source. It also incentivizes the commercialization of a technology that is far from a clean energy source because methane combusted for electricity generation produces CO_2 emissions. This subsidy to WCMG power facilities along with a proposed AU$270 million "Coal Sector Adjustment Fund" which the government proposes establishing within the Climate Change Action Fund to provide funding for coal sector abatement projects and capital grants (Government of Australia, 2009a), represents a level of financial assistant to a dirty energy source that should be taxed not subsidised.

A third feature of concern related to the RET involves the duration of the program. As it stands now, the program is designed to expire in 2030 with annual targets fixed in the manner outlined in Table 8.2 (Government of Australia, 2009g).

Table 8.2: Annual Generation Targets under Australia's Renewable Energy Target

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021-2030
Annual Target (gigawatts hours)	12,500	14,400	16,300	18,200	20,100	22,000	26,600	31,200	35,800	40,400	45,000	45,000

Source: Council of Australian Governments, 2009

The renewable energy targets increase steadily over the first decade to reflect a cumulative increase in installed capacity. To illustrate, the annual target of 14,400 GWh in 2011 conceptually consists of 12,500 GWh of pre-existing renewable energy generation and 1900 GWh of new generation to be added in 2011. Accommodation is made for adding annual generation up to 2020 when the annual target of 45,000 GWh of total generation is slated to be met. No additional generation has been targeted beyond 2020 because the CPRS was expected to be enacted at the same time as the RET and it was felt that emissions trading under the CPRS would become robust enough to level the technological playing field and render the RET moot (COAG, 2008; Government of Australia, 2008b). Unfortunately the CPRS Bill was defeated in Parliament and this has significantly weakened the efficacy of the RET as originally planned. As it now stands, in the final 10 years of the RET program, there will be diminished incentive for electricity retailers to add additional renewable energy capacity beyond that which was established in the first ten-year period. Barring any post-2020 amendments to this target or the implementation of CO_2 emission reduction policies, one can expect a significant drop-off in renewable energy growth once the target of 45,000 GWh of total generation is reached (cf. IEA, 2005). An additional complication arising from the manner in which the targets have been laid out over the 20-year period is that there will likely be heavy competition amongst renewable energy developers in the first five years of the scheme because establishing renewable technology capacity in the early years of the program guarantees renewable energy developers a 15 to 20 year revenue flow. Such revenue certainty is irresistible to renewable energy developers who typically extend debt financing and amortize investments over 15-year periods (Gerardi, et al., 2007; Wizelius, 2007). Conversely, renewable energy developers bidding for the 4600 GWh of new electricity supply between 2019-2020 will only have 10 years of guaranteed revenue before the program expires. Consequently, assuming there is no emergent policy to regulate CO_2 emissions, one can anticipate reduced competition for renewable energy sales in the latter part of the program and; therefore, comparatively higher renewable sales prices.

In short, the current structure of the RET works counter to the goal of encouraging an acceleration of renewable energy demand to support the economies of scale to facilitate further reductions in renewable energy prices. It supports the process half way and then allows the market to drop out.

A fourth feature of concern relates to a multiplier scheme established to support small electricity generators. Essentially under this mechanism, renewable electricity credits produced by small-scale (rated output under 1500 KW) solar PV, solar thermal (water), wind and hydro electricity systems will be multiplied by a pre-established "multiplier" for electricity output as outlined in Table 8.3 (Government of Australia, 2009g). Under this system, 10 MWh of electricity generated by an approved small-scale technology will receive REC credit for 50 MWh of generation, thereby reducing the RET pool by that inflated amount. In short, the program creates “phantom credits” that exaggerate the real amount of renewable electricity generated. Moreover, although this will catalyze robust sales in early years for solar thermal heaters and household-scale electricity generators, the added competition from small generators might be significant enough to impair the development of utility-scale renewable electricity projects during the 2010-2015 period, which is specifically when wind power and other larger utility-scale developments need to be initialized in order to provide 10 to 15-years of revenue to allow developers to profitably amortize investments.

Table 8.3: Australia’s Multiplier System for Small Generation Units

	2010	2011	2012	2013	2014	2015	2016 Onwards
Multiplier	5	5	5	4	3	2	No multiplier

Source: Council of Australian Governments, 2009

Finally, as a fifth feature of concern, the strategic decision to design a capped target system for renewable energy as opposed to offering renewable energy developers a feed-in subsidy or production tax credit for unlimited amounts of electricity generated is a questionable strategy if the goal is to nurture the emergence of a commercially-viable domestic renewable energy industry. For wind power developers to be successful in any given market over a sustained period, two things must exist. First, the wind power developers must be able to make a profit in order to support the type of investment (i.e. capital investment, R&D initiatives, capacity expansion etc.) that is essential for reducing future costs and enhancing the long-term commercial viability of wind power. Second, revenue flows need to be cumulative, the current year's revenues building on past years. This provides wind power developers with increasing economies of scale which further help reduce costs and further enhance the long-term commercial viability of wind power. Under a capped target system, especially one with relatively mild targets at the front end such as that exhibited by the RET, neither of these two criteria are likely to be met. First, wind power developers will see profits squeezed by heated competition in the early years (with small-scale solar thermal water heaters complicating the competitive mix); and therefore, wind developers will have diminished capacity to finance capital expenditures and other investments to stimulate cost reduction. Second, the capped target system disrupts revenue flow predictability and undermines strategic planning. Under the RET, unless there is a drastic change in market economies or additional policies to support a transition to renewable energy, it is likely that market demand for new renewable energy capacity will diminish in 2020. This means that established wind power firms that have gained momentum over 10 years of progressive revenue increases will suddenly find themselves mired in a contracting market with the bulk of revenue being provided by an asset base is gradually aging toward obsolescence.

8.4 IMPROVING THE RENEWABLE ENERGY TARGET

Methods for improving the RET will differ depending on whether or not the CPRS is eventually enacted.

If the CPRS which the Australian government proposed at the same time as the RET is eventually passed, the five weaknesses of the current RET which were outlined earlier would be offset by the benefits that a robust cap and trade regime could provide. First, the financial benefits to the coal industry that the waste coal mine gas (WCMG) subsidy provides would be significantly minimised if the WCMG project developers had to purchase CO_2 emission permits and still generate WCMG-fired power at competitive rates. Second, the CPRS would level the competitive playing field between coal-fired power and wind power and enhance long-term revenue prospects for wind power that extend beyond the duration of the RET. Third, the small generator multiplier intended to give a boost to small-scale technologies would be less of a threat to wind power market development because the business lost to small-scale generators in early years would be compensated for through business taken away from carbon-intensive power plants in ensuing years as the electricity industry evolves in response to the positive market signals that a CPRS would convey. Finally, the cap of 45,000 GWh would no longer be an issue of concern regarding progressive wind power market growth because the once the CPRS begins to reflect international values for CO_2 emissions credits, wind power would become cost competitive and render the

RET cap moot. In summary, under a scenario which includes enactment of the CPRS, the RET as it now stands is sufficient for supporting wind power development.

Obviously, this presupposes that the CPRS would set annual emission ceilings at a level that would significantly alter the comparative costs of electricity sources. A weak cap and trade system would do little to level the competitive playing field in the manner necessary to provide wind developers with long-term market growth prospects. Indications are that the proposed CPRS is designed to be an aggressive program under which annual permits would be restricted over time to achieve the national 60% GHG reduction target (based on 2000 levels) by 2050 (Government of Australia, 2008b). A robust program of this type would substantially increase the overall cost of fossil fuel-based electricity and significantly alter market dynamics.

In a “business as usual” scenario where the CPRS is not enacted, the RET is not currently sufficient to improve commercial viability of wind power. As such, all five of the weaknesses identified earlier need to be amended.

First, if the goal is to wean the nation off a dependence on coal-fired electricity, the WCMG should not be eligible for RECs. Any part of the coal value chain that is subsidised in this way strengthens the economic case for continued reliance on coal-fired power and makes it harder for utility-scale alternative electricity sources (such as wind power) to compete on a level basis. Already, alternative energy technologies face an uphill battle when competing against coal-fired electricity providers due to disproportional government support. For example, the coal sector benefits from two programs - COAL21 which is a 10-year, AU$1 billion public-private partnership program to finance research into reducing emissions from coal (Government of Australia, 2009d) and the CCS Flagship program which is a 9-year AU$2.4 billion program to support carbons capture and sequestration research (Government of Australia, 2009a) – while the main renewable energy support program under the Clean Energy Initiative provides just AU$465 million to be shared across numerous renewable energy technology platforms. If the release of methane from coal mines is a concern, flaring or capture for energy use should be regulated, not subsidized.

Second, the government should consider formally extending the RET program to facilitate a measured expansion of installed renewable energy capacity from 2020 onward in order to encourage the scale of transformation necessary to meet the government's 2050 target of 60% GHG reduction (based on 2000 levels). Table 8.4 provides a quantified recommendation in this context. If the targets outlined in Table 8.4 were adopted, renewable power developers would have a high degree of financial certainly past the 2020 period and would be incentivized to make the investments necessary to aim for an entrenched market position beyond 2040. Although it can be argued that such long-term security can inadvertently encourage commercial apathy (Komor, 2004), Australia's unique system of pooled bids for electricity ensures that even amongst renewable energy providers, a high degree of cost competition will ensue as firms vie for long-term market share leadership. The final target of 120,000 GWh recommended in Table 8.4 would represent approximately 50% of Australia's electricity supply and as such the dynamics of load balancing would very likely catalyze coordinated initiatives to expand wind power (the most commercially viable renewable technology) and geothermal power (the renewable technology that holds the most potential for providing peak load supply). Not only would the extension of the RET encourage the development of two technologies that are key to a carbon-free electricity sector, the achievement of the targets outlined in table 8.4 would place Australia firmly on track to achieving the 60% reduction on GHG emissions levels (based on 2000 emission levels) by 2050 (Government of Australia, 2008b) and position Australia to achieve the type of aggregate deep emission reductions (in the range of 80% from 1990 levels) that each nation will have to make to offset the worst impacts associated with global warming (IPCC, 2007a; Stern, 2006). Obviously, setting such bold wind power targets would benefit from advances in storage technology. Therefore, the government should consider ramping up funding support for storage technology research. This is arguably more sustainable use of the AU$2 billion in government funding that has been earmarked for carbon capture and sequestration research (Government of Australia, 2009a)

Table 8.4: Proposed Extended Renewable Energy Capacity Targets Post-2020

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Annual Target (GW hours)	12,500	14,400	16,300	18,200	20,100	22,000	26,600	31,200	35,800	40,400	45,000
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031 - 2040
Extended Target (GW hours)	50,000	55,500	61,500	68,000	75,000	82,500	90,500	99,000	108,000	120,000	120,000

An additional benefit of extending renewable energy generation targets beyond the 2020 period is that the new targets would mitigate the threat posed by the multiplier system for small-scale generators and negate the fourth concern associated with the current RET that a capped target system does not encourage long-term market investment. Although, under the proposed target extensions in Table 8.4 a cap is still in place, the cap comes into play far enough into the future to provide the long-term revenue guarantees (15 years +) necessary to entice wind power developments (after the incentivization of solar water heaters runs its course) and provides more time to allow research in renewable energy technology to yield the cost-saving innovations needed to compete without market support.

In summary, the best approach for the government is to push for the enactment of the CPRS regime because this approach gives market mechanisms a chance to facilitate optimal market outcomes. However, in lieu of a CPRS, eliminating WCMG from the RET list of eligible energy sources and extending the RET targets to a 2040 target of 120,000 GWh will enable wind power developers and other renewable energy developers to achieve the scale of activity necessary to support the type of radical transition that the nation acknowledges is necessary in the face of the threats posed by global warming (Government of Australia, 2009h)

At the end of the day, it comes down to the political will and capacity of the new Labor government to fight the battles necessary to infuse the RET with the transformational impact it was intended to exhibit. In the absence of such political will, like so many other national governments in states where wind power is underperforming, it ends up being the governing party in Australia that is responsible for “braking wind” in Australia.

CHAPTER 9

WIND POWER DEVELOPMENT IN CANADA

Abstract

This chapter investigates the impact that a federal government structure has on strategic selection of renewable energy policy instruments. The context for this study centres on wind power development in Canada. Canada is a nation that is blessed by all the attributes necessary to catalyze global leadership in installed wind power capacity. Unfortunately, the constitutional separation of powers that underpins Canada's federal system impedes the creation of a national wind power development strategy because Canada's provinces have constitutional authority over electricity governance. The insights gleaned from the case study are used to develop a conceptual framework for understanding the impact that federal structure has on policy instrument selection and efficacy under areas of federal, regional and concurrent policy jurisdiction. Finally, this framework is re-applied to identify specific approaches the Canadian federal government could take to resolve what currently amounts to be a fragmented, ineffective approach to wind power development planning.

9.1 INTRODUCTION

Should policymakers facilitate renewable energy capacity development through distributive policies (i.e. subsidies), regulatory policies (i.e. CO_2 emission caps), redistributive policies (i.e. carbon taxes) or constituent policies (i.e. green energy campaigns) (Lowi, 1972)? A preponderance of research has gone into addressing this question from various conceptual perspectives which include popular themes such as comparing the efficacy of various policy instruments (cf. Blakeway & White, 2005; EWEA, 2005; Lipp, 2007; Menza & Vachona, 2006), championing the efficacy of one specific instrument (cf. Mathews, 2008; Sorrell & Sijm, 2003), assessing the impact that socio-economic dynamics have on the selection or design of policy instruments (cf. Huang & Wu, 2009; Maruyama, et al., 2007), investigating policy instrument selection in stakeholder networks (cf. Mander, 2008; Rowlands, 2007), investigating hurdles to effective policy instruments implementation (cf. Alvarez-Farizo & Hanley, 2002), and examining challenges associated with evaluating policy instrument efficacy (cf. Mallon, 2006; Vine, 2008).

Despite the proliferation of studies on policy instruments in the renewable energy policy field, there are no prominent examples of studies which investigate the impact that the federal form of government has on strategic selection of policy instruments. Federal government systems are characterized by power-sharing between the central authority and the regions comprising the federation. For federal policymakers, the manner in which power is divided can pose significant policymaking problems (Thorlakson, 2003). Specifically, federal attempts to apply coercive policy instruments in policy areas of regional or concurrent (shared) authority can generate political, legal or operational resistance by regional authorities. Even when developing policy for areas under federal jurisdiction, regional authorities have to their avail various “thrust and riposte” tactics to undermine the efficacy of disagreeable federal policies (Braun, Bullinger, & Walti, 2002). Given that there are 24 nations with a federal government structure (including the major economies of the United States, Germany, Canada, Australia, Russia, India, Spain, Brazil and Mexico), a formal enquiry into the impact that federal structure has on renewable energy policy instrument development is merited.

This case study seeks to contribute to such enquiry by investigating the hurdles that one federal nation – Canada – faces in trying to propel wind power development through federal policies and provincial cooperation. The study will demonstrate why the application of policy instruments that are popularly used for facilitating renewable energy development such as carbon taxes, CO_2 emission regulations, CO_2 emission cap and trade systems, and renewable portfolio standards is tenuous under Canada's federal structure. The insights gleaned from the case study will then be used to develop a conceptual framework for understanding the impact that federal structure has on policy instrument selection and efficacy. Lastly, this framework will be re-applied to identify specific approaches the Canadian federal government could take to resolve what currently amounts to be a fragmented, ineffective approach to wind power development planning in order to demonstrate how such knowledge can be applied in a contextual setting.

The layout of this chapter is as follows. Section 9.2 presents Canada's electricity profile and enumerates the importance of wind power development in Canada. Section 9.3 provides data on installed wind power capacity in Canada and presents an argument that Canada is uniquely endowed with the assets necessary to achieve global leadership in wind power development, while Section 9.4 explains why such a goal would be desirable. Section 9.5 addresses some of the prominent but resolvable challenges to wind power development in Canada. Section 9.6 examines Canada's federal political structure and related obstacles in developing a national wind power development strategy. Section 9.7 draws the insights gleaned from Section 9.6 into a framework for conceptualizing the efficacy of different types of renewable energy policy instruments under the various jurisdictions of authority commonly found in a federal system (federal, regional and concurrent) and applies these insights to the search for a solution to facilitating a collaborative approach to optimize wind power development in Canada. Section 9.8 provides some concluding thoughts on the contribution this paper makes to better understanding the nexus between federal political structure and policy instrument design and implementation.

9.2 CANADA'S ELECTRICITY SECTOR

With the world's 14th largest economy (CIA, 2009) and severe winter conditions in much of the country, it should come as no surprise that overall electricity consumption in Canada consistently ranks amongst the highest in the world. On a per capita basis, Canada's highly affluent population (US$39,300 in per capita GNP (PPP) in 2008) of 33 million people consumed on average 1,910 watts of electricity per hour (W/h), ranking 4th highest in the world behind only Iceland (3,152 W/h), Norway (2,812 W/h) and Finland (1,918 W/h) (CIA, 2009).

Canada's electricity grid is the sixth largest in the world, supported by 124,240 MW of total installed generation capacity, incorporating six generation technologies (Statistics Canada, 2009a). As Table 9.1 indicates, Canada abounds in hydropower resources. In 2008, only China consumed more hydropower than Canada (BP, 2009).

Table 9.1: Electrical Generation Capacity by Source in Canada in 2007

	2007	% of total
Hydro	73,435,687	59%
Wind and tidal	1,600,399	1%
Steam (mainly coal)	27,211,548	22%
Nuclear	13,345,000	11%
Internal combustion	593,480	0%
Combustion turbine	8,054,193	6%
TOTALS	**124,242,314**	**100%**
(capacity in kilowatts)		

Data source: (Statistics Canada, 2009b)

Despite an abundance of hydropower, Canada's electricity carbon footprint is sizable due in large part to heavy reliance on fossil fuels for steam and combustion turbine electricity systems. Canada has a legal obligation under the Kyoto Protocol to reduce aggregate greenhouse gas (GHG) emissions to 6% below 1990 levels. Yet, between 1990 and 2006, Canada's GHG emissions increased by 54.8% and CO_2 emissions increased by 68.3% (including land use, land change and forestry) (UNFCCC, 2008). Since CO_2 emissions represent a little over 70% of Canada's GHG emissions (UNFCCC, 2008) and electricity generation represents the largest source of CO_2 emissions in Canada, reducing CO_2 emissions in the electricity sector is an imperative element of Canada's climate change mitigation strategy.

Ominously, as Table 9.2 portends, Canada's CO_2 emissions from electricity generation are not expected to improve much in the next 20-30 years. Although electricity generated from renewable sources (which includes hydropower) is expected to increase significantly, so is the amount of electricity generated by natural gas. Meanwhile, the amount of coal-fired electricity will remain virtually unchanged (EIA, 2008b). If these projections are accurate, CO_2 emissions associated with electricity generation will inevitably increase.

Table 9.2: Electricity Consumption Projections in Canada by Fuel, 2005-2030

(data in Quadrillion Btu)		Projections					
Fuel source	2005	2010	2015	2020	2025	2030	Avg. annual % change
Liquids	0.2	0.1	0.1	0.1	0.1	0.1	-2.8
Natural gas	0.6	0.6	0.7	0.7	0.7	0.8	1.5
Coal	1.2	1.2	1.2	1.2	1.2	1.2	0
Nuclear	1.0	1.2	1.3	1.4	1.4	1.5	1.7
Renewables	3.7	4.1	4.5	4.9	5.2	5.5	1.6
Total	6.6	7.3	7.8	8.2	8.7	9.1	1.3

Source: (EIA, 2008b).

As Table 9.2 indicates, expansion of renewable and nuclear energy capacities by approximately 50% is expected by 2030. Although the growth estimate for renewable energy represents the progression of a growth trend that will likely continue for decades, expansion prospects for nuclear power in Canada face diminishing potential due to public opposition. A public opinion survey conducted in 2006 found that 3 of 4 Canadians were opposed to nuclear power (Saint Consulting, 2007). Although Canada is a major supplier of uranium and Canada's CANDU nuclear reactor technology is marketed around the world, only three Canadian provinces – Ontario, New Brunswick and Québec (to a lesser extent) – have managed to sufficiently dispel public opposition to facilitate nuclear power plant development. Consequently, if Canada is to significantly reduce CO_2 emissions associated with electricity generation, it will need to do so primarily by: 1) improving both supply and demand side electricity efficiency, 2) facilitating the transition from "dirty" fossil fuels (i.e. coal) to "cleaner" fossil fuels (i.e. natural gas, carbon capture and sequestration etc.), and 3) fostering expansion of non-fossil fuel electricity generation capacity.

This study addresses the third policy challenge of fostering expansion of alternative energy capacity. Specifically, this chapter focuses on the challenge of enhancing wind power development in Canada due to the emergent commercial viability of wind power. Given the high cost of competing renewable energy technologies (such as solar PV, utility-scale solar thermal, and tidal energy), widespread opposition to nuclear power (Saint Consulting, 2007) and the increasing difficulty of establishing large-scale hydropower projects due to opposition based on environmental concerns (IEA, 2004b; Islam, Fartaj, & Ting, 2004), wind power exhibits the highest potential of all renewable energy sources to abate CO_2 emissions associated with electricity generation over the short to medium terms.

9.3 WIND POWER IN CANADA

As Table 9.3 illustrates, the last five years has been a banner period in Canada for wind power developers. Since 2004, installed wind power capacity has increased nearly sevenfold. As of the end of 2008, Canada occupies 11th position in the world in total installed wind power capacity (WWEA, 2009).

Table 9.3: Canada`s Installed Wind Power Capacity

Year	Capacity (MW)	Annual Growth
2000	137	
2001	198	45%
2002	236	19%
2003	322	36%
2004	444	38%
2005	684	54%
2006	1460	113%
2007	1770	21%
2008	2369	34%
2009	3022	28%

Data source: Canada Wind Energy Association (www.canwea.ca)

With only 10 other nations possessing higher installed wind power capacity than Canada, wind power development in Canada appears from a statistical perspective to be comparatively successful. However, comparing Canada's wind power potential to most other nations in the world is like comparing a Ferrari to a herd of horses in a street race. Canada is blessed by four unique attributes that position the nation to become the undisputed world leader in wind power capacity.

First, Canada's huge tracts of undeveloped land could easily accommodate tens of thousands of wind turbines. It has been estimated that harnessing the wind potential of 0.25% of Canada's landmass would generate enough electricity to meet Canada's total electrical demand (CanWEA, 2008b). As an illustration of its unbridled potential, Canada is 28 times larger than Germany, yet in 2008, Germany currently had 10 times more installed wind capacity than Canada which is a notable disparity in performance even after factoring in the higher population base in Germany (Pembina Institute, 2008).

Second, from east to west Canada stretches nearly 6,000 kms. This allows wind farms to be geographically dispersed to mitigate the threats posed by wind *intermittency* (Gil, Joos, DesLauriers, & Dignard-Bailey, 2006). *Intermittency* refers to the disruptive influence that sporadic lulls and gusts of wind have on the consistent generation of electricity (Ackerman, 2005). Geographic dispersal smoothes the aggregate power fluctuations from wind turbines because when wind is not blowing in one province, it is blowing in another (Wizelius, 2007).

Third, as outlined earlier, 59% of all electricity generated in Canada comes from hydropower. Hydropower is an ideal complement to wind power because it can expediently compensate for power fluctuations arising from the intermittency of wind (Boyle, et al., 2004; Gil, et al., 2006).

Fourth, Canada's only land-connected neighbor, the United States, is also the world's largest consumer of electricity, with demand for electricity expected to increase by 39% between 2005 and 2030 (IEA, 2008c). Canada is already the United States' foremost supplier of electricity. In 2007, exports of electricity to the United States via established cross-border transmission conduits amounted to 25,310 GW worth over C$3.2 billion (Statistics Canada, 2009a). Given that the US faces enormous costs just to upgrade existing transmission and distribution networks and replace aging generation facilities (Sovacool, 2008a), the likelihood that the US will seek increased imports of Canadian electricity in the future is high. For Canadian wind power generators, the US electricity market provides nearly exclusive access to an expanding market opportunity.

The combination of these four factors gives Canada an incomparable national competitive advantage in harnessing wind power. In fact, it is conceivable that if the Canadian authorities were to adopt an aggressive approach to developing wind power, as much as 40% of Canada's electricity needs could be provided by wind power. Denmark, which has considerably less hydropower capacity than Canada, has already proven that wind penetration levels of up to 40% of total system demand can be cost-effectively managed (Gil, et al., 2006) and is aiming for 50% wind power penetration by 2030 (Ackermann & Soder, 2002). The implication of targeting a 40% contribution from wind power is that in conjunction with Canada’s high capacity in hydropower (currently 59% of total generation capacity) and initiatives intended to improve electricity utilization efficiency, Canada could conceivably eliminate virtually all CO_2 emissions from the electricity generation process.

To meet a 40% target by 2040, approximately 130,000 MW of installed wind power capacity would be required[12]. This represents a many fold increase over the current installed capacity of 2,775 MW. Assuming that the rated capacity of the average installed wind turbine were 2 MW, meeting the 40% target would require the installation of approximately 65,000 turbines.

Although 65,000 turbines seems a vast amount, it is useful to recall that at the turn of the 20th century, it is purported that at least 600,000 were used for farm irrigation across North America (Ackermann & Soder, 2002; CanWEA, 2008a). Obviously a modern-day utility scale wind turbine is significantly more complicated and more aesthetically invasive than the windmills that were built in the 1900s. However, the amount of land required to accommodate a modern turbine is not significantly greater than that required for 20th-century windmills. The challenge would be daunting but it would not be unprecedented.

9.4 THE MERITS OF LEADERSHIP IN WIND POWER

For every reason why Canada could attain global leadership in wind power development, there is an equally salient incentive to do so. First, in response to the increasing certitude of missing its original Kyoto Protocol emission reduction target, the Canadian government has recently announced revised targets. It now aims to reduce greenhouse gas emissions to 20% below 2006 levels by 2020 (which equates to

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[12] This estimate is based on the following calculation: The Energy Information Administration in the US estimates that Canadian electricity demand will increase by 40% by 2040, given current trends (EIA, 2008b). Therefore, total electricity demand will be 617,469 GWh (2007 electricity production according to Statistics Canada) x 1.4 = 864,457 GWh. A 40% contribution from wind power amounts to 864,457 GWh x 0.4 = 345,782 GWh. To find the amount of installed wind power capacity required given a 30% capacity load factor the calculation is: (((Yearly Demand / Days in a Year) / Hours in a Day) / capacity load factor) = (((345,782 GWh / 365) / 24) / 0.3) = 131,576 MW of installed wind power capacity required.

24% above 1990 levels) and 60-70% below 2006 levels by 2050 (which equates to 39-54% below 1990 levels) (Government of Canada, 2009). Without significantly reducing CO_2 emissions associated with the electricity sector, achieving even these more lenient targets will be very unlikely, especially since trends indicate that the demand for electricity will increase by over 40% between now and 2040.

Second, employment and economic opportunities in the wind power sector eclipse similar opportunities attributed to the traditional power sector. Currently, a little over 75,000 people are employed by Canada's electricity utilities (Statistics Canada, 2009a). This represents 0.60 jobs per MW of installed capacity. Conversely, extrapolating from estimates based on global wind power industry employment statistics, if 20% of Canada's electricity were produced by wind power, at least 52,000 new jobs would be created (CanWEA, 2008b). This equates with 2.09 jobs per MW of installed capacity; over twice the rate of employment in the traditional power sector. In terms of economic opportunities, evidence from countries such as Germany, Denmark and Spain indicate that large-scale development of wind power catalyze business opportunities in the manufacture of turbines, turbine towers, rotor blades, castings, forgings, nacelle assemblies and nacelle covers. Furthermore many of these employment opportunities are in value-added production (CanWEA, 2008b).

Third, the North America power grid represents an underutilized market opportunity. The combination of blossoming demand in the US for clean energy, a dearth of alternative energy capacity in the US (Sovacool, 2008a), a favourable trade agreement (NAFTA) and a shared border that extends 6,416 km (CIA, 2009), positions Canada to establish a whole new service industry of generating and distributing "clean" energy to the US. Economic benefits alluded to in the previous paragraph could be significantly accentuated by exploiting this market opportunity.

Fourth, although Canada is rich in fossil fuel and uranium energy resources, these resources are finite and have the potential to contribute significantly to global warming. Canada’s proven oil reserves are estimated to be 179 billion barrels (including 173 billion barrels of oil sands), which places Canada second only to Saudi Arabia in terms of total oil reserves (Alberta Provincial Government, 2008). However, extraction and utilization of oil from tar sands emits levels of CO_2 which compare closer to coal than oil on a kWh basis. Liming and colleagues estimate (2008) that at current rates of production, oil reserves excluding tar sands will be depleted in 158 years. Natural gas reserves which amounted to 56.1 trillion cubic feet in 2005 will be depleted in less than a decade at current rates of production (Liming, et al., 2008). In coal, Canada has an estimated 7.3 billion short tons of recoverable reserves, enough to last 100 years at current production rates (Liming, et al., 2008). For the Canadian government to assert that it also has the interests of future generations of Canadians in mind, the current pace at which fossil fuel reserves are being drawn down needs to be attenuated. When an opportunity exists to produce similar quantities of energy through wind power, the current pace of fossil fuel resource utilization is both myopic and irresponsible.

Fifth, the extensive environmental and health costs associated with fossil fuel combustion can be largely mitigated by a wide-scale transition to carbon-free electricity generation. The Ontario Medical Association estimated that health problems in the late 1990s stemming from pollution attributed primarily to power generation annually cost Ontario C$1 billion and contribute to over 1900 deaths (Rowlands, 2007).

Sixth, significantly enhancing wind power capacity represents one way for Canada's government to mitigate a mounting nuclear waste storage dilemma. Given that nuclear power is one of the only utility-scale, carbon-reduced alternatives to wind power, there will be increasing pressure to build more nuclear power plants in order to abate CO_2 emissions. Unfortunately, this would be a mistake that shifts the burden of nuclear waste management to future generations of Canadians. Currently, in the absence of long-term storage facilities, over two million 24-kilogram bundles of highly-radioactive used fuel (enough to fit into 6 ice hockey rinks) generated since the 1950s by Canada's nuclear power plants are stored on an “interim basis” at six nuclear facilities (NWMO, 2008). Although Canada is a geographically sizable nation, the safe management and storage of nuclear waste poses tremendous technological and economic challenges (Winfield, Jamison, Wong, & Czajkowski, 2006).

In summary, not only does Canada exhibit tremendous potential for large-scale wind power development, there are significant international, political, economic and environmental reasons to exploit this potential. Given these observations, the salient question is: *What is impeding wind power development in Canada?*

9.5 WIND POWER DEVELOPMENT CHALLENGES IN CANADA

In Canada, as in most countries, cost is the critical element that stymies wind power expansion because external costs associated with fossil fuel generation are not internalized. In 2005, the average *cost* of electricity generated ranged between C$47 and C$70 per MWh (Canadian Electricity Association, 2006). Conversely, the Canadian Wind Energy Association (2006) estimated that the cost of generating wind power in 2006 ranged between C$70 and C$100 per MWh. Until wind power generation costs decline or externalities associated with fossil fuel combustion are internalized, government subsidies and support becomes essential for wind power expansion. Unfortunately, the most significant federal subsidy has been a production subsidy of C$10 per MWh (Guha, Soloumah, & Kar, 2005), which is too low to bridge the cost differential. By and large, due to this low federal subsidy, wind power expansion in Canada has been driven notably by provincial government mandated renewable energy purchase initiatives which are both temporally and provincially inconsistent (Guha, et al., 2005).

If legislative authority over electricity governance in Canada were centralized, a number of widely-heralded policy instruments could be applied to facilitate wind power development. For example, carbon taxes could be levied to bridge the cost differential between fossil fuel-generated power and wind power. Alternatively, utilities could be compelled to gradually increase the amount of electricity generated by renewable technologies through regulatory policy and/or cap and trade systems (cf. Komor, 2004). Provinces that have high levels of hydropower could be forced to inter-connect with other provinces that do not have an abundance of hydropower in order to provide inexpensive, clean electricity back-up to compensate for power intermittency issues associated with wind. Unfortunately, as the next section will explain, Canada's legislative authority over electricity governance is not centralized.

9.6 POLITICAL POWER AND ELECTRICITY GENERATION

9.6.1 Who Holds the Power?

Canada is a federation of 10 provinces and three territories. Historically, the need for a federal system of government in Canada stemmed from the challenge of unifying the culturally disparate regions of Anglophone-dominated Ontario and Francophone-dominated Québec. A federal system fit the challenge because it provides citizens of disparate regions with more autonomous representation while at the same time providing centralized government services which help to tie the regions together (Thorlakson, 2003). To this day, many political experts in Canada would agree with the contention that Canada's "separation of powers" has played a vital role in preventing national breakup (Wimmer, 2007).

Canada's Constitution, which consists of the Constitution Acts of 1867 and 1982, divides political power between the federal government and provincial legislatures. In total, provincial legislatures were granted exclusive authority over 16 areas (Baier, 2005) including natural resources and electricity generation, which is explicated in Table 9.4. As a result, Canada does not have a national electricity generation strategy (Liming, et al., 2008); rather, Canada's electricity generation strategy is an amalgamation of strategic decisions made at the provincial level.

Table 9.4: Section 92A(1) of the Constitution Act, 1867

In each province, the legislature may exclusively make laws in relation to

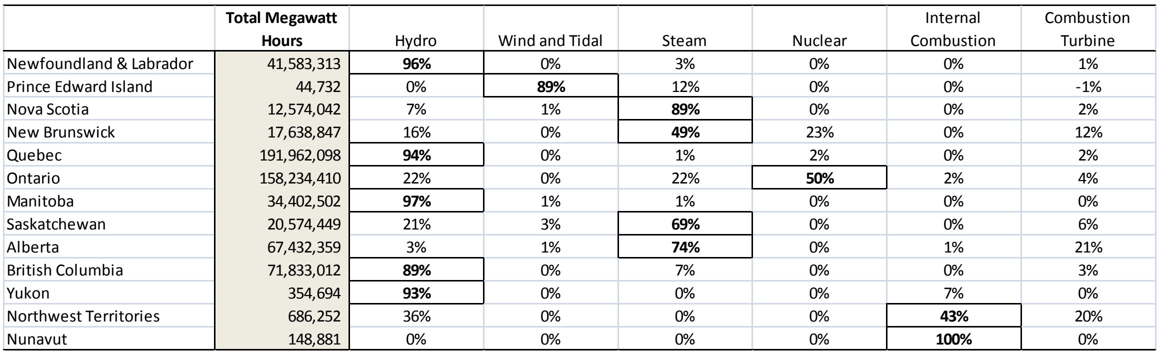
a) exploration for non-renewable natural resources in the province;
b) development, conservation and management of non-renewable natural resources and forestry resources in the province, including laws in relation to the rate of primary production therefrom; and
c) development, conservation and management of sites and facilities in the province for the generation and production of electrical energy.

Source: Canada Constitution Act 1867 / 1982

9.6.2 Impediments to Collaborative Wind Power Development Strategy

The aggregate national data on electricity generation in Canada presented earlier, fails to convey just how disparate the provincial approaches are to electricity generation and how complicated the task of developing a collaborative wind power development strategy would be. Table 9.5 summarizes the sources of electricity employed in each province.

Table 9.5: Sources of Electricity Generation by Canadian Utilities and Industry and Percentage of Provincial Electricity Mix in 2007 (dominant sources in boxes)



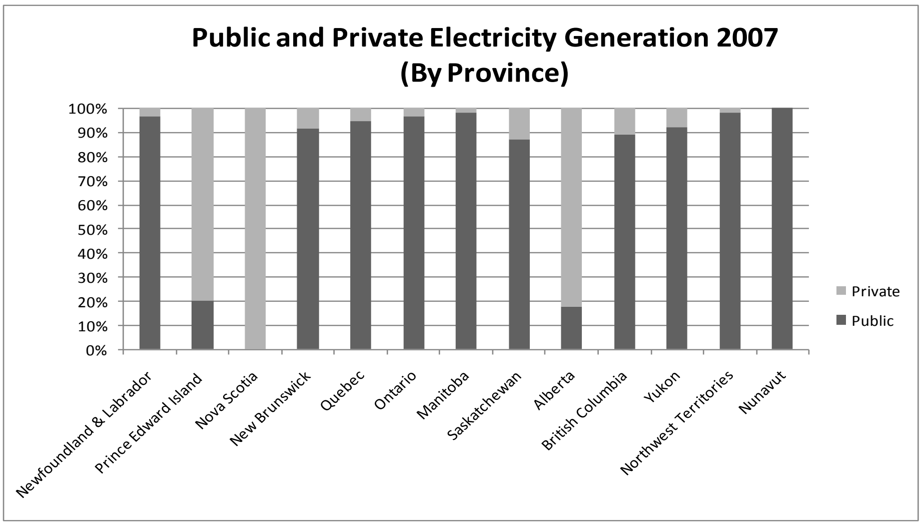
	Total Megawatt Hours	Hydro	Wind and Tidal	Steam	Nuclear	Internal Combustion	Combustion Turbine
Newfoundland & Labrador	41,583,313	**96%**	0%	3%	0%	0%	1%
Prince Edward Island	44,732	0%	**89%**	12%	0%	0%	-1%
Nova Scotia	12,574,042	7%	1%	**89%**	0%	0%	2%
New Brunswick	17,638,847	16%	0%	**49%**	23%	0%	12%
Quebec	191,962,098	**94%**	0%	1%	2%	0%	2%
Ontario	158,234,410	22%	0%	22%	**50%**	2%	4%
Manitoba	34,402,502	**97%**	1%	1%	0%	0%	0%
Saskatchewan	20,574,449	21%	3%	**69%**	0%	0%	6%
Alberta	67,432,359	3%	1%	**74%**	0%	1%	21%
British Columbia	71,833,012	**89%**	0%	7%	0%	0%	3%
Yukon	354,694	**93%**	0%	0%	0%	7%	0%
Northwest Territories	686,252	36%	0%	0%	0%	**43%**	20%
Nunavut	148,881	0%	0%	0%	0%	**100%**	0%

Data source: (Statistics Canada, 2009a)

As Table 9.5 implies, the compulsion to embrace wind power to mitigate CO_2 emissions associated with electricity generation will vary greatly from province to province. Four provinces and one territory derive the vast majority of electricity from hydropower while another province (Prince Edward Island-PEI) generates most of its electricity from wind and tidal power. The carbon footprint of electricity generation in these regions is low. Conversely, four provinces generate most electricity through coal-fired steam power plants and two territories generate the majority of their power from fossil fuel internal combustion systems. These six regions – Alberta in particular – exert a disproportionately high carbon footprint. Finally, Ontario, which is Canada's most populated province, generates half of its electricity through nuclear power. Although it has plans to phase out coal-fired power (partly through a more aggressive approach toward supporting wind power), it currently exhibits a high carbon footprint due to extensive use of coal-fired power.

Table 9.5 also shows that some provinces are in a technologically superior position to adopt high levels of wind power. Labrador, Québec, Manitoba and British Columbia have high levels of installed hydropower capacity which is conducive to supporting high levels of wind power. The other provinces which predominantly utilize either high levels of coal-fired power or nuclear power would likely need to either rely on inter-provincial grid connections or bolster reserve capacity to incorporate levels of wind power in excess of 20% (DeCarolis & Keith, 2006). Fortuitously, these six provinces all have established transmission line connections with other provinces (National Energy Board, 2004). The challenge lays in encouraging hydropower rich provinces to share their back-up capacity and bolster inter-provincial connections to create a more resilient power grid.

Figure 9.1: Degree of Electricity Market Privatization by Canadian Province



Data source: (Statistics Canada, 2009a)

Disparate provincial electricity market structures and on-going liberalization programs also complicate collaboration. As Figure 9.1 illustrates, electricity sectors in three Canadian provinces (PEI, Nova Scotia, Ontario and Alberta) are dominated by private suppliers while electricity sectors in the remaining provinces and territories are dominated by public utilities. Collaboration would require private "profit seeking" firms to work with public utilities that are often guided by a broader set of priorities (National Energy Board, 2004).

To compound the challenge, all 10 of Canada's provinces now have initiatives to encourage electricity market liberalization (Table 9.6). Not only are markets in flux very difficult to coordinate; market fragmentation, which is often ineluctably bound to market liberalization, increases the number of stakeholders that must be consulted when forming a collaborative strategy. Achieving consensus becomes more difficult with a greater number of stakeholders (Sabatier & Jenkins-Smith, 1993).

Table 9.6: Electricity Market Liberalization Status by Canadian Province

Province	Market Status	Regulator	Interconnections
Alberta	Wholesale and retail open access; Functional separation	Energy and Utilities Board (EUB)	British Columbia, Saskatchewan
British Columbia	Wholesale open access; Functional separation	Public Utilities Commission	Alberta, Washington state
Manitoba	Wholesale open access; Functional separation	Province of Manitoba and Public Utilities Board	Saskatchewan, Ontario, North Dakota, Minnesota
New Brunswick	2003 Transmission wholesale & industrial retail open access	Provincial Government	Nova Scotia, PEI, Québec, Maine
Newfoundland & Labrador	Energy policies under review	Commissioners of Public Utilities	Québec
Nova Scotia	New energy policy imminent in 2002	Utility Review Board	New Brunswick
Ontario	Wholesale and retail open access; Corporate separation of generation, transmission and system control functions	Ontario Energy Board	Québec, Manitoba, New York, Michigan, Minnesota
Prince Edward	Distribution network only	PEI Regulatory &	New Brunswick

Island		Appeals Commission	
Québec	Wholesale open access; Functional separation	Régie de l'énergie	Newfoundland, New Brunswick, Ontario, New England, New York
Saskatchewan	Wholesale open access Functional separation	Province of Saskatchewan	Alberta, Manitoba, North Dakota

Sources: Canadian Electric Association (www.canelect.ca) and National Energy Board (2004)

As the list of transmission interconnections in Table 9.6 implies, the importance of electricity as a trade commodity also differs by province. Some provinces earn substantial export revenues from inter-provincial and cross-border trade in electricity. As Table 9.7 details, inter-provincial export of electricity is of significant economic importance to the province of Newfoundland & Labrador. Similarly, New Brunswick, Québec, Ontario, and Manitoba posted sizable trade surpluses with the United States in electricity in 2007. These five provinces would exhibit considerable sensitivity in response to any attempt by federal authorities to restrict or redirect electricity trade. On the other hand, all provinces have inter-provincial electricity connections and six of the 10 provinces have cross-border electricity connections with states in the US (National Energy Board, 2004) which implies that initiatives to bolster trade in electricity would be generally well-received.

Table 9.7: Canadian Inter-Provincial and Cross-Border Electricity Flows, 2007

(in Megawatt Hours)	Received from Other Provinces	Delievered to Other Provinces	Imported from US	Exported to US
Newfoundland and Labrador	16,947	30,096,817	0	0
Prince Edward Island	1,160,935	0	0	0
Nova Scotia	280,597	27,303	62,917	30,634
New Brunswick	1,466,014	1,556,758	641,755	1,780,259
Quebec	33,966,926	3,558,708	3,355,838	15,711,988
Ontario	3,711,520	4,501,487	7,070,359	11,089,756
Manitoba	173,568	1,782,187	534,285	11,092,806
Saskatchewan	1,031,828	840,178	203,343	391,579
Alberta	1,781,495	1,208,616	222,902	154,748
British Columbia	1,101,312	1,119,088	7,288,705	4,438,820
Yukon	0	0	0	0
Northwest Territories	0	0	0	0
Nunavut	0	0	0	0
TOTALS	**44,691,142**	**44,691,142**	**19,380,104**	**44,690,590**

Data source: (Statistics Canada, 2009a)

Overall, this analysis of provincial electricity markets should make it abundantly clear that provinces view electricity strategies from widely varying perspectives. This implies that seeking voluntary provincial collaboration on wind power development would likely be fraught with disagreement over strategic objectives of such collaboration. At the very least, this analysis tells us that voluntary collaboration based on an appeal to one shared strategic vision (i.e. reduction of CO_2 emissions, expansion of electricity exports etc.) will likely be unsuccessful.

9.6.3 Wind Power Development in the Provinces

It should come as no surprise given the varied nature of the electricity profiles in each province that installed wind power capacity also varies significantly by province (see Table 9.8). Intriguingly, three provinces - Ontario, Québec and Alberta - currently boast 80% of Canada's total installed wind power capacity.

Table 9.8: Canadian Wind Power Capacity by Province

(in MW as of June 2009)		
	Installed Capacity	**% of Canada Total**
Newfoundland and Labrador	54.40	2.0%
Prince Edward Island	72.40	2.6%
Nova Scotia	59.30	2.1%
New Brunswick	96.00	3.5%
Quebec	531.80	19.2%
Ontario	1,161.50	41.9%
Manitoba	104.00	3.7%
Saskatchewan	171.20	6.2%
Alberta	523.90	18.9%
British Columbia	0.00	0.0%
Yukon	0.81	0.0%
Northwest Territories	0.00	0.0%
Nunavut	0.00	0.0%
TOTALS	**2,775**	**100.0%**

Data source: Canada Wind Energy Association (www.canwea.ca)

Wind power success in Ontario, Québec, Manitoba and Saskatchewan highlights a historical affinity for request for proposal (RFP) and other mandatory purchase initiatives as the prime instrument for driving growth. Ontario's mandatory purchase initiatives were the most ambitious of the bunch, driven by severe public pressure to mitigate reliance on coal-fired and nuclear powered energy (Rowlands, 2007). The main drawback to mandatory purchase initiatives is that development depends on the willingness of provincial authorities to mandate wind power purchases. Overall, this approach fails to optimize wind power development because investment decisions are influenced more by the financial capacity of the provincial government or provincial electricity consumers to support such investment, rather than basing investment decisions on strategic investment criteria.[13] Moreover, with each province pursuing standalone RFP wind power procurement programs, synergies from inter-provincial cooperation are often sub-optimized.

It is worth noting that of the four provinces that have the capacity to foster the highest levels of wind power due to dominant hydropower capacities (Newfoundland and Labrador, Québec, Manitoba and British Columbia), only Québec has made significant inroads in this regard - although initiatives are currently unfolding in British Columbia and to a lesser extent in Manitoba (see Table 9.9). The slow uptake of wind power in these three high-potential provinces can arguably be attributed in part to hydropower induced Dutch Disease displayed by the respective provincial electricity planning authorities that understandably are less motivated to add higher

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[13] Given these concerns, it is noteworthy that Ontario's RFP program has recently been replaced by a new feed-in tariff (FIT) program, which is North America's first guaranteed pricing program for renewable energy development. The FIT program substantively offers between C$130-$190 per MWh for electricity generated by wind power (NUS Consulting, 2009). Barring further policy developments in other provinces, this program will very likely widen Ontario's lead in wind power development.

priced wind power to electricity grids that already exhibit comparatively low carbon footprints.

The points put forth in the previous two paragraphs highlight an unsettling truth about electricity planning in Canada. The provinces are akin to electricity fiefdoms. As such, success or failure of wind power development programs is dependent on malleable provincial government renewable energy policies.

Table 9.9: Canadian Provincial Initiatives on Wind Energy
(Updated June 2009)

Jurisdiction	Initiative	Status
British Columbia	Government aims to achieve energy self-sufficiency by 2016. 50% of new generation to come from clean energy sources (no specific wind energy target).	325 MW of wind energy contracts in place. BC Hydro Call for Clean Power in 2008 sought 5,000 GWh and received 17,000 GWh in bids. Awarding of contracts expected by July 2009
Alberta	No provincial target.	Alberta Electric System Operator (AESO) has applied to build new transmission infrastructure to accommodate up to 3000 MW of wind generation in Southern Alberta.
Saskatchewan	Provincial energy plan seeks to have 300 MW of wind energy in Saskatchewan by 2011.	171 MW currently in place. Preliminary results of wind integration study by SaskPower expected early summer 2009.
Manitoba	Manitoba Government seeking 1000 MW of wind energy by 2016.	Currently 104 MW in place. In 2007, Manitoba Hydro launched a RFP process for an additional 300 MW of wind. Resulting contracts have yet to be finalized.
Ontario	The Ontario Power Authority's Integrated Power System Plan called for 4,600 MW of wind energy by 2020. IPSP is currently being reviewed, following a Ministerial directive. New Green Energy Act was announced in March 2009. The Act was passed on May 14 2009, and is awaiting proclamation (expected in summer 2009).	964 MW currently in place, with almost 400 MW of additional wind energy projects currently under construction. In January 2009, OPA announced contracts for six new wind energy projects in Ontario totaling 492 MW. The Green Energy Act puts in place a new feed-in tariff procurement process, and a streamlined environmental assessment process. The intent of the GEA is to create certainty & stability for wind energy development in Ontario.
Quebec	Quebec Government seeking 4,000 MW of wind energy by 2015.	531 MW currently in place and nearly 3,500 MW contracted. 500 MW of new Requests for Proposals for First Nations / Municipal wind projects was issued April 30, 2009.

New Brunswick	NB Power seeking 400 MW of wind energy by 2016.	96 MW currently in place. 300 MW of additional contracts announced in 2008.

Source: Canada Wind Energy Association (www.canwea.ca)

Table 9.9 summarizes the different levels of commitment to developing wind power in the major provinces. Ontario and Québec are on track to fortify the leadership positions they've established in wind power capacity installation, British Columbia has unveiled more aggressive policies to support wind power development, Saskatchewan, Manitoba and New Brunswick have adopted rather flaccid mandatory purchase programs and Alberta is set to experience an amplified level of wind power installation, driven by private interests attracted to Alberta’s liberal electricity sector.

In terms of federal support for wind power development, it is worth noting that initiatives to date have been largely peripheral. In 2002, the federal government launched a Wind Power Production Initiative (WPPI) which offers a comparatively minor financial subsidy to wind power developers (guaranteed over 10 years of the approved project) of C$12 per MWh for projects approved between 1 April 2002 and 31 March 2003, C$10 per MWh for projects approved between 1 April 2003 and 31 March 2006 and C$8 per MWh for projects approved between 1 April 2006 and 31 March 2007. However, funding for this program was terminated prematurely in 2006 to give way to the C$1.5 Billion ecoENERGY for Renewable Power program which provides a similar productive incentive of C$10 per MWh over a ten-year period for all eligible renewable energy projects commissioned between April 1, 2007 and March 31, 2011 (IEA Global Renewable Energy Database, 2009).[14] Additionally, special tax regulations allow wind power developers to accelerate write-offs of capital

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[14] International Energy Agency Global Renewable Database, Accessed on 22 November 2009 at http://www.iea.org/textbase/pm/?mode=re&action=detail&id=3829

equipment (Liming, et al., 2008). Overall, given the average electricity cost data outlined earlier, one can conclude that the federal subsidies have been too small to make wind power a commercially attractive investment in most parts of Canada. Accordingly, it can be argued that the mandatory purchase initiatives of the provincial governments have had the strongest influence in catalyzing wind power development.

If all of the provincial plans come to fruition, Canada will have approximately 16,000 MW of installed wind power capacity (4,800 MW of average output capacity, assuming a 30% capacity load factor) by 2015/16. Based on total installed electricity generation capacity in 2007 of 124,242 MW, this would represent approximately 3.8% of total output capacity. Although this would be an improvement over the current situation, it falls well short of the high levels of wind power output capacity that Canada should be targeting.

In order to optimize the country's wind power potential, a much higher degree of inter-provincial coordination will be necessary for three key reasons. First, a high degree of spatial coordination is required in order to optimize geographic dispersion of wind farms for the purpose of reducing the disruptive influence of wind intermittency. Second, electricity transmission and distribution needs to be more actively integrated to enhance national grid stability. Integration allows provinces that lack hydropower capacity to install higher levels of wind power by tapping into the hydropower peaking reserves of neighbouring provinces. Third, by more effectively coordinating transmission and distribution between Canadian and American electricity grids, Canadian power authorities could further stabilize grid operation despite incorporating high levels of wind power.

9.6.4 *What is Impeding Provincial Collaboration?*

Consider for a moment what a transition from fossil fuel electricity generation to wind power means for a province like Alberta which currently derives 95% of its electricity from locally extracted fossil fuels. By tapping into cheap domestic fossil fuel supplies, residents and industries in the province enjoy electricity prices that are amongst the lowest in the world (NUS Consulting, 2007). If the provincial government were somehow compelled to incorporate 40% wind power into the electricity mix, the average cost of electricity would increase due to the comparably high cost of wind power. This would displease voters and make it more expensive for electricity-intensive industries to operate in Alberta. The only way the Albertan government could offset higher energy costs is by providing a subsidy to the utilities. In short, a shift to wind power would contribute to the federal goal of reducing CO_2 emissions but from the perspective of the Albertan government (and other fossil fuel rich provincial governments), it would adversely impact economic conditions. Under such circumstances, a savvy Albertan government would likely demand some sort of federal transfer payment to accept such an economically disadvantageous policy.

In Canada, without the authority to force provinces to collaborate to optimize wind power development, the federal government would be compelled to offer coercive incentives to Alberta (or any other fossil fuel rich province) to engender cooperation. Unfortunately, it is unlikely that Canada's federal government, which is already wrestling with a deficit of over C$50 billion, could muster the public support for a policy of compensating fossil fuel rich provinces for playing a role in abating national CO_2 emissions (Curren, 2009). This dilemma, therefore, raises a critical question: *Is there anything the federal government can do to force provincial collaboration?*

9.6.5 *Influencing Provincial Energy Policy (in Theory)*

Constitutionally, there are at least four strategies that the federal government could attempt to apply in order to coerce provinces to collaborate on the development of a unified wind power development strategy. For starters, under Section 92A(3) of the Constitution Act of 1867, the authority granted to the provinces over the exportation of electricity is constitutionally subject to federal approval (Government of Canada, 1867 / 1982). Moreover, Section 91(2) of the Constitution gives the federal government authority over the regulation of trade and commerce (Government of Canada, 1867 / 1982). Together, these two authorities give the federal government a theoretical right to bar provinces from exporting electricity pending provincial cooperation. As a second alternative, the federal government could theoretically establish export quotas or levy taxes on electricity exports in any manner it sees fit because the Constitution also gives the federal government authority to raise funds through taxation of any form (Section 91(3)) (Government of Canada, 1867 / 1982).

Third, Section 132 of the Constitution bestows the federal government of Canada with "*all Powers necessary or proper for performing the Obligations of Canada or of any Province thereof, as Part of the British Empire, towards Foreign Countries, arising under Treaties*" (Government of Canada, 1867 / 1982). The implication of this power is that the federal government has authority to compel provincial legislatures to comply with programs designed to reduce greenhouse gas emissions as per Canada's obligation under the Kyoto Protocol.

Finally, Section 91 of the Constitution bestows the federal government with all authorities which are not expressly allocated to the provinces (*residual powers*)

(Government of Canada, 1867 / 1982). One highly relevant residual power is the federal government's authority over trans-provincial environmental governance. The federal government has a right to pass legislation which regulates trans-boundary pollution. Presumably, this includes passage of laws to regulate harmful emissions associated with electricity generation.

The current legislation that governs trans-boundary environmental issues is known as the Canadian Environmental Protection Act, 1999 (CEPA). CEPA authorizes the government to regulate products controlling toxic substances and prevent the release of potentially dangerous substances. Given the perilous nature of global warming, CO_2 emissions should theoretically fall into the category of “dangerous substances”. However, as of 2007, neither authority has been exercised. CEPA also authorizes the government to require industries to submit pollution prevention plans; but as of 2007, only seven such notices have been issued (Government of Canada, 2007). This then begs the question: *Given the theoretical powers that the federal government has to coerce provinces to collaborate on a unified energy policy, what is preventing this from happening?*

9.6.6 Influencing Provincial Energy Policy (in Practice)

In practice, any federal government attempt to use its constitutional powers to influence provincial behaviour can be thwarted by provincial counter-strategies. Four illustrative counter-strategies will be examined in this section.

First and foremost, the courts would likely overturn federal policies that can be shown to infringe on constitutionally-granted provincial authorizes (Baier, 2005), such as section 92A(1) of the Constitution which grants authority to provinces to *exclusively make laws in relation to… development, conservation and management of sites and facilities in the province for the generation and production of electrical energy*. This implies that policy tools that are commonly used to facilitate development of renewable energy – taxing CO_2 emissions, taxing electricity generated by fossil fuel sources, requiring utilities to incorporate specified amounts of renewable energy, placing regulatory limits on CO_2 emissions – could all be subject to legal challenges by provincial authorities as constituting an infringement on provincial sovereignty over electricity generation.

Second, even if legal attempts to demonstrate an infringement on provincial authority were unsuccessful, Part 3, Section 36 of the Constitution Act of 1982 provides other avenues of provincial recourse (Table 9.10)

Table 9.10: Part 3, Section 36 of Canada's Constitution Act, 1982

Commitment to promote equal opportunities:
36. (1) Without altering the legislative authority of Parliament or of the provincial legislatures, or the rights of any of them with respect to the exercise of their legislative authority, Parliament and the legislatures, together with the government of Canada and the provincial governments, are committed to
(a) promoting equal opportunities for the well-being of Canadians;
(b) furthering economic development to reduce disparity in opportunities; and
(c) providing essential public services of reasonable quality to all Canadians.

Commitment respecting public services:
(2) Parliament and the government of Canada are committed to the principle of making equalization payments to ensure that provincial governments have sufficient revenues to provide reasonably comparable levels of public services at reasonably comparable levels of taxation.

Source: Canada Constitution Act 1867 / 1982

The two provisions embedded within Section 36 provide at least two potential constitutional grounds for challenging federal policy instruments aimed at influencing provincial energy policy. Section 36(1) compels the federal government to ensure "*equal opportunities*" and to "*reduce disparity in opportunities*". Provinces that are dependent on fossil fuel generated electricity could argue that any federal policies which increase the comparative cost of fossil fuel electricity generation increase the cost of doing business in the province and enhance "disparity in opportunities" when compared with provinces which are for example, blessed by abundant access to hydropower. Authorities from provinces dependent on fossil fuel generated electricity could also argue that federal policies which inflate fossil fuel electricity costs impair the promotion of “*equal opportunities for the well-being* (which presumably includes economic well-being) *of Canadians*”.

Section 36(2) requires the federal government to provide "equalization payments" to provinces which are adversely affected by circumstances that result in comparatively higher costs for public services. In response to any federal policy which increases the cost of fossil fuel electricity, authorities from provinces that are dependent on fossil fuel electricity could argue that electricity is a public service, the policy resulted in an inequitable provision of this public service and therefore, "equalization payments" are necessary. If successful, such a claim could render policy implementation financially untenable.

Third, even if provinces failed in legal actions to overturn federal policies which infringe on provincial constitutional sovereignty over electricity governance, there is also a political avenue to derail intrusive federal policies. In accordance with Section

53 of the Constitution, federal policies which seek to tax goods or services must be approved by the House of Commons which (in accordance with Section 49) requires a simple majority (Government of Canada, 1867 / 1982). The trouble is that the five Canadian provinces that are highly dependent on fossil fuel electricity (Ontario, Alberta, Saskatchewan, Nova Scotia and New Brunswick) hold 160 of the 295 seats in Canada's House of Commons. In short, members of the House from these provinces could conceivably block passage of such a policy.

Fourth, if all legal challenges and all political resistance failed to derail federal efforts to pass policies that would force provincial cooperation in developing a unified wind power development strategy, the efficacy of the policy could still be undermined by political gamesmanship. For example, a jaded provincial authority could counter a national carbon tax with provincial counter-subsidies to fossil fuel electricity generators in order to dilute the coercive efficacy of the federal policy. Alternatively, a provincial authority could discourage federal authorities from adopting provincially unpopular policies by threatening to withhold cooperation in other areas (i.e. the collection of federal income taxes) in order to place pressure on federal authorities to negotiate less coercive energy policies. Given the need for cooperation in areas such as social security, agricultural policy and education, it does not serve the federal government to alienate the provinces.

In summary, the Constitutional authorities outlined earlier *theoretically* provide the federal government with coercive mechanisms for compelling provincial governments to collaborate on a national wind energy development strategy; however, in practice, coercive federal strategies can be rendered ineffective due to legal, political or administrative resistance by the provinces. Braun and colleagues referred to these resistance tactics as “thrust and riposte” (Braun, et al., 2002, p. 117). In fact, even the *threat* of challenging a federal policy on any of these grounds could serve as a deterrent to implementation.

The threat of thrust and riposte strategies applied at both federal and provincial levels prompted the International Energy Agency to conclude, "*the only viable approach in addressing the most important energy policy challenges seems to be a process of intensive dialogue and consultation to achieve a national consensus on the goals and needs of energy policies, but this process takes time*" (IEA, 2004b, p. 255). As the chairman of the Canadian Electricity Association summarized, "*the debate is not about the merits of long-term reductions in greenhouse gases or air emissions, but over how quickly we can get there, at what cost and who pays*" (Canadian Electricity Association, 2008, p. 1).

In the next section, this analysis of the complexities inherent in Canada's federal system will be drawn upon to create a conceptual framework to understand how different assignations of authority influence the viability of renewable energy policy instruments. By creating such a framework, the list of feasible policy instruments for facilitating a collaborative approach to wind power development in Canada will become clearer.

9.7 POLICY INSTRUMENT SELECTION IN A FEDERAL SYSTEM

9.7.1 Developing the Framework

Prior to examining the policy instrument options open to the Canadian federal government for facilitating a more aggressive, provincially collaborative approach to wind power development, it serves to first review the types of policy instruments that are popularly employed for supporting development of renewable energy. Theodore Lowi's taxonomy for classifying policy instruments is employed for this review (Lowi, 1972) in part because of the clarity with which it enables classification of renewable energy development policy tools.

Table 9.11: Lowi's Taxonomy and Renewable Energy Policy Instruments

Instrument Classification	Examples of Renewable Energy Policy Instruments
Distributive policy	Feed-in subsidy, production subsidies, subsidies for technology development, land grants for siting renewable energy facilities, R&D funding
Regulatory policy	CO_2 emission regulations, CO_2 emission cap and trade systems, mandatory utility purchase of renewable energy (renewable portfolio standards)
Redistributive policy	Carbon taxes, CO_2 emission taxes, taxes on fossil fuel resources
Constituent policy	Establishing an agency for unifying national energy strategy, media campaigns emphasizing the imperative for CO_2 emission reduction

It should be evident from Table 9.11 that Canada's constitutional separation of powers renders application of regulatory or redistributive policies problematic in regard to supporting wind power development. Any regulatory or redistributive policies which adversely affect the fortunes of some provinces over others (contravening section 132 of the Constitution Act, 1982) or infringe on the constitutional authority granted to the provinces over electricity generation (contravening section 92 of the Constitution Act,

1867) could be challenged by the provinces in the courts. As mentioned earlier, even if legal recourse is unsuccessful in nullifying adverse regulatory or redistributive policies, there are other "thrust and riposte" techniques that provinces can employ to stymie federal incursion into provincial sovereignty.

Insights from the earlier analysis pertaining to the viability and efficacy of different policy instruments in encouraging enhanced wind power development in Canada can be used to guide the construction of a rough framework that attempts to summarize the influence that a federal form of government has on policy instrument design and implementation. Although admittedly done at a high level of abstraction and generalization, Table 9.12 summarizes the efficacy of different policy instruments in areas which are subject to federal, regional (provincial) or shared (concurrent) authority. The stars convey a loose ranking (see legend of Table 9.12) of the viability and efficacy of federally employing each instrument under the various delegations of authority. Generalizations of this sort assume that there are no extant socio-cultural, political, bureaucratic or economic conditions that justify the use of one policy instrument over others. In short, Table 9.12 answers the question "ceteris paribus, which policy tools can be effective in a federal environment?"

Table 9.12: A Framework for Policy Tool Implementation in a Federal System

	Authorities Presiding over Relevant Policy Field		
	Federal authority	Regional authority	Concurrent authority
Regulatory policies	✮✮✮	✖	✮✮
Redistributive policies	✮✮✮	✮	✮✮
Distributive policies	✮✮✮	✮✮✮	✮✮✮
Constituent policies	✮✮	✮✮	✮✮

✮✮✮✮ = highly effective ✮✮✮ = effective ✮✮ = marginally effective

✮= largely ineffective ✖ = unworkable

National regulatory policies can be effective in policy fields over which the federal government has constitutional authority; however, even in areas of federal jurisdiction, there is always the possibility that regions which are disadvantaged by the policy will provide active resistance through political gamesmanship. Conversely, in policy areas over which the regional government has constitutional authority, direct regulatory policies are not generally workable. A more viable regulatory approach in such circumstances is to try to identify peripheral areas over which the federal government has sovereignty to enact regulatory policies. For example, rather than placing regulations on CO_2 emissions from electric utilities (over which the provincial government has authority), a peripheral regulation would be to regulate national CO_2 emissions by allocating quotas to the provinces (which would be justified by the federal government's authority over inter-provincial environmental governance). In general, federal attempts to regulate areas under regional authority increase the propensity for federal-regional conflict, which rarely results in a win-win outcome. Lastly, in policy areas where concurrent authority exists, federally designed regulatory policy is an option; however, negotiation between the federal and regional authorities that share concurrent authority typically leads to the design of regulations which have been diluted through the negotiation process (Braun, et al., 2002). Canada's failed Clean Air Act, 2006 is illustrative of an ineffective regulatory policy which attempted to federally regulate activities over which the federal and provincial governments have concurrent authority.

Redistributive policies share many similarities with regulatory policy in terms of feasibility and efficacy of application within federal systems. If a redistribution policy is implemented in a policy area under federal jurisdiction, it can be effective provided it does not induce opposition by regional authorities or voters. In policy areas under concurrent authority, redistributive policies suffer the same weakness as regulatory policies - compromises frequently dilute the efficacy of the measure (Braun, et al., 2002). Lastly, redistributive policies are largely ineffective in policy areas under regional jurisdiction because regions which are adversely affected will resist federal intrusions on regional authority. With that said, redistribution policy may be viable in spite of regional resistance if there is strong enough public (voter) support for such a policy. For example, 20 years ago, there was not enough public support in Canada for wind power to justify federal taxes on carbon emissions. However, 84% of all Canadians now support further development of wind power, while 42% are opposed to further expansion of fossil fuel power plants (Saint Consulting, 2007). The viability of redistributive policies in areas of regional jurisdiction depends on the creation of policies that are not unfairly biased to punish one region and reward another (Bird & Vaillancourt, 2001).

Distributive policies are usually the most well-received policy instruments from a regional perspective because federal distributions are perceived as "free money" for the regions, despite the fact that distributive policy funding comes from tax payers (Bemelmans-Videc, Rist, & Vedung, 2003). In Canada, many of Canada's federal policies are distributive in nature (Wimmer, 2007). The obvious weakness associated with a distributive policy is that such policies must be federally financed by either further taxation or fiscal cuts in other areas. This is a particular weakness in relation to supporting wind power development because financial requirements for subsidizing wind power development could amount to tens of billions of dollars (to be discussed in Section 9.7.2). Due to the financial imposition of distributive policies on national budgets, they have been allocated three instead of four stars in the matrix (Table 9.12).

Finally, the value of constituent policies for supporting other policy instruments should not be overlooked. Constituent policies policy are frequently less expensive to implement than distributive or regulatory policies (Bemelmans-Videc, et al., 2003) and can typically be customized to fit any power-sharing scenario. The drawback to constituent policies is that they are frequently less influential in altering behaviour; and as a result, when they are applied alone, they rarely achieve the impact associated with the other three types of policy instruments (Hood, 1986).

In summary, under a federal government system, distributive, redistributive or regulatory policy instruments are more or less equally feasible and effective when dealing with policy areas that fall under the constitutional authority of the federal government. However, in dealing with policy areas that fall under the constitutional authority of regional governments, policy instruments vary in terms of viability and efficacy. Regulatory and redistributive policies can be particularly problematic under such circumstances if regional authorities perceive the federal policies to infringe on regional sovereignty. As for areas of concurrent authority, all policy instruments are feasible; however, they vary in degree of efficacy. Under concurrent authority, the efficacy of regulatory and redistribution policies tends to be diluted by compromise. Consequently, distribution policies (despite their high costs) and constituent policies (despite lower levels of impact) tend to be more effective.

9.7.2 Applying the Framework to the Canadian Wind Power Development

Given these initial observations, it is possible to link the emergent framework back to the challenge faced by the Canadian federal government in facilitating a national wind power development policy. Table 9.13 integrates the analysis of the challenge that the Canadian government faces in facilitating a more effective wind power development strategy back to the framework presented in the previous section and qualitatively attempts to approximate the efficacy of various policy instruments.

Table 9.13: Efficacy of Different Wind Power Development Policy Tools in Canada

	Regional authority	Examples of Instruments
Regulatory policies	✗	CO_2 emission regulations, CO_2 emission cap and trade systems, mandatory utility purchase of renewable energy (renewable portfolio standards)
Redistributive policies	✯	Carbon taxes, CO_2 emission taxes, taxes on fossil fuel resources
Distributive policies	✯✯✯	Feed-in subsidy, production subsidies, subsidies for technology development, land grants for siting renewable energy facilities, R&D funding
Constituent policies	✯✯	Establishing an agency for unifying national energy strategy, media campaigns emphasizing the imperative for CO_2 emission reduction
✯✯✯✯ = highly effective ✯✯✯ = effective ✯✯ = marginally effective ✯= largely ineffective ✗ = unworkable		

As Table 9.13 suggests, some form of enhanced distributive policy may be the most effective approach for encouraging more aggressive provincial wind power development strategies. Interestingly, in the federation with the greatest success in wind power development (Germany), a feed-in subsidy and land lease grants played major roles in catalyzing development (Komor, 2004; Wizelius, 2007). Similarly, production subsidies were instrumental in supporting wind power development in two other federations, the United States (Production Tax Credit) and Spain (Mallon, 2006).

In Canada's case, introducing a production tax credit is perhaps the least contentious alternative.

The main hurdle to implementing a federal production tax credit as a distributive policy to promote wind power development comes down to program cost (or rather revenue foregone). To illustrate, assume that federal policymakers wanted to introduce a production tax credit program of 15-year duration (to provide financial certainty to developers) at C$60 per MWh (which would make wind power projects attractive even in provinces with the lowest electricity prices), valid to a total capacity of 20% of total national electricity generation capacity. Once the program reaches full capacity, the federal government would be foregoing approximately C$8.6 billion per year in tax revenue.[15] For a government that is currently wrestling to bring down a federal deficit of C$50 billion, foregoing tax revenue of this magnitude would be politically untenable.

9.7.3 The Value of Combined Policy Instruments

The general consensus amongst policy instrument scholars is that cobbling together a program employing various policy instruments often delivers enhanced results (cf. Bemelmans-Videc, et al., 2003; Hood, 1986; Salamon, 2002). There is anecdotal evidence that this tenet extends to federal systems. For example, in support of regulatory activities associated with the Canadian Environmental Protection Act of 1999, the federal government undertook an extensive public relations campaign to

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[15] In 2007, electricity production in Canada was 617,469 GWh (Statistics Canada, 2009). Assuming a yearly increase in production of 1.3% (EIA, 2008), by 2012 electricity production will have increased to 715,815 GWh. Accordingly, assuming that all wind turbines were in place by 2012, the annual total payments required to provide a subsidy of C$60 per MWh would amount to C$8,589,789,641 for 143,163 GWh (20% of 715,815).

explain its impact. Moreover, a Council of Ministers of the Environment (which includes all 13 regional Environment Ministers and the federal Environment Minister) meets bi-annually to “develop national strategies, norms, and guidelines that each environment ministry across the country can use” (www.ccme.ca). The combination of these policy instruments allowed a federal regulatory act to be implemented even though it intrudes on areas of provincial authority.

Combining policy instruments to improve policy program efficacy presents some intriguing possibilities in regard to developing a collaborative wind power development program in Canada. For example, although electricity policy falls under provincial sovereignty, could the federal government succeed in implementing a carbon tax (a redistributive policy) or cap and trade system (a regulatory policy) if it supplemented the program with an enhanced production tax credit policy (distributive policy), initiated a campaign to engender public support (constitutive policy) and delegated program design to the Council of Energy Ministers to minimize provincial opposition through collaborative policy setting (constitutive policy)? If so, a combined approach to policy setting could significantly spread-out the burden of subsidizing wind power development initiatives when compared to the distributive policy outlined earlier.

Regardless of the ultimate policy package, delegating the development of a policy program to the Council of Energy Ministers (or some other unified body) represents sound judgment. Currently, this Council of the 13 regional (provincial and territory) Energy Ministers plus the Federal Energy Minister meets annually to discuss provincial collaboration and share information. In Canada, where policy decisions are best designed and operationalised through consultation with the provinces (IEA, 2004b), it seems logical to task this group with the responsibility to cobble together a unified policy approach. Failure to enlist provincial support in developing a collaborative strategy increases the possibility that provincial authorities will consider emergent strategies to be unwarranted intrusions on provincial sovereignty over electricity governance.

Considering financial feasibility, a combination of policies may represent a way for the federal government to enact a collaborative approach to wind power development without having to foot the entire bill associated with an enhanced federal production subsidy program. Unfortunately, an absence of empirical research comparing the efficacy of different combinations of renewable policy tools in a federal environment stymies identification of an optimal policy mix for Canadian policymakers. Accordingly, it is hoped that the conceptual cornerstones established in this chapter will encourage more extensive research into the efficacy of combined policies in a federal setting. All 24 of the world’s federal nations would benefit from further research in this regard.

9.8 CONCLUSION

Research into the nexus between federal political structure and policy implementation has tended to focus on pieces of the puzzle. Some have endeavoured to examine the efficacy of different federal structures in specific contexts such as industrial relations (Patmore, 2009), domestic peace (Wimmer, 2007) or inter-governmental relations (Baier, 2005). Others have explored the inner-workings of the federal-state (province) interface (Erk, 2006). Still others have undertaken comparative studies to better understand the influence that a federal structure has on policy making by examining either broad differences between federal nations (Braun, et al., 2002; Thorlakson, 2003) or more detail comparative analysis between nations (; Rich, 2004). However, all have approached such inquiry in an ad hoc manner, pursuing specific themes of interest rather than focusing on a macro analysis of how federal structure influences policy instrument choice and efficacy.

Conversely, this study which uses the challenge of unifying national energy policy for supporting wind power development in Canada has attempted to employ critical analysis to better understand the nexus between policy instruments and federal political structures from a macro-level. To the best of the author's knowledge the framework put forth in Table 9.12 and subsequently applied to a specific context (wind power development policy) in Table 9.13, represents the first attempt of its kind to explicate the relationship between the various manifestations of power found in federal systems and the types of policy instruments that in theory should be more effective. As an emergent taxonomy, the author does not claim that the framework represents the final word on understanding this nexus; however, it does represent the establishment of a conceptual starting point around which empirical testing can be devised.

Clearly there are exceptions which will challenge the predictive and applied efficacy of the framework outlined in Table 9.12. In fact, this discussion has already touched upon two such exceptions. Firstly, the Canadian Environmental Protection Act of 1999 was a federal regulatory policy which infringed on areas of provincial sovereignty, yet it succeeded. Although part of the success stems from the collaborative approach taken through the Ministers of the Environment to implement the Act, its success reminds us that policy approaches that may be problematic if applied in isolation can be effectively applied by combining different policy approaches to offset negatives with positives. In focusing on policies applied in an isolated manner, the framework put forth in this paper does not yet address this important area of policy making strategy. Secondly, it was earlier suggested that a regulatory policy (a mandatory feed-in requirement) might be effective in facilitating enhanced development of wind power despite provincial authority over electricity generation if supplemented by a distributive policy (a production tax credit). This tells us that portfolios of policy instruments might elicit different degrees of efficacy. Accordingly, much more research is needed to highlight the nuances of combining different types of policy instruments to achieve end goals.

In conclusion then, the framework put forth in this chapter is admittedly raw, but it is a step forward and fills an important gap in understanding the nexus between policy instrument efficacy and federal political structure. As the Chinese are fond of saying, “a journey of a thousand miles begins with one step”. But at least this journey will have the wind at our backs.

CHAPTER 10

WIND POWER DEVELOPMENT IN JAPAN

Abstract

This chapter 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 centrepiece 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.

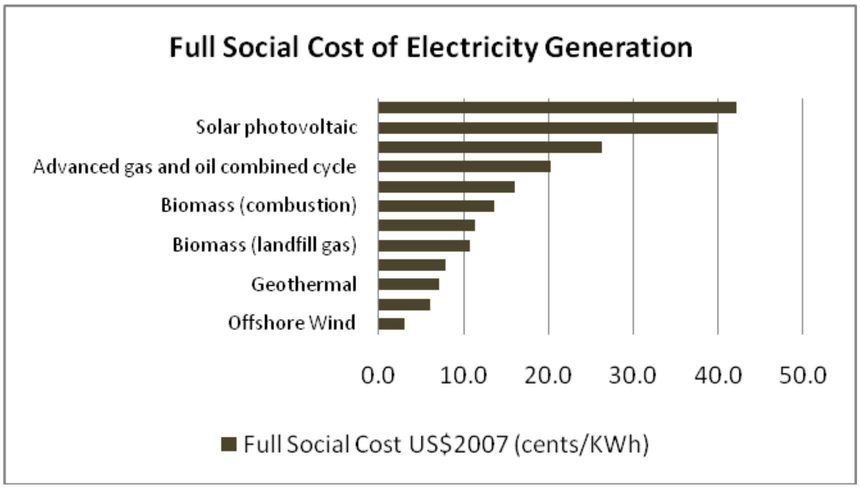
10.1 INTRODUCTION

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 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 policymakers 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 figure 10.1). Moreover, the CO_2 lifecycle footprint of wind energy is amongst the lowest of all renewable energy technologies (Sovacool, 2008b).

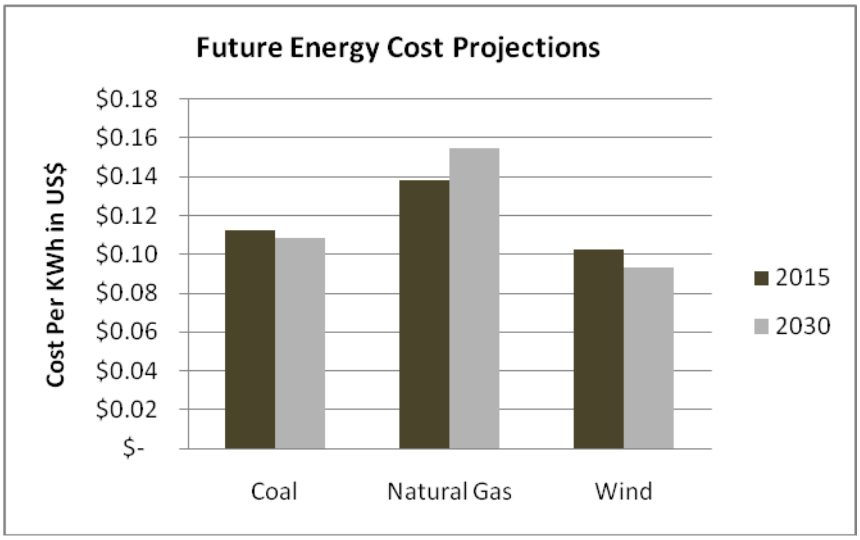
Figure 10.1: Full Social Cost Comparison of Electricity Generation Technologies



Source of data: (Sovacool, 2008a)

Alternatively, for readers who are uncomfortable with the use of social cost projections to argue a case for the economic merits of wind energy, figure 10.2 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 policymakers would be remiss to ignore wind energy as an economically viable component of any low-carbon energy strategy.

Figure 10.2: Projected Electricity Costs in the EU in 2015 and 2030



Source: (IEA World Energy Outlook, 2008)

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 7,636 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 in respect to the diffusion of wind energy. However, as this case study 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 chapter 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. Specifically, this case 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 plausible interpretation.

In addition to providing a thorough analysis of the energy strategy of the world's second largest economy, this case study hopes to contribute to the growing body of knowledge on effective and ineffective elements of applied energy policy. Specifically, this 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.

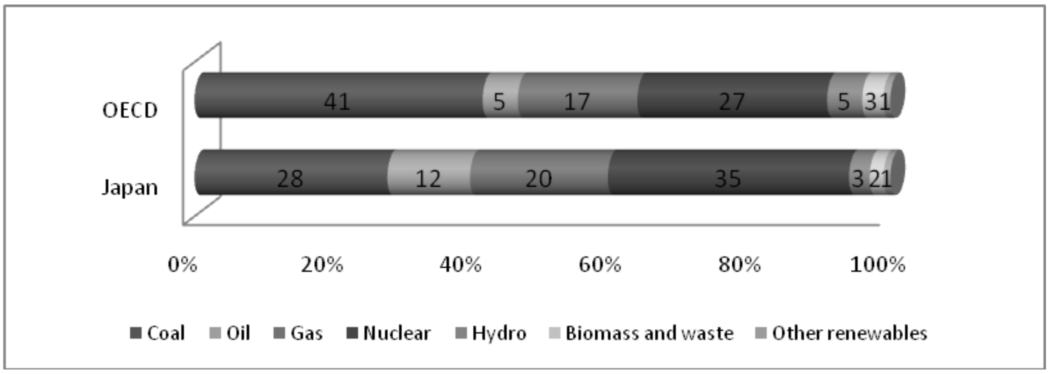
The knowledge foundation of the study stems from a series of interviews and academic conferences attended during a one-year attachment to the University of Tokyo's Graduate School of Public Policy. Where possible, government publications or existing research have been referenced to support assertions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

This chapter is organized in the following manner. Section 10.2 launches the journey by briefly examining the overall energy profile in Japan. Section 10.3 then 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 10.4 examines the impact that Japan's power generation strategy has had on wind energy diffusion and Section 10.5 attempts to explain the factors that discourage Japan's energy utilities from purchasing greater quantities of wind power. Section 10.6 summarizes the short-comings Japan's power generation strategy and Section 10.7 offers recommendations for redressing these short-comings.

10.2 JAPAN'S ENERGY SITUATION

Figure 10.3 contrasts Japan's power generation mix with the average power generation mix found in OECD countries (IEA, 2008c). 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 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.

Figure 10.3: Power Generation in Japan and the OECD

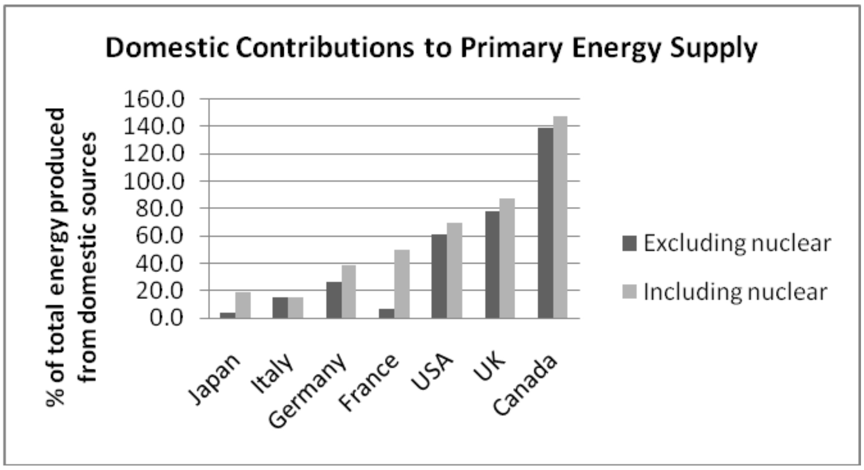


Source of data: (IEA, 2008c)

One other critical element of Japan's power generation mix is not conveyed in Figure 10.3 - Japan imports 59% of its power generation feed-stocks. Virtually all coal, oil and gas feed-stocks are imported (EIA, 2008b). Moreover, it imports these feed-stocks in vast quantities. In 2005, Japan consumed 226 million tons of oil equivalent (Mtoe) energy for power generation (IEA, 2008c). 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 figure 10.4 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.

Figure 10.4: Japan's Energy Self-Sufficiency Compared to Other OECD Nations



Source of data: (FEPC, 2008)

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 held 328 million barrels of oil in strategic reserves (EIA, 2008a).

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 10.5, 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 (FEPC, 2008).[16] 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.

10.3 JAPANESE ENERGY POLICY

10.3.1 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

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[16] There are now 10 private regional electric utilities in Japan. The 10th region was created in 1972 when Okinawa rejoined Japan. (FEPC, 2008)

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 which 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 which 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 10.3.3 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.

10.3.2 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 (IEA, 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, p. 1):

- *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.

10.3.3 Power Generation Policy Programs

The penchant for prioritising 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 analysed in the context Japan's strategic energy objectives.

- #### *10.3.3.1 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 10.1 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 tonnes of oil equivalent energy per year. This is significantly lower than consumption levels in Canada (8.4 tonnes) and the United States (7.9 tonnes) but similar to per capita energy consumption levels in France (4.4 tonnes), Germany (4.2 tonnes) and the UK (3.9 tonnes) (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, 2008a). 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, 1998, 2005).

- *10.3.3.2. Energy Efficiency through Technological Development*

The Japanese government has sponsored a plethora of initiatives to encourage the development of energy efficient technologies. Some of the more prominent initiatives are outlined in Appendix 10.2. Encouraging development of energy efficient technologies supports Japanese industrial development strategy in at least three ways. Firstly, industries, which use resources (i.e. energy) more efficiently, establish competitive advantage over foreign competitors (Porter, 1990; Porter & 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.

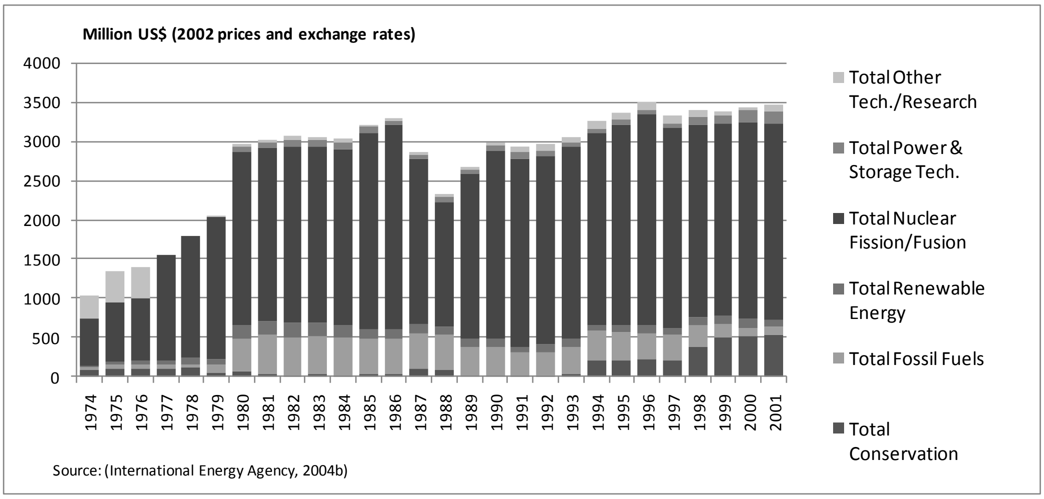
A number of examples stand out as testament to the success of these initiatives. Japan has become one of the leading exporters of products and services to support energy-efficiency in engineering and construction projects (EIA, 2008a). The 1500°C class gas turbines that have been developed in Japan boast 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, 2008a). 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 (IEA, 2004c). 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 10.1).

- *10.3.3.3. Nuclear Energy Support Programs*

For decades, the lion's share of government funding for energy research has gone into nuclear energy research. As figure 10.5 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.

Figure 10.5: Japanese Government Energy R&D Expenditure



Source: (International Energy Agency, 2004b)

This consistent commitment to nuclear energy research has yielded remarkable results. According to METI, nuclear power has 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, 2008a).[17] 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 (JAEC, 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

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[17] 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 case study will describe, this artificially inflates the attractiveness of nuclear energy.

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 (FEPC, 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) (JAEC, 2008).*

It isn't 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

(JAEC, 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, p. 6). Under this logic, imported automobiles would be domestic forms of transportation.

• *10.3.3.4. Initiatives to Minimize Supply Risk*

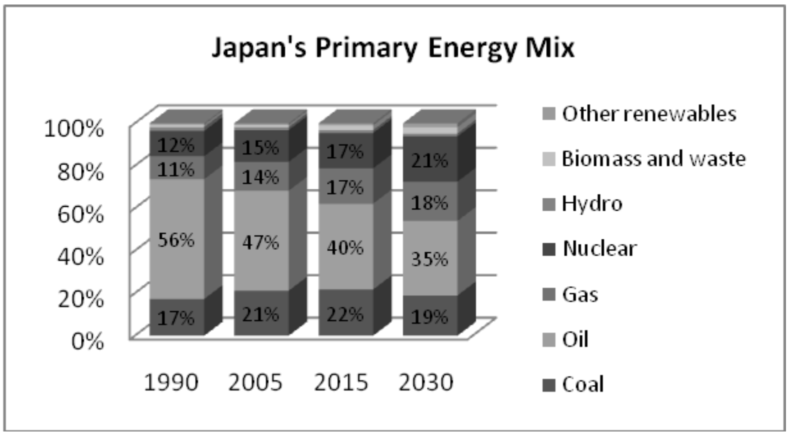
Japan's precarious dependence on foreign energy supplies has shaped public policy for over 100 years. An ambition to gain access to Korea's ample coal reserves was a causal factor of the Sino-Japanese War of 1894-1895 (Paine, 2003). In the early 20th century, as the Japanese economy grew and its overseas 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 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 (EIA, 2008a; 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 tonnes of LNG annually to Japan (Sakhalin Energy, 2003).

The goal of minimizing dependence on energy imports from unstable nations centres on reducing dependence on Middle Eastern oil, which accounts for 90% of Japan's oil imports (ANRE, 2006). As figure 10.6 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.

Figure 10.6: The Changing Face of Japan's Primary Energy Mix (Power + Transport)



Source of data: (IEA, 2008c)

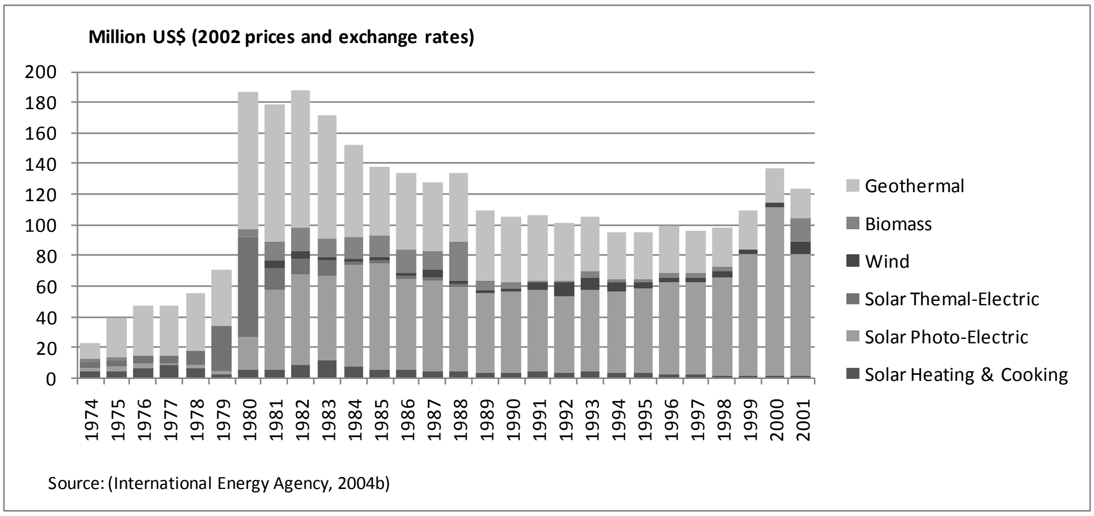
Figure 10.6 also highlights Japan's progress toward achieving the third goal of diversifying its energy mix. In 1973, 77% of the nation's primary energy requirements were met through oil (ANRE, 2006). By 2005, the role of oil had diminished to 47% (IEA, 2008c). By 2030, Japan aims to establish a diversified energy mix with the bulk of reliance spread over four energy sources - coal, oil, natural gas and nuclear power. As will be discussed later, renewable energy is not expected to make a major contribution to energy diversification.

- *10.3.3.5. 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 centres 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 Figure 10.7 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.

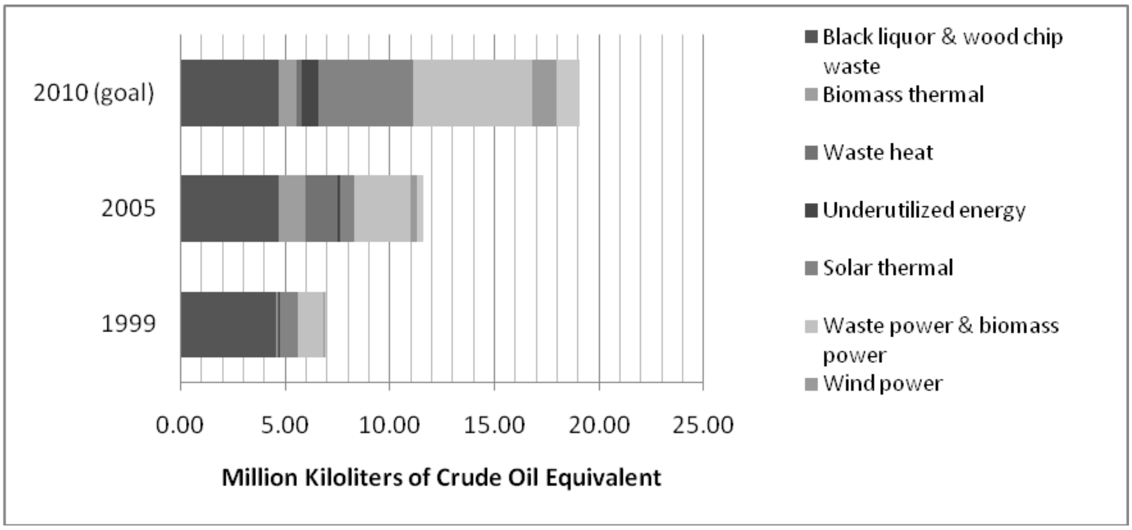
Figure 10.7: Japanese Government Funding for Renewable Energy



Source: (International Energy Agency, 2004b)

By international standards, government-sponsored renewable energy R&D programs in Japan are well-funded (IEA, 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 figure 10.7). Aside from wind turbine prototype testing in 1992-1993 (Inoue & Miyazaki, 2008), wind energy research has been largely ceded to private R&D initiatives.

Figure 10.8: The Dynamics of "New" Energy Generation 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.

Figure 10.8 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 figure 10.8 suggests 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).

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 (IEA, 2009). The Japanese RPS also has a "banking" mechanism which allows utilities to store credits for any renewable energy acquired that exceeds quota (ANRE, 2008b). Annual RPS quotas in terawatt hours are presented in Table 10.1.

Table 10.1: Annual RPS Generation Quotas (in TWh) in Japan, 2003-2014

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

Source of data: (IEA, 2009)

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).

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 & 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 worth noting that solar photovoltaic energy is accorded special treatment under this program. Each kWh of solar PV electricity that is purchased equates to 2 kWh generated by other renewable energy technologies (IEA, 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.

10.3.4 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.

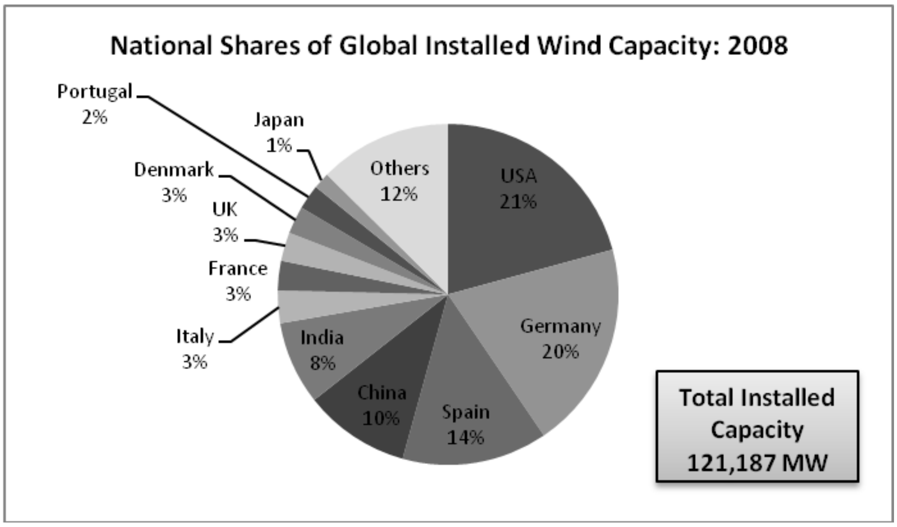
10.4 WIND POWER IN JAPAN: THE NUMBERS

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, Wong, Zhou, & Ziser, 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 (WWEA, 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 & Miyazaki, 2008). In short, despite Japan's geographical constraints, there is evidence of significant amounts of untapped wind power potential in Japan.

As Figure 10.9 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.

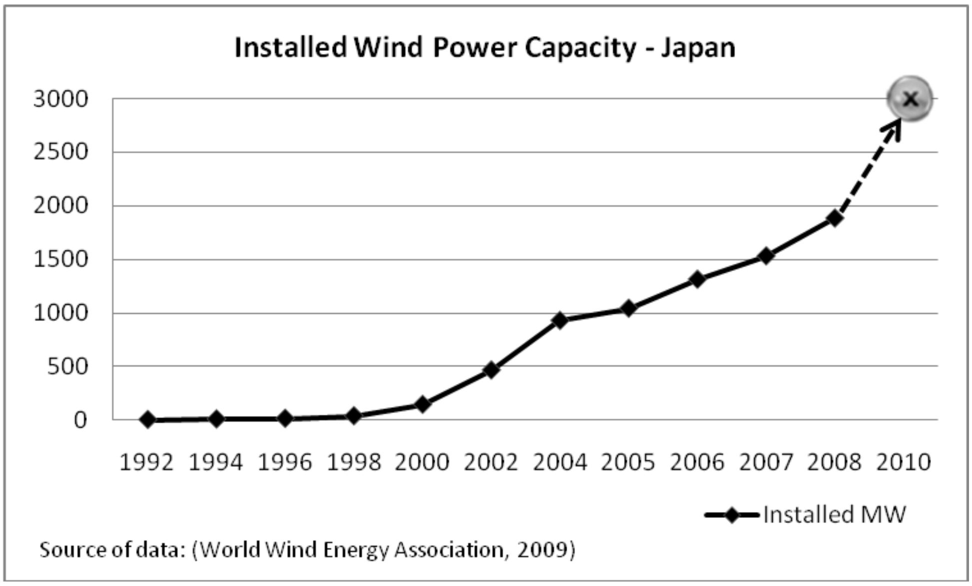
Figure 10.9: Wind Power Capacity in Japan – A Global Comparison



Source of data: (WWEA, 2009)

Figure 10.10 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 two years. As the trend line of Figure 10.10 demonstrates, if the pace of growth remains unchanged, Japan will likely fall short of its 2010 target.

Figure 10.10: The Past and Future of Wind Energy in Japan



Source of data: (World Wind Energy Association, 2009)

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% (IEA, 2008c). 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 technologies. Solar PV and biomass power generation will be 2.5 times greater than the power supplied by wind energy (ANRE, 2006). Moreover, hydropower generation will exceed wind power generation by a factor of 10 (IEA, 2008c). In short, even within the context of Japan's uninspired renewable energy programs, wind power underperforms. The next section examines why.

10.5 BARRIERS TO WIND POWER DEVELOPMENT

The ten regional utility monopolies in Japan are the gatekeepers 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 underpin utility resistance: i) cost disincentives, ii) operational inconveniences, and iii) strategic conflicts. These themes will be examined in turn.

10.5.1 Cost Disincentives

In Japan, electricity is sold to the end-consumer at a fixed price regardless of the generation technology used. The government acts in a regulatory role to ensure 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.

Table 10.2: Comparative Electricity Generation Costs in Japan

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%

Source: (ANRE, 2008a)

Given the importance of cost control for profitability, utilities are incentivized to favour the cheapest technologies. Table 10.2 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 come as no surprise that these three technologies supply over 80% of Japan's electricity (IEA, 2008c). 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 costly.

There is, however, reason to question the accuracy of the data presented in Table 10.2. 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 & 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.

- *10.5.1.1. 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 & Ishihara, 2007). In such areas, achieving a CLF of 24%-26% is common (Morthorst & 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 10.2. 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).

- *10.5.1.2. The Intermittency Question*

Stochastic power flows are widely regarded as the biggest hurdle facing wind energy diffusion today (Ackerman, 2005; Boyle, 2004; DeCarolis & 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 & 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 stochastic nature 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 stochastic power flows (Nagai, Yaga, & Ameku, 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 stochastic power flows are unfounded at current capacity levels.

10.5.2 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 stochastic power flows 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 three 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 1,000 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).

10.5.3 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 (FEPC, 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 & Miyazaki, 2008). Espousing unfounded concerns over technical hurdles or exaggerating cost disparities exemplify such resistance.

10.6 GRAND PLAN OR GROUP THINK?

The analysis presented in this case study 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 centred 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.

10.7 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) (Government of Japan, 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 policymakers to make economically optimised 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 (FEPC, 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 underway 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 industrialised 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 minimise 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 policymakers accept the challenge of laying the strategic 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.

Appendix 10.1: Significant Energy Conservation Initiatives 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.
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.
1979	Energy Conservation Law (AKA. The Law Concerning the Rational Use of Energy) - Mandated energy management programs in approximately 3,500 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 CO2 emissions.
1998	Further Revision to the 1979 Energy Conservation Law - Expanded the number of "designated energy management factories" to include medium-sized factories. Over 9,000 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 10.2: Significant Energy Efficiency Technology Initiatives in 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.

CHAPTER 11

WIND POWER DEVELOPMENT IN TAIWAN

Abstract
This chapter investigates a theme that is commonly encountered by policymakers in a number of policy settings - how can appropriate policies be developed when two (or more) seemingly valid, yet disparate scientific or technical estimates confound objective analysis? The study adopts the context of wind power development policy in Taiwan to demonstrate how to employ organizational analysis to identify factors which influence subjective assumptions underpinning disparate estimates of wind power potential and then demonstrates the application of two concepts from chaos theory – fitness landscapes and strategic real options – for guiding policymaking amidst the existence of technological dissent. In contrast to progressively declining subsidies that are commonly associated with fledgling renewable energy programs, this study introduces the concept of progressively escalating procurement rates to encourage the development of mature markets – in this case, the Taiwan wind power market.

11.1 INTRODUCTION

After a cursory review of Taiwan's energy situation and its national energy strategy, wind power appears to be an obvious candidate for fast-track development policies. Key objectives of Taiwan's national energy strategy include enhancement of domestic power generation capacity, minimization of power generation costs, stabilization of fuel-stocks cost, and reduction of CO_2 emissions leading to a target of 50% of 2000 emission levels by 2050 (TBOE, 2009b). With hydropower in Taiwan nearing maximum capacity, wind power is the only under-utilized utility-scale power source that possesses the attributes for meeting all these objectives. Yet, evidence indicates that the development of wind power in Taiwan has hit a plateau. Taiwan's only private wind power developer recently announced an intention to shift its operational focus to other national markets unless the government takes measures to improve the unprofitable business conditions for wind power in Taiwan (Lu & Ko, 2009).

As the reader will learn, estimating wind power potential in Taiwan is a contentious issue. On the one hand, the Taiwan Power Company (Taipower) – Taiwan's public utility – estimates that wind power potential is moderate; and as a result, it prioritizes other technologies and other policies for achieving national strategic energy goals. On the other hand, Infravest – a private wind power developer – contends that wind power potential is much greater than Taipower estimates and harnessing this potential could contribute significantly to achieving national strategic energy goals. The theme of this chapter centres on the challenge of developing policy when confronted with two disparate technical estimates that both appear to be based on sound reason and judgment. Although the context of this case study centres on wind energy policy, the challenge of developing sound policy when two (or more) seemingly valid, yet disparate scientific or technical estimates confound objective analysis is relevant to policymakers in all fields.

One of the key contributions that this study aims to make is to demonstrate how techniques attributable to chaos theory can be applied to the resolution of political deadlocks caused by dissenting yet equally plausible scientific evaluations. The study also contributes to the propagation of knowledge for fostering renewable energy capacity expansion through policy instruments by introducing a new policy application for development subsidies. Development subsidies are typically seen as mechanisms for supporting the development of renewable energy technologies that are not yet commercially viable. Under such circumstances, an effectively managed incentive system incorporates mechanisms for gradually *reducing* the subsidy in order to encourage developers of renewable energy technologies to innovate and minimize costs. In this study, a strategically managed procurement rate program is put forth as a mechanism for supporting market development of a mature technology, wind power. In this new application, the procurement rate program incorporates a mechanism for gradually *increasing* the rate in order to incentivize development of sites deemed commercially unviable under the old rate.

In considering challenges to implementing the development subsidy recommended in this chapter, the study concludes with an examination of the concept of *strategic intent* which is a strategic management concept that advocates the importance of structural realignment to support changing strategy. In Taiwan's case, Taipower's strategic behaviour to date has been entirely consistent with the government’s mandate to enhance national energy security. If the government wishes to encourage Taipower to aggressively support the expansion of wind power capacity, it must re-align Taipower's strategic objectives and redesign incentive programs to encourage a more aggressive approach to seeking out new wind power sites.

The format of this chapter is as follows. Section 11.2 outlines Taiwan's energy situation. It provides an overview of the power generation industry, describes the industry structure, summarizes strategic challenges relating to energy governance and describes some of the programs designed to meet these challenges. Section 11.3 provides an overview of wind power in Taiwan and analyzes two disparate estimates of realizable wind power potential. The analysis attempts to explain why these estimates differ and how this influences the policymaking process. Section 11.4

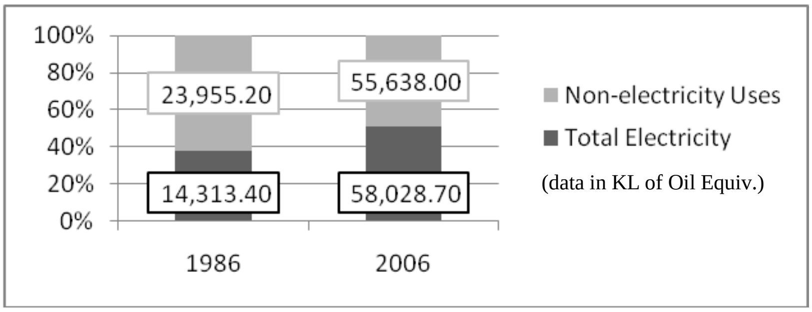
provides advice for Taiwan's energy policymakers in regard to how to proceed with wind energy policy development in the face of conflicting wind power potential estimates. In this section concepts are borrowed from chaos theory to steer the policymaking process. In section 11.5, the recommendations put forth in section 11.4 are discussed in relation to Taiwan's current development incentivization program. The discussion reveals how a new subsidy program could be effectively appended to Taipower's current approach. Finally section 11.6 concludes with a summary of lessons that policymakers and analysts can glean from the Taiwan story.

11.2 TAIWAN’S ENERGY SITUATION

11.2.1 Market Overview

With just under 23 million living on a 32,000 km² island, Taiwan is one of the most densely populated nations in the world. It is also one of the world's most affluent nations with a per capita GDP of US$31,900 (PPP) in 2008 (CIA, 2008). The combination of a highly concentrated, affluent population and an expansive industrial sector has inauspiciously fuelled Taiwan’s ascension to become the world's third highest per capita consumer of electricity (TBOE, 2005), mushrooming from 2,871 kWh / person in 1986 to 9,977 kWh / person in 2006 (TBOE, 2007). Despite its comparatively small population size, Taiwan was the 17th largest national consumer of electricity in the world 2008, with aggregate electricity consumption of 233,000 GWh (CIA, 2008). Furthermore, as Figure 11.1 illustrates, due to a proliferation of electricity-intensive industries, energy consumed for power generation is playing an increasingly dominant role in Taiwan's energy profile.

Figure 11.1: The Expanding Role of Electricity in Taiwan's Energy Profile



Source: Taiwan Bureau of Energy (TBOE, 2007)

Taiwan is heavily dependent on imported fuel-stocks for power generation. Aside from electricity generated through hydropower and co-generation, the remaining 81.1% of electricity generated in 2006 employed imported fuel-stocks.

Table 11.1: Taiwan’s Evolving Electricity Mix

KL of Oil Equivalent					
	1986		***2006***		**Average Annual**
Source of Electricity	**KLOE**	**%**	**KLOE**	**%**	**Growth Rate**
Conventional Hydro	652	5%	727	1%	0.60%
Coal-fired Thermal	4,686	33%	22,821	39%	8.24%
Oil-fired Thermal	1,777	12%	4,798	8%	5.09%
LNG-fired Thermal	-	0%	8,270	14%	-
Nuclear Power	7,195	50%	11,170	19%	2.22%
Solar and Wind Power	4	0%	20	0%	8.28%
Cogeneration	-	0%	10,224	18%	-
Solar Thermal	-	0%	0	0%	-
TOTAL	**14,313**	**100%**	**58,029**	**100%**	**7.25%**

Source: Taiwan Bureau of Energy (TBOE, 2007)

Although imports of coal have risen significantly in the 20-year period 1986-2006, growth in oil imports have slowed due to government efforts to replace oil-fired power with LNG-fired power. In terms of low-carbon power sources, national hydropower capacity has nearly reached peak potential, nuclear power capacity is expected to increase by 2.7 GW in 2011 when Taiwan's fourth nuclear power plant commences operation (TBOE, 2009b) and renewables (solar and wind power) have been slow to develop as utility-scale power sources (TBOE, 2007) (Table 11.1).

The nation's reliance on fossil fuel energy for power generation (61.9%) fosters two noteworthy problems for Taiwan's energy policymakers. Firstly, the volatile nature of fossil fuel prices destabilizes industrial strategy and erodes corporate profitability. To date, such adverse impacts have been side-stepped by government regulatory refusal of Taipower appeals to pass along cost increases to end-consumers (Hsin-Chin Shih, 2007). However, due to significant amplification of fossil fuel costs over the past three years, Taipower has suffered increasingly large financial deficits which must be reconciled through a drawdown of reserve capital. Losses of NT$23.25 billion (US$705 million) in 2006, NT$330 billion (US$10 billion) in 2007 and NT$130 billion (approximately US$4 billion) in 2008 have severely depleted Taipower’s capital reserves thereby impairing financial well-being and raising concerns of insolvency, prompting Taipower's Vice-president of Finance Wen-Kuei Tsai to quip “If we close, who is going to supply electricity to the nation?" (Ho, 2007). The second problem related to Taiwan's reliance on fossil fuels is that Taiwan's per capita carbon dioxide emissions are enormous. In 2006, per capita CO_2 emissions in Taiwan (13.19 tonnes per capita) were the third-highest in the world behind only Australia (20.58 tonnes) and the United States (19.78 tonnes) (Tchii, 2009). As Taiwanese President Ma Ying-Jeou asserted in a 2008 World Environment Day speech, although Taiwan is not a member of the UN, nor a signatory to the Kyoto Protocol, Taiwan has an obligation to the international community to take the matter of decreasing greenhouse gas emissions seriously.

11.2.2 Industry Structure

Responsibility for the generation, transmission and distribution of electricity in Taiwan has been historically vested with Taipower which is a public monopoly.

Virtually all transmission and distribution lines in Taiwan are installed and owned by Taipower (K. M. Wang, 2006).

End-user electricity pricing is fixed by government energy regulators after consulting with Taipower and taking into consideration global energy pricing trends and the competitive needs of domestic industry. As suggested earlier, Taipower faces extreme consumer and political antipathy regarding appeals to pass along cost increases to end-consumers. Consequently, between 1983 and 2006 electricity prices in Taiwan were held unchanged. In July 2006, Taipei was allowed to raise its rates by 5.8% in order to compensate for increased fuel costs (L. Wang, 2008). Two subsequent price increases of 12.6% in July and October of 2008 have done little to attenuate operating losses. Table 11.2 indicates the extent to which electricity is underpriced. As the table illustrates, the shortfall between average cost and retail price in 2008 amounted to 1.85 US cents per kilowatt hour (kWh). With 233,000 GW hours of electricity consumed in 2008, this represents an aggregate operating margin deficit of US$4.255 billion. It is, however, worth noting that the cost estimates from Taipower in Table 11.2 are indicative of the politicized nature of energy pricing in Taiwan. Taipower claims that the cost of advanced nuclear power in 2008 was US¢1.88 / kWh. Given that advanced nuclear power was estimated at US¢4.9 / kWh in the US in 2007 (Sovacool, 2008a) and advanced nuclear power in Japan cost approximately US¢6.4 / kWh in 2007 (FEPC, 2008), this estimate is of dubious accuracy if it entails the total capitalised cost of advanced nuclear power. Nevertheless, although there is reason to doubt the accuracy of the nuclear cost estimate, the overall cost estimate and the average end consumer prices which provide support for the contention that Taipower is operating in deficit are subject to external auditing; and as a result, they are reliable.

Table 11.2: Cost and Retail Price of Electricity in Taiwan in 2008[18]

Electricity Source	Cost in US¢ per Kilowatt Hour*
Oil	15.33¢
Natural Gas	17.82¢
Coal Power	5.67 ¢
Nuclear (Advanced technology)	1.88 ¢
Overall Cost per kWh for Taipower in 2008:	8.82¢/ kWh
Average End Consumer Price:	6.97¢/ kWh
Average Gross Margin Deficit per Kilowatt Hour:	1.85¢/ kWh

*Calculated using the following exchange rate: NT$33/US$1

Executives at Taipower face limited options for managing operational finances. Regarding retail price control, Taipower has to accept the prices set by government regulators. Regarding cost control over fuel-stocks, purchase prices of imported fuel-stocks are largely fixed through long-term supply contracts which are deemed necessary for supporting Taipower's main strategic remit to maintain a secure and reliable electricity supply[19]. Essentially, Taipower managers only have significant control over operating costs and capital equipment costs. Although government monopolies are infamous for cost inefficiencies, the recent financial deficits posted by Taipower are less attributable to operational inefficiencies than to the unenviable position of having to adhere to fixed retail prices when material costs are increasing.

In 1994, in an attempt to improve market efficiency, the government partially liberalized the electricity market. Under this initiative, the electricity market was opened to independent power producers (IPP) and Taipower was required to sign 25-year power purchase agreements (PPA) with these power producers (K. M. Wang, 2006). As Table 11.3 indicates, nearly one-third of Taiwan's electricity generation

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[18] This data was provided by Mark Chuang, Director of The Corporate Planning Department of Taipower through personal e-mail correspondence on May 23, 2009.

[19] Interview with Taipower executives on May 15, 2009

capacity now rests with IPPs. The success of the 1994 liberalization campaign is easily explained. Taipower is required to purchase electricity from IPPs at a price that equals the cost that Taipower incurs for generating electricity through similar technologies at its own facilities. Given the added costs associated with Taipower's mandate to ensure energy security, and with prices guaranteed for 25 years through PPAs, profits for IPPs are virtually guaranteed after winning contracts (Hsin-Chin Shih, 2007). Unfortunately, this system fails to introduce the requisite competition to encourage enhanced production efficiency at Taipower. In fact, diffusing power generation in this way likely undermines Taipower's economies of scale.

Table 11.3: The Expanding Role of Private Electricity Generation Capacity in Taiwan

TAIPOWER CAPACITY (MW)	*2000*	*2003*	*2005*	*2007*
Total Hydro	4,422.0	4,502.0	4,501.0	4,513.0
Conventional	1,820.0	1,900.0	1,899.0	1,911.0
Pumped storage	2,602.0	2,602.0	2,602.0	2,602.0
Total Thermal	17,819.0	17,886.0	19,231.0	21,016.0
Coal-fired	8,100.0	8,100.0	8,650.0	8,800.0
Oil fired	5,405.0	3,563.0	3,609.0	3,610.0
LNG fired	4,312.0	6,223.0	6,972.0	8,606.0
Wind	-	2.0	18.0	131.8
Nuclear	5,144.0	5,144.0	5,144.0	5,144.0
Total Taipower	27,385.0	27,534.0	28,894.0	30,804.8

IPP CAPACITY (MW)	*2000*	*2003*	*2005*	*2007*
Thermal	7,385.0	12,557.0	14,236.0	15,001.0
Cogeneration	*5,134.0*	*6,807.0*	*7,016.0*	*7,781.0*
IPP's	2,250.0	5,750.0	7,220.0	7,220.0
Hydro	-	8.8	10.7	22.2
Wind	2.6	6.1	6.1	55.9
Solar	0.1	0.5	1.0	2.4
Total Non-Taipower	7,387.7	12,572.4	14,253.8	15,081.5

TOTAL CAPACITY (MW)	2000	2003	2005	2007
Total Generation Capacity	34,772.7	40,106.4	43,147.8	45,886.3
Total IPP Share of Capacity	21.2%	31.3%	33.3%	32.9%

Source: (TBOE, 2009a)

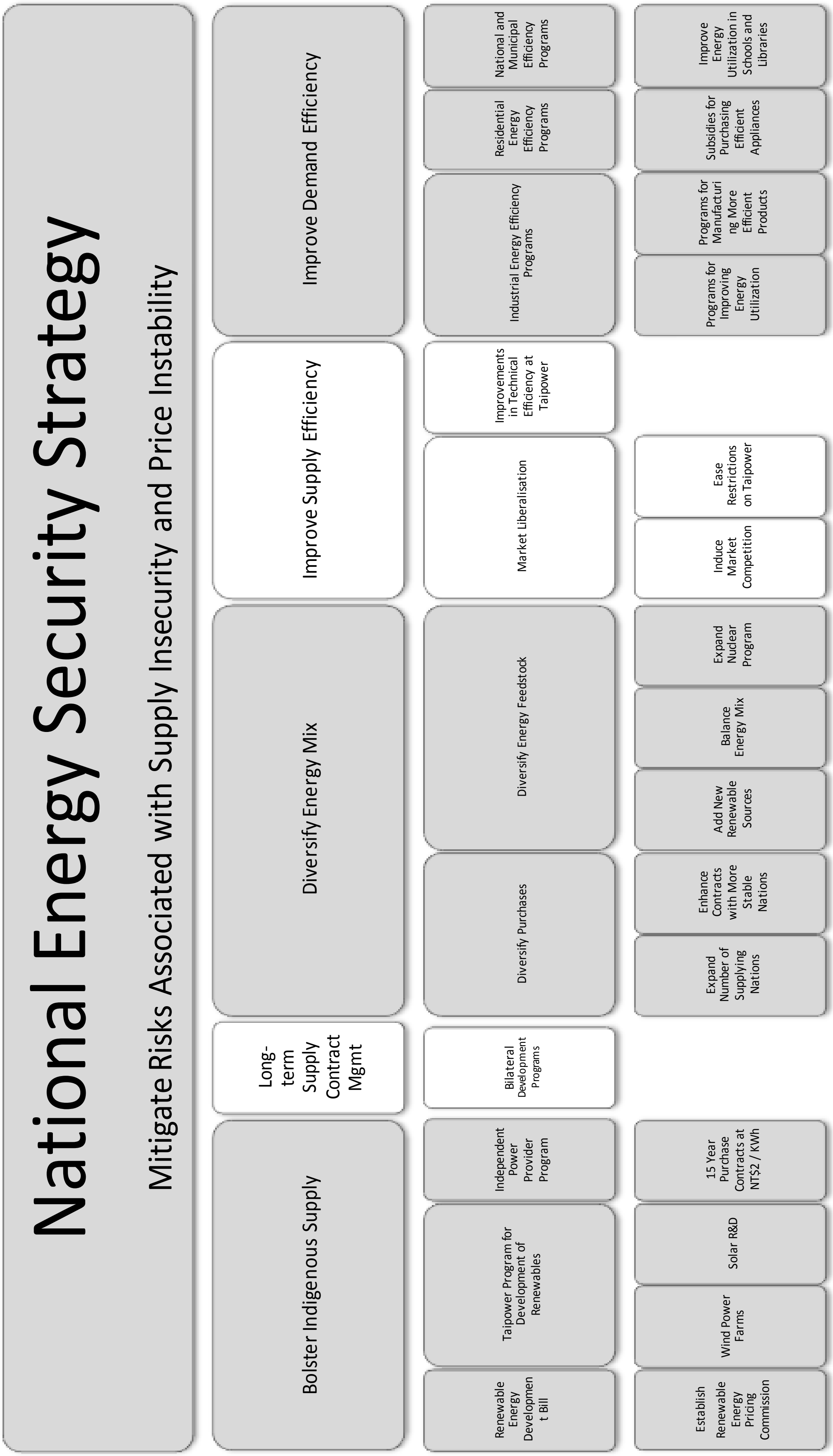
11.2.3 Present Strategic Challenges

Enhancement of national energy security dominates Taiwanese strategic energy policy. Taiwan's utter dependence on energy imports implies that adverse international energy market dynamics (over which Taiwan has no control) could deeply affect domestic socio-economic stability (Yue, Liu, & Liou, 2001). Broadly speaking, there are two overarching objectives guiding Taiwan’s national energy security strategy. Firstly, a series of strategic programs are in place to mitigate the risk of energy supply disruption. Secondly, strategic programs to mitigate the risk of energy price instability are also progressively unfolding. Figure 11.2 outlines the five main program streams which support these two strategic objectives. The figure also provides some examples of key initiatives which fall under each program stream.

The program stream most relevant to renewable energy developers involves efforts to bolster Taiwan's indigenous supply of energy because Taiwan's dependence on imported energy ranks with Japan and Italy as being amongst the most precarious in the world. There are three major initiatives underway to upgrade indigenous energy supplies.

The first initiative is the implementation of a Renewable Energy Development Bill that was finally passed in June 2009 after being mired in legislative debate for the past seven years (Tchii & Wang, 2009). The bill formalizes a subsidy program for renewable energy and establishes the legal basis for the creation of a pricing commission which will quantify procurement prices and purchase targets for each form of renewable energy.

Figure 11.2: Key Elements of Taiwan's National Energy Security Strategy



The second initiative strives to strengthen Taipower's renewable energy development programs. In the short-term, Taipower plans to further encourage wind power capacity development, aiming for an ultimate goal of 2159 MW of installed wind power capacity by 2010 (Lin et al., 2009). However, as Chi-Yuan Liang, an economist at Academia Sinica observes, achievement of this target is doubtful given that only 281 MW of installed capacity currently exists.[20] In the long-term, Taipower is investing in solar photovoltaic (PV) power research because it is believed that solar PV power has the greatest potential of all current mainstream renewable energy alternatives.[21]

The third initiative for enhancing domestic energy supplies entails augmentation of the IPP program. The government has proposed amendments to the Electricity Act which will make it easier for renewable energy providers to develop projects in Taiwan (K. M. Wang, 2006).

Another program stream of relevance to wind energy developers involves efforts to diversify Taiwan’s pool of national energy suppliers and the type of energy that is purchased. In terms of diversifying national suppliers, Taiwan aims to reduce its dependence on Middle Eastern oil which accounts for 80.8 % of its oil imports (TBOE, 2009b). In terms of diversifying the energy mix, Taiwan is attempting to facilitate a transition from oil to LNG for power generation (K. M. Wang, 2006). Moreover, the role of nuclear power in the power generation mix will be fortified when the fourth nuclear power plant comes online in 2011 (TBOE, 2009b). In terms of the role renewable energy will play in the diversified energy mix, Taiwan is aiming to increase

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[20] Source: Bloomberg New Service, “Energy Bureau Looking to Boost Wind-Power 10-fold”, 28 September 2007.

[21] Interview with Taipower executives on 15 May 2009.

the contribution that renewable energy makes to national power generation from 5.9% in June 2007 to 12% by 2020 (Lin, et al., 2009; TBOE, 2009b). While the bulk of current renewable capacity consists of hydropower (1922 MW of 2782 MW) (TBOE, 2008), wind and solar PV technologies are expected to contribute most to achieving the 12% target (TBOE, 2008).

The three other main program streams include initiatives to enhance efforts to improve right of access to foreign energy supplies, initiatives to enhance power generation efficiency at Taipower through technical upgrading and initiatives to improved demand-side power utilization. Although initiatives to improve energy efficiency are typically seen as most cost effective, perceptions that renewable energy capacity is limited (to be further elaborated upon in the next section), place even greater impetus on embracing aggressive energy efficiency goals. The current objective is to improve energy efficiency by at least 2% per year based on 2005 energy intensity levels with an aggregate goal of reducing energy intensity to 50% of the 2005-level by 2025 (Taiwan MOEA, 2008). Already there are a number of programs in place to encourage improved utilization efficiency in industry, the residential sector and government circles (Hsiu-Chuan Shih, 2008).

In addition to the strategic challenges related to enhancing national energy security, politicians and citizens alike are beginning to view Taiwan's high per capita CO_2 emissions as a national mark of shame. Taiwan has struggled with decoupling electricity growth from GDP growth. For the past 25 years, the economic and CO_2 emission growth rates have paralleled one another with both measures increasing by over 400% between 1980 and 2006 (Hsin-Chin Shih, 2007). Despite the fact that

Taiwan’s diplomatic status prevents membership in international climate change mitigation regimes, Taiwan's current President Ma Ying-jeou, in an address at the National Energy Conference held in April 2009, announced commitments to stabilize CO_2 emissions at the 2008-level between 2016 and 2020, reduce national CO_2 emissions to the 2000-level by 2025 and to further reduce that amount by 50% by 2050 (Tchii & Wang, 2009). Given Taiwan's massive dependence on fossil fuels, this is a bold initiative that will require significant structural adjustments to Taiwan's power industry.

11.2.4 Evaluation of Taiwan’s CO_2 Emission Reduction Challenge

In interviews with executives of the Taiwan Bureau of Energy (TBOE) and Taipower, there was general agreement that many of the initiatives for enhancing national security would also contribute to CO_2 emission reductions. Progress in improving supply-side generation efficiency and demand-side energy utilization can help to attenuate the aggregate amount of energy used; and in doing so, reduce related CO_2 emissions. Initiatives to diversify the energy mix can also lessen CO_2 emissions. In particular, reducing reliance on oil by enhancing contributions from nuclear power, renewable energy and LNG can facilitate sizable CO_2 emission reductions. However, executives at both the TBOE and Taipower were quick to point out that renewable energy potential was encumbered by land constraints and as such, the contribution that these technologies could make to CO_2 emission reduction was perceived to be marginal in comparison to improvements in energy efficiency or progress toward adopting a cleaner energy-mix profile.

Overall, there was a considerable amount of scepticism expressed by policymakers who were interviewed over the viability of achieving the President's penultimate CO_2 emission target of 50% of 2000-levels by 2050. A rough analysis explains the source of scepticism. Between 2000 and 2007, power generation capacity expanded by 32% (from 34,772 MW to 45,886 MW) to accommodate escalating power demands. If growth trends continue at a similar pace, over 240,000 MW of installed capacity would be required by 2050. If we optimistically assume that Taiwanese initiatives to improve supply-side and demand-side energy efficiency resulted in a doubling of energy efficiency (which would be an unprecedented national achievement), Taiwan would still require 120,000 MW of installed capacity to meet electricity demands in 2050. Evaluating the contributions each clean energy technology could make to the 2050 capacity estimate (120,000 MW) provides insight into the amount of fossil fuel energy that would still be required to meet electricity requirements. Table 11.4 summarizes the growth potential for each clean energy technology. Based on estimates provided by executives of Taipower and the Bureau of Energy, the maximum potential capacity for clean electricity amounts to 58,000 MW.

Table 11.4: Growth Potential of Alternative Energy Technologies in Taiwan

Alternative Energy Technology	Max. Capacity Potential by 2050	Source of Estimate
Wind Power	3,000 MW	Taipower (assuming technology advances)
Solar, Geothermal, Tidal Power	3,000 MW	Bureau of Energy targets
Hydro power	5,000 MW	Extrapolation of growth trend
Cogeneration	30,000 MW	Optimistically assuming a 400% growth in capacity
Nuclear power	17,000 MW	Taipower estimate of capacity expansion potential for current sites (20 reactors)
TOTAL CLEAN ENERGY	**58,000 MW**	

This informal analysis tells us that if the estimates of potential are accurate and barring major technological breakthroughs, an additional 62,000 MW of installed fossil fuel generation capacity would be needed to cover our hypothetical 120,000 MW capacity requirement for 2050. Even if Taiwan were to fulfil this additional capacity requirement by utilizing only LNG-fired power (in order to minimize CO_2 emissions), CO_2 emissions from the thermal power plants under this hypothetical scenario would still be 30% greater than 2000-levels. As this hypothetical scenario illustrates, meeting the government's interim goal of reducing CO_2 emissions to 2000-levels by 2025 and the penultimate goal of reducing CO_2 emissions to 50% of 2000-levels by 2050 appear to represent Herculean challenges.

Whether or not Taiwan succeeds in its quest to meet its ambitious CO_2 emission reduction targets critically hinges on the accuracy of the maximum capacity estimates for each alternative energy technology represented in Table 11.4. As the above analysis indicates, if these alternative energy capacity estimates are accurate, then even the achievement of unprecedented gains in energy efficiency improvement will fail to come close to the established targets.

Perusing the capacity estimates presented in Table 11.4, the wind power capacity estimate appears to be particularly conservative. In terms of facilitating a transition away from fossil fuel energy, wind power is the proverbial "low hanging cherry" on the tree of options. Globally, wind power is now commercially competitive with LNG-fired and oil-fired power (DeCarolis & Keith, 2006; Morthorst & Awerbuch, 2009). If the cost of social and environmental externalities associated with fossil fuel combustion are factored into a cost comparison, wind power is also commercially competitive with coal-fired power (Sovacool, 2008a). Given the commercial viability of this clean energy resource, nations which are endeavouring to expediently bolster renewable energy capacity should strive to fully exploit the potential capacity of wind power. If wind power capacity in Taiwan could be expanded to capacity levels found in vanguard nations such as Denmark and Germany, 20-30% of total power requirements could be met through this one energy source. Accordingly, one of the crucial questions that should be asked in regard to renewable energy development in Taiwan is "*What is the reason for such a low wind power capacity estimate?*".

As this analysis of wind power policy in Taiwan will illustrate, in attempting to answer this question, a series of intriguing insights will emerge in regard to policy making amidst technical uncertainty. The Taiwan wind power story should encourage policymakers to consider how the existence or absence of technical information influences their policy realms. Moreover, the recommendations put forth for guiding policymakers in designing policy amidst uncertainty are strategic management techniques that can be readily adapted to policy design and implementation in any number of policy fields. In short, what follows is a story of wind power development in Taiwan, but application of the recommendations put forth is relevant to all policymakers.

11.3 WIND POWER IN TAIWAN

11.3.1 Market Overview

Government policy has significantly influenced the development of Taiwan's wind power industry. In May 1998, the government announced a renewable energy expansion plan aimed at boosting the renewable energy supply to 3% of total power generation by 2020 (Tsai, 2005). In March 2000, The Bureau of Energy announced a support program for wind power demonstration projects which included subsidies of up to 50% of the installation cost for wind power demonstration systems (up to a maximum subsidy of NT$16,000 (US$480) per kilowatt) (Huang & Wu, 2009). This catalyzed a number of wind power demonstration projects and by the end of 2003, installed wind power capacity amounted to 8.54 MW (Tsai, 2005). In 2002, the Renewable Energy Development Bill mentioned earlier was drafted which put forth policies to support more vigorous development of renewable energy projects (Wu & Huang, 2006). While the bill was being debated in the Executive Yuan, Taipower announced interim plans to offer 10-year energy procurement contracts at a contract price of NT$2 (approximately US 6.16¢) per kWh (Wu & Huang, 2006). The contractual period has been subsequently extended to 15-years (Lin, et al., 2009). This procurement program accelerated wind power capacity expansion. In 2004 alone, 18 MW of wind power capacity was installed.

Although the Renewable Energy Development Bill was finally approved in June 2009, the development of concrete incentives will take some time because an energy commission needs to be set up to consider appropriate pricing levels given Taipower’s precarious financial situation. In the meantime, Taipower's interim program for purchasing wind energy at US 6.16¢ per kWh is still stimulating development. Despite criticism that the purchase price of US 6.16¢ per kWh is too low to stimulate large-scale investment (Lu & Ko, 2009), wind power capacity in Taiwan continues to expand. As of 2008, there were 155 wind turbines amounting to 281.6 MW of installed capacity at various locations around Taiwan (see Table 11.5).

Table 11.5: Wind Power Facilities in Taiwan

Wind farm	**Developer**	**Number of Turbines**	**Total Capacity (MW)**
Penghu Jhongtun: Phase 1	Taipower	4	2.4
Shihmen (1st NPP)	Taipower	6	3.96
Hengchun (3rd NPP)	Taipower	3	4.5
Penghu Jhongtun: Phase 2	Taipower	4	2.4
Taoyuan Datan	Taipower	3	4.5
Taoyuan Dayuan- Guanyin	Taipower	20	30
Taichung Power Plant	Taipower	4	8
Taichung Harbor	Taipower	18	36
Changbin Industrial Park	Taipower	23	46
Hsinchu Siangshan	Taipower	6	12
Yunlin Mailiao	Formosa Heavy Industries	4	2.64
Hsinchu Chunfong	Cheng Loong Corp.	2	3.5
Miaoli Jhunan	InfraVest GmbH	4	7.8
Miaoli Dapeng	InfraVest GmbH	21	42
Changbin Lugan	Luway / InfraVest GmbH	33	75.9
TOTALS		**155**	**281.6 MW**

Source: (TBOE, 2008)

In addition to current installations, 230 onshore wind turbines sporting combined capacity of 467.8 MW are now at various stages of planning or construction (see Table 11.6).

Table 11.6: Wind Power Onshore Facilities under Development in Taiwan

			Share of total capacity (in MW)	
Stage of Development	Number of Projects	Total Capacity (MW)	*Taipower*	*Private Sector*
Planning	119	239.5	*70.8*	*168.7*
Consent	71	149.5	*68*	*81.5*
Construction	40	78.8	*35.1*	*43.7*
TOTALS	230	467.8	*173.9*	*293.9*

Source: (TBOE, 2008)

Additionally, Taiwan's first offshore wind power development which will total 300 MW of wind power capacity has recently been ratified by the Executive Yuan and is now in the initial stages of planning. When these projects are completed, Taiwan will be able to boast a total installed wind power capacity of 1049.4 MW (TBOE, 2008).

As a result of these positive developments, the Taiwanese government has raised its long-term target capacity target for renewable energy to 10% of total electricity capacity by 2010 and 12% of total electricity capacity by 2020 (TBOE, 2009b). The anticipated contribution from wind energy has been estimated at 2159 MW of installed capacity by 2010. This amounts to 42% of the 2010 target for renewable energy (5130 MW). Coupled with the current installed capacity for hydropower of 1911 MW (see table 11.3), wind and hydropower together are expected to account for 79% of installed renewable energy capacity in 2010 (Lin, et al., 2009).

In terms of aggregate national wind power potential estimates, excellent wind potential can be found along Taiwan's western coastline, its southern peninsula and several small surrounding islands. These areas are characterized by wind speeds that are greater than 4 m/s at 10 m above ground (Chang, et al., 2003). Moreover, many prospective sites in Taiwan feature between 3000-3500 hours per year of harvestable wind.[22] Unfortunately, the majority of Taiwan's population resides along the western coastline. Therefore, although technical potential for wind energy in Taiwan may be high, competing land uses severely limit exploitable capacity (Yue, et al., 2001).

Estimates of wind power potential for Taiwan are both disparate and contentious. Taipower, for example, estimates that total *technical* potential for wind energy in

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[22] Interview with Chun-Li Lee, Senior Specialist, Taiwan Bureau of Energy on May 13, 2009.

Taiwan is 4600 MW of onshore potential and 9000 MW of offshore potential. However, when factoring in current land-use restrictions, the economic viability of siting wind turbines in various locations and competition for development, Taipower contends that only a portion of total technical potential is currently realizable and that realizable potential is somewhat malleable because improved economic conditions tend to enhance realizable potential. Taipower estimates that current realizable wind energy potential amounts to 1000 MW onshore and 1200 MW offshore after factoring in development limitations. This implies that the government target for 2010 of 2159 MW represents nearly full exploitation of realizable potential under current economic conditions. If Taipower's estimate for total realizable wind power of 2200 MW is accurate, full exploitation would amount to 4.8% of 2007's installed electricity generation capacity (Table 11.3: 2007 data). Moreover, when the projects that are currently in development are finally completed, 75% of onshore realizable potential and 25% of offshore realizable potential will have been exploited.

On the other hand, Karl-Eugen Feifel of Infravest (Taiwan's only private wind power developer) estimates that 3000 MW of onshore wind power and 5000 MW of offshore wind power could be feasibly *realized* if Taipower increased its wind power procurement rate from the current level of US6.06¢ per kWh to US12.12¢ per kWh. This procurement rate would still be considerably less than the rate at which Taipower generates oil-fired power, which is 15.33¢/kWh (Table 11.2). Infravest contends that procurement rates that exceed US8.48¢ per kWh would begin to make inland projects financially viable and intensify project activity. If Infravest's estimate for total realizable wind power of 8000 MW is accurate, full exploitation of all wind power potential would amount to a robust 17.4% of 2007's total installed electricity generation capacity. Under Infravest's projections, when the projects that are currently in development are finally completed, only 25% of realizable onshore potential and 6% of realizable offshore potential will have been exploited.

The importance of wind power in contributing to Taiwan's CO_2 emission reduction efforts varies significantly depending on which of these two estimates best approximates reality. Moreover, the nature and intensity of government policies for expediting wind power expansion would likely differ depending on which estimate is accurate. If the Taipower estimate of realizable potential is accurate, one could argue that Taipower has done a superb job of reducing the cost of wind power procurement while fostering capacity development programs that have nearly fully tapped onshore wind potential. In such a case, the main policy challenges going forward would be to: i) design an incentive system to encourage the development of offshore wind power projects which are typically more expensive to construct and, ii) sweeten the incentives for onshore wind power development in order to encourage developers to harness the remaining 25% of onshore potential which likely includes less financially lucrative wind farm sites. Conversely, if the Infravest estimate for realizable wind energy potential is accurate, a great deal of wind power potential remains untapped. Under this scenario, maximizing wind power capacity could contribute significantly to CO_2 emission abatement; therefore, the main policy challenge going forward would be to design bold development policies in order to amplify the pace of wind power development.

11.3.2 Evaluating Disparate Projections for Wind Power Potential

Table 11.7: Comparing Estimates of Realizable Wind Power Potential in Taiwan

	Technical potential (MW) (Taipower)	Realizable potential (MW) (Taipower)	% of technical potential	Realizable potential (MW) (Infravest)	% of technical potential
Onshore	4600	1000	21.7%	3000	65.2%
Offshore	9000	1200	13.3%	5000	55.6%
Total	13,600	2200	16.2%	8000	58.8%

In comparing Taipower and Infravest estimates of realizable wind power potential, the primary source of disparity appears to stem from differing assumptions made when deriving *realizable* potential from *technical* potential. As Table 11.7 illustrates, if one were to assume that the Taipower estimates for *total technical potential* are reasonably accurate, as we have assumed in this paper, the *realizable* potential estimates from Infravest are considerably bolder than the Taipower estimates. The most obvious reason why these estimates would differ stems from the economic assumptions each party makes because typically in wind power markets, higher procurement prices make previously unviable sites viable, thereby enhancing realizable potential estimates. Infravest's estimate for realizable potential is based on a specific end-price scenario (US¢12.12 per kWh) and reflects what Infravest believes is achievable if the government were to raise the purchase price for wind power. Although Taipower executives did not explain the rationale for their estimate of realizable potential, their estimate appears to be based on the current procurement price of US¢6.06 per kWh which even Taipower executives admit is too low. In short, the Taipower estimate appears to reflect a degree of insouciance toward wind power development. One possible explanation for this is that nuclear power expansion is both anticipated and supported by Taipower executives. Accordingly, wind power may be viewed as an added threat to the nuclear power development program which is already a hotly contested political issue. However, as the following paragraphs will illustrate, competing economic assumptions do not tell the whole story. Influences arising from disparate organisational characteristics also impact estimates of realizable potential.

Infravest’s first wind power project was in Germany. Executives in the firm possess extensive knowledge regarding the evolution of the German wind power industry. As such, projections for realizable wind power potential in Taiwan are likely influenced by the German precedent of how a wind power market can flourish under proper market incentives. Indeed, in an interview with Infravest Chairman Karl-Eugen Feifel, who is a German national, he specifically drew attention to the history of wind power development in Germany to emphasize how inland sites that typically exhibit inferior wind quality can develop in the presence of commercially attractive development incentives. Experience with the evolution of the wind power market in Germany also provides Infravest with one other insight regarding the nature of wind power development. In Germany, commercially attractive development incentives encouraged German farmers to organize cooperatives to invest in wind turbines as a secondary source of income from existing farmland (Komor, 2004). This phenomenon enhanced the amount of *realizable* potential because it added a number of existing agricultural plots to the pool of prospective sites. Typically, conservative estimates of realizable potential would exclude such land that is already reserved for other uses. It is very likely, that Taipower's estimate of realizable potential has underestimated the potential for siting wind turbines on existing agricultural plots. Overall, it can be surmised that Infravest's estimate of realizable wind power potential in Taiwan is influenced by experience with developing wind power in other countries that may or may not be fully applicable for Taiwan.

Regarding Taipower's estimate, there is evidence to indicate that organizational characteristics induce conservative estimation of realizable wind power potential. One of the key mandates of public monopolies is to safeguard the public interest. Taipower's mandate is no different. Its priority is to enhance energy security. Accordingly, the ideological approach embraced by Taipower strategists is significantly different than the ideological approach that strategists from a private utility operating in a liberalized market would adopt. A comparison of probable strategic behaviour illustrates the relevance of this ideological difference for estimation of realizable wind power potential. The purported cost of LNG-fired power in Taiwan is US 17.82¢/kWh, while the procurement cost of wind power is set to equate with the cost of generating wind power at Taipower owned wind farms, US 6.06¢/kWh. A profit-seeking utility that is less concerned about enhancing energy security would seek to substitute wind power for LNG-fired power in order to maximize profitability. Assuming that the average wind turbine can generate 2190 hours of capacity power per year (applying an average capacity factor of 25%), for each 1000 MW of wind power capacity that replaces LNG-fired power, the utility would save US$257.5 million per year.[23] With cost savings of this magnitude, a profit-seeking utility would aim to maximize capacity expansion of wind power at the expense of LNG-fired power. For aggressive firms, this may threaten the integrity of the electricity grid because of the importance of LNG-fired power in supporting peak-

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[23] Based on the following equation: ((capacity factor x total hours in a year x total installed capacity in MW x x 1000) x (cost of LNG - cost of wind power)) which yields ((0.25 x 8760 x 1000 MWh x 1000) x (0.1782 – 0.0606)) = US$ 257.5 million per year.

load fluctuations. Wind power cannot serve the same function (Boyle, 2004). Conversely, Taipower has resisted such a substitution strategy because the forces which catalyze profit-seeking behaviour (i.e. lucrative bonuses and promotions based on profit maximization) are not the primary forces governing strategic behaviour at Taipower. Although Taipower executives may be somewhat incentivized to improve financial performance, they are primarily evaluated on performance in relation to preserving national energy security. This ideological difference influences Taipower's perspective on wind power potential because their strategic planners are less incentivized to ferret out all wind power development options. On the other hand, profit-seeking firms would be much more aggressive in identifying new sites to exploit and as such, would be more apt to produce more vigorous estimates of realizable potential.

Another organizational characteristic which likely dampens Taipower's estimate of realizable wind energy potential is a more conservative perspective on managing public opposition in comparison to the prevalent perspective at Infravest. Infravest largely views public opposition as a commercially resolvable hurdle. As the Chairman of Infravest pointed out in an interview, opposition to wind power developments are frequently resolvable through compensatory payments made to dissenting parties.[24] On the other hand, Taipower's perspective reflects the government's aversion to public antipathy. Public opposition to energy projects is something to be avoided if possible. These divergent perspectives on managing public opposition influence the estimation of wind power potential because a component of any realizable potential estimate includes assumptions regarding the amount of technical potential that could be

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[24] Interview of May 14, 2009.

harnessed without incurring public opposition. For example, during an interview with an official at the Bureau of Energy, it was mentioned that an environmental group had recently lodged an objection to offshore wind power development due to concerns that such developments could adversely affect the habitat of an endangered marine mammal, the white-beaked dolphin. The official pointed out that if the concern is validated, prohibitions to offshore wind power developments in certain areas may be inevitable.[25] Therefore, the Taipower estimate may exclude sensitive marine habitats, while the Infravest estimate might not.

Although there may be other ideological differences between Taipower and Infravest which further induce disparate assumptions upon which realizable wind energy potential is estimated, the examples provided above are sufficient for qualifying the nature of the two estimates. The Infravest estimate can be considered to be a best case scenario predicated on the assumption that the Taiwanese wind power market will respond similarly to the German wind power market if proper market development incentives are enacted. Meanwhile, the Taipower estimate can be considered to be a highly conservative estimate that has been significantly tempered by organizational characteristics which encourage guarded projections.

In summary, seeking to understand the ideologies guiding behaviour within an organisation sheds light on its strategic behaviour. In this case, such an analysis helps us to conclude that actual realizable wind energy potential in Taiwan is likely considerably more than 2200 MW projected by Taipower; however, it may not be as high as Infravest estimates, 8000 MW. What our analysis fails to do is to give us an

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[25] Interview with Bureau of Energy officials on May 13, 2009.

accurate indication of where actual realizable wind energy potential lies on this spectrum. Accordingly, it may seem logical on the surface to recommend that the government commission one or more additional independent studies of wind energy potential in Taiwan.

The problem with funding additional wind power potential studies is that the resultant estimates will likely be no better than the Taipower or Infravest estimates at predicting actual realizable potential. This is because the accuracy of such estimates is dependent on the nature of subjective assumptions made when estimating both technical potential and realizable potential. For example, in estimating technical potential, an estimate based on an assumption that the average rated turbine capacity in the future will be 4 MW (which is a reasonable assumption given that 5 MW and 6 MW systems are currently being produced) could wind up being 100% higher compared to an estimate which assumes the average rated turbine capacity will be 2 MW (which may be the most economical size in the future), depending on estimates made in regard to how many turbines are clustered together and what the spacing is between the turbines. Similarly, assumptions made regarding the degree to which technically feasible sites can actually be developed will have a huge impact on final capacity estimates.

Updating an older study of realizable wind energy potential in Taiwan serves to illustrate the impact that assumptions can have on final estimates. In 1999, the Taiwan Energy Commission (the predecessor of the Bureau of Energy) commissioned a study which concluded that there was 8046 km^2 of land in Taiwan graced with average wind speeds greater than 4 m/s at 10 m heights. In estimating onshore wind power potential, researchers assumed that the rated capacity of the average wind turbine would be 1.8

MW and that only 2.5% of 8046 km² could be earmarked for wind farms due to competing land uses, site impracticalities, land-use restrictions etc. In estimating offshore potential, the researchers concluded that 700 km² of coastal seabed in areas of suitable wind quality were accessible at depths less than 15 m. The researchers further estimated that only 10% of the 700 km² could be exploited due to practical constraints such as access limitations, interference with shipping lanes etc. In aggregate, the study concluded that there were 1667 MW of onshore wind power potential and 2333 MW of offshore potential (Yue, et al., 2001).[26]

If the 1999 estimate for onshore potential was recalculated under the assumptions that the average rated turbine capacity would be 3.6 MW (which is currently feasible), that the increase in turbine size would result in 33% fewer total turbines placed across the country and that 4% of the land exhibiting average wind speeds of greater than 4 m/s could be developed (which is the norm used in German calculations) (Yue, et al., 2001), the estimate for onshore wind power potential would increase from 1667 MW to 3574 MW.[27] Furthermore, if the 1999 estimate for offshore potential was updated to incorporate advances in turbine technology, reworking the calculations based on an average rated turbine capacity of 4 MW (the emergent norm for offshore turbines) would be reasonable. Moreover, due to advances in platform technology, revising the estimate of exploitable area from 10% to 20% of the 700 km² could be justified. Under these revised assumptions, the offshore wind power potential would be revised upward from 2333 MW to 6947 MW if we were to once again assume that the

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[26] It is interesting to note that in the decade that has passed since the Energy Commission sponsored this study, the assumptions regarding realizable potential have clearly become more conservative. The study concluded that total realizable wind power potential was 4000 MW. Taipower now estimates the total realizable wind power potential to be 2200 MW.

[27] Based on the following equation: (1999 onshore potential x proportional increase in rated turbine capacity x ratio of new turbines to old x proportional increase in estimate for exploitable land), which yields (1667 MW x 2.0 x .67 x 1.6).

increase in turbine size would result in 33% fewer total turbines placed across the country.[28] In short, a revised set of assumptions would increase the 1999 estimate of total realizable wind power potential in Taiwan from 4000 MW to 10521 MW. Under these revisions, Taiwan would be transformed from a nation with negligible wind power potential to a nation in which wind power could contribute significantly to national power generation.

The point of this illustration is not to introduce yet another estimate of realizable wind power potential in Taiwan, but to highlight the point that estimates of wind power potential are dependent on the nature of assumptions made in regard to the variables included in the estimates. In turn, such assumptions are heavily influenced by ideological biases and vested interests. So where does this leave Taiwanese policymakers who wish to have as accurate an indication as possible regarding realizable wind power potential in order to ascertain the contribution that wind power could make to a fuel import reduction and CO_2 emission reduction strategy and design appropriate policies to guide wind power expansion?

11.4 DESIGNING POLICY AMIDST UNCERTAINTY

The absence of a scientifically objective estimate for wind power potential places Taiwanese energy policymakers in the unenviable position of having to develop policies amidst an environment of uncertainty. As undesirable as this position may be, developing policy in an environment of uncertainty is a common challenge for policymakers. Although the elements of uncertainty may differ, policymaking almost

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[28] Based on the following equation: (1999 offshore potential x proportional increase in rated turbine capacity x ratio of new turbines to old x proportional increase in estimate for exploitable land), which yields (2333 MW x 2.22 x .67 x 2.0).

always occurs in complex, dynamic environments (Cohen, March, & Olsen, 1972). When developing strategies for complex, dynamic environments, insights from chaos theory can prove useful.

11.4.1 Fitness Landscapes

Eric Beinhocker (1999) describes a complex, dynamic business environment as being analogous to a geographic landscape (which he calls a "Fitness Landscape") that is constantly changing due to volcanic activity and plate tectonics. He posits that the task of accurately predicting where the tallest mountains will emerge (which is his analogy for a prime emergent market opportunity) is unfeasible due to the complexity of latent forces. Consequently, the best strategic approach for operating in a complex, dynamic environment is to utilize available information to predict areas of likely emergent activity (in his analogy this is accomplished by identifying geological conditions conducive to mountain formation) and prepare the firm for rapid response when opportunities do emerge. Applying this approach to the challenge faced by Taiwanese energy policymakers, a program could be implemented to stimulate wind power development and monitor the pace and scope of activity. Policymakers should then be prepared to enhance the stimulus measures should the pace or scope of activity fail to meet expectations. Given that the preferred policy instrument for stimulating wind power development in Taiwan has been a fixed procurement rate, it would be a logical extension of this policy to prime wind power development by increasing the procurement rate. The natural question that arises when pondering an increase in the procurement rate is, *What level of increase should be implemented?*

11.4.2 Real Options

Another perspective on developing strategy in complex, dynamic business environments provides guidance for addressing this question. Robert Grant (2005) in a leading textbook on strategic analysis describes a concept that he refers to as *real options*. A *real option* is essentially a risk mitigation technique for uncertain environments that is modeled upon the underlying principle of stock options. The idea is to limit risk exposure by implementing conservative programs that permit strategic forays into areas of promise without incurring full financial risk. As performance data emerge, managers begin to revise and reset strategic direction. The revised strategies catalyze new outcomes which are then evaluated and the process begins a new iteration.

A real options strategy is applicable to public policy circumstances in which a general program direction is understood to be desirable but the overall impact of program implementation is not fully predictable. An underlying premise of a real options strategy is acceptance that program implementation in complex, dynamic policy settings will never produce optimal results due to the confounding influence of unforeseen variables. Consequently, optimizing policy in such a policy setting is done by making small adjustments to the existing program as information emerges regarding performance of the program.

Examining what a real options strategy is not, helps to shed light on what it is. A real options strategy is not a workable approach for situations that require emergency response. For example, it would not be acceptable to test *potentially suitable* policy responses in addressing an outbreak of avian flu. A real options strategy is also not a "ready, fire… aim" strategy. Prior to implementing a real options strategy, extensive background research is required in order to develop the best possible policy design. With a real options strategy, there is clear initial direction; however, there is also an understanding that initial program implementation may not be the most effective solution. It is an "aim, fire, re-aim, fire" strategy. A real options strategy is also not a strategy that can be applied to situations involving dichotomous outcomes (i.e. live or die; pass or fail etc.) because such situations are optimized when the favoured outcome is produced - there is no scope for adjusting the policy to optimize the outcome. Lastly, a real options strategy is not a "satisficing" strategy which is deemed successful upon producing satisfactory results. Rather, a real options strategy is an iterative process that begins with an initial policy based on best available data and then progresses to a performance evaluation stage which subsequently lead to program refinements in order for the cycle to begin again. It seeks to produce optimal results over time.

11.4.3 Applying Chaos Theory to Wind Power Development Policy

Relating the concept of real options to the challenge of establishing new higher wind power procurement rates, policymakers would be best advised to initiate a moderate increase that is high enough to capitalize new activity but not too high to significantly alter Taipower's cost base. It is time well spent to try and seek an optimized price for encouraging in-land development because for every 1000 MW of installed capacity, every US 1¢/kWh increase in procurement price will cost Taipower US$21.9 million in forgone revenue.[29]

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[29] Based on the following equation: (total installed wind capacity x annual operational hours x capacity factor x cent increase in procurement rate) which yields: (10^9 x 8760 x 0.25 x (.01)).

There are a number of possible methods for identifying a suitable procurement rate increase. One method of establishing a procurement rate that will catalyze inland development exploits Taipower’s own competency in wind power development. Taipower could establish an inland wind farm of its own in order to ascertain its cost and then base the revised procurement rate on this cost. A rough projection based on feedback from interviews indicates that the cost of generating wind power from an inland site plus the addition of a small mark-up to induce private development suggests a wind power cost of approximately US 9.09¢/kWh, which is 50% higher than the current procurement rate. Given that procurement prices in countries such Germany, Belgium Portugal, France and Spain all exceed US 12¢/kWh[30], an initial increase to US 9.09¢/kWh would represent a conservative “real option” adjustment that will catalyze new development.

Monitoring systems should be established prior to implementation of the initial procurement rate increase in order to evaluate performance of the enhanced rate (Mallon, 2006). Tracking the growth rate in applications for wind power development permits might be the best benchmark for monitoring the effectiveness of the new procurement rate. When applications for wind power development permits begin to exhibit a trend toward unabated decline (i.e. six months of progressive decline), it indicates that a further increase in the procurement rate may be required to encourage accelerated development. However, as was the case with the initial procurement rate increase, any additional increases should not be too excessive because a slowdown in wind power development permits may also indicate that the market is nearing saturation. Only by gradually sweetening the procurement rate can policymakers

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[30] European feed-in tariff estimates taken from a PowerPoint presentation of Infravest (9 February 2009).

unconditionally confirm whether the wind power market is slowing due to profitability constraints or capacity constraints.

The reason that a real options strategy is well-suited to wind power market development stems from the manner in which wind power markets typically evolve. In new wind power markets, developers begin by exploiting the most financially attractive sites first. Typically, coastal sites which are blessed by high quality wind and which lay in closest proximity to a grid connection are developed first (Wizelius, 2007). The wind power market continues to expand as developers exploit all viable sites where revenues earned exceed operating costs plus required rates of return. Eventually a first stage of saturation is reached wherein the commercially attractive sites have been fully developed leaving only unprofitable sites for future development. At this stage, in the absence of economies of scale or technological developments which reduce project costs, further subsidies become necessary to catalyze market expansion. Increasing the procurement price represents such a subsidy. Once all the commercially attractive sites at this higher level of subsidization are fully developed, the cycle once again slows. In wind power markets around the world, the sequence of development typically begins with coastal sites that boast superior wind quality followed by coastal sites with less superior wind quality, then inland sites and finally offshore sites (DeCarolis & Keith, 2006; Wizelius, 2007). Since wind power markets typically evolve in commercially viable stages, programs which introduce progressively higher procurement rates are effective at controlling costs while stimulating activity.

11.5 INTEGRATION WITH THE CURRENT STRATEGY

Auspiciously, the foundation for an effective development incentive system is already in place in Taiwan. As described earlier, Taipower already offers wind power providers US 6.06¢/kWh for wind power generated and this has cost effectively incentivized initial development. Although even executives at the Bureau of Energy who were interviewed for this study admitted that US 6.06¢/kWh may now be too low given current market dynamics, establishing this low rate of procurement catalyzed development of the most commercially viable wind power sites. Although it may be true that US 6.06¢/kWh is now too low to facilitate inland wind power projects, it is undeniable that Taipower's procurement policy to date has benefited the public by positively contributing to Taipower's bottom line. Assuming that Taipower's cost of producing wind power at its wind farms is at least equal to the cost at which it procurers wind power from private providers (US 6.06¢/kWh)[31] and assuming that the average wind turbine provides 8760 hours of operational wind power each year at a capacity factor of 25%, wind power contributed at least US$5.6 million to Taipower's gross margin in 2008.[32]

Emerging signs that the most financially attractive wind power sites have been developed indicate that the time might be right for increasing the procurement rate. With 281.6 MW of installed wind power capacity and another 467.8 MW of wind power capacity at various stages of planning and development, onshore wind power capacity in Taiwan will reach 75% of the total realizable potential estimated by

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[31] Recently, a television reporter quoted the President of Taipower as informally stating that Taipower's cost for generating wind power was NT$1.68 / kWh (US 5.09¢/ kWh).

[32] Based on the following equation: (total 2008 installed wind capacity in kWh x annual operational hours x capacity factor x (average retail price of energy - average cost of wind power)) which yields: ((281,000) x 8760 x 0.25 x (.0697-.0606)).

Taipower. Incentives are needed to encourage offshore developments. Moreover, even officials from the Bureau of Energy have acknowledged that 6.06¢/kWh is too low to encourage development of less profitable inland wind power projects (or more costly offshore projects).[33] Finally, Taiwan's only private wind project developer has taken the extreme measure of publicly denouncing the current procurement price as an impediment to development. It has indicated that unless the current procurement rate changes, it may be forced to consider shifting development plans to other markets.

A hypothetical example which assumes a modified procurement rate of US 9.09¢/kWh serves to illustrate the financial benefits that such an increase could have for Taipower. If 3000 additional MW of wind power capacity (in-land and offshore) could be developed as a substitute for oil-fired power which the government wishes to phase out[34], the resultant cost savings would amount to US 6.24¢/kWh (cost of oil @ US 15.33¢/kWh – cost of wind @ US 9.09¢/kWh). Assuming that the new wind power facilities provide 8760 hours of annual power generation and a capacity factor of 25%, the addition of 3000 MW of wind power capacity would generate 6.57 billion kWh of electricity each year. At a cost savings of 6.24¢/kWh, the switch would save Taipower US$409,968,000 per year.

Admittedly, increasing the procurement price to US 9.09¢/kWh will eventually result in cost increases for procurement of wind power at existing wind power installations. However, this represents a negligible cost given the US$410 million which will be

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[33] Anonymous interviews with senior officers of the Bureau of Energy May 13, 2009.

[34] In addition to government intentions, it is the contention of this author that current capacity of oil-fired power (3600 MW) is not necessary for supporting peak fluctuations due to the sufficient capacity in hydropower (4513 MW), LNG-fired power (8606 MW) and cogeneration power (7220 MW) which together account for approximately 45% of Taiwan's total power generation capacity.

saved by switching from oil to wind power. Even if all existing wind power procurement contracts were renegotiated at the new rate of US 9.09¢/kWh, the overall cost increase to Taipower would amount to less than US$19 million. Clearly, absorbing a cost increase of US$19 million for the prospect of saving US$410 million represents a trade-off that any organization would accept. In reality, it is believed that the current procurement system contractually locks in purchases at the rate of US 6.06¢/kWh for 15 years. Accordingly, in practice, a rate increase will not increase costs associated with existing wind power installations until this contractual period ends.

11.6 POLICY LESSONS LEARNED

11.6.1 Scientific and Technical Studies as Strategic Tools

For policymakers in general, the Taiwan case study serves as a reminder that scientific and technical studies that are frequently commissioned to guide decision making are rarely objective. We saw how two technical estimates dealing with a common theme (the realizable potential of wind power) differed significantly due to incommensurable subjective assumptions upon which the estimates were based. Consequently, although this is not a new insight for policy experts, it serves as an important reminder that policy evaluation is frequently a continuation of politics by other means (Bovens, Hart, & Kuipers, 2006). For agents of change who are seeking to overcome opposition from vested interests, seeking to master the strategic applications of scientific and technical studies improves one's capacity for persuasion. For policymakers who are seeking transparency in decisions which impact the public, the case reminds us that efforts should be made to explicate the assumptions upon which scientific and technical studies have been carried out.

The Taiwan case also demonstrates how attempts to understand the organizational culture of a given organization can help to shed light on the nature of technical or scientific assumptions it makes to defend its strategic practices. The caveat for public policymakers who are developing policies based on internally generated scientific or technical studies should be obvious. Technical studies which are developed by public organizations may understandably be based on assumptions which are inherently conservative. Therefore, decisions based on these studies may not fully incorporate market reactions to initiatives based on the merits of these studies. Policymakers should endeavour to compare internally generated scientific and technical studies to privately commissioned studies in order to assess the extent to which organizational forces influence objectivity. If policymakers at the Bureau of Energy in Taiwan undertook such an exercise, the disparity between Taipower and Infravest realizable wind potential estimates might have been enough to encourage a more aggressive policy toward wind power development.

Finally, for policymakers in the field of energy, the case serves as a reminder that energy is a highly politicized field in which scientific and technical studies are regularly employed as strategic tools for defending ideological positions. Campaigns of misinformation have been highlighted as one of the most important contributors to public apathy over climate change (Hansen, 2008). In considering the nexus between Taipower's estimate for realizable wind power potential and its suspiciously low data on the price of nuclear power in Taiwan (Table 12.2), one cannot help but wonder if there are not political influences that taint both data sets. If policymakers are to counter misinformation put forth by entrenched vested interests (i.e. nuclear and fossil fuel advocates and lobbyists), formal communication strategies must be put in place to counter such propaganda. This further implies that policy campaigns for encouraging organizations in the energy industry to modify strategic behaviour would benefit from strategic use of scientific and technical studies.

11.6.2 The Real Options Strategy for Public Policy

The Taiwan case study provided insight into requisite conditions for applying a real options strategy in public policy. Primarily, it is effective in complex, dynamic policy settings where a general policy direction is indicated but existing information is insufficient for supporting the implementation of aggressive policies which are then left to run their course. Other requisite conditions include: 1) the policy challenge must be non-critical (i.e. not an emergency response) because a real options strategy assumes that the initial policy will likely be suboptimal, 2) performance of the policy must be measurable on a progressive rather than a dichotomous basis because continual improvement is the goal, and 3) organizational and structural elements need to be malleable enough to support continuous policy improvement. These conditions describe many policy challenges. Consequently, it is a strategic approach that is widely applicable in the policy world.

The Taiwan case study also provided some guidance on conditions which render real options strategies necessary. At some point during the lifespan of a policy, indications begin to emerge (usually from external sources) that the policy is potentially no longer appropriate. Amongst other reasons, indications of policy mismatch arise due to changing social dynamics, changing market dynamics, changes in ideology or even the emergence of data which indicate that the current policy may be either ineffective or misguided. In the Taiwan case study, social, commercial, and political changes catalyzed concern that perhaps the conservative wind power potential estimate upon which wind power development policy was predicated is considerably lower than actual realizable wind power potential. The emergent concern merits further attention because if actual realizable wind potential in Taiwan is significantly higher than Taipower projects, a robust wind power development program could substantially contribute to the achievement of desirable strategic objectives (improving domestic energy security, stabilizing energy prices, reducing CO_2 emissions etc.) and save millions of dollars in costs.

The case also demonstrated that in the presence of dissonance between a current policy position supported by vested interests and affected stakeholders, a real options strategy can mitigate opposition to change by producing tangible results which can be utilized to support a more comprehensive policy design. The history of policymaking has proven that it is easier to implement small programs than larger more expensive programs and it is easier to modify existing programs than to initiate new programs (Fischer, Miller, & Sidney, 2006; Salamon, 2002). Therefore, a real options strategy represents a formalized method for operationalizing policy insights which have stood the test of time. On a practical note, implementing a policy based on real options strategy also delivers an added benefit of allowing policymakers to modify policies based on actual experience in order to enhance effectiveness.

In closing, it is insightful to differentiate a real options strategy from social experiments, which are well-known in policy circles and exhibit some similar characteristics. A social experiment is similar to a real options strategy in that both attempt to validate policies based on actual performance. In social experiments, researchers segregate a given population into a treatment group and a control group. A policy is then applied to the treatment group and the impact that this policy has on the group is compared to the control group in order to determine the effectiveness of the policy. The main purpose of a social experiment is to determine whether or not applying a policy is superior to the status quo (or another treatment) according to a prescribed set of performance indicators (Cook & Campbell, 1979). A social experiment does not necessarily seek to improve the policy itself. Conversely, a real options strategy does seek continual improvement. The manner in which a real options strategy makes iterative adjustments to policies based on ongoing feedback represents a fundamental difference that distinguishes it from social experiment strategies. However, this difference does not preclude the strategies from being combined. Conceivably, a real options strategy could be implemented in a manner that utilizes social experiments to track the effectiveness of each progressive policy improvement. Although the time-consuming nature of this approach would limit application, combining the two approaches together would induce a degree of scientific rigor to the application of a real options strategy that would not otherwise exist. This perhaps represents a future challenge for enterprising researchers interested in social experiment methodologies.

11.6.3 The Expanded Use of Feed-in Subsidies

In renewable energy policy circles, feed-in subsidies are generally promoted as policy tools which can allow fledgling technologies to gain a foothold in an established energy market (Komor, 2004). When employed for achieving such an objective, experience has shown that feed-in subsidies should be gradually decreased over time in order to encourage innovation and cost reduction efforts on the part of parties who are developing the technologies. The feed-in subsidy implemented in Germany in the 1990s and subsequently amended in 2000 to reflect progressive cost improvements in renewable energy exemplifies the effectiveness of feed-in subsidies for supporting emergent technology (Komor, 2004).

The Taiwan case study presents an alternative application of feed-in subsidies. It was asserted in the study that a feed-in subsidy can be aimed at established technologies in order to encourage innovation and reinvigorate market development. When employed for achieving these types of objectives, the feed-in subsidy should be raised rather that lowered over time. Initial procurement rates should be established at levels which are just sufficient to encourage the development of projects in the most commercially viable areas first. As the most economically attractive developments reach saturation point, the procurement rate should be increased to encourage market players to develop areas which may not have been exploited under the lower procurement rate.

11.6.4 The Benefit of Conveying Strategic Intent

Overall, the Taiwan case also reminds us that the concept of *strategic intent* which is well-known in strategic management circles also applies to public policy-making. Strategic intent can be defined as a conscious attempt by strategists to structurally commit an organization to a clear strategic direction (Hamel & Prahalad, 1989). The value of doing this is that it consolidates understanding of organizational objectives and engenders commitment. For example, when Spanish conquistador Hernán Cortes landed in Veracruz, Mexico in 1519 with the intent of establishing a colonial settlement, he purportedly ordered the demolition of the boats which had carried the settlers. By removing the strategic option of giving up and leaving, he effectively committed the settlers to establishing an effective colony.

Critics of the concept of strategic intent warn that the strategy must be employed cautiously because in competitive environments the act of revealing one's strategy can allow competitors to exploit strategic weaknesses (Bartlett, et al., 2003). However, in public policy, the benefits associated with clarifying policy direction far overshadow the threats associated with exposing policy intents to those who may oppose the policy because effective coordination of stakeholders is frequently a requisite for policy success (Salamon, 2002).

In the case of Taiwan, although there has been talk about radically reforming Taiwan's energy markets and President Ma has publicized a political commitment to reduce CO_2 emissions to 50% of 2000-levels by 2050, there is a conspicuous lack of strategic intent to support achievement of such aspirations. If the goal is to encourage the emergence of a carbon-free energy sector, stakeholders must be incentivized to achieve such a goal. For example, new incentives should be devised for Taipower to encourage a prioritization of renewable energy capacity development. Barring the introduction of new incentives, Taipower will continue to do the exemplary job it has done in the past of securing Taiwan's national energy security. Similarly, incentive systems need to be designed to encourage market players to proactively seek out new sites. Admittedly, Taiwan is a nation that faces land constraints which place certain limits on the development of traditional renewable energy programs (i.e. biofuel initiatives, wind farms, applied title technology etc.). However, if incentives are significant enough, innovation will emerge and solutions will be found to facilitate a transition to more sustainable energy generation technologies.

CHAPTER 12

A STEP Toward Understanding Macro-Level Wind Power Development Policy Barriers in Advanced Economies

Abstract
Part 2 of this thesis examined wind power development in four economically advanced economies that exhibit phlegmatic progress in wind power development – Australia, Canada, Japan and Taiwan – with the objective of identifying impediments to wind power development in these nations. In this chapter, insights from all four cases studies are extracted and integrated into a STEP framework which summarises social, technical, economic and political forces that impede the pace of wind power development. The findings from the case studies lend general support to the widely accepted premise that implementation of economic policy instruments, which are designed to close the cost gap between wind power and entrenched fossil fuel power generation technologies, will enhance levels of wind power development. However, the findings also suggest that social, technical and political barriers can also impede the pace of wind power development. The conclusions of this analysis are two-fold. First, failure to mitigate all STEP forces may undermine the efficacy of any given economic policy instrument that aims to close the cost gap between wind power and entrenched generation technologies. Second, efforts to mitigate these impediments might represent a strategy for achieving better policy results with less government financial commitment.

12.1 INTRODUCTION

International negotiations aimed at reducing greenhouse gas emissions to mitigate advanced levels of global warming have been characterized by ideological chasms that are so wide they have begun to resemble a circular debate between schoolboys concerning which flavour of ice-cream is truly the greatest in the galaxy. Yet, there is one area of common ground. Leaders of virtually every nation share a concern that replacing fossil fuel-based electricity technologies will adversely impact national economic well-being. As former UK Prime Minister Tony Blair summarizes, "*The* *blunt truth about the politics of climate change is that no country will want to sacrifice its economy in order to meet this challenge, but all economies know that the only sensible long term way of developing is to do it on a sustainable basis.*"[35] Leaders from key nations such as the United States, China, India, Canada and Australia have all publically bemoaned that a transition away from fossil fuel generated energy will impair the competitiveness of domestic industries in international markets (Hofman & Li, 2009; IGES, 2005; Weber & Peters, 2009). But is the phlegmatic pace of shifting to alternative energy technologies such as wind power really all about economics? Was Barrack Obama correct in his assessment of US energy policy that "*to truly transform our economy, protect our security, and save our planet from the ravages of climate change, we need to ultimately make clean, renewable energy the profitable kind of energy*"[36]? Or are there other obstacles which extend beyond the realm of economic rationality that inhibit the development of wind power, and if so what are they?

Comparing the costs of electricity generation technologies is a complicated, contentious exercise. The process of estimating current cost profiles critically depends on assumptions made regarding inputs such as the specific technological components to be used, future costs for fuel stock procurement, connection distance to the power grid, and capacity load factor estimates, to name but a few malleable factors. Emergent research suggests that, depending on assumptions made, wind power is not necessarily a more expensive technology in comparison to nuclear power, oil-fired power or gas-fired power (Blanco, 2009; DeCarolis & Keith, 2006; Morthorst & Awerbuch, 2009; Sovacool, 2008a). Moreover, the majority of research indicates that

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[35] Tony Blair, *Speech to the London G8 Climate Change Conference*, 1 November 2005.
[36] Barack Obama, *Address to Joint Session of Congress*, 24 February 2009.

if the external economic and environmental costs associated with the various forms of electricity generation were internalized, wind power would be an economically superior form of electricity generation even compared to coal-fired power (ATSE, 2009; Hirschberg et al., 2007; Sovacool, 2008a). In short, although there are no absolute claims that can be made when comparing generation costs across different technological platforms, there is evidence that cost disparity is not the only factor inhibiting wind power development.

This chapter seeks to contribute to a clearer explication of barriers to wind power development by summarising all barriers that were evident in the case studies on wind power development in Australia (Chapter 8), Canada (Chapter 9), Japan (Chapter 10) and Taiwan (Chapter 11).

To aid the identification and classification of barriers to wind power development in these nations, a STEP analysis was employed, wherein focused efforts were made to identify social (S), technical (T), economic (E) and political (P) factors that impinge on wind power development. In strategic management, a STEP analysis is a common tool for assessing exogenous influences on market development prospects (Grant, 2005); and as such, it was deemed a transferrable tool for evaluating wind power market development prospects.

A three-step coding approach was adopted for collating the data extracted from the case studies. First, all forces that could be identified as impeding development of wind power were extracted from each case study and background notes. Second, these forces were assigned to one of the four STEP categories. For example, reports that some communities in Japan opposed wind power development due to a predilection for preserving community aesthetics were assigned to the “social” category of the STEP analysis under the heading “community concerns over aesthetic intrusion”. Similarly, there were also reports that Taiwanese maritime groups opposed offshore wind power development due to concerns over adverse impact on fishing grounds. This observation was also listed under the “social” category under the heading “community concerns over adverse ecological impact”. Third, an attempt was made to reduce the total number of elements assigned to each STEP category by searching for commonalities of elements; and when identified, grouping the common elements into condensed categories. For example, the two social hurdles described above were combined under the condensed heading of “NIMBY concerns”.

The outline of this chapter is as follows. Sections 12.2-12.5 employ the STEP framework to summarize all the main hurdles to wind power development evident in the four case studies and background notes. This represents step two of the coding process described earlier. Section 12.6 combines the insights from the four case studies and presents a STEP analysis at a higher level of abstraction that conflates commonalities found in the case studies. This represents step three of the coding process described earlier. Section 12.7 outlines areas for further research and presents concluding observations.

12.2 CASE BRIEF: AUSTRALIA

12.2.1 Summarising the Wind Power Development Challenge in Australia

Given that Australia boasts 24.1% of the world's economically viable reserves of brown coal and 5.4% of the world’s economically viable reserves of black coal, it should come as no surprise that coal-fired power dominates Australia's electricity mix. In 2006-07, brown and black coal accounted for 83.8% of Australia's electricity generation, with the remaining electricity supplied by natural gas (12%), hydropower (2%), oil (1%) and wind power (1%) (ABARE, 2009).

Despite being a vast, scantily populated nation, wind power in Australia has fallen appreciably short of its technical potential. With most of Australia's coastal areas boasting average annual wind speeds in excess of 8 m/s (Coppin, et al., 2003), the potential of wind power to contribute at least 20% to Australia’s electricity supply is almost unequivocal (Diesendorf, 2003).

The new Labor government which recognises the need for a bolder commitment to renewable energy announced a Renewable Energy Target (RET) initiative, which upon commencement in 2010 will mandate purchases of renewable energy with the objective being to encourage 45,000 GWh of renewable electricity generation by 2020 (representing a 20% overall contribution to the electricity supply) (Government of Australia, 2009g). Unfortunately as Chapter 8 suggests, the efficacy of the RET is undermined by program flaws such as eligibility of waste coal mine gas (WCMG) for renewable energy credits (REC) under the RET, a multiplier mechanism which creates “phantom credits” (thereby reducing the pool of available RECs), the limited duration of the program which will discourage investment after 2020 and failure to pass complementary legislation to enact a carbon emissions trading scheme.

12.2.2 STEP Variables that Impair Wind Power Development in Australia

A STEP analysis of the conditions which led to this state of affairs in Australia provides insight into why the RET developed in this matter and highlights some of the hurdles that policymakers must seek to mitigate in order to enhance the scope and pace of wind power development (Table 12.1).

Table 12.1: Key STEP Variables that Impair Wind Power Development in Australia

Social

- NIMBY concerns over aesthetics and ecological issues have stymied wind power development (Gross, 2007).
- Low electricity prices fuel social resistance to more expensive electricity generation portfolios (Government of Australia, 2009c).
- The fossil fuel industry is traditionally a major employer in Australia and still employs over 100,000 workers (IEA, 2005). However, due to a 45% contraction of jobs since the mid-1980s (Diesendorf, 2003), there is a high degree of sensitivity to the threat of further job losses in mining communities.

Technical

- There are concerns over the stochastic properties of wind destabilizing grid load management (cf. Ackerman, 2005).
- The liberalized electricity market complicates coordination of numerous, private electricity generators (NEMMCO, 2005).
- Managing electricity inputs from many smaller wind power projects are more troublesome for utilities (ESAA, 2009).
- Many regions of greatest wind potential are separated from the large population centres (Coppin, et al., 2003). This increases the cost of transmission.
- Australia’s pooled purchase system for electricity complicates the process of integrating stochastic wind power inputs (NEMMCO, 2005).

Economic

- External costs of fossil fuels are not internalized (ATSE, 2009).
- Significant effort is currently expended on improving energy efficiency rather than financing alternative energy projects. This absorbs finances and planning time (Government of Australia, 2009h).
- Government support for carbon capture and sequestration (AU$1 billion over 9 years) means that fossil fuel power plants receive free R&D support (Schlapfer, 2009).
- Government support of wind power technology innovation (i.e. improving storage etc) is scant (Government of Australia, 2009h; IEA, 2005).
- The RET program is not ambitious enough to effectively catalyze improved economies of scale for wind power (Government of Australia, 2009h; IEA, 2005).
- Widespread concern exists over what higher energy costs will do to Australia’s economy (Gailey, 2009; Schlapfer, 2009).
- Inexpensive and secure fossil fuel resource availability relieves energy security pressures (IEA, 2005; Owen, 2009).

- The inclusion of WCMG as an eligible fuel under the RET creates an indirect subsidy to the coal industry (Government of Australia, 2009e, 2009g).
- There is steadfast support for Australia's fossil fuel sector which contributes substantial export revenues and royalties to government coffers (Government of Australia, 2009c; Riedy, 2003).

Political

- Fossil fuel electricity provision exhibits a degree of "stickiness" due to the existence of established supply networks and transmission & distribution infrastructure (MacGill, et al., 2006; Riedy, 2003; Saddler, et al., 2007).
- As a key exporter of uranium and coal (IEA, 2005), there is considerable political pressure in Australia to support these industries (Wesley, 2007).
- States control electricity supply management but strategic cooperation between states to work toward a carbon-free electricity system is low (Moran, 2006).
- Few concerns over foreign dependence on fossil fuel supplies. Relatively self-sufficient (IEA, 2005).
- Government backtracking exists regarding original Kyoto Protocol commitments (Government of Australia, 2008a). New short-term targets are too lax, long-term targets are too far off to catalyze immediate change.
- Liberalized markets and decentralized generation make it hard to achieve technological collaboration (Chester, 2007; ESAA, 2009).
- Commitment to other alternative energy technologies (notably solar thermal and geothermal) diffuses support for wind power (Government of Australia, 2009g).
- Rejection of CO_2 emission trading scheme (CPRS) undermines the efficacy of the RET (Government of Australia, 2009h).

Table 12.1 summarizes the prominent barriers to enhanced development of wind power in Australia that were detailed in chapter 8. Continued government subsidization of fossil fuel technologies and failure to internalize the external costs associated with each electricity generation technology have created a false economy wherein coal-fired power is perceived to be the best economic alternative for generating electricity. As a recent government report highlighted, if the hidden costs associated with fossil fuel combustion were internalized, the current cost differential between wind power and coal-fired power which currently stands at between $AU30 - $40 per MWh (Macintosh & Downie, 2006), would be more than offset by a net increase in the cost of coal-fired power of $42 - $52 per MWh (ATSE, 2009). Unfortunately, the proposed cap and trade scheme (CPRS) has failed to clear political hurdles; and as such, the internalization of costs associated with CO_2 emissions has yet to be achieved (Government of Australia, 2008b).

However, the cost disparity between coal-fired power and wind power does not fully explain languid wind power development in this nation of high wind power potential; nor does it fully explain why external costs have not been internalised. There are social barriers which include misperceptions that a transition away from fossil fuel technologies will adversely affect the economic well-being of communities dependent on fossil fuel mining revenues. There are also misperceptions that wind turbines will adversely impact the aesthetics and ecology of communities.

Technical barriers which centre primarily on the stochastic nature of wind power also exist. Concerns that high levels of wind power will destabilize the grid require technical solutions that require R&D support (Saddler, et al., 2007). Similarly, the challenge of managing wind power inputs from numerous sources within the context of Australia's pooled electricity purchase system requires systematic restructuring of load management systems.

Finally, there is entrenched political support for Australia's fossil fuel industry and this support manifests itself through political initiatives to support carbon capture and sequestration research, the maintenance of robust coal industry support schemes and political resistance to the CPRS.

In summary, in addition to enacting initiatives to close the economic divide between the costs of coal-fired power and wind power, all of these non-economic barriers need to be mitigated if Australia’s policymakers are to optimize wind power development policy.

12.3 CASE BRIEF: CANADA

12.3.1 Summarising the Wind Power Development Challenge in Canada

Canada's electricity grid is the sixth largest in the world, supported by 124,240 MW of total installed generation capacity, incorporating six main generation technologies (Statistics Canada, 2009a). As Table 12.2 indicates, hydropower resources in Canada are in abundance. In 2008, only China produced more hydropower than Canada (BP, 2009). The responsiveness of hydropower generation makes it a perfect complement to wind power development (Boyle, et al., 2004). Consequently, if Canada's provincial electricity grids were integrated and optimized, the predominance of hydropower within Canada's electricity mix and vast tracts of undeveloped land provide the necessary conditions to technically displace coal-fired power and bestow Canada with an electricity mix dominated by low-carbon technologies.

Table 12.2: 2007 Installed Electrical Generation Capacity by Source in Canada

	2007	% of total
Hydro	73,435,687	59%
Wind and tidal	1,600,399	1%
Coal	27,211,548	22%
Nuclear	13,345,000	11%
Internal combustion	593,480	0%
Combustion turbine	8,054,193	6%
TOTALS	**124,242,314**	**100%**
(capacity in kilowatts)		

Data source: (Statistics Canada, 2009a)

As chapter 9 emphasized, the main barrier to achieving the laudable goal of an electricity mix dominated by low-carbon technologies relates to the Canada's federal structure. Under Canada's federal charter, constitutional authority over electricity generation has been expressly assigned to Canada's provinces (Government of Canada, 1867 / 1982). This constitutional fragmentation of electricity governance has spawned a national grid which is only loosely interconnected. Inter-provincial electricity connections are not nearly sufficient enough in order to allow electricity generated by hydropower sources to be effectively exchanged between provinces (National Energy Board, 2004). Moreover, some of Canada's provinces which happen to be rich in fossil fuel resources (notably Alberta and Saskatchewan) have insubstantial hydropower resources, accentuating fossil fuel dependence in these provinces (Statistics Canada, 2009b).

12.2.2 STEP Variables that Impair Wind Power Development in Canada

As chapter 9 detailed and Table 12.3 summarises, in considering approaches for resolving the fragmentation of Canada's electricity grid, the federal government faces a number of social, technical, economic and political hurdles.

Table 12.3: Key STEP Variables that Impair Wind Power Development in Canada

Social
• Heavy contribution from hydropower reduces social pressures to reduce carbon footprint associated with electricity (Valentine, 2010a).
• Historically low electricity prices (NUS Consulting, 2007) fuel social resistance to more expensive electricity portfolios.
Technical
• Managing electricity inputs from many smaller wind power projects are more troublesome for utilities (Valentine, 2010a).
• Concerns exist over stochastic wind power flows destabilizing the grid because inter-provincial grid connections are sub-optimal (National Energy Board, 2004).
• Weak grid inter-connectivity between provinces stymies capitalization of full wind potential (National Energy Board, 2004)
• Provinces that are rich in wind power potential (i.e. Alberta, Saskatchewan) seldom have access to hydropower for peak load support (Statistics Canada, 2009b).
• Provinces that are rich in hydropower have low carbon footprints and reduced incentive to invest in wind power (Valentine, 2010a).

Economic

- External costs of fossil fuels and nuclear power are not internalized (Valentine, 2010a).
- A federal production subsidy of 1¢ per kWh for wind power is insufficient to make wind power an economically competitive alternative to coal power (Guha, et al., 2005).
- Abundant fossil fuel resources reduce energy security risk (NUS Consulting, 2007).
- There is strong support for fossil fuel in fossil fuel-rich provinces due in part to tax and royalty revenues earned on natural resource extraction (Alberta Provincial Government, 2008).
- An acute federal budget deficit restricts the capacity to provide improved wind power production subsidies (Curren, 2009).

Political

- Fossil fuel electricity systems have a degree of “stickiness” due to the existence of established supply networks in many provinces (Vicente, 2005).
- There is considerable political pressure in Canada to support oil, gas and coal industries due to their economic value (Alberta Provincial Government, 2008; IEA, 2004b).
- Provinces control electricity supply management but strategic cooperation between provinces to work toward a carbon-free electricity system is low (Liming, et al., 2008).
- Few concerns over foreign dependence on fossil fuel supplies. Canada is largely self-sufficient (IEA, 2004b).
- Government backtracking exists regarding original Kyoto Protocol commitments. The federal government has now announced less ambitious targets (Government of Canada, 2009).
- Liberalized markets and no centralized control makes it hard to achieve national collaboration (National Energy Board, 2004).
- Provincial constitutional authority over electricity governance enables provinces to resist federal attempts to coerce wind power development (Valentine, 2010a).

Unquestionably, failure to internalise external costs associated with each electricity generation technology along with access to relatively cheap, abundant fossil fuel resources has created a false economy in Canada wherein fossil fuel-fired power is perceived to be economically superior. However, the economic cost disparities do not describe the whole story regarding languid wind power development in a nation with wind power potential that stands in the top echelon internationally. As chapter 9 detailed, (and Table 12.3 summarised), there are a number of significant social, technical, political and economic barriers which impede progress.

Constitutional delegation of authority over electricity governance to the provinces is patently the most significant of these barriers. It poses an enormous impediment to creating a national electricity management strategy capable of enhancing the level of inter-provincial electricity grid integration and collaboration necessary to fully tap wind power potential.

Provincial authority over electricity governance also complicates resolution of many technical impediments. In order to ensure that stochastic wind power fluctuations do not destabilize provincial electricity grids, capacity enhancement of weak interprovincial grid connections is necessary; however, political incentive for enacting such technical fixes is currently weak. Provinces that are rich in hydropower, which serves a vital role in providing efficient peak-load support capability, would be understandably reluctant to voluntarily impinge on provincial self-sufficiency in this inexpensive, low-carbon energy resource through sharing capacity. Meanwhile, provinces boasting fossil fuel resource abundance are able to exploit existing fossil fuel excavation and transportation infrastructure and enjoy an abundance of relatively cheap fossil fuel energy.

Even the economic realm is affected by Canada’s constitutional structure. The current federal subsidy for encouraging wind power development of 1¢ per kWh has been criticized as insufficient for fostering significant change within the current electricity regime (Guha, et al., 2005). Without internalizing the external costs of fossil fuel combustion, closing the price gap between wind power and coal-fired energy would require a level of federal funding that is likely untenable as federal government attempts to reduce a vitiating federal budget deficit (Curren, 2009). However, forcing provincial electricity regimes to internalise external costs is also less tenable when the provinces hold constitutional authority over electricity governance and each province views the challenge of abating CO_2 emissions from different perspectives and with differing perceptions of exigency (Valentine, 2010a).

Finally, although civic advocacy is prominent in Canada, there is a degree of insouciance in civic and environmental circles regarding CO_2 emissions from electricity generation. The primary concern in Canada is on improving energy efficiency related to transportation and inefficient end-use activities (Government of Canada, 2009). The electricity sector tends to fly under the environmental radar (except in fossil fuel-intense provinces) because 71% of Canada's electricity is generated by low-carbon energy sources (59% hydro, 11% nuclear, 1% wind) (Statistics Canada, 2009a).

In summary, the Canadian case study mirrors the Australian study in indicating that economic fixes alone will not fully optimise wind power development. In Canada, political hurdles are arguably as influential in blocking wind power development as economic hurdles. Moreover, social and technical hurdles also need to be addressed if Canadian policymakers wish to better exploit Canada’s wind power potential.

12.4 CASE BRIEF: JAPAN

12.4.1 Summarising the Wind Power Development Challenge in Japan

As chapter 10 illustrated, Japan faces daunting national energy security challenges. Japan’s 127 million people (1.9% of the global population) consume 5.3% of all power generated in the world (IEA, 2008b). Yet, over 97% of the energy consumed in

Japan comes from imported fuel stocks. Japan imports virtually all coal, oil and gas feedstock (FEPC, 2008).

In order to improve national energy security, the government announced a five-pronged strategy which includes the following goals: i) improve energy efficiency by at least 30%, ii) reduce oil dependence by 40% or lower, iii) reduce oil dependence in the transport sector to 80%, iv) target the share of nuclear power in electricity generation to 30-40% and, v) increase the share of crude oil owned by Japanese companies to 40% (Amari, 2006). In short, commitments to bolster renewable energy capacity are relegated to a secondary role in government energy security strategy. Wind power development in particular has been largely neglected.

12.3.2 STEP Variables that Impair Wind Power Development in Japan

Table 12.4 summarises some of the social, technical, economic and political hurdles outlined in chapter 10 that confront Japan's wind power developers.

Table 12.4: Key STEP Variables that Impair Wind Power Development in Japan

Social

- NIMBY opposition in a nation that values traditional vistas impairs site selection (Maruyama, et al., 2007).
- Resistance to government plans (i.e. governance of electricity) is customarily muted (Valentine, 2009).
- Geographic siting constraints exist due to high population density (Ushiyama, 1999; Valentine, 2009).

Technical

- Concerns exist that stochastic wind power flows will destabilize the grid. This nurtures demands to store wind power before feeding it into the electricity grid (Englander, 2008).
- Private regional utilities enjoy monopoly positions (FEPC, 2008) which inhibits interconnected “smart” grid development.
- Managing electricity inputs from many smaller wind power projects are more troublesome for

utilities (Valentine, 2009).

- Sites with the greatest wind potential are separated from main population centers (Ushiyama, 1999; Yamaguchi & Ishihara, 2007). This increases the cost of transmission (Wizelius, 2007).
- Entrenched prioritization of nuclear research (well over US$60 billion investment since 1981) (IEA, 2004c) .
- Low estimates for wind power capacity load factors (20%) artificially inflate the cost of wind power (ANRE, 2008a; Morthorst & Awerbuch, 2009).

Economic

- External costs of fossil fuel and nuclear power are not internalized (Valentine, 2009).
- Advanced nuclear power is seen as the key technology for economically meeting Japan's future energy needs (JAEC, 2008, 2009).
- Funding emphasizes energy efficiency initiatives over financing alternative energy projects (Government of Japan, 2005). This further diverts funding away from wind power storage.
- Nuclear research is significantly subsidized by the government (IEA, 2004c). This results in artificially low cost estimates for nuclear power production (FEPC, 2008).
- Research to improve storage of wind power received little government support (Valentine, 2009).
- The renewable portfolio standard used to encourage development of renewable energy (targeting less than 1% of total electricity supply in 2009) is insufficient for substantively improving wind power economies of scale (Englander, 2008; Nishio & Asano, 2003).
- Deep concerns exist regarding the impact of higher energy costs on a stagnant economy (METI, 2006).

Political

- Nuclear power is a preferred long-term electricity technology due to its large-scale generation capability. Campaigns to improve the image of nuclear energy are evident (JAEC, 2008, 2009).
- Nuclear power technology is considered to be an attractive export commodity (JAEC, 2008, 2009).
- Fossil fuel electricity provision exhibits a degree of "stickiness" due to the existence of established supply networks (Valentine, 2009)
- Commitment to supporting other alternative energy technologies (notably solar PV) diffuses the market for wind power (IEA, 2004c, 2008a).
- Due to lack of direct government pressure, regional utilities are less motivated to reduce CO_2 emissions through alternative energy projects. Meanwhile, wind power developers face interconnection hurdles established by the utilities (Englander, 2008).

Of all the hurdles that wind power developers face in Japan, economic hurdles are the most daunting. Failure to internalize the external costs associated with fossil fuel and nuclear power creates sizable cost disparities between wind power and these entrenched power sources. Cost disparities are accentuated by ardent government

R&D support for nuclear power and advanced fossil fuel power generation technology while R&D support for wind power and power storage technology is insignificant (IEA, 2004c). Most of Japan's utilities are so averse to managing the stochastic nature of wind power that wind power developers complain of being forced to store generated wind power prior to feeding it into the regional electricity grids (Englander, 2008). This accentuates the cost disparity between wind power and the entrenched power sources. A renewable portfolio standard has been developed to encourage clean energy development but the mandated purchases for 2009 amount to less than 1% of the total electricity supply, too low to foster the levels of scale economies necessary to help wind power developers close the cost divide.

Although it may seem logical to conclude that policies aimed at rectifying the cost disparities between wind power and other entrenched power sources would pave the way for amplified levels of wind power development, political roadblocks complicate the challenge. In addition to political reluctance to enforce internalization of external electricity generation technology costs out of concerns that higher electricity prices might threaten industrial competitiveness, two other political barriers foster perpetuation of the status quo. First, the Japanese government has granted regional monopolies to 10 private vertically-integrated utilities (FEPC, 2008). The higher cost of wind power undermines profitability unless utilities can successfully negotiate rate increases with inflexible government regulators. Therefore, utilities are reluctant to proactively pursue wind power expansion programs especially considering the technical burden of integrating stochastic power flows in the regional grids. Second, there is considerable political support for nuclear power capacity expansion (JAEC, 2008, 2009). Consequently, an enormous amount of government research funding goes to nuclear research (well over US$60 billion channelled to nuclear power research since 1981) (IEA, 2004c) instead of to programs that could close the economic cost divide between wind power and the entrenched generation technologies. In short, the economic cost divide is a symptom of a host of complex political obstructions.

Of the social factors that tend to deter wind power development, public apathy toward a national energy policy which supports nuclear power development over the enhancement of renewable energy capacity is most striking given the anti-nuclear sentiments that still exist in Japan. There appears to be an underlying belief that despite the hazards posed by nuclear power, particularly concerning waste disposal, technical solutions will eventually be developed to mitigate the externalities caused by nuclear power (Valentine, 2009).

In summary, the Japanese case highlights the ineluctable nature of many of the STEP elements. Barriers in one realm (i.e. economic) are frequently underpinned or supported by obstacles in other realms (i.e. political, technical and social). Therefore, policy initiatives to alter electricity governance should seek comprehensive mitigation of STEP obstacles in order to minimize systematic impediments to policy effectiveness.

12.5 CASE BRIEF: TAIWAN

12.5.1 Summarising the Wind Power Development Challenge in Taiwan

As chapter 11 explained, despite having a small population, Taiwan was the 17th largest national consumer of electricity in the world 2008, with aggregate electricity consumption of 233,000 GW hours (CIA, 2008). Like Japan, Taiwan is heavily dependent on imported fuel-stocks for power generation. Imported fuel-stocks fuelled 81.1% of all electricity generated in 2006 (coal - 39.3%, oil - 8.3%, LNG - 14.3%, nuclear - 19.2%) (TBOE, 2007), with the remainder coming from hydropower and co-generation. Although imports of coal rose significantly in the 20-year period 1986-2006, growth in oil imports slowed due to government efforts to replace oil-fired power with LNG-fired power. In terms of low-carbon power sources, national hydropower capacity has nearly reached peak potential, nuclear power capacity is expected to increase by 2.7 GW in 2011 when Taiwan's fourth nuclear power plant commences operation (TBOE, 2009b) and renewables (solar and wind power) have been slow to develop as utility-scale power sources (TBOE, 2007). Historically, responsibility for the generation, transmission and distribution of electricity in Taiwan has rested with Taipower, which is a public monopoly. Virtually all transmission and distribution lines in Taiwan are still installed and owned by Taipower (K. M. Wang, 2006), but the electricity generation sector is undergoing privatization (TBOE, 2009a; K. M. Wang, 2006).

In the short-term, Taipower plans to further encourage wind power capacity development, aiming for an ultimate goal of 2159 MW of installed wind power capacity by 2010 (Lin, et al., 2009). In 2009, a Renewable Energy Development Bill was passed after seven years of political debate and resistance. However, the development of concrete development incentives will be delayed because a newly formed Energy Commission must now deliberate over setting appropriate pricing levels. In the meantime, Taipower has an interim program in place for purchasing wind energy at US 6.16¢ per kWh. Despite criticism that US 6.16¢ per kWh is insufficient to stimulate large-scale investment (Lu & Ko, 2009), wind power capacity in Taiwan continues to progress albeit sluggishly. As of 2008, there were 155 wind turbines amounting to 281.6 MW of installed capacity at various locations around Taiwan. As Chi-Yuan Liang, an economist at Academia Sinica summarised, achievement of the 2159 MW target is doubtful given such a low current base.[37]

Estimates of wind power potential in Taiwan are both disparate and contentious. Taipower, for example, estimates that total *technical* potential for wind energy in Taiwan amounts to 4600 MW of onshore potential and 9000 MW of offshore potential. However, current land-use restrictions and competition for development results in a much lower estimate for *realizable* wind energy potential – 1000 MW onshore and 1200 MW offshore. On the other hand, Infravest (Taiwan's only private wind power developer) estimates that 3000 MW of onshore wind power and 5000 MW of offshore wind power could be feasibly realized if Taipower increased its wind power procurement rate from the current level of US6.06¢ per kWh to US12.12¢ per kWh.

12.5.2 STEP Variables that Impair Wind Power Development in Taiwan

Table 12.5 summarizes the major STEP barriers to wind power development in Taiwan that were examined in detail in chapter 11.

Table 12.5: Key STEP Variables that Impair Wind Power Development in Taiwan

Social
• Social and political divisions over nuclear power keeps nuclear power on the agenda (Bor & Chou, 2003; TBOE, 2009b; Tchii, 2009). • There are geographic siting constraints due to high population density (Yue, et al., 2001).

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[37] Source: Bloomberg New Service, "Energy Bureau Looking to Boost Wind-Power 10-fold", 28 September 2007.

- There are NIMBY concerns regarding offshore wind development driven by perceptions of adverse impact on fisheries and protected marine species (Tsai & Chou, 2005; Valentine, 2010b).

Technical

- Concerns exist regarding stochastic wind power flows destabilizing the grid. This results in demands by Taipower for wind power developers to build sub-transformers at each wind site (Valentine, 2010b).
- Managing electricity inputs from many smaller wind power projects are more troublesome for utilities (Tsai, 2005; Valentine, 2010b).
- Sites with the greatest wind potential (east coast) are separated from major population centers (west coast) (Huang & Wu, 2009; Yue, et al., 2001). This increases the cost of transmission.
- Differences of opinion over total wind power potential in Taiwan results in political reluctance to aggressively pursue wind power (Chang, et al., 2003; Valentine, 2010b).

Economic

- External costs of fossil fuel power and nuclear power are not internalized (Valentine, 2010b; Yue, et al., 2001).
- Deep concerns exist regarding the impact of higher energy costs on an already flagging economy (Tchii, 2009; K. M. Wang, 2006)
- Funding emphasizes energy efficiency initiatives over financing alternative energy projects (Taiwan MOEA, 2008).
- Government support for wind power research to improve storage is insufficient (Chiang, 2004; Taiwan MOEA, 2008; Valentine, 2010b; Wu & Huang, 2006).
- The development incentive used to encourage development of wind power is criticized as insufficient for fostering development beyond the most attractive sites (Chen, Lu, Chi-Chuan, & Chang, 2008; Lu & Ko, 2009; Valentine, 2010b).
- Financial budget constraints at Taipower limit prospects of the utility spearheading wind investment (Ho, 2007). Development is left largely to market players.
- 25-year electricity purchase contracts fix the generation profile for long periods of time (Valentine, 2010b).

Political

- Taiwan is not a party to the UNFCCC framework so there are no formal international commitments to reduce CO_2 emissions (UN, 1992).
- The public utility has no competition and so decisions made on the electricity mix are final (Valentine, 2010b; K. M. Wang, 2006).
- Fossil fuel electricity provision exhibits a degree of "stickiness" due to the existence of established supply networks (Valentine, 2010b).

In Taiwan, as in the other three case study nations, failure to internalize external costs associated with fossil fuel sources of electricity artificially inflates the economic attractiveness of fossil fuel electricity generation. However, cost disparity does not tell the whole picture. For example, oil-fired power cost Taipower an average of US¢15.33 per kWh in 2008, considerably less than the US¢12.12 per kWh which would purportedly catalyze significant offshore and onshore wind power development (Valentine, 2010b). Yet, Taipower has been reluctant to alter its current interim procurement price for wind power of US6.06¢ per kWh for many of the non-economic reasons explicated in Table 12.5.

Taipower's resistance to integrating high levels of wind power stems from a number of technical and operational concerns. First, Taipower contends that realizable wind power potential in Taiwan is limited and; therefore, wind power does not represent a viable long-term solution to low-carbon electricity generation. Second, Taipower engineers are concerned that incorporating significant levels of wind power will complicate load management due to the stochastic nature of wind power. Third, Taipower has significant sunken capital investment in fossil fuel power plants and has commitments to long-term fuel stock supply purchase contracts which lock Taipower into current technologies (Valentine, 2010b). Finally, Taipower is going through financial difficulties due to reluctance of the national government to permit Taipower to charge higher electricity prices to cover rising fossil fuel costs (Ho, 2007). Accordingly, it does not have the financial resources to risk investing in a power source of dubious potential.

These technical, political and economic influences on strategic behaviour at Taipower are exacerbated by delays in passing and implementing the Renewable Energy Development Bill which would provide a legislative justification for Taipower to raise electricity prices to finance wind power development initiatives. Taiwan's civic society has also played a minor yet not inconsequential role in the political process. Special interest groups concerned about adverse impacts to Taiwan’s fishing industry and endangered marine species (such as the white-beaked dolphin) have provided politicians who are opposed to wind power development with the necessary backing to stymie implementation of the Renewable Energy Development Bill.

In summary, wind power development in Taiwan, like in the other three case study nations, is not impeded by just one or two barriers. A number of obstacles from all four STEP realms conflate within Taiwan’s electricity regime to create a network of mutually reinforcing, ineluctable barriers that all need to be addressed in order to optimise wind power development policy.

12.6 TOWARD A GENERIC STEP FRAMEWORK

In reviewing the STEP elements inhibiting wind power development in the four case study nations summarized in Tables 12.1, 12.3, 12.4 and 12.5, common elements became evident. Consequently, a coding exercise was undertaken to cluster the variables identified in each case study into fewer but broader categories in order to enhance manageability (Charmaz, 2006). The result is a framework composed of seven social forces, six technical forces, eight economic forces and eight political forces which generically describe the forces that stymie wind power development in the four nations (Table 12.6). In this section, each of the forces will be briefly summarized from a policy context.

Table 12.6: A STEP Framework of Factors Influencing Wind Power Development in Advanced Nations

Social	Technical	Economic	Political
NIMBY Concerns	Stochastic Nature of Wind Power	External Costs not Internalized	Political Conflict Over Optimal Electricity Mix
Level of Civic Activism	Multi-stakeholder Grid Management	Other Competing Alternative Technologies	Level of Fossil Fuel Industry Opposition
Geographic Hurdles	Logistical "Bother"	Subsidies to Traditional Technologies	Diffused Alternative Energy Support
Market Information Asymmetry	Distance to Grid	Insufficient Renewable Energy Subsidies	Energy Efficiency Initiatives Prioritized
Social Complacency	Inadequate R&D to Improve Storage	Long-term Fossil Fuel Purchase Commitments	Complacency Regarding CO_2 Reductions
Electricity Price Sensitivities	Underestimated Potential	Market Players Lack Investment Incentives	Vertically Integrated Utility Monopoly
Concerns over Community Impact		Government Budget Limitations	Weak Adjoining Grid Coordination
		National Advantage in Other Energy Resources	Lack of R&D Support for Wind Power

12.6.1 Social Factors

1. **NIMBY Concerns** entail perceptions that wind power developments adversely affect living standards and/or the surrounding ecology. It is noteworthy that international experience with wind power indicates many NIMBY concerns are misperceptions. For example, in contrast with concerns in Taiwan that offshore wind power plants could adversely affect the marine habitat, research in Europe indicates that the concrete foundations of offshore wind turbines can actually provide a safe harbour for the cultivation of corals necessary to support many aquatic creatures (Snyder & Kaiser, 2009). Similarly, concerns in Japan that onshore wind power turbines will degrade the beauty of scenic vistas have been contradicted by international experience wherein public support for wind power is generally positive in communities where such developments have been established (Firestone & Kempton, 2007; Haggett, 2008). The lesson for policymakers is that

public perceptions need to be managed in order to minimize NIMBY resistance and separate actual threats from misperceptions (Gross, 2007).

2. A low **Level of Civic Activism** was exhibited in Japan where citizens tend to avoid interfering in the process of governance. Politicians are elected to do a job and the decisions they make (i.e. postponing nuclear waste disposal planning) are not scrutinized to the extent they are in other countries. Nations characterised by low civic activism tend to exhibit political regimes driven by special interests (i.e. fossil fuel interests) and are susceptible to groupthink (Valentine, 2009).
3. **Geographic Hurdles** are typically evident in smaller, densely populated nations such as Taiwan and Japan. In such nations, the erection of wind turbines will inevitably intrude on communal space; thereby, posing wind power developmental hurdles and inflaming NIMBY opposition.
4. **Market Information Asymmetry** refers to insufficient public knowledge regarding the external costs associated with fossil fuel and nuclear power generation. If the public were more aware of the total costs of fossil fuel power generation, wind power developments would stand a better chance of being supported both in communities and at the national level because the cost disadvantage frequently attributed to wind power would be eliminated. For policymakers, it is imperative to ensure the public fully understands the true total costs associated with all generation technologies.
5. **Social Complacency** is a form of “Green Dutch Disease” that is characteristic of countries which enjoy an abundance of renewable resources, such as hydropower in Canada or geothermal power in Iceland. In terms of proactive public support for renewable energy, there appears to be diminishing returns as levels of installed renewable power capacity increase.

6. **Electricity Price Sensitivities** were understandably evident in all case study nations. Perceptions that adding higher percentages of comparatively expensive wind power to the electricity grid would adversely affect national economic well-being represent a common source of opposition to enhanced levels of wind power. However, academic evidence does not support these perceptions. A study done by the Australia Institute concluded that adding approximately 5% more wind power would only cost consumers AU$15-$25 per year extra (Macintosh & Downie, 2006). The lesson for policymakers is that fear-mongering, which seems to be linked to campaigns to oppose wind power, needs to be countered with scientific enquiry to ascertain actual impact.
7. **Concerns over Community Impact** were ironically evident in fossil fuel rich nations when it came to wind power development. In countries such as Australia and Canada, the fossil fuel sector is a major employer in some communities. Such communities are particularly sensitive to the threat of job losses associated with declining domestic use of fossil fuel resources. Given insatiable overseas demand for fossil fuel resources such concerns are largely unfounded. Nevertheless, for policymakers, the bifurcate challenge is i) to rectify any misperceptions through studies estimating actual impacts and ii) to clearly communicate the economic benefits that wind power projects generate, which in many countries have been shown to produce positive net employment (CanWEA, 2008b; Renner, 2008).

12.6.2 Technical Factors

1. The **Stochastic Nature of Wind Power** is frequently mentioned by utility managers and policymakers as a key deterrent to more aggressive wind power development policies. This concern was evident in all four case study countries

but frequently exaggerated. The stochastic nature of wind power only becomes a threat to grid stability at high levels of wind power contribution. Not only has international experience demonstrated that up to 20% wind power can be incorporated into an electricity grid by utilizing existing spare capacity to provide stability, a number of mitigating techniques have also been developed to attenuate output fluctuations (Ackerman, 2005; Boyle, et al., 2004; Holttinen, 2008). Furthermore, even after all technical attenuation techniques have been exhausted, research has shown that existing storage technology adds only $10-$20 per MWh to the cost of wind power (DeCarolis & Keith, 2006; Diesendorf, 2003; Macintosh & Downie, 2006). In short, policymakers should be aware that although there is some validity to technical concerns over the stochastic nature of wind power, these concerns are frequently exaggerated either due to lack of sufficient technical knowledge or due to political gamesmanship.

2. **Multi-stakeholder Grid Management** hinders wind power development in Japan, Canada and Australia. In Japan, 10 regional utilities enjoy monopolies over their respective regional grids. In Australia and Canada, the electricity grids in each state (or province) are administered by separate organizations, some public and some private. Effectively interconnected grids enhance system stability and support higher levels of wind power (Boyle, et al., 2004; EWEA, 2009).
3. **Logistical "Bother"** tends to be an issue ignored by mainstream academic research but is an evident hurdle when speaking informally with engineers from electricity utilities. In order to integrate high levels of stochastic wind power flows into a power grid, load management systems have to be revised, wholesale electricity purchase programs need to be altered to suit unpredictable wind power flows and a greater number of grid connections must be installed and maintained.

All of these obligations represent logistical activities that would otherwise not require attention. Consequently, for many engineers, wind power represents a logistical "bother".

4. **Distance to the Grid** can render wind power projects commercially unviable. It has been estimated that the infrastructure costs associated with connecting to a grid in advanced economies are at least US$80 per meter (Wizelius, 2007). Therefore, if one were to establish wind turbines in a remote area in order to avoid NIMBY opposition, the connection cost for every 10 km span would amount to US$800,000. The obvious lesson for policymakers is that in order to minimise the cost (per kWh) of wind power in remote regions, larger scale wind power projects should prevail.
5. **Inadequate R&D to Improve Storage** is both a technical and a political issue. The capability to economically store power would eliminate hurdles associated with the stochastic nature of wind power. Realizing the full promise of wind power and solar PV power depends on the development of economical storage technologies.
6. **Underestimated Potential** was evident both in Japan and Taiwan. In Japan, wind power potential was estimated using a capacity load factor of 20% which was extremely conservative when compared to international data which suggests that 30 to 35% is more representative of current technological capacity. Substituting a capacity load factor of 30% instead of 20% would yield a wind power potential estimate that is 50% higher. In Taiwan, the national utility (Taipower) and Taiwan's largest wind power developer (Infravest) have released wind power estimates that differ by over 360% (Valentine, 2010b). If the Taipower estimate is accurate, wind power potential in Taiwan is relatively low and other technologies

should be prioritised. If the Infravest estimate is accurate, more emphasis should be given to supporting wind power development. In summary, although estimates of wind power potential are technical in nature, estimates are based on assumptions which underpin them, which in turn are influenced by ideologies and politics.

12.6.3 Economic Factors

1. **External Costs Not Internalised** refers to the economic costs associated with the social and environmental impacts of electricity generation technologies. External costs of any type are rarely incorporated into electricity generation cost data. For fossil fuels, CO_2 emissions represent the most significant economic externality. For nuclear power, storage of nuclear waste and decommissioning of obsolete plants represent significant externalities. Failure to include these real external costs into the true total cost of electricity generation for each power source distorts market forces. For example, one Australian study indicates that if the environmental cost of greenhouse gas emissions were internalized, the cost of brown coal-fired power would increase by US$34/MWh, the cost of oil-fired power would increase by US$26/MWh and the cost of gas-fired power would increase by US$17/MWh (ATSE, 2009). Given the average wholesale price of electricity in Australia is AU$40/MWh (ATSE, 2009), internalizing economic costs associated with just CO_2 emissions would significantly alter electricity market dynamics. The distortions caused by failure to internalize external costs unquestionably represent the largest barrier to wind power development within the STEP framework.

2. A dominant presence of **Other Competing Alternative Technologies** hinders the development of wind power in two ways. Firstly, when governments prioritize other alternative energy technologies, they tend to commit higher levels of R&D and market support to these technologies. The end result is a self-fulfilling prophecy wherein the technologies that receive more support begin to display commercial progress, thereby justifying further support. Perhaps the best example of this is in Japan's nuclear power industry. Thanks to government investment of over $60 billion in R&D support since 1982, Japan's nuclear power industry boasts generation costs that are competitive with most other forms of fossil fuel electricity generation (IEA, 2004c). However, it is conceivable that $60 billion invested in virtually any alternative energy technology would achieve similar progress. Secondly, in many nations, financial support for renewable energy technology research and capacity development is limited. Consequently, gains by other technologies are made at the expense of wind power development. This is exemplified in Australia wherein power contributions from small-scale solar thermal technologies are favoured. In the first year of the RET program, every 1 kWh of solar thermal power reduces the potential market for all renewable electricity by 5 kWh (Government of Australia, 2009g).
3. **Subsidies to Traditional Technologies** still exist in many nations despite global warming concerns. All four of the case study nations subsidize traditional fossil fuel and nuclear power technologies in some manner. In Australia and Canada, government financial support exists for carbon capture and storage research (Government of Australia, 2009h). In Japan, nuclear power research receives enormous government financial support (IEA, 2004c). In Taiwan, the government subsidizes research in advanced fossil fuel generation technology (TBOE, 2009b).

Not only do such subsidies mask the actual costs associated with traditional technologies, the financial commitments detract from the pool of government funding that could be used for supporting wind power development.

4. **Insufficient Renewable Energy Subsidies** are particularly problematic in the absence of policies to internalise external costs associated with fossil fuel combustion. In all four case study nations, renewable energy subsidies failed to close the cost divide between fossil fuel electricity generation and wind power. Despite different policy tools employed – Japan has adopted a renewable portfolio standard, Taiwan has adopted a feed-in subsidy, Australia has adopted a mandatory purchase program, and Canada has adopted a production subsidy – in all cases, the aggregate subsidy was insufficient to allow wind power to effectively compete with fossil fuel technologies. The bottom line is that subsidies which fail to close the economic gap between the cost of fossil fuel electricity generation and wind power will produce sub-optimal results.
5. **Locked-in Fossil Fuel Purchase Commitments** represent an economic hurdle to wind power development because long-term purchase obligations tend to delay phasing out undesirable technologies such as coal-fired power. Conditions in both Japan and Taiwan exemplify the "stickiness" that long-term fossil fuel purchase obligations have on the pace of technological transition. Both nations secure fossil fuel supplies through long-term purchase contracts with overseas suppliers; and once these commitments are made (Valentine, 2009, 2010b), the technologies that utilize these supplies often become entrenched for the duration of the purchase contract.
6. **Market Players Lacking Investment Incentives** is common in nations where government support for wind power is unclear (Taiwan, Australia) or nugatory

(Canada). In many affluent nations, wind power purchase guarantees are frequently of insufficient value and duration to provide wind power developers with the confidence necessary to begin making long-term market development commitments. Research indicates that wind power purchase guarantees need to be at least 15-years in duration in order to allow wind power developers to fully amortize project costs (Wizelius, 2007). Failure to provide such guarantees leads to exploitative behaviour in which wind power developers seek to exploit commercially attractive sites and then turn to other markets for new business. Such is the case in Taiwan.

7. Insufficient support for renewables due to **Government Budget Limitations** emerged as a notable barrier to wind power development in Canada where an enormous federal budget deficit severely curtails the government's ability to bolster renewable energy development subsidies (Valentine, 2010a). However, the existence of a national budget deficit is not the only obstacle in regard to government financial support. Periods of economic contraction tend to impair government revenues and place pressure on policymakers to find ways to support established levels of government service provision with reduced budgets. Accordingly, in stagnant economies, acquiring sufficient government financing to close the cost disparities between fossil fuel powered electricity and wind power is a contentious budget allocation issue. Overall, policymakers in support of wind power development need to understand that a number of interests compete annually for a fixed pool of government funds and financial support for wind power is usually attained by demonstrating that financially supporting wind power is a superior use of fiscal funds. This is a political process that requires systematic planning in order to maximise funding success.

8. **National Advantage in Other Energy Resources** of some type poses barriers to wind power development in Australia, Canada and Japan. In Australia and Canada, governments enjoy sizable revenue flows from fossil fuel royalties and taxes (ABARE, 2009; Alberta Provincial Government, 2008). Accordingly in both nations, there is a high degree of political will to support fossil fuel industries and this translates into initiatives such as government funding for carbon capture and sequestration, despite indications that other alternative energy technologies may represent more prudent long-term electricity generation solutions. In Japan, advanced waste processing technology and nuclear reactor design are seen as promising exportable commodities which deliver the dual benefit of providing concentrated flows of comparatively cheap electricity and export revenues (JAEC, 2008, 2009). The lesson appears to be that governments have a hard time disaggregating domestic energy planning from strategies to support fossil fuel or nuclear technology exports. Energy sources that have high export value tend to engender support within domestic electricity regimes.

12.6.4 Political Factors

1. **Political Conflict over the Optimal Electricity Mix** can be conceptualised on three levels. First there is understandable conflict between actors who support the status quo and those who seek some level of change. Resistance to those seeking change can be significant, as illustrated by rejection of legislation in support of CO_2 emission trading in Australia. Second, within the realm of those seeking change, there are competing interests. These competing interests frequently oppose each other in the same manner that parties seeking change oppose parties who wish to maintain status quo. For example, in Australia, geothermal energy,

concentrated solar thermal energy and wind energy are all supported by special interests, each seeking to obtain an increased portion of a fixed market. Furthermore, some alternative technologies are better equipped to financially compete against wind technology. For example, in Japan and to a lesser extent in Taiwan, there are strong pro-nuclear groups that argue vociferously for government research funding, thereby drawing funds away from wind power support initiatives. Finally, the existence of abundant supplies of fossil fuels or uranium gives rise to a political form of Dutch Disease – one shared reason why wind power potential in both Australia and Canada is underutilized is that both nations boast an abundance of traditional fuel stock reserves. Such wealth tends to discourage the level of strategic stretch necessary to proactively embrace a transition to renewable technologies.

2. **Fossil Fuel Industry Opposition** inhibited wind power development in all four case study nations. Entrenched fossil fuel regimes enjoy considerable cost economies thanks to historical subsidization of fossil fuel generation infrastructure, decades of cumulative R&D investment (frequently supported by government subsidies) (Deffeyes, 2005) and political lobbying to discourage policies to internalise the external costs of fossil fuel combustion. In addition to commercial advantages, a fossil fuel plant can be operational for more than 30 years (Sovacool, 2008a). These plants represent capitalized investments which locks-in utilization of fossil fuel generation plants.
3. **Diffused Alternative Energy Technology Support** is a political obstacle as well as an economic obstacle because diffused research funding commitments detract from funding for R&D to support wind power. In Japan, financial support for solar PV research detracts from funding could be channelled into storage technology

research. Similarly, in Australia, government support for solar thermal, geothermal and carbon capture and sequestration technologies channel funding away wind power development initiatives. Furthermore, in countries which have mandatory renewable energy purchase programs, such Australia, diffused support for alternative energy technologies typically reduces the market potential for wind power because it allows more technologies to compete for shares of a fixed market.

4. The **Prioritization of Energy Efficiency Initiatives** is a political barrier in that the decision to prioritise energy efficiency (i.e. Japan and Taiwan) represents a political decision to exploit short-term gains before investing in sustainable energy technologies. Commitments to energy efficiency programs reduce the pool of funding available for other clean energy initiatives; and as such, hinder financial support for wind power R&D and market development. Although the situation is most evident in Japan, virtually all nations with CO_2 abatement strategies have embraced the widely accepted notion that energy efficiency initiatives represent necessary first steps.
5. **Complacency Regarding CO_2 Reduction** programs is a political artefact that is enhanced by i) the absence of concrete international political commitments (i.e. Taiwan is not a signatory to the Kyoto Protocol), ii) political confidence that other policy measures will achieve the requisite CO_2 reductions necessary to meet international obligations (i.e. Japanese authorities are confident that energy efficiency improvements can significantly abate CO_2 emissions; Australian authorities view carbon capture and sequestration as the low-carbon technology of the future) or iii) general political apathy toward international obligations (i.e. the Canadian government has revised CO_2 emission reduction targets upward after claiming that the previous targets established by the former governing party were

unrealistic). As nations adopt stronger public CO_2 emission reduction commitments, support for wind power tends to be elevated with the rising tide.

6. The presence of a **Vertically Integrated Utility Monopoly** is a political hurdle to wind power development for at least three reasons. First, monopolies exhibit bureaucratic, non-commercial ideologies that tend to resist change (Posner, 1999). Second, government controlled monopolies are frequently insulated from external pressures to change. Strategic decisions regarding the types of fuel sources to be used for electricity generation are frequently made in well-insulated policy circles. This promotes "groupthink" wherein decisions made by the most powerful members of the strategic circle are embraced by all. The current situation in Taiwan exemplifies how this phenomenon can adversely impact wind power development. In Taiwan, key executives at Taipower (the government utility) do not believe there is sufficient wind power potential in the country to commit to aggressive wind power development programs. Third, utility monopolies are often mandated to keep electricity costs to a minimum and as such they can rarely accumulate sufficient capital to support wide-scale technology transitions (Valentine, 2010b).
7. **Weak Adjoining Grid Coordination** is a technical hurdle in that failure to effectively connect adjoining grids represents a missed opportunity to enhance grid stability and safely accommodate higher volumes of stochastic wind power. However, there is also a political dimension in that governments typically initiate the negotiations necessary to make such connections happen. One of the main reasons why Denmark has been capable of supporting such a high level of installed wind power capacity stems from its interconnectedness with the broader European grid (Meyer, 2004; Toke, 2002). In Australia, Canada and Japan, sub-

optimal interconnectivity between regional grids prevents higher levels of wind power from being integrated into the respective grids without destabilizing operations.

8. **Lack of R&D Support for Wind Power** was shown to inhibit wind power development in all four case study nations. In all case study nations, wind power is apparently considered to be a mature, commercially viable alternative energy technology; and as such, the government has ceded support for wind power to the free market. Unfortunately, with many fossil fuel technologies also receiving government support, wind power developers are forced to compete on an uneven playing field. While it is perhaps understandable to leave R&D funding to major wind turbine manufacturers such as the Vestas and Goldstar in order to improve turbine efficiency, investment in storage technologies which are vital for utility-scale viability of both wind and solar power technologies need government support to consolidate focus.

12.7 FURTHER RESEARCH REQUIREMENTS AND CONCLUSION

The STEP framework presented in Section 12.6 conflates insights from the four case studies in Part 2 to demonstrate that wind power development initiatives in any given nation are subject to impediments arising from social, technical, economic and political forces. The main implication of this for policymakers is that economic policy instruments designed to catalyze free-market change such as carbon taxation, emission trading schemes, renewable energy production subsidies or renewable energy production tax credits are subject to confounding forces from other STEP realms. Forebodingly, neglecting the influence of these forces puts any given economic policy at risk of producing sub-optimal results. Promisingly, attempts to mitigate these impediments might represent a way to achieve better policy results with less financial commitment.

Unfortunately, the STEP framework presented in this chapter falls short of providing policymakers with a definitive cognitive framework of forces which inhibit wind power development for at least four reasons. First, the framework has been developed from data extracted from only four case study nations. Analyses of more nations would help to validate the comprehensiveness of the variables presented in the STEP framework. Second, the four case study nations are all advanced economies. It is likely that the forces identified in the framework may differ depending on whether a country is industrialized, developing or underdeveloped. For example, many underdeveloped countries are characterized as exhibiting poor infrastructure, high levels of corruption and autocratic governments. It is very likely that in such countries, conditions pertaining to these three variables alone would have a significant impact on the pace, scale and scope of wind power development. Two separate frameworks may be necessary for understanding wind power development hurdles in developed and developing countries. Third, although the framework identified key STEP variables which have influence over wind power development in advanced nations, word limitations precluded an evaluation of the *relative* influence that these variables have on change within a given electricity regime. Understanding the relative influence of each variable is a necessary exercise if policymakers are to identify forces which will have the strongest potential for catalyzing electricity regime change. Fourth, given the numerous inter-relationships between the STEP forces, attempts must also be made to understand the nature of these connections and explicate how the forces which inhibit wind power development respond to changes occurring to other factors within the complex adaptive policy system. All four of these limitations need to be subjugated through further research in order to move the STEP framework forward from being a conceptual tool to a practical tool that policymakers can use to guide the development of better wind power development policy.

In closing, it is worth reiterating that Part 2 of this thesis began with a question. Are there other obstacles that extend beyond the realm of economic rationality that inhibit the development of wind power, and if so what are they? The STEP framework presented in this paper presents evidence that non-economic obstacles do exist and provides a clearer explication of both economic and non-economic barriers to wind power development. Although the STEP categories might require refinement as more nations are examined in the context of this framework and deeper understanding of the influence that each STEP force has on wind power development both directly and indirectly (through catalyzing change in other forces) is required to allow policymakers to fully utilize the STEP analysis for improving wind power development policy, the framework as presented indisputably achieves the goals of demonstrating that other non-economic barriers to wind power exist and cataloguing the forces in manageable STEP clusters. From this perspective alone, the analysis presented herein advances understanding of the socio-technical political economy of wind power development. If policymakers took steps to try and mitigate the confounding influences of the barriers identified in this STEP framework, it is likely that the efficacy of wind power development policy would be improved, if only by one STEP.

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