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FINDING A BALANCE BETWEEN RENEWABLE ENERGY AND NATIONAL SECURITY CONCERNS: WIND TURBINES AND INTERFERENCE WITH RADAR SYSTEMS

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ABSTRACT

A balance must be maintained between the competing agendas of renewable energy production and the national security of Canada.

Most countries are working towards fully implementing an energy security program and renewable energy sources are playing an important role in these energy security plans. As a country, Canada is slowly moving towards a goal of a reduced carbon footprint and a reduced reliance on fossil fuels to meet its growing energy needs. Without significantly increasing Canada's nuclear energy producing capability, the only viable means of doing this is to increase the amount of renewable energy being produced domestically. As renewable energy expands, health and safety concerns have sparked growing opposition to many forms of green energy. The opposition to the expansion of wind energy, wind turbines and wind farms has increased significantly over the last few years and potential health problems associated with wind farms are now receiving large amounts of publicity. However, wind turbines also create security concerns that have come to the attention of the Department of National Defence.

This paper analyzes the safety and security concerns of wind turbines and aviation safety and air defence, and the actions taken by governmental and non-governmental agencies in response to these concerns.

INTRODUCTION

> *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.*
>
> - Barack Obama, Address to Joint Session of Congress, Feb. 24, 2009

Energy Security is an important part of any countries overall security platform.[1] Most countries are working towards fully implementing an energy security program and renewable energy sources are playing an important role in these energy security plans. As a country, Canada is slowly moving towards a goal of a reduced carbon footprint and a reduced reliance on fossil fuels to meet our growing energy needs. Without significantly increasing our nuclear energy producing capability, the only viable means of doing this is to increase the amount of renewable energy being produced domestically. The major areas of renewable energy being developed are hydro, solar, wind, geothermal and biomass energy. As these approaches to delivering green energy expand and increase

[1] The author of this thesis has been a member of the Canadian Forces for the past 24 years. He is an Air Force Communications and Electronics Engineering officer who has served in tactical, operational and strategic roles. While employed within the Chief of the Air Staff, Directorate of Air Force Programs from 2005 to 2007, he served as the Canadian representative on the North Atlantic Treaty Organization (NATO) Air Traffic Management Committee, Communications, Navigation and Surveillance Working Group. In this capacity, he was exposed to strategic level discussions surrounding wind turbine interference with radio and radar systems. The author had access to briefings and documents from various NATO countries as well as the European Organisation for the Safety of Air Navigation (EuroControl) on wind turbine interference with radar systems and was given access to unclassified wind turbine interference reports and studies from several NATO countries. In Canada, the author led the working group made up of multiple government departments and non-governmental agencies that was responsible to address the problem of wind turbine interference in Canada. He was also the primary coordinator in developing the Technical Information on the Assessment of the Potential Impact of Wind Turbines on Radio Communication, Radar and Seismo-acoustic Systems published in 2006, which provided the initial guidance on the topic in Canada. The author has considerable background knowledge and a portion of this paper quotes from a reference document that he played a part in developing. Based on this professional experience, the author has a bias regarding the potential options for the Canadian Forces. This paper provides additional research and analysis to further the discussion on this critical security threat.

their portion of the energy that is brought to the market place, there are a growing number of groups that have begun speaking out about the negative impact of various types of renewable energy on health, safety and environmental issues.

Public and private opposition to the expansion of wind energy, wind turbines and wind farms has increased significantly over the last few years and potential health problems associated with wind farms are now receiving large amounts of publicity.

Another area of concern specific to wind energy are potential negative impacts that wind turbines have on both the radio and telecommunication industry as well as government departments that are responsible for the delivery of aviation safety and national security.

This paper will take a detailed look at the safety and security concerns that wind turbines have created with regards to aviation safety and air defence and the actions taken by governmental and non-governmental agencies in response to these concerns. The security concerns regarding wind energy are centred on the interference that individual and groups of wind turbines cause with radio communications and radar systems. This interference can reduce or eliminate radio communication signals, reduce the ability of weather radars to accurately predict the weather, increase the potential risk to air travel by cluttering air traffic control scopes and reduce the ability of the Department of National Defence to provide reliable air defence coverage for Canadian air space. This is seen as a significant national security concern.

As the number of wind farms increase in Canada, the number of conflicts between wind farm developers and the Department of National Defence has also increased. There is a need to find a balance between the goal of increasing green energy production and

meeting our security requirements to a level that is acceptable to both the department and our allies. This balanced approach will have to find a middle ground between developers that want to build turbines in locations close to airports and radars and the Department of National Defence, that want to keep wind turbines out of the line of sight of any radar installation and away from key areas where flying operations take place, including the approach paths to the airfields.

In trying to find this balance, we need to discuss some of the following questions: Does the renewable energy agenda trump energy security, economic progress, environmental protection, and national security? Is there a requirement to implement government regulations that would allow a department to halt development of renewable energy initiatives if they will negatively impact the ability of a department to deliver on its assigned security and safety roles and responsibilities? More specifically for the Department of National Defence, should the government be able to halt the development of a proposed wind turbine farm if it will create safety concerns, create or increase the possibility of flight safety incidents, or reduce the level of coverage of air traffic control or air defence radars?

CHAPTER 1 – ENERGY SECURITY

Energy security is a critical part of most countries overall national security plan and it plays a major role in every country's economy. But we must keep in mind that what constitutes energy security is unique to each country. Countries rich in energy resources have a very different view of energy security than countries that must rely on imports to meet most or all of their energy needs.[2]

Energy security can be defined as the "adequate, reliable and affordable supply of energy to support the functioning of the economy and social development"[3] or as "the uninterrupted availability of energy sources at an affordable price, while respecting environmental concerns."[4] And, the US Department of Energy lists the diversification of energy supplies as "its primary energy security goal, along with improvements in efficiency and environmental performance."[5] Energy security blends national security, natural resource availability, energy production, energy distribution and energy consumption into an interdependent combination that will have critical implications on the future stability of any country.

Energy security can be looked at from two primary aspects: short term and long-term energy security. Short-term energy security can be seen to focus on the ability of the

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[2] Canadian Security Intelligence Service (CSIS), "Canadian Energy Security: What Does Energy Security Mean for Canada?" 2009-10 Capstone seminar student report, 5, last accessed 1 Apr 2013, http://www.csis-scrs.gc.ca/pblctns/cdmctrch/Cnd_nrg_Scrt_Rprt-eng.pdf

[3] Government of Australia, "National Energy Security Assessment 2009," last accessed 1 Apr 2013, http://www.ret.gov.au/energy/Documents/Energy%20Security/National-Energy-Security-Assessment-2009.pdf.

[4] International Energy Agency (IEA), "Energy Security," last accessed 1 Apr 2013, http://www.iea.org/topics/energysecurity/

[5] US Department of Energy, "The Department of Energy Strategic Plan 2011", DOE/CF-0067, last accessed 1 Apr 2013, http://energy.gov/sites/prod/files/2011_DOE_Strategic_Plan_.pdf

energy system to react promptly to sudden changes in the supply-demand balance. This type of reaction is highly automated and is dependent on the capabilities of the distribution system to handle these types of changes. Long term energy security is mainly focused on sources of energy supply and the degree of control that is required, as well as the requirement to assist with economic developments and ensure environmental concerns are taken into consideration when developing and operating energy sources.[6]

A country's energy security strategy should consider energy independence as the desired end state. The strategy must include the mandatory diversification of energy supplies, an increase in conservation, a decrease in greenhouse gas emissions, sustained growth in domestic renewable energy sources, investment into new energy related technology, modernization of the energy distribution system and upgrading of existing energy production capabilities.[7]

Many countries across the globe place a high level of significance on energy security and have developed national energy policies and detailed energy security strategies. However, the importance of energy security is not just understood by individual countries, but by international and local organizations in all regions of the world. Various energy groups or agencies have been created by the United Nations, and regional organizations such as the European Union (EU), the North Atlantic Treaty Organization (NATO) and the Organization for Security and Cooperation in Europe (OSCE) have created energy related committees. These groups and agencies have many

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[6] IEA, Energy Security, last accessed 15 Apr 2013. http://www.iea.org/topics/energysecurity/

[7] Col George Wright, "It's Time for a National Energy Security Strategy." Master of Strategic Studies paper, US Army War College, 2008, 2.

common principles that are based around the sustainable use and sound management of existing natural energy sources, improving the efficiency of energy production, attempting to find energy efficiencies and reduce current energy consumption, developing new technology to meet the energy needs of the future, and working to increase the use of renewable energy sources.

"Sustainable energy for all" was launched by the United Nations Secretary-General. The organization brings key actors from all sectors of society together to work towards three key objectives, which they hope to achieve by 2030: increasing access to modern energy services; doubling the current level of energy efficiency; and increasing the market share of renewable energy by 100% across the globe.[8]

The International Energy Agency (IEA), made up of 28 member countries, was formed due to the 1973/1974 oil crisis. Initially, the IEA planned and coordinated the release of emergency oil stocks in case of potential major disruptions in the supply of oil. The IEA mission has evolved over time and the agency now works to ensure reliable, affordable and clean energy. The IEA focuses on energy security, economic development of energy resources and minimizing the potential environmental impacts of energy production.[9]

The World Energy Council (WEC) was formed in 1923 and is an UN-accredited global energy body. The WEC is seen as an impartial organization composed of world energy leaders drawn from various governments, private and state corporations,

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[8] United Nations Secretary General, "Sustainable Energy for All", last accessed 15 Apr 2013. http://www.sustainableenergyforall.org/about-us

[9] International Energy Agency, last accessed 15 Apr 2013. http://www.iea.org/aboutus/

academia, NGOs and energy-related stakeholders. These groups can seriously impact national energy strategies across the globe by hosting events where the approaches to energy policy can be discussed and publishing studies that will impact existing and future national energy plans, with an eye to delivering a future where energy supplies are affordable, stable and environmentally sensitive.[10]

These organizations and many more understand the importance of energy and the direct link between energy security and prosperity across the globe. A continued reliance on foreign owned fossil fuels can impact the direction of a country's foreign policies, weaken international leverage, undermine foreign policy objectives, as well as forcing countries to become involved with or support unstable or hostile regimes. Additionally, a dependence on fossil fuels can seriously undermine the economic stability of a country.[11] Most countries now agree that continuing to rely on fossil fuels for the majority of their energy does not provide a long-term solution for their energy needs. For an enduring solution, energy security must include a major increase in the development and implementation of renewable energy, to ensure all countries can meet the growing demand for energy in a safe and environmentally responsible manner.[12]

Canadian Energy Security:

Canada has a diverse resource base that meets a large share of the energy requirements of the country. This resource base gives Canada the flexibility to export

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[10] World Energy Council, last accessed 15 Apr 2013. http://www.worldenergy.org/about-wec/

[11] Center for Naval Analysis (CNA), *Powering America's Defense: Energy and the Risks to National Security*, (CNA, May 2009), vii.

[12] Center for Naval Analysis (CNA), Powering America's Economy: Energy Innovation at the Crossroads of National Security Challenges, (CNA, Jul 2010), viii.

energy resources. Canada also benefits from its unique relationship with the US. Canada is seen as a secure partner, capable of providing reliable energy to meet the needs of the US and in return, the US provides Canada with a growing market for its energy exports.[13]

Commodities	World production ranking 2010	Exports 2010		Destination		
Total energy	–	**$90.0B**	**(100.0%)**	**U.S.**	**$88.6B**	**(98.4%)**
Petroleum	Sixth (4.1%)	$72.3 B	(80.5%)	U.S.	$70.9 B	(98.1%)
Natural gas	Third (5.0%)	$15.6 B	(17.5%)	U.S.	$15.6 B	(100.0%)
Electricity	Sixth (3.0%)	$2.2 B	(2.0%)	U.S.	$2.0 B	(100.0%)

Table 1: Canadian Energy Facts[14]

However, the fact that Canada has significant energy resources contributes to the fact that Canada does not have a solid understanding of the importance of energy security. It also may impact the importance Canada places on access to energy and how other countries that need energy resources interact with Canada.[15]

Canada is a country rich in natural resources, with diverse sources of energy, including significant oil and natural gas reserves.

	2007	2008	2009	2010	2011	% Change (2010-2011)
Petroleum	6 939	6 839	6 785	7 090	7 506	5.9
Natural gas	6 657	6 385	5 984	5 772	5 765	-0.1
Hydroelectricity	1 311	1 346	1 314	1 253	1 350	7.7
Nuclear Electricity	318	326	306	308	324	5.3
Coal	1 539	1 512	1 379	1 524	1 500	-1.6
Wind, Tidal and Solar Electricity	11	14	24	35	37	7.3
Other	581	575	534	523	516	-1.4
Total	**17 356**	**16 996**	**16 327**	**16 505**	**16 998**	3.0
Annual % Change		-2.1	-3.9	1.1	3.0	

Table 2: Canadian Domestic Energy Production by Energy Source (petajoules)[16]

[13] Monica Gattlinger, "From Government to Governance in the Energy Sector: The States of the Canada-US Energy Relationship," American Review of Canadian Studies, vol 35 no 2, 322.

[14] NRCan, "Energy Facts 2010," last accessed 15 Apr 2013. http://www.nrcan.gc.ca/statistics-facts/energy/895

[15] CSIS, Canadian Energy Security…, 6.

[16] National Energy Board, "Canadian Energy Overview 2011 - Energy Briefing Note," last accessed 15 Apr 2013. https://www.neb-one.gc.ca/clf-nsi/rnrgynfmtn/nrgyrprt/nrgyvrvw/cndnnrgyvrvw2011/cndnnrgyvrvw2011-eng.html#s2

Yet, despite being a net energy exporter, we rely on oil imports to meet nearly half of our domestic needs. Oil is still the primary fuel when it comes to meeting the world's energy needs.

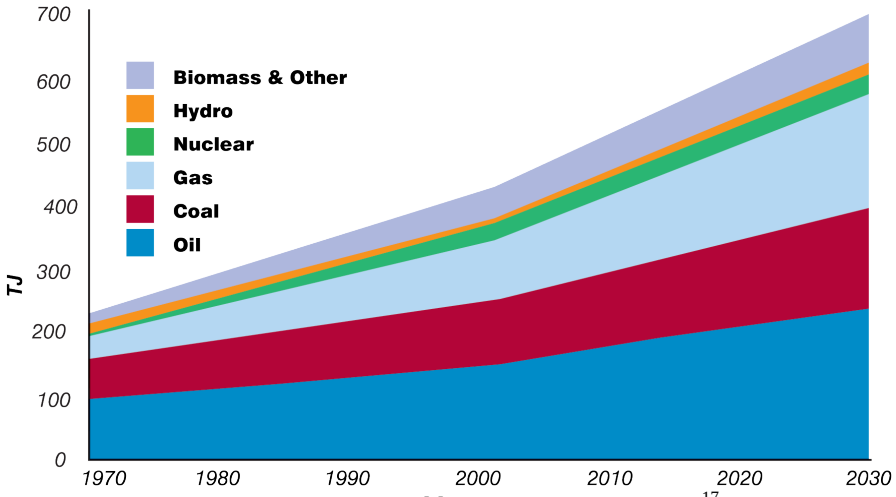

Figure 1: World primary energy sources[17]

The importance of energy to Canadian society is no different than any other country, with the population depending on energy to function. If we look at the vital everyday services that we rely on, including those provided by the government, by banks and other financial and commercial institutions, as well as companies that provide the ability to communicate, we will find an extreme level of dependence on reliable energy supplies. This dictates that the safeguarding or acquiring of the resources required to fuel our current and future society is of critical importance. These conditions are hardly unique to Canada; governments around the world are apprehensive about the sources of their energy and the potential impact to their energy security. Yet the Canadian government

[17] OECD/IEA World Energy Outlook 2004, "World Primary Energy Sources," last accessed 15 Apr 2013. http://www.world-nuclear.org/info/Energy-and-Environment/Uranium,-Electricity-and-Climate-Change/#.UW3zTzNzarQ

appears unconcerned about energy resources and environmental impacts, as Canada does not even have a current energy security policy.[18]

Part of the problem in Canada is related to the fact that energy and electricity is a provincial responsibility. The federal government is limited to inter-provincial and international facets of energy policy.[19] The closest document we have to an energy security policy may be the security policy of the National Energy Board (NEB). In April 2005, the National Energy Board Act was amended to include "security" within the mandate of the NEB. This provided clear direction that the NEB was responsible to regulate the security of the energy infrastructure under its jurisdiction. The NEB has implemented regulatory changes that have directed private companies to develop, document, implement and maintain a security program. However, the NEB is only responsible to regulate oil, natural gas and electricity. Other forms of energy are under the responsibility of other government departments. This fragmented approach to energy security does little to ensure that the government can react to an energy emergency in a timely manner.[20]

The last reference to a specific policy on Canada and energy security is "Energy Security: A Canadian Perspective," published by the Department of Foreign Affairs and International Trade (DFAIT) under the Conservative government in July 2008, just before the general election in October of 2008. It stated that:

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[18] CSIS, Canadian Energy Security…, 2.

[19] Crane, Bauer and Fickling, "Inextricably Intertwined: Canada and the United States as Global Partners in Securing Safe, Reliable and New Sources of Energy," Canada-United States Law Journal, Vol 36 no 2, 2011, 15.

[20] National Energy Board, Security Summary, last accessed 15 Apr 2013. https://www.neb-one.gc.ca/clf-nsi/rsftyndthnvrnmnt/scrty/scrty-eng.html

> Although Canada is a secure, stable, democratic country that produces and exports energy, it needs to be an active player in international efforts to address the crosscutting challenges faced by energy producers and consumers alike, and to enhance global energy security writ large. However, rather than prescribe active government intervention in the global energy market, DFAIT states that Canada is a trade-dependent economy strongly supportive of open, transparent and rules-based international markets, and that this is particularly true for the international energy market. DFAIT summarised the key energy security challenges as follows: Steadily rising demand, coupled with under-investment in energy infrastructure; disruption of supply due to political intervention, armed conflicts or natural disasters; an absence of transparency and predictability in regulatory, judicial and/or taxation frameworks; and increasingly unsustainable production and consumption of energy resources. In response to global energy security challenges, DFAIT states that the appropriate role for governments, whether of a developed or developing country, is primarily to establish an enabling business environment. That environment includes regulatory, judicial and taxation regimes.[21]

Any reference to this policy and all electronic copies have been removed from the government's website.

It is noteworthy that only the Green Party of Canada has published a national energy security strategy, which includes a requirement to develop a Canada-first National Energy Security Strategy and calls for "the implementation of a rapid transition from oil and other fossil fuel-based energy sources to secure, sustainable Canadian renewable energy sources."[22]

To have a balanced energy security plan, a country's energy mix must be diverse. Ensuring a more diverse mix of energy can result in a reduction in the level of dependence on single types of energy products or single sources of supply. This can lead

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[21] Lieutent Colonel Max Shaw, "Implications of Global Energy Security Concerns for the Canadian Forces: A Risk Management Approach," CFC, JCSP 35, 13.

[22] Green Party of Canada, "National Energy Security Strategy," last accessed 15 Apr 2013. http://www.greenparty.ca/vision-green/p5.18

to an increase in the country's resilience to unforeseen increases in price and unanticipated delivery problems. With the existing oil and gas reserves, the potential for additional oil and gas discoveries, nuclear power plants and a large hydroelectric capacity, Canada's supply of energy is one of the most diversified mixes of energy in the world. Although we are meeting todays demands, as our population continues to expand, more sources of energy will have to be brought on-line to meet the future needs of Canadians. Luckily, the potential for expansion within the Canadian renewable energy sector, to meet these future energy needs, has been proven to be very high.[23]

Canada, due to its varied geography spread out over a large landmass, has extensive renewable resources found in all regions of the country that can be used to produce energy; including hydro, geothermal, solar, biomass and wind options. Canada is considered to be one of the world leaders in the manufacturing, fabrication and use of energy from various types of renewable resources. Currently, the total production of those various sources of renewable energy provide well over 15% of Canada's total energy supply. Hydro dams are the key renewable energy source in Canada, providing almost 60% of Canada's total electricity generation. In fact, Canada is currently the second largest producer of hydroelectricity in the world, behind only China.[24] Over the last ten years, wind production has increased to the point that it is now the second most important renewable energy source in Canada. It only accounts for roughly 2% of electricity generation in Canada, but its market share is increasing every year. Biomass has been over taken by wind energy and has dropped to the third largest renewable

[23] CSIS, Canadian Energy Security…, 10.

[24] Statistics Canada, "Electric Power Generation, Transmission and Distribution: Analysis", 20 April 2009, last accessed 1 Apr 2013 http://www.statcan.gc.ca/pub/57-202-x/2007000/part-partie1-eng.htm

resource in Canada, generating slightly more than 1% of Canada's electricity. Neither geothermal nor solar energy currently play a significant role in meeting the energy needs of Canadians. However, over the last ten years, technical advances surrounding wind turbines and significant improvements in solar photovoltaic panels have led to substantial progress for both of these potential sources of electricity in Canada.[25]

Globally, in what was once a niche market, the renewable energy sector is now growing at significant rates, providing substantial amounts of energy and contributing to the world's supply of electricity in a meaningful way. Additionally, as countries continue to escalate their domestic energy production and lessen both their dependence on fossil fuels and the impact on the environment when fossil fuels are burnt, the share of renewable energy sources in the overall energy market will continue to grow.[26]

The importance of renewable energy has also grown worldwide, as more importance is placed on reducing emissions and greenhouse gases. Most governments have created renewable energy goals. Some countries have set these goals in legislation, leaving no ambiguity as to if a government will meet them or not. The European Union has set highly ambitious targets, such that 20% of the total energy needs of all member states must come from renewable energy sources by 2020. [27] This importance on renewable energy and climate change must be kept in mind by any country or government department that wants to discuss placing additional regulations or limitations

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[25] Natural Resources Canada (NRCan), "About Renewable Energy," last accessed 1 Apr 2013 http://www.nrcan.gc.ca/energy/renewable/1297

[26] North American Electrical Reliability Corporation, "Accommodating high levels of variable generation," (NERC, April 2009), 22. last accessed 1 Apr 2013, http://www.nerc.com/files/IVGTF_Report_041609.pdf,

[27] European Commission, "Renewable Energy Targets," last accessed 3 Apr 2013, http://ec.europa.eu/energy/renewables/targets_en.htm

on green energy development. No government wants to be seen as trying to limit the growth of renewable energy sources. In Canada, this would go against the fact that many segments of the Canadian population hold a love of nature and a concern for the natural environmental in high regard. This love of nature has translated into a strong environmental ethic, with eight out of ten Canadians believing that environmental protection should have priority over economic growth.[28] When Canada withdrew from the Kyoto Protocol in 2011, it made front page news across the country. The majority of the articles quoted various spokespersons from many different environmental organizations, whose opinions on the subject portrayed the decision and the government in a negative light to the Canadian public. Most of the articles provided a few lines to repeat the government's position as to why this was a good decision for the country.[29] Although this issue did not bring down the government, it did create concern about what Canada was doing to fight climate change and the government was kept on the defensive for months, until the story moved off the front page of newspapers. The current government has shown that it is willing to make unpopular decisions when it comes to reducing environmental protection and oversight in Canada and taking on environmental groups, left leaning news organizations and the opposition environmental critics.[30] However, that does not mean they are looking for opportunities to anger an industry that

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[28] David Boyd, "Unnatural Law: Rethinking Canadian Environmental Law and Policy," University of British Columbia, UBC Press 2003, 3.

[29] "Canada First Nation to Withdraw from Kyoto Protocol," last accessed 15 Apr 2013. http://www.thestar.com/news/canada/2011/12/12/canada_first_nation_to_withdraw_from_kyoto_protocol.html

[30] Kirsty Duncan, "The Harper Government's war on the environment," iPolitics Insight, 10 Apr 2012, last accessed 15 Apr 2013. http://www.ipolitics.ca/2012/04/10/kirsty-duncan-the-harper-governments-war-on-the-environment/

is based around renewable energy or create additional negative press without a solid reason to do so.

Summary:

Energy security is an important aspect of a countries overall security program. To help achieve energy security, most countries are increasing the development and implementation of domestic renewable energy projects. Canada has not published a current national energy policy or a comprehensive energy security platform. This direction from the government is needed to lay out long term energy goals, ensure clear priorities when dealing with both renewable and non-renewable energy sources and reconcile energy and environmental impacts.[31]

The following chapter will examine several renewable energy sources that should be part of any energy security program.

[31] Annette Hester, "The New Global Energy Geopolitical Game: Is Canada Ready to Play?" Canadian International Council, Jun 2009, 26, last accessed 15 Apr 2013. http://www.opencanada.org/wp-content/uploads/2011/05/The-New-Global-Energy-Geopolitical-Game-Annette-Hester1.pdf

CHAPTER 2 - RENEWABLE ENERGY

Renewable energy can be defined as energy that has been obtained from natural resources, where these resources can be naturally replenished or renewed within a reasonable amount of time. A reasonable amount of time is considered to be within a human lifetime. Due to their origins, some natural resources, such as water, wind and light from the sun are not at risk of being exhausted, no matter how much they are used for energy production.[32]

Renewable energy sources produce very low amounts of pollutants and carbon dioxide (CO2) and are increasingly being pursued as alternatives to fossil fuels. Such fossil fuels, like gas, oil and coal release energy when they are burned and are not renewable during a human life span. The resulting heat is used to generate steam that spins turbines, which generates power that meets the world's energy needs. The process of burning fossil fuels also releases air pollutants, such as sulphur dioxides, nitrogen oxides, mercury and CO2 into the atmosphere, which contributes to the production of haze, smog, acid rain and climate change.[33]

Another factor to consider is that supplies of fossil fuels are limited and as we keep on using oil, gas and coal to meet our energy needs, the world will eventually run out of fuel. With the projected growth of the world's population and the continuing progress and development of former third world countries, energy demand is growing

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[32] NRCan, "About Renewable Energy," http://www.nrcan.gc.ca/energy/renewable/1297

[33] Public Works and Government Services Canada (PWGSC), "Key Environmental Issues and Green Procurement," last accessed 8 Apr 2013http://www.tpsgc-pwgsc.gc.ca/ecologisation-greening/achats-procurement/trousse-toolkit/page-1-eng.html

fast. It is estimated that by 2035, there could be a jump of up to 50% in global energy demand.[34]

According to the 2012 International Energy Outlook, proven reserves of fossil fuels were estimated to be 43 years for oil (depleted in 2055), 60 years for natural gas (depleted in 2072), and 116 years for coal (depleted in 2128). Fortunately, besides what are defined as proven reserves, there are still a large number of discovered reserves that have not been developed as well as a large number of probable reserves that have not yet been found.

Global Fossil Fuel Reserves	**World Petroleum** (Billion Barrels)	**Natural Gas** (Trillion Cubic Feet)	**Coal** (Billion Short Tons)
World Reserves (Jan 1, 2000)	1,017	5,150	1089*
World Potential Reserve Growth	730	3,660	--
World Undiscovered Potential	939	5,196	--
TOTAL RESERVES	2,686	14,006	1,089
ANNUAL WORLD CONSUMPTION	27.340	84.196	4.740
YEARS OF RESERVES LEFT**	**98**	**166**	**230**

**World Estimated Recoverable Coal* ***Based on current levels of consumption and estimated total reserves*

Table 3: World Fossil Fuel Assessment[35]

In the future, as new technology becomes available or as increasing prices make specific developments financially advantageous, these reserves may increase the total amount of proven reserves of fossil fuels. Keeping these factors in mind, some experts suggest that oil supplies will last for another 100 years or more and the same level of increases can be expected with gas and coal. Experts have agreed that although technology will play a key role in the life expectancy of our fossil fuel reserves, the cost consumers are willing to pay for energy and the amount of energy the world continues to consume will also have a

[34] World Energy Outlook, "World Energy Outlook Fact Sheet 2012," last accessed 8 Apr 2013, http://www.worldenergyoutlook.org/media/weowebsite/2012/factsheets.pdf

[35] Colorado River Commission of Nevada, "World Fossil Fuel Reserves and Projected Depletion," March 2002, last accessed 15 Apr 2013. http://crc.nv.gov/docs/world%20fossil%20reserves.pdf

part to play. Nothing is certain, except the fact that one day in the future, we will no longer be able to rely on fossil fuels to meet our energy needs.[36]

Understanding the amount of time it takes to develop renewable sources of energy; most countries realize the urgency to continue pushing the development of renewable energy now, to ensure it is fully operational in the future when it is needed.

This chapter examines five of the major types of renewable energy that are in use in Canada and around the globe; hydro, geothermal, solar, biomass and wind. Additional details regarding wind power and wind turbines will be provided in order to set the stage for discussions surrounding interference issues later in the paper.

Hydro Energy

Hydroelectric power comes from the natural movement of water as it flows downstream. Usually, hydroelectric developments are built around an existing waterfall or an area of the river with a large current, to take advantage of the speed of the water. The electricity produced by a hydroelectric system is created by the flow of the water or the fall of the water over the blades of a turbine. The amount of electricity produced is determined by the volume of water passing through the turbine as well as the speed of the water. The turbine is connected directly to a generator and the turning blades convert the energy into electricity. Hydropower production mainly originates from two types of

[36] US Energy Information Administration (EIA), "International Energy Outlook 2011," last accessed 8 Apr 2013, http://www.eia.gov/forecasts/ieo/index.cfm

plants; large hydro plants that usually involve dams to help control and regulate the flow of water, and small hydro stations that are normally run off an existing river system.[37]

Figure 2: Priest Rapids Hydroelectric Dam, Columbia River, Washington State[38]

Hydropower is considered a clean, domestic, and renewable source of energy. The principal advantages include a reliable and renewable water source, extremely limited polluting emissions during operation and very low operating costs. Additionally, hydropower utilizes energy efficiently when generating power. This high level of efficiency allows the hydro station to convert almost 90% of the available energy from the water into electricity, as compared to less than 60% efficiency for most fossil fuel plants.[39] Cost effectiveness is also a major factor when looking at hydro developments. Other types of energy development take less time to design, the approval and environmental assessment process is shorter, the construction takes less time and the initial investment can be recovered quicker. However, developers have to balance these

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[37] EIA, "Energy Explained," last accessed 8 Apr 2013, http://www.eia.gov/energyexplained/index.cfm?page=hydropower_home

[38] US Department of Energy, Priest Rapids Dam, last accessed 15 Apr 2013. http://www1.eere.energy.gov/tribalenergy/guide/m/hydropower_large.html

[39] Pembina Institute, "Renewable Energy and Efficiency: Energy Source Hydro," last accessed 8 Apr 2013, http://www.pembina.org/re/sources/hydro-power

factors against higher operating costs, in conjunction with shorter operating lives of ten to twenty years. A hydropower plant has a high capital cost, but once construction is complete, maintenance costs are marginal when compared to other sources of energy production. The typical life of a hydro plant is 40-50 years and this can be easily extended in a relatively cheap manner by completing proper maintenance and scheduling periodic equipment upgrades. Additionally, the payback period for a hydropower investment is relatively short, as the operating costs have little variation and there is no price for the water itself.[40]

One key factor when evaluating potential hydro developments is that hydropower is more responsive than most other energy sources for meeting energy demands that vary during the day. Hydro power has the ability to regulate flow and reduce generating capacity when responding to load demands during reduced periods. This change to generating capacity can be started or stopped almost instantly. Water can be stored in a reservoir until needed, and then released through turbines to generate maximum power to help supply the demand at peak times. This flexibility can help ensure a reliable supply of energy and can help reduce the probability of brownouts and blackouts, when other sources of energy are unable to meet the needs of the region.[41]

Another area of hydro energy is based on the tides. In some parts of the world, water levels near the shore can vary up to 11 metres due to tides and a tidal range of only 3 metres can produce tidal energy economically. Tidal barrages can be placed across an

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[40] Alberta Agriculture and Rural Development, "Hydroelectric Power," last accessed 8 Apr 2013, http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/eng4431

[41] US Department of the Interior Power Resources Office, "Hydroelectric Power: Managing Water in the West," last accessed 8 Apr 2013, http://www.usbr.gov/power/edu/pamphlet.pdf

inlet to create a simple generation system. Gates on the barrages can be used to control water levels and flow rates, allowing the water to fill the tidal basin on the high tide rises and to empty in a controlled manner through the turbine system as the tide recedes. One of the two commercial-sized barrages operating in the world is located in Annapolis Royal, Nova Scotia. Instead of barrages, tidal turbines can be installed. Tidal turbines can be described as wind turbines located in the water and the turbines can be installed in many areas where there is strong tidal flow. Tidal turbines are larger, heavier and more expensive to build but are capable of capturing more energy. One major benefit of utilizing the tide to generate power is that tides are more predictable than wind energy and solar power.[42]

Geothermal energy

Geothermal energy is defined as heat that comes from the Earth. It is a renewable resource that provides clean energy by using the heat that radiates from the molten core of the Earth. The core of the planet will remain extremely hot for millions of years to come, which in effect ensures a never ending supply of heat. The construction of geothermal power plants allow this heat to be captured and the heat is then converted to energy, normally in the form of electricity. The geothermal energy can also produce electricity by directly pumping the heated underground water or steam through the deep wells to the surface, where it powers the generators.[43]

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[42] EIA, "Tidal Power," last accessed 8 Apr 2013, http://www.eia.gov/energyexplained/index.cfm?page=hydropower_tidal

[43] Geo-energy, "A Guide to Geothermal Energy and the Environment," last accessed 8 Apr 2013, http://geo-energy.org/reports/environmental%20guide.pdf

Figure 3: Nesjavellir Geothermal Power Plant, Iceland[44]

Geothermal reservoirs occur naturally and are found deep underground. In most cases there are few visual clues that would indicate the presence of this resource. When geothermal energy does find its way to the surface, it is normally found in the form of volcanoes, hot springs and geysers. High levels of geothermal resources are associated with fault lines or other areas where magma comes close to the surface. The molten magma then heats the ground water that has been trapped in porous rock or is running along fault lines far below the earth's crust. Currently, geothermal energy is normally used in one of three main ways:

- District heating systems make use of hot water that originates from springs or reservoirs near the surface. Hot water is piped directly into district heating systems, providing heat for buildings and industries.
- Geothermal power plants generating electricity pipe steam or hot water to the surface. The steam turns the generator turbines. These plants are generally built in

[44]What is Geothermal energy, "How Geothermal Energy Works", last accessed 15 Apr 2013. http://www.what-is-geothermal-energy.com/how-geothermal-energy-works-part-iii/

areas where geothermal reservoirs have been found within a few kilometres of the surface. Geothermal power plants emission levels are very low and the plants also use scrubber systems to clean the air before it is released into the atmosphere. Additionally, to balance the system, water from a geothermal reservoir that has been used by the plant and has cooled is injected back into the Earth.

- Geothermal heat pumps control building temperatures above ground by using water that is kept at stable temperatures just below the Earth's surface to cool or heat the building. While temperatures above ground change continuously throughout the year, temperatures just 3 metres below the Earth's surface remain nearly constant. This results in soil temperatures that are warmer than the air in winter and cooler than the air in summer. Water that circulates in the ground also remains at that common temperature. The process is then based around pumps that circulate the water from below ground into buildings, allowing the transfer of the heat from the water to the building in winter and reversing the process in the summer. According to the U.S. Environmental Protection Agency (EPA), "geothermal heat pumps are the most energy efficient, environmentally clean, and cost effective systems for temperature control."[45]

There are many advantages associated with geothermal energy. The energy can be extracted from the earth without requiring the burning of a fossil fuel. The process utilized when creating electricity from geothermal fields produces very little CO2. It has been shown that when compared to a power plant fueled by clean natural gas, the

[45] EIA, "Geothermal Energy," last accessed 8 Apr 2013, http://www.eia.gov/energyexplained/index.cfm?page=geothermal_home

geothermal plant produces approximately 15% as much CO2. The operating costs of geothermal plants are relatively inexpensive; as little as 20% compared to plants utilizing fossil fuels.[46] Electricity from geothermal energy is consistently available, as compared to the sources of solar and wind energy, which fluctuate based on many factors. The earth is providing the heat that is the source of geothermal energy, and that heat is available every hour of every day, all year long. Additionally, once the initial construction is completed, geothermal plants normally have very low scheduled and unscheduled outage rates.[47]

In the future, geothermal energy can represent a large, domestic resource that can compete with fossil fuels and provide electric power and heat with minimal environmental impacts. It can provide a secure, robust, long lasting option for energy production, working in conjunction with other forms of renewable energy to meet the energy needs of the country.[48]

Solar energy

Solar energy is the sun's solar radiation that has passed through the atmosphere and reached the surface of the Earth. Solar energy technologies can convert this radiation directly into other forms of energy, such as heat and electricity.[49]

Solar energy can be harnessed either through passive or active solar technologies. Passive techniques start with the location of building and involve orienting the direction

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[46] National Geographic, "Geothermal Energy," last accessed 8 Apr 2013, http://environment.nationalgeographic.com/environment/global-warming/geothermal-profile/

[47] U.S. Department of Energy, "Geothermal Energy: Clean Sustainable Energy for the Benefit of Humanity and the Environment," (Energy and Geosciences Institute at University of Utah, May 2001), last accessed 8 Apr 2013 http://www.geo-energy.org/RedBrochure.pdf.

[48] Massachusetts Institute of Technology, "Panel Report - The future of geothermal energy," last accessed 8 Apr 2013, http://www1.eere.energy.gov/geothermal/pdfs/egs_chapter_1.pdf

[49] US Department of Energy, "Solar Resources," last accessed 8 Apr 2013, http://www.eere.energy.gov/basics/renewable_energy/solar_resources.html

it is facing with respect to the sun, as well as various other elements, such as the type and composition of the windows. This takes advantage of the sun to assist with the lighting and heating of a building and significantly reduces the use of electricity. Passive solar heating does not use any mechanical equipment. Active solar technology harnesses the energy for heat and electricity generation. Solar collectors or panels located on or near a building can heat water to assist in heating a building or the collectors can heat the air for use in ventilating a building. Solar thermal power plants are built to allow solar collectors to capture the sun's rays and utilize this energy to heat fluids and produce steam, which is then used to power a generator. Solar photovoltaic technology uses a slightly different approach, where solar cells are built to allow them to capture the sun's rays and directly convert the sunlight into electricity.[50] Many individuals use this technology every day without even thinking about it. Tiny photovoltaic systems are installed on wrist watches and provide a miniscule amount of power to operate the watch. Small solar energy systems are meant to provide power to a few homes or a business. These small systems can also be used to meet the power needs of remote communities that are not close to the power grid. Larger solar energy systems are built to provide significant amounts of electricity to be sold to the electricity companies and added to the electrical grid.[51]

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[50] NRCan, "Solar Energy," last accessed 8 Apr 2013, http://www.nrcan.gc.ca/energy/renewable/1297#solar

[51] US Department of Energy, Solar Energy, last accessed 8 Apr 2013, http://www.eere.energy.gov/basics/renewable_energy/solar.html

Figure 4: Concentrated Solar Power Plant, Sicily Italy[52]

Solar energy currently plays a minor role in Canadian energy production. Most of the solar energy that is captured in Canada is used in water and home heating systems. It can also be used to bring reliable power to remote locations without developing the expensive infrastructure to transport the electricity. Canada does possess significant solar potential and to encourage the development of a Canadian solar industry, some provinces have guaranteed solar producers a high fixed rate for any power fed to the grid. It is estimated that if all residential buildings installed solar panels on their roofs, approximately 50% of Canada's housing electricity requirements could be met.[53]

In the past, solar energy growth was limited due to the technological barriers with collection, distribution, and storage of the energy. The existing technology was too expensive and the efficiency of solar collectors that captured and converted the energy into electricity was too low to compete with fossil fuels. However, the increasing cost of

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[52] Inhabitat, "Worlds first molten salt solar plant," last accessed 15 Apr 2013. http://inhabitat.com/worlds-first-molten-salt-solar-plant-produces-power-at-night/

[53] CSIS, "Canadian energy security…," 12.

energy, in conjunction with improved technology and increased silicon production are acting to make photovoltaic cells more competitive. At some point in the future, solar energy will be able to compete with fossil fuels and will begin to make significant inroads into the energy market.[54]

Biomass energy

Biomass is made up of renewable organic material made from plants and animals that can be converted to energy, and can be found in solid, liquid or gaseous form. The energy that we find in plants is absorbed from the sun's energy in a process called photosynthesis. Animals gain that stored energy when they eat the plants. Biomass is considered a renewable energy source as we can plant and grow more trees and crops to replace those we use, and organic waste will always exist as a by-product of various industries. Some different categories of biomass fuels are wood and wood products, crops, manure, and some garbage. Bioenergy is comprised of the different forms of usable energy obtained from biomass. When burned with the proper technology and equipment, biomass creates heat, which is then used to either provide heat to industries and homes or produce steam which is used to power the generator to create electricity. It is important to note that products such as coal or petroleum, which originated as organic material but over extremely long periods of time were transformed into their current state, are excluded from this definition.[55]

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[54] MIT Technology Review, "Energy Storage for Solar Power," last accessed 8 Apr 2013, http://www.technologyreview.in/energy/38257/

[55] US EIA, "Biomass," last accessed 8 Apr 2013, http://www.eia.gov/energyexplained/index.cfm?page=biomass_home

Figure 5: Biomass Energy Plant, Vaskiludon Voima Voi in Vaasa, Finland[56]

Energy can be released from biomass by various means, in addition to burning. Methane gas or other transportation fuels, such as ethanol and biodiesel, are converted forms of biomass. Methane can be produced from several different sources, including landfills, manure and agricultural waste. Transportation fuels are created from sugar, which is extracted from agricultural crops like corn and sugar cane and then distilled into alcohol. The alcohol is then added to existing fuels or utilized in specialized engines that are built to run on biofuels. Biodiesel is another form of biofuel. There are two distinct types of biodiesel, one of which can be used in standard diesel engines and a second type that is produced from discarded food products like vegetable oils and other waste oils to fuel converted diesel engines. Biodiesel can also be blended with regular diesel fuel. To encourage the production and use of biofuels now and in the future, many governments have introduced regulations that require a minimum percentage of renewable content in fuel products. This content level may increase over the coming years. A large number of

[56] Renews, "140MW plant takes bio crown," last accessed 15 Apr 2013. http://renews.biz/140mw-plant-takes-bio-crown/

other systems are being developed or already exist that make use of other biomass feedstock.[57]

With the significant size of its forestry and agricultural industries, Canada has the ability to increase its biomass energy production utilizing diversified resources from various parts of the county. Currently, industrial wood waste is the primary biomass ingredient in the production of steam and electricity in Canada. In an interesting dynamic, the waste from the pulp and paper industry provides the fuel that is burned as biomass to provide more than half of the energy used by that industry. This energy is then used by pulp and paper plants to create more wood waste. Due to this harmonious relationship, the pulp and paper industry is by far the largest industrial user of bioenergy in Canada. Currently, bioenergy is the third largest category of renewable energy in Canada, representing almost 5% of Canada's total primary energy.[58]

Biomass power has been proven to have many benefits over fossil fuels and even over other forms of renewable energy. Biomass power is reliable, economical and environmentally sustainable and should be an essential component in any nation's energy strategy. Biomass power plants that have a sustainable and economically available source of biomass are a viable source of clean renewable electricity and are a crucial tool, along

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[57] US Department of Energy, "Biofuels," last accessed 8 Apr 2013, http://www.eere.energy.gov/basics/renewable_energy/biofuels.html

[58] NRCan, "Bioenergy," last accessed 8 Apr 2013, http://www.nrcan.gc.ca/energy/renewable/1297#geo

with other renewable energy resources, to meet future energy needs while addressing climate change.[59]

Wind energy

Wind is defined as a form of solar energy. Winds are the result of the uneven heating of the earth's atmosphere by the sun, varying atmospheric pressures due to irregular elevations of the earth's surface, and the rotation of the planet. Wind energy has been harnessed for centuries, but today the kinetic energy of the wind is being harvested by wind turbines and used to generate electricity. Wind is a renewable energy source that release little to no pollutants into the atmosphere, so it is seen by many proponents as an excellent alternative to fossil fuels.[60]

Figure 5: Klondike Wind farm, Oregon[61]

There are four main components to a wind turbine: the blades, nacelle, tower and base. The blades turn as the wind flows over them. This is much like the effect of wind

[59] American renewable, "Biomass Energy," last accessed 8 Apr 2013, http://www.amrenewables.com/biomass-energy/biomass-experts.php

[60] European Wind Energy Association (EWEA), "Wind Energy," last accessed 8 Apr 2013, http://www.ewea.org/wind-energy-basics/wind-energy-faq/

[61] Renewable Northwest Project, "Windfall from the Wind Farm - Sherman County Oregon", last accessed 15 Apr 2013. http://www.rnp.org/sites/default/files/pdfs/Klondike%20Paper.pdf

passing over airplane wings, which creates lift and allows the airplane to fly. The major difference is that the blades on a turbine can be adjusted as the wind direction changes, allowing the turbine to capture the maximum energy from the wind.

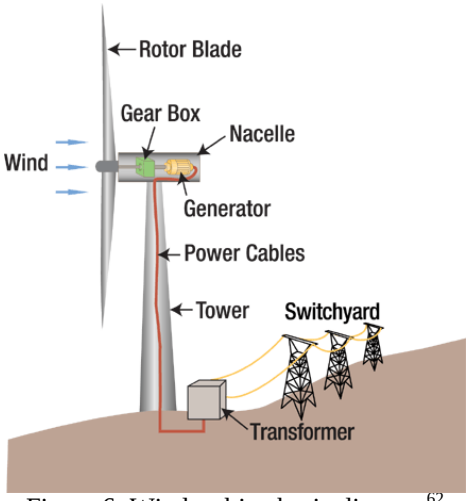

Figure 6: Wind turbine basic diagram[62]

Common turbine blades are about 30 to 50 metres tall. The blades spin relatively slowly, rotating at about 20 revolutions per minute (RPM), which is deceiving as the speed at the blade tip can be over 240 kilometres per hour. The blades capture the wind's energy, turning a generator in the nacelle to produce electricity. The tower supports the nacelle and it contains the electrical conduits. Most towers are designed in the shape of a steel cylinder, about 60 to 100 metres tall and 3 to 5 metres in diameter. The base, which has to support the whole structure with constant pressure from the wind, is made of reinforced concrete and steel. Although you may see a limited number of single wind turbines, most often they are built in large groups of between 20 and 100 turbines to form wind farms or wind power plants. It is interesting to note that electrical output depends on wind speed and the combination of blade diameter and generator size. Building bigger

[62] Working Wind, "Parts of a wind turbine," last accessed 15 Apr 2013. http://www.workingwind.com/what-are-the-parts-of-a-wind-turbine

blades and putting a bigger generator on top of a taller tower can allow the turbine to capture more wind, but it does not mean it is more efficient at generating energy than smaller models. Larger turbines are however more expensive and require a correspondingly larger area around them, expanding the total size of the farm.[63]

The wind farms are normally located in strategic areas that have proven to have good wind regimes over long periods of time. Developers also look to build wind farms in close proximity of existing electrical grids, to minimize the cost of installing new infrastructure to get the power to the grid. Electricity generated by wind farms may be used locally; however most major wind farms sell their energy to the electric companies, to power homes and businesses farther away.[64]

Wind energy is captured only when the wind is blowing at a sufficient speed to move the turbine blades. Turbines are not used in high winds, as the turbine may be damaged if the blades spin too quickly or in an uncontrolled manner. And there is still the problem of meeting electricity needs when the wind is too weak or isn't blowing at all and the turbines are not producing power.[65] Wind turbines start operating when the wind is blowing at wind speeds of as little as 4 to 5 metres per second. Maximum power output is achieved when the winds reach around 15 metres/second. At wind speeds above 25 metres/second (gale force winds), the wind turbines shut down. A modern wind turbine located in an area with reliable winds produces some amount of electricity 70-85% of the

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[63] Energy Centre of Wisconsin, "Wind Power," last accessed 8 Apr 2013, http://www.ecw.org/windpower/web/cat2a.html

[64] Canadian Wind Energy Association (CanWEA), "Wind Energy," last accessed 8 Apr 2013, http://www.canwea.ca/wind-energy/index_e.php

[65] NRCan, "Wind Power," last accessed 8 Apr 2013, http://www.nrcan.gc.ca/energy/renewable/1297#wind

time, but the amount of power that it generates are dependent on the wind speed.[66] For planning purposes, a turbine will typically operate at 25-35% of maximum capacity over time.

Utilizing wind to generate power has advantages and disadvantages. A natural advantage of wind energy is that energy demand and the amount of energy that is produced operate on the same schedule. Daytime periods where demand is high coincide with windier conditions, whereas nighttime periods of reduced demand coincide with less wind and less energy production. This is convenient, as it is not possible to store wind energy, due to the nature of the Canadian electricity grid. It is possible to reduce production by regulating the turbine blades. A natural disadvantage of wind energy is a reduction in wind levels during cold winter conditions as well as during hot periods in the summer.[67] Research into large-scale electricity storage is critical if alternative energy sources that only produce power intermittently are going to thrive. New developments improving battery technology could remove one of the major detractors from wind energy.[68] Due to the underlying unreliability of wind energy, it should only be one of many sources of power generation in a diversified energy plan.

Canada has significant potential to expand wind power generation in many areas of the country. Large regions of the country have proven to have excellent wind resources and would make first-rate locations for wind farm developers. Some of the areas with the

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[66] EWEA, "Wind Energy," http://www.ewea.org/wind-energy-basics/wind-energy-faq/

[67] CSIS, Canadian Energy Security…, 11.

[68] Yale Environment 360, "The Challenge for Green Energy - How to Store Excess Electricity," last accessed 8 Apr 2013, http://e360.yale.edu/feature/the_challenge_for_green_energy_how_to_store_excess_electricity/2170/

highest quality winds are offshore and along the coastline. But due to the fact that the majority of Canada's coastline is not close to the existing electrical grid, the development of offshore and coastal wind farms has been restricted. Closer to the electric grid, there are also inland areas in Canada where wind farms would flourish, including locations on hilltops, in open plains or other areas where the geography results in the production of wind funneling. The total quantity of wind generated electricity has grown significantly in Canada and around the world in recent years. Ontario, Quebec and Alberta are the provincial leaders when it comes to wind power production capacity and Alberta has put forward plans to increase its wind capacity six fold over the next five years.[69]

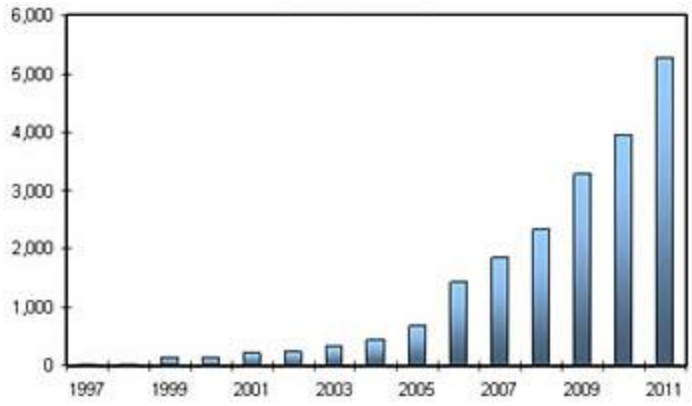

Fig 7: Installed Wind Power Capacity in Canada (in megawatts)[70]

In locations with the best available wind resource as well as nearby access to the electricity grid, wind power plants can be competitive with conventional electricity producers. The wind energy sector is making significant improvements, increasing the performance of the wind turbines and new technologies are significantly reducing the

[69] NRCan, "Wind Energy," last accessed 8 Apr 2013, http://canmetenergy.nrcan.gc.ca/renewables/wind/2171

[70] NRCan, "Installed Wind Power Capacity in Canada," last accessed 8 Apr 2013, http://www.nrcan.gc.ca/energy/sites/www.nrcan.gc.ca.energy/files/images/wpc-cpe-e.jpg

cost of operating and maintaining them once installed. The estimated lifetime of an individual turbine is 20-25 years. The overall result has been a reduction in the cost of producing electricity from wind and an increase in profitability. Further growth in wind power has also been encouraged by offering renewable energy projects significant taxes breaks, as well as authorizing the creation of green pricing programs. Under green energy pricing programs, many utilities around the country offer customers the option to pay more for electricity, but will guarantee that the electricity comes from renewable sources.[71]

Summary

Today, the world is heavily dependent on fossil fuels; primarily oil, coal and natural gas for its energy. It is understood that fossil fuels are non-renewable and draw on limited resources that cannot be replaced. These forms of energy are becoming more expensive each year and have a significant impact on the environment. As seen in this chapter, there are many types of renewable energy resources that will never run out and provide valid options to reduce our dependency on fossil fuels, while taking the first steps towards finding a long term solution to our energy needs.[72] Most experts agree that no single energy solution can meet the future energy needs of any industrialized country. To increase our energy security, a long term solution must come from a diverse family of energy sources and technologies, including various forms of renewable energy that will

[71] EIA, "Electricity Generation from Wind," last accessed 8 Apr 2013, http://www.eia.gov/energyexplained/index.cfm?page=wind_electricity_generation

[72] Renewable Energy World, "Types of renewable energy", last accessed 15 Apr 2013. http://www.renewableenergyworld.com/rea/tech/home

not destroy our environment.[73] The following chapter will look at some of the potential problems associated with renewable energy sources.

[73] Ecology.com, Fossil Fuels vs Renewable Energy Resources, http://www.ecology.com/2011/09/06/fossil-fuels-vs-renewable-energy-resources/

CHAPTER 3 - PROBLEMS WITH RENEWBLE ENERGY

All energy sources impact our environment, but importance must be placed on the degree of that effect. Scientists have shown that fossil fuels create considerably more CO2 and other greenhouse gases than renewable energy sources. Due to these levels of CO2 emissions, it is felt that fossil fuels do substantially more harm to our environment than renewable energy sources.[74]

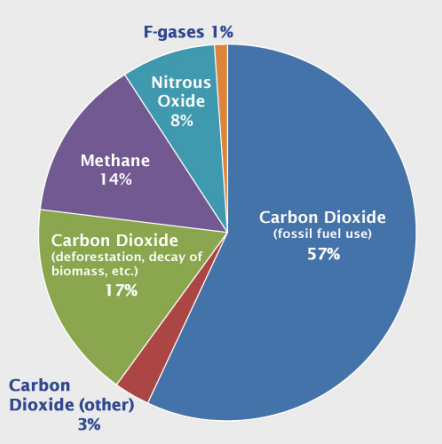

Figure 8: Global Greenhouse Gas Emissions by Gas

However, even renewable energy sources such as hydropower, geothermal, solar, biomass and wind have the power to create undesirable impacts on the environment. To fully understand renewable energy and compare the benefits it brings in relation to fossil fuels, it is important to understand the potential negative impacts of this greener form of energy production. Over time, various problems have been identified with the different categories of renewable energy. Some of these problems are minor in nature, while others are more significant. Some of the problems have been proven, while others are still theoretical or being investigated. Industry and governments have taken steps to address

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[74] Union of Concerned Scientists, "Environmental Impacts of Renewable Energy Technologies," last accessed 15 Apr 2013. http://www.ucsusa.org/clean_energy/our-energy-choices/renewable-energy/environmental-impacts-of.html

some of these problems, while others are ingrained in the basic design of delivering their energy. By having a better understanding of the current and potential environmental concerns and problems associated with the various types of renewable energy sources, steps can be taken to minimize or eliminate these impacts, as renewable energy sources deliver a larger portion of our electric supply in the future. [75]

Problems with Hydropower:

Although hydroelectric power claims to be one of the most environmentally-friendly sources of energy, multiple reports, including the Report on Continental Energy Sector Issues prepared by the Canadian Energy Research Institute in March 2004 have shown that hydro developments have the capability to alter or significantly damage their surroundings. When the first hydropower plants were constructed, there was little to no consideration made with regards to environmental effects. Today, every effort is made in North America to insure that any hydro development has a minimal environmental and social effect on the surrounding areas. However, this is not always the case in other countries, such as China.[76]

One of the problems surrounding hydroelectric power is based on a significant impact on downstream water quality. This impact can include higher water temperatures, a reduction in the oxygen content, an increase in the amount of silt carried in the water as

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[75] Union of Concerned Scientists, "Environmental Impacts of Renewable Energy," last accessed 8 Apr 2013, http://www.ucsusa.org/clean_energy/our-energy-choices/renewable-energy/environmental-impacts-of.html

[76] Alberta Agriculture and Rural Development, "Hydroelectric Power," last accessed 8 Apr 2013, http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/eng4431

well as rise in phosphorus and nitrogen content.[77] Many of the major hydroelectric projects have involved the construction of large dams, which result in a river habitat being replaced by a lake habitat. This leads to the destruction or severe alteration of the habitats of wildlife and water based organisms.[78] Dams logically lead to the creation of reservoirs, where greenhouse gases, CO2 and methane may form, due to the decomposition of plants in the flood areas. The movement of the water through the turbines then allows these gases to be released into the atmosphere. There is uncertainty regarding how much greenhouse gas is produced from reservoirs, but some opponents of hydro developments claim the generation of an equivalent amount of electricity may result in more CO2 emissions from a hydro plant than from a fossil fuel plant.[79] Another major problem occurs when dams slow down and reduce the flow of the river, resulting in the removal of water that was needed by the healthy ecosystem that existed before the construction of the dam. This reduction in water levels disrupts the natural flow of the river and can create obstructions for various species of fish and other marine life. Salmon were especially impacted by hydroelectric dams, which prevented the fish from migrating upstream to spawn. Fortunately, a solution was found for this problem with the invention and production of fish ladders. These structures created a passageway for fish to navigate past any major obstruction in the river, including a dam.[80] When discussing the

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[77] Foundation for Water and Energy Education, "How a Hydro-electric Project can Affect a River," last accessed 8 Apr 2013, http://fwee.org/environment/how-a-hydroelectric-project-can-affect-a-river/changes-to-the-ecosystem/

[78] Oak Ridge national Laboratory, "Hydro Power: Licensed to Protect the Environment," last accessed 8 Apr 2013, http://www.ornl.gov/info/ornlreview/rev26-34/text/hydmain.html

[79] Earth Island Journal, "Are Dams Fueling Climate Change?" last accessed 8 Apr 2013, http://www.earthisland.org/journal/index.php/eij/article/bubbling_waters/

[80] Canadian Energy Research Institute, "Continental Energy Sector Issues," (National Round Table on the Environment and the Economy, March 2004), 28, last accessed 8 Apr 2013, http://www.ec.gc.ca/energie-energy/default.asp?lang=En&n=79B18E90-1

construction of dams and their impact on the environment, it is interesting to note that most dams that were built in the United States were built mainly to minimize the chances of flooding, to ensure the supply of water for cities and to assist with the irrigation of farmland. Only a limited number of dams were ever designed and built specifically for hydropower generation.

Tidal power also comes with potential disadvantages. A tidal station can have serious effects on plants and animals that live in and around the area where the station is installed. Tidal barrages can result in changes to the tidal level in the basin and may increase the amount of material that is found in the water, thereby changing the makeup of the water content.[81]

Problems with Geothermal Power

Geothermal technologies have proven many environmental advantages over conventional power generation, but it is possible to find environmental problems with this form of renewable green energy as well. The main concerns with geothermal energy production are directed towards the release of hydrogen sulfide into the atmosphere and the requirement to dispose of some geothermal fluids, which may contain low levels of toxic materials, including arsenic, mercury, lithium and boron.[82]

Additional concerns are centred on the fact that the process of removing geothermal fluids from the ground in some locations has been shown to remove heat from natural reservoirs in the earth's crust at over 10 times their rate of replenishment. The

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[81] EIA, "Tidal Power," last accessed 8 Apr 2013, http://www.eia.gov/energyexplained/index.cfm?page=hydropower_tidal

[82] National Geographic, "Geothermal Energy," last accessed 8 Apr 2013, http://environment.nationalgeographic.com/environment/global-warming/geothermal-profile/

extraction of geothermal fluids and the subsequent pressure reduction in underground reservoirs creates the potential for the land to sink. The largest settling of an area that was being utilized to generate geothermal power sank by almost half a metre every year. In 2005, measurements of the ground found that it had sunk 14 metres since the construction of the power station. There is also concern about potential damage caused to natural geothermal features, such as hot springs, mud pools, geysers and steam vents. These natural phenomena are easily and irreparably damaged by geothermal development in their region.[83]

Problems with Solar Power

Although solar panels that are installed on the roofs of buildings have a minimal environmental impact and solar energy systems have been shown to produce no air pollutants or CO2, some groups have still raised several areas of concern. The first concern is actually a limitation. Solar energy can only be captured during daylight hours, and only when the sun is shining. This can easily be interrupted or blocked by clouds, buildings or other obstacles. The potential to capture solar energy is lower in coastal regions as there is increased cloud coverage, and is higher in the inland regions due to increased levels of sunlight.[84] When looking at and measuring sunlight, the amount that hits each area of the Earth's surface fluctuates depending on the exact location, the time of day, the season, and specific weather conditions. Due to the limited amount of sunlight that is delivered at any one specific location at any one time, solar panels would have to

[83] The Encyclopedia of New Zealand, "Geothermal Energy," 5, last accessed 8 Apr 2013, http://www.teara.govt.nz/en/geothermal-energy/page-5

[84] US DOE, "Solar Resources," last accessed 8 Apr 2013, http://www.eere.energy.gov/basics/renewable_energy/solar_resources.html

be spread out over a large surface area to ensure that sufficient energy was collected to make the project cost effective.[85]

Figure 9: Wyandot Ohio Solar Energy Farm[86]

Solar energy also has some indirect effects on the environment. When photovoltaic cells and solar collectors are manufactured, toxic materials and chemicals are used and some solar thermal systems utilize hazardous fluids. All of this equipment and the fluid will require proper handling and disposal.[87] Environmental considerations when reviewing larger solar developments should also look into land use impacts, including potential impacts to specially designated areas, vegetation, wildlife, wildlife habitat, and sensitive species.[88]

The problem of conserving and storing power that is produced intermittently and allowing its use when it is needed has not yet been resolved. The use of solar cells will

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[85] Financial Post, "Solar panel makers grapple with hazardous waste problem," 11 Feb 2013, last accessed 8 Apr 2013, http://business.financialpost.com/2013/02/11/solar-panel-makers-grapple-with-hazardous-waste-problem/?__lsa=0762-b074

[86] PSEG Energy Holdings, Wyandot Solar Farm press kit, last accessed 15 Apr 2013. http://pseg.com/wyandot/

[87] EIA, "Solar Energy," last accessed 8 Apr 2013, http://www.eia.gov/energyexplained/index.cfm?page=solar_home

[88] Solar Energy Development Info Centre, "Solar Energy Development Environmental Considerations," last accessed 8 Apr 2013, http://solareis.anl.gov/guide/environment/index.cfm

continue to be limited until more efficient and economical batteries can be produced or other storage systems can be developed.[89]

Problems with Biomass Power

When evaluating biomass as a viable renewable energy source and part of the solution to the problem of energy security, there are two main issues that need to be discussed. The first is the actual production of biomass products and the potential effects if biomass is produced by utilizing existing farm land that was intended to grow food crops. The second issue is based on the potential effects as the factory converts biomass into usable energy or electricity and specifically, what types of biomass are authorized to be burned in those factories. When discussing biomass as a valid renewable energy resource producing green energy, there are experts on both sides of the argument. There is proven environmental and economic benefits due to the growth of the biomass industry, while some environmentalists have shown certain detriments that occur over time due to the continued production of biomass energy. This has created a problem as to how to properly evaluate the potential success of biomass as an alternative fuel.[90]

Producing biomass was not seen as a problem. Finding a use for forest residues and by-products of other industries was beneficial. However, sustainability has become a concern as more biomass is required. Forests are now being cut to meet the needs of the

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[89] Solar Choice, "Solar Power Storage Solutions," last accessed 8 Apr 2013, http://www.solarchoice.net.au/blog/solar-power-storage-solutions-beyond-batteries/

[90] Alternate Energy, "Biomass," last accessed 8 Apr 2013, http://www.altenergy.org/renewables/biomass.html

biomass industry and food crops are being replaced with crops destined as use in the energy sector.[91]

Burning methane gas produced in landfills eliminated an environmental problem. While it is true that burning landfill methane gas does not eliminate all of the pollution, it is much better to burn methane gas than to simply vent it into the atmosphere. Burning landfill gas is viewed by many environmentalists as an ecologically sound practice, but at the same time they have argued that this does not make methane an acceptable source of biomass energy.[92]

The biggest concern with biomass plants is the requirement to ensure that when anything is burned, it is burned cleanly and it does not release pollutants back into the atmosphere. The factor that comes into play is the lack of clear definitions on what can and what cannot be used as biomass. The largest problem involves what types of garbage are allowed to be burned and what types of materials can and cannot be contained in waste products that are burned in biomass plants. The type of biomass utilized and what type of energy sources it is being compared against can significantly change the results. This could create the potential for biomass energy production to actually produce more air pollution than some fossil fuel plants.[93] To try and address this issue, incinerators and waste-to-energy power plants have been mandated to use technology to prevent harmful gases and particles from entering the atmosphere. The Environmental Protection Agency

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[91] European Commission, "Report From The Commission To The Council And The European Parliament on sustainability requirements for the use of solid and gaseous biomass sources in electricity, heating and cooling 2010," 4, last accessed 8 Apr 2013, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0011:FIN:EN:PDF

[92] Alternate Energy, "Biomass," last accessed 8 Apr 2013, http://www.altenergy.org/renewables/biomass.html

[93] EIA, "Biomass Environmental Effects," last accessed 8 Apr 2013, http://www.eia.gov/energyexplained/index.cfm?page=biomass_environment

(EPA) applies strict environmental rules to waste-to-energy plants and monitor the use of anti-pollution devices, that capture air pollutants.[94]

There are also concerns regarding biofuels. Increasing the use of biofuels and the corresponding requirement to utilize more farmland to grow plants for use in the creation of biofuels is controversial. The biggest issue that has been raised is the fact that there is a lack of arable land that can be used to grow food crops, and yet more and more farmers are planting biofuel crops. Additionally, in some parts of the world, entire ranges of forests have been cut down to make room to plant and grow crops for ethanol and biodiesel production. To combat this problem, the U.S. government is supporting efforts to research and develop other sources of biomass that will be cheaper to produce and will not compete with food crops.[95]

Problems with Wind Power

As with all energy technologies, there are environmental costs and concerns associated with wind power, which have generated opposition from residents in the vicinity of wind farm developments. The wind industry claims that wind energy has no impact on the environment due to the fact it requires no fuel to generate electricity and because it does not emit pollution or greenhouse gas. Opponents to wind farms have raised concerns with regard to the noise produced by the rotor blades, the visual impacts the turbines have on the surrounding countryside, and the deaths of thousands of birds and bats that fly into the rotors. Issues such as drops in property values, loss of tourism,

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[94] EIA, "Biomass Environmental Effects," last accessed 8 Apr 2013, http://www.eia.gov/energyexplained/index.cfm?page=biomass_environment

[95] EIA, "Biomass Environmental Effects," last accessed 8 Apr 2013, http://www.eia.gov/energyexplained/index.cfm?page=biomass_environment

the disconcerting effect of the flickering of reflected light on both people and animals, as well as dangers from ice build-up have also been raised by advocates and lobbyists.[96]

Modern wind turbines can be extremely large machines, and they can significantly change the landscape when they are installed. The natural beauty of a region can be lost as dozens of metal monstrosities dominate the view of the countryside.

Figure 10: The Braes O'Doune Wind Farm near Stirling Castle, Scotland[97]

Figure 11: Wind farm in Palm Springs California[98]

Mechanical problems have resulted in the engines inside the turbine catching on fire, and in rare cases, lubricating fluids have leaked out and been spread over a large swath of

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[96] At Issue: What Energy Sources Should Be Pursued, "A Problem with Wind Power," (Greenhaven Press, 2005), last accessed 8 Apr 2013, http://www.aweo.org/problemwithwind.html

[97] A view from the right, "Wind Energy: Just a Bunch of Hot Air?" last accessed 12 Apr 2013, http://aviewfromtheright.com/2010/09/05/wind-energy-just-a-bunch-of-hot-air/

[98] A view from the right, "Wind Energy: Just a Bunch of Hot Air?" last accessed 12 Apr 2013, http://aviewfromtheright.com/2010/09/05/wind-energy-just-a-bunch-of-hot-air/

land. In the winter, large chunks of ice that built up while the turbine was inactive have been known to fall off the blades and could injure or kill someone if they were in the vicinity of the turbine.

The biggest complaint when you discuss wind turbines is the sound that the wind turbine blades make. For individuals living in the vicinity of turbines, the existing minimum separation distances between turbines and residences in not enough and the never-ending sound of the blades has driven some families to move.[99] Some people living close to wind turbines have also claimed their health has been negatively impacted. There is limited testing that shows that some people living in close proximity to turbines are impacted by the noise emissions or the flickering light and shadow as the blades spin. Medical problems have included severe sleeping problems, constant headaches, unexplained dizziness and high blood pressure. Other environmental impacts of wind farm developments can include construction of 20 metre wide access roads, the installation of new power lines and associated infrastructure, as well as clear cutting of acres of forest in the vicinity of each turbine. Construction of a 25-turbine wind facility results in the cutting of enough trees to fill 100 football fields.[100]

Reports as far back as 1992 have shown that some types of wind turbines at specific sites have caused significant numbers of bird and bat deaths.[101] More recent studies have supported this claim.[102]

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[99] EIA, "Wind Energy," last accessed 8 Apr 2013, http://www.eia.gov/energyexplained/index.cfm?page=wind_environment

[100] Wind Power Problems, "Wind Power Problems," last accessed 8 Apr 2013, http://www.wind-power-problems.org/

[101] S Orloff and A. Flannery. "Wind Turbine Effects on Avian Activity, Habitat Use, and Mortality in Altamont Pass and Solano County Wind Resource Areas 1989-1991: Final Report." Prepared for Planning Departments of Alameda, Contra Costa, and Solano Counties and the California Energy Commission Grant #990-89-003. March 1992.

Figure 12: Birds flying near wind turbines at the Maple Ridge wind farm[103]

The United States Government Accountability Office (GAO) completed a study titled "Wind Power Impacts on Wildlife and Government Responsibilities for Regulating Development and Protecting Wildlife" in 2005. The study found that "the impacts of wind power facilities on birds and other wildlife vary by region and by species."[104] Although the deaths of significant numbers of avian wildlife in two specific locations was raised as a red flag by scientists, regulators, and the public, studies at other locations that were utilizing newer turbines showed relatively lower bird and bat mortality. Interestingly, the report found a significant lack of existing research on the impacts of wind farms on wildlife, as well as a shortage of studies that have examined mitigation measures and strategies that could be used to reduce the potential effect wind turbines was having on birds and bats.[105] As a result of the report, the wind energy industry and

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[102] C. P Nicholson, R. D. Tankersley, Jr., J. K. Fiedler, and N. S. Nicholas. "Assessment and Prediction of Bird and Bat Mortality at Wind Energy Facilities in the Southeastern United States." Prepared for the Tennessee Valley Authority. 2005.

[103] Syracuse.com, "Wind turbine placement should take migrating birds into consideration, ornithologist says," last accessed 12 Apr 2013, http://blog.syracuse.com/outdoors/2009/11/wind_turbine_placement_should.html

[104] US Government Accountability Office (GAO) report 2005, "Wind Power Impacts on Wildlife and Government Responsibilities for Regulating Development and Protecting Wildlife," (GAO 05-906), 2, last accessed 8 Apr 2013, http://www.gao.gov/new.items/d05906.pdf

[105] GAO report 2005…, 10, last accessed 8 Apr 2013, http://www.gao.gov/new.items/d05906.pdf

the U.S. government are continuing to research how wind farms can minimize their impact on birds and bats.[106]

Additionally, it has been determined that, in certain circumstances, wind turbine farms can negatively affect radio communications and radar systems. This is mainly based around instances when the turbines are built too close to radio transmitters or radar sites. This issue will be looked at in depth in the following chapters.[107]

Although wind turbines do have negative impacts on the environment, those impacts should be viewed in light of our need for more diverse forms of electricity. More importantly, using the wind to produce energy has a much lower overall environmental impact when compared to other sources of energy. As well, because Canada is a sparsely populated country, we have the capacity to build wind farms away from large concentrations of people, unlike more densely populated countries in Europe.

Summary

Renewable energy can provide a portion of the energy needs of the future and reduce many of the current environmental problems associated with fossil fuels. But it must be understood that renewable energy is not a perfect solution and it has the potential to create adverse environmental impacts, as bad as or worse than the current impacts of conventional energy sources. Any plan to implement "green" energy projects must take the time to evaluate the drawbacks and understand the environmental impacts that could

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[106] EIA, "Wind Energy," last accessed 8 Apr 2013, http://www.eia.gov/energyexplained/index.cfm?page=wind_environment

[107] UK Civil Aviation Authority, "Wind Energy and Aviation Interests interim guidelines," 1, last accessed 8 Apr 2013, http://www.caa.co.uk/default.aspx?catid=7&pagetype=90&pageid=1209

be caused, and follow the necessary steps to ensure proper utilization of any renewable energy source while minimizing the possible environmental impact.[108]

In addition to environmental concerns, renewable energy sources can also cause safety and security concerns. The following chapters will take a look at the interference that wind turbines cause with radar systems and how this interference can impact national security.

[108] S.A. Abbasi, Naseema Abbasi, "The likely adverse environmental impacts of renewable energy sources," Centre for Pollution Control & Energy Technology, Pondicherry University, India.

CHAPTER 4 – SECURITY CONCERNS WITH WIND ENERGY

Concerns have been raised with every categories of renewable energy that is being pursued today. Some of these concerns are valid, while others have yet to be proven. However, wind energy has also created new safety and security issues. Although many of these are minor, a small number of them are significant and have created some apprehension within the defence community.

In its broadest sense, energy security is defined as securing control over the various processes that are utilized to extract and deliver energy. This can include oil fields and oil platforms along with the oil and gas pipelines. It can include waterways and rivers that feed hydroelectric dams. It can include global shipping that deliver energy products as well as the electrical grid that delivers the power. It must also include a plan to reinvest in the electrical power infrastructure, to ensure the grid is robust enough to meet both the current and future electrical needs of the country. A viable energy security plan must also be able to map out how disruptions from any one energy source would be handled, to minimize the effect on the country's well-being.[109]

When discussing energy security concerns, the most significant issue to come up is actually the energy grid itself and the ability to deliver electricity. As seen during several recent storms, the grid is highly vulnerable even without a deliberate attack. Add in the element of a malicious and intentionally designed attack, and the problem could be catastrophic. In 2012, the National Academy of Sciences (NAS) released its study Terrorism and the Electric Power Delivery System to the public. The study had been

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[109] CSIS, Canadian Energy Security…, 2.

prepared at the request of the Department of Homeland Security in 2007 but kept under wraps as classified information. The report concluded that a carefully planned attack on the electricity grid could deny large regions of the country access to power for weeks or even months. Combined with extreme heat or extended periods of extreme cold weather, this could potentially result in thousands of deaths.[110]

The growth of the wind turbine industry has brought additional concerns about the electricity grid and its ability to grow as energy demands increase. Existing grids may become susceptible to having too many entry points, where external sources feed electricity to the grid. In southern Ontario for example, the current electrical infrastructure cannot support the sheer number of proposed wind projects. Until the grid infrastructure is upgraded in that area of Ontario, future development may be limited.

Interference Caused By Wind Turbines

Another security concern, specific to renewable energy, is interference caused by wind turbines. Wind turbines, either as a single unit or as part of a larger wind farm can negatively impact radio, telecommunications, seismo-acoustic and radar systems. The rotating blades of the wind turbine and the tower supporting the structure can cause significant interference with amplitude modulated (AM) radio frequency signals.

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[110] Peter Kelly-Detwiler, "Protecting the Electric Grid from Terrorism -- Nobody is in Charge," Forbes, 16 Nov 2012, last accessed 1 Apr 2013, http://www.forbes.com/sites/peterdetwiler/2012/11/16/protecting-the-electric-grid-from-terrorism-nobody-is-in-charge/

Frequency modulated (FM) signals are only impaired if the transmitter is in very close proximity to a wind turbine.[111]

Radio and Telecommunications

Since the early-1990s, we have known that wind turbines can negatively impact radio communications. Wind turbines can affect radio and telecommunications systems by creating a shadow behind the wind farm, where the signal cannot reach, by reflecting the signal or by scattering the signal as it passes through the wind farm. Although wind turbines have been proven to have a significant negative effect on all radio communications using fixed systems, cell phones and other mobile systems have proven more resilient, with little to no effect observed. In 2002, Dr David F. Bacon, an expert in radar and radio wave propagation and propagation modelling, published a pioneering study that examined the potential impact a single wind turbine could have on radio links when the wind turbine was located directly in the line of sight of the transmitter.[112] More recent field studies that measured the effects of large wind farms on radio systems have found much greater levels of interference than predicted in previous studies. The probability of interference with radio and other telecommunications systems is of concern to all security organizations. The ability to communicate is critical and any potential reduction in communications could impact command and control capabilities in specific regions of the country.

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[111] Radio Advisory Board of Canada (RABC), "Technical Information on the Assessment of the Potential Impact of Wind Turbines on Radio Communications, Radar and Seismo-acoustic Systems," (2006) 5.

[112] David F. Bacon, "Fixed-link wind-turbine exclusion zone method," (Ofcom UK, October 2002).

To resolve this problem for most radio and telecommunications sites, the current guidelines recommend keeping the turbines at least 2.0 kilometres from the transmitter.[113]

Seismo-acoustic Systems

Wind turbines can affect seismo-acoustic systems in a different way. The noise and vibration from the blades of the wind turbines can hamper the detection of earthquakes and nuclear explosions. Any proposed construction of wind turbines in the vicinity of a seismo-acoustic array would have to be reviewed by the Department of Natural Resources, which are responsible for seismo-acoustic monitoring equipment in Canada. The acceptable level of reduction in monitoring capability will be different for each station and the number, type, size and specific location of each wind turbine being installed will impact the amount of seismic and acoustic background noise they will create in the area. A total acceptable level of noise would have to be generated for each monitoring station using computer models, based on information provided by the wind turbine developer. This model would determine which specific wind turbines could be installed.[114]

To minimize the possibility of this type of interference occurring, the current guidelines have recommended that no wind turbine be built within 10 kilometres of a

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[113] RABC, Technical Information…, 12.

[114] P. Styles, I. Stimpson, S. Toon, R. England, and M. Wright, "Microseismic and Infrasound Monitoring of Low Frequency Noise and Vibrations From Wind Farms: Recommendations on the Siting of Wind Farms in the Vicinity of Eskdalemuir, Scotland," (School of Physical and Geographical Sciences, Keele University; 18 July 2005) 90.

seismo-acoustic monitoring station and any proposed construction within 50 kilometres of a monitoring station must be reviewed by Natural Resources Canada.[115]

Radar Systems

By the mid-1990s, there were initial reports that wind turbines also created interference with some radar systems. Wind farms can impact different types of radar systems, including those used for detecting aircraft, marine vessels or weather systems. However, the potential effect of wind turbines on each radar systems is different. The key factor that determines if a wind turbine may have a negative effect upon radar performance is whether or not the wind turbine is in direct Line Of Site (LOS) of the radar. Additionally, each radar has a distinctive coverage footprint, depending on its physical location, its elevation and the surrounding landscape, resulting in a unique LOS footprint for each radar site. Where wind turbines are in direct LOS to the radar, studies have shown that both the physical support structure of the tower and the rotating blades of the turbine can have a negative impact on radar data and can cause interference on conventional and Doppler radar signals, masking real targets, creating false targets, and potentially causing flight safety issues.[116] Additionally, this impact can vary depending on the type of radar and the exact location and number of wind turbines that are within the LOS of the radar.

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[115] RABC, Technical Information…, 9.
[116] RABC, Technical Information…, 7.

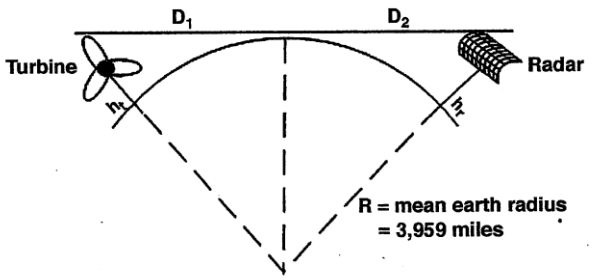

Figure 13: Schematic geometry between a wind farm and a radar at the edge of the LOS[117]

The most common types of interference that wind turbines cause with radar systems is blockage and clutter. In some cases, blockage can be caused by a single turbine that was built very close to a radar site. A different scenario is created when a group of turbines are built at a distance from the radar. Either of these cases can result in a blockage of a certain angular sector of the radar beam, preventing the radar from "seeing" anything behind the wind turbine farm.

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Figure 14: Potential Radar Blockage Due to a Wind Farm[118]

Clutter is defined as unwanted signal returns on a radar display. The impact of clutter is dependent on the radar cross section (RCS) of the object that is returning the radar signal. In the case of wind farms, "clutter" has been created by unwanted radar echoes from the spinning blades of the wind turbines. An individual wind turbine can create a maximum possible RCS approximately equal to that of a large civilian aircraft, such as a Boeing 747. This can have a significant negative impact on the validity of radar data being displayed on the scope.[119]

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[117] US Department of Commerce, National Telecommunications and Information Administration (NTIA), "Technical Report TR-08-454 Assessment of the Effects of Wind Turbines on Air Traffic Control Radars," (July 2008) 6.

[118] EuroControl, "EuroControl Guidelines on How to Assess the Potential Impact of Wind Turbines on Surveillance Sensors," (2010), 37. Reproduction.

[119] RABC, Technical Information…, 8.

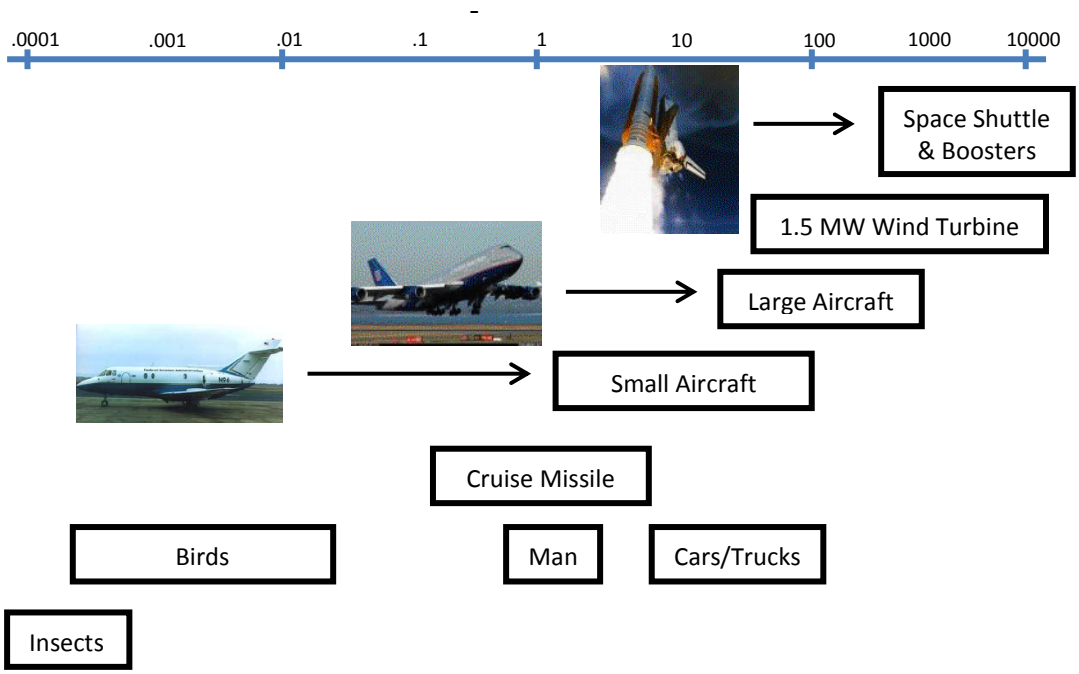

Figure 15: RCS values for several common objects[120]

DND uses Air Traffic Control radars and Air Defence radars and utilize the information from Doppler weather radars. Each type of radar is impacted differently and should be looked at independently.

Doppler Weather Radar:

Doppler weather radars use the Doppler Effect to detect the motion of targets and use this information to display current severe weather, including storm detection, rainfall/snowfall rates as well as low level wind shear, which are important for aviation safety. The movement of the blades on wind turbines as well as the turbulence in the air around the blades degrades meteorological data over a very large area and block the radar

[120] Report to the Congressional Defense Committees, "The Effects of Windmill Farms on Military Readiness," (2006), 15.

from seeing beyond the wind turbine farm. This signal blockage and the returns from the turbine blades negatively impacts on the ability of the Doppler radar to provide current weather as well as weather forecasting in the vicinity of the wind turbines, potentially causing extreme weather conditions to go undetected.[121]

Air Traffic Control Radar:

Air Traffic Control (ATC) radars are used by Air Traffic Controllers to assist with controlling aircraft within their airspace. When an aircraft is operating under Instrument Flight Rules (IFR), it must rely on direction from the Air Traffic Controllers to maintain safe separation from other aircraft. Anything that would negatively affect the ability of Air Traffic Controllers to detect and control aircraft in Canadian aerospace is of great concern to Nav Canada and DND. Although other forms of interference exist, wind turbines that are within the LOS of a radar can be detected at a significant distance due to their height and high RCS. The high RCS results in strong radar reflections, creating false target reports on the ATC displays. The size of a wind farm spreads the interference over a large volume of airspace. An interesting fact is the interference exists over all altitudes within the area surrounding a wind farm. The size of an aircraft flying over a wind farm and the altitude of the target does not change the fact that it is masked by the false returns from the wind farm. Air Traffic Controllers must always treat displayed radar returns as a real aircraft. As such, the radar interference from the wind farm could hamper the ability

[121] METEO France, "Impact of Wind Turbines on weather radars," (31 March 2005), 1.

of an ATC operator to safely provide ATS to an aircraft that was flying in the vicinity of the wind farm because it was not possible to differentiate the real and false targets.[122]

Air Defence Radar:

Air Defence (AD) Radars are used as part of the Canadian Air Defence System (ADS), which is comprised of 52 radars, located throughout the arctic, as well as on both the east and west coast. These radars provide aerospace surveillance and constitute Canada's commitment to the North American Aerospace Defence (NORAD) Atmospheric Early Warning System (AEWS). AD radars must be capable of tracking all targets in Canada's aerospace, both friendly targets that are broadcasting their presence as well as hostile targets that are trying to keep their presence hidden. Wind turbines create serious problems for AD radars, including reducing the radar's ability to detect real targets, creating false targets, and reporting erroneous positional information on actual targets.[123]

Low Flying Aircraft:

Low flying aircraft are also impacted by wind farms and even individual wind turbines. Wind turbines can reach over 200 metres above the ground, which is a potential physical obstacle for aircraft flying at low altitude, or aircraft approaching an airfield that is located in the vicinity of wind turbines. Low flying aircraft can operate in some countries as low as 100 metres above the ground and helicopters can fly at ground level. Additionally, there is concern that the radar on board the aircraft may also be affected by

[122] RABC, Technical Information…, 9.
[123] RABC, Technical Information…, 8.

the wind turbines. Some military pilots practise flying at a low level using terrain following radar. This type of radar may only see the first row of wind turbines, which would impact the ability of the pilot to determine how far the wind farm extends. More trials with terrain following radar are needed to determine the impact of this potential issue.[124]

There is also some concern about potential interference with the Traffic Collision Avoidance System (TCAS), which is installed onboard aircraft and is designed to reduce the chance mid-air collisions by notifying aircrew of other aircraft in the vicinity. This potential problem has only recently come to light and has not yet been investigated.

[124] A Marston, S Omer, M Hall, and N Robinson, "Wind Turbine Interference with Air Traffic Control – Issues and Current Research," (University of Nottingham, 2008), 2.

CHAPTER 5 – SECURITY CONCERNS IN OTHER COUNTRIES

Concerns about wind turbines causing interference have been ongoing in many countries around the world since the 1990s. Some countries completed basic testing and initially decided it was not a serious issue while others had serious concerns but did not move forward with scientific testing to prove or disprove the potential problems. Canada entered into the discussions late in the game and has taken few independent steps to address the issue.

As the number of wind turbines and wind farms being constructed increased, the pressure mounted on both civilian and military organizations to formalize their concerns and start working on the problem. Both the United Kingdom and the United States have completed significant testing and advanced the issue of potential interference from wind farms and the resulting safety and security concerns. The directions and regulations published by these two countries have been utilized by Canada to develop the initial guidelines dealing with this issue in Canada.

United Kingdom:

In the United Kingdom (UK), airspace control is the responsibility of the Civilian Aviation Authority (CAA) along with the Ministry of Defence (MoD). The CAA utilizes the statutory Safeguarding of Aerodromes process to ensure the safety of flying operations around all aerodromes.[125] However, this document does not deal specifically with wind turbines or the interference they create with radar systems.

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[125] Civil Aviation Authority. CAP 738. Safeguarding of Aerodromes. Dec 2006.

The issue of wind turbine interference with radars in the UK has been of interest to the aviation community and the MoD since the mid-90s. There have been studies and trials to evaluate both the potential for physical obstruction as well as safety issues involving the control of aircraft in the vicinity of airports utilizing Primary Surveillance Radars. The MoD had additional concerns surrounding low flying zones as well as the impact on Air Defence (AD) radars.[126]

The first documented flight trials to analyse the potential impact of wind turbines on ATC radars were conducted in the UK by the MoD in 1994 using a Sea King helicopter flying over and around a small wind farm a few kilometres from a Watchman radar. As a result of the trial, the MoD requested that it be consulted for wind farm developments within 66 kilometres of an ATC radar and within 74 kilometres of an AD radar. Further trials were conducted in 2004 and 2006 involving different types of both ATC and AD radars and several larger wind farms that resulted in the consultation zones being increased to include any wind farm developments within the LOS of an ATC or AD radar, regardless of the distance.[127]

In 2002, the UK released the Wind Energy and Aviation Interests interim guidelines. These guidelines were developed by a joint working group made up of wind energy, defence and civil aviation interests and are one of the most comprehensive guidelines to help understand the issues and concerns surrounding wind turbines, radar systems and air safety. This resulted in the creation of a non-statutory wind turbine safeguarding process to ensure wind farm developers contacted the CAA or the MoD

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[126] Marston, Wind Turbine Interference…, 2.

[127] Julian Chafer, Head of Safeguarding, Defence Estates, UK MoD, correspondence with author, Mar 2006.

early in the project. The overall safeguarding process would be responsible to either ensure permits were not granted for developments that would impact the safe use of aerodromes, radar systems and low flying areas; or ensure permits were granted for developments whose impact to operations would be within appropriate guidelines.[128] Zones were created around aerodromes and radar sites, within which wind farm developers had to enter into the safeguarding process. The initial consultation process was spelled out and in those cases where a developer and the CAA or the MoD could not reach a compromise or mutually acceptable solution, an appeals process was also mapped out, with an independent planning inspector deciding on the case.[129]

In 2006, CAA Policy and Guidelines on Wind Turbines was released. Although not a statutory document, it provides official policy for wind farm developers who must deal with civilian aviation safety concerns. This document has been updated in 2010 and provides additional details for wind farm developers that are looking to build in the vicinity of aerodromes or within range of civilian radars or navigational aids. Developers looking at locations within the vicinity of defence aerodromes or defence radars must still contact the MoD separately. [130]

Research did not find any additional policies or official publications and the 2002 Guidelines are still used as reference material when discussing the issue of wind turbine interference. There has been discussion regarding new flight trials, but no details are available at this time.

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[128] UK Wind Energy and Aviation Interests – Interim Guidelines (2002), 8.

[129] Julian Chafer, Head of Safeguarding, Defence Estates, UK MoD, correspondence with author, Mar 2006.

[130] CAP 764, "CAA Policy and Guidelines on Wind Turbines," (Jan 2012), 2.

United States:

The situation of radar interference from wind turbines in the United States (US) has become more visible over the last ten years. Prior to 2006, the Federal Aviation Administration (FAA) had legal jurisdiction over structures over 200 feet tall to ensure safety to air navigation. Structures exceeding 200 feet or local obstruction standards in the vicinity of aerodromes had to be marked and/or lighted. Wind turbines exceeding 200 feet required a hazard determination from the FAA for each turbine prior to construction. No other authority existed specifically dealing with wind turbines, aviation safety and radar interference.[131] Due to this lack of policy, other federal agencies with radar assets, such as the Department of Defense (DOD), the Department of Homeland Security (DHS), and the National Oceanic and Atmospheric Administration (NOAA) had to be notified by the FAA regarding proposed wind farm projects that could impact their systems. This notification gave these departments the opportunity to raise objections with the FAA. Input and concerns from these departments would then impact the FAA's hazard determination for the wind farm.[132]

In discussion with NORAD and the DOD in 2005, the US Air Force was fully aware of the problem surrounding radar interference, but nothing official had been done to deal with the situation. The Long Range Radar Joint Program Office (JPO) is responsible to manage the joint use of long range surveillance assets. Before 9/11, the DOD was responsible to run the JPO and their systems were primarily looking outwards,

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[131] HART Aviation, "Wind Energy and Aviation Interests study for Sustainability Victoria," (July 2009), 7.

[132] American Wind Energy Association, "Siting Policy", last accessed 1 Apr 2013, http://www.awea.org/issues/siting/

using sites along the border areas. Post 9/11, the DOD and DHS were mandated to jointly manage primary radar operations and the JPO also began looking inwards, utilizing over 170 sites across the country to provide a continuous air picture of the interior and approaches to the US. Their new mission statement was to ensure a reliable primary long range radar system and associated air navigation, surveillance and communications systems, to provide airspace security and defense throughout the Continental US and adjacent regions as required by National Security authorities.[133] Local base commanders dealt with potential developers whenever they were notified of a potential project and ensured the issues were passed to the JPO. If the wind turbines were within the LOS of a radar site, or if they determined there could be interference issues, their concerns were forwarded to the FAA. If a situation arose where a developer wanted to build a wind farm in the vicinity of an AD radar and was not willing to move the wind farm outside the LOS of the radar, the DHS was the fall back position. It was felt that the DHS had the authority to stop any development if they deemed that it would negatively impact the ability of the federal government to meet their security and defense mandates.[134]

As the number of wind farm proposals increased in the US, there was a corresponding increase in the number of wind farm hazard determinations that were being released by the FAA due to concerns from other government agencies regarding interference with radar systems. This led to a growing number of complaints from wind developers, some of which were forwarded to senators and congressmen. Public and political pressure resulted in Congress passing the 2006 Defense Authorization Act,

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[133] US DOD Long Range Radar Joint Program Office (JPO), JPO Wind Farm briefing package (July 2006).

[134] JPO, telecon with author, fall 2005.

which called for the DOD to submit a report to Congress on the effects of wind farms on military readiness. Specifically, the DOD had to determine if wind turbines created interference with military radar. In March of 2006, the DOD and DHS issued a joint interim policy on proposed wind farm developments. The JPO interim policy was to "contest any establishment of wind farms within radar LOS of the National Air Defense and Homeland Security radars."[135] The interim policy had the sweeping effect of stalling or stopping the development of many wind energy projects across the country.

Due to delays in the report to Congress, political pressure was turned up in July 2006 when Democratic senators announced they would put a hold on the nomination of the Assistant Secretary for Aviation and International Affairs until the FAA provided irrefutable proof as to how individual wind farms under construction in the mid-west would interfere with specific radar systems.[136]

In September of 2006, the DOD released its report, The Effect of Windmill Farms on Military Readiness. The report concluded that "wind farms located within LOS of an AD radar had the potential to degrade the ability of the radar to perform its intended function, however the magnitude of the impact was dependant on the number and location of the turbines."[137] It further concluded that primary mitigation measures were limited to removing wind turbines from the LOS of the radar if their effect "degraded the ability of the radar to unambiguously detect and track objects of interest."[138] The report stated that the FAA was responsible to determine possible impacts of wind farms on ATC

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[135] JPO, Wind Farm briefing package...

[136] Renewable Energy World, "U.S. Senators Flex Muscles on Wind Power, Radar Issue" Jul 2006. Last accessed 1 Apr 2013, http://www.renewableenergyworld.com/rea/news/article/2006/07/u-s-senators-flex-muscles-on-wind-power-radar-issue-45564

[137] Report to the Congressional Defense Committees, "The Effects of Windmill Farms on Military Readiness," (2006), 4.

[138] *Ibid*.

radars and the National Weather Service was responsible to determine possible negative impacts on weather radars. Additionally, it recommended following the UK lead regarding limitations surrounding wind turbine developments within 50 kilometres of seismic or atomic energy monitoring sites.[139]

Research did not find any additional policies or official publications released in the US although new flight tests utilizing newer radar systems have been planned and should take place in the near future. Some private companies have conducted testing of new radar products in the vicinity of wind farms, but these tests have not been independently verified.

Although all of the information developed by the UK and the US was available to Canada, little work was done in this country to address the issue. Wind turbines were seen as a physical obstruction only and were addressed as such. The following chapter will look at the initial actions that were taken in Canada in 2005 to begin to address the larger aviation safety and national security concerns caused by wind farms.

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[139] *Ibid*.

CHAPTER 6 - INITIAL ACTIONS TAKEN IN CANADA

Prior to 2005, DND had taken a limited interest in wind turbines. The department was aware that wind turbines could cause interference with radio communications and radar systems. The department took initial steps to create an Office of Primary Interest (OPI) who would deal with any company that notified DND that they were building wind turbines in the vicinity of one of the department's radio transmitters or radar sites. The OPI also coordinated with other government departments and the Radio Advisory Board of Canada (RABC) to ensure DND was aware of any other potential wind turbine developments that had not contacted DND. Although internal processes were created to ensure interference checks were carried out, no action was taken to provide external documentation on the issue or to develop a structure of zones surrounding radio communication transmitters or radar sites where coordination with wind turbines promoters was desired.

The Air Force had a representative on the North Atlantic Treaty Organization (NATO) Air Traffic Management - Communications, Navigation and Surveillance Working Group (ATM - CNS WG). This working group is a technical body that develops consolidated NATO views, policies, doctrines and guidance on Air Traffic Management matters.[140] In 2005 this working group began discussing the impact of wind turbines on Air Traffic Control radars as well as radars installed onboard aircraft. This lead to the issue being brought back to Canada with documentation from NATO and the European Organisation for the Safety of Air Navigation (EuroControl), as well as contacts in the

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[140] NATO, "NATO Air Traffic Management Committee," last accessed 1 Apr 2013, http://www.nato.int/cps/en/natolive/topics_69339.htm

UK that had completed testing of various systems to determine the extent of the interference on both Air Traffic Control radars and Air Defence radars.

In 2006, the Air Force organized a meeting of the various federal departments and non-governmental agencies that could be affected by wind turbine interference. Representatives from the Department of National Defence, Industry Canada, Transport Canada, Natural Resources Canada and Environment Canada were consulted to determine if they were aware of the potential problems and what if anything each individual organization was doing to address the issue. Although most departments were aware of the issues, little had been done. Everyone was in the same situation, with no rules or regulations to fall back on. DND also invited Nav Canada to the meeting to discuss the issue. Nav Canada is a private sector corporation that is responsible for the operation and maintenance of Canada's civil air navigation service (ANS). It co-ordinates aircraft operating in Canadian domestic airspace and international airspace assigned to Canadian control and is responsible for numerous Air Traffic Control radars as well as a network of over 1,000 ground-based navigation aids located across the country. Although it was aware of the issue, they did not see the interference as a serious issue for their organization. Civilian ATC did not rely on Primary Search Radar to the extent that DND does and the limited impact that wind turbines had on Secondary Surveillance Radar was deemed acceptable in most instances.[141] The major issue for Nav Canada at the time was to ensure no wind turbines were built too close to an actual airport, where they would be considered a hazard to air navigation.

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[141] Nav Canada, telecon with author, fall 2006.

A working group of government departments and Nav Canada was developed and it was agreed that the best way forward for now was to try and develop guidelines to get the word out to industry about the potential problems and begin to work with the Canadian Wind Energy Association to create a process where developers would contact the various departments if a wind farm was going to be developed in the vicinity of one of the radars, towers or arrays operated by the government. No other department was interested in taking the lead on this issue, so DND took on the role of chair of the working group.[142]

The working group began communicating with the RABC, which was addressing this issue from the point of view of the radio and telecommunications industries. An agreement was made to develop one set of guidelines that would address all the potential problems and the Radio Advisory Board of Canada would publish the final document. The working group recommended that the RABC contact the Canadian Wind Energy Association (CanWEA) and ask if the association would assist with a review of the guidelines and agree to co-publish the final product. As the intent was to avoid wind turbine developers finding out about problems after they had expended time, money and effort on a proposed site, it was in everybody's best interest to get the guidelines published and ensure everyone was on the same page when it came to areas where one or more department would have concerns. The worst case scenario was for a wind farm developer to go through the entire approval process and begin actual construction (or possibly finish construction) and then find out that the wind farm was going to seriously interference with a radar or array in the area. CanWEA came on board as an active

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[142] NATO NATMC, Minutes of CNS Working Group attended by author, May 06.

partner in the development and review of the document and provided additional input from the point of view of the wind energy developers.

The result of this working group was the publication of the "Technical Information on the Assessment of the Potential Impact of Wind Turbines on Radio Communication, Radar and Seismoacoustic Systems" in 2006.[143] This document was reviewed, updated, renamed the "Technical Information and Coordination Process Between Wind Turbines and Radiocommunication and Radar Systems" and re-released by RABC, in coordination with CanWEA in 2010.[144]

It must be remembered that this document is a guideline, provided by a group of government departments to the wind energy industry and potential wind farm developers. Developers are asked to voluntarily follow the guidelines and contact the various departments, depending on where they are looking to build wind turbines and what consultation zones are impacted. Developers are also asked to work with departments to resolve any conflicts. Where a mutually acceptable resolution is unsuccessful, the developer is requested to abide by requests made by a government department to not build the proposed turbines or the entire wind farms in the area where it would negatively affect the radio or radar system. Developers are free to follow these guidelines and requests, or not.[145]

Without any legislative support or an existing regulation to build on, it was decided by the working group that the best they could hope for as a first step was to work

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[143] RABC/CanWEA, "Technical Information on the Assessment of the Potential Impact of Wind Turbines on Radio Communication, Radar and Seismoacoustic Systems," 2006.

[144] RABC/CanWEA, "Technical Information and Coordination Process Between Wind Turbines and Radiocommunication and Radar Systems," 2010.

[145] RABC, Technical Information…, 4.

with CanWEA and create a voluntary guideline that would get the required information out to Canadian developers. The guidelines were modeled on the UK concept that was already in place and working well.

CHAPTER 7 – WIND TURBINES IN CANADA

To understand the issues surrounding wind turbines and wind farms, it is necessary to have a basic understanding of both the process that is involved when a developer wants to build a single wind turbine or a wind farm, as well as the rules and regulations that come into play, depending on where exactly the wind farm is going to be built.

Building a Wind Farm in Canada

CanWEA has provided potential developers with a rough outline of the many steps that are involved with planning and building a wind farm. Each province has different rules and regulations that must be followed before approval can be given, but most of the steps in the process are similar. Below is a short synopsis of the steps as identified by CanWEA.[146]

Site Proposal/Wind Assessment: The first and most important step is to decide on a proposed site. Developers should then negotiate with land owners for agreements or options to potentially purchase the land in the future. These agreements would also give the company the right to conduct testing on the proposed property with regards to wind potential. Wind speed and other climatic conditions should be measured for at least one year. The resulting data can estimate how much energy the wind farm will produce. Another factor in assessing a potential site is access to existing power infrastructure or the distance from the site to existing power infrastructure. Costs to install each kilometre

[146] CanWEA, "Planning Wind Farms," last accessed 1 Apr 2013, http://www.canwea.ca/farms/planning_e.php

of new infrastructure to connect to the power grid can be expensive. Following successful testing of the wind potential on the land, the developer will convert the options into firm land lease or land purchase agreements.

Permitting and Consultations with Municipalities: Depending on the location of the proposed wind farm, developers must seek municipal, provincial and federal permits before any work can begin. The developer should also meet the local communities to present and discuss the concept behind the project, increase knowledge about wind farms, ask for feedback and seek community support. Early contact with both the municipality where the wind farm will be located and the people in the community that may be impacted is critical to the planning process. Questions and/or concerns must be addressed and the approval process and required documents should be reviewed.

Wind Farm Design: The design of the wind farm is based on wind data combined with topographical information. The exact location of each wind turbine, as well as its height is optimized around the wind flow, how each turbine should perform, as well as limitations or concerns with regard to sound levels and other parameters. The local electric network must be mapped out and the connection to the electricity grid or any required upgrades should be examined in detail.

Environmental Study: This is a critical part of the approval process and can vary greatly depending in which province the development is located as well as what type of land is going to be developed (Federal, Provincial, etc). Environmental assessments are conducted to identify any potential impacts on plants, wildlife, soil, water and the surrounding communities. During the environmental assessment, many provinces also

mandate the evaluation of potential impacts to other activities, such as the effects on aviation and telecommunications. Negative environmental impacts can easily derail a project or delay it for long periods of time. Designs must be adjusted to avoid or mitigate any identified impacts on the environment.

Economic and Financial Analysis: To raise the funds to build the wind farm, developers must show the bank or financial supporters the economic viability of the project. Detailed estimates are required to break down the cost of purchasing and installing the turbines, road construction, electrical integration, operation and maintenance, as well as the projected income from the energy produced by the wind farm over a specific period of time. Negotiations with the respective power utility for long term contracts, such as a Feed In Tariff (FIT) or Power Of Purchase (PPA) agreements should also be completed.

Site Preparation and Construction: Crews have to prepare the site, which would include building access roads and clearing the areas around each individual turbine. Foundations must be excavated and poured. Following delivery of all components, the assembly will require a crane to erect the tower and mount the nacelle and rotor with its hub and blades. Concurrently, the electrical infrastructure can be installed within the turbines and connected to the local electrical substation.

As seen in the previous steps, there is no requirement to specifically contact government departments or civilian companies if the development is located within a specific range of a telecommunications transmitter or a radar system. Unless the provincial environmental assessment requires that check, it is possible for a developer to

complete construction and activate a wind farm without ever notifying the owner of a radio transmitter or radar in the vicinity of the wind farm.

Lack of Regulations in Canada:

Energy legislation enacted by the Government of Canada should provide the basis to create national level energy policy, directives and regulation. In Canada, there are multiple Acts that impact and regulate the development of renewable energy. They include the Department of Natural Resources Act, the Energy Efficiency Act, the National Energy Board Act, the Cooperative Energy Act, the Energy Administration Act, the Energy Monitoring Act, the Energy Supplies Emergency Act, and the Emergencies Act.

However, currently in Canada, the federal regulations that control or directly impact wind turbine development specifically are extremely limited. The main three are the Aeronautics Act, the Radio Communication Act and the Environmental Act. Relevant sections of the acts that pertain to the development of wind farms in the vicinity of defence facilities are included for consideration.

Canadian Aeronautics Act:

Transport Canada is responsible for managing the Aeronautics Act. Several portions of the act comes into play when dealing with wind turbines and wind farms, including the section dealing with general regulatory powers, the section dealing with airport zoning (including physical obstructions in the vicinity of an airfield or airport) and

the section that allows the Minister to put in place interim orders.[147] The Department of National Defence contacted Transport Canada in 2006 to determine if the Aeronautics Act could be used to develop rules, regulations or limitations on wind turbine developments in the vicinity of radar systems. Transport Canada's view was that as long as a wind farm developer does not violate the regulations dealing with obstructions in the vicinity of an aerodrome, and follows the rules with regard to proper markings and lighting on potential obstructions to aircraft, the Aeronautics Act has no further impact on wind turbine development.

Upon further review, it has been determined that both the Minister of Transport and the Minister of Defence have authority to put in place interim orders and to make further regulations with regards to the Aeronautics Act.[148] The Aeronautics Act authorizes the Governor in Council to make regulations, among other things, with respect to:

- Section 4.9 (k) …use of airspace and the control and use of aerial routes, (l) the prohibition of the use of airspace…, (m) the prohibition of the doing of any other act or thing in respect of which regulations under this Part may be made, (n) the enforcement of such laws as may be deemed necessary for the safe and proper operation of aircraft, (o) the use and operation of any objects that in the opinion of the Minister are likely to be hazardous to aviation safety, and (q) the investigation of …any alleged contravention under this Part or any incident involving aircraft that, in the opinion of the Minister, endangered the safety of persons;
- Section 5.4 (2) airport zoning - to prevent lands adjacent to or in the vicinity of a federal airport or an airport site, from being used or developed in a manner that is, in the opinion of the Minister, incompatible with the operation of an airport, the safe operation of an airport or aircraft, and causes interference with signals or communications to and from aircraft or to and from those facilities; and

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[147] Department of Transport, *Canadian Aeronautics Act*, (R.S.C., 1985, c. A-2), Section 4.9, 5.4 and 6.41.

[148] 1 Canadian Air Division, "1 Canadian Air Division Orders (1 CADO), Vol 4, 4-510: Wind Turbine Radar Impact Assessment for Industry," (2012), C1.

- Section 6.41, permits the Minister to first put in place an interim order that contains any provision that may be contained in an upcoming regulation made under this Part.[149]

As the authority exists to enforce existing legislation and to implement additional regulations, the problem may have more to do with potential fallout of making the development of a renewable energy source more difficult.

Radio Communications Act:

Industry Canada is responsible for the Radio Communications Act. The Act provides regulations that pertain to the development of wind turbines where interference may occur with existing radio or telecommunications systems. Sections that may pertain to the development of wind farms in the vicinity of defence facilities are:

- Section 2, which defines "interference-causing equipment" as "any device, machinery or equipment, other than radio apparatus, that causes or is capable of causing interference to radiocommunication".
- Section 6(1), Powers of Governor-in-Council; prohibit, restrict or regulate the technical requirements and standards and installation of, among other things, interference-causing equipment;
- Section 9(1) – prohibits any person, without lawful excuse, to interfere with or obstruct any radio communication; and
- Section 52 of the Radio communication Regulations, allows the Minister of Industry to issue an order to cease or modify the use of equipment that causes interference to radio communication.[150]

Environmental Act:

Environment Canada is responsible for the Environmental Act. However, most environmental issues have been allocated to provincial jurisdiction. In those cases where

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[149] Department of Transport, Canadian Aeronautics Act, (R.S.C., 1985, c. A-2), Section 4.9, 5.4 and 6.41

[150] Department of Industry, "Radio Communications Act," (R.S.C., 1985, c. R-2), Section 2, 9 and 52.

a project involving the construction and operation of a wind turbine farm was enabled or assisted by a federal authority, the project is subject to an environmental assessment (EA) under the Canadian Environmental Assessment Act 2012. The responsibility for ensuring that the EA is conducted and completed rests with the federal authority that would enable the project, not with the Canadian Environmental Assessment Agency. Natural Resources Canada (NRCan), as the primary regulator of the wind generation industry, is usually the only federal authority involved in the EA of wind turbine projects, but Fisheries and Oceans Canada may also be involved occasionally if some aspect of the project could affect fish habitat, such as an access road that crosses a stream. As in any other EA, the scope of the environmental assessment and related factors to be addressed in the assessment of a wind turbine farm is determined by NRCan and any other responsible authority. In doing so, NRCan would be expected to consult any other federal authority that might have expert knowledge about potential effects of the project.[151]

Most wind turbine proposals only require a provincial EA, which follows the rules and regulations set out by each individual province. Currently, there is no requirement for any provincial environmental agency to contact any federal department that may have a concern regarding a proposed wind energy development, although some provinces do include contacting other government departments, such as DND, as part of the assessment process. Nova Scotia currently sends all proposals that they are considering for approval to DND for final review. If DND has not offered concurrence, the provincial approval will be conditional. NS currently is the only provincial

[151] Canadian Environmental Assessment Agency, e-mail with author, 17 May 2006.

environment ministry that consults with DND before approving an environmental assessment.[152]

Current Canadian Guidelines:

When DND realized the potential problems that could occur with regard to interference from wind turbines, the Air Force began looking into the situation further and realized there were no federal rules or regulations to oversee wind turbine development. The department had no options available to handle the potential problems that were foreseen. This led to the development of the "Technical Information on the Assessment of the Potential Impact of Wind Turbines on Radio Communication, Radar and Seismo-acoustic Systems" guideline that was covered earlier in this document.[153]

It is worth repeating that this document was published as a guideline and has no legal implications. It was meant to assist potential developers so that they would be aware of potential problems before they went too far into the approval process for a development on a specific site. It was also intended to get developers in contact with the various departments that have equipment that could be negatively impacted by a wind turbine farm. The guidelines recommended consultation zones around sites where interference may occur. Developers were asked to consult with DND if a proposed wind turbine site was within 100 kilometres of AD radar, or 80 kilometres of ATC radar. No wind turbine should ever be constructed within 10 kilometres of a major civilian or

[152] Aerospace Telecommunications and Engineering Support Squadron, e-mail with author, 10 Apr 2013.

[153] RABC, Technical Information…, 1.

military airfield, as it would be very difficult to not violate airport zoning regulations or impact flying operations.

Following the publication of the "Technical Information on the Assessment of the Potential Impact of Wind Turbines on Radio Communication, Radar and Seismo-acoustic Systems" guidelines, the Air Force then developed an official order (1 Canadian Air Division Order 4-510) to outline the policy and procedures that would be followed when dealing with industry on potential wind turbine developments that could impact ATC or AD radars, as well as flying operations at or near military installations.[154]

This order reinforced that DND did not oppose the development of wind farms or other forms of renewable energy, as long as they did not negatively impact the ability of the department to perform its duties. Each wind farm that was within the consultation zone would be evaluated on a case by case basis and the Air Force would work with developers to find mutually acceptable solutions in areas where it was determined there was a potential negative impact to flying operations. In those cases where a development would cause an unacceptable impact, the Air Force would first notify the developer of the objections via e-mail. Most problems are solved by face to face discussion. In those rare cases where no solution can be found, DND will notify the developer via a letter of non-concurrence. Letters of non-concurrence are used as a last resort. Copies of letters of non-concurrence are also sent to TC, NRCan, affected provincial approval office, affected municipal approval offices, appropriate regulatory agencies as well as numerous military organizations that are involved with Air Force operations. To date, only three letters of non-concurrence have been issued and one of them has since been rescinded.

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[154] 1 CADO 4-510…, 1.

It should be noted that under the existing guidelines published to assess the impact of wind turbines on radar systems, letters of non-concurrence have had an unexpected impact in several areas. These impacts can be linked back to the EA that must be completed for each development and the financial backing that is required to get a wind farm proposal moving forward.

Specifically EAs in Nova Scotia require a letter of concurrent from DND before the EA will be signed off. Letters of non-concurrence will prevent a proposal from getting its EA approved and will prevent the project from moving forward.

With regard to the financial backing required to move a Wind farm project forward, banks and other financial institutions, as well as insurance agencies may be unwilling to approve funding if a letter of non-concurrence from DND has been received. It would appear that banks will only support projects that they could take over if required to secure the debt, which explains the concerns that are raised when a the letter of non-concurrence is issued to a developer.

Although letters of non-concurrence have no legal standing and can be ignored by developers, the fact that a federal department has provided written opposition to a proposed wind farm project carries significant weight. An example of the impact of federal opposition can be seen in Germany, where a single wind turbine that encroached into a night low level flying area slipped through the review process and was constructed. The case is currently before the German courts to determine if the turbine should be dismantled or not.[155] To date, no wind farm development in Canada with letters of non-

[155] P Jago and N Taylor, "Wind Turbines and Aviation Interests – European Experience and Practice," (2002), 19.

concurrence have proceeded without making the required changes to either the location of the farm or the location of specific wind turbines that raised concerns from DND.

The current voluntary process utilized in Canada is in line with the processes used in several European countries, including the UK. The German system is also similar to the UK, however, the consultation process is a legal requirement, with a committee that oversees the consultation with relevant agencies, including the Air Force.[156]

[156] P Jago and N Taylor, "Wind Turbines…, 43.

CHAPTER 8 - MITIGATION OF RADAR INTERFERENCE

With the significant impact that wind turbine farms can have on radars, there have been many studies and reports on potential solutions to the problem. The easiest solution is based on non-technical mitigation, by which construction of wind turbines anywhere where they encroach on the LOS coverage of a radar system would be blocked from proceeding. But this solution is not practical. If we want to encourage the growth of renewable energy, and wind turbines in particular, we need to find solutions that will meet the needs of both the Wind Energy industry and the organizations that use radar systems.[157]

Policy Recommendations:

One possible way ahead would be to change the rules regarding ATC and airspace control. The government could mandate that transponders must be used by all aircraft flying within controlled airspace and dictate that controlled airspace would include any area covered by ATC or AD radar. The government could also state that primary search radar is not required and a solid signal from the transponder on board an aircraft to the secondary surveillance radar would suffice for air traffic control requirements.[158] However, many aircraft are not equipped with a transponder, and even those that do have a transponder have the ability to turn it off. In this post 9/11 world, relying on an aircraft to voluntarily tell you where it is at all times would not be acceptable from an AD perspective. And since the returns from ATC radars are used to help develop the entire

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[157] Michael Brenner, "Wind Farms and Radars", (Jan 2008), 4.
[158] *Ibid*…5.

AD picture, allowing ATC radars to rely solely on secondary surveillance and transponders would be a hard pill to swallow.

Non-technical Mitigation:

Although outright denial of construction is not a feasible answer, it does lead to the option of careful siting of wind turbines through consultation with owners of radar systems. Wind turbines can be constructed inside the coverage zone of a radar, as long as the moving blades do not break the LOS of the radar. The layout of the radar farm can also have an impact on the radar returns. Companies can work with government agencies to discuss the siting of the turbines and can come to agreements as to the number and locations of turbines, as well as potential discussions regarding acceptable levels of interference or specific zones where some interference would not impact operations or seriously degrade coverage.[159] A development of 50 turbines on a hill top 40 kilometres away from an AD radar may cause serious interference, whereas a development of 100 turbines on the far side of a hill only 20 kilometres from the radar may have no impact whatsoever. Any interference on an approach path might be unacceptable, whereas a small amount of interference in a zone with little to no air traffic may not be considered a problem.

The "Technical Information and Coordination Process Between Wind Turbines, Radio Communication and Radar Systems[160]" document created consultation zones around each type of radar system that could be impacted by wind turbines. These

[159] Dr. Laith Rashid and A. Brown, "Wind Turbines and Radar Interaction," University of Manchester, (Apr 2011), 7.

[160] RABC, Technical Information…, 9.

consultation zones are meant to notify wind project proponents where interference issues may occur and assist developers in contacting the appropriate department early in the development stages of a wind farm project. The goal of these consultation zones was to ensure that funds were not expended on an installation that would create unacceptable interference with a radar in the region, which could result in expensive changes or delays in the completion of the construction of the wind farm development. The consultation zones vary by type of radar.

For Doppler radars, the current guidelines have recommended that any proposed construction of wind turbines within 80 kilometres of a Doppler radar must be reviewed by Environment Canada, which is responsible for Doppler radars in Canada.[161]

NAV Canada and DND operate Area or Primary Surveillance Radar (ASR/PSR) and Secondary Surveillance Radar (SSR) in Canada to provide civilian ATC services. Additionally, DND operates Precision Approach Radar (PAR) at many of its airfields. An ASR/PSR has a consultation zones of 80 kilometres, a SSR has a consultation zone of 15 kilometres, while a PAR has a consultation zone of 40 kilometres.[162] AD radars operated by DND are more powerful search radars. As such, the consultation zone surrounding AD radars is 100 kilometres.[163]

Technical Solutions:

Most technical solutions are based around either making modifications to the wind turbines or making modifications to the radar systems.

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[161] RABC, Technical Information…, 13.
[162] *Ibid*…12.
[163] *Ibid*…13.

Reducing the Radar Signature of the Wind Turbines:

Reducing the radar signature of wind turbines can be done through two principle means; changing the design of the wind turbine or changing the material used to manufacture the turbine.

Changing the design of the turbine is based around physically minimizing the radar cross section (RCS) of the turbine tower and nacelle through careful shaping. The design of both the tower and nacelle would have to be altered such that they would never present a flat/concave surface to the radar bore-sight. However, RCS returns from the blades can only be effectively controlled though the use of absorbing materials.[164]

Changing the material used to manufacture the turbine is based around the use of Radar Absorbing Materials (RAM), or stealth technology. It has been suggested that adding a layer of material with stealth characteristics to the outside of the blades of the wind turbine would significantly reduce or eliminate the radar return from the spinning blade. However, this concept has not been proven to work with large wind turbines and the actual cost of using this type of material may push the overall cost of purchasing wind turbines past the point of financial feasibility.[165]

Radar System Software Modifications:

Many companies have been working on software upgrades to the radar system that will allow the radar to eliminate the returns from the wind turbines, while keeping

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[164] G Poupart, QinetiQ, "Wind Farms Impact on Radar Aviation Interests – Final Report," D.o.T. and.Industry, (2003), 91.

[165] M Brenner, "Wind Farms and Radar," 6.

the returns from aircraft. However, most of these software modifications require a newer digital radar to run the software. Unfortunately, many AD radars are using older technology and may not be capable of using the newer software. Additionally, although many companies are running trials, no software modification for an existing system has been successfully deployed into an operational unit.[166]

Radar System Hardware Modifications:

There are two main areas of research and development regarding radar system hardware modifications; the replacement of the complete radar system with a newer system or the addition of a hardware filter component that could be integrated into the existing system.

Radars that do not have the capability to mitigate the interference from wind turbines would have to be replaced. Many of the older ATC and AD radars are nearing their projected end of life and are due to be replaced or upgraded in the near future. However, the replacement of a radar system is very expensive, with the complete life cycle costs of upgrading a single radar site running into the tens of millions of dollars. Several of the newer systems on the market claim to have solved the wind turbine interference issue and have run demonstrations that show this.[167] However, there has not been any independent proof of these claims. In the past, claims of finding solutions to the problems have been proven to actually be only partial solutions, or solutions that work in one specific situation.[168] Until these newer systems are purchased and installed in areas

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[166] US Congressional report…, 46.
[167] Lockheed Martin, "Wind Farm Compatible Radar Briefing," Fall 2011.
[168] US Congressional report…, 46.

with wind turbine farms, we are forced to rely on the sales brochures of the companies that manufacture the systems.

DND is currently working on a project to replace the old ATC radars across the country. The replacement project has been announced and the new radar will have wind turbine mitigation capability utilizing advanced algorithms to suppress false targets and improved tracking. Once the radars are installed, additional testing can be completed to determine the extent of the mitigation.

The second area of research is based around adding a new component to existing radar systems. Unwanted returns could be reduced by adding an advanced digital filtering kit to the existing radar. These solutions are normally aimed at large Doppler based ATC and AD radars. Successful trials have been run by several companies using different types of digital ATC search radars. However, the cost of the filters runs into the hundreds of thousands of dollars and any proposed installation would have to be tested on each specific radar before any impact could be confirmed.[169]

Gap Filler Radar:

Another concept that has been put forward has been the installation of small gap filler radars. In areas where wind turbines would cause unacceptable interference, a second supplementary radar would be installed, with the idea being that having two independent views of the wind turbine farms would increase the probability of seeing the aircraft and eliminating some of the interference. However, there has been no proof that adding a second radar would eliminate the interference, although it would eliminate any

[169] A Marston, Wind Turbine Interference…, 7.

loss of coverage in the blind areas behind the wind turbine farm where the primary radar could not see the target. There is also no data available to confirm if both radars would see the false targets that are generated by the wind farms.[170]

With the number of potential solutions, or partial solutions that are either under development or on the market, independent testing should be instigated to confirm if either the software modifications or the hardware filters can successfully eliminate or reduce the wind turbine interference, and what models of radars can be modified. Additional testing will also be required to determine if there are any limitations on the new radar systems with built in wind turbine interference mitigation that are now hitting the market.

[170] US Congressional report…, 46.

CHAPTER 9 – A BALANCED WAY AHEAD

Globally, the number and size of wind turbine developments are projected to continue growing as governments attempt to find greener ways of meeting their energy needs. In Canada, there has been a corresponding growth in the number of potential wind turbine developments in various regions across the country over the last decade. However, due to the weakened economy, increased public backlash, limited grid capability to accept further development as well as provinces reducing or eliminating FIT programs that initially offered guaranteed returns to wind developers, the number of new wind farm developments has significantly slowed down over the last year.

Due to the fact that both the government and CanWEA have been publicizing the impact of wind turbines on radar systems, potential builders have been contacting the owners of radars in the vicinity of their proposed developments. DND, EC, NRCan and Nav Canada have seen a significant growth over the last five years in the number of consultations they are having with builders. Most of these consultations are courteous, with both sides trying to work towards a solution that meets both their needs. However, several situations have occurred over the last couple of years where companies have invested significant amounts of time and money in a proposed development, and they were initially unwilling to make major changes to their plan. In the near future, the government may find itself in a situation where a developer is going to begin construction over the objection of a department. The development may end up having a detrimental effect on ATC in the region and the government has no means of stopping the development. Compounding the issue in Canada is that energy is considered a provincial concern, with each province utilizing different approval processes. Some provinces, such

as Nova Scotia have delegated this approval down to the municipality. Conversely in Ontario, municipalities have little say in the wind turbine siting approval process.

The government has many different options available if it decides to put some measure of federal control in place on wind turbine developments, including regulations, orders, directives and bylaws. Utilizing an existing statute, such as the Aeronautics Act, or the Radio Communications Act, regulations could be developed that could be used to limit wind turbine development in those rare situations where serious interference would occur and no compromise could be reached between the developer and the department whose equipment or systems would suffer interference.

However, any future action by the government would have to take into consideration how it would look to the public if a minister was pushing to implement a regulation or order that could be seen as putting limits on green energy. With this in mind, it is doubtful that any official action could be taken that would not be spun by the media or environmental activists as a move against renewable energy.

While it may be unfeasible to move forward on this issue at this time, it would be wise of the federal government to look at this situation and appoint one of the departments to work on draft regulations that could be moved forward in the future if the situation came to the point where the government felt it was necessary to implement some level of oversight or control at the federal level.

Without official regulations in place, the situation reverts back to guidelines developed by the government with voluntary observance by industry. The existing guidelines in Canada are contained in the “Technical Information and Coordination

Process between Wind Turbines and Radio-communications and Radar Systems[171]", published by RABC, in conjunction with CanWEA. These guidelines are sometimes difficult to find and include too many industries grouped together. In other countries, guidelines are developed that deal solely with safety of aviation and interference with defence systems. It is recommended that DND work with other departments or agencies to develop a more detailed guideline, dealing specifically with the impact of wind turbines on aviation safety and corresponding interference with defence radio communications and radar systems. These guidelines should be based on the UK's Guidelines on Wind Energy and Aviation Interests[172] and utilize appropriate documentation from CAA and EuroControl. These enhanced guidelines should include some way of resolving conflicts, when both parties cannot come to a mutual agreement.

With the recent update of 1 CADO 4-510, the Air Force has named the Aerospace and Telecommunication Engineering Support Squadron (ATESS) as the single Point Of Contact (POC) for the Canadian Air Force on all matters dealing with wind turbine projects. It also mandated that ATESS be an expert on wind turbine assessments and stay abreast of wind turbine technology and approval processes. ATESS is also the single POC to deal with outside agencies on wind turbine issues. This is an excellent centralization of authority with a unit that has been involved with wind turbine interference issues since 2006.[173]

The Air Force needs to immediately procure advanced modeling software to allow it to better evaluate the impact of proposed wind farms on radar systems. Simply

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[171] RABC, Technical Information…, 2010.
[172] UK Wind Energy and Aviation Interests interim guidelines.
[173] 1 CADO 4-510, Dec 2012.

using LOS as a means of determining the impact is unacceptable. The new CADO has directed that the Radar and Communications Systems (R&CS) section within the Directorate of Aerospace Equipment Program Management (DAEPM), will become the technical SMEs for turbine analysis . Further, the CADO has directed that ATESS and R&CS will consult with Defence Research and Development Canada (DRDC) to allow better technical evaluation of those proposals where significant interference is expected. A more thorough report will put more weight behind letters of non-concurrence.

The Air Force should endeavour to send both a military representative from ATESS, along with a scientist from DRDC to attend the meetings held by the exploratory team of the NATO Sensors & Electronics Technology (SET) Panel. This panel was tasked to assess studies and field trials regarding wind turbine interference that have already been conducted by NATO member nations; identify any gaps in understanding the underlying phenomenology; develop a co-ordinated approach to address these gaps and any other issues; and develop a co-ordinated plan for the necessary studies, analyses, or field trials to obtain any additional data needed to fully understand the issue of wind turbine interference.[174]

The Air Force must ensure that the various governmental and non-governmental agencies meet at least once a year to review the situation regarding wind turbine interference and discuss any changes to mitigation strategies, new technologies or proposed changed to the existing guidelines. They must also ensure that the working group meets with CanWEA representatives to discuss ongoing problems, issues or concerns. An open dialogue with CanWEA and being part of the team that is continuing

[174] NATO Sensors & Electronics Technology (SET) Panel, "Terms of Reference – Wind Turbine Interference Exploratory Team," 2006.

to work towards finding solutions to the problem of interference is the best way of minimizing potential future conflicts with developers.

The Air Force must remain in contact with EuroControl and stay current on any new developments or documents that are released by EuroControl regarding wind turbine interference on ATC radars in Europe. The Air Force must also remain in contact with the offices in the UK and the US that are responsible for handling the issue of wind turbine interference and ensure any new reports or studies are forwarded to Canada. There is a need for more recent trials utilizing newer radar technology to determine the impact of these newer radar systems dealing with both older and newer wind turbines. Without results that reflect current technology, it is difficult to ensure that DND is doing everything it can to support the development of wind farms in the vicinity of radars, while ensuring a minimal impact flying operations.

It is critical that DND stay abreast of any new systems or capabilities that companies are planning or putting forward that would assist with the mitigation of the interference from wind turbines. This will require attendance at yearly conferences dealing with ATC and AD radar systems and participation in ongoing trials, whenever possible. When ATC and AD modernization projects begin looking at replacing older radars with state of the art systems, the potential exists for additional mitigation measures or elimination of the problem entirely.

DND should begin a dialogue with the provinces to investigate the possibility of adding a consultation with DND into each provincial EA for a wind turbine development. DND would review and comment on all proposals that they are considering for approval and if DND has not offered concurrence, the provincial approval will be conditional.

CONCLUSION:

Energy Security is an important part of any countries overall security platform. Energy security strategies should have goals of energy independence centred on diversifying and increasing energy supplies nationally. It is not necessary for any one type of energy production to meet 100% of the nation's energy needs. There will also be a need to increase energy conservation, decrease greenhouse gas emissions and modernize energy distribution systems. To meet these priorities, governments must set energy targets and cannot push off investing in green energy until some date in the future when they might be more economically viable. Renewable energy sources must play an important role in meeting energy security goals. This will require a significant increase in the amount of renewable energy being produced domestically.

Wind energy is a growing industry in Canada. Correspondingly, the number of cases where wind farm developments will have potential interference concerns with radio communications and radar systems will continue to grow as well. The aviation safety and national security concerns raised due to this interference cannot be ignored. However, the safety and security concerns surrounding renewable energy don't simply trump energy security, economic progress and the environmental benefits that wind energy brings to the table. The problem of balancing our national security with the need to increase renewable wind energy production is complex and it is clear that no department can move forward with a mitigation strategy that simply forbids wind turbine development in all areas surrounding radio transmitters and radar stations. Understanding the need to expand the amount of wind energy being produced in our country, it is clear that DND must work

with CanWEA and other partners to find a better solution that meets the needs of both the department as well as wind developers.

This balanced approach will require governmental and non-governmental agencies to continue to work together to find a middle ground between developers that want to build turbines in locations close to airports and radars and DND, that want to keep wind turbines up to 100 kilometres away from airfields and radar installations. To do this, DND will need to fully understand the impacts caused by wind turbine interference and have a valid assessment process in place to determine the level of impact of each individual proposed development. It is also critical that DND continue to work with industry on developing mitigation options or utilizing technology to avoid or minimize the potential impacts of future wind farm developments.

Currently, there is no pressing need to implement federal government regulations to manage wind farm developments. The voluntary guidelines currently in place in Canada seem to be working and the voluntary processes implemented in other countries also appear to provide an acceptable balance between the wind energy industry and government departments involved with ensuring the safety and security of the country.

The steps that DND has taken to date, including the creation of the RABC assessment document and the centralizing of responsibility for wind turbine interference issues with one unit are an excellent start. The department simply needs to continue on this path, working with CanWEA and wind developers, and taking every opportunity to find innovative ways to enhance the ability of wind turbines and radars to co-exist in close proximity in a harmonious and balanced relationship.

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