3.4.3 Low Scenario Overview:

Assumptions used in the creation of the low scenario include:

- Low political support for continued procurement of wind energy generation capacity:
    - Potential changes to the domestic content rules.
- Minor transmission additions to facilitate additional project awards and installations (by 2018).
- Potential interruptions to original project schedules:
    - Permitting – significant;
    - Construction – few (chiefly due to winter weather);
    - OPA's 1 year extension on COD – significant; and
    - Project cancellations – significant.

3.4.3.1 Installation Rate in Ontario

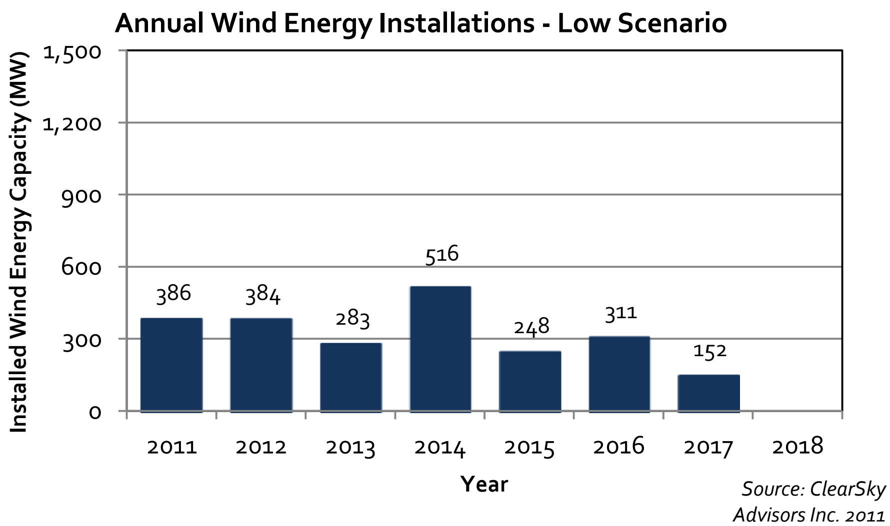

Figure 3.6: Annual Wind Energy Installations in Ontario (in MW), Low Scenario (2011-2018)

- Total 2011-2018 installations: 2,280 MW - total cumulative installations by 2018: 3,708 MW.
- Average annual installations: 285 MW - ranging from 0 MW (2018) to 516 MW (2014).

3.4.3.2 Trends

- Annual installations will peak in 2014 due to:
    1. The Bruce to Milton transmission expansion project
- Market supply capacity for wind turbine installations of 600 - 700 MW per year:
    - It is unlikely that the market will experience any domestic content supply constraints from 2011-2018.
    - Most parts of the value and supply chains have significant flexibility in terms of scaling production and service up and down. Further, additional supply in the Ontario marketplace could be used to serve other North American markets fairly easily due to the strong transportation infrastructure in Ontario. As such, though the market capacity will be far greater than demand in most years, it is unlikely that there will be a surplus of equipment and/or production capacity that could cause decreases in price.

4 Economic Impacts

4.1 Overview of Economic Impacts

Investment in the wind energy sector impacts a number of stakeholder groups within the province of Ontario in a variety of ways, including stimulation of local spending, generation of tax revenue, lease payments, job creation, and the development of local expertise and innovation[7]. Based on market activities corresponding with the "expected" scenario laid out in the previous section, the key economic indicators are:

- The wind energy sector will result in 80,328 person years of employment (PYE) from 2011-2018.
- Total private sector investment for wind turbine installations will be more than $16.4billion, of which greater than $8.5billion will be spent locally in Ontario from 2011-2018, shown in Figure 4.1.
- Total private sector benefits paid in Ontario, demonstrated in Table 4.7, as a result of installations in 2011-2018 will surpass $1.1billion (based on and paid over 20-year contracts from the installation date), including:
  - $1.03billion in lease payments to landowners; and
  - $147million in taxation payments to municipalities.

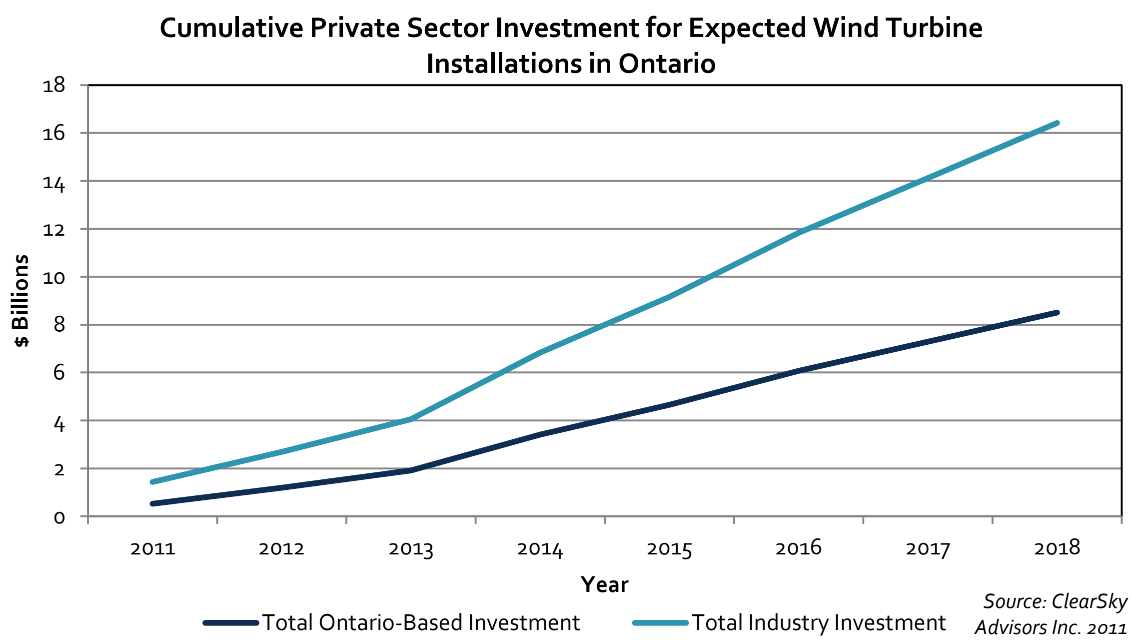

Figure 4.1: Cumulative Private Sector Investment for Wind Turbine Installations in Ontario, Expected Scenario 2011-2018

[7] The analysis in this report does not include the economic or labour impacts associated with the decommissioning, re-powering, and/or refurbishment of wind turbines at the end of their service life. It is likely that a combination of all three options will be employed for wind turbines in Ontario, but at this point in time it is unclear what percentage of turbines will subjected to each end of service life option.

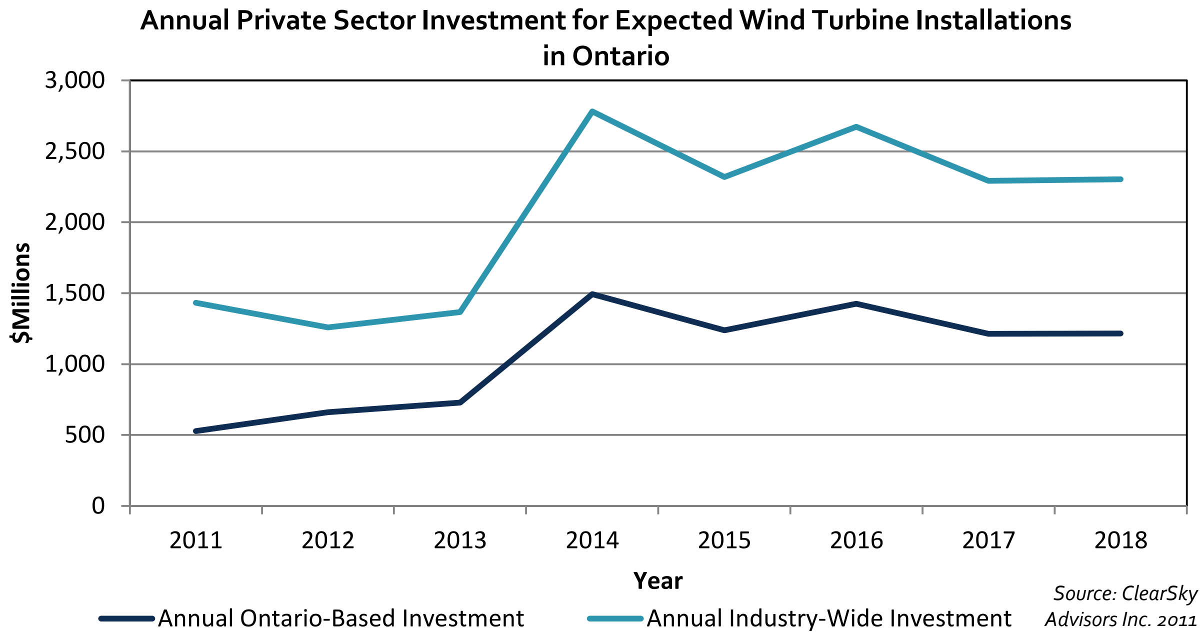

Figure 4.2: Annual Private Sector Investment for Wind Turbine Installations in Ontario, Expected Scenario 2011-2018

4.2 Job Creation

When compared to existing traditional energy sources in Ontario, the wind energy sector creates more employment opportunities per unit of energy produced and does so at a lower cost per job. This fact, as demonstrated in the following figures, helps to explain why the province of Ontario and other governments from around the world are including wind energy as a growing part of their energy mix.

In general, when considering jobs created by the wind energy sector, it is useful to make a distinction between pre-connection and post-connection jobs. Post-connection jobs are typically ongoing and include operation and maintenance (O&M) while pre-connection jobs are more variable in nature and include project development, onsite labour, manufacturing, wholesale, and distribution. For the purposes of our study, we have termed pre-connection jobs as "Construction Phase" and have assumed that the pre-connection jobs would be one-time[8]. In order to be sustained on an ongoing basis, these jobs would need to be maintained with export projects and/or additional local market awards.

In order to compare ongoing jobs with one-time jobs, we use a measure called person-years of employment (PYE). As the name suggests, PYE represent one year of employment for one individual (i.e. 40 hours per week for 52 weeks). To illustrate, since Ontario FIT contracts last for 20 years, we equate one O&M job associated with a FIT contract to 20 PYE.

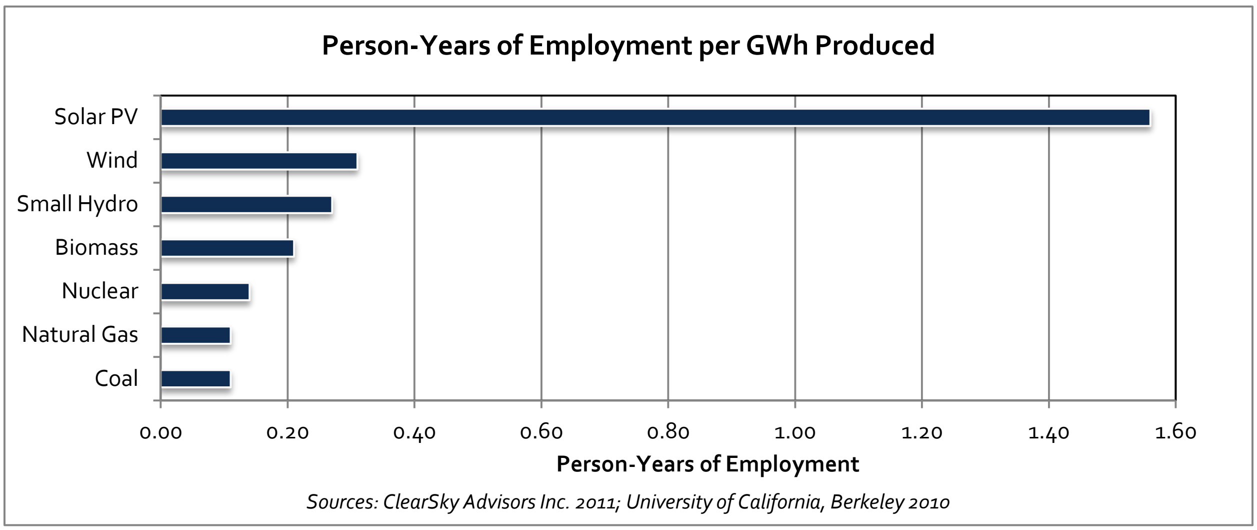

Figure 4.3: Person Years of Employment per GWh of Generated Energy by Various Technologies Employed in Ontario.

To compare job creation (in terms of PYE) by various generation technologies, it is most useful to measure the number of PYE created per unit of energy produced (GWh in this case). Figure 4.3 demonstrates PYE per GWh by different technologies used in Ontario for energy generation. Results from a 2010 study published in Energy Policy by Wei et al. that synthesized data across 15 job studies

[8] Re-powering construction phase employment was not taken into consideration as it will appear much later than the scope covered in this report. A continuous wind market will create these jobs and allow for a number of construction phase jobs to be self-sustaining.

were coupled with Ontario-specific conditions (such as wind regime, solar insolation, and FIT contract data) to inform the model used in Figure 4.3[9].

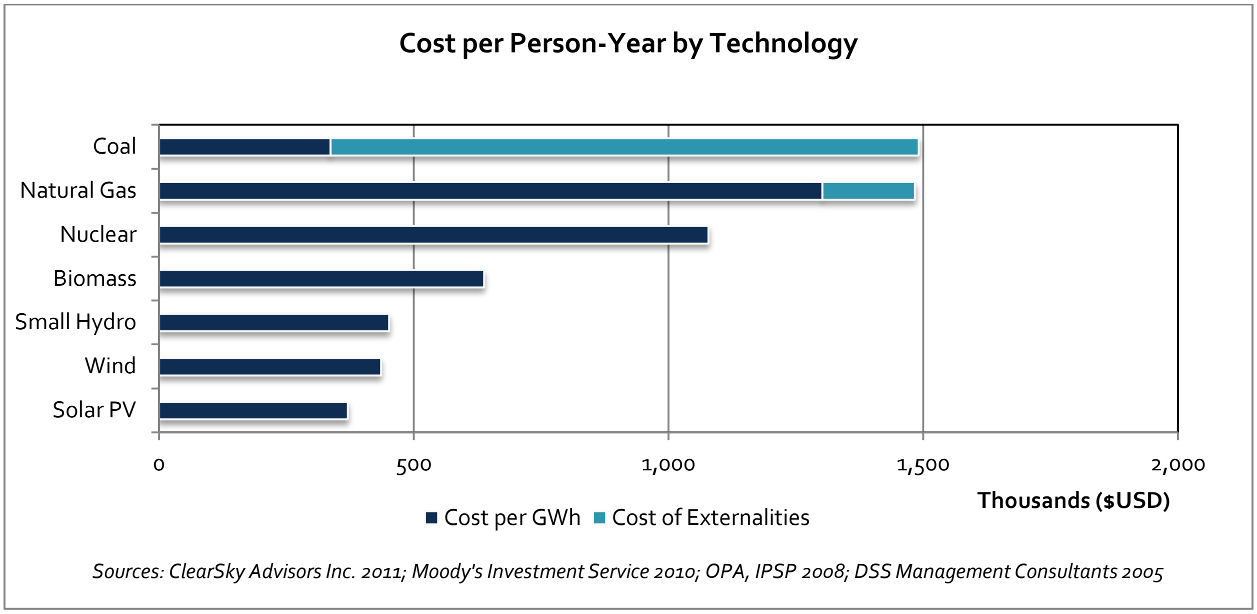

Figure 4.4: Cost per Person Year of Employment by Various Energy Generating Technologies Used in Ontario

The cost of job creation can be calculated by comparing PYE per unit of energy with the cost per unit of energy. Our cost calculations have come from current Feed-In Tariff rates, Moody's Investment Service (for nuclear data)[10], and the OPA's integrated power system plan (IPSP) evidence[11]. In order to reflect a more complete and accurate cost to Ontarians, our assumptions for the cost of fossil fuels incorporates conservative estimates (2¢/kWh for natural gas and 12.7¢/kWh for coal)[12] published by the Ontario Ministry of Energy of the cost of health and environmental externalities caused by these types of power generation[13].

[9] Wei, M., Patadia, S., Kammen, D. 2010. Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US? Energy Policy. 38: 919-931.
[10] Weis, T., Stensil, S.-P., & Stewart, K. (August, 2010). Renewable is Doable. http://pubs.pembina.org/reports/ontario-green-energy-report-august-web.pdf
[11] Ontario Power Authority. (2007). Methodology and Assumptions for the Cost to Consumer Model. http://www.powerauthority.on.ca/ipsp/Storage/53/4886_G-2-1_Att_1_corrected_071019.pdf; and Ontario Power Authority. (2008). Integrated Power System Plan for the Period 2008-2027. http://www.powerauthority.on.ca/integrated-power-system-plan/g-plan-outcomes
For natural gas pricing the OPA considered several scenarios that fall within a spot-price range from $4.00 to $12.00; as present day prices are close to the low end of that range, we used the OPA's low price case in our cost calculations. Ontario Power Authority. (2008). Integrated Power System Plan for the Period 2008-2027. http://www.powerauthority.on.ca/integrated-power-system-plan/g-plan-outcomes.
[12] DSS Management Consultants Inc., RWDI Air Inc. (2005). Cost Benefit Analysis: Replacing Ontario's Coal Fired Electricity Generation. Toronto, ON: Ontario Ministry of Energy.
[13] Externalities of 18¢/kWh due to coal were reported in a Harvard study. (Reuters. (2011). Coal's hidden costs top $345 billion in U.S.-study.)

4.2.1.1 Total Jobs Created Annually and Total for 2011-2018

Figure 4.5 demonstrates annual job creation in Ontario by the wind energy industry. The number of PYE presented includes both one-time and ongoing jobs. All PYE from permanent jobs are attributed to the year in which the project was installed[14].

The cumulative expected PYE created by the wind energy sector in Ontario from 2011-2018 is shown in Table 4.1. It should be noted that the jobs reported here are solely a result of the LTEP.

- From 2011-2018, 80,328 PYE will be created in Ontario due to the wind energy sector.
- On an annual basis, the number of jobs created varies from a low of 5,708 PYE in 2011 to 14,249 in 2014.

Note: The O&M job numbers listed for each year in Figure 4.5, are created as a result of the projects built that year, but are actually carried out over the 20 year period a project is expected to be in operation. Figure 4.8 illustrates that fact in more detail.

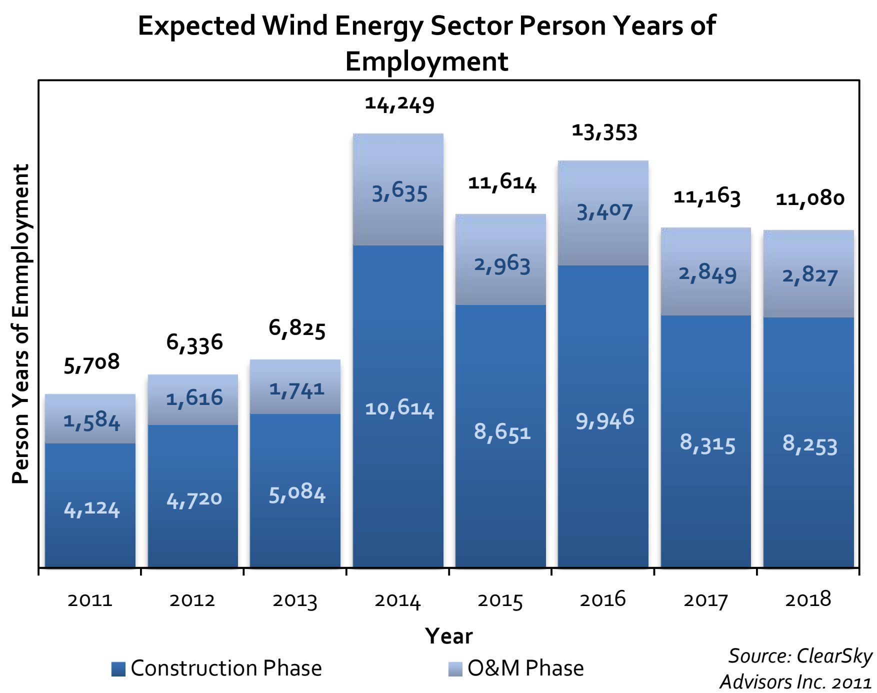

Figure 4.5: Person Years of Employment Created by the Wind Energy Sector in Ontario, Expected Scenario 2011-2018

4.2.1.2 Jobs Creation by Type in Ontario for 2011-2018

Figure 4.6 demonstrates the relative proportion of employment by different types of jobs in Ontario from 2011-2018, due to the wind energy sector.

- 54% of PYE created in Ontario due to the wind energy sector will occur in the construction phase due to labour and manufacturing employment.

[14] Developmental PYE are included in the construction phase as service jobs. As the employment calculations are for only connected projects, any development work in the prospecting phase, as well as any other development, manufacturing, and/or construction work for incomplete projects are not accounted for in our scenarios.

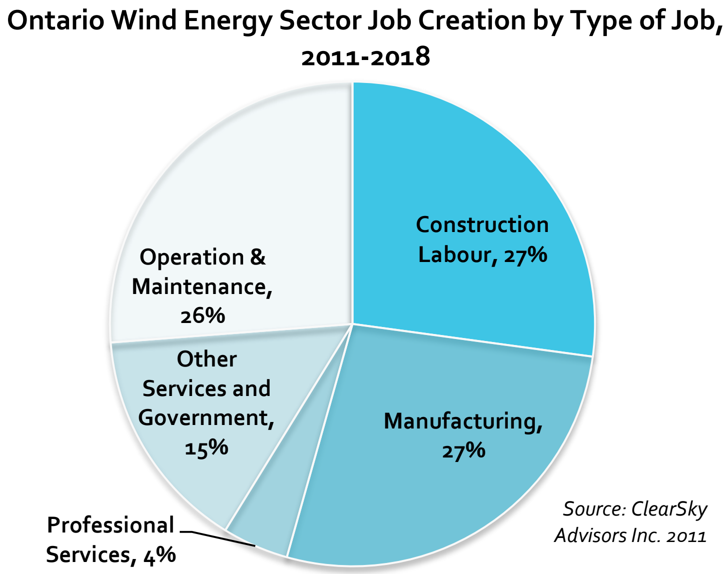

Figure 4.6: Total Ontario Wind Energy Sector Job Creation by Type of Job, Expected Scenario 2011-2018

PYE can be classified into three categories: direct, indirect, and induced.

- Direct PYE are jobs that are created to immediately serve the actual supply chain, such as wind turbine manufacturing and construction.
- Indirect[15] PYE are jobs that have been created to facilitate the creation and maintenance of the supply chain, such as the construction and manufacture of facilities and equipment used in the wind energy generation supply chain.
- Finally, induced PYE are jobs that are created elsewhere in the economy as a result of spending from both direct and indirect workers and firms[16]. Induced PYE were not included in this study so as to be conservative with PYE estimates as well as due to their ambiguous nature. Induced jobs are real, but quantifying them is difficult, so we have focused our analysis on direct and indirect jobs.

Expected PYE creation due to Ontario's Wind Energy Sector from 2011-2018, demonstrated in Table 4.1, will be almost equally split between direct and indirect employment:

- 38,135 direct PYE; and
- 42,193 indirect PYE will be generated in Ontario due to the wind energy sector.

[15] Note: The model assumes (based on inputs and multipliers from Statistics Canada) that a certain percentage of indirect jobs would need to exist in the province to serve the wind energy sector. These jobs are counted in the year in which the installations are complete and not necessarily in the year that they occur.
[16] Estimates of Job Creation from the American Recovery and Reinvestment Act of 2009. http://www.whitehouse.gov/assets/documents/Job-Years_Revised5-8.pdf

Table 4.1: Job Creation (PYE) in the Ontario Wind Energy Sector, 2011-2018

Wind Energy Sector Job Creation (PYE) in Ontario, 2011-2018										
		2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Total**
Expected Scenario	*Direct*	2,651	3,013	3,246	6,776	5,523	6,349	5,308	5,269	38,135
	Indirect	3,057	3,323	3,579	7,473	6,091	7,003	5,855	5,811	42,193
	Total	5,708	6,336	6,825	14,249	11,614	13,353	11,163	11,080	80,328
High Scenario	*Direct*	3,349	3,138	4,540	7,643	6,714	6,985	7,285	6,947	46,602
	Indirect	3,863	3,461	5,007	8,430	7,405	7,704	8,035	7,663	51,567
	Total	7,212	6,598	9,548	16,073	14,120	14,689	15,319	14,610	98,169
Low Scenario	*Direct*	1,979	2,642	1,950	3,549	1,710	2,138	1,069	-	15,037
	Indirect	2,282	2,914	2,150	3,914	1,885	2,359	1,155	-	16,658
	Total	4,262	5,557	4,100	7,462	3,595	4,497	2,223	-	31,695

Source: ClearSky Advisors 2011

Note: In Table 4.1 all jobs created by an installation in a given year are tied back to that year regardless of when the job actually occurs. See Figure 4.7 for an alternative view of the same data.

Table 4.2: Net Job Creation (PYE) Difference Between Market Scenarios (Relative to the Expected Scenario), 2011-2018

Net Difference in Job Creation (PYE) in Ontario Relative to the Expected Scenario, 2011-2018									
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Total**
Expected Scenario	5,708	6,336	6,825	14,249	11,614	13,353	11,163	11,080	80,328
High Scenario	1,504	262	2,723	1,824	2,506	1,336	4,156	3,530	17,841
Low Scenario	(1,446)	(780)	(2,725)	(6,787)	(8,020)	(8,856)	(8,940)	(11,080)	(48,633)

Source: ClearSky Advisors 2011

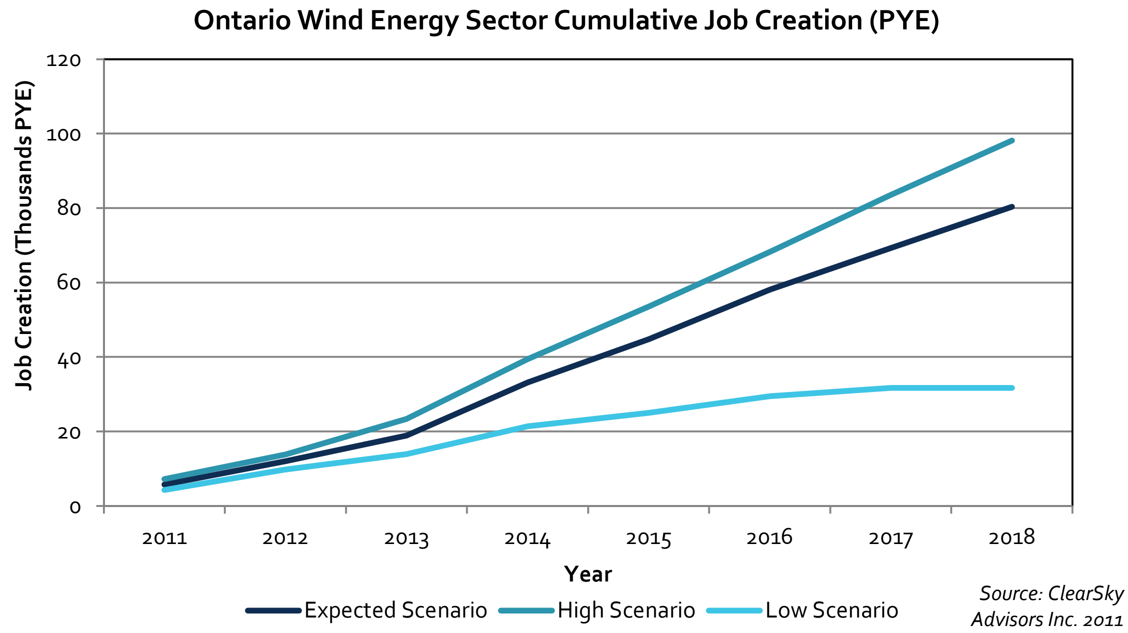

Figure 4.7: Ontario Wind Energy Sector Cumulative Job Creation (in PYE), 2011-2018

Alternatively expected job creation by year and by job type from 2009 to 2038[17] as a result of the wind energy sector in Ontario is shown in Figure 4.8, assuming that:

- Each project is awarded at the beginning of the 1st year;
- Services (developmental and other) take place in years 1 and 2;
- Sufficient lead-time is provided to allow for manufacturing to mainly take place in the 1st and 2nd years;
- Construction is not performed over the winter and is a 2 year process;
  - Foundation and infrastructure work is completed in year 2
  - Turbine erection is completed in year 3
- Each project will be connected and generating at the end of year 3;
- O&M work will begin at the beginning of the 4th year and last for 20 years; and
- Tax payments and lease payments to landowners will begin in year 4 and last for 20 years.

Note: These figures are ONLY for the projects forecast for installation in 2011 through 2018. The actual number of jobs is likely to be higher because no jobs are included for export, pre-contract development, or any ongoing installations after 2018. Furthermore, we have only considered direct and indirect jobs and not induced jobs. Therefore, these numbers are conservative for all years. The drop-off in employment after 2017 would only occur if exports and continued project awards beyond 2018 did not materialize.

[17] For the purposes of this model direct and indirect employment were assumed to occur at the same time. As such, there is no differentiation between these two employment categories in this measure of employment.

- During the forecast window, the number of jobs created varies from a low of 4,761 in 2011 to 9,951 in 2014; and
- 1,031 O&M jobs, ongoing after the end of the forecast window, are expected to be maintained until 2031 when they will slowly decline until a low of 141 in 2038 as wind energy generation projects reach decommissioning and the end of their generation contracts.

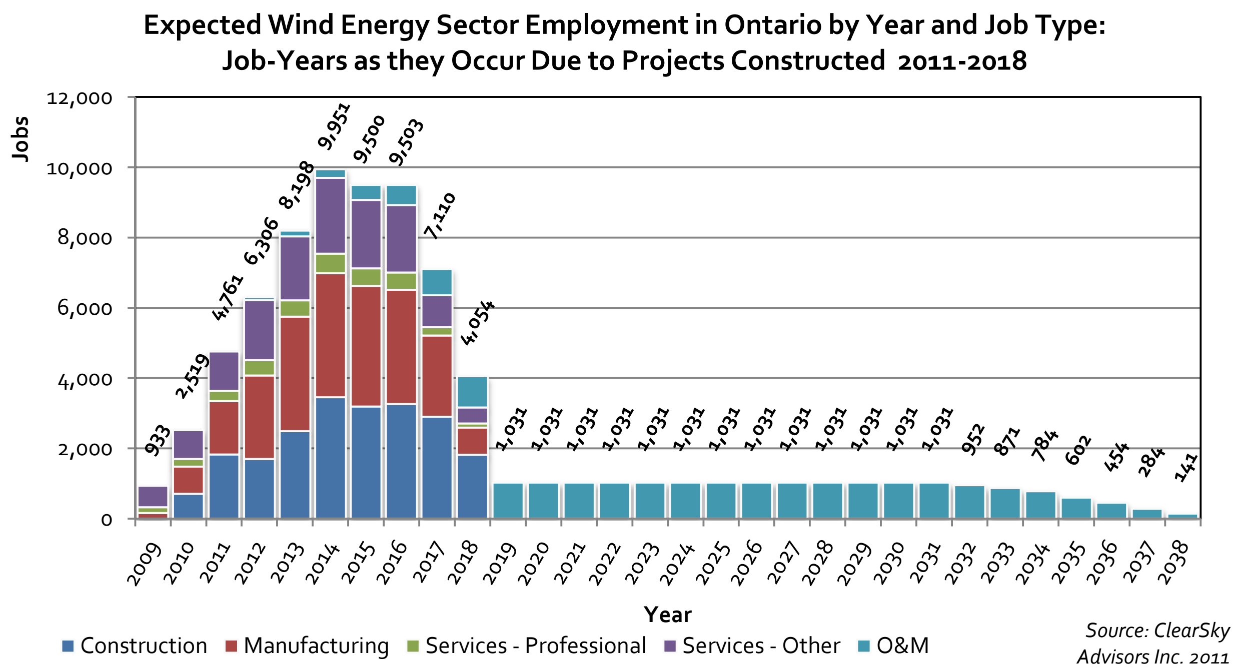

Figure 4.8: Expected Ontario Employment due to Wind Construction 2011-2018: Job Years as They Occur, 2009-2038

4.2.2 Jobs Multipliers for Construction & Operation Phases of Wind Energy in Ontario

Based on ClearSky Advisor's Forecast of the Wind Energy Sector in Ontario 2011-2018 (Chapter 3.4) we expect wind energy to have an impact on employment in Ontario in the next several years.

- On average, expected wind energy installations will create 14.1 person-years of employment in Ontario per MW of nameplate capacity:
  - Per average installed wind turbine in Ontario, 30.2 PYE are created in Ontario;
  - During the construction phase, on average, 10.5 PYE per MW of installed wind capacity will be created;
  - During the O&M phase of wind energy, on average over the 20 year contract, 3.6 PYE per MW will be generated in Ontario.

Table 4.3: Summary of Wind Energy Sector Job Creation Studies, in PYE/MW

Wind Energy Sector Job Creation (PYE) Comparison		
Location	**PYE/MW**	**Original Source**
Ontario	14.1 PYE/MW	ClearSky Advisors
European Union	21.7 PYE/MW	EWEA
California	12.3 PYE/MW*	CALPIRG
Colorado	5.4 PYE/MW	Colorado State University and The WSARE Program
Nevada	7.7 PYE/MW*	REPP
The United States of America	15.3 PYE/MW*	McKinsey
The United States of America	10.0 PYE/MW*	EPRI
Global Average	13.0 PYE/MW	Wei et al., 2010

** Calculated from Wei et al., 2010.*

Source: ClearSky Advisors 2011; Wei et al. 2010; EWEA, Wind at Work 2009; Colorado State University Cooperative Extension and the Western Sustainable Agriculture Research and Education (WSARE) Program, Wind Energy in Colorado

As a comparison, the 14.1 PYE per MW forecasted for Ontario falls within the reported range of 5.4PYE per MW to 21.7 PYE per MW reported for wind energy generation and is slightly higher than the peer-reviewed global average of 13.0 PYE per MW reported by Wei et al. (2010) and shown in Table 4.3[18]. This slightly higher number for Ontario could be explained by the domestic content requirements of the FIT program, which were reflected in our calculations.

[18] Wei, M., Patadia, S., Kammen, D. 2010. Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US? Energy Policy. 38: 919-931; The European Wind Energy Association (EWEA). (2009). Wind at Work, Wind energy and job creation in the UE; Colorado State University Cooperative Extension and the Western Sustainable Agriculture Research and Education (WSARE) Program, Wind Energy in Colorado.

4.3 Economic Benefits& Market Value

4.3.1 Market Size &Value for Ontario

4.3.1.1 Size of Market Opportunity for Wind Energy Sector Supply Chain in Ontario

A significant amount of all goods and services purchased by the Ontario wind energy sector will be produced in Ontario. In general, the wind energy sector tends to spend locally on construction, manufacturing, development, operation, and maintenance. Domestic content requirements in the FIT program in Ontario are reinforcing this approach and will drive further local spending on manufacturing and professional services. From 2011-2018, it is anticipated that over $8.5billion will have been captured by the Ontario-based wind energy sector supply chain, as demonstrated in Table 4.4. The investment into the wind energy generation sector is different from many other investments made in public infrastructure in Ontario as it is entirely from the private sector, to be paid back by the rate-payer if, and only if, the wind turbine installations produce power.

Table 4.4: Economic Value of the Ontario-Based Wind Energy Sector Supply and Value Chain ($Millions)

Economic Value of the Ontario-Based Wind Energy Sector Supply and Value Chain, 2011-2018 ($Millions)										
		2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Total**
Expected Scenario	*Ontario-Based*	$528	$662	$729	$1,494	$1,237	$1,425	$1,213	$1,215	$8,503
	Industry-Wide	$1,433	$1,260	$1,367	$2,781	$2,318	$2,673	$2,293	$2,303	$16,427
High Scenario	*Ontario-Based*	$665	$689	$1,009	$1,685	$1,500	$1,570	$1,648	$1,589	$10,355
	Industry-Wide	$1,797	$1,314	$1,885	$3,136	$2,806	$2,947	$3,100	$3,003	$19,988
Low Scenario	*Ontario-Based*	$397	$581	$448	$795	$406	$502	$272	$49	$3,451
	Industry-Wide	$1,082	$1,108	$847	$1,490	$779	$958	$536	$127	$6,928

Source: ClearSky Advisors 2011

4.3.1.1.1 Market Size for Service & Supply Chain During Construction

The market size of the supply chain serving the construction phase of Ontario's wind energy generation sector, demonstrated in Table 4.5, makes up the vast majority of spending in the industry:

- Most of this spending will be on the wind turbine nacelle (described in Chapter 3.2).
- By 2018, it is expected that almost $8.1billion will be spent on the construction phase Ontario-based service and supply chain, as shown in Table 4.5.

Table 4.5: Economic Value of the Ontario Based Wind Energy Sector Construction Phase Supply Chain ($Millions)

Economic Value of the Construction Phase Supply Chain, 2011-2018 (Millions)										
		2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Total**
Expected Scenario	*Ontario-Based*	$513	$642	$692	$1,444	$1,177	$1,354	$1,132	$1,123	$8,077
	Industry-Wide	$1,366	$1,178	$1,269	$2,649	$2,159	$2,483	$2,076	$2,060	$15,240
High Scenario	*Ontario-Based*	$648	$669	$968	$1,629	$1,431	$1,489	$1,553	$1,481	$9,868
	Industry-Wide	$1,726	$1,227	$1,775	$2,988	$2,625	$2,731	$2,848	$2,716	$18,637
Low Scenario	*Ontario-Based*	$383	$563	$416	$756	$364	$456	$223	$-	$3,161
	Industry-Wide	$1,020	$1,033	$762	$1,387	$668	$836	$409	$-	$6,116

Source: ClearSky Advisors 2011

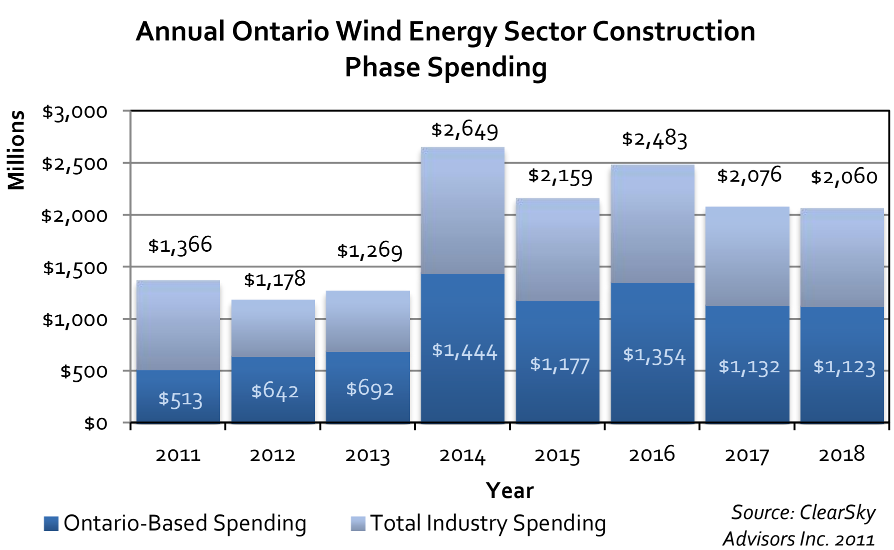

Figure 4.9: Expected Annual Ontario Wind Energy Sector Construction Phase Spending, 2011-2018

4.3.1.1.2 Market Size for Operation & Maintenance in Ontario

The market size of the supply chain serving the O&M phase of Ontario's wind energy sector, shown in Table 4.6, makes up a smaller component of spending in the industry (relative to construction):

- O&M materials spending will far outweigh labour costs;
- By 2018 it is expected that over $1.1billion will be cumulatively spent on O&M services for wind turbine installations in Ontario; and
- It is expected that by 2018 $91.6million will be spent annually in Ontario due to O&M services.

Table 4.6: O&M Phase Spending due to the Ontario Wind Energy Sector by Segment, 2011-2018

Economic Value of the O&M Phase Supply Chain, 2011-2018 (Millions)										
		2011	2012	2013	2014	2015	2016	2017	2018	Total
Expected Scenario	*Labour*	$6.5	$7.9	$9.5	$12.8	$15.4	$18.5	$21.1	$23.6	$115.2
	Materials	$60.1	$73.7	$88.3	$118.7	$143.5	$172.1	$195.9	$219.6	$1,071.9
	Total	$66.6	$81.6	$97.7	$131.5	$159.0	$190.6	$217.0	$243.2	$1,187.2
High Scenario	*Labour*	$6.9	$8.4	$10.6	$14.3	$17.6	$20.9	$24.5	$27.8	$131.1
	Materials	$64.3	$78.4	$98.8	$133.2	$163.4	$194.8	$227.5	$258.7	$1,219.2
	Total	$71.3	$86.9	$109.5	$147.5	$180.9	$215.7	$252.0	$286.6	$1,350.3
Low Scenario	*Labour*	$6.0	$7.3	$8.2	$10.0	$10.8	$11.8	$14.7	$14.7	$79.9
	Materials	$56.1	$68.0	$76.7	$92.7	$100.3	$110.0	$112.2	$112.2	$732.0
	Total	$62.1	$75.3	$85.0	$102.6	$111.1	$121.8	$127.0	$127.0	$811.9

Source: ClearSky Advisors 2011

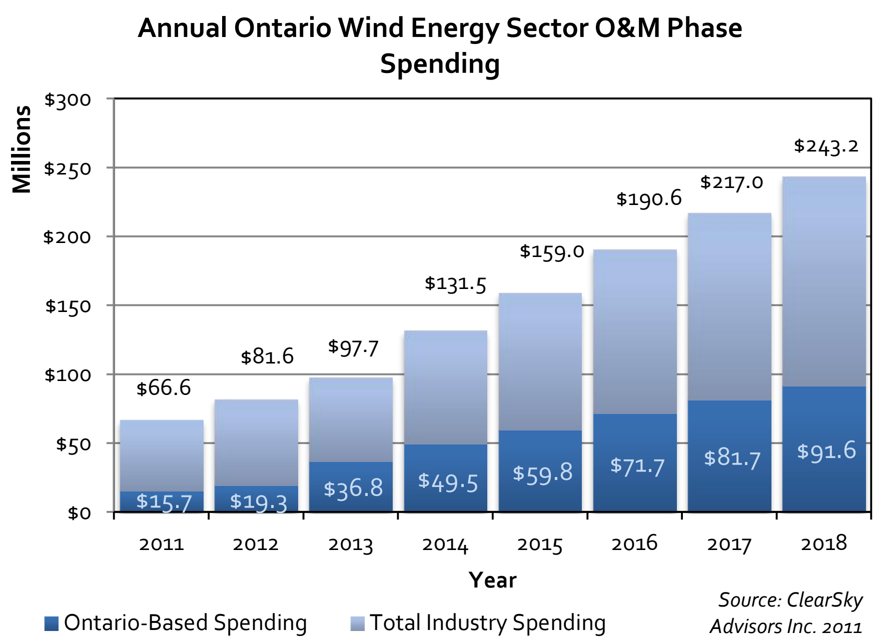

Figure 4.10: Expected Ontario Wind Energy Sector Cumulative O&M Phase Spending, 2011-2018

4.3.2 Economic Benefits for Landowners

Landowners with wind turbines on their property will also receive an economic benefit as a result of the wind energy sector in Ontario. Due to the dispersed nature of turbines for wind energy generation projects across many properties, income is distributed to landowners more widely relative to other, non-renewable sources of electricity and therefore a larger number of individuals in the community benefit. On average an annual lease payment of $19,334 is received by landowners for every MW of installed wind energy capacity on their property. Our research indicated that lease payments can range from under $10,000 to nearly $30,000 per MW. The value of agreed upon lease payments typically is project specific and greatly depends upon:

- Market conditions (i.e. demand for quality sites has increased over time as supply has decreased);
- Wind energy procurement program (i.e. RES, RESOP, FIT, etc.);
- Quality of wind resource;
- Ease of access to the land; and
- Other project specific location characteristics.

From 2011-2018, it is expected that over $313million will be paid to landowners in lease payments due to the wind energy sector in Ontario, as demonstrated in Table 4.7. For wind energy generation capacity installations from 2011-2018, it is expected that over $1billion will be paid in land leases to landowners in Ontario by the end of the 20-year generation contracts[19].

- Total private sector investment, demonstrated in Table 4.7, as a result of installations in 2011-2018, will reach over $1.1billion (based on 20 year contracts):
    - Over $1billion of this total will be through lease payments to landowners

Table 4.7: Economic Benefits to Landowners and Municipalities

Economic Benefits to Landowners and Municipalities from New Wind Turbine Installations (2011-2018)				
		Lease Payments	**Municipal Taxation****	**Total**
Average Annual Payment	*Per MW*	$19,334*	$1,302	$20,636
	Per Turbine	$41,271	$2,779	$44,050
Expected Scenario	*Total Payments from 2011-2018*	$313,936,159	$44,792,293	$358,728,452
	20-Year Payments (from 2011-2018 installations)	$1,027,745,099	$147,710,917	$1,175,456,017
High Scenario	*Total Payments from 2011-2018*	$357,080,534	$50,969,381	$408,049,915
	20-Year Payments (from 2011-2018 installations)	$1,256,927,721	$180,693,145	$1,437,620,866
Low Scenario	*Total Payments from 2011-2018*	$214,691,479	$30,540,836	$245,232,314
	20-Year Payments (from 2011-2018 installations)	$412,990,330	$59,071,665	$472,061,995

* *This is an average lease payment value. Our research indicated that lease payments for wind turbine installations can range from under $10,000 to nearly $30,000 per MW.*
** *Minimum municipal taxation payments as calculated based upon the property assessment of wind turbines according to the Municipal Property Assessment Corporation and multiple 2010 municipal tax rates across Ontario.*
Source: ClearSky Advisors 2011; Statistics Canada 2010

[19] The economic benefit calculated for landowners does not include any effects on property values.

4.3.3 Economic Benefits for Communities

In addition to supporting spending and employment in the province, the wind energy sector will affect municipal tax bases. Minimally, the economic benefit to communities from taxation on expected wind turbine installations will generate over $44million of tax revenue for Ontario municipalities from 2011-2018, as demonstrated in Table 4.7. For expected wind energy generation capacity installations from 2011-2018, nearly $148million of taxation payments will be made to Ontario municipalities by the end of the 20 year generation contracts[20].

The property assessment, for taxation purposes, of wind turbine installations in Ontario is determined by the Municipal Property Assessment Corporation. In Ontario, only the wind turbine tower is subjected to property taxation; meaning that the blades, nacelle, and foundation are exempt. Additionally, the taxable value for a wind turbine tower is fixed at $40,000 per MW of generation capacity. Moreover, it is assumed that each installed turbine requires one acre of land and the land upon which the turbine sits is assessed in the same manner as the immediately surrounding land. Thus, property assessment of wind turbine installations in Ontario is calculated according to:

$$\begin{aligned} Assessment &= (\$40{,}000 \times MW\ of\ Installed\ Capacity) \\ &\quad + (\#\ of\ Turbines \times Cost\ of\ Land\ per\ Turbine) \end{aligned}$$

Payable municipal property taxes are calculated using the property assessment of the wind turbine installation and the industrial property tax rate in the municipality.

In addition to taxation other municipal benefits have been observed in the province. In some instances the necessary privately funded infrastructure investments (such as roadway improvements) required for wind turbine installations provide opportunities at the community level. These investments are regularly maintained throughout the project lifetime. Additionally, some developers and municipalities agree upon amenity fees to be paid by the developer, which may take a variety of forms, ranging from a percentage of gross revenue to the construction of community centres and arenas. These provide additional benefits, beyond lease payments and municipal taxation, to the entire community as a whole but are difficult to quantify as part of this report.

In many cases the non-taxation benefits to communities can often meet or exceed the taxation benefits to municipalities.

[20] Anticipated Taxation was calculated based upon multiple 2010 municipal tax rates across the province as well as the value of farm land from Statistics Canada (Statistics Canada. (2010). Value of Farm Capital.)

4.4 100 MW Project Sample

To illustrate the findings in this report we have created an example of what could be expected for a typical 100 MW nameplate capacity wind energy generation project to be installed in Ontario. For this example we assume:

- The project is awarded at the beginning of year 1;
- Services (developmental and other) take place in years 1 and 2;
- Sufficient lead-time is provided to allow for manufacturing to mainly take place in years 1 and 2;
- Construction is not performed over the winter and is a 2 year process;
    - Foundation and infrastructure work is completed in year 2
    - Turbine erection is completed in year 3
- The project will be connected and generating at the end of year 3;
- O&M work will begin at the beginning of year 4 and last for 20 years; and
- Tax payments and lease payments to landowners will begin in year 4 and last for 20 years.

Table 4.8: Summary of 100 MW Project Sample Costs, Benefits, and Employment

100 MW Project Sample Costs, Benefits, and Employment		
Expected Cost	*Total Lifetime Cost (in 2011 $)*	$337,530,679
	Total 20 Year O&M Cost	$68,501,669
	Total Expected Installation Cost	$269,029,010
20 Year Economic Benefits to Landowners and Municipalities	*Total 20 Year Economic Benefits*	$41,271,945
	20 Year Lease Payments	$38,668,407
	20 Year Tax Payments	$2,603,538
Expected PYE	*Total*	1,416
	Construction Phase	1,052
	O&M Phase	363

Source: ClearSky Advisors 2011

- The total lifetime costs to the developer (including all-in installed costs and a 20-year O&M service agreement) would be nearly $338million;
- Over $41million in economic benefits to landowners and municipalities will be realized by the end of the contract; and
- 1,416 PYE will be created over the entire 23 year project timespan.

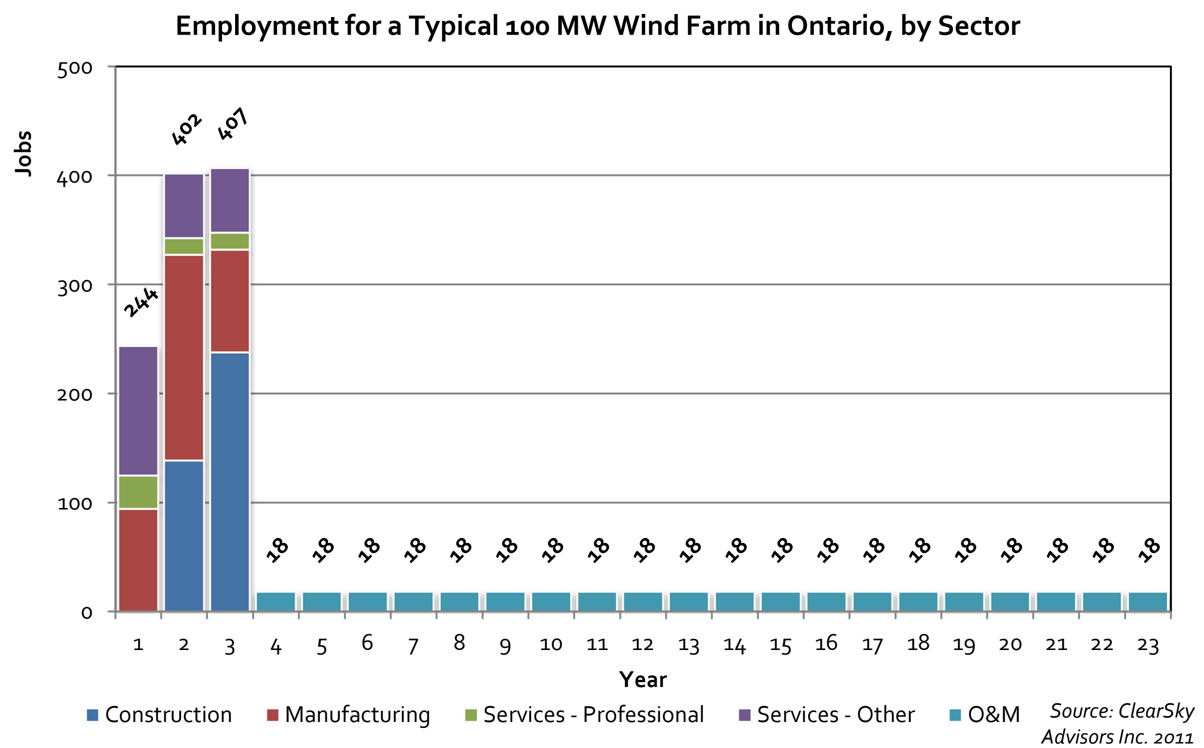

Figure 4.11: Expected Employment by Sector and Time for a Typical 100 MW Wind Farm in Ontario[21]

[21] For the purposes of this model direct and indirect employment were assumed to occur at the same time. As such, there is no differentiation between these two employment categories in this measure of employment.

Appendix

Table A.1: Ontario's Electricity Market Forecast by Generation Type, 2010-2018

Ontario's Electricity Market Forecast 2010-2018 (TWh)									
	2010	2011	2012	2013	2014	2015	2016	2017	2018
Total Demand	148.7	150.9	152.9	154.8	156.8	158.7	160.9	163.2	165.5
Conservation	6.7	8.0	9.2	10.5	11.7	13.0	14.6	16.2	17.8
Nuclear Generation	82.9	88.3	93.8	93.8	93.8	93.8	75.5	69.1	61.6
Coal Generation	12.6	7.5	7.5	6.1	2.6	-	-	-	-
Natural Gas Generation	20.5	22.6	22.9	23.2	23.5	23.8	24.1	24.5	24.8
Hydro Generation	30.7	30.9	30.9	31.0	31.4	33.1	33.1	33.1	33.1
Wind Generation	2.8	4.4	5.4	6.5	8.8	10.6	12.7	14.5	16.2
Other Types of Generation	1.3	1.9	2.7	4.2	4.7	5.1	5.4	5.7	5.9
Net Export	8.8	12.7	19.6	20.4	19.7	20.7	4.5	(0.2)	(6.1)

Sources: ClearSky Advisors 2011; OPA, IPSP Planning and Consultation Overview 2011; OPA, Ontario's Long Term Energy Plan 2010; IESO, 18 Month Outlook December 2010

Table A.2: The OPA's Domestic Content Grid as Classified by Ontario's Wind Energy Sector Supply Chain

The OPA's Domestic Content Grid[22]			
Designated Activity	**Description**	**Domestic Content Qualifying Percentage**	**Supply Chain Classification**
1	Wind turbine blades	16%	Blades
2	Pitch system	3%	Nacelle
3	Yaw system	7%	Nacelle
4	Hub and hub casing	2%	Nacelle
5	Gearbox	11%	Nacelle
6	Generator and brake	3%	Nacelle
7	Heat exchanger	1%	Nacelle
8	Drive shaft	1%	Nacelle
9	Power converter	5%	Nacelle
10	Towers	4%	Towers
11	All steel that was formed and shaped into the towers	9%	Towers
12	Control panel and electronics	2%	Electrical
13	Nacelle frame	2%	Nacelle
14	Nacelle shell	2%	Nacelle
15	Pad mount or equivalent transformers	2%	Transformer
16	Grid connection	10%	HV Systems
17	Construction and on-site labour	15%	Labour
18	Consulting services	5%	Developmental

Sources: ClearSky Advisors 2011; OPA, Feed-In Tariff Contract 2010

[22] The official domestic content grid, as part of the Feed-In Tariff contract is available at: http://fit.powerauthority.on.ca/Storage/11202_FIT_Contract_Version_1.4.pdf

Table A.3: Job Creation (PYE) in the Ontario Wind Energy Sector by Employment Segment, Expected Scenario 2011-2018

Construction Phase										
		2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Total**
Construction	*Direct*	478	409	441	920	750	862	721	715	5,295
	Indirect	1,448	1,241	1,337	2,791	2,275	2,616	2,187	2,170	16,066
Manufacturing	*Direct*	332	880	948	1,979	1,613	1,855	1,551	1,539	10,696
	Indirect	332	881	949	1,981	1,615	1,856	1,552	1,540	10,706
Professional Services	*Direct*	237	196	211	440	359	412	345	342	2,542
	Indirect	87	72	78	162	132	152	127	126	935
Other Services and Government	*Direct*	773	665	716	1,495	1,219	1,401	1,171	1,163	8,604
	Indirect	436	376	405	845	689	792	662	657	4,861
O&M Phase										
		2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Total**
Direct		831	863	930	1,941	1,582	1,819	1,521	1,510	10,998
Indirect		753	753	811	1,694	1,381	1,588	1,328	1,318	9,625

Source: ClearSky Advisors 2011

Table A.4: Job Creation (PYE) in the Ontario Wind Energy Sector by Employment Segment, High Scenario 2011-2018

Construction Phase										
		2011	2012	2013	2014	2015	2016	2017	2018	Total
Construction	*Direct*	604	426	616	1,038	911	948	989	943	6,476
	Indirect	1,830	1,293	1,870	3,149	2,766	2,877	3,001	2,862	19,648
Manufacturing	*Direct*	419	917	1,326	2,233	1,961	2,040	2,128	2,029	13,053
	Indirect	420	917	1,327	2,235	1,963	2,042	2,130	2,031	13,065
Professional Services	*Direct*	300	204	295	497	436	454	473	451	3,110
	Indirect	110	75	108	183	160	167	174	166	1,143
Other Services and Government	*Direct*	977	692	1,002	1,687	1,482	1,541	1,608	1,533	10,522
	Indirect	551	391	566	953	837	871	909	866	5,945
O&M Phase										
		2011	2012	2013	2014	2015	2016	2017	2018	Total
Direct		1,050	899	1,301	2,190	1,924	2,001	2,087	1,990	13,442
Indirect		952	784	1,135	1,911	1,679	1,747	1,822	1,738	11,766

Source: ClearSky Advisors 2011

Table A.5: Job Creation (PYE) in the Ontario Wind Energy Sector by Employment Segment, Low Scenario 2011-2018

Construction Phase										
		2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Total**
Construction	*Direct*	357	359	265	482	232	290	142	-	2,126
	Indirect	1,082	1,089	803	1,462	704	881	431	-	6,451
Manufacturing	*Direct*	248	772	569	1,036	499	625	305	-	4,055
	Indirect	248	773	570	1,037	500	625	306	-	4,058
Professional Services	*Direct*	177	172	127	231	111	139	68	-	1,024
	Indirect	65	63	47	85	41	51	25	-	376
Other Services and Government	*Direct*	525	530	391	712	343	429	210	-	3,141
	Indirect	266	269	198	361	174	218	106	-	1,593
O&M Phase										
		2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Total**
Direct		620	757	559	1,017	491	613	323	-	4,379
Indirect		562	660	487	887	427	535	263	-	3,822

Source: ClearSky Advisors 2011

Table A.6: Supply Chain Value for the Ontario Wind Energy Sector, 2011-2018

Wind Energy Sector Supply Chain for Ontario, 2011-2018 ($Millions)										
		2011	2012	2013	2014	2015	2016	2017	2018	Total
Expected Scenario	*Construction Phase*	$1,366	$1,178	$1,269	$2,649	$2,159	$2,483	$2,076	$2,060	$15,240
	O&M Phase	$67	$82	$98	$131	$159	$191	$217	$243	$1,187
	Ontario-Based Total Value	$528	$662	$729	$1,494	$1,237	$1,425	$1,213	$1,215	$8,503
	Industry-Wide Total Value	$1,433	$1,260	$1,367	$2,781	$2,318	$2,673	$2,293	$2,303	$16,427
High Scenario	*Construction Phase*	$1,726	$1,227	$1,775	$2,988	$2,625	$2,731	$2,848	$2,716	$18,637
	O&M Phase	$71	$87	$109	$148	$181	$216	$252	$287	$1,350
	Ontario-Based Total Value	$665	$689	$1,009	$1,685	$1,500	$1,570	$1,648	$1,589	$10,355
	Industry-Wide Total Value	$1,797	$1,314	$1,885	$3,136	$2,806	$2,947	$3,100	$3,003	$19,988
Low Scenario	*Construction Phase*	$1,020	$1,033	$762	$1,387	$668	$836	$409	-	$6,116
	O&M Phase	$62	$75	$85	$103	$111	$122	$127	$127	$812
	Ontario-Based Total Value	$397	$581	$448	$795	$406	$502	$272	$49	$3,451
	Industry-Wide Total Value	$1,082	$1,108	$847	$1,490	$779	$958	$536	$127	$6,928

Source: ClearSky Advisors 2011

Table A.7: Total Construction Phase Spending due to the Ontario Wind Energy Sector, Expected Scenario 2011-2018

Total Ontario Wind Energy Sector Construction Phase Spending, 2011-2018 (Millions)									
Equipment									
	2011	2012	2013	2014	2015	2016	2017	2018	Total
Nacelle	$549	$476	$513	$1,070	$872	$1,003	$839	$832	$6,154
Blades	$121	$105	$113	$236	$192	$221	$185	$183	$1,356
Towers	$167	$144	$155	$325	$265	$304	$254	$252	$1,866
Transportation	$135	$117	$126	$262	$214	$246	$205	$204	$1,508
Balance of Plant									
	2011	2012	2013	2014	2015	2016	2017	2018	Total
Materials	$204	$175	$188	$393	$320	$368	$308	$306	$2,262
Labour	$131	$112	$121	$252	$205	$236	$197	$196	$1,448
Developmental	$60	$50	$54	$112	$91	$105	$88	$87	$646

Source: ClearSky Advisors 2011

Note: This table represents construction phase spending for projects installed in each given year as indicated above. This spending may not all occur in that year, but would likely occur over the course of 2-3 years prior to commercial operation date (COD).

Table A.8 :Economic Value of the Ontario-Based Wind Energy Sector O&M Phase Supply Chain for 20-Year Generation Contracts ($Millions)

20-Year Economic Value of the O&M Phase Supply Chain, 2011-2018 (Millions)										
		2011	2012	2013	2014	2015	2016	2017	2018	Total
Expected Scenario	*Ontario-Based*	$84	$71	$122	$254	$207	$238	$199	$197	$1,371
	Industry-Wide	$354	$300	$323	$675	$550	$632	$528	$525	$3,886
High Scenario	*Ontario-Based*	$106	$74	$170	$286	$252	$262	$273	$260	$1,683
	Industry-Wide	$447	$312	$452	$761	$668	$695	$725	$692	$4,753
Low Scenario	*Ontario-Based*	$62	$62	$73	$133	$64	$80	$40	-	$515
	Industry-Wide	$264	$263	$194	$353	$170	$213	$104	-	$1,562

Source: ClearSky Advisors 2011

Note: This table represents the total O&M phase spending for projects installed in each given year as indicated above. This spending will not all occur in that year, but will occur over the course of the 20 year generation contracts. For a more detailed breakdown of likely spending by year see Table A.6.

About ClearSky Advisors

ClearSky Advisors is an independent research and advisory firm focused on renewable energy markets. The firm was formed by experienced executives and consultants that have worked with many of the world's largest and most respected energy, technology, and manufacturing companies. The founders and principle consultants have been responsible for more than $100M of research activities over the past two decades. Adding to that, our founders and analysts have expertise in strategy development, business planning, project management, quantitative and qualitative research, process design, and research methods.

Through a variety of research and consulting projects in the renewable energy field, ClearSky Advisors has developed specific expertise in the renewable energy markets in general (in Ontario, Germany, and the US) and the Ontario renewable energy market in particular.

ClearSky Advisors' clients include energy sector equipment and materials manufacturers, project developers, EPC providers, investors and governments.

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ENVIRONMENTAL HEALTH

REVIEW Open Access

Health effects and wind turbines: A review of the literature

Loren D Knopper[1*] and Christopher A Ollson[2]

Abstract

Background: Wind power has been harnessed as a source of power around the world. Debate is ongoing with respect to the relationship between reported health effects and wind turbines, specifically in terms of audible and inaudible noise. As a result, minimum setback distances have been established world-wide to reduce or avoid potential complaints from, or potential effects to, people living in proximity to wind turbines. People interested in this debate turn to two sources of information to make informed decisions: scientific peer-reviewed studies published in scientific journals and the popular literature and internet.

Methods: The purpose of this paper is to review the peer-reviewed scientific literature, government agency reports, and the most prominent information found in the popular literature. Combinations of key words were entered into the Thomson Reuters Web of Knowledge^{SM} and the internet search engine Google. The review was conducted in the spirit of the evaluation process outlined in the Cochrane Handbook for Systematic Reviews of Interventions.

Results: Conclusions of the peer reviewed literature differ in some ways from those in the popular literature. In peer reviewed studies, wind turbine annoyance has been statistically associated with wind turbine noise, but found to be more strongly related to visual impact, attitude to wind turbines and sensitivity to noise. To date, no peer reviewed articles demonstrate a direct causal link between people living in proximity to modern wind turbines, the noise they emit and resulting physiological health effects. If anything, reported health effects are likely attributed to a number of environmental stressors that result in an annoyed/stressed state in a segment of the population. In the popular literature, self-reported health outcomes are related to distance from turbines and the claim is made that infrasound is the causative factor for the reported effects, even though sound pressure levels are not measured.

Conclusions: What both types of studies have in common is the conclusion that wind turbines can be a source of annoyance for some people. The difference between both types is the reason for annoyance. While it is acknowledged that noise from wind turbines can be annoying to some and associated with some reported health effects (e.g., sleep disturbance), especially when found at sound pressure levels greater than 40 db(A), given that annoyance appears to be more strongly related to visual cues and attitude than to noise itself, self reported health effects of people living near wind turbines are more likely attributed to physical manifestation from an annoyed state than from wind turbines themselves. In other words, it appears that it is the change in the environment that is associated with reported health effects and not a turbine-specific variable like audible noise or infrasound. Regardless of its cause, a certain level of annoyance in a population can be expected (as with any number of projects that change the local environment) and the acceptable level is a policy decision to be made by elected officials and their government representatives where the benefits of wind power are weighted against their cons. Assessing the effects of wind turbines on human health is an emerging field and conducting further research into the effects of wind turbines (and environmental changes) on human health, emotional and physical, is warranted.

Keywords: Wind turbines, health, annoyance, infrasound, sound pressure level, noise

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Background

Wind power has been identified as a clean renewable energy source that does not contribute to global warming and is without known emissions or harmful wastes [1]. Studies on public attitudes in Europe and Canada show strong support for the implementation of wind power [2]. Indeed, wind power has become an integrated part of provincial energy strategies across Canada; in Ontario, the Ontario Power Authority has placed a great deal of emphasis on procuring what they term "renewable and cleaner sources of electricity", such as wind [3].

Although wind power has been harnessed as a source of electricity for several decades around the world, its widespread use as a significant source of energy in Ontario is relatively recent. As with the introduction of any new technology, concerns have been raised that wind power projects could lead to impacts on human health. These concerns are related to two primary issues: wind turbine design and infrastructure (i.e., electromagnetic frequencies from transmission lines, shadow flicker from rotor blades, ice throw from rotor blades and structural failure) and wind turbine noise (i.e., levels of audible noise [including low frequency noise] and infrasound). If left unchecked and unmanaged, it is possible that individually or cumulatively, these issues could lead to potential health impacts. In terms of noise, high sound pressure levels (loudness) of audible noise and infrasound have been associated with learning, sleep and cognitive disruptions as well as stress and anxiety [4-8].

As a result, minimum setback distances have been established world-wide to reduce or avoid potential effects for people living in proximity to wind turbines. Under the Ontario Renewable Energy Approval (REA) Regulation (O. Reg. 359/09, as amended by O. Reg. 521/10), a minimum setback distance of 550 m must exist between the centre of the base of the wind turbine and the nearest noise receptor (e.g., a building or campground). This minimum setback distance was developed through noise modeling under worst-case conditions to give a conservative estimate of the required distance to attain a sound level of 40 dB(A) [9], the noise level that corresponds to the WHO (Europe) night-noise guideline, a health-based limit value "necessary to protect the public, including most of the vulnerable groups such as children, the chronically ill and the elderly, from the adverse health effects of night noise" [8]. Globally, rural residential noise limits are generally set at 35 to 55 dB(A) [10].

This paper focuses on the research involving land-based wind turbine projects. There are several international off-shore marine projects that are in operation. There was considerable interest in Ontario in developing off-shore wind projects on the Great Lakes. However, in February, 2011 the Province announced that it would not proceed with proposed offshore wind projects until further scientific research is conducted http://www.news.ontario.ca/ene/en/2011/02/ontario-rules-out-off-shore-wind-projects.html. This does not appear to have been related, however, to health concerns.

Regardless, debate is ongoing with respect to the relationship between reported health effects and wind turbines, specifically in terms of audible and inaudible noise. People interested in this debate tend to turn to two sources of information in order to make decisions: scientific peer-reviewed studies published in scientific journals, and the popular literature and internet. For the general public, the latter sources are the most readily available and numerous websites have been constructed by individuals or groups to support or oppose the development of wind farms. Often these websites state the perceived impacts on, or benefits to, human health to support the position of the individual or group. The majority of information posted on these websites cannot be traced back to a scientific peer-reviewed source and is typically anecdotal in nature. This serves to spread misconceptions about the potential impacts of wind energy on human health making it difficult for the general public (and scientists) to ascertain which claims can be substantiated by scientific evidence.

Accordingly, the purpose of this paper is to provide results of a review of the peer-reviewed scientific literature and the most prominent information found in the popular literature. We have selected this journal as the source of publication because it is a scientifically credible journal with peer-reviewed articles that are easily accessible by the general population who are interested in the subject of wind turbines and health effects. Results of this review are used to draw conclusions about wind turbines and health effects using a weight-of-evidence approach.

Methods

Peer-Reviewed Literature

Publication of scientific findings is the basis of scientific discourse, communication and debate. The peer review process is considered a fundamental tenet of quality control in scientific publishing. Once a research paper has been submitted to a journal for publication it is reviewed by external independent experts in the field. The experts review the validity, reliability and importance of the results and recommend that the manuscript be accepted, revised or rejected. This process, though not perfect, ensures that the methods employed and the findings of the research receive a high level of scrutiny, such that an independent researcher could repeat the experiment or calculation of results, prior to their publication. This process seeks to ensure that the published research is of a high standard of quality, accurate, can be reproduced and demonstrates academic/professional integrity.

In order to assess peer-reviewed studies designed to test hypotheses about the association between potential health effects in humans and wind turbines, a review of the primary scientific literature was conducted. While our review did not strictly follow the evaluation process outlined in the Cochrane Handbook for Systematic Reviews of Interventions [11], the standard for conducting information reviews in healthcare and pharmaceutical industries, it was conducted in the spirit of the Cochrane systematic review in that it was designed based on the principle that "science is cumulative", and by considering all available evidence, decisions could be made that reflect the best science available. It also involves critical review and critique of the published literature and at times weighting some manuscripts over others in the same scientific field.

To facilitate this review, combinations of key words (i.e., annoyance, noise, environmental change, sleep disturbance, epilepsy, stress, health effect(s), wind farm(s), infrasound, wind turbines(s), low frequency noise, wind turbine syndrome, neighborhood change) were selected and entered into the Thomson Reuters (formerly ISI) Web of Knowledge[SM]. The Web of Knowledge[SM] is a database that covers over 10,000 high-impact journals in the sciences, social sciences, and arts and humanities, as well as international proceedings coverage for over 120,000 conferences. The Web of Knowledge[SM] comprises seven citation databases, two of which are relevant to the search: the Science Citation Index Expanded (SCI-Expanded) and the Social Sciences Citation Index (SSCI). The SCI-Expanded includes over 6,650 major journals across 150 scientific disciplines and includes all cited references captured from indexed articles. Coverage of the literature spans the year 1900 to the present. On average, 19,000 new records per week are added to the SCI-Expanded. SSCI is a multidisciplinary index of the social sciences literature. SSCI includes over 1,950 journals across 50 social sciences disciplines from the year 1956 to the present. It averages 2,900 new records per week. Use of this literature search platform means the most up-to-date multidisciplinary studies published and peer-reviewed could be obtained.

Although hundreds of articles were found during the search, very few were related to the association between potential health effects and wind turbines. For example, numerous articles have been published about infrasound, but very few have been published about infrasound and wind turbines. Indeed, only fifteen articles, published between 2003 and 2011, were found relevant [12-26]. What can be seen from these articles is that the relationship between wind turbines and human responses to them is extremely complex and influenced by numerous variables, the majority of which are nonphysical. What is clear is that some people living near wind turbines experience annoyance due to wind turbines, and visual impact tends to be a stronger predictor of noise annoyance than wind turbine noise itself. Swishing, whistling, resounding and pulsating/throbbing are sound characteristics most highly correlated with annoyance by wind turbine noise for those people who noticed the noise outside their dwellings. Some people are also disturbed in their sleep by wind turbines. In general, five key points have come out of these peer-reviewed studies with regards to health and wind turbines.

1. People tend to notice sound from wind turbines almost linearly with increasing sound pressure level

In the studies designed to evaluate the interrelationships amongst annoyance and wind turbine noise, as well as the influence of subjective variables such as attitude and noise sensitivity, Pedersen and Persson Waye [13-15] showed that people tend to notice sound from wind turbines almost linearly with increasing sound pressure level. Briefly, Pedersen and Persson Waye conducted cross-sectional studies (in 2004: n = 351; in 2007: n = 754) and gave people questionnaires regarding housing and satisfaction with the living environment, including questions about degree of annoyance experienced outdoors and indoors and sensitivity to environmental factors, wind turbines (noise, shadows, and disturbances), respondents' level of perception and annoyance, and verbal descriptors of sound and perceptual characteristics. The third section had questions about chronic health (e.g., diabetes, tinnitus, cardiovascular diseases), general wellbeing (e.g., headache, undue tiredness feeling tensed/stressed, irritable) and normal sleep habits (e.g., quality of sleep, whether or not sleep was disturbed by any noise source). The last section comprised questions on employment and working hours. Of import, the purpose of the study was masked in the questionnaires, which was done to reduce the potential for survey bias.

Of the 754 respondents involved in the Pedersen and Persson Waye study [14], 307 (39%) noticed sound from wind turbines outside their dwelling (range of sound pressure level: < 32.5, 32.5-35.0, 35.0-37.5, 37.5-40.0, and > 40.0 dB(A)) and the proportion of respondents who noticed sound increased almost linearly with increasing noise. In the 37.5-40.0 dB(A) range, 76% of the 71 respondents reported that they noticed sound from the wind turbines; 90% of respondents (n = 18) in the > 40.0 dB(A) category noticed sound from the wind turbines. The odds of noticing sound increased by 30% for each increase in dB(A) category. When data from both studies [13,14] were combined (n = 1095) results were the same: the proportion of respondents who noticed sound from wind turbines showed increased almost linearly with increasing sound pressure level from roughly 5-15% of people noticing noise at 29 dB(A) to 45-90% noticing noise at 41 dB (A)[15].

In 2011 Pedersen [25] reported on the results of three cross-sectional studies conducted in two areas of Sweden (a flat rural landscape (n = 351) and suburban sites with hilly terrain (n = 754) and one location in the Netherlands (flat landscape but with different degrees of road traffic intensity (n = 725)) designed assess the relationship between wind turbine noise and possible adverse health effects. Questionnaires were mailed to people in the three areas to obtain information about annoyance and health effects in response to wind turbines noise. Pedersen included questions about several potential environmental stressors and did not allow participants to know that the focus of the study was on wind turbine noise, again in an attempt to reduce self-reporting survey bias. For each respondent, sound pressure levels (dB(A)) were calculated for nearby wind turbines. The questionnaires were designed to obtain information about people's response to noise (i.e., annoyance), diseases or symptoms of impaired health (i.e., chronic disease, diabetes, high blood pressure, cardiovascular disease, tinnitus, impaired hearing), stress symptoms (i.e., headache, undue tiredness, feeling tense or stressed, feeling irritable), and disturbed sleep (i.e., interruption of the sleep by any noise source). Results showed that the frequency of those annoyed with wind turbines was related to an increase in sound pressure level as shown by odds ratios (OR) with 95% confidence intervals (CI) greater than 1.0. Sleep interruption was associated with sound level in two of the three studies (the areas with flat terrain), but unlike the finding that people tend to notice sound from wind turbines almost linearly with increasing sound pressure level, sleep disturbance did not increase gradually with noise levels, but spiked at 40 dBA and 45 dBA.

2. A proportion of people that notice sound from wind turbines find it annoying

Results of the Pedersen and Persson Waye studies [13-15] also suggested that the proportion of participants who were fairly annoyed or very annoyed remained quite level through the 29-37 dB(A) range (no more than roughly 5%) but increased at noise levels above 37 dB(A), with peaks at 38 db(A) and 41 dB(A), where up to 30% of people were very annoyed. Respondents in the cross-sectional studies (and other studies [12]) noted that swishing, whistling, resounding and pulsating/throbbing were the sound characteristics that were most highly correlated with annoyance by wind turbine noise among respondents who noticed the noise outside their dwellings. This was also found by Leventhall [16]. Seven percent of respondents (n = 25) from the Pedersen and Persson Waye study [13] were annoyed by noise from wind turbines indoors, and this was related to noise category; 23% (n = 80) were disturbed in their sleep by noise. Of the 128 respondents living at sound exposure above 35.0 dB(A), 16% (n = 20) stated that they were disturbed in their sleep by wind turbine noise. The authors comment that some people may find wind turbine noise more annoying than that of other types of noise (e.g., airplane and traffic) experienced at similar decibel levels.

Similar results were shown by Pedersen and Persson Waye [14]: a total of 31 of the 754 respondents said they were annoyed by wind turbine noise. In the < 32.5 to the 37.5 dB(A) category 3% to 4% of people said they were annoyed by wind turbine noise; in the 37.5-40.0 dB(A) category, 6% of the 71 respondents were annoyed; and in the > 40.0 category, 15% of 20 of respondents said they were annoyed by wind turbine noise. In addition, 36% of those 31 respondents who were annoyed by wind turbine noise reported that their sleep was disturbed by a noise source. Nine percent of those 733 respondents not annoyed said their sleep was disturbed by a noise source. Results of Pedersen [25] showed similar results: the frequency of those annoyed was related to an increase in sound pressure level. Moreover, self reported health effects like feeling tense, stressed, and irritable, were associated with noise annoyance and not to noise itself (OR and 95% CI > 1.0). Sleep interruption, however, was associated with sound level and annoyance (OR and 95%CI > 1.0). Pedersen notes that this finding is not necessarily evidence of a causal relationship between wind turbine noise and stress but may be explained by cognitive stress theory whereby "an individual appraises an environmental stressor, such as noise, as beneficial or not, and behaves accordingly". In other words, it appears that it is the change in the environment that is associated with the self-reported health effects, not the presence of wind turbines themselves.

Keith et al. [17] proposed that in a quiet rural setting, the predicted sound level from wind turbines should not exceed 45 dB(A) at a sensitive receptor location (e.g., residences, hospitals, schools), a value below the World Health Organization guideline for sleep and speech disturbance, moderate annoyance and hearing impairment. The authors [17] suggest this level of noise could be expected to result in a 6.5% increase in the percentage of highly annoyed people. Since publication of the Keith et al. study, the WHO Europe Region has released new Night Noise Guidelines for Europe [8] and state that: "The new limit is an annual average night exposure not exceeding 40 decibels (dB), corresponding to the sound from a quiet street in a residential area". The value of 40 dB is considered the lowest observed adverse effect level (LOAEL) for night noise based on the finding that an average night noise level over a year of 30-40 dB can result in a number of effects on sleep such as body movements, awakening, self-reported sleep disturbance and arousals [8]. The WHO states that even in the worst cases these effects seem modest [8].

3. Annoyance is not only related to wind turbine noise but also to subjective factors like attitude to visual impact, attitude to wind turbines and sensitivity to noise

Pedersen and Persson Waye [13] revealed that attitude to visual impact, attitude to wind turbines in general, and sensitivity to noise were also related to the way people perceived noise from turbines. For example, 13% of the variance in annoyance from wind farms could be explained by noise and the odds that respondents would be annoyed by noise from wind turbines increased 1.87 times from one sound category to the next. When noise and attitude to visual impact was statistically assessed, 46% of the variance in annoyance from wind farms could be explained and the odds that respondents would be annoyed from wind turbines increased 5.05 times from one sound category to the next. Statistical analyses showed that while attitude to wind turbines in general and sensitivity to noise were also related to annoyance, they did not have a greater influence on annoyance than visual effect. Building on their 2004 paper, Pedersen and Persson Waye [14] conducted a cross-sectional study in seven areas in Sweden across dissimilar terrains and with different degrees of urbanization. Three areas were classified as suburban; four as rural. Noise annoyance related to wind turbines was also statistically related to whether or not people live in suburban or rural areas and landscape (flat vs. hilly/complex). Visual impact has come out as a stronger predictor of noise annoyance than wind turbine noise itself. People who economically benefit from wind turbines had significantly decreased levels of annoyance compared to individuals that received no economic benefit, despite exposure to similar sound levels [18].

One suggestion of the difference between rural and suburban areas is level of background sound and interestingly, perception and annoyance was associated with type of landscape, "indicating that the wind turbine noise interfered with personal expectations in a less urbanised area... pointing towards a personal factor related to the living environment" [14]. The authors also concluded that visual exposure enhances the negative associations with turbines when coupled with audible exposure. They also point out that this study showed that aesthetics play a role in annoyance: "respondents who think of wind turbines as ugly are more likely to appraise them as not belonging to the landscape and therefore feel annoyed" [14].

In 2007 Pedersen et al. [19] conducted a grounded theory study to gain a deeper understanding of how people living near wind turbines perceive and are affected by them. Findings indicated that the relationship between exposure and response is complex and possibly influenced by variables not yet identified, some of which are nonphysical. The notion that wind turbines are "intruders" is a finding not reported elsewhere. A conclusion of this paper is that when the impacts of wind turbines are assessed, values about the living environment are important to consider as values are firmly rooted within a personality and difficult to change.

In 2008, Pedersen and Larsman [20] conducted a study to assess visibility of wind turbines, visual attitude and vertical visual angle (VVA) in different landscapes. This study follows up on the findings of previous work showing a relationship between noise annoyance in people living near wind turbines and the impact of visual factors as well as an individual's attitude toward noise [13-15,25]. Overall, Pedersen and Larsman concluded that respondents in a landscape where wind turbines could be perceived as contrasting with their surroundings (i.e., flat areas) had a greater probability of noise annoyance than those in hilly areas (where turbines were not as obvious), regardless of sound pressure level, if they thought wind turbines were ugly, unnatural devices that would have a negative impact on the scenery. The enhanced negative response could be linked to aesthetical response, rather than to multi-modal effects of simultaneous auditory and visual stimulation. Moreover, VVA was associated with noise annoyance, especially for respondent who could see at least one wind turbine from their dwelling, if they were living in flat terrain and rural areas. Pedersen and Larsman suggest that these results underscore the importance of visual attitude towards the noise source when exploring response to environmental noise. In 2010 Pedersen et al. [21] hypothesized that if high levels of background sound can reduce annoyance by masking the noise from a wind farm, then turbines could cause less noise annoyance when placed next to motorways instead of quiet agricultural areas. In general, the hypothesis was not supported by the available data [15], further providing support for the notion of visual cue being a strong driver of annoyance.

4. Turbines are designed not to pose a risk of photo-induced epilepsy

Harding et al. [22] and Smedley et al. [23] investigated the relationship between photo-induced seizures (i.e., photosensitive epilepsy) and wind turbine blade flicker (also known as shadow flicker). This is an infrequent event, typically modelled to occur less than 30 hours a year from wind turbine projects we have reviewed and would be most common at dusk and dawn, when the sun is at the horizon. Both studies suggested that flicker from turbines that interrupt or reflect sunlight at frequencies greater than 3 Hz pose a potential risk of inducing photosensitive seizures in 1.7 people per 100,000 of the photosensitive population. For turbines with three blades, this translates to a maximum speed of rotation of 60 rpm. The normal practice for large wind farms is for frequencies well below this threshold.

Although shadow flicker from wind turbines is unlikely lead to a risk of photo-induced epilepsy there has been little if any study conducted on how it could heighten the annoyance factor of those living in proximity to turbines. It may however be included in the notion of visual cues. In Ontario it has been common practice to attempt to ensure no more than 30 hours of shadow flicker per annum at any one residence.

5. The human ear responds to infrasound

Infrasound is produced by physiological processes like respiration, heartbeat and coughing, as well as man-made sources like air conditioning systems, vehicles, some industrial processes and wind turbines. Salt and Hullar [24] provide data to suggest that the assumption that infrasound presented at an amplitude below what is audible has no influence on the ear is erroneous and summarize the results of previous studies that show a physiological response of the human ear to low frequency noise (LFN) and infrasound. At very low frequencies the outer hair cells (OHC) of the cochlea may be stimulated by sounds in the inaudible range. Salt and Hullar hypothesize that “if infrasound is affecting cells and structures at levels that cannot be heard this leads to the possibility that wind turbine noise could be influencing function or causing unfamiliar sensations”. These authors do not test this hypothesis in their paper but suggest the need for further research.

To assess the possibility that the operation of wind turbines may create unacceptable levels of low frequency noise and infrasound, O’Neal et al. [26] conducted a study (commissioned by a wind energy developer, NextEra Energy Resources, LLC) to measure wind turbine noise outside and within nearby residences of turbines. At the Horse Hollow Wind Farm in Taylor and Nolan Counties, Texas, broadband (A-weighted) and one-third octave band data (3.15 hertz to 20,000 hertz bands) were simultaneously collected from General Electric (GE) 1.5sle (1.5 MW) and Siemens SWT-2.3-93 (2.3 MW) wind turbines. Data were collected outdoors and indoors over the course of one week under a variety of operational conditions (it should be noted that wind speeds were low during the measurements; between 3.2 and 4.1 m/s) at two distances from the nearest wind turbines: 305 meters and 457 meters. O’Neal et al. found that the measured low frequency sound and infrasound at both distances (from both turbine types at maximum noise conditions) were less than the standards and criteria published by the cited agencies (e.g., UK DEFRA (Department for Environment, Food, and Rural Affairs); ANSI (American National Standards Institute); Japan Ministry of Environment). The authors concluded that results of their study suggest that there should be no adverse public health effects from infrasound or low frequency noise at distances greater than 305 meters from the two wind turbine types measured.

Popular Literature

Scientific studies peer reviewed and published in scientific journals are one way of disseminating information about wind turbines and health effects. The general public does not always have access to scientific journals and often get their information, and form opinions, from sources that are less accountable (e.g., the popular literature and internet). Some of the same key words used to obtain references from the primary literature were entered into the common internet search engine Google: “health effects wind farms” returned 300,000 hits; “health effects wind turbines” returned 120,000 hits; “annoyance wind turbines” returned 185,000 hits and “sleep disturbance wind turbines” returned 19,500 hits. What is apparent is that numerous websites have been constructed by individuals or groups to support or oppose the development of wind turbine projects, or media sites reporting on the debate. Often these websites state the perceived impacts on, or benefits to, human health to support the position of the individual or group hosting the website. The majority of information posted on these websites cannot be traced back to a scientific, peer-reviewed source and is typically anecdotal in nature. In some cases, the information contained on and propagated by internet websites and the media is not supported, or is even refuted, by scientific research. This serves to spread misconceptions about the potential impacts of wind energy on human health, which either fuels or diminishes opposition to wind turbine project development.

Works by Dr. Michael Nissenbaum conducted at Mars Hill and Vinalhaven Maine [27] and Dr. Nina Pierpont in New York [28] seem to be the primary popular literature studies referenced on websites. These works suggest a causal link between human health effects and wind turbines. Works by Dr. Robert McMurtry and Carmen Krogh, and Lorrie Gillis, Carmen Krogh and Dr. Nicholas Kouwen [29] have also been used to suggest a relationship between health and turbines. These works have been presented as reports or as slide presentations on websites and authors of these studies have presented their findings in various forua such as invited lectures, affidavits, public meetings and open houses. Briefly, Nissenbaum evaluated 22 exposed adults (defined as living within 3500 ft of an arrangement of 28 1.5 MW wind turbines) and 27 unexposed adults (living about 3 miles away from the nearest turbine). Participants were interviewed and asked a number of questions about their perceived health, levels of stress and reliance on prescription medications in relation to the turbines [27].

In 2009, a book entitled Wind Turbine Syndrome: A Report on a Natural Experiment by Dr. Nina Pierpont, was self-published and describes “Wind Turbine Syndrome”, the clinical name Dr. Pierpont coined for the collection of symptoms reported to her by people residing near wind turbines [28]. The book describes a case series study she conducted involving interviews of 10 families experiencing adverse health effects and who reside near wind turbines. Similar to the process followed by Nissenbaum, people living in proximity wind turbines were interviewed about their health. For all of these works, self-reported symptoms generally included sleep disturbance, headache, tinnitus (ringing in the ears), ear pressure, dizziness, vertigo, nausea, visual blurring, tachycardia (rapid heart rate), irritability, problems with concentration and memory and panic episodes. These symptoms have been purported to be associated with proximity to wind turbines, and specifically, to the infrasound emitted by the turbines. It should be noted that of the 351 people assessed by Pedersen and Persson Waye [13], 26% (91) reported chronic health issues (e.g., diabetes, tinnitus, cardiovascular diseases), but these issues were not statistically associated with noise levels. Results of Pedersen [25] showed similar results: self reported health effects like feeling tense, stressed, and irritable, were associated with noise annoyance and not to noise itself. Sleep interruption, however, was associated with sound level and annoyance.

In 2007, Alves-Pereira and Castelo Branco http://www.wind-watch.org/documents/industrial-wind-turbines-infrasound-and-vibro-acoustic-disease-vad/ issued a press-release suggesting that their research demonstrated that living in proximity to wind turbines has led to the development of vibro-acoustic disease (VAD) in nearby home-dwellers. It appears that this research has only been presented at a conference, has not been published in a peer-reviewed journal nor has it undergone thorough scientific review. Moreover, Alves-Pereira and Castelo Branco appear to be the primary researchers that have promulgated VAD as a hypothesis for adverse health effects and wind turbines. Indeed, Dr. Pierpont has noted that VAD is not the same “wind turbine syndrome” [28].

To date, these studies have not been subjected to rigorous scientific peer review, and given the venue for their distribution and limited availability of data, it is extremely difficult to assess whether or not the information provided is reliable or valid. What is apparent, however, is that these studies are not necessarily scientifically defensible: they do not contain noise measurements, only measured distances from study participants to the closest turbines; they do not have adequate statistical representation of potential health effects; only limited rationale is provided for the selection of study participants (in some cases people living in proximity to turbines have been excluded from the study); they suffer from a small number of participants and appear to lack of objectivity as authors are also known advocates who oppose wind turbine developments. Unlike the questionnaires used by Pedersen et al. [13-15,25], the purpose of the studies are not hidden from participants. In fact, the selection process is highly biased towards finding a population who believes they have been affected by turbines. This is not an attempt to discount the self-reported health issues of residents living near wind turbines. Rather, it points out that the self-reported health issues have not been definitively linked to wind turbines.

What the peer reviewed literature and popular literature have in common is the conclusion that wind turbines can be a source of annoyance for some people. Of note are the different reasons and possible causes for annoyance. In the peer reviewed studies, annoyance tends to peak in the > 35 dB(A) range but tends to be more strongly related to subjective factors like visual impact, attitude to wind turbines in general (benign vs. intruders) and sensitivity to noise rather than noise itself from turbines. In the popular literature, health outcomes tend to be more strongly related to distance from turbines and the claim that infrasound is the causative factor. Though sound pressure level in most of the peer reviewed studies was scaled to dB(A) (but refer to O’Neal et al. [26] for actual measurements of low frequency noise and infrasound), infrasound is a component of the sound measurements and was inherently accounted for in the studies.

Annoyance

Studies on the health effects of wind turbines, both published and peer-reviewed and presented in the popular literature, tend to conclude that wind turbines can cause annoyance for some people. A number of governmental health agencies agree that while noise from wind turbines is not loud enough to cause hearing impairment and are not causally related to adverse effects, wind turbines can be a source of annoyance for some people [1,30-34].

It has been hypothesized that the self reported health effects (e.g., sleep disturbance, headache, tinnitus (ringing in the ears), ear pressure, dizziness, vertigo, nausea, visual blurring, tachycardia (rapid heart rate), irritability, problems with concentration and memory, and panic episodes) are related to infrasound emitted from wind turbines [28]. Studies where biological effects were observed due to infrasound exposure were conducted at sound pressure levels (e.g., 145 dB and 165 dB [5,16]; 130 dB [7]) much greater than what is produced by wind turbines (e.g., see O’Neal et al. [26]). Infrasound is not unique to wind turbines but is ubiquitous in the environment due to natural and man-made sources, meaning that people living near wind turbines were exposed to infrasound prior to turbine operation. For example, Berglund and Hassmen [35] reported that infrasound (a component of low frequency sound) is emitted from road vehicles, aircraft, industrial machinery, artillery and mining explosions, air movement machinery including wind turbines, compressors, and air-conditioning units, and Leventhall [5] reported that infrasound comes from natural sources like meteors, volcanic eruptions and ocean waves. Indeed, many mammals communicate using infrasound [36]. Given the low sound pressure levels of infrasound emitted from wind turbines and the ubiquitous nature of these sounds, the hypothesis that infrasound is a causative agent in health effects does not appear to be supported.

Peer reviewed and scientifically defensible studies suggest that annoyance and health effects are more strongly related to subjective factors like visual impact and attitude to wind turbines rather than to noise itself (both audible and inaudible [i.e., infrasound]). Indeed, many of the self reported health effects are associated with numerous issues, many of which can be attributed to anxiety and annoyance (e.g., Pedersen 2011 [25]). Shargorodsky et al. [37] published that roughly 50 million adults in the United States reported having tinnitus, which is statistically correlated (based on 14,178 participants) to age, racial/ethnic group, hypertension, history of smoking, loud leisure-time, firearm, and occupational noise, hearing impairment and generalized anxiety disorder (based on 2265 participants) identified using a World Health Organization Composite Diagnostic Interview). In fact, the odds of tinnitus being related to anxiety disorder were greatest for any of the variables tested. Folmer and Griest [38], based on a study of 174 patients undergoing treatment for tinnitus at the Oregon Health Sciences University Tinnitus Clinic between 1994 and 1997, reported that insomnia is associated with greater severity of tinnitus. Insomnia is also associated with anxiety and annoyance. Bowling et al. [39] described statistically that people's perceptions of neighbourhood environment can influence health. Perceptions of problems in the area (e.g., noise, crime, air quality, rubbish/litter, traffic, graffiti) were predictive of poorer health score. In their 2003 publication Henningsen and Priebe [40] discussed the characteristics of "New Environmental Illness", illnesses where patients strongly believe their symptoms are caused by environmental factors, even though symptoms are not consistent with empirical evidence and medically unexplained. A key component to such illnesses is the patient's attitude toward the source of the environmental factor. What is more, health effects from annoyance have been shown to be mitigated though behavioural and cognitive behavioural interventions [30,41], lending support to Pedersen's [25] conclusion that health effects can be explained by cognitive stress theory. In other words, it appears that it is the change in the environment that is associated with health effects, not a turbine-specific variable like infrasound.

Conclusions

Wind power has been harnessed as a source of power around the world. Debate is ongoing with respect to the relationship between reported health effects and wind turbines, specifically in terms of audible and inaudible noise. As a result, minimum setback distances have been established world-wide to reduce or avoid potential effects for people living in proximity to wind turbines. People interested in this debate turn to two sources of information to make informed decisions: scientific peer-reviewed studies published in scientific journals and the popular literature and internet.

We found that conclusions of the peer reviewed literature differ in some ways from the conclusions of the studies published in the popular literature. What both types of studies have in common is the conclusion that wind turbines can be a source of annoyance for some people. In the peer reviewed studies, wind turbine annoyance and some reported health effects (e.g., sleep disturbance) have been statistically associated with wind turbine noise especially when found at sound pressure levels greater than 40 db(A), but found to be more strongly related to subjective factors like visual impact, attitude to wind turbines in general and sensitivity to noise. To date, no peer reviewed scientific journal articles demonstrate a causal link between people living in proximity to modern wind turbines, the noise (audible, low frequency noise, or infrasound) they emit and resulting physiological health effects. In the popular literature, self-reported health outcomes and annoyance are related to distance from turbines and the claim is made that infrasound is the causative factor for the reported effects, even though sound pressure levels are not measured. Infrasound is not unique to wind turbines and the self reported health effects of people living in proximity to wind turbines are not unique to wind turbines. Given that annoyance appears to be more strongly related to visual cues and attitude than to noise itself, self reported health effects of people living near wind turbines are more likely attributed to physical manifestation from an annoyed state than from infrasound. This hypothesis is supported by the peer-reviewed literature pertaining to environmental stressors and health.

The authors have spent countless hours at community public consultation events hosted by proponents announcing new projects and during updates to their environmental assessment process. Historically, citizens' concerns about wind turbine projects appeared to involve potential impact on property values and issues surrounding avian and bat mortality. Increasingly in North America the issue surrounding fears of potential harm to residents' health have come to the forefront of these meetings. It is clear that the announcement of a new project can led to a heightened sense of anxiety and annoyance in some members of the public, even prior to construction and operation of a wind turbine project. The authors have been involved in all manner of risk communication, consultation and risk assessment projects in the energy sector in Canada and it has been our experience that this heightened sense of annoyance, agitation or fear is not unique to the wind turbine sector. Whether the proposed project is a wind turbine, gas-fired station, coal plant, nuclear power plant, or energy-from-waste incinerator we have seen a level of concern in a sub-set of the population that goes well beyond anything that would be considered the traditional sense of not-in-my-back-yard (NIMBY). These people genuinely are fearful about the potential health effects that the project may cause, regardless of the outcomes of quantitative assessments that demonstrate that there is a *de minimus* of potential risk in living next to a particular facility. The literature and our own experience highlight the need for informative discussions between wind power developers and community members in order to attempt to reduce the level of apprehension. We encourage continued dialogue between concerned citizens and developers once projects become operational.

Canadian public health agencies subscribe to the World Health Organization definition of health. *"Health is a state of complete physical, mental and social well-being and not merely the absence of infirmity or disease"*, a quote often used by both sides of the wind turbine debate. We believe that the primary role of the environmental health/risk assessment practitioner is to ensure that physiological manifestation of infirmity or disease is not predicted to occur from exposure to an environmental contaminant. In terms of wind power, ethics dictate an honest reporting of the issues surrounding annoyance and the fact that it appears that a limited number of people have self-reported health effects that may be attributed to the indirect effects of visual and attitudinal cue. We believe that any physiological based effect can be mitigated through the use of appropriate setback distances. However, it is not clear that for this hypersensitive annoyed population that any set back distance could mitigate the indirect effects. Therefore, it is up to our elected officials and ministerial staff when establishing an energy source hierarchy to weigh all of the information before them to determine the trade-offs between "mental and social well-being" of these individuals against the larger demand for energy and its source.

A number of governmental health agencies agree that while noise from wind turbines is not loud enough to cause hearing impairment and are not causally related to adverse effects, wind turbines can be a source of annoyance for some people. Ultimately it is up to governments to decide the level of acceptable annoyance in a population that justifies the use of wind power as an alternative energy source.

Assessing the effects of wind turbines on human health is an emerging field, as demonstrated by the limited number of peer-reviewed articles published since 2003. Conducting further research into the effects of wind turbines (and environmental change) on human health, emotional and physical, as well as the effect of public consultation with community groups in reducing pre-construction anxiety, is warranted. Such an undertaking should be initiated prior to public announcement of a project, and could involve baseline community health and attitude surveys, baseline noise and infrasound monitoring, observation and questionnaires administered to public during the siting and assessment process, noise modeling and then post-construction follow-up on all of the aforementioned aspects. Regardless it would be imperative to ensure robust study design and a clear statement of purpose prior to study initiation.

We believe that research of this nature should be undertaken by multi-disciplinary teams involving, for example, acoustical engineers, health scientists, epidemiologists, social scientists and public health physicians. Ideally developers, government agencies, consulting professionals and non-government organizations would form collaborations in attempt to address these issues.

List of Abbreviations

ANSI: American National Standards Institute; CI: Confidence intervals; dB(A): A-weighted decibels; DEFRA: Department for Environment, Food, and Rural Affairs; LFN: low frequency noise; LOAEL: lowest observed adverse effect level; MW: mega watt; O.Reg.: Ontario Regulation; OR: odds ratio; OHC: outer hair cells; REA: Renewable Energy Approval; SCI: Science Citation Index; SSCI: Social Sciences Citation Index; VAD: vibro-acoustic disease; VVA: vertical visual angle; WHO: World Health Organization

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None

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Authors' contributions

LDK and CAO both researched and wrote the manuscript. Both authors read and approved the final version.

Competing interests

In terms of competing interests (financial and non-financial), the authors work for a consulting firm and have worked with wind power companies. The authors are actively working in the field of wind turbines and human health. Dr. Ollson has acted as an expert witness for wind power companies during a number of legal hearings. Although we make this disclosure, we wish to reiterate that as independent scientific professionals our views and research are not influenced by these contractual obligations. The authors are environmental health scientists, trained and schooled, in the evaluation of potential risks and health effects of people and the ecosystem through their exposure to environmental issues such as wind turbines.

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References

1. World Health Organization (WHO): **Fourth Ministerial Conference on Environment and Health.** Energy, Sustainable Development and Health; 2004.
2. Devine-Wright P: **Beyond NIMBYism: towards an integrated framework for understanding public perceptions of wind energy.** *Wind Energy* 2005, **8**:125-139.
3. Ontario Power Authority (OPA), 2008 Annual Report: **On the Path to a Sustainable Electricity Future.** 2008.
4. Bronzaft AL: **The effect of a noise abatement program on reading ability.** *J Environ Psychol* 1981, **1**:215-222.
5. Leventhall G, Pelmear P, Benton S: **A Review of Published Research on Low Frequency Noise and its Effects.** Department for Environment, Food and Rural Affairs, London, UK; 2003.
6. Kristiansen J, Mathiesen L, Nielsen PK, Hansen AM, Shibuya H, Petersen HM, Lund SP, Jørgensen MB, Søgaard K: **Stress reactions to cognitively demanding tasks and open-plan office noise.** *Int Arch Occup Environ Health* 2009, **82**:631-641.
7. Yuan H, Long H, Liu J, Qu L, Chen J, Mou X: **Effects of infrasound on hippocampus-dependent learning and memory in rats and some underlying mechanisms.** *Environ Toxicol Pharm* 2009, **28**:243-247.
8. World Health Organization Europe: **Night Noise Guidelines for Europe.** 2009, ISBN 978 92 890 4173 7.
9. Ontario Ministry of the Environment: *Development of Noise Setbacks for Wind Farms Requirements for Compliance with MOE Noise Limits* 2009.
10. Walsh O: *No Global Standards* 2010 [http://www.windvigilance.com/international-symposium].
11. Higgins JPT, Green S, editors: **Cochrane Handbook for Systematic Reviews of Interventions, Version 5.0.2.** *The Cochrane Collaboration* 2009.
12. van den Berg GP: **Effects of the wind profile at night on wind turbine sound.** *J Sound Vibrat* 2003, **277**:955-970.
13. Pedersen E, Persson Waye K: **Perception and annoyance due to wind turbine no*ise - a dose - r*esponse relationship.** *J Acoust Soc Am* 2004, **116**:3460-3470.
14. Pedersen E, Persson Waye K: **Wind turbine noise, annoyance and self-reported health and well-being in different living environments.** *J Occup Environ Med* 2007, **64**:480-486.
15. Pedersen E, Persson Waye K: **Wind turbines - low level noise sources interfering with restoration?** *Environ Res Lett* 2008, **3**:1-5.
16. Leventhall G: **Infrasound from wind turbines - fact, fiction or deception?** *Can Acoust* 2006, **34**:29-36.
17. Keith SE, Michaud DS, Bly SHP: **A proposal for evaluating the potential health effects of wind turbine noise for projects under the Canadian Environmental Assessment Act.** *J Low Freq Noise V A* 2008, **27**:253-265.
18. Pedersen E, van den Berg F, Bakker R, Bouma J: **Response to noise from modern wind farms in The Netherlands.** *J Acoust Soc Am* 2009, **126**:634-643.
19. Pedersen E, Hallberg LR-M, Persson Waye K: **Living in the vicinity of wind turbines–a grounded theory study.** *Qualitative Research in Psychology* 2007, **4**:49-63.
20. Pedersen E, Larsman P: **The impact of visual factors on noise annoyance among people living in the vicinity of wind turbines.** *J Environ Psychol* 2008, **28**:379-89.
21. Pedersen E, van den Berg F, Bakker R, Bouma J: **Can road traffic mask the sound from wind turbines? Response to wind turbine sound at different levels of road traffic.** *Energy Policy* 2010, **38**:2520-2527.
22. Harding P, Wilkins A: **Wind turbines, flicker, and photosensitive epilepsy: Characterizing the flashing that may precipitate seizures and optimizing guidelines to prevent them.** *Epilepsia* 2008, **49**:1095-98.
23. Smedley ARD, Webb AR, Wilkins AJ: **Potential of wind turbines to elicit seizures under various meteorological conditions.** *Epilepsia* 2010, **51**:1146-1151.
24. Salt AN, Hullar TE: **Responses of the ear to low frequency sounds, infrasound and wind turbines.** *Hear Res* 2010, **268**:12-21.
25. Pedersen E: **Health aspects associated with wind turbine noise–Results from three field studies.** *Noise Control Eng J* 2011, **59**:47-53.
26. O'Neal RD, Hellweg Jr, Lampeter RM: **Low frequency noise and infrasound from wind turbines.** *Noise Control Eng J* 2011, **59**:135-157.
27. Nissenbaum M: **Affidavit of Dr. Michael M. Nissenbaum.** [http://www.wind-watch.org/documents/affidavit-of-dr-michael-m-nissenbaum-m-d/].
28. Pierpont N: *Wind Turbine Syndrome* Santa Fe, NM: K-Selected Books; 2009.
29. Krogh K, Gillis L, Kouwen N: **A self-reporting survey: adverse health effects with industrial wind turbines and the need for vigilance.** *Wind Vigilance for Ontario Communities* [http://5468964569013158095-a-1802744773732722657-s-sites.googlegroups.com/site/windvigilancecom/healt_survey_rev14final.pdf?attachauth=ANoY7cplDenR6Eib4UJc4SF7PTCtAT_SA73tC9MnPHDzR22r3AYn7hZIh0cPyETeKl4lbkal2GMyyhydn6NuzAp5e9BGnDWcaJlKqC6Ui_tkKvVS_U_eUdydnYt-EpqvskDtJgVF_cDNsbND596DS4C2_Ofk8VwXYrP_aAHk8zkwfCuQWreczfRDbiBRDShMnoPq2PifKvmHS7LNfOkGkouIWNdu3xAkeA%3D%3D&attredirects=0].
30. Leventhall G, Benton S, Robertson D: **Coping strategies for low frequency noise.** *J Low Freq Noise V A* 2008, **27**:35-52.
31. Chatham-Kent Public Health Unit: *The Health Impact of Wind Turbines: A Review of the Current White, Grey and Published Literature* 2008.
32. Minnesota Department of Health Environmental Health Division: *Public Health Impacts of Wind Turbines* 2009.
33. Chief Medical Officer of Health (CMOH) Ontario: *The Potential Health Impact of Wind Turbines* 2010.
34. Australian Government, National Health and Medical Research Council: *Wind Turbines and Health: A Rapid Review of the Evidence* 2010.
35. Berglund B, Hassmen P: **Sources and effects of low-frequency noise.** *J Acoust Soc Am* 1996, **99**:2985-3002.
36. Langbauer WR: **Elephant Communication.** *Zoo Biol* 2000, **19**:425-445.
37. Shargorodsky J, Curhan GC, Farwell WR: **Prevalence and Characteristics of Tinnitus among US Adults.** *Am J Med* 2010, **123**:711-718.
38. Folmer RL, Griest SE: **Tinnitus and Insomnia.** *Am J Otolaryngol* 2000, **21**:287-293.
39. Bowling A, Barber J, Morris R, Ebrahim S: **Do perceptions of neighbourhood environment influence health? Baseline findings from a British survey of aging.** *J Epidemiol Community Health* 2006, **60**:476-483.
40. Henningsen P, Priebe S: **New environmental illnesses: What are their characteristics?** *Psychother Psychosom* 2003, **72**:231-234.
41. Tazaki M, Landlaw K: **Behavioural mechanisms and cognitive-behavioural interventions of somatoform disorders.** *Int Rev Psychiatr* 2006, **18**:67-73.

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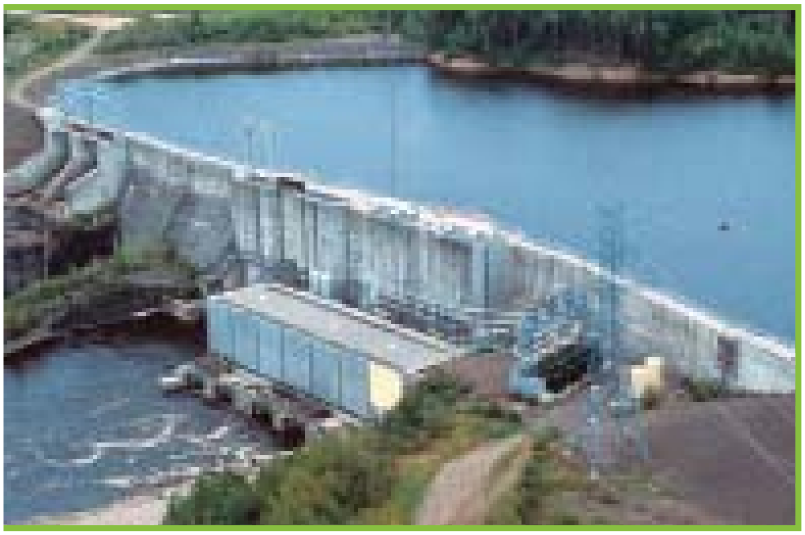
Ontario's Long-Term Energy Plan



Building Our Clean Energy Future

Ontario

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foreword

Maintaining a clean, modern and reliable electricity system for all Ontarians is this government's number one energy priority. Ontario families, businesses and the economy rely on the efficiency, dependability and environmental sustainability of electric power. We have to keep the lights on in Ontario homes, schools, hospitals and businesses and power everything from the coffee-maker to the CT scanner. We also need a clean system that won't threaten the health of current and future generations.

Ontarians deserve balanced, responsible long-term energy planning for electricity to ensure that Ontario has clean air, reliable energy and a strong economy for our children and grandchildren. This report represents an update to the McGuinty government's long-term energy plan and outlines how we are helping families and businesses with increasing electricity costs.

Prior to 2003, Ontario's electricity system was weakening and unreliable. Our reliance on coal meant that our electricity sources were polluting and dirty. Between 1995 and 2003, the electricity system lost 1,800 megawatts (MW) of power — the equivalent of Niagara Falls running dry. A brief deregulated pricing experiment in 2002 resulted in sharply increased prices, prompting the government of the time to freeze consumer prices. Energy infrastructure was crumbling, a shortage of supply caused risks of brownouts.

Worst of all, Ontario relied heavily on five air-polluting coal plants. This wasn't just polluting our air, it was polluting our lungs. Doctors, nurses and researchers stated categorically that coal generation was having an impact on health increasing the incidence of various respiratory illnesses. A 2005 study prepared for the government found that the average annual health-related damages due to coal could top $3 billion. For the sake of our well-being, and our children's well-being, we had to put a stop to coal.

Over the past seven years, the McGuinty government has made tremendous progress after inheriting a system with reduced supply and little planning for the future. Today, our system is cleaner, more modern, more reliable and we plan ahead.

The McGuinty government has made electricity cleaner: we are on track to eliminate coal by 2014, the single largest climate change initiative in North America in that timeframe. We have already reduced the use of coal by 70 per cent. Last year our greenhouse gas emissions from the electricity sector reached the lowest they have been in 45 years. In 2009, more than 80 per cent of our generation came from emissions-free sources like wind, water, solar, biogas and nuclear.

Conservation efforts have been working — many Ontario families and businesses are becoming very active energy conservers. Through various programs, Ontarians have conserved more than 1,700 MW of electricity since 2005 — the equivalent of more than half a million homes being taken off the grid.

Today we have enough electricity to power our homes, businesses, schools and hospitals. Our government has increased Ontario's energy capacity by adding over 20 per cent (more than 8,000 MW) of new supply to the system – enough to power two million homes. Investments in Ontario are transforming the electricity system and have helped to make Ontario a leading jurisdiction in North America for renewable and reliable energy. And since 2007, we've used a formal 20-year planning process to help us forecast and meet the province's electricity needs.

Ontario's electricity system is more reliable. Investments in new generation and upgrades to 5,000 kilometres of our transmission and distribution lines — about the width of Canada from coast to coast — have ensured that our electricity system is able to manage peak and sudden swings in demand and supply availability.

We are moving toward a modern, smart electricity system that will help consumers have greater control over their energy usage — even when they're not at home. A smart grid can isolate outages allowing for faster or even automated repair. This will improve overall reliability for all electricity consumers and make it easier for consumers to produce their own power.

As part of the Open Ontario plan, the McGuinty government is moving Ontario from dirty coal dependency to a clean, modern and reliable energy economy that creates jobs. Energy is one of the engines of our economy and employs more than 95,000 Ontarians. Recent investments to modernize the system are helping to create and support jobs and opportunities for people and communities across the province. Ontario's landmark Green Energy and Green Economy Act, 2009 is projected over three years to support over 50,000 direct and indirect jobs in smart grid and transmission and distribution upgrades, renewable energy and conservation.

We've accomplished a great deal in the past seven years, but there is more to do. Ontario has sufficient electricity supply — but we will require more clean power for the future. As Ontario's energy infrastructure ages, we will need to rebuild or create another 15,000 MW of generating capacity over the next 20 years. We will also need to continue to upgrade and update transmission and distribution lines.

While we are proud of our collective efforts so far, we must continue to develop cleaner forms of electricity and foster a conservation-oriented culture. We need to have a balanced low-carbon supply mix to meet energy needs cleanly and reliably — Ontario will be ready for when North America moves to greenhouse gas regulation. We also need to maximize the electricity assets we have and ensure that those assets continue to provide clean, reliable supply.

The necessary, unavoidable investments that Ontario has been making in our electricity system are paid by ratepayers. The cost to bring our system back up to date and build a clean energy economy is having an impact on household and business bills.

We are all paying for previous decades of neglect. In Ontario, in order to have clean air, reliable generation and modernized transmission, residential prices over the next 20 years are expected to increase by about 3.5 per cent per year.

Increases to electricity bills are not easy for Ontario families and businesses. Even though Ontarians are committed to clean air, every increase takes a bite out of take-home income, and that is difficult for families during lean times. To help with rising costs, the McGuinty government has created a number of tax credits for families and seniors to help manage electricity increases. But we need to do more.

In this Plan, and the government's 2010 Economic Outlook and Fiscal Review we have taken steps to ensure that we help families and businesses with electricity costs while investment in clean energy continues. On November 18, 2010, the McGuinty government introduced the Ontario Clean Energy Benefit.

If passed, the Ontario Clean Energy Benefit will give Ontario families, farms and small businesses a 10 per cent benefit on their bills for five years. That would be 10 per cent off your electricity bill every month, effective January 1, 2011.

The proposed Clean Energy Benefit will help families, hard-working small business owners and Ontario farms. The McGuinty government is doing this to help those who are feeling the pinch of the rising cost of living and especially, rising electricity prices. Every little bit helps during lean economic times.

This balanced and responsible Plan sets out Ontario's expected electricity needs and the most efficient ways to meet them.

The Honourable Brad Duguid
Minister of Energy

overview

Ontario Electricity 1906-2003

On October 11, 1910, when Adam Beck lit up a Kitchener street sign that read "For the People," the town went wild, and the electrification of Ontario began. It was the first major project of the Hydro-Electric Power Commission of Ontario, created in 1906 as the world's first publicly owned electric utility. Beck, a municipal and provincial politician, believed that it was essential to the province's economic development that electricity be available to every Ontarian.

The Queenston-Chippawa power station at Niagara (renamed Sir Adam Beck I in 1950) helped Ontario meet the growing demand for electricity during the postwar economic boom. But despite continued expansion, it had become increasingly clear that hydropower alone would not be able to keep up with the province's demand.

As a result, Ontario began to diversify its supply mix in the 1950s, adding new sources of power, including six coal-fired generating stations built near areas where demand was highest. Between the early 1970s and the early 1990s, nuclear power was also added at three generating facilities. In the meantime, in 1974, the Hydro-Electric Power Commission was recognized as a crown corporation and renamed Ontario Hydro.

This trio of electricity sources — hydro, coal and nuclear — would support Ontario's economic prosperity into the 1990s. By then, much of the province's electricity infrastructure was aging and in need of replacement or refurbishment. The system had become unreliable, and there was widespread concern about whether supply would be able to meet projected demand.

Between 1996 and 2003, Ontario's generation capacity fell by six per cent — the equivalent of Niagara Falls running dry, while electricity demand grew by 8.5 per cent. Investments to build new supply and the upkeep of lines were modest. Investments in upgrades to transmission and distribution were less than half of current levels. There were no provincially funded conservation programs.

In 1998, Ontario passed legislation that authorized the establishment of a market in electricity. In April 1999, Ontario Hydro was re-organized into five successor entities. The move to break up Ontario Hydro and partially privatize the electricity system saddled Ontario with a stranded debt of over $20 billion.

A brief market-deregulation scheme saw electricity prices spike an average of over 30 per cent in just seven months. The government of the day was forced to cap prices for residential and small business owners — an unsustainable policy. The cap just masked the underlying problem of rising cost pressures in an electricity system in need of renewal and additional supply.

Ontario was also heavily reliant on coal-fired generation. About 25 per cent of electricity generation came from polluting coal-fired plants. In addition, Ontario imported coal power from neighbouring American states. Ontario, a province with ample power resources, had become a net importer of power.

Ontario Electricity Accomplishments 2003-2010

After taking office in 2003, the Ontario government faced a number of challenges including: a shortfall in supply, a system reliant on dirty coal-fired generation, a lack of conservation programs, an unsustainable pricing regime and little long-term planning.

The shortfall in supply was restored with investments of over $10 billion to keep the lights on in the province's homes and businesses. Since 2003, about 8,400 megawatts (MW) of new cleaner power have come on line — over 20 per cent of current capacity. That's enough electricity to power cities the size of Ottawa and Toronto. Ontario completed the return to service of Pickering A Unit 1 and enabled hydro and other renewable projects. The province also invested $7 billion to improve some 5,000 kilometres of transmission and distribution lines — the equivalent of the distance between Toronto and Whitehorse, Yukon.

Ontario's power has become cleaner by shutting down coal-fired generation and investing in renewables. In 2005, the government permanently shut-down the Lakeview coal-fired plant in Mississauga — the equivalent of taking 500,000 cars off the road. The province is on track to phase out coal-fired electricity by 2014, the largest climate change initiative of its kind in North America.

Currently, Ontario is Canada's solar and wind power leader, and home to the four largest operating wind and solar farms in the country. The province is developing a smart electricity grid that will help integrate the thousands of megawatts of new renewable power from these projects and others.

Public conservation programs were reintroduced to Ontario in 2005 to encourage and provide incentives for families, businesses and industry to consume less energy. Conservation is now a cornerstone of long-term electricity planning, recognizing that all Ontarians — for generations to come — will benefit from cleaner air and a lower carbon footprint.

In 2004, the government introduced a stable pricing regime that better reflected the true cost of electricity in Ontario. As a result, in 2005 the Ontario Energy Board (OEB) released a Regulated Price Plan, which brought predictability to electricity prices for residential and small business consumers. The OEB updates rates and adjusts prices every six months to reflect the costs of supply for that period.

Ontario has also taken steps to lower the stranded debt left by the previous government. Since 2003, Ontario has decreased the stranded debt by $5.7 billion.

In 2004, the government established the Ontario Power Authority (OPA) as the province's long-term energy planner. That set into motion a planning process that would ensure that Ontario's energy infrastructure would continue to be modernized. In 2007, the OPA prepared a 20-year energy plan (formally known as the Integrated Power System Plan or IPSP). The 2007 Plan focused on creating a sustainable energy supply, targeted to improving current natural gas and renewable assets at a sustainable and realistic cost. The government has made significant progress on the items outlined in the 2007 Plan.

2007 Plan Goal/ Target	Accomplishments
Ensure adequate supply	Invested over $10-billion to bring about 8,400 MW of new supply online — enough capacity to meet the annual requirements of 2 million households.
Double the amount of renewable supply (to 15,700 MW by 2025)	More than 1,500 MW of clean, renewable energy online since 2003, enough power for more than 400,000 homes.
Reduce demand by 6,300 MW by 2025.	More than 1,700 MW of conservation (reduction in demand) since 2005, equivalent to more than 500,000 homes being taken off the grid.
Replace coal in the earliest practical time frame	Phasing out coal-fired generation by 2014 Four units closed in 2010, ahead of schedule.
Strengthen the transmission system	Over $7 billion in investments since 2003 — upgrades to more than 5,000 kilometres of wires Moved forward on transmission projects to enable additional renewables; import potential; and refurbished nuclear generation
Ensure stable energy prices for Ontarians	The Regulated Price Plan introduced in 2005 has provided predictability Electricity prices have increased on average by about 4.5 percent per year over the past seven years Introduced energy tax credits to help residential and small business consumers with electricity costs

In 2009, the government introduced the groundbreaking Green Energy and Green Economy Act, 2009 (GEA). The GEA is sparking growth in clean and renewable sources of energy such as wind, solar, hydro, and bioenergy. A series of conservation measures in the GEA are providing incentives to lower energy use. In its first three years, the GEA will help create 50,000 clean energy jobs across the province. A clean-energy manufacturing base has been growing in the province and creating jobs for Ontarians.

Ontario's Energy Future 2010-2030

The priorities that the government sets and the investments the government makes today are laying the groundwork for an Ontario of tomorrow that will feature a modern, clean and globally competitive economy; healthy, vibrant and liveable communities; and an exceptional quality of life for all Ontarians. The government has a responsibility to ensure a clean, modern and reliable system for the health and well-being of Ontario families and businesses.

By 2030, Ontario's population is expected to rise about 28 per cent — a gain of almost 3.7 million people. Ontario's population will become more urbanized with population growth taking place in primarily urban areas. The Greater Toronto Area (GTA) population will increase by almost 38 per cent over the same period.

The overall composition of the economy will evolve as high-tech and service industries grow and manufacturers change how they do business to keep pace with technological advances and global competition. The output of large industrial customers, which accounts for about 20 per cent of electricity demand, is expected to grow moderately.

Getting around will be easier for all Ontarians. Improved regional and local transit systems that form integrated transportation networks will make it easy to travel, both within and between urban centres. There will be more electric cars on the road — Ontario's goal is that by 2020, about one in every 20 vehicles on the road will be electric.

All of this means that Ontario needs a more modern energy system and a diverse supply mix. Clean, reliable energy is the fuel that will power Ontario's future economic prosperity. Ontario must take steps today to ensure that the right kind of energy will continue to be there for us tomorrow.

Ontario is building a culture of conservation and as a result, it is expected that the province's demand for energy will grow only moderately over the next 20 years. Increased demand in the long term will be due to the rising population, industrial growth and increased use of electrical appliances and vehicles.

The Smart House of the Future

A smarter electricity grid will enable Smart Houses in the future by using technologies that have built-in intelligence. With Smart Grid infrastructure, homes will be able to use power when it is least expensive, charge electric vehicles, generate their own power via solar panels or other generation – and all of this can be controlled by the owner online, or by smart phone.

The Plan

Since the 2007 Plan, developments in technology, trends in demographics, changes in the economy and the advancements of the renewable energy sector (the success of the Feed-in-Tariff program) mean that Ontario needs an updated plan. This updated long-term energy plan will help to ensure that Ontario can meet the needs of an evolving economy and shifting electricity demands, while providing affordable electricity.

Currently, Ontario's electricity system has a capacity of approximately 35,000 MW of power. The OPA forecasts that more than 15,000 MW will need to be renewed, replaced or added by 2030. Because of capacity brought online in recent years, Ontario has some flexibility moving forward. The challenge is in choosing the right mix of generation sources and the necessary level of investment to modernize Ontario's energy infrastructure to meet future needs.

Through initiatives already underway, the province will be able to reliably meet electricity demand through 2015. Ontario needs to plan now for improving the power supply capacity to meet the province's electricity needs beyond 2015. Ontario must plan in advance because:

- Insufficient investment between 1995 and 2003 left an aging supply network and little new generation
- Additional clean generation will be needed to ensure a coal-free supply mix after 2014
- Nuclear generators will need to go offline while they are being modernized
- The population is projected to grow.

To meet these needs Ontario will need a diverse supply mix. Each type of generation has a role in meeting overall system needs. Ontario requires the right combination of assets to ensure a balanced supply mix that is reliable, modern, clean and cost-effective. Ontario will also, first and foremost, make the best use of its existing assets to upgrade, expand or convert facilities.

As part of a reliable network, the system needs both small and large generators. Nuclear power will continue to reliably supply about 50 per cent of the province's electricity needs. It does not emit air pollutants or emissions during production. Hydroelectric power is expanding to include increased capacity from the Niagara Tunnel project and the Lower Mattagami project — producing clean energy by tapping into a renewable and free fuel source. Natural gas-fired plants have the flexibility to respond when demand is high — acting as peak source or cushion for the electricity system. Natural gas is the cleanest of the fossil fuels, emitting less than half of the carbon dioxide emitted by coal.

Ontario is also planning for future energy generation that will focus on efficient, localized generation from smaller, cleaner sources of electricity rather than exclusively from large, centralized power plants transmitting power over long distances. This strategy is known as "distributed generation". Distributed generation also opens up opportunities for smaller power producers, allowing individuals, Aboriginal communities and small co-operatives or partnerships to become generators.

Renewable energy—wind, solar, hydro, and bioenergy — is an important part of the supply mix. Once the initial investment is made in equipment and infrastructure, fuel cost and greenhouse gas emissions are zero or very low. Renewable energy makes it possible to generate electricity in urban and rural areas where it was not feasible before.

In developing this report, the government heard from over 2,500 Ontarians (individuals, energy organizations, community representatives, and First Nation and Métis leaders and groups). Their views have helped to inform this report. In addition, the Ontario Power Authority (OPA), Hydro One, Ontario Power Generation (OPG), the Ontario Energy Board (OEB) and the Independent Electricity System Operator (IESO) contributed information and advice.

Ontario's Long-Term Energy Plan will help guide the province as it continues to build a clean, modern, and reliable electricity system for Ontario families now and well into the future. It will ensure Ontario continues to be a North American leader for clean energy jobs and technology and becomes coal-free by 2014. Key features of the plan include:

- Demand will grow moderately (about 15 per cent) between 2010 and 2030.
- Ontario will be coal-free by 2014. Eliminating coal-fired generation from Ontario's supply mix will account for the majority of the government's greenhouse gas reduction target by 2014. Two units at the Thunder Bay coal plant will be converted to gas and Atikokan will be converted to biomass. Two additional units at Nanticoke will be shut down in 2011.
- The government is committed to clean, reliable nuclear power remaining at approximately 50 per cent of the province's electricity supply. To do so, units at the Darlington and Bruce sites will need to be modernized and the province will need two new nuclear units at Darlington. Investing in refurbishment and extending the life of the Pickering B station until 2020 will provide good value for Ontarians.
- Ontario will continue to grow its hydroelectric capacity with a target of 9,000 MW. This will be achieved through new facilities and through significant investments to maximize the use of Ontario's existing facilities.
- Ontario's target for clean, renewable energy from wind, solar and bioenergy is 10,700 MW by 2018 (excluding hydroelectric) – accommodated through transmission expansion and maximizing the use of the existing system. Ontario will continue to grow the clean energy economy through the continuation of FIT and microFIT programs.
- Natural gas generation for peak needs will be of value where it can address local and system reliability issues. Natural gas will support the increase in renewable sources over time and supplement the modernization of nuclear generators.
- Combined Heat and Power is an energy-efficient source of power and the OPA will develop a standard offer program for projects under 20 MW.
- Ontario will proceed with five priority transmission projects needed immediately for reliability, renewable energy growth, and changing demand. Future Plans will identify more projects as they are needed.
- Ontario is a leader in conservation and the government will continue to increase and broaden its targets to 7,100 MW and reduce overall demand by 28 terawatt-hours (TWh) by 2030.
- Over the next 20 years, estimated capital investments totalling $87 billion will help ensure that Ontario has a clean, modern and reliable electricity system.
- Measures outlined in this Plan will help create and sustain jobs and investments in Ontario's growing clean energy economy.
- Residential bills are expected to rise by 3.5 per cent per year over the next 20 years. Industrial prices are expected to rise by 2.7 per cent per year over the next 20 years.
- The government is proposing an Ontario Clean Energy Benefit to give Ontario families, farms and small businesses a 10 per cent benefit on their electricity bills for five years.

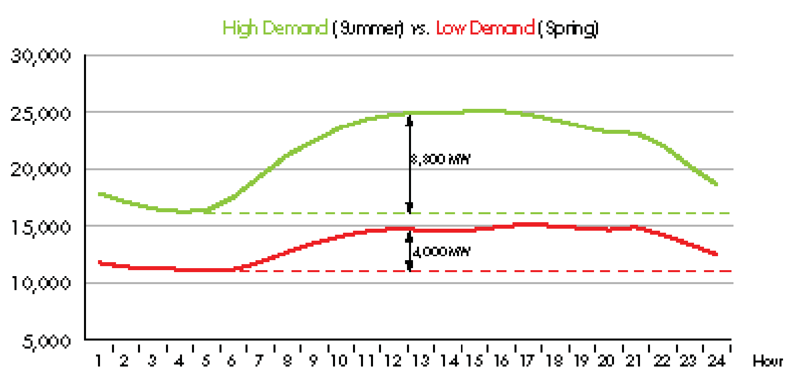
This plan will help ensure that Ontario is able to meet its electricity needs until 2030 and build a modern, clean, reliable system that will provide energy to Ontario homes and businesses for generations to come.

1 demand – an updated forecast

A forecast of the demand for electricity establishes the context for long-term planning — it predicts the amount of electricity Ontario will need.

System planning requires a complex forecast of the total amount of electricity that will be used over the course of a year, as well as the amount required to meet peak demand. The next step is to match these requirements with available generation and transmission capacity. Demand fluctuates with the time of day, weather, time of year and the structure of the economy. Ontario's demand can fluctuate between 11,000 MW on an early Sunday morning in spring to 25,000 MW on a hot Thursday afternoon in summer.

FIGURE 1: ONTARIO ELECTRICITY DEMAND COMPARISON



Unlike other forms of energy, electricity cannot be easily stored. Ontario's electricity system must be able to produce and move enough electricity to meet the changing demand for it instantaneously — all day and all night, every day and every night.

Ontario is part of an interconnected grid consisting of thousands of generators linked by tens of thousands of kilometres of transmission lines, crossing international, provincial and regional borders. The interconnected nature of the grid, supported by mandatory reliability standards, helps to ensure a stable power supply even when major components fail or when demand exceeds what can be met with domestic resources. Trade in electricity takes place over this interconnected system — for instance, between Ontario, Quebec and the U.S. — on a daily basis. In 2003, Ontario was a net importer and much of this imported supply came from U.S. coal power, which increased prices and reduced Ontario's air quality. Ontario is now a net exporter of electricity.

Electricity demand in Ontario has declined since reaching a peak in 2005. For the next 10 years, demand is expected to recover from the recent recession and then stay relatively flat as conservation efforts and an evolving economy change Ontario's energy needs.

Accomplishments

Ontario families and businesses have participated in conserving energy through various government conservation programs and shifting the demand away from peak hours.

- Ontario's conservation initiatives have been successful. Since 2005, Ontarians have saved enough energy to meet the combined electricity demand of Mississauga and Windsor.
- peaksaver®, a residential and small business electricity demand reduction program that temporarily powers down central air conditioning systems, has conserved enough to power a community the size of Thunder Bay.

Future Needs

Demand is recovering slowly in 2010 after the global economic recession. Future demand will depend on a number of factors including: the speed of Ontario's economic recovery, population and household growth, greater use of electronics in appliances and home entertainment systems, the pace of the recovery of large, energy-intensive industry and the composition of the economy (e.g. a shift to more high-tech and service jobs). Demand will also be impacted by the success of conservation efforts, as well as the potential electrification of public transit and the number of electric vehicles on the road. Weather can also have a pronounced effect.

To account for generation maintenance, extreme weather or significant changes in the amount of electricity the province needs, it is important to have electricity capacity in reserve.

The Plan

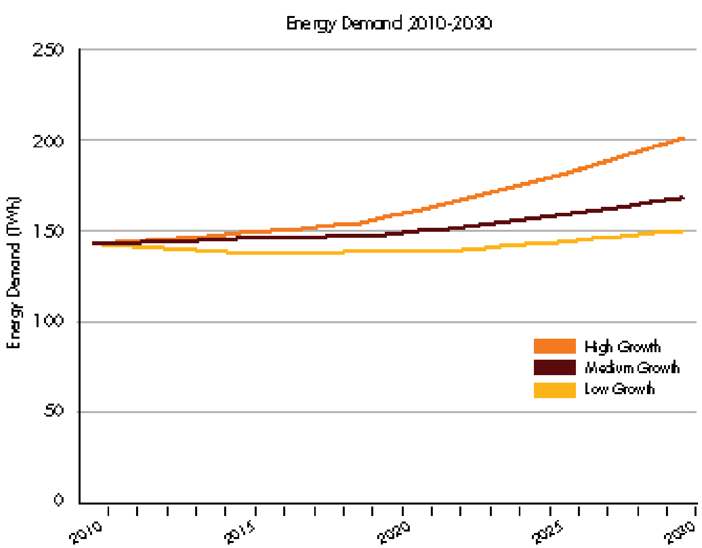
Based on OPA analysis, this Plan outlines three potential scenarios (net of conservation) for electricity demand:

1. Low growth (yellow) assumes that Ontario's manufacturing and industrial sectors continue to grow modestly in accordance with the current trend. Some of the recent decline in consumption is due to conservation, some to restructuring in the various industrial sectors, and some due to the recession. This forecast assumes a lower rate of population growth than in the other two scenarios. It further assumes that only 13 per cent of people use electricity for heating and that small appliance use accounts for 30 per cent of growth.

2. Medium growth (brown) represents moderate growth in the industrial sector and in population. This scenario assumes continued growth in the residential, commercial and transportation sectors. This forecast assumes that there is a consistent move towards high-tech and service industries and somewhat higher provincial population growth than the low growth scenario. This scenario is consistent with the current government goal for electric vehicles: five per cent by 2020.

3. High growth (orange), or aggressive electrification, assumes that there is a significant increase in electric transportation — both public and private. It assumes that there is aggressive North American greenhouse gas regulation, faster population growth than the low growth scenario, significant industrial change and that by 2030 about 12 per cent of vehicles on the road are electric.

FIGURE 2: RANGE OF ENERGY DEMAND FORECAST



The three scenarios do not differ significantly until 2018, allowing time to adjust as the Long-Term Energy Plan will be updated every three years. For planning purposes, the government is using the medium growth line to predict future electricity needs. The medium growth scenario balances the expected growth in residential and commercial sectors, with modest, post-recession growth in the industrial sector. The addition of 1.1 million households and the expected increase in the use of entertainment electronics, and small appliances will increase residential electricity demand. The addition of 132 million square metres of commercial space and the associated use of air-conditioning, lighting and ventilation will increase electricity demand in the commercial sector.

Based on the medium growth scenario, Ontario's demand will grow moderately (15 per cent) between 2010 and 2030, based on the projected increase in population and conservation as well as shifts in industrial and commercial needs. As a result, for planning purposes, the system should be prepared to provide 146 TWh of generation in 2015 rising to 165 TWh in 2030.

Ontario is also planning to create sufficient flexibility in the system to accommodate the higher growth scenario.

2 supply

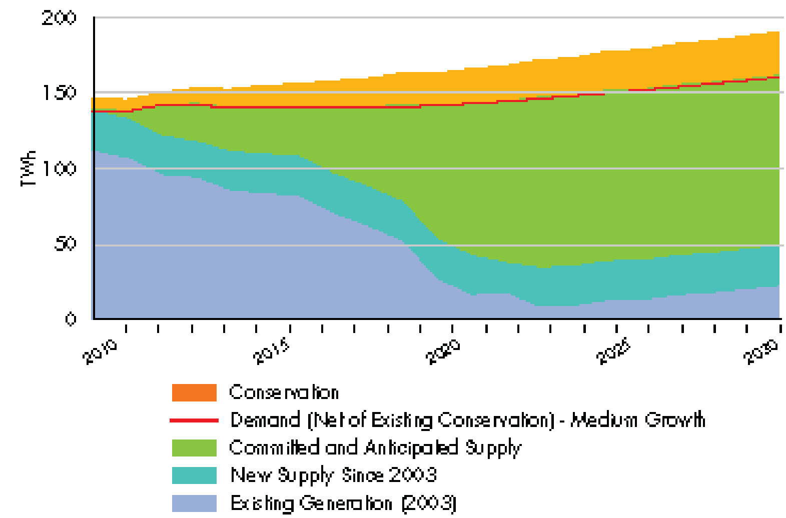
With a long-term demand forecast in place, Ontario must determine the most effective way to meet that demand so that there is no gap in supply. Ontario needs a balanced, cost-effective supply mix that supports the economy, is modern, can adapt to future changes and provides clean, reliable electricity to Ontario families and businesses for generations to come.

A clean, reliable energy system relies on a balance of resources. Good system planning includes a sustainable supply mix that meets the demands of the public. It also means continually looking for efficiencies and emphasizing the best use of current resources. Ontario's supply mix includes:

- Conservation: As the best and first resource, it reduces consumption and therefore demand on the system. By avoiding the need to build new generation, all consumers benefit through cost savings.
- Baseload power: Generation sources, such as nuclear and hydro stations, designed to continuously operate (Niagara Falls, for example). Baseload power is the foundation of a stable, secure supply mix.
- Variable or intermittent power: Generation sources that produce power only during certain times such as wind and solar projects. These are important contributors to a cleaner supply mix.
- Intermediate and peak power: Generation sources designed to ramp up and down as demand changes throughout the day such as natural gas and hydro generation with some storage capability. These function as a cushion to the system to ensure reliability when demand is highest.

This supply mix balances reliability, cost and environmental performance.

FIGURE 3: FORECAST SUPPLY AND DEMAND (2010-2030)

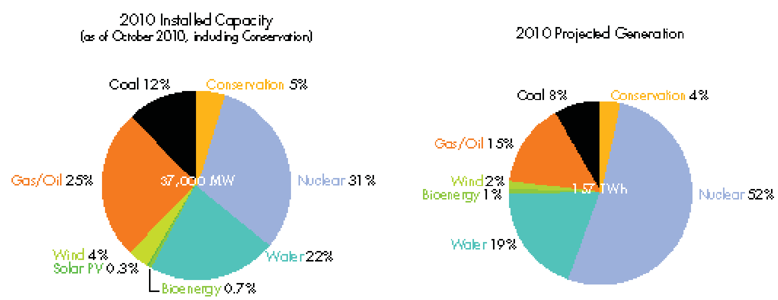


Energy Storage can help to balance the electricity grid by storing off-peak generation and using it during peak hours. This helps to reliably incorporate more renewable generation into the grid. Energy storage is an important part of the move to a Smart Grid. Ontario will continue to investigate the potential for new storage technologies. There are a number of issues that impact the development of energy storage:

- The capital costs for large-scale electricity storage are high largely due to high engineering and construction costs.
- Research is underway on flywheel storage, plug-in vehicle storage, various forms of thermal storage as well as other storage options.
- There are growing opportunities for small storage projects, particularly as battery technology improves.
- Ontario has a pumped storage facility in the Sir Adam Beck Pumping Generating Station at Niagara Falls. OPG is currently studying the possible expansion of the reservoir to allow for further storage at the station.

The capacity of the system is necessarily larger than what is actually generated. It is critical to have more capacity than generation to be able to manage normal equipment maintenance and shutdowns, unprecedented peak demands or an unexpected shutdown of an electricity generator. Generation, or the amount of electricity Ontario produces, is measured in terawatt hours (TWh or billion kWh). The capacity of the system, or what it is able to generate, is measured in megawatts (MW).

FIGURE 4:
CONTRAST BETWEEN GENERATION AND INSTALLED CAPACITY



Selecting a supply mix and investment in supply is a matter of choices and trade-offs. A variety of power supply sources — some designed for baseload requirements, some designed for meeting peak requirements — is superior to relying heavily on only one source. For this long-term plan the government has considered environmental, economic, health, social and cost implications to come up with the best possible supply mix.

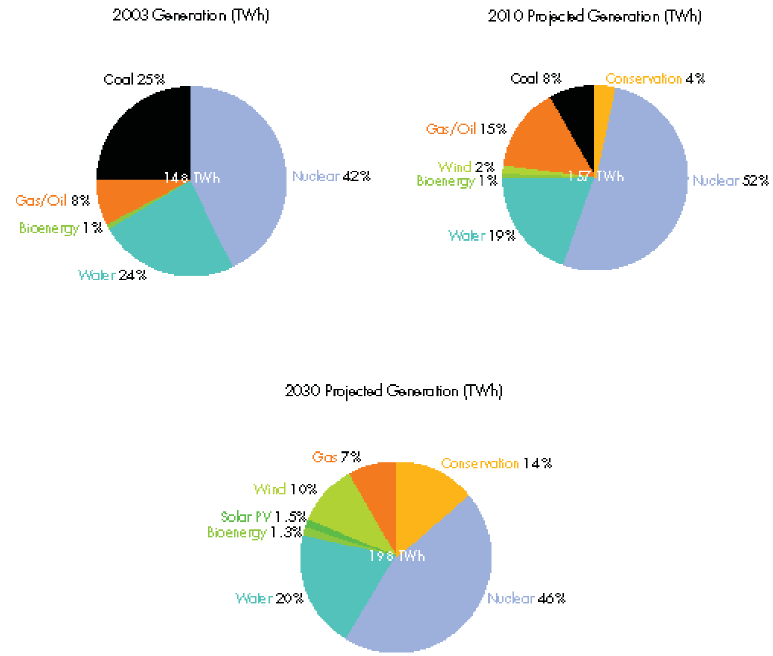
This improved supply mix will be cleaner, sustainable, modern and reliable. It phases out coal-fired generation at a faster pace, it modernizes Ontario's nuclear fleet, it includes more renewables, it maximizes hydroelectric power over the near term, and it advances Ontario's conservation goals.

By 2030, Ontario will have completely eliminated coal as a generation source and will have also increased wind, solar and bioenergy from less than one per cent of generation capacity in 2003 to almost 13 per cent. To ensure reliability, the strategic use of natural gas will be required to complement renewable generation. Nuclear will continue to supply about 50 per cent of Ontario's electricity needs.

The following chapter will include a review of the various components of Ontario's electricity supply:

- Coal
- Nuclear
- Renewables: Hydroelectric
- Renewables: Wind, Solar and Bioenergy
- Natural gas
- Combined Heat and Power (CHP)

FIGURE 5: BUILDING A CLEANER ELECTRICITY SYSTEM



Coal Free

The Ontario government is committed to improving the health of Ontarians and fighting climate change. Coal-fired plants have been the single largest source of greenhouse gas emissions in the province and among the largest emitters of smog-causing pollutants. Ontario's reliance on coal-fired generation shot up 127 per cent from 1995-2003, significantly polluting the province's air. During that period Ontario also relied on importing coal-fired power from the United States. An Ontario study found the health and environmental costs of coal at $3 billion annually ("Cost Benefit Analysis: Replacing Ontario's Coal-Fired Electricity Generation," April 2005).

Since 2003, the government has reduced the use of dirty coal-fired plants by 70 per cent. Eliminating coal-fired electricity generation will account for the majority of Ontario's greenhouse gas reduction target by 2014 — the equivalent of taking 7 million cars off the road.

In addition, Ontario Power Generation (OPG) is required to meet strict government-mandated greenhouse gas emission targets, including ensuring that between 2011 and 2014 annual emissions are two-thirds lower than 2003 levels.

Ontario is the only jurisdiction in North America that is phasing out coal-fired generation. The government has committed to eliminating coal-fired generation by 2014 and is introducing clean and reliable sources of energy in its place. Until then, coal and natural gas plants will continue to provide power in peak-demand periods to maintain the reliability of the system.

Accomplishments

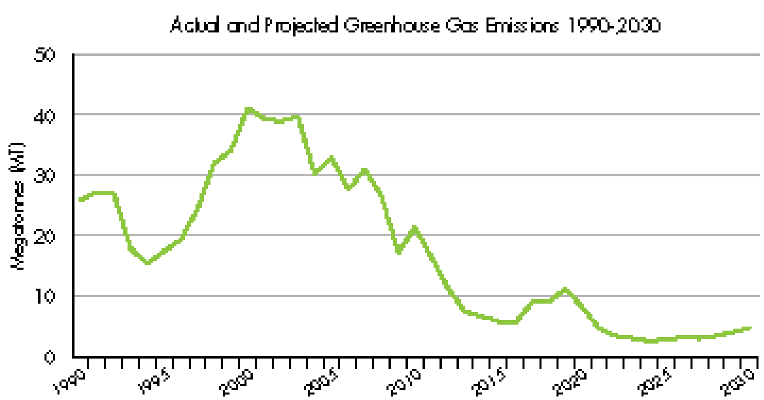
The government of Ontario has shut down eight coal units since 2003 (3,000 MW) and will close the remaining units by 2014 or earlier.

- Lakeview (Mississauga) – four units closed April, 2005
- Nanticoke – two units closed October, 2010
- Lambton – two units closed October, 2010

After the closure of four coal units on October 1, 2010, coal-fired generation makes up only 13 per cent of Ontario's electricity capacity.

Ontario's electricity sector emissions will decrease dramatically to only five megatonnes post-2020 as a result of becoming coal-free. Between 2015 and 2019, extensive nuclear refurbishments will take place and Ontario will rely on its natural gas-fired stations to maintain reliable electricity supply.

FIGURE 6:
REDUCING EMISSIONS IN ONTARIO'S ELECTRICITY SECTOR



The Plan

Coal-fired plants will cease to burn coal in 2014. Ontario will shut down two additional units at Nanticoke Generating Station before the end of 2011.

The government recognizes the potential benefits of continuing to use Ontario's existing electricity-generating assets and sites. Coal-fired plants could be converted to use alternative fuels, such as natural gas. Similar to coal, biomass and/or natural gas can provide electricity on demand for peak periods.

In line with the Growth Plan for Northern Ontario and future needs of the Ring of Fire, the province is replacing coal at Atikokan and Thunder Bay and re-powering these facilities with cleaner fuel sources.

Converting the Atikokan Generating Station to biomass by 2013 will create up to 200 construction jobs and help protect jobs at the plant. It will also support jobs in Ontario related to the production of wood pellets and sustain other jobs in the forestry sector. The project is expected to take up to three years to complete. Once converted, the plant is expected to generate 150 million kilowatt-hours of renewable power, enough to power 15,000 homes each year.

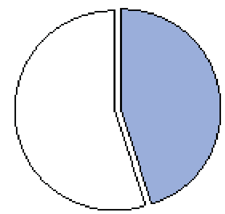
At the Thunder Bay Generating Station, two units will be converted to natural gas in a similar timeframe. The Thunder Bay plant is needed not only for local supply to the city of Thunder Bay, but for system reliability in northwestern Ontario, particularly during periods of low hydroelectric generation and until the proposed enhancement to the East-West tie enters operation. The government will work with suppliers on the planning process to convert the Thunder Bay units.

Ontario will continue to explore accelerating the closure of the remaining six units (four at Nanticoke and two at Lambton), taking into consideration the impact of the closures on system reliability.

Ontario will monitor the progress of the continued operation of nuclear units at Pickering. The government expects in 2012 to have an update on the progress of extending the life of these units. At this time, Ontario will consider the possible conversion of some of the units at Nanticoke and Lambton to natural gas, if necessary for system reliability. Due to the lead times involved, planning and approval work for the natural gas pipeline infrastructure required to Nanticoke will begin soon.

Ontario will continue to explore opportunities for co-firing of biomass with natural gas for any units converted to natural gas. Decisions on other biomass opportunities will have to carefully take into account the ability to bring in fuel supply and the cost of conversion.

Nuclear – New/Modernized



Nuclear power is a reliable, safe supplier of the province's baseload generation needs — accounting for about 36 per cent of the province's installed electricity capacity. Nuclear operates 24 hours a day, seven days a week and it produces about 50 per cent of the electricity generated in Ontario. Nuclear power does not produce any primary air pollution or release greenhouse gases into the atmosphere.

Nuclear power plants are able to operate steadily, providing a plentiful, consistent supply of energy for decades at stable prices. In addition, the fuel cost for a nuclear power plant is a small portion of its total costs, so nuclear power is generally not impacted by fuel price escalation or fluctuations.

- Ontario has used nuclear power for more than 40 years.
- In 2009, more than half of the province's electricity came from nuclear energy.
- Ontario's nuclear power stations and waste storage facilities have an excellent safety record. OPG won the Zeroquest Platinum (Sustainability) Award from the Infrastructure Health and Safety Association (IHSA) in June 2010.
- Over 70,000 jobs in Canada are directly or indirectly related to the nuclear power industry.

Accomplishments

A number of nuclear power producing units have been modernized and returned to service since 2003 including:

- Pickering A Unit 1, in November 2005, providing 515 MW (or about 6 per cent of new supply)
- Bruce Unit 3, in March 2004, providing 770 MW (or about 9 per cent of new supply)
- Bruce Unit 4, in November 2003, providing 770 MW (or about 9 per cent of new supply)

Future Needs

Nuclear power is crucial to providing reliable electricity to the province. Units at Bruce B and Darlington are expected to reach the end of their service lives over the next decade. To extend the life of these units, each would have to be shut down for about three years while being modernized.

At the time of the 2007 Plan, there was a need for new nuclear planning to begin immediately. Since then, demand has declined and renewable generation has become a bigger contributor to the system. Investment in renewables, the reduction in demand and the availability of natural gas have all reduced the immediate need for new nuclear. However, to preserve the long-term reliability of the system, particularly for baseload generation, additional investment in nuclear generation will be required.

Ontario will continue to rely on nuclear power – at its current level of contribution to the supply. Nuclear generation is ideally suited for providing baseload generation because of its unique economic and operating characteristics. Nuclear plant operational design and economics depend on the plants being able to operate steadily throughout the year. A generation mix of 50 per cent nuclear combined with baseload hydroelectric generation is sufficient to meet most of Ontario's baseload requirements.

If nuclear capacity beyond this were added, the hours in the year in which nuclear capability exceeded Ontario demand could substantially increase. Under such surplus conditions, some nuclear units might need to be shut down or operate differently than intended. This could lead to significant system and operating challenges and so therefore, generating too much nuclear is undesirable.

The Plan

Over the first 10 to 15 years of this Plan, 10,000 MW of existing nuclear capacity will be refurbished. Investment should focus first and foremost on the improvement of existing assets so that those facilities can continue to provide reliable, affordable electricity. A coordinated refurbishment schedule was agreed to in 2009 by a working group including OPG, Bruce Power, the OPA and the Ministry of Energy. This schedule will be regularly reviewed and updated to reflect current information on resources and plant performance and conditions.

The government is committed to continuing to use nuclear for about 50 per cent of Ontario's energy supply — a capacity of 12,000 MW will produce that amount of energy. The remaining nuclear capacity of 10,000 MW at Darlington and Bruce will need to be refurbished and modernized.

The remainder of the nuclear capacity that Ontario will need for its projected demand (about 2,000 MW) will be made up of new nuclear at Darlington.

The construction of new nuclear infrastructure requires a significant lead time (approximately 8 to 10 years to commercial operation) and while new nuclear supply will be needed in Ontario, it must be provided at a fair price to ratepayers. Both refurbishment and new build will have significant positive impacts on local economies – and considerable employment opportunities.

In February 2008, the government of Ontario launched a process to procure two new units at the Darlington site. Atomic Energy of Canada Limited (AECL) was one of three vendors who met the February 2009 bid submission deadline. AECL emerged as the only compliant bidder in the process; however the AECL bid price exceeded the province's target. Ontario then sought to finalize a deal with the company to procure the units at an acceptable price.

During the discussions between the Ontario government and the federal government, the federal government announced its intention to sell AECL in May 2009. The news cast a great deal of uncertainty over Ontario's procurement process. The position of uncertainty that the federal government placed AECL in, together with a much higher than anticipated price, made it very difficult for Ontario to finalize a procurement that was in the best interest of ratepayers. As a result, Ontario suspended the RFP process in June 2009.

The Province continued to engage AECL, as the only compliant bidder, in discussions with the hope that a deal could still be finalized. The talks did not lead to any demonstrable progress. Consequently, the Premier of Ontario wrote to the Prime Minister requesting that the process to sell AECL be halted. It was Ontario's position that both levels of government should try to complete the procurement with AECL before the company was sold so that Ontario's need for significant nuclear refurbishment and new nuclear generation could be met while simultaneously protecting jobs and preserving the industry in Canada. This proposal was not pursued by the federal government and their process is continuing without a deal with Ontario being completed.

It is anticipated that the federal government will identify a preferred vendor by the end of this year. Ontario is expecting that the federal government will restructure AECL in a manner that will allow Ontario to be able to complete a deal with the new owner at a price that is in the best interest of ratepayers.

The decrease in demand together with the new supply added in recent years, means that Ontario is well-positioned to examine a number of options for negotiating new nuclear production at the right time and at a cost-effective price.

In the meantime, OPG is continuing with two initiatives that were underway prior to the suspension of the new build procurement process: the environmental assessment and obtaining a site preparation licence at Darlington. It is essential that the province stay ready to construct new nuclear plants as part of the government's ongoing commitment to modernize Ontario's nuclear fleet.

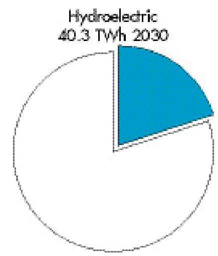
OPG will invest $300 million to ensure the continued safe and reliable performance of its Pickering B station for approximately 10 years, to 2020. Following this, OPG will begin the longer term decommissioning process and will work with the community of Pickering and the advisory committee to explore future opportunities for the site.

A 2010 report by the Canadian Manufacturers and Exporters estimates the employment and economic benefits from refurbishing and operating the Bruce and Darlington reactors will be substantial: almost 25,000 jobs and annual economic activity of $5 billion.

In developing a new-build procurement and modernization strategy Ontario will:

- Secure an acceptably priced contract for construction of nuclear new build under specified timeframes.
- Pursue project terms that are in the best interest of ratepayers.
- Retain the maximum number of high-quality, high-paying nuclear industry jobs in the province while providing opportunities for long-term growth of the nuclear industry.

Renewables: Hydroelectric

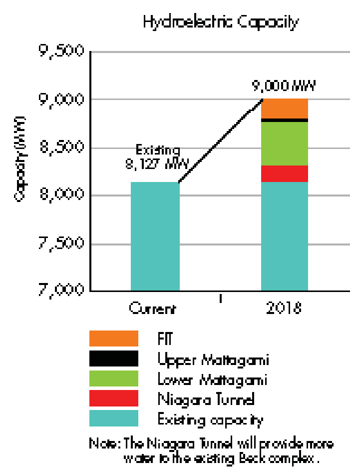


Ontario has been generating renewable power from water — hydroelectric power — for over 100 years. Hydroelectric power is clean, renewable, cost-effective and helps to contribute to clean air quality. Hydro currently makes up the vast bulk — about 90 per cent — of Ontario's total renewable energy supply, representing 8,127 MW of capacity. It is a reliable source of electricity that can continue to provide clean energy for generations to come.

Accomplishments

The 2007 Plan projected a total of 7,708 MW of hydroelectric capacity by 2010. The government has exceeded this goal. Ontario has also launched significant hydroelectric projects — the first major investments in 40 years. Since October 2003, 317 MW of new hydro projects have been brought online.

FIGURE 8: HYDROELECTRIC CAPACITY



Some of the larger completed and ongoing hydro projects to meet Ontario's future needs include:

- Niagara Tunnel project, which will increase the amount of water available for power generation at the Sir Adam Beck Generating Station
- The Lower Mattagami project expansion – the largest hydroelectric project undertaken in Ontario in 40 years. This project will add about 440 MW of clean electricity generating capacity to Ontario's energy grid, while providing $2.6 billion of investment in the North
- Healey Falls, a 15.7 MW facility near Campbellford, east of Peterborough
- Lac Seul Generating Station, a 12.5 MW facility near Ear Falls
- Trent Rapid Hydroelectric Station, an 8 MW facility near Peterborough
- Sandy Falls, a 5.5 MW facility on the Mattagami River, near Timmins.

Future need

More hydroelectric power will be added to Ontario's electricity system in the next eight years than over the previous 40 years. Unlike Quebec, Ontario does not have the geography to support massive reliance on hydroelectric power. (Quebec has almost four times the hydro capacity of Ontario.) New hydroelectric generation will continue to be an important part of a clean, reliable system over the next 20 years. The government is also reviewing how crown land is made available for waterpower projects, particularly for smaller Feed-InTariff (FIT) Program projects.

The Plan

Ontario will continue to develop the province's hydroelectric potential and is planning for 9,000 MW of hydroelectric capacity by 2018.

Once the Niagara Tunnel expansion is complete, it will provide enough electricity to power 160,000 homes. When the capacity expansion at Lower Mattagami is complete, the project will provide enough electricity to power over 300,000 homes. These projects will help to maximize Ontario's existing hydro projects.

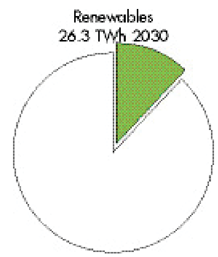
Existing hydro is the cheapest form of generation in Ontario and in many cases, it can help to meet peak power demand. There are a number of projects that are currently under consideration, such as:

- Two hydroelectric generating stations on the Little Jackfish River (north of Lake Nipigon) that could add 100 MW of capacity
- New Post Creek, a 25 MW project in the development stage
- Mattagami Lake Dam, a 3-6 MW development at Kenogamissi Falls on the Mattagami River.

Ontario will plan for future hydroelectric development where it is cost-effective to build. This will mean FIT-level hydro projects (less than 50 MW) will also be considered.

New hydro projects complement other renewable initiatives and help to eliminate coal by 2014. Some additional projects will be considered, but large-scale projects, usually in remote locations, are not economically feasible at this time due to high capital and construction costs. Transmission, engineering and environmental factors are also challenges. However, due the importance of hydroelectric generation, Ontario will continue to study Northern hydro options over the period of the Plan.

Renewables: Wind, Solar and Bio-energy



Ontario has become a North American leader in producing energy from sources that are continually renewed by nature such as wind, sun and bioenergy. Renewables do not produce harmful emissions, which contribute to smog, pollution and climate change. Increasing Ontario's renewable energy supply helps reduce the province's reliance on fossil fuels. Greater investments and reliance on renewable energy help to ensure that Ontario has a clean and reliable electricity system for generations to come.

Accomplishments

Ontario is now Canada's leading province for wind and solar capacity and home to the country's four largest wind and solar farms. The world's largest photovoltaic solar farm is in Sarnia (Enbridge's 80 MW Sarnia Solar) and Canada's largest wind farm is near Shelburne (the 199.5 MW Melancthon EcoPower Centre). In 2003, Ontario had 10 wind turbines; today, the Province has more than 700.

Since October 2003, the government has signed more than 16,000 renewable energy supply contracts from wind, water, solar and bio-energy sources. This includes almost 2,400 MW of small and large renewable power projects under North America's first comprehensive Feed-in Tariff (FIT) Program, introduced in 2009. These FIT contracts represent a private sector investment of $9 billion and are projected to create approximately 20,000 direct and indirect clean energy jobs.

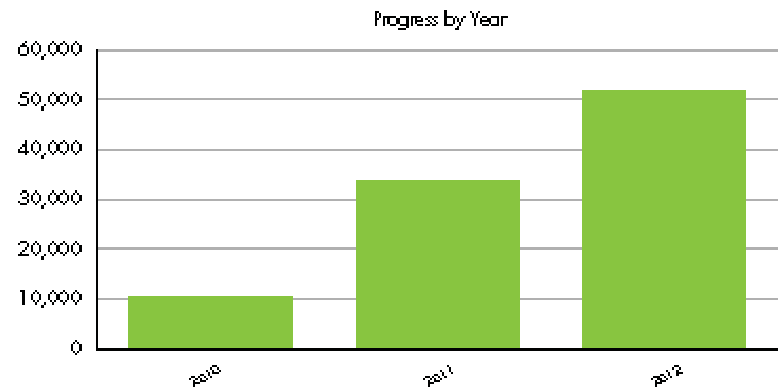
The success of the FIT Program has also attracted the notice of global investors, including a consortium of companies led by Samsung C&T Corporation, laying the foundation for Ontario to become a global clean energy production and manufacturing hub.

> Ontario's Feed-in Tariff (FIT) Program combines stable, attractive prices and long-term contracts for energy generated using renewable resources.
>
> Homeowners, business owners and developers may apply to the FIT Program if they use one or more forms of renewable energy, including wind, waterpower, solar photovoltaic (PV) power and bioenergy.
>
> The Program is the first comprehensive FIT program in North America. It was launched through the Green Energy and Green Economy Act, 2009.
>
> Over 1,000 FIT contracts are currently in place for clean energy projects.

Some 51 community projects will provide renewable electricity supply to the grid through the Ontario FIT program. From these projects, more than 200MW of clean electricity will be generated by communities engaging in, solar, wind and bio-energy projects across Ontario.

Thousands of Ontarians are also participating in the microFIT Program. Homeowners, farmers or small business owners, are able to develop a very small or "micro" renewable electricity generation project (10 kilowatts or less in size) on their properties. Under the microFIT program, they are paid a guaranteed price for all the electricity they produce for 20 years.

FIGURE 9: PROGRESS ON 50,000 PROJECTED GREEN ENERGY ACT JOBS



Major Private-Sector Renewable Investments in Ontario

The $7-billion Green Energy Investment Agreement with Samsung C&T Corporation and Korea Electric Power Corporation (Consortium), is the single largest investment in renewable energy in provincial history. It will:

- Build 2,500 MW of wind and solar power.
- Deliver an estimated 110 million megawatt-hours of emissions-free electricity over the 25-year lifetime of the project — enough to supply every Ontario home for nearly three years.
- Create more than 16,000 new clean energy jobs to supply, build, install and operate the renewable generation projects.
- Lay the groundwork with major partners to attract four manufacturing plants.

Out of the 16,000 new clean energy jobs, this investment is expected to create or sustain 1,440 manufacturing and related jobs, building wind and solar technology for use in Ontario and export across North America.

As part of the Green Energy Investment Agreement, Samsung and Siemens have announced plans to build Ontario's first wind turbine blade manufacturing plant, which will create up to 900 direct and indirect jobs. The Consortium will negotiate with manufacturing partners to locate three other plants in Ontario for wind turbine towers, solar inverters and solar module assembly.

Under the agreement, three of the four manufacturing facilities are scheduled to be ready in 2013, while the fourth is scheduled to be in operation by the end of 2015. The Consortium also intends to use Ontario-made steel and other Ontario content in its renewable energy projects for items such as wind turbine towers.

More than 20 companies have publicly announced plans to participate in Ontario's clean energy economy, in the last year. These companies are currently operating or plan to set up solar and wind manufacturing facilities in Ontario in the following categories: solar PV modules, mounting systems, inverters, wind turbine blades and wind turbine towers. Some recent examples include:

- Heliene Inc., producing modules in Sault Ste. Marie;
- Canadian Solar, will manufacture modules in Guelph;
- Photowatt, producing modules in Cambridge;
- Samco, an auto parts manufacturer now also producing solar mounting systems in Scarborough;
- Schletter, producing solar mounting systems in Windsor;
- Sustainable Energy Technologies partnering with Melitron to produce inverters in Guelph;
- Satcon, producing inverters in Burlington;
- Siemens will be producing wind turbine blades; and,
- DMI Industries is producing wind turbine towers in Fort Erie.

Future Needs

Ontario will continue to be a leader in renewable energy development and generation. The growth of the renewable energy sector will be influenced by electricity demand, the ability of the system to accommodate additions to the grid, continued innovation in the renewable technology sector and global demand for renewable energy production. Expansions and upgrades to the transmission and distribution system will be necessary to increase the capacity for renewable energy in Ontario.

As more and more of Ontario's electricity comes from renewable energy sources and research and innovation of Smart Grid technologies continues, there will be increased opportunities for renewable energy projects, both large and small to be established in Ontario.

There will also be greater opportunity for employment in this field. Renewable energy projects require skilled labour, such as engineers as well as construction and maintenance labour across the province. As renewable energy projects are established, the need for skilled and general labour will continue to provide jobs for thousands of Ontarians over the next decade. Innovation in new technology also contributes high skilled jobs and economic opportunities for Ontario.

> Biomass is dispatchable and can be used as a peaking resource. This attribute allows it to complement increased wind and solar generation. The conversion of Atikokan Generating Station to run on biomass will contribute to long-term system reliability, especially during low water conditions in the region. The conversion from coal to biomass at Atikokan by 2013 will create up to 200 construction jobs and help protect jobs at the plant. It will also support jobs in Ontario related to the production of wood pellets and sustain other jobs in the forestry sector. Ontario will continue to monitor the conversion of Atikokan and consider future potential of biomass generation.

The Plan

Ontario will continue to develop its renewable energy potential over the next decade. Based on the medium growth electricity demand outlook, a forecast of 10,700 MW of renewable capacity (wind, solar, and bioenergy) as part the supply mix by 2018 is anticipated. This forecast is based on planned transmission expansion, overall demand for electricity and the ability to integrate renewables into the system. This target will be equivalent to meeting the annual electricity requirements of two million homes.

The province's renewable energy capacity target will be met with the development of renewable energy projects from wind, solar, biogas, landfill gas and biomass projects across Ontario.

Future rounds of FIT projects will be connected to the Bruce to Milton transmission line and the priority transmission projects identified as part of this Long-Term Energy Plan. This will enable 4,000 MW of new renewable energy projects to be connected.

In the near term, the OPA will be releasing information regarding the status of all FIT applications not offered contracts as of June 4, 2010. These applications will be subject to the first Economic Connection Test (ECT) under the FIT program. The ECT process, to be conducted on a regular basis and in alignment with major planning or system development milestones, will help to determine whether the costs of grid upgrades to allow a FIT project to connect to the grid are economically viable.

For the period after 2018, depending on changes in demand, Ontario will look for opportunities to increase the development of renewable energy projects and expand renewable energy capacity in the Province. Ontario will review the electricity demand outlook in the next Long-Term Energy Plan to explore whether a higher renewables capacity forecast is required.

FIT contract prices were set following extensive consultations and are designed to ensure a reasonable rate of return for investors while providing good value for clean, renewable energy for Ontario ratepayers.

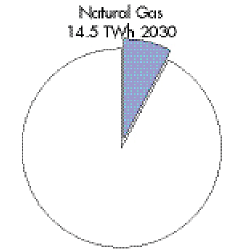
As part of the scheduled two-year review of the FIT Program in 2011, the FIT price of renewables in Ontario will be re-examined. Successful and sustainable FIT programs in a number of international jurisdictions (such as Germany, France and Denmark) have decreased price incentives. Advances in technology and economies of scale reduce the cost of production. A new price schedule will be carefully developed to achieve a balance between the interests of ratepayer and the encouragement of investment in new clean energy in Ontario.

The response to the microFIT and FIT programs has been a tremendous. Thousands of Ontarians are participating in the program to feed clean energy into the grid.

Given the popularity of Ontario's growing clean energy economy, applications to the microFIT and Capacity Allocation Exempt (CAE FIT) program are outpacing needed upgrades to the grid. To continue to ensure the growth of small clean energy projects, Ontario will continue to invest in upgrades to the transmission and distribution systems to accommodate renewable supply.

In areas where there are technical challenges, the OPA, Hydro One and Local Distribution Companies will continue to work with proponents that have already applied to the CAE FIT or microFIT program.

Natural Gas



Natural gas plants have the flexibility to respond well to changes in demand, making them an important cushion for Ontario's electricity system — particularly for peak periods.

Natural gas produces electricity either by burning to directly power a gas turbine or by producing steam to drive a steam turbine. A combined cycle gas plant combines these two technologies. Natural gas can supplement baseload power supply and, because it responds quickly to increases in demand, it can also complement the intermittent nature of wind and solar electricity generation.

Natural gas is much cleaner than coal. Some air emissions — particularly mercury and sulphur dioxide — are totally eliminated when natural gas replaces coal. Carbon dioxide emissions are reduced by between 40 and 60 per cent. Currently, Ontario's electricity generation capacity from natural gas is over 9,500 MW.

By replacing coal with natural gas and renewable energy sources, Ontario has greatly reduced greenhouse gas emissions from its electricity supply mix. This policy has prepared Ontario for the possibility of greenhouse gas regulation in the North American market.

Accomplishments

The Ontario government and the OPA have launched a number of clean natural gas and cogeneration projects since 2003 to help with local reliability and peak demand.

The 2007 Plan projected that some 12,000 MW of natural gas would be needed by 2015. Since then, changes in demand and supply — including about 8,400 MW of new, cleaner power across the system and successful conservation efforts — means that less capacity will be required.

Future Needs

In 2009, about 10 per cent of Ontario's electricity generation came from natural gas. In the coming years, the government anticipates that it will be necessary to maintain the amount of natural gas supply at its current level in the supply mix.

The Plan

Natural gas will continue to play a strategic role in Ontario's supply mix as it helps to:

- Support the intermittent supply from renewables like wind and solar
- Meet local and system reliability requirements
- Ensure adequate capacity is available as nuclear plants are being modernized

The 2007 Plan outlined a forecast need for an additional three gas plants in the Province, including one in the Kitchener-Waterloo-Cambridge and one in the southwest GTA.

Because of changes in demand along with the addition of approximately 8,400 MW of new supply since 2003, the outlook has changed and two of the three plants — including the proposed plant in Oakville — are no longer required. However, a transmission solution to maintain reliable supply in the southwest GTA will be required.

As indicated in 2007 Plan, the procurement of a peaking natural gas-fired plant in the Kitchener-Waterloo-Cambridge area is still necessary. In that region, demand is growing at more than twice the provincial rate.

Ontario is taking advantage of its existing assets with the conversion of two coal-fired units in Thunder Bay to natural gas. (See page 21 on Coal.)

Over the next few years, non-utility generation contracts, which were entered into between the private sector and the former Ontario Hydro in the early 1990s, will begin to expire. Many of these are natural gas-fired. These non-utility generators — or NUGs as they are known — have been part of Ontario's overall supply mix for 20 years. They can contribute up to 1,550 MW of clean power to the system. The contracts with NUGs are currently held by the Ontario Electricity Financial Corporation, an agency of the Ministry of Finance.

As non-utility generator contracts expire, the IESO and the OPA will determine if the generation is still required to help ensure reliability. The government will direct the OPA to design contracts that will encourage NUGs to operate during periods when it would most benefit the electricity system. The OPA will be authorized to enter into new contracts where this generation is needed and will negotiate to get the best value for consumers.

CHP (Combined Heat and Power/Cogeneration)

Combined Heat and Power is the simultaneous production of electricity and heat using a single fuel such as natural gas. The heat produced from the electricity generation process is captured and used to produce steam or hot water that can then be used for industrial and commercial heating or cooling purposes, such as district energy systems.

CHP can make more efficient use of fuel and therefore reduce greenhouse gas emissions. CHP overall efficiency can exceed 80 per cent — which means that 80 per cent of the energy can be captured as electricity or usable heat.

Accomplishments

Currently, the total industrial CHP capacity in Ontario is estimated to be about 2,000 MW, or about 6 per cent of Ontario's installed generation capacity.

In October 2006, the OPA awarded seven contracts with a total capacity of 414 MW — enough to provide the power for 400,000 Ontario homes. Much of this new capacity (395 MW) will be coming from industrial projects. These facilities are in communities across the province including: Windsor, Kingsville, London, Oshawa, Markham, Sault Ste. Marie and Thorold.

Algoma Energy Cogeneration Facility

The 63 MW Algoma Energy Cogeneration Facility is located in Sault Ste. Marie, Ontario. The facility uses the by-product fuels from cokemaking and ironmaking (blast furnace and coke oven gas) to generate electricity and steam used for steel manufacturing operations.

The facility reduces Essar Steel Algoma's reliance on the provincial power grid by 50 per cent on average, freeing up this capacity for the rest of the province. This cogeneration facility helps to reduce Essar Steel Algoma's nitrous oxide emissions by 15 per cent (approximately 400 metric tonnes a year).

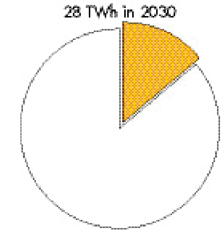
The Plan

Ontario will target a total of 1,000 MW of CHP. It will be procured through the OPA and will include existing contracts, individual negotiations for large projects and a new standard offer program for smaller projects in key strategic locations.

The government will encourage new local CHP generation projects, where price, size and location make sense. The government will work with the OPA to develop options for small, targeted programs. Over the next 20 years, Ontario will see more community-scale CHP projects. The OPA will create a new standard offer program for CHP projects under 20 MW in specific locations.

The OPA will continue to negotiate larger CHP projects on an individual basis. For example, the OPA and St. Marys Paper Corporation recently signed a 10-year contract for the company to generate clean electricity at a new 30 MW biomass-fuelled plant to be built next to St. Marys existing mill in Sault Ste. Marie. The plan is expected to reach commercial operation by early 2014 and will support 550 direct and indirect jobs.

3 conservation



Conservation is Ontario's most environmentally friendly and cost-effective resource. Conservation initiatives save money and reduce greenhouse gas emissions. Reducing consumption reduces bills for consumers and reduces demand on the system, avoiding the need to build new generation. For every dollar that is invested in conservation, two to three dollars of net savings are realized over the life of the investment. Conservation can also create local jobs in energy audits and energy services.

Accomplishments

From 1995 to 2003, there were no provincial conservation programs — it was not a priority. Since 2003, Ontario has had goals for conservation and as a result, this province has become a North American leader. The goal to reduce peak demand by 6,300 MW by 2025 was included in the 2007 Plan. Ontario is on target to meet this goal.

Ontario's A+ 2009 National Energy Efficiency Report Card from the Canadian Energy Efficiency Alliance

The province raised its grade from a "C-" in 2004 to an A+ in 2009 with its strong commitment to energy efficiency and conservation as cornerstones of its energy plan. In addition to the Green Energy and Green Economy Act, 2009, the report lauds Ontario's energy conservation programs, improved energy efficiency in building codes and product standards, as well as other initiatives supporting energy efficiency.

To improve the quality of the province's air and the efficiency of the system, Ontario invested about $1.7 billion in conservation programs from 2006 to 2010. This will save ratepayers $3.8 billion in avoided costs.

Conservation programs also give customers the tools to help them manage costs, and balance demand in peak periods in winter and summer. Conservation programs also create jobs in the clean energy sector.

Ontario has helped to create a culture of conservation since 2003 by:

- Updating Ontario's building code to make energy efficiency a core purpose.
- Delivering the Home Energy Savings Program which has helped over 393,000 homeowners with energy audits and helped nearly 250,000 homeowners with energy savings and retrofits. Despite the federal government's early withdrawal from funding this conservation program in March 2010, Ontario will continue to support the Home Energy Savings Program until March 31, 2011. This program helped save annual greenhouse gas emissions equivalent to taking over 83,000 cars off the road.
- Initiating the OPA's Great Refrigerator Round Up which has removed more than 230,000 old appliances since 2007. It will result in lifetime savings of more than one million megawatt hours over the life of the program.
- Providing $550 million over two years for energy retrofits in schools.
- Launching the Ontario Solar Thermal Heating Initiative for solar water and air heating projects for institutional, commercial or industrial organizations. The program continues until March 31, 2011. Almost 600 projects have been launched or completed to date.
- Moving forward with Smart Meters and Time of Use billing to encourage consumers to shift electricity consumption away from peak periods of demand; Avoided system expenditures help keep costs down for Ontarians.
- Reducing electricity consumption in government buildings through initiatives such as deep lake water cooling — a reliable, efficient and sustainable way to cool buildings while reducing demand on the grid.

Over the past five years, Ontario's conservation programs have generated over 1,700 MW of peak demand savings — the equivalent of over 500,000 homes being taken off the grid. Local Distribution Companies have been partners in helping Ontario achieve its conservation targets.

Conservation efforts are measured by looking at the results of conservation programs. The impacts of the global economic recession are not counted as part of conservation efforts, although they did result in a significant reduction in electricity demand. The recession also affected the level of participation in conservation programs which, although successful, are not expected to allow Ontario to meets its 2010 interim target. Confirmation of this will occur late in 2011, after program results undergo rigorous verification by independent third-parties. Had the global recession not had a significant impact on Ontario's economy, 2010 conservation achievements would have been significantly higher.

The Plan

Working together to reduce electricity use at peak times makes sound economic and environmental sense. Providing consumers with the benefit of up-to-date and accurate electricity consumption readings is also critical to the creation of a culture of conservation. The government is committed to moving forward with implementation of a Time-of-Use pricing structure that balances benefits for both the consumer and the electricity system as a whole.

To help families, Ontario will move the off-peak period for electricity users to 7 p.m. which will provide customers with an additional two hours in the lowest cost period. This change will be in effect for the May 2011 Regulated Price Plan update.

Time-of-Use

"On average, most farmers will pay slightly less on time-of-use billing than they currently pay. Advantages for farmers will be modest with a savings in the range of one to five per cent. However, the advantages for the power supply system will be substantial…"

- Don McCabe, Ontario Federation of Agriculture

Ontario is already a North American leader in conservation (the province conserved over 1,700 MW since 2005). The government's target is 7,100 MW and 28 TWh by 2030. This would mean the equivalent of taking 2.4 million homes off the grid. This level of conservation will reduce Ontario's greenhouse gas emissions by up to 11 megatonnes annually by 2030. These targets are among the most aggressive in North America.

As part of the Green Energy and Green Economy Act, 2009, Local Distribution Companies (LDCs) will become a more recognizable "face of conservation" and have been assigned conservation targets which they must meet as a condition of their licence. LDCs will meet their targets through a combination of province-wide and local conservation programs.

Ontario proposes to provide support for homeowners to have energy audits to become better informed of the opportunities to improve the energy efficiency of their homes.

Conservation targets

Date	2015	2020	2025	2030
Capacity	4,550 MW	5,840 MW	6,700 MW	7,100 MW
Generation	13 TWh	21 TWh	25 TWh	28 TWh

These targets will be met through a combination of programs and initiatives:

- Innovative energy efficiency programs for residential, commercial and industrial sectors
- Next-generation building code updates and standards for appliances and products
- Demand response programs to help reduce peak demand
- Time-Of-Use rates

The government anticipates that the commercial sector will contribute 50 per cent of the conservation target; residential sector will contribute 30 per cent; and industrial sector 20 per cent.

Over the next 20 years, Ontario's conservation targets and initiatives are projected to save about $27 billion in ratepayer costs on the basis of a $12 billion investment. Conservation will also do more than that by helping to ensure that Ontario's air is cleaner and the electricity sector reduces its impact on the environment.

Ontario will continue to provide broad support for achieving these targets through policy initiatives such as bringing forward a proposed regulation to require the broader public sector (municipalities, universities, schools and hospitals) to develop energy conservation plans.

In early 2011, together with LDCs, Ontario will launch a number of new programs, which will allow the province to meet its conservation targets over the next few years and make up for the slower period between 2009 and 2010. The programs will target all sectors, be better coordinated and have greater customer focus than previous programs.

Ontario is designing, implementing and funding a province-wide electricity conservation and demand management program for low-income residential consumers . Ontario is also developing a low-income energy program comprised of natural gas conservation, customer service standards and emergency financial assistance.

These new conservation programs, together with programs for very large industrial customers, will require an investment of about $3 billion over the next five years. The results will be significant: an avoided lifetime supply cost of $10 billion and a net benefit to Ontario ratepayers of about $7 billion over the life of the conservation measures.

4 reliable transmission/ modern distribution

Reliable transmission and modern delivery is the backbone of Ontario's electricity system. It is crucial for supporting Ontario's evolving supply mix, including the closing of coal-fired plants by 2014 and the further expansion of Ontario's clean energy resources. Reliable, safe transmission brings electricity from large generators to Ontario's largest industries and local distribution companies who in turn, deliver to homes and businesses. A modern distribution system, utilizing new technology, allows for greater customer control, incorporates renewable energy, enhances reliability, and supports new technology like electric vehicles.

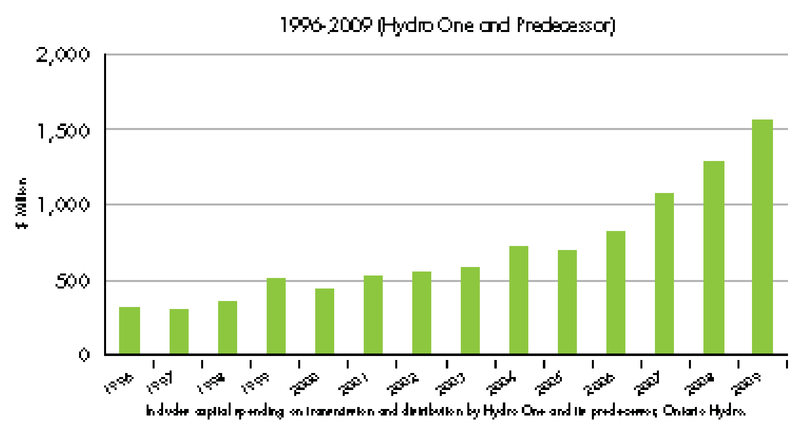
Transmission

Ontario must take the transmission system that's been built over the past century and continue to renew and update it to meet Ontario's growing population, evolving supply mix, and enable more distributed generation.

The Ontario government has taken early and decisive steps to enhance existing electricity infrastructure. It is important to ensure that Ontario can efficiently upgrade the grid to carry additional renewable generation to homes, businesses and industries.

Since 2003, Hydro One has invested more than $7 billion in its transmission and distribution systems. The average annual investment has been double what it was from 1996-2003.

FIGURE 10: GRID INVESTMENTS



Some of Ontario's recent investments include:

- The launch of the Bruce to Milton transmission expansion project — the largest electricity transmission investment in Ontario in the last 20 years, which will connect refurbished nuclear units and additional renewable energy to the grid.
- Ongoing work to reinforce the power transfer capability between northern and southern Ontario including additional 750 MW of planned clean northern generation (Lower Mattagami and some northern FIT Program projects).
- The new Ontario-Québec Interconnection Project (2010), which increased access to 1,250 MW of hydroelectric power and enhanced system reliability in eastern Ontario.
- Additional transmission projects that will facilitate the retirement of coal-fired generation, including transmission reinforcement in the Sarnia area, the installation of new transformers in the northern GTA, and voltage support facilities in the Niagara, London and Kitchener areas. These projects represent an investment of over $400 million.
- Over 15 per cent of transformer stations across Ontario have received overhauls in the past five years, amounting to a total investment of $850 million.
- Installation of almost 4.3 million smart meters across the province, which are already helping with outage management and remote meter reading and reducing the number of estimates for consumers.
- Early investments in Smart Grid infrastructure and technologies, including pilots and demonstration projects. These projects will help Ontario move toward a Smart Grid system that can integrate energy monitors, home automation systems, in-home renewable generation and electric cars.
- Hydro One's $125-million Grid Control Centre opened in 2004 and uses some of the most sophisticated technology in the world to efficiently manage the bulk of Ontario's electricity network.

Reliability has also been improved since 2003 due to a combination of new generation, transmission upgrades, reduced load growth and successful conservation programs. For example, Toronto's reliability was enhanced with the installation of two new underground cables between downtown transfer stations and will be further assisted by reinforcement and upgrade projects worth about $360 million. Annual capital investments by Ontario's Local Distribution Companies, including Hydro One, have averaged $1.1 billion between 2004 and 2009, maintaining reliable and high quality power for Ontario's electricity customers. These investments have made the operation of the system more cost-effective, which will have an impact on Ontarians' bills over the long term.

Modern Distribution

Local distribution systems are an important link in how electricity moves from generators to homes and businesses. In 2003, Ontario's distribution systems often relied on older technology. The government's move towards a Smart Grid was driven by the need to replace aging infrastructure, introduce customer control, incorporate more renewable energy and accommodate new adaptive technology such as electric vehicle charging. Over time, LDCs will have to replace old mechanical infrastructure with newer automated infrastructure that meets Ontario's future needs.

A modern distribution system must be able to accommodate new energy supply from a variety of sources and deliver it reliably to consumers. It must take advantage of Smart Grid technologies to enable efficient and cost-effective delivery of electricity, helping customers to better manage their electricity use, and integrate more renewable energy.

Building a Smart Grid that can coordinate the production of power from large numbers of small power producers and allow utilities to more efficiently manage their grid infrastructure is another essential element of Ontario's clean energy future. Other jurisdictions (Australia, Great Britain and California) are moving toward a smarter grid, but Ontario is leading the way in many areas. By leveraging existing communications technology, a Smart Grid will enable the two-way power flow of electricity across the grid. The Smart Grid will help incorporate distributed generation. It will also improve grid automation with real-time information that will help save energy, reduce the cost of supply over time and increase reliability.

A Smart Grid is a more intelligent grid infrastructure, incorporating communications technology and automation to:

- Maximize existing infrastructure
    - Rather than building out more traditional grid infrastructure (poles, wires, etc), a Smart Grid will use Information Technology solutions to improve and automate distribution.
- Modernize the grid
    - The current distribution system in some places is decades old. A modernized grid is critical for improving reliability, home automation and adapting to evolving transportation needs.
- Lay the foundation for Smart Homes
    - A Smart Grid will put in place the intelligent infrastructure required to support applications for home automation, conservation and smart charging for electric vehicles.

The Green Energy and Green Economy Act, 2009 identified three main areas of focus for Ontario's Smart Grid:

- Helping consumers become active participants in conservation.
- Connecting new and renewable sources of energy to the overall system (consumers and businesses produce energy that can be connected to the local system) to help address power demands.

- Creating a flexible, adaptive grid that can accommodate the use of emerging, innovative energy-saving technologies and control systems.

Smart meters provide a foundation for the Smart Grid and provide customers with timely and accurate information about their electricity use. Smart meters also provide utilities with automatic notification of outages, save on in-person meter-reading costs and enable Time-of-Use pricing.

Smart meters also help avoid system costs that in turn save money for ratepayers: Hydro Ottawa saved $200,000 in meter reading in 2008 and Toronto Hydro estimates that smart meters will cut meter-reading costs by $2.5 million by 2010.

Future Needs

The Ontario government, working with its agencies, will move forward responsibly on a number of new and modernizing transmission projects as well as on improving and maintaining the province's existing infrastructure across all regions in Ontario. These improvements will also balance environmental concerns and the cost to ratepayers. In addition to evaluating the province's need for transmission to integrate renewables, meet provincial demand growth and ensure reliable service, system planning will address community needs. For example, a transmission solution to maintain reliable supply in the southwest GTA will be required.

The Plan

In 2009, the government asked Hydro One to start planning and developing a series of new transmission and distribution projects. Since that time, there have been a number of developments, such as the substantial interest in the Green Energy and Green Economy Act, 2009 to develop renewable energy projects.

Based on the advice of the OPA, the government will prudently move forward with cost-effective priority transmission projects that meet current and future demand and also:

- Accommodate renewable projects;
- Serve new load; and
- Support reliability.

Ontario will proceed first with an investment of approximately $2 billion in five priority projects to be completed in the next seven years, which will ensure a growing mix of renewable sources can be reliably transmitted across the province. These priority projects together with the Bruce to Milton line, in addition to various other station and circuit upgrades, will enable approximately 4,000 MW of additional renewable energy.

FIGURE 11: TRANSMISSION INVESTMENTS: COMPLETE, UNDERWAY AND PROPOSED

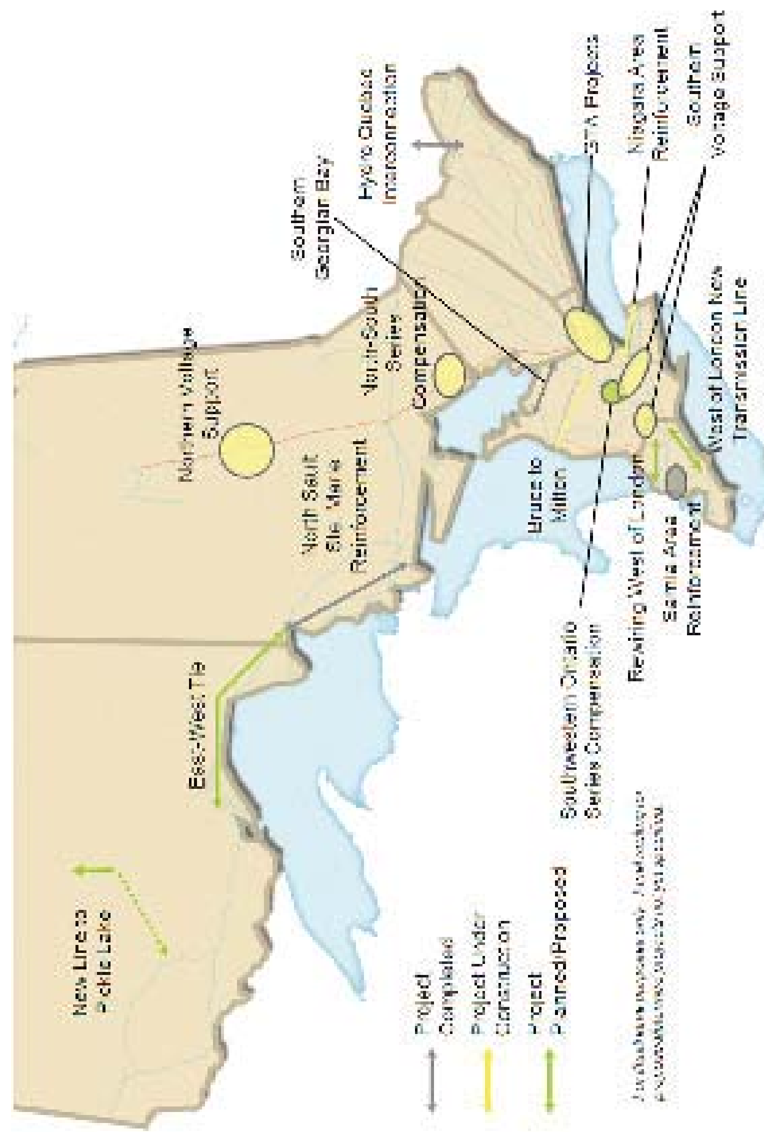


FIGURE 12: PRIORITY TRANSMISSION PROJECTS

Project	Type	Need	Target Completion Date
Series compensation in Southwestern Ontario	Upgrade	Add renewables to grid	2014
Rewiring west of London	Upgrade	Add renewables to grid	2014
West of London	New Line	Add renewables to grid	2017
East-West Tie	New Line	Maintain system reliability, allow more renewables, accommodate electricity requirements of new mineral processing projects.	2016-17
Line to Pickle Lake	New line	Serve industry needs and help future remote community connection	Pending consultation

Given the nature of the transmission upgrades in southwestern Ontario, including series compensation, rewiring and a new line west of London, the government intends to direct Hydro One to carry out these projects immediately.

The East-West tie will be submitted to the OEB to carry out a designation process to select the most qualified and cost-effective transmission company to develop the line.

To ensure successful and timely implementation of the line to Pickle Lake, the government will work with its agencies and the multiple parties involved, including the Federal government, local industries, and First Nation communities that stand to benefit from the project to establish an implementation schedule and a proponent for the line.

Transmission planning will also continue at the regional level, using an approach that considers conservation, demand management, distributed generation and transmission. Regional plans will assess needs based on a region's unique resource mixes and community priorities. Load growth and system reliability are also factors in determining system planning and transmission solutions. Ontario will continue to plan and study additional transmission projects as demand and changes to supply require.

To build a modern system, the government will issue a set of Smart Grid principles and objectives to the Ontario Energy Board. These will provide guidance to LDCs in modernizing their distribution systems and enable the smart home of the future. LDCs will develop smart grid plans and ensure that these are coordinated across the Province. The government will also establish a Smart Grid Fund in 2011 which will provide assistance to Smart Grid companies with a strong Ontario presence. This will lead to new economic development opportunities and bolster Ontario's position as a leader in the Smart Grid.

5 aboriginal communities

Accomplishments

The Ontario government is committed to encouraging opportunities for Aboriginal participation in the energy sector and has launched several initiatives to support participation by First Nation and Métis communities in energy projects, including:

- The Aboriginal Energy Partnerships Program
- The FIT Program: 17 aboriginal-led or partnered projects have secured contract offers
- The $250-million Aboriginal Loan Guarantee Program

Ontario also has a significant partnership at the $2.6 billion Lower Mattagami hydroelectric project, which will see Moose Cree First Nation have up to a 25 per cent equity position with OPG.

Future Needs

First Nation and Métis communities have diverse energy needs and interests. Ontario will work to ensure there is a wide range of options for Aboriginal participation in Ontario's energy future.

Conservation

Conservation priorities and the applicability of programs will vary between First Nation and Métis communities. Community education and youth engagement are also critical for conservation success. Ontario will launch programs to support participation in conservation initiatives, including Aboriginal Community Energy Plans and targeted conservation programs.

Renewable Energy

Future opportunities for First Nation and Métis communities include:

- Partnerships with private developers on confirmed FIT projects under development,
- Development of smaller renewable microFIT projects, like small wind or solar, to build community capacity in energy and generate income.

Existing Green Energy and Green Economy Act, 2009 support programs will be adjusted to ensure that aboriginal communities can take advantage of these opportunities. Aboriginal participation levels will also be reviewed during the regular FIT program review to determine whether adjustments are needed to the rules and incentives.

Transmission

Where new transmission lines are proposed, Ontario is committed to meeting its duty to consult First Nation and Métis communities in respect of their aboriginal and treaty rights and accommodate where those rights have the potential to be adversely impacted. Ontario also recognizes that Aboriginal communities have an interest in economic benefits from future transmission projects crossing through their traditional territories and that the nature of this interest may vary between communities.

There are a number of ways in which First Nation and Métis communities could participate in transmission projects. Where a new transmission line crosses the traditional territories of aboriginal communities, Ontario will expect opportunities be explored to:

- Provide job training and skills upgrading to encourage employment on the transmission project development and construction.
- Further Aboriginal employment on the project.
- Enable Aboriginal participation in the procurement of supplies and contractor services.

Ontario will encourage transmission companies to enter into partnerships with aboriginal communities, where commercially feasible and where those communities have expressed interest. The government will also work with the OPA to adjust the Aboriginal Energy Partnerships Program — currently focussed on renewable energy projects — to provide capacity funding for aboriginal communities that are discussing partnerships on future transmission projects.

The Plan

Ontario recognizes that successful participation by First Nation and Métis communities will be important to advance many key energy projects identified under a Long-Term Energy Plan. The path forward needs to be informed by regular dialogue with First Nation and Métis leadership through distinct processes. Working with First Nation and Métis leadership, Ontario will look for opportunities to promote on-going discussion of these issues.

Ontario's remote First Nation communities currently rely on diesel generation for their electricity supply — but diesel fuel is expensive, difficult to transport, and poses environmental and health risks. According to analysis done so far, transmission connection would be less expensive over the long term than continued diesel use for many remote communities.

New transmission supply to Pickle Lake is a crucial first step to enable the connection of remote communities in northwestern Ontario. A new transmission line to Pickle Lake — one of this plan's five priority projects — will help to service the new mining load and help to enable future connections north of Pickle Lake. Subject to cost contributions from benefiting parties, Ontario will focus on supplying Pickle Lake from the Ignace/Dryden area immediately. A line to serve the Nipigon area specifically will continue to be considered as the need for it evolves.

As part of this project, the government will also ask the OPA to develop a plan for remote community connections beyond Pickle Lake, including consideration of the relevant cost contributions from benefiting parties, including the federal government. This plan may also consider the possibility of onsite generation such as small wind and water to reduce communities' diesel use.

6 energy in Ontario's economy — capital investments

Energy has a significant impact on Ontario's economy. Ontario businesses rely on electricity to produce goods and services and it is essential to our quality of life.

- Ontario's electricity sector is a $15 billion annual industry.
- Energy accounts for eight per cent of Canada's GDP.
- Some 95,000 Ontarians are currently directly and indirectly employed in the energy sector.
- More than $10 billion has been invested in Ontario in new clean energy projects that are online or under construction.
- Ontario has attracted more than $16 billion in private sector investments in the energy sector in the past year.

Ontario's progress in modernizing and upgrading electricity has not only benefited electricity users, it has strengthened the economy by attracting investment and creating jobs. Large infrastructure projects typically have high GDP and employment impacts, and this is also true of the ongoing and planned investments in Ontario's electricity sector.

Hydroelectric investment

Waterpower has been helping to fuel Ontario's economic growth for more than 100 years and is the backbone of renewable supply.

Ontario hydroelectric producers spend $250 million annually in operating and maintenance costs and in the past decade alone have made additional capital investments of $400 million to bring new waterpower online. Today, Ontario's hydroelectric producers directly employ more than 1,600 people and support an additional 2,000 jobs.

Hydroelectric has an even greater impact in Ontario's north, where it accounts for more than 80 per cent of the electricity generated. Twenty-four of 65 generating stations run by OPG are located in Ontario's north, representing close to 2,000 MW.

Many older hydroelectric facilities date to Ontario's early industrial mining and forestry activities and some of these sites are being rebuilt at higher capacity. Recent substantial investments are playing an important economic role in the north. The Lower Mattagami River Hydroelectric Project, Ontario's largest hydroelectric project in 40 years, will bring a $2.6-billion investment into northeastern Ontario and create up to 800 construction jobs.

In southwestern Ontario, work is underway on the Niagara Tunnel project, the single biggest construction project for the Niagara region since the Beck 2 Generating Station was built 55 years ago. The project means that region will benefit from over 230 construction jobs.

Wind, Solar and Bio-Energy investment

Ontario is creating a new sector for investment and is becoming a global destination of choice for clean energy developers and suppliers. Ontario's Green Energy and Green Economy Act, 2009 has laid the foundation for economic opportunities throughout the province. In the coming years, over 20,000 people will be employed in renewable energy and development activities including manufacturing triggered by North America's most comprehensive FIT program.

Ontario has already attracted more than $16 billion of private sector investment and over 20 companies have announced plans to set up or expand operations in Ontario. This activity will create or support indirect jobs in areas such as finance, consulting and other manufacturing, service, and development industries.

Many communities that were hard-hit during the recent economic downturn are reaping benefits of Ontario's growing clean energy economy. According to the Windsor Essex Economic Development Commission, of the 6,000 new jobs created in Windsor in the past 10 months, five to 10 per cent are tied to renewable energy.

The Green Energy and Green Economy Act, 2009 has already attracted the single-largest investment in renewable energy in provincial history. The Consortium, led by Samsung C&T Corporation, is investing $7 billion to create 2,500 MW of new wind and solar power in Ontario. The investment will lead to more than 16,000 new clean energy jobs to build, install and operate the renewable generation projects and associated manufacturing. The consortium is also working with major partners to secure four manufacturing plants in the province. This will lead to the creation of 1,440 manufacturing and related jobs to build wind and solar technology for use in Ontario and export across North America.

Plans for the first of the four plants have already been announced. Samsung and Siemens have said they intend to build Ontario's first wind turbine blade manufacturing plant, creating up to 900 direct and indirect jobs. The supply-chain of Ontario's new clean energy economy is providing benefits to other sectors of the economy. For example, the Consortium intends to use Ontario steel in its projects, subject to necessary quality standards.

The clean energy sector is also providing new opportunities to people in rural Ontario. Farmers are leasing portions of their land for wind turbines, allowing them to generate income while continuing to farm. For example, in Port Alma, local farmers and landowners are leasing their land to the 44-turbine Kruger Energy wind power project, which produces enough clean electricity to power 30,000 households.

Province-wide, farmers and agri-food businesses received a total of $11.2 million to develop and build generating systems that produce clean energy, reduce electricity costs and contribute to local economies through OMAFRA's Biogas Systems Financial Assistance Program, which ran from September 2008 to March 2010.

> "Building a clean energy economy is not an issue that splits left from right. It's about past and future. People of all political stripes who are entrusted in building a modern economy can – and do – look ahead."
>
> \- Rick Smith, founding partner of Blue Green Canada

Modernization of nuclear fleet

The nuclear sector has contributed a great deal to Ontario's economy over the past forty years. According to the Canadian Nuclear Association, the sector supports over 70,000 jobs across Canada and injects some $6 billion into the national economy every year. The Organization of CANDU Industries estimates that its 165 members employ over 30,000 people, many of them here in Ontario. Its members supply goods and services for nuclear reactors in domestic and export markets.

Plans to upgrade and refurbish Ontario's nuclear plants are expected to create and support thousands of jobs and inject billions of dollars into this sector over the next decade. A report by the Canadian Manufactures and Exporters estimates that the refurbishment and operation of the Bruce and Darlington units will create or sustain 25,000 jobs and provide $5 billion in annual economic activity.

The design and construction of two new nuclear units at Darlington will employ up to 3,500 people and support many thousands more indirect jobs. Ongoing operation at the plant will require a further 1,400 tradespeople, nuclear operators, and engineering and technical support staff for the duration of the plant's life.

Transmission upgrades

Thousands of Ontarians are employed in the province's electricity transmission sector and billions of dollars in planned upgrades to and expansion of the system are expected to support and create thousands more jobs in the future.

Fully owned by the Province of Ontario, Hydro One is the province's largest electricity transmission and distribution company. It owns 97 per cent of the transmission facilities in the province and employs approximately 5,400 workers, many of them highly skilled technicians, in communities throughout Ontario.

This Plan includes a commitment to develop five priority transmission projects. Employment on the five priority projects alone will peak at over 5,000 in 2013. This new transmission capacity will enable further generation development, including many new private-sector renewable projects.

The rollout of new transmission projects will also allow communities, including Aboriginal communities, to develop more small-scale renewable generation and, in certain cases, reduce their dependence on polluting forms of electricity generation.

Coal plant conversion

Converting Ontario's existing coal-fired generating stations to new fuels will create new constructions jobs and support clean energy jobs in operations and maintenance.

For example, the Atikokan biomass conversion project will create up to 200 construction jobs and help protect jobs at the plant. It will also support an estimated 20 to 25 jobs in Ontario related to the production of wood pellets and sustain other jobs in the forestry sector. The project will provide engineering and construction jobs during the conversion as well as ongoing employment in the forestry and transportation sectors to keep the station supplied with fuel. Natural gas conversion at Thunder Bay will provide additional jobs in pipeline construction and ongoing operations.

Conservation

Conservation programs contribute to local and regional jobs, creating employment and new business opportunities in a number of areas, including technology and product development, manufacturing, distribution, marketing, sales, installation and maintenance. For example, Ontario's $3-billion investment in conservation programs over the next five years is expected to create or sustain about 5,000 jobs annually.

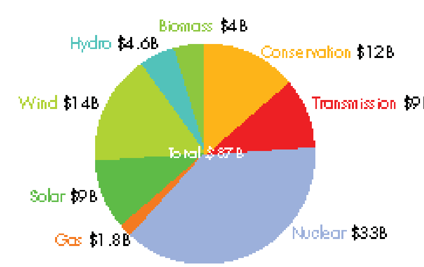
Capital Investments

Ontario's electricity sector is a $15-billion annual industry. Investments in the electricity system are helping to clean Ontario's air, improve the reliability of the energy supply and create jobs and economic opportunities in communities across the province. Since 2003, over $10 billion has been invested to bring new supply on line, and over $7 billion has been spent to strengthen the transmission system. Ontario has also attracted more than $16 billion in private sector investment through the FIT program.

Investments over the past seven years to build new cleaner generation and modernize electricity infrastructure has increased significantly to make up for years of underinvestment. Needed capital investments in Ontario's energy system over the next 20 years will be significant, and are in line with the government's efforts to upgrade and replace aging infrastructure. For example, the ReNew Ontario Infrastructure plan invested $30 billion over four years in capital projects across the province.

This Plan outlines essential capital expenditures to continue building a clean and modern electricity system and to keep the lights on for Ontario families and businesses. The total capital cost in 2010 dollars is estimated to be $87 billion over the life of the Plan. This accounts for new and refurbished energy supply, transmission and distribution infrastructure and conservation investments. This Plan provides more investments over the 2007 Plan due to increased investments in renewables, updated capital cost assumptions, and more certainty on the costs of nuclear refurbishments and new build. These cost estimates will be further refined by the OPA in the coming months and then submitted to the OEB.

FIGURE 13: ESTIMATED CAPITAL COST OF LONG-TERM ENERGY PLAN: 2010 TO 2030 ($ BILLIONS)



The capital investments outlined are through both the private and public sector, and the majority will be paid for by electricity consumers spread over many years, depending on the cost recovery mechanism. (For example, electricity generators typically recover their investment over 20 years, whereas transmission investments may take up to 40 years to be fully repaid). This ensures that the annual costs to consumers, as reflected on electricity bills are spread over a longer period of time.

Conservation expenditures in this Plan include direct program costs and additional capital expenditures driven by higher appliance energy efficiency standards and higher building code efficiency standards.

Overall, renewables account for one third of total expenditures, nuclear just over one third, and natural gas, conservation and transmission the remainder. The breakdown is reflective of the Plan's objective to deliver a balanced and diverse supply mix that is cost effective, clean and helps create clean energy jobs.

7 electricity prices

Over the past 20 years, the price of water, fuel oil and cable TV have outpaced the price of electricity. Over the next 20 years, Ontario can expect stable prices that also reflect the true cost of electricity. The government will need to take a balanced and prudent approach to investment and pricing that ensures that Ontario's children and grandchildren have a clean, reliable system.

Ontarians now pay the true cost of electricity to ensure that essential investments are made in clean energy and modern transmission. About 40 per cent of Ontario's electricity generation is subject to price regulation, contributing significantly to predictable prices for Ontario consumers. Regulated Price Plan (RPP) rates (adjusted every six months) ensure pricing reflects the true cost of generating electricity. This helps to provide stable and predictable electricity prices for consumers.

Accomplishments

In 2003, the electricity system was in significant decline but Ontario families and businesses have invested in the creation of cleaner sources and the restoration of reliability. The cost of energy has increased in order to provide cleaner, more reliable energy for generations to come.

The government has also taken several steps to keep the cost of electricity down for Ontario families and businesses. Actions taken to prudently manage expenditures total over $1 billion, including:

- Freezing the compensation structures of all non-bargained public sector employees for two years – which include the five energy agencies.
- Limiting travel costs and other expenses for public sector workers.
- Requesting that Hydro One and Ontario Power Generation revise down their 2010 rate applications to find savings and efficiencies.
- The IESO has reduced costs by $23 million over the past seven years.
- For 2011, the OPA has reduced its overall operating budget by 4.1 per cent.
- Hydro One will reduce operations costs by $170 million in 2010 and 2011. Information technology upgrades will save $235 million over the next four years.
- OPG is reducing operations costs by more than $600M over the next four years.

Ontario has taken steps to lower the hydro debt left by the previous government. In 1999, the restructuring of Ontario Hydro and the attempt to sell-off Hydro left electricity consumers with a debt of $20.9 billion. Since 2003, Ontario has decreased that stranded debt by $5.7 billion. Payments toward the debt are made through Payments in Lieu of Taxes, dedicated income from government energy enterprises, and by ratepayers through the Debt Retirement Charge.

The government has also launched a number of initiatives to help Ontario families and businesses manage electricity bill increases. Some of these include:

- The Northern Ontario Energy Credit, a new, permanent annual credit to help families and individuals in the North who face high energy costs. The yearly credit of up to $130 for a single person and up to $200 for a family would be available to over half of all northern Ontario households.
- Ontario Energy and Property Tax Credit, starting with the 2010 tax year, to low-income Ontarians who own or rent a home would receive up to $900 in tax relief, with seniors able to claim up to $1,025 in tax relief to help with both their energy costs and property tax. Overall, the proposed Ontario Energy and Property Tax Credit would provide a total of about $1.3 billion annually to 2.8 million Ontarians.

Energy Consumer Protection Act, 2010:

On January 1, 2011, new rules will take effect under the Energy Consumer Protection Act, 2010 that will help protect electricity and natural gas consumers by putting an end to unfair practices by energy retailers. The rules will ensure that consumers receive accurate price disclosure from all energy retailers before they sign contracts, helping to protect Ontario families and seniors.

Ontario is helping low-income Ontarians with their energy costs through a province-wide strategy to help consumers better manage their energy consumption and costs, including:

- Establishing a new emergency energy financial assistance fund.
- Implementing enhanced customer service rules that will assist all customers, particularly low-income Ontarians.

Ontario is also developing a comprehensive electricity conservation program for low-income households in coordination with the natural gas utilities. Through the conservation measures, customers will be better able to manage their energy bills.

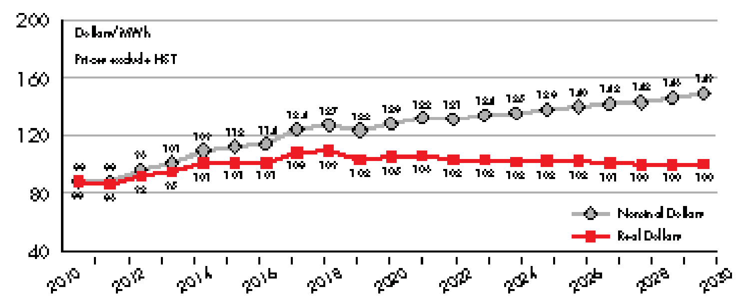
The Plan

Industrial Users

Due to investments to make the electricity system cleaner and more reliable for industry, the government projects that the industrial rate will increase by about 2.7 per cent annually over the next 20 years. The Ontario government has introduced initiatives to enhance the efficiency and competitiveness of large industrial consumers as well as protect jobs and local economies. These include:

- The Industrial Conservation Initiative will help the province's largest industrial and manufacturers to conserve energy, save on costs and increase their competitiveness. By changing the Global Adjustment Mechanism, large industrial users can shift their usage off peak times and save on electricity costs.
- The OPA's Industrial Accelerator Program has been launched to assist transmission-connected industrial electricity users to fast-track capital investment in major energy-efficiency projects.
- The Northern Industrial Energy Rate Program provides electricity price rebates for qualifying northern industrial consumers who commit to an energy efficiency and sustainability plan. On average, the program reduces prices by about 25 per cent for large facilities.

FIGURE 14: INDUSTRIAL PRICE PROJECTIONS (2010-2030)



Helping Ontario Small Businesses and Families

In order to ensure that Ontario has a clean, modern system that increases renewables, ensures reliability and creates jobs, continued investments in the electricity system are essential.

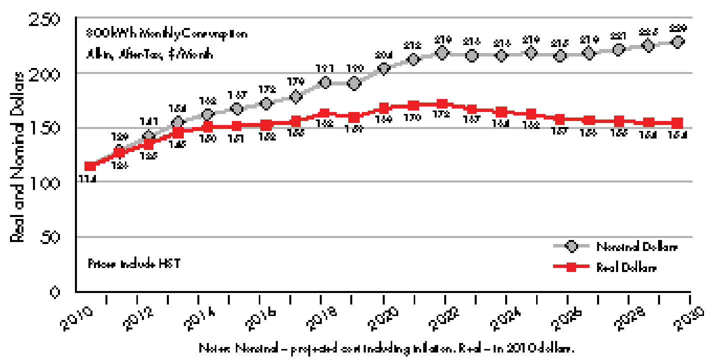
Based on the significant investments in clean, modern energy outlined in this plan, the government projects, based on current forecasts, that electricity prices will increase. Over the next 20 years, prices for Ontario families and small businesses will be relatively predictable. The consumer rate will increase by about 3.5 per cent annually over the length of the long-term plan.

Over the next five years, however, residential electricity prices are expected to rise by about 7.9 per cent annually (or 46 per cent over five years). This increase will help pay for critical improvements to the electricity capacity in nuclear and gas, transmission and distribution (accounting for about 44 per cent of the price increase) and investment in new, clean renewable energy generation (56 per cent of the increase).

Continued investments in transmission, conservation and supply are needed for a system that provides more efficient and reliable electricity to consumers whenever they need it and does not pollute Ontario's air or negatively affect the health of citizens and future generations.

After five years, Ontario will have largely completed the transition to a cleaner more reliable system due to the replacement of coal-fired generation and new renewable generation under the GEA. Once these investments have been made, price increases are expected to level off. The investments that the entire province is making in the future of electricity will help to ensure that Ontario never finds itself in the dire straits it was in just seven years ago.

FIGURE 15: RESIDENTIAL PRICE PROJECTIONS (2010-2030)



However, in the next five years, the government recognizes that the increases will have an impact on Ontario families and businesses.

The government's 2010 Ontario Economic Outlook and Fiscal Review took action to help Ontarians who are feeling the pinch of rising costs and electricity prices. The Ontario government proposed direct relief through a new Ontario Clean Energy Benefit (OCEB).

For eligible consumers, the proposed OCEB would provide a benefit equal to 10 per cent of the total cost of electricity on their bills including tax, effective January 1, 2011. Due to the length of time required to amend bills, the price adjustments would appear on electricity bills no later than May 2011, and would be retroactive to January 1, 2011.

Every little bit of assistance helps during lean times. The proposed OCEB together with the Northern Ontario Energy Credit and the Ontario Energy and Property Tax Credit will all help mitigate electricity costs for families.

Eligible consumers would include residential, farm, small business and other small users. The proposed OCEB would help over four million residential consumers and over 400,000 small businesses, farms and other consumers with the transition to an even more reliable and cleaner system.

Benefits for Eligible Consumers

Customer Monthly Consumption	Current Estimated Monthly Bill	Estimated Bill after Ontario Clean Energy Benefit	Monthly Benefit* (10%)	Yearly Benefit (10 %)
Typical Residential 800kWh	$128	$115.20	$12.80	$153.60
Small Business 10,000kWh	$1,430	$1,287	$143	$1,716
Farm 12,000kWh	$1,710	$1,539	$171	$2,052
*Typical 2011 monthly benefit for a consumer. Benefit amount will vary based on actual price, consumption and location				

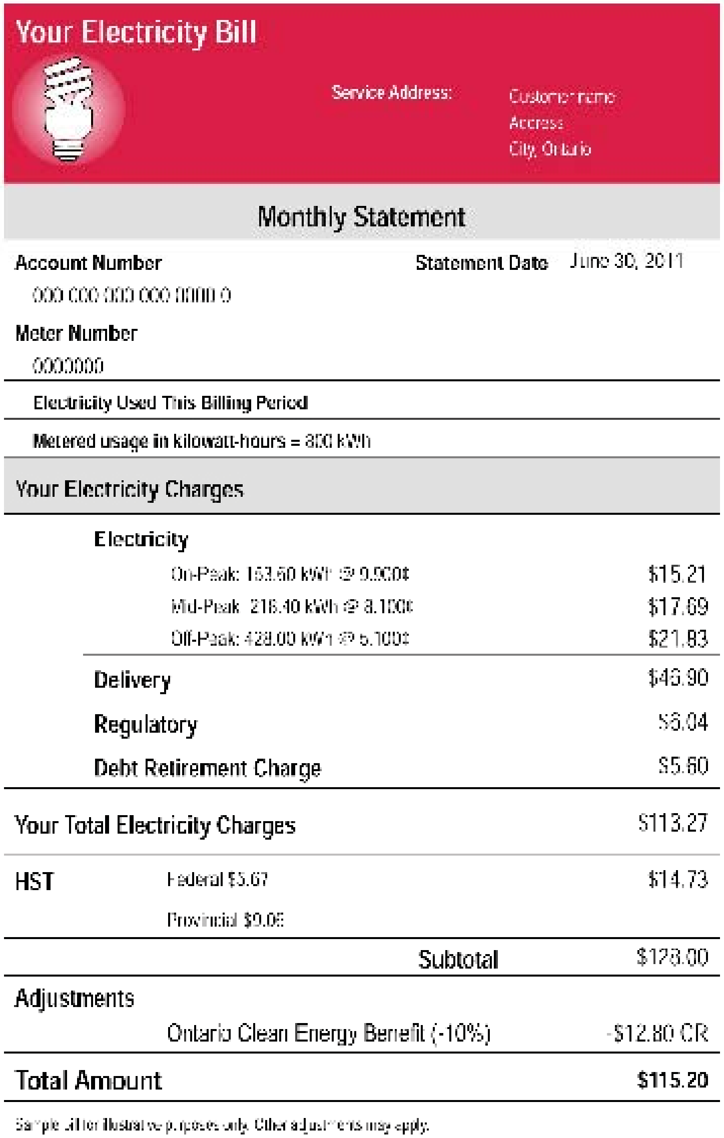
Providing the 10 per cent OCEB to Ontarians is a responsible way of helping Ontario families and businesses through the transition to a cleaner electricity system. The OCEB would help residential and small business consumers over the next five years as the grid is modernized. The government has introduced legislation to implement the proposed OCEB.

Working together to reduce electricity use at peak times makes sound economic and environmental sense. Providing consumers with the benefit of up-to-date and accurate electricity consumption readings is also critical to the creation of a culture of conservation. The government is committed to moving forward with implementation of a Time-of-Use pricing structure that balances benefits for both the consumer and the electricity system as a whole.

To help families, Ontario will move the off-peak period for electricity users to 7 p.m. which will provide customers with an additional two hours in the lowest cost period. This change will be in effect for the May 2011 Regulated Price Plan update.

This plan has outlined a new clean, modern and reliable electricity system for the people of Ontario. Instead of a system that was polluting, unreliable and in decline with unstable pricing, Ontarians will have a North American-leading clean energy system that keeps the lights on for generations to come, creates jobs for Ontario families and ensures that the air they breathe is cleaner.

FIGURE 16: SAMPLE BILL



Your Electricity Bill

Service Address: Customer name / Address / City, Ontario

Monthly Statement

Account Number: 000 000 000 000 00000 0 — Statement Date: June 30, 2011

Meter Number: 0000000

Electricity Used This Billing Period

Metered usage in kilowatt-hours = 800 kWh

Your Electricity Charges

Electricity		
	On-Peak: 153.60 kWh @ 9.900¢	$15.21
	Mid-Peak: 216.40 kWh @ 8.100¢	$17.69
	Off-Peak: 428.00 kWh @ 5.100¢	$21.83
Delivery		$46.90
Regulatory		$6.04
Debt Retirement Charge		$5.60
Your Total Electricity Charges		$113.27
HST	Federal $5.67 / Provincial $9.06	$14.73
	Subtotal	$128.00
Adjustments	Ontario Clean Energy Benefit (-10%)	-$12.80 CR
Total Amount		$115.20

Sample bill for illustrative purposes only. Other adjustments may apply.

Appendix One:

who does what

Ontario Power Generation: Generates 60 per cent of Ontario's electricity.

Hydro One: Operates 97 per cent of Ontario's transmission network.

Independent Electricity System Operator: Ensures reliability, forecasts short-term demand and supply, monitors supply, and manages the Ontario wholesale market.

Ontario Power Authority: Responsible for system planning (generation, transmission, demand and conservation), contracts for new generation and conservation, and manages contracts for about 40 per cent of Ontario's generation.

Ontario Energy Board: Independent, quasi-judicial regulator of Ontario's energy sector

Licensed Transmission System Operators: Transmit electricity (There are five; Hydro One Networks is the largest).

Local Distribution Companies: More than 80, mostly owned by municipalities, deliver electricity and serve customers in a given area.

Electricity Retailers: Seventy-seven private-sector companies that sell contracts to businesses and consumers

Privately-owned generators: Facilities that produce energy (Bruce Power, wind and solar energy companies)

Appendix Two:

consultations and next steps

Ontario's Long-Term Energy Plan was informed by public and stakeholder consultations as well as advice from the OPA. In addition to issuing this plan, the government is posting a proposed supply mix Directive on the Environmental Registry for a 45 day public comment period. Following this posting, the directive will be finalized and sent to the OPA. The OPA will consult publicly during the development the Integrated Power System Plan (IPSP) and submit the plan to the OEB. The OEB will conduct a review of the IPSP including public hearings. The final IPSP will constitute the detailed long-term energy plan for the next 20 years. It will be updated every three years as required by regulation.

Public and Stakeholder and Online Consultations
September 21st – November 18, 2010
More than 40 stakeholder sessions and over 2,500 online response

↓

Ontario's Long-Term Energy Plan
November 23, 2010

↓

45-Day Posting on Environmental Registry of Proposed Supply Mix Directive
www.ebr.gov.on.ca
November 23, 2010-January 7, 2011

↓

OPA prepares detailed IPSP, holds consultations and submits it to the OEB
Mid-2011

↓

OEB Review
2011-2012

Appendix Three:

installed capacity (MW)

Installed Capacity	2003	2010 (Projected)	2030 (Projected)
Nuclear	10,061	11,446	12,000
Renewables – Hydroelectric	7,880	8,127	9,000
Renewables – Wind, Solar, Bioenergy	155	1,657	10,700
Gas	4,364	9,424	9,200
Coal	7,546	4,484	0
Conservation	0	1,837	7,100
Total	30,006	36,975	48,000

glossary – of energy terms

Baseload Power: Generation sources designed to operate more or less continuously through the day and night and across the seasons of the year. Nuclear and generally large hydro generating stations are examples of generators that operate as baseload generation.

Biomass: Energy resources derived from organic matter, including wood, agricultural waste and other living cell material that can be burned to produce heat energy or electricity.

Demand Response (DR): Programs designed to reduce the amount of electricity drawn by customers from the grid, in response to changes in the price of electricity during the day, incentive payments and/or other mechanisms. In Ontario, both the OPA and the IESO run demand response programs.

Dispatchable Generation: Sources of electricity such as natural gas that can be dispatched at the request of power grid operators; that is, output can be increased or decreased as demand or availability of other supply sources changes.

Distribution: A distribution system carries electricity from the transmission system and delivers it to consumers. Typically, the network would include medium-voltage power lines, substations and pole-mounted transformers, low-voltage distribution wiring and electricity meters

Feed-in Tariff (FIT): A guaranteed rate program that provides stable prices through long-term contracts for energy generated using renewable resources

Greenhouse Gas (GHG): Gases that contribute to the capture of heat in the Earth's atmosphere. Carbon dioxide is the most prominent GHG, in addition to natural sources it is released into the Earth's atmosphere as a result of the burning of fossil fuels such as coal, oil or natural gas. Widely acknowledged as contributing to climate change.

Intermittent Power Generation: Sources of electricity that produce power only during certain times such as wind and solar generators whose output depends on wind speed and solar intensity.

Kilowatt (kW): A standard quantity of power in a residential-size electricity system, equal to 1,000 watts (W). Ten 100-watt light bulbs operated together consume one kW of power.

Kilowatt-hour (kWh): A standard unit of electrical energy in a residential-size system. One kWh (1,000 watt-hours) is the amount of electrical energy produced or consumed by a one-kilowatt unit during one hour. Ten 100-watt light bulbs, operated together for one hour, consume one kWh of energy.

Load or Demand Management: Measures undertaken to control the level of energy usage at a given time, by increasing or decreasing consumption or shifting consumption to some other time period.

Local Distribution Company (LDC): An entity that owns a distribution system for the local delivery of energy (gas or electricity) to consumers.

Megawatt (MW): A unit of power equal to 1,000 kilowatts (kW) or one million watts (W).

Megawatt-hour (MWh): A measure of the energy produced by a generating station over time: a one MW generator, operating for 24 hours, generates 24 MWh of energy (as does a 24 MW generator, operating for one hour).

MicroFIT: Ontario residents are able to develop a very small or "micro" renewable electricity generation project (10 kilowatts or less in size) on their properties. Under the microFIT Program, they are paid a guaranteed price for all the electricity they produce for at least 20 years.

Peaking Capacity: Generating capacity typically used only to meet the peak demand (highest demand) for electricity during the day; typically provided by hydro, coal or natural gas generators.

Peak Demand: Peak demand, peak load or on-peak are terms describing a period in which electricity is expected to be provided for a sustained period at a significantly higher than average supply level.

Photovoltaic: A technology for converting solar energy into electrical energy (typically by way of photovoltaic cells or panels comprising a number of cells).

Regulated Price Plan (RPP): Rates (adjusted every six months) to ensure electricity pricing reflect the true cost of generating electricity. They provide stable and predictable electricity prices for consumers.

Smart Grid: A Smart Grid delivers electricity from suppliers to consumers using digital technology with two-way communications to control appliances at consumers' homes to save energy, reduce costs and increase reliability and transparency.

Supply Mix: The different types of fuel that are used to produce electricity in a particular jurisdiction. Normally the mix is expressed in terms of the proportion of each type within the overall amount of energy produced.

Terawatt-hour (TWh): A unit of power equal to a billion kilowatt-hours. Ontario's annual electricity consumption is around 140 TWh.

Transmission: The movement or transfer of electricity over an interconnected group of lines and associated equipment between points of supply and points at which it is transformed for delivery to consumers, or is delivered to other, separate electric transmission systems. Transmission of electricity is done at high voltages (50kV or higher in Ontario); the energy is transformed to lower voltages for distribution over local distribution systems.

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Ontario

Consulting Report

Wind Energy Study - Effect on Real Estate Values in the Municipality of Chatham-Kent, Ontario

Prepared for:

CANADIAN WIND ENERGY ASSOCIATION

Prepared By:

George Canning, AACI, P.App.

and

L. John Simmons, AACI, FRI, CMR, PLE

February 2010

CANNING CONSULTANTS INC. & JOHN SIMMONS REALTY SERVICES LTD.

February 4, 2010

CanWEA,
170 Laurier Avenue West,
Suite 810,
Ottawa Ontario
K1P 5V5

Attention: Mr. Tom Levy, P. Eng., Manager of Technical and Utility Affairs

Re: Wind Farm Study – Effect on Real Estate Values in the Municipality of Chatham-Kent, Ontario

Further to your request, we have now completed our study analysing the effect on real estate values arising from the installation and operation of wind turbines. For the purpose of preparing this consulting report, the location selected for analysis comprised an area of South Western Ontario, south of the City of Chatham, along the north shore of Lake Erie near the community of Merlin.

The following consulting report was prepared in accordance with the *Canadian Uniform Standards of Professional Appraisal Practice* for the **APPRAISAL INSTITUTE OF CANADA**. The report was required to enable the addressee to consider the impacts on the market value of nearby residential properties and their marketability, on behalf of the Association members. The applicability of the study results to wind farm developments in other regions of Ontario and Canada is discussed herein. The report, if necessary, may also form the basis of testimony at subsequent hearings.

A more detailed description of the properties analysed, together with the reasoning leading to the conclusions reported herein, is contained in the body of this report.

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This report demonstrates the following:

In the study area, where wind farms were clearly visible, there was no empirical evidence to indicate that rural residential properties realized lower sale prices than similar residential properties within the same area that were outside of the viewshed of a wind turbine.

The opinions reported herein are subject to the extraordinary assumptions, qualifications, limiting conditions and underlying assumptions as set out herein. This report contains 85 pages including Addendums, and is not valid unless it contains original signatures.

The authors reserve the right to revise the opinions set out herein, in light of any facts and conditions that become known subsequent to the date of the report, which have an impact on the conclusions reached.

A special note of thanks is extended to Paul Puopolo of the IBI Group in Kitchener for his help in providing background material etc. An outline of their most recent experience in the Electrical Energy related field has been included in Addendum “B”.

Thank you for choosing our firms to conduct this important study on wind farms.

Respectfully submitted,

John Simmons Realty Services Ltd. **Canning Consultants Inc**

L. John Simmons, AACI, FRI, CMR, PLE George Canning, AACI, P.App, PLE

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EXECUTIVE SUMMARY

STUDY PURPOSE: Execute a market-based empirical study into the effect of wind turbines on local residential real estate values. This study focuses only on the Municipality of Chatham-Kent.

FUNCTION OF REPORT: Provide an independent, objective and reproducible analysis of market evidence into the effect of wind turbines on real estate values in the Municipality of Chatham-Kent.

BACKGROUND: Wind energy development has occurred in many countries around the world for decades. While some real estate value studies have been undertaken, there have been a limited number executed in Canada. Most studies have their basis in subjective analysis, relying on anecdotal evidence and survey responses to form a basis for conclusions. This report considers only market based evidence, and applies a widely recognized and accepted approach to statistical evaluation of data sets in order to evaluate the effect on real estate values.

SCOPE OF ANALYSIS: Due to the number of existing wind energy projects in the Province of Ontario, it was necessary to select a study area wherein:

- there have been a sufficient volume of sales of properties that have taken place in close proximity to a wind farm following its completion;
- there have been a sufficient volume of sales of similar properties in the same general area but not in proximity to a wind farm (beyond the viewshed); and
- there is sufficient access to registry office sales records, and local area real estate board listing information.

STUDY AREA SELECTION: The Chatham-Kent Region of Ontario was selected as a suitable study area as it met the primary selection criteria listed above, and a sufficient volume of property sale transactions for which MLS® and registry office details were available.

IMPACTS CONSIDERED: Data was analyzed to determine the effect on real estate values as a result of proximity to wind turbines and, more specifically, on properties within the viewshed and those not within the viewshed of wind turbines. Some concerns expressed by those near proposed or existing wind farms include:

- aesthetics;
- shadow flicker; and
- sound, audible and low frequency.

None of the above influences on price were measured independently. If there is an effect on real estate values from any or all of these influences, it will be measurable from market data. Recommendations for future studies are presented within the body of the report.

DATE OF INSPECTIONS: The study area was visited on several occasions between May 18, 2009 and June 31, 2009 in order to view all properties within the viewshed as well as the control group of properties. This is known as a “ground-truthing” exercise.

EFFECTIVE TIME FRAME: Primary research material was obtained during the month of May 2009, while additional data was obtained during the month of June 2009.

STUDY METHODOLOGY:

A Multiple Regression Analysis (MRA) statistical technique formed the basis for evaluating market data for this study. The MRA procedure is the most definitive tool to segregate data in a numerical format for further analysis and interpretation. Within the MRA framework data was divided into those characteristics that best explain the variance in selling prices of comparable real estate. The focus of this study is the measurement of the effect on real estate values due to the presence of wind farms; therefore, the data was further assigned a viewshed and a control group value.

MRA is used to determine the causal effect between variables by assigning a coefficient to each variable and determining its standard error as a function of sample size relative to population size. The "T score" is defined as the relationship between the coefficient of every variable and its respective standard error.

Data sampling did not return as large a volume of sale data as expected. Accordingly, other evaluation techniques were employed to aid in the evaluation of the data through improved matching of datasets. Within the report, Optimal and Coarsened Exact Matching (CEM) techniques were relied upon as additional data matching tools to further enhance the ability to analyze data by obtaining more closely matched pairs of data from the original dataset.

The study was not limited to MRA itself, nor was it limited to data filtering systems; rather, the study also explored the raw data that formed 14 pairs of identical property sales that were sold within and beyond the viewshed of a wind turbine. This is the more traditional approach to evaluating effects on real estate, and it was considered useful to compare merits of various options of data analysis available.

STUDY CONCLUSIONS

No statistical inference to demonstrate that wind farms negatively affect rural residential market values in Chatham-Kent was apparent in this analysis. Furthermore, this study did not find any consistent evidence from the analyzed data that such a negative correlation exists in the Municipality of Chatham-Kent. During the course of gathering data, there were no unusual quantities of rural residential properties listed for sale in the study area. Four unrelated data processes were used in studying the property sales information for Chatham-Kent. The only consistency was that each evaluation methodology found that it was highly unlikely that any type of a causal relationship exists between wind farms and the market values of rural residential real estate.

BACKGROUND AND STUDY PURPOSE

Wind farm developers have out of necessity been required to address some concerns from local property owners adjacent and nearby to proposed development locations that their real estate values could decline due to the presence of a wind farm within their viewshed. Some segments of the population feel that wind turbines can intrude on viewsheds. Opposition has, in some cases been based on a belief that real estate values will diminish. While it is understandable that some property owners do not like change in their communities that they deem to be undesirable, it becomes difficult for wind farm developers to address objectors in a subjective manner.

In North America, some studies have attempted to evaluate the relationship between residential real estate values and proximity to a wind turbine. While some of these studies have found a negative effect on nearby real estate value that has been attributed to the proximity of a wind farm, others have not found such a correlation.

This study has focused entirely on tangible market-based data obtained through recognized means such as MLS®. In addition, some research has been conducted into similar studies in other jurisdictions. Although exhaustive research was not conducted, studies conducted in the U.S.A., Australia, England and one in Ontario were reviewed. Some of these were based on anecdotal evidence and some on the basis of survey responses. To the best of our knowledge, no reports have been produced within Canada presenting a comprehensive analysis of market data, such as that presented herein.

CLIENT AND FUNCTION

This report has been prepared for the Canadian Wind Energy Association (CanWEA) to assess the effect of wind turbines on the market value of local residential real estate in the Municipality of Chatham-Kent, Ontario.

PROPERTY RIGHTS ANALYSED

The ownership rights of those properties analysed in this report are those of the ***"Fee Simple Interest"***, subject to the four powers of government: taxation, expropriation, police power and escheat. A ***"Fee Simple Interest"*** may be defined as *"the ownership of real property rights unencumbered by any other interest."*[1]

DATE OF INSPECTION

Properties adjacent and near to various existing wind energy developments were identified, researched and inspected by the authors during the months of May and June 2009. The initial site inspection was conducted on May 18, 2009.

EFFECTIVE DATE OF REPORT

July 1, 2009 has been selected as the effective date of this report as it encompassed the time frame of inspections and data research.

DEFINITION OF MARKET VALUE

"Market Value" is defined[2] as:

> *The most probable price which a property should bring in a competitive and open market as of the specified date under all conditions requisite to a fair sale, the buyer and seller each acting prudently and knowledgeably, and assuming that the price is not affected by undue stimulus.*

---

[1] The Appraisal of Real Estate, (Canada Edition, 1992), 12

[2] Canadian Uniform Standards of Professional Appraisal Conduct 04/15/2008

Implicit in this definition are the consummation of a sale as of the specified date and the passing of title from seller to buyer under conditions whereby*:*

1) buyer and seller are typically motivated;

2) both parties are well informed or well advised, and acting in what they consider their best interests;

3) a reasonable time is allowed for exposure in the open market

4) payment is made in terms of cash in Canadian Dollars or in terms of financial arrangements comparable thereto; and

5) the price represents the normal consideration for the property sold unaffected by special or creative financing or sales concessions granted by anyone associated with the sale.

The foregoing definition of Market Value assumes a competitive scenario with more than one potential buyer, and a seller who is willing to sell in accordance with the Highest and Best Use of the property. This inherently assumes that the seller no longer needs or wants the property and wishes to convert the asset to cash.

The intent of this study is to evaluate the effect of wind farms on the market value of nearby residential properties.

EXPOSURE TIME:

With respect to Item *3* above in the Market Value definition, exposure time is the estimated length of time the property interest being appraised would have been offered in the market prior to its hypothetical sale at the estimated market value on the effective date of the appraisal. Reasonable exposure encompasses not only adequate, sufficient and reasonable time, but also adequate, sufficient and reasonable effort. In addition to price, exposure time is also a function of use and type of real estate.

As this study does not estimate market value of a specific property, consideration of the exposure time as a specific undertaking is unnecessary. The relationship of exposure time to selling price was considered in general terms relative to the impact of nearby wind farms.

Some studies attempting to reflect or measure a loss in market value due to the proximity to a wind farm have suggested that the influence has resulted in increased marketing times. In order to address this possibility, a review of MLS® listings in the area was undertaken to ascertain if the exposure to a view or proximity to a wind turbine contributed to the length of time a property was listed on the market before a sale was recorded. While many properties were listed on a 90 day listing basis, some listings sold within that time frame, and some expired unsold. Some were relisted for sale and others not, while others were relisted at reduced prices, and still others not. There are a number of variables that can influence the length of time that a property is listed for sale, including:

- asking price was too high;
- condition of the property less than desirable;
- poor curb appeal;
- location relative to employment;
- undesirable neighbouring properties;
- regional economic conditions/unemployment levels;
- time of year;
- volume of competing listings; and
- inadequate marketing/agency representation.

These are the primary reasons, within which there are subcategories of more specific issues that may explain the length of time a property is listed for sale. A study incorporating a detailed analysis of these factors and isolating any specific influence of proximity to a wind turbine is beyond the scope of this report. Further, a greater volume of sales data would be required over an extended period of time. Reliance on anecdotal opinions as a basis for a credible indication of value influence or loss is not evidentiary, nor is it reproducible.

Even though the review of the evidence conducted for this study did not disclose any probative evidence to suggest that proximity to a wind turbine had an influence on the length of listing time, this issue would require a more comprehensive (and independent) study to reach a firm conclusion.

DEFINITIONS

In this report certain words and terms have been used that require defining for those readers unfamiliar with this type of report. As considered by the authors, these are as follows:

Algorithm:	A step by step method of solving a problem using numbers in computations.
Avg:	This is the short form for Average being the number of observations divided by their total.
Bins:	Bins are used in statistical graphing or displaying of items of a similar value or characteristic**.**
CEM:	Coarsened Exact Matching is the name of another matching data program used in the study.
Coefficient:	The coefficient is the returned number allocated to a specific property variable from using regression analysis.
Control Group:	That group of properties not affected by the alleged impacts of a wind turbine.
Histogram:	A bar chart that represents a frequency distribution of data.
Log:	The log is the power that a base number is raised to.
Mean(s):	A mean, or arithmetic mean, is the total of a list of numbers divided by the number. It is an average. It reflects a central tendency.
MW:	Short form of "megawatt", which equals 1,000 kilowatts or 1,000,000 watts.
Optimal:	This is the name of a matching data program used in the study.
Rated Capacity:	Manufacturer specified maximum power output of a wind turbine. Typical large wind turbines have rated capacities of 1.5 megawatts or more.

Regression: The relationship between the mean value of a random variable and the corresponding values of one or more independent variables.

Scatterplot: This is a graph that shows any variable on the "X" axis plotted against any variables on the "Y" axis.

Viewshed: A point within the study area whereby a sale property had a view of one or more wind turbines.

Viz: Short form for visible.

No Viz: Short form for not being Visible

Wind Farm: A project containing more than one wind turbine, each electrically connected to each other, for the purpose of selling electricity to the electrical grid.

Wind Turbine: A structure that uses airfoils (commonly referred to as a blade) to extract kinetic energy from the wind, and converts this to electrical energy. Each wind turbine typically contains three blades. In this study area, typical wind turbines have hub heights of 80 m, blade lengths of 41m, for a total max height of 121 meters.

CRITICAL AND EXTRAORDINARY ASSUMPTIONS

For every hypothetical condition, an Extraordinary Assumption is required. According to the *Canadian Uniform Standards of Professional Appraisal Practice* (CUSPAP 04/15/2008), an Extraordinary Assumption *"refers to a hypothesis – either supposed or unconfirmed – which, if not true, could alter the appraiser's opinions and conclusions."*

In order to achieve this objective, the following specific critical assumptions were made in the preparation of this study:

1. That comparable sale transactions negotiated at or after the issuance of building permits for tower and turbine installations would have reflected any and all concerns in the purchase price.

2. That none of the comparable sale transactions relied upon in this report are the subject of legal actions resulting from non-disclosure of information regarding the towers or turbines by any agents or vendors involved in the property sales.

3. That any and all adverse effects on market value as perceived by market participants would be reflected in the market evidence of nearby real estate transactions.

4. All estimates and projections are based upon circumstances and economic conditions prevailing as of the effective date, and that the critical assumptions above have been made.

SCOPE OF VALUATION AND REPORTING PROCESS:

The findings and conclusions outlined in this study are based on:

- Identification of wind farms wherein nearby residential property sales have taken place;
- Exterior inspection of properties sold in close proximity to wind farms, and those properties outside the viewshed;
- Research conducted for comparable property sales through MLS® records, GeoWarehouse®, MPAC (Municipal Property Assessment Corporation) and the records of the Land Registry Office. Photostatic copies of this data are available in the appraiser's file.
- Analysis and inspection of comparative data, confirmation of sale details and ownership/title transfer;
- Determination that the Highest and Best Use of target property and comparative sales properties are as categorized;
- A review of published statistical data as relating to economic indicators, and where necessary, a discussion in some detail;
- Research and selection of appropriate study references;
- Confirmation of data relied upon in the analytical process

VALUATION PROBLEM

The purpose of this study is to consider the effect on the market value of residential properties due to the presence of a wind farm. Based on the background research, it is evident that some members of the general public hold negative opinions with respect to the desirability of wind farms and perceptions of their effect on real estate value. This report considers a variety of perceived influences, and provides an estimate of their effect on local real estate values.

The most frequently identified factors perceived to have an adverse effect on the market value of residential real estate are:

- aesthetics;
- shadow flicker;
- vibration; and,
- audible sound (low frequency waves);

Measuring the extent of these perceptions and how they affect local real estate values requires the analysis of a wide range of variables associated with any given property.

The thesis is that when an identified study property is valued both with and without the identified impact, the difference represents the change in market value attributable to that impact. This study considers the impacts identified above on residential properties adjacent to an existing wind farm on a collective basis, not individually.

Real estate types considered in this study are rural residential properties.

During the course of conducting research and assembling the data for analysis, the following was undertaken:

- review of real estate effect studies prepared by others in Canada, USA, Great Britain, Australia and Europe (see Addendum C);
- review of fact sheets, guidelines and other relevant publications prepared by the Ministry of the Environment, Ontario (See Addendum D);
- attendance at a public meeting on the proposed regulations to implement the new Green Energy and Green Economy Act, 2009;

- discussions with a number of property owners in attendance;
- discussions with real estate developers, real estate brokers and other market participants; and
- discussions with several consultants involved in the development of wind farms.

During the course of research it was noted that although building permits are issued for construction of wind turbines, there could be a time delay of as much as 1 year from when the permits are issued to when work begins. These delays were attributed to a variety of reasons such as a shortage of cranes or ground conditions for preparing access routes tower sites.

While some of the nearby residential sale transactions may have been completed at or after the issuance of a building permits for the wind turbines, the towers may not have been in place or in operation. In such instances, due to a public information meeting regarding the approval process, combined with ongoing news media coverage of the projects, an assumption was made that purchasers of a particular property would have made a conscious decision as to whether or not the proximity of wind turbines influenced their purchase price. Only one owner, who purchased a vacant lot for a future house, expressed disappointment that he had not been aware of the nearby wind farm approval. He had not decided whether to build or not.

STUDY AREA SELECTION

Initially a number of areas containing wind farm developments were investigated to locate a suitable location for study. The criteria for selection included:

- A reasonable number of wind farm developments within a region, each having similar economic influences;
- Availability of MLS® data and registry office records for data confirmation;
- A base of residential properties that have potential for being influenced by exposure to wind farm developments;
- A sufficient volume of transactions of similar property transactions within that region that would provide an adequate base for analysis; and
- A reasonable travelling distance for conducting research since several property and area inspections would be required.

The Chatham-Kent area was ultimately selected as it met the above criteria. At present there are understood to be 64 operating wind turbines in the area. Chatham-Kent is attempting to position itself as a leader in Ontario’s renewable energy sector. Wind turbines erected in the study area had rated capacities of 1.5 MW, and turbine blade lengths of 41m metres. According to the Chatham-Kent web site, February 2009, the Ontario Power Authority recently awarded three additional wind power projects. These approved wind farm development projects are expected result in the addition of a further 165 wind turbines for a total of 229 turbines within this region.

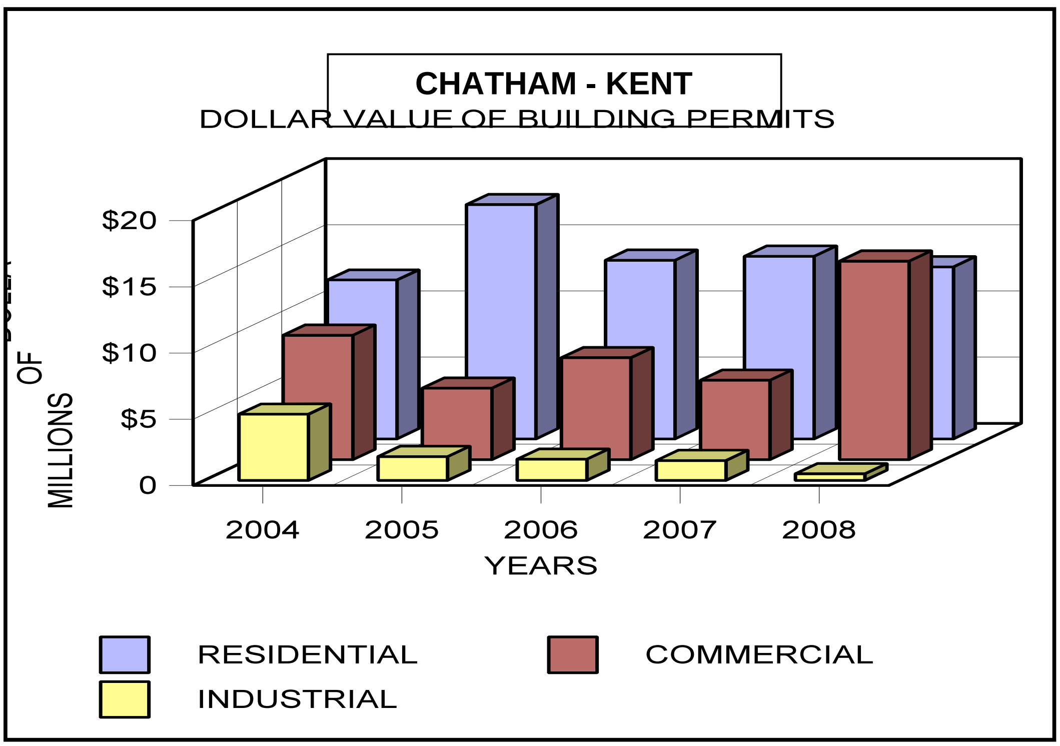
GENERAL OVERVIEW OF THE STUDY AREA

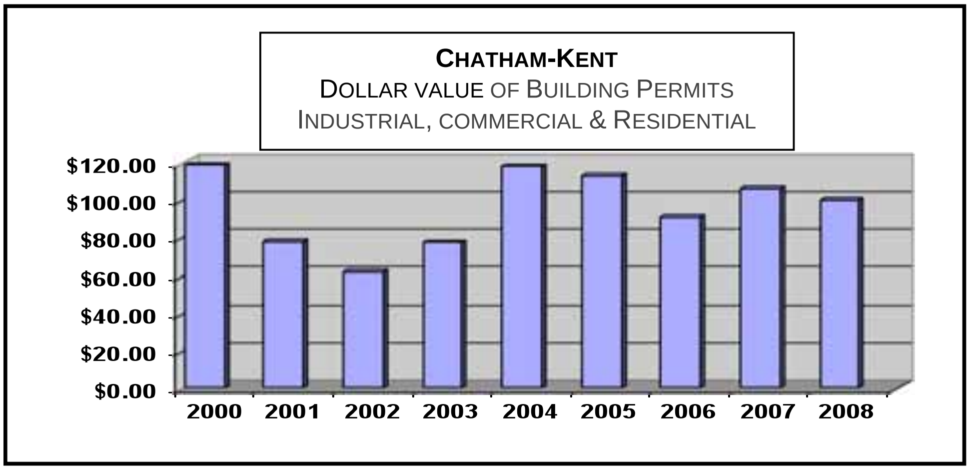
The study area in which the sale properties were located is known as the Municipality of Chatham-Kent. This Municipality is composed of 9 major communities and the surrounding rural areas that were amalgamated on January 1, 1998. The location of Chatham-Kent relative to major cities is shown below.

The population of Chatham-Kent as of 2006 was 108,177 compared to a population of 107,341 as of 2001(last census). .

The total workforce within Chatham-Kent is 58,860 persons. The occupation by industry that has the highest number of workers is Manufacturing and Construction, followed by Wholesale and Retail Trade, Business and Other Services. Agriculture and Other Resource based industries employ 10% of the labour force. If the work force was divided by Occupations, the highest percentage would go to Sales and Service Occupations followed by Trades, Transport and Equipment Operator and related Occupations. A strong tertiary occupation would be unique to processing, manufacturing and utilities.

International Truck and Engine Corp is the largest manufacturer in Chatham-Kent with 1,150 employees as of 2004. They are now down to 200 and there is a potential total plant layoff as of June 30th of this year. Union Gas Limited has 679 employees as of 2004 and this has not changed. Autolive Canada with 600 employees as of 2004 are now reduced to 50 employees, while YA Canada Fas Track Mail Processing Facility has 500 employees as of 2003 and are now reduced to 450 employees. Many of the smaller industries have between 200 to 300 employees. The following is a graph of the dollar value of building permits issued between 2000 and 2008 for the Chatham-Kent expressed in millions of dollars.

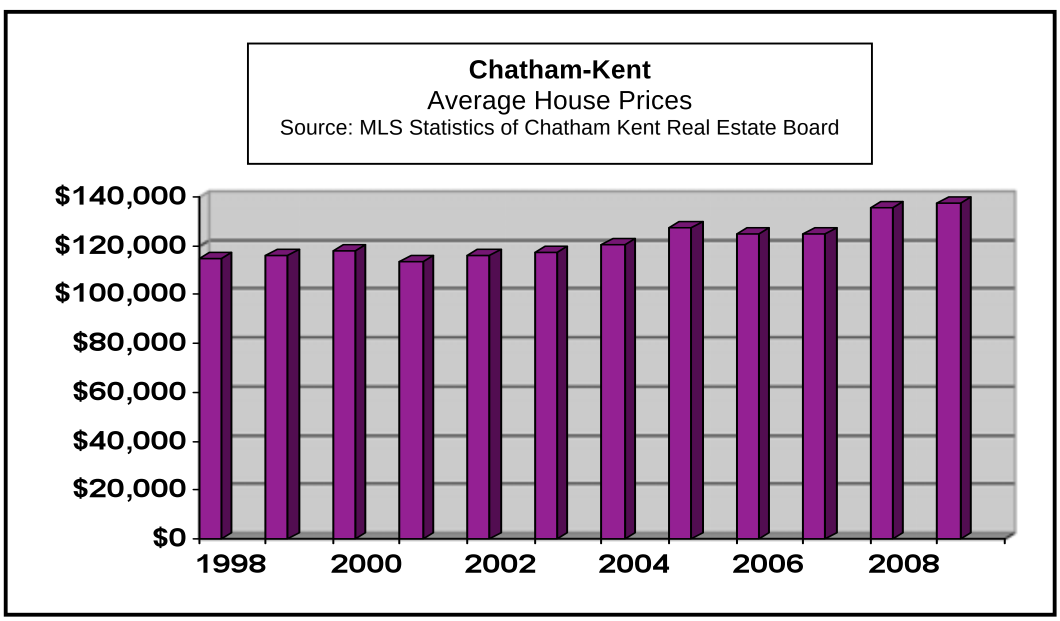




A surge in overall construction activity was seen at the turn of the millennium following the severe recessionary period during the early 1990's. Construction activity then slowed during a period of absorption followed by improvement during 2003. Since that time construction activity has been largely stable.

The impetus of growth in new residential construction resulted from low interest rates and the pent up demand for new housing following the recession in the early 1990's. The major focus of new residential construction has been within the urban areas of the City of Chatham.

A review of Multiple Listing Service (MLS®) statistics for Chatham-Kent show the average selling house prices for a given year. The following graph plots these average house prices between 1998 and 2008.



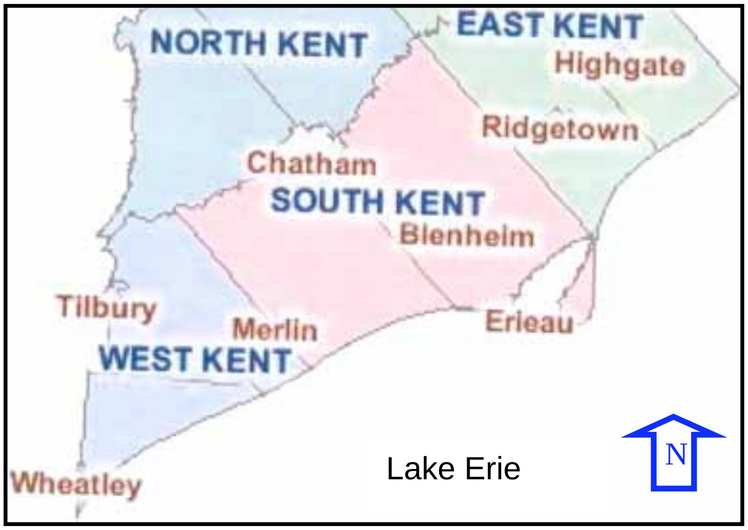
The previous chart of average house prices indicates a general increasing trend in average property sale price within Chatham-Kent. This graph shows prices that include a large volume of house prices from the urban area in the City of Chatham which are believed to have an impact on the overall annual average price. The MRA used in this study demonstrates that within the data set analysed, general price levels in the rural areas were not a significant factor in explaining the variances of sale prices.

STUDY AREA

The study area has a rural character, implying that the primary economic driver is agriculture or agriculture-related. In 2008, Chatham-Kent was the third highest producer in the entire Southwestern Ontario region for Winter Wheat, Grain Corn and Soybeans. In 2007(most recent) Chatham-Kent was the highest producer of tomatoes in Southwestern Ontario.

Transportation through Chatham-Kent is via Highway 401 which bisects Chatham-Kent traverses the full width of the municipality. Highway 401 extends from Windsor/Detroit to the easterly boundary of Ontario. Chatham-Kent is bounded to the south by Lake Erie. The study area is located between Lake Erie and Highway 401.

The rural housing type throughout Chatham-Kent is diverse and ranges from turn of the century homes (built between 1850 and 1900) to modern homes less than a year old. Typical structures include wood frame construction with brick veneer or wood siding, and 1 to 2 storey, including a single or double garage and an outbuilding that could serve as a workshop or as exterior storage. There are no single rural areas of Chatham-Kent that contain a higher concentration of rural properties. These property types are homogeneous throughout the Municipality of Chatham-Kent, and are commonly found throughout Southwestern Ontario. A general map of Chatham-Kent is provided below.



SUMMARY

Municipality of Chatham Kent

The Municipality of Chatham-Kent is dependant to a significant degree upon agriculture, manufacturing, and vehicle related industries. The City of Chatham has recently experienced an economic downturn of the auto and truck manufacturing sector due to its proximity to Windsor and Detroit, while the agricultural sector has been largely unaffected.

The Municipality comprises of the former City of Chatham with a population of approximately 44,000 people, with another eight communities within its borders with a total population between 1,000 and 12,000 people. Chatham-Kent has not grown substantially over the last five to ten years. It has remained fairly stable. Very little growth is expected within this region of South Western Ontario over the next decade. This is typical of other regions.

Study Area

The study area has been dominated by the agricultural industry for well over 100 years. Its success is due to fertile soils and fairly high heat units. Heat units in the Chatham-Kent region range from 3,340 and 3,560, in contrast to just north east in the London to Guelph area where the heat units range between 2,680 and 2,890. In other respects, the Chatham-Kent region is fairly typical to rural areas throughout other parts of South Western Ontario. Land uses within the study area are heavily dependent on cash crop farming. There is also a good mixture of rural housing that offers a wide range of amenities and locations.

ANALYSIS METHODOLOGY

The market for rural residential real estate consists of those individuals or families typically seeking property that provide a location, utility and area features consistent with their individual needs, and accordingly, are willing and prepared to pay a competitive price. In a competitive market, an informed purchaser will pay no more for a particular property than the cost of acquiring a satisfactory substitute that provides equal expected accommodations without undue delay. Those properties having undesirable features, either within the property itself, or nearby, often require a longer market exposure or tend to sell at lower prices. Wind farms are perceived by some to be such a nearby adverse external influence. Market value is typically estimated through the analysis of similar properties that have sold proximate to the date of valuation. If the market demonstrates that wind farms are indeed a negative influence, then an observable trend in lower selling prices should be apparent. The primary focus of this analysis is to assess the presence (or lack of) trend, and to quantify the extent of the price differential.

The identification and measurement process firstly requires the careful selection of properties that have sold proximate to a wind farm development. The properties must have been sold on the open market, with the vendor and purchaser being at arms length, both parties being fully aware of the neighbouring land uses, and neither being unduly motivated to complete the transaction. The selling prices of those properties are then compared to sales at or about the same time period that are distant from the wind farm project, yet are similar in nature and utility to the study properties.

There are basically two techniques for measuring the effect of a feature on the value of real estate, namely a “Paired Sales” analysis and by MRA.

A “Paired Sales” analysis has been used over the last few decades as the “default” solution for extracting variables that influence price. A “Paired Sale” would be a sale of a property that is identical to some other property under study with the exception that it is not subject to a specific variable (whatever that might be). In studying the two different index groups, the real estate analyst would extract a difference in price levels. The conclusion that would be reached is that the differences in the price levels of the comparable sales would be due to the influence of the variable in question.

Unfortunately, this “Paired Sales” methodology contains inherent limitations and is often considered to be flawed. Many academics and real estate practitioners have therefore stopped using this approach to evaluating effects from externalities on local real estate values. The difficulties and flaws with this procedure include:

(1) Insufficient quantities of “Paired Sales”. Ideal paired sales rarely, if ever, exist in the market place.

(2) Variations between the “Paired Sales” and the influencing factor under review require a substantial volume of “Paired Sales” to hold constant the other property differences or variables within the group.

The analysis is often undertaken by an application of a Direct Comparison Approach through a process of adjustment. The comparable sale properties, when adjusted for differences in the site size, building features, zoning, municipal services, financing etc, are thought to provide a basis or benchmark for indicating the market value of a study property absent the perceived influencing factor. A weakness in its application is that the adjustments are mostly unsupported and contain unconscious bias that can invalidate the results.

In this study a “Paired Sales” was prepared by using analytical tools such as CEM and Optimal which selects “Paired Sales” through a process of utility scores and bins. Since the selection process is not the sale price, these “Paired Sales” are drawn without bias.

The application of “Paired Sales” was enhanced by applying re-sales of properties within the main data set since a re-sale is closer in identity to what a “Paired Sale” should be.

Although considered in this study, it is recognised that it is an imperfect methodology applied to measure influences in an already imperfect market place.

MULTIPLE REGRESSION ANALYSIS (MRA)

The MRA technique has the ability to study large quantities of transacted sales data that are influenced by numerous variables over a specific time period. It is also known as a Multivariate Linear Regression Analysis.

Single Linear Regression analysis is a means for building models that describe how variation in one set of measurements affects variation in another set. The analyst forms a hypothesis that one variable is dependent on or responds to another variable (independent or predictor variable). In real estate value analysis, the dependent variable is often the sale price of a property in total or on a price per unit basis. The independent or predictor variable can be a characteristic of the property that is believed to have an influence on the dependent variable-sale price in this example. Aided by a computer with the ability to perform many calculations quickly, regression analysis provides a systematic method for building an equation that summarizes the relationship between the two variables. The resultant equation can then be used for the prediction of value.

Multiple Regression Analysis (MRA) extends the idea of a two variable linear regression model by allowing an analyst to include many explanatory factors to the regression equation. As in simple linear regression, a regression coefficient measures the impact of changes in each explanatory variable on the response variable. In MRA, the coefficient for each variable represents the effect of that variable on the dependent variable while holding the affect of all the other variables constant. In addition to its usefulness in prediction, this allows the use of MRA as an exploratory tool where the coefficients can be interpreted as a level of contribution of the predictor variable.

For this particular study, an MRA model can be specified that reduces the many characteristics of index properties into values for different variables. A regression run on a complete data base can then generate coefficients for the variables. The analyst's expertise in deciphering or interpreting these coefficients will lead to many conclusions of the market place.

Regression analysis is based on a number of assumptions as to the nature of the underlying data. The use of mathematical statistics allows the analyst to perform many diagnostic tests on the specified model to assess the level to which the assumptions are met. This allows the analyst to explicitly state the level of confidence that can be given to the results of regression modeling. The recipients of the findings of such analysis can then make better informed decisions.

IMPLEMENTATION OF MRA

By using MRA, a “Model” of behaviour is developed that explains the variation in the prices of the comparables found in the market place. The comparables are sampled from a total potential number of sales within the array. The comparative data gathering process has the potential to gather a very high percentage of all possible sales. When using MRA, more sales data are better.

Once the data is placed into the MRA model, a “regression” run plots the results. MRA models are “smoothed” out to improve accuracy and functionality when deciphering the large quantities of data. Statistic tests are performed that assess the overall reliability of the model.

Once efficiency is established, the MRA produces a number of statistical reports. The ones of interest to this study are the coefficients. Graphics within the report demonstrate the possible relationships between variables.

The MRA indicates how much or how little wind farms have on real property, positive or negative. The MRA also provides a confidence interval. Statistically, the accepted confidence interval is established at the 95% to the 99% level. (The goal is to determine how statistically confident we are of the results and to demonstrate what the results mean.)

Like most types of analysis, MRA requires large quantities of data that particularly demonstrate the differences between properties. We are hopeful that there is a sufficient quantity of data that can be gathered for this type of study. MRA is the only known process that can effectively absorb and examine numerous interactive factors that influence real estate prices, all at the same time. It accomplishes this task by building all the factors of influence into the regression equation. As the model studies the influence of say, distance, it holds all the other factors (age, site size, building size, etc) constant. It continually repeats this individual process. That is why MRA is ideal for isolating the coefficients (expressed in dollars) to a given variable. Interpretation of the results is a key. It is not prudent to simply accept the results of the MRA blindly. The analyst must “step back” from the MRA outcomes to see if the results coincide with our appraisal knowledge of the problem at hand.

VALIDATION OF THE USE OF REGRESSION ANALYSIS

Regression analysis is a statistical modelling tool that has been employed very successfully in “Data Mining” and is used frequently at the corporate and government levels.

The Province of Ontario has adopted MRA in the assessment of residential properties for their new base of 1996. They also have test projects underway to extend MRA to other property sectors (vacant commercial land, industrial buildings, bank buildings and commercial plazas).

The Province of British Columbia has been using MRA in assessment for many years and has been a major consultant to the Province of Ontario on the implementation of their system.

Regression analysis is used by Statistics Canada in determining the Gross National Product for Canada and for the analysis of national data.

Regression Analysis was used in the USA by a large accounting firm to justify to the IRS the existence of “economic obsolescence” in large industrial buildings.

In this report a Regression Analysis was adopted as the preferred technique, however, due to the availability of several paired sales, these were analysis as a method of confirmation.

APPLICATION OF MULTIPLE REGRESSION ANALYSIS (MRA)

A total of 83 house sales within parts of Chatham-Kent that occurred over the last two years were analysed, proximate to wind farms, with the most recent sale in May 2009. This is a small sample relative to the size of data sets usually used in observational studies of this type. While a larger volume of sale would be preferred, this was a constraint attributable to the rural nature of the area where wind farms are placed. They are generally not developed in densely populated areas.

A ground qualitative view assessment technique was used to assign a sale property to either the viewshed group or the control group. For the purpose of this study, the viewshed is “a point within the study area whereby a sale property had a view of one or more wind turbines”. Any sale property found that did not have a view of a wind farm was deemed to be outside of the viewshed. Wind farms were not visible to all properties within the general area, as the view was sheltered either by bush lots or tree rows.

A simple difference in the means of sale prices between the viewshed group and the control group was employed to estimate the impact of a wind turbine(s). When these groups are different in characteristics relevant to the outcome of sale price, as they usually are in observational studies, the study is required to adjust for these differences. Regression modeling was the primary approach to make these adjustments. This approach was first used on the entire data sample and then on reduced data samples after the data was preprocessed through matching methods. These matching methods (Optimal and CEM) make the viewshed and control groups more comparable by pruning the least comparable sales from the full data set. Adjustments are then made on remaining differences in the reduced data sets by regression.

IDENTIFICATION OF COMPARABLE SALES

In assembling the comparative sales data, research was conducted with local Real Estate Board MLS® records, GeoWarehouse®, MPAC (Municipal Property Assessment Corporation) and at the Land Registry Office, with a view to finding properties within the viewshed and outside of the view shed.

The assembly of data did not focus on specific target residential property types, only residences on small acreages or lots that were within the viewshed or not in the viewshed. Sales of residences within small hamlets or communities were omitted from the data set since the selling prices of these properties were influenced by the convenience municipal services and amenities. Furthermore, wind farms are not typically situated in proximity to these locales. Sales of farm acreages with buildings were not included in this analysis as there was an insufficient volume of transactions for an effective analysis.

All of the comparable sales were inspected from the roadway. The sales were then cross referenced chronologically to identify any type of a buying pattern related to the sale dates of the transactions used in the study. The property variables or characteristics that were identified as having a potential influence on the study results are as follows.

Address: The address of the sale property.

Age of the House: The chronological age of the house at the time of the sale.

Basement: The sales were identified as either having a full basement or not at the time of the sale.

Basement Finishing: The sales were identified as either having some basement finishing or not at the time of the sale.

Condition of the House: Each house is classified as being in Fair, Good or Very Good condition.

Date of Sale: The date at which the sale property was determined to be the data whereby all conditions of the sale were met.

Elapsed Months: The difference in time between the oldest dated sale and the next occurring sale in months.

Garage: The sales were identified as having a garage or not.

House Size: The exterior square footage of the house above grade.

Lake Front: Signalling the difference between properties that were located on a river or lake front as opposed to not.

Location: Considers the possible difference of the sale property (within and beyond the viewshed) relative to important amenities such as major highways and goods and services.

Lot Size: The size of the lot of the sales expressed in square feet.

Number of Storeys: The number of storeys of the house on a given sale property.

Outbuildings: The sales were identified as having some type of a outbuildings such as a shed or barn.

Selling Price: The price which was agreed upon by the buyer and the seller.

Viewshed: Any sale that was located within a view of a wind turbine.

Viewshed Within: Any sale that was located in a viewshed was differentiated by a score that would separate the proximity of the wind farm to any sale within the view shed.

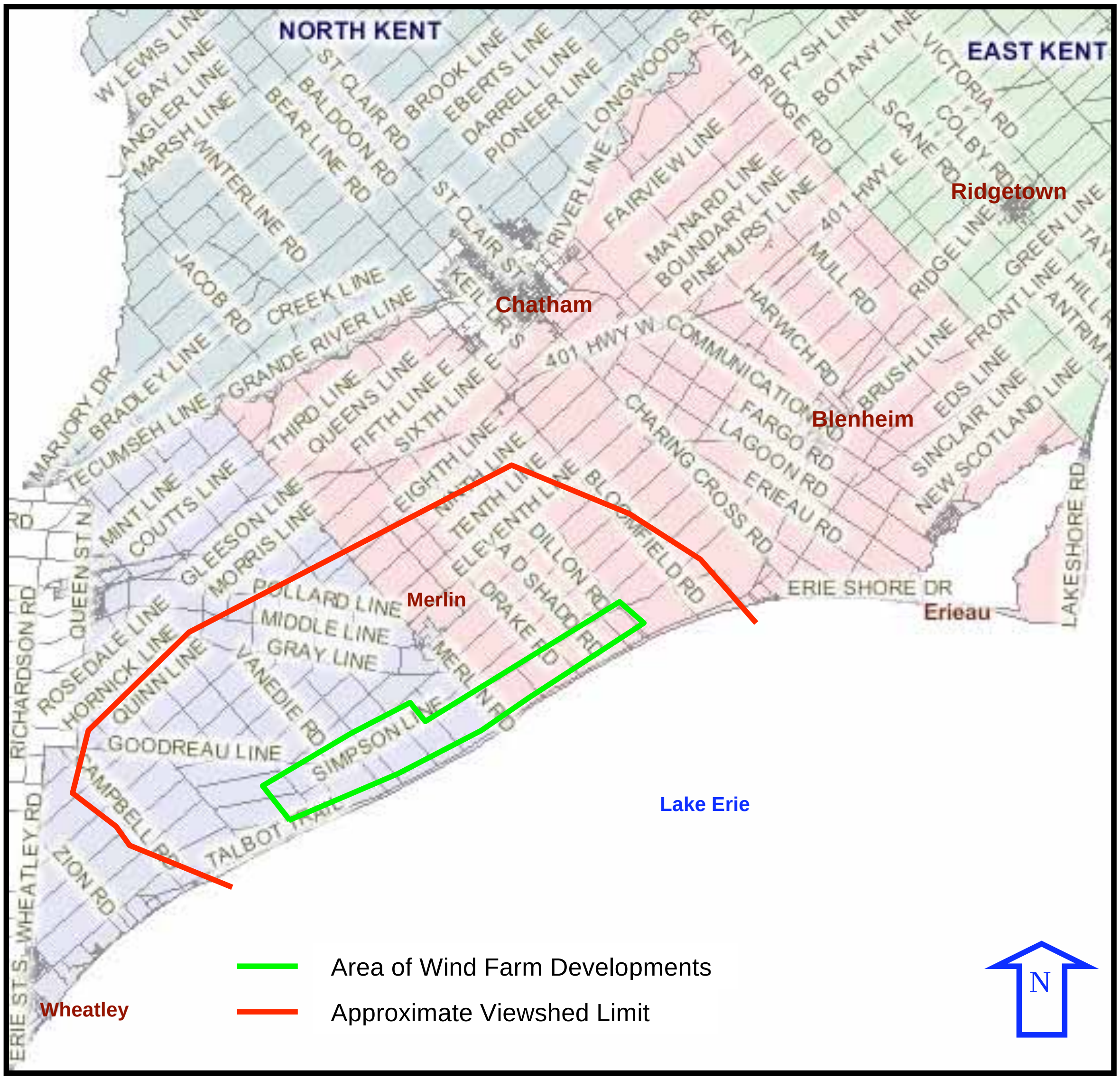
The specific Viewshed Within variable ultimately eliminated and said either the property had an average view or a no view. This is identified by Viewshed3. The number 3 does not have any reference other that this is the third name in the selection process of variables that tried to consider distance.

OVERVIEW OF THE PROBLEM AND THE TECHNICAL REPORTING ASPECTS OF THE STUDY

Introduction

Wind farms can be perceived by some nearby residential homeowners to be a source of nuisance, as a result of audible sound and aesthetics (visual appearance). Some claims have been made that suggest the presence of a wind turbine or wind farm could result in diminished real estate values for properties within the viewshed. Rural residential real estate is the principal target of this perceived association.

An analysis of sales of single family houses in south Chatham-Kent's rural area was undertaken to test this hypothesis. This study attempts to determine if residential properties located within a wind turbine's viewshed were or were not negatively influenced by reflecting lower sale prices in a statistically significant manner. By comparing properties that sold during the last several years, with a wind turbine(s) clearly visible and those farther way and outside the viewshed, but which are of similar age, lot size, and with similar amenities and economic influences, the differences in the selling prices of properties within the turbine's viewshed, on average, should be noticeably lower than the selling prices similar of similar properties outside a wind turbine's viewshed. The following is a map of the approximate area of the overall view shed. The red arc signifies the approximate location of the view shed. It should also be noted that some properties within this red arc were classified as being outside of the viewshed as the wind turbines were not visible due to tree lines or bush lots.



Study Design

This study focused on the inferred effects of Chatham Kent wind turbines on property prices. Specifically, it examined how the local market prices residential properties located within the viewshed of wind turbines compared to a control group of property sales outside the viewshed. As the wind turbines of this study are in a rural area of the County, obtaining a sample of sufficient size required the collection of house sales over a period of 2 years.

As part of this study's design, an examination of other previously executed studies, undertaken to measure the effect of wind turbine views on property pricing was completed. Although there is substantial literature on measuring effects of undesirable land uses on residential properties, research on the actual market effects of wind farms is lacking. Wind farms as a large scale energy source are relatively new to Ontario, which may explain the thin inventory of available studies. Schedule "A" outlines the research literature referenced at the outset of this study.

In this study, the loss measured is the realized capitalized loss that occurs when a property is sold. This study does not look at the losses associated with a delayed sale or other issues that may affect the bundle of property rights infringed by the proximity of a wind turbine. It was noted that it was nearly impossible to determine the exact time when the wind farms were constructed. A considerable time lag was noted between the issuance date of the building permit to when the wind farm was actually physically constructed. The time lag was alleged to be due to weather, the availability of cranes to erect wind turbines, and road construction. However, it is known that considerable public awareness of the construction of wind farms was imminent since public meetings occurred and wind farm developers held barbeques and information meetings regarding the construction of wind farms in areas of Chatham-Kent.

This study presupposes the existence of two causal states, which are based on visual perception of a nearby wind turbine from a property or absence of such. For our purposes, they are labeled avg viz and no viz. They are not, however, well-defined states because of their qualitative nature and the observation made from one point on the ground. Although a wind turbine may be visible to an observer from an upper floor window of a house, it may not be visible to an observer on the ground. Any individual sale property in our data was assigned to one of two possible causal states and associated potential outcomes based on a view of a wind turbine(s) or not.

In this study, the effect of a wind turbine as the difference in the sample average of the observed sale price between the avg viz group and the no viz control group was estimated.

Excluding ID variables, these data were measured on 14 physical and location variables. Of these 14 predictor variables, only 8 variables were discovered to be important predictors of sale price based on initial regressions. These predictors and the binary variable viewshed3, which is instrumental to measuring wind turbine visibility effect on price, were regressed on sale price in the final regression model on the full data sample. A random sample of 6 sales from the data set measured on these variables is in Table 1. Variable definitions are given in Table 2.

Figure 1 shows graphically the distribution of values for the variables in the data set employed for the final model of the regression analysis. As indicated by the plot for the binary viewshed3 variable of primary interest in this study, the control category has about 3 times the number of sales in the avg viz category. The distributions of sale price, house size and lot size are skewed to the higher values.

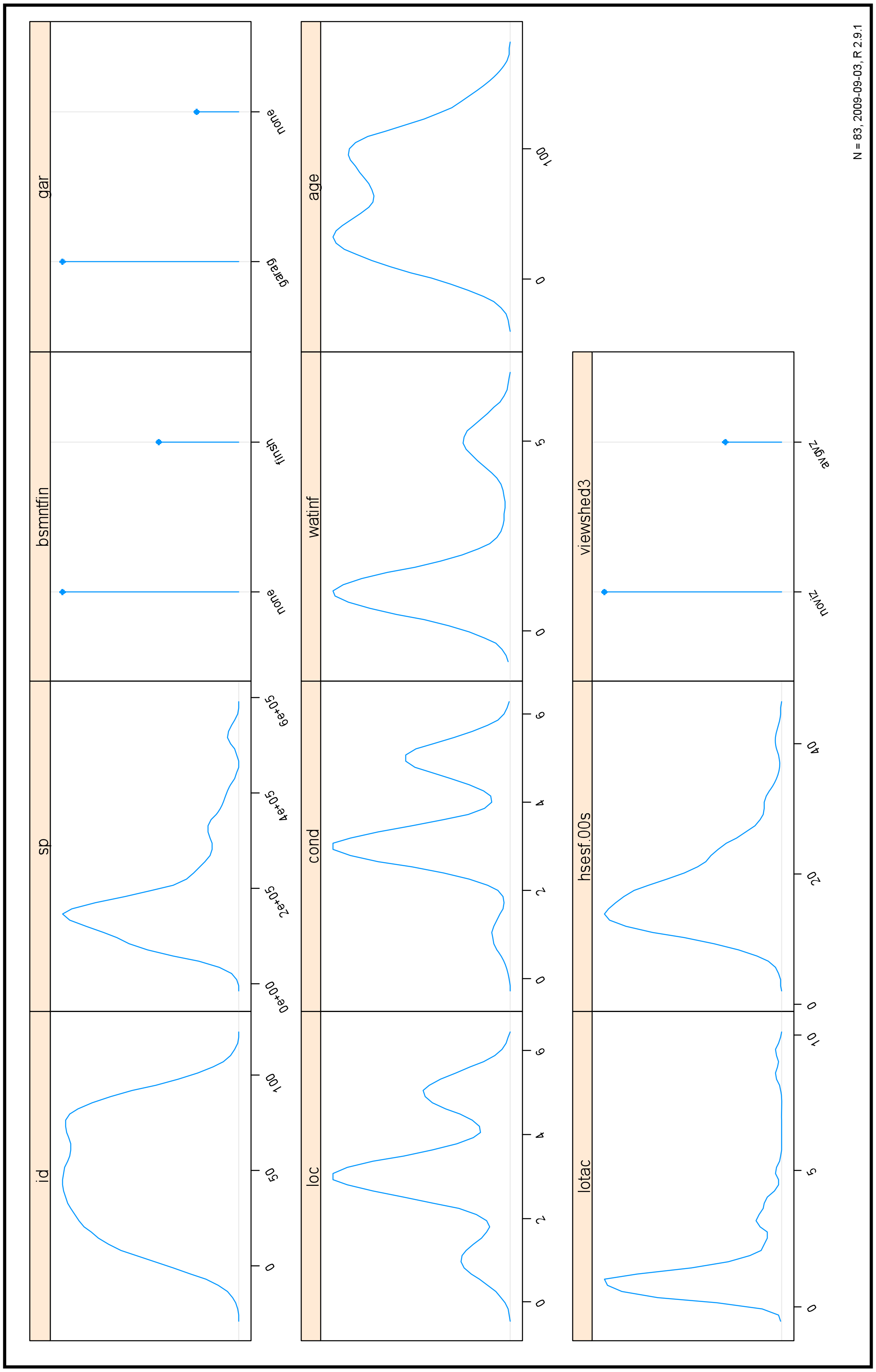
Table 1

id	sp	bsmntfin	gar	loc	cond	watinf	age	lotac	hsesf.00s	viewshed3
1	96000	none	garage	3	3	1	30	0.373	17.85	avg viz
3	124000	none	garage	1	3	1	49	0.744	10.73	avg viz
4	79000	none	garage	1	3	1	44	0.625	7.92	no viz
5	174000	none	garage	1	5	1	97	0.920	23.26	no viz
6	99500	none	garage	1	3	1	98	0.497	12.70	no viz
7	120000	none	none	1	3	1	82	1.311	15.14	no viz

Table 2: Variable Definitions

Id: property sale identification	**cond**: qualitative assessment of house condition - 1=fair, 3=average, 5=good
sp: continuous variable - sale price	**gar**: binary variable indicating if a property has a garage or otherwise
lotac: continuous variable - site area in acres.	**waterinf:** qualitative assessment of linkage to a body of water - 1=none, 3=water view, 5=water front
loc: qualitative assessment of location variable – 1=remote, 3=typical, 5=near town	**hsesf.00s**: continuous variable - size of living area excluding basement in hundreds of square feet
bsmntfin: binary variable designating if a house has basement finish or otherwise	**age**: continuous variable – age of the house in years
viewshed3: binary variable designating if one or more wind turbines are visible from a property	

Figure 1


gar
age
bsmntfin
watinf
viewshed3
sp
cond
hsesf.00s
id
loc
lotac
N = 83, 2009-09-03, R 2.9.1

Methodology

The primary objective of this study is to compare the house sales identified as located within the viewshed of one or more wind turbines with the sales of houses without this influence as a comparison (control) group. As this is an observational study, property sales self-assign to either the viewshed group or the control group based on the observations taken from site visits. Randomized assignment to either group, the gold standard of a causal inference study design, is clearly not possible with property sales data. Without random assignment, it could well be the case that these two groups, viewshed and control, are different from the onset. Those differences, not the impact of a visible wind turbine, may cause the measured difference in sale price between the groups, if any.

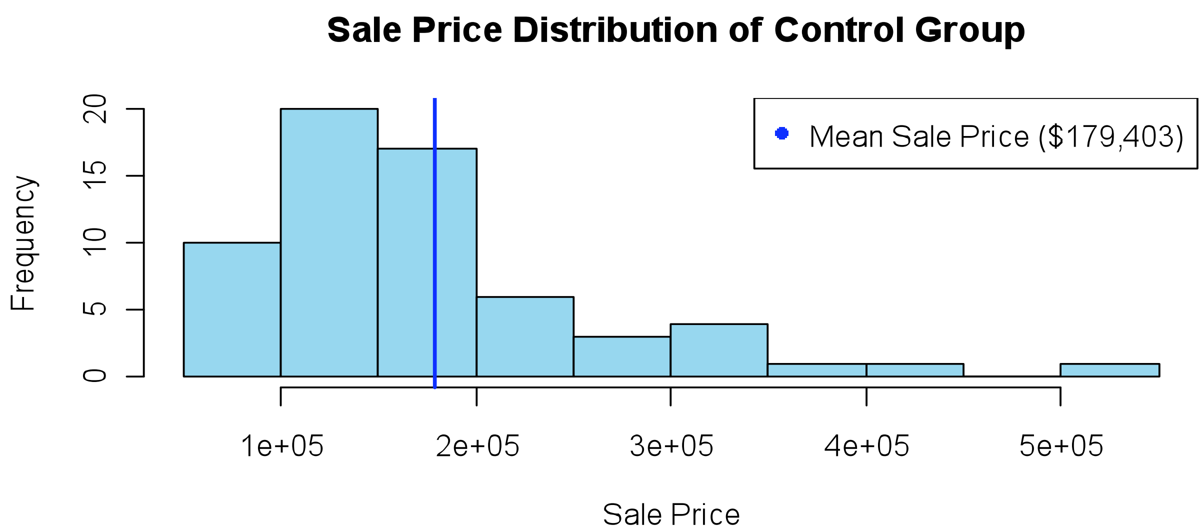
Several approaches were employed in this study to control for these differences. As a basic strategy, regression analysis was employed as an adjustment technique. Sale price was transformed to its natural log for the regressions as this allowed the interpretation of the estimates as a percentage. A second approach was to obtain smaller but more comparable samples by first preprocessing the data through matching of sales in the viewshed group with sales in the control group on their attributes. Two matching algorithms were employed for the matching exercise.

Exploratory Analysis

Figure 2 below is a graphic comparison of the distribution of sale prices before any adjustment by regression for differences between the viewshed group and control group. A comparison of the histograms of the two groups indicates the mean sale price of the viewshed group sale price distribution is less than that of the control group. The mean value of the viewshed group is approximately 7% lower than the mean value. Their distributions are similarly skewed to the right.

As indicated by the scatterplot (Figure 3) of sale price on the number of months that have elapsed (emths) for each sale between the date of sale and the date of the oldest sale, changes in market conditions is not an important price influencing variable for this data. As the smoother line on the plot clearly shows, there is no clear sale price trend.

Figure 2


Sale Price Distribution of Control Group
Mean Sale Price ($179,403)
Frequency
0
5
10
15
20
1e+05
2e+05
3e+05
4e+05
5e+05
Sale Price

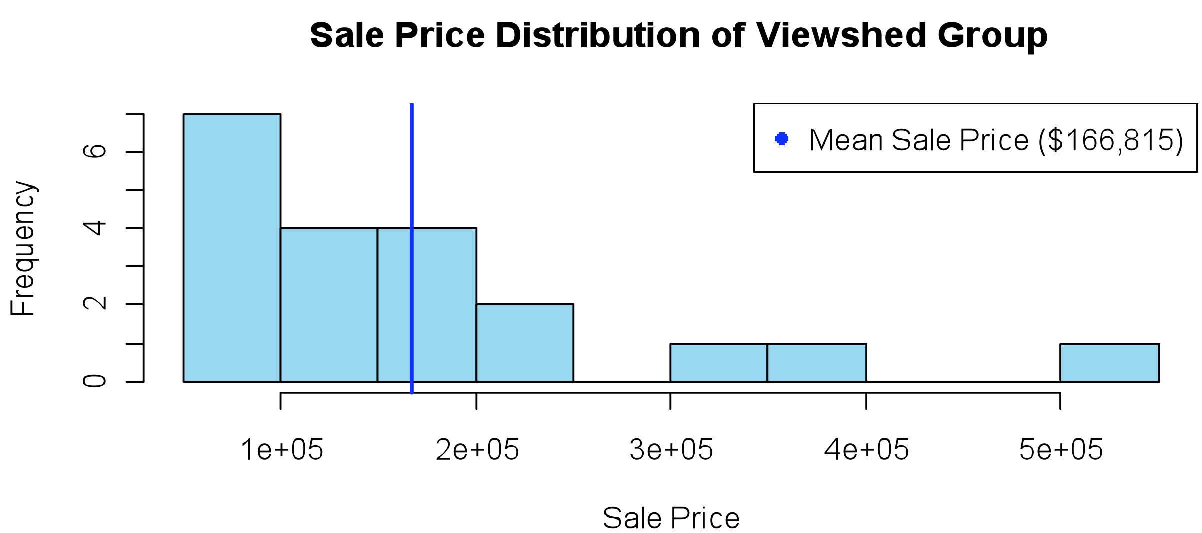
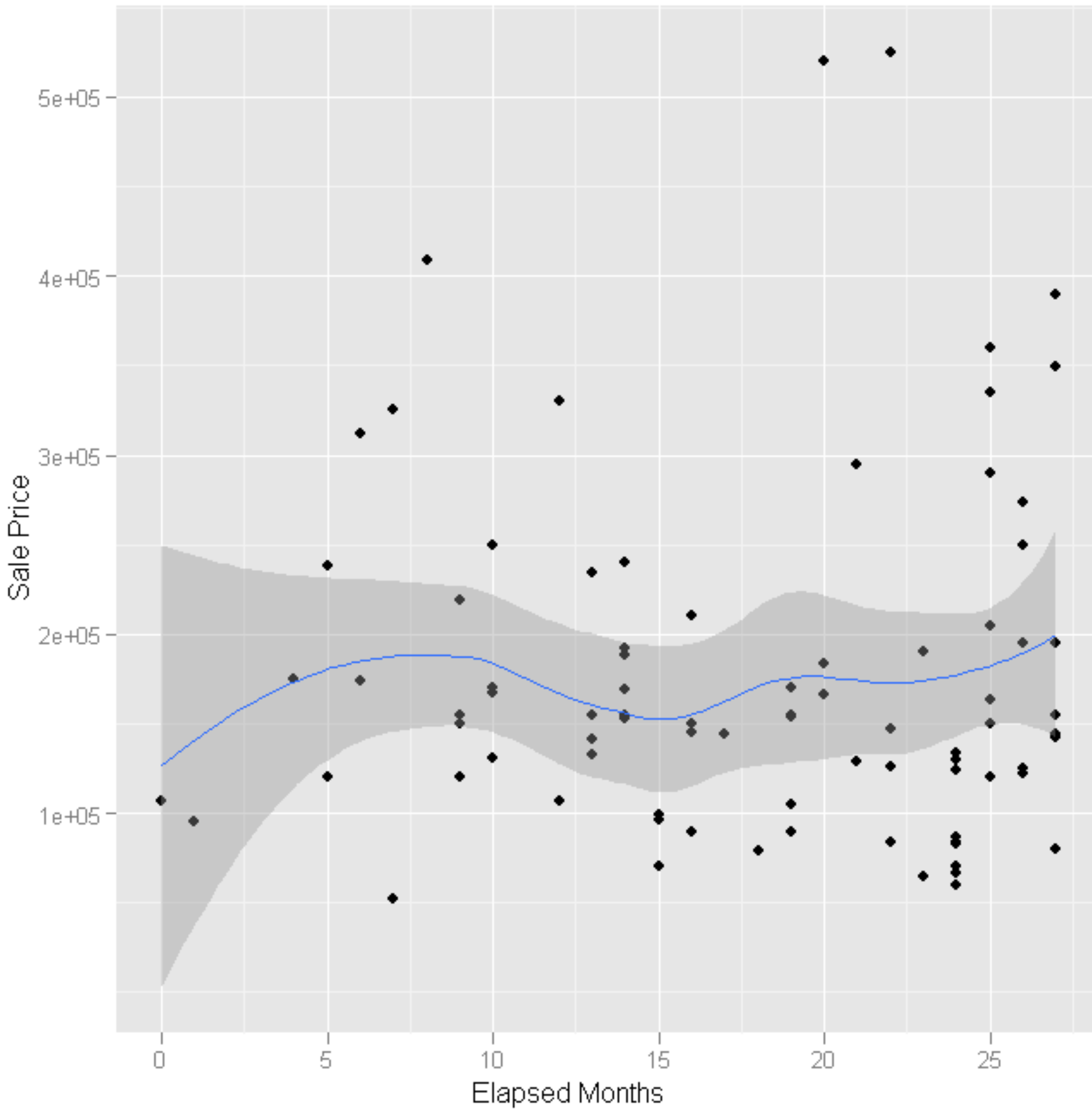

Sale Price Distribution of Viewshed Group
Mean Sale Price ($166,815)
Frequency
0
2
4
6
1e+05
2e+05
3e+05
4e+05
5e+05
Sale Price

Figure 3


5e+05
4e+05
3e+05
2e+05
1e+05
Sale Price
0
5
10
15
20
25
Elapsed Months

The exploratory analysis revealed that sale properties in the control group differ from the viewshed group on some characteristics; in other words they are not closely comparable. This imbalance must be addressed before a comparison of mean prices between the two groups of properties can be inferred to measure the effect of a wind turbine on the values of nearby properties from which a wind turbine or turbines are visible. Two strategies were used in this study to balance the comparability between the two groups of properties. They are regression modeling and pre analysis matching.

Altogether, three approaches to estimate wind turbine effect were conducted in this study. Matching was combined with regression in two of these analyses.

Regression Analysis

The use of regression analysis to adjust the sale prices of individual properties in the sample for differences between them is common to studies of the type conducted here. After controlling for the differences in the measured characteristics of the sale properties, the difference in the sample means between the viewshed and Control groups is inferred to be the causal effect of wind turbines that are visible to the nearby properties.

As regression analysis is a statistical technique, it offers a measure of sampling error. It provides a measure of the confidence that can be placed in the estimate of turbine effect on price.

This study considered a sequence of regressions to arrive at the final model specification described here. All regression modeling was done with the log of sale price as the outcome variable, using various sets of predictor variables. The choice of variables selected for the final regression model depended on their predictive power for sale price.

The regression model results for the initial approach on the full data, presented in Table a.1, shows the adjustment variables are associated with sale price in an expected manner and with the correct signs. As none of these non-viewshed effect relationships is surprising, they are not discussed further in this report.

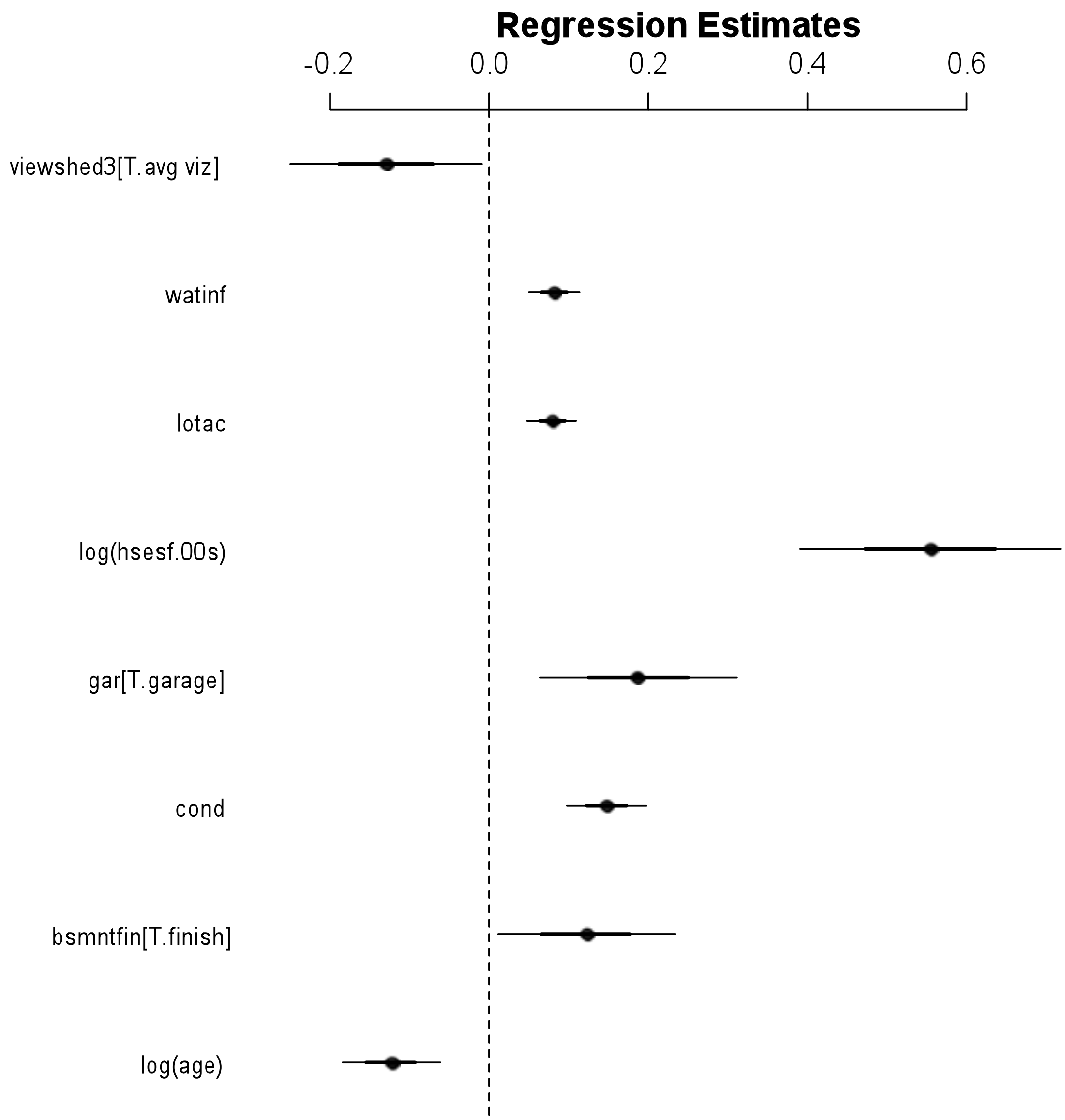
Table A.1: Summary of Final Regression Model

```
lm(formula = log(sp) ~ log(age) + bsmntfin + cond + gar +
log(hsesf.00s) +
lotac + watinf + viewshed3, data = wind.cln)

Residuals:
Min        1Q    Median        3Q       Max
-0.467791 -0.093272  0.002240  0.132561  0.405398

Coefficients:
Estimate Std. Error t value Pr(>|t|)
(Intercept)           9.92138    0.25967  38.208  < 2e-16 ***

log(age)             -0.12236    0.03080  -3.973 0.000163 ***

bsmntfin[T.finish]    0.12295    0.05537   2.220 0.029454 *

cond                  0.14775    0.02467   5.989 7.04e-08 ***

gar[T.garage]         0.18784    0.06200   3.030 0.003369 **

log(hsesf.00s)        0.55485    0.08158   6.801 2.30e-09 ***

lotac                 0.07977    0.01542   5.173 1.90e-06 ***

watinf                0.08210    0.01592   5.159 2.01e-06 ***

viewshed3[T.avg viz] -0.12879    0.05984  -2.152 0.034627 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.2054 on 74 degrees of freedom

Multiple R-squared: 0.8476,   Adjusted R-squared: 0.8312

F-statistic: 51.46 on 8 and 74 DF,  p-value: < 2.2e-16
```

The regression summarized in Table A.1 has an adjusted R-squared measure of 83%, which indicates a considerable proportion of the variation of the log of sale price is explained by the eight predictors included in the final model. Viewshed3 is the variable of interest for this study, and it is presented within the Table in bold type. Because the untransformed predictors are regressed on sale price expressed on the logarithmic scale, their coefficients can be interpreted as proportional differences. Thus, with all else held constant, houses with basement finish (bsmntfin) have sale prices, on average, approximately **12% greater** than houses without basement finish, houses on a water body like a lake or river have, on average, sale prices about **8% higher** than others, and so forth.

These patterns, however, are not comparable in the strength of their signal. The plot below relates the estimates and their associated level of certainty.

Figure A.1: Plot of Regression Estimates and Confidence Intervals - Final Model



The plot above outlines the coefficients presented in Table A.1 and ±1 standard error (thick line) and ±2 standard error (thin line) intervals estimated from the final regression. Strongest patterns are associated with the shortest lines relative to the size of coefficient; thus we have the greatest certainty with effect on sale price estimates for condition (cond), water influence (watinf), and house (log(hsesf.00s)) and lot size (lotac). Noticeably, the estimate for houses with wind turbine visibility (viewshed3) displays a wide confidence interval relative to its affect size. For the -13% impact on sale price from wind turbine visibility estimate, this translates to a margin of error between -3% and -23%.

Matched Samples

Overview

In observational studies, the use of regression modeling alone presents a risk of estimate bias (not human) because of dependency on model specification and the underlying assumptions that premise such a model. One approach often used to reduce the potential of bias in observational studies is to mimic a randomized experiment through data preprocessing by matching the treatment (in the viewshed) and control (out of the view shed) groups. By obtaining a sample of control sales that agrees as closely as possible with the viewshed group sales on an array of property characteristics that excludes their sale price, preprocessing the data by matching reduces dependence on the regression model and brings us closer to this goal. Matching the estimators for the two groups attempts to balance the characteristics between the groups so they are more alike than not, both in their distributions and coverage. The basis of this type of analysis is drawn from traditional appraisal methodology using “paired sales”. The differences are that specific programs are used to match the “Paired Sales” as opposed to human selection. It eliminates the problem of bias either conscious or unconscious and achieves better results. Two matching analyses were conducted.

OPTIMAL

The “MatchIt” package[3] of the R statistical software program was used to obtain a sample of sales in the Control Group matched to the 20 sales in the viewshed group as closely as possible on house characteristics that are independent of the wind turbines, before adjusting for remaining differences with regression. This automated matching process is summarized in Panel B below.

[3] Daniel Ho; Kosuke Imai; Gary King; and Elizabeth Stuart (2007), ``Matching as Nonparametric Preprocessing for Reducing Model Dependence in Parametric Causal Inference,'' Political Analysis 15(3): 199-236, http://gking.harvard.edu/files/abs/matchp-abs.shtml.
Full and optimal matching are implemented via the `optmatch` package (Hansen, 2004).

Using the Optimal Matching Sequence

Panel B: Regression Model on Data Matched by MatchIt Package Using Optimal Method

```
Call:
matchit(formula = viewshed ~ hsesf.00s + cond + loc + lotac +
age + watinf, data = mwind, method = "optimal")
```

Table B1: Summary Of Balance For All Data

	Means Treated	Means Control	SD Control	Mean Diff	eQQ Med	eQQ Mean	eQQ Max
distance	0.390	0.194	0.169	0.197	0.168	0.193	0.366
hsesf.00s	16.727	17.352	6.038	-0.625	0.885	1.337	9.460
cond	3.000	3.762	1.160	-0.762	0.000	0.700	2.000
loc	3.500	3.159	1.208	0.341	0.000	0.600	2.000
lotac	1.627	1.379	1.388	0.247	0.100	0.230	0.851
age	63.600	64.905	36.474	-1.305	8.000	8.600	30.000
watinf	2.700	1.603	1.420	1.097	0.000	1.100	4.000

Table B2: Summary Of Balance For Matched Data

	Means Treated	Means Control	SD Control	Mean Diff	eQQ Med	eQQ Mean	eQQ Max
distance	0.390	0.362	0.181	0.029	0.008	0.029	0.102
hsesf.00s	16.726	17.630	5.572	-0.903	0.920	1.123	3.600
cond	3.000	3.000	1.124	0.000	0.000	0.200	2.000
loc	3.500	3.400	1.392	0.100	0.000	0.300	2.000
lotac	1.627	1.401	1.855	0.226	0.146	0.257	0.851
age	63.600	62.300	40.901	1.300	5.000	6.800	29.000
watinf	2.700	2.400	1.957	0.300	0.000	0.300	4.000

Table B3: Percent Balance Improvement

	Mean Diff.	eQQ Med	eQQ Mean	eQQ Max
distance	85.457	95.384	84.98	72.119
hsesf.00s	-44.423	-3.955	16.04	61.945
cond	100.000	0.000	71.43	0.000
loc	70.698	0.000	50.00	0.000
lotac	8.684	-45.662	-11.76	0.000
age	0.365	37.500	20.93	3.333
watinf	72.648	0.000	72.73	0.000

Table B4: Matched Sample Size

	Control	Treated
All	63	20
Matched	**20**	**20**
Unmatched	43	0
Discarded	0	0

Tables B1 to B4 are output from the matching process. Tables B1 and B2 outline the comparability of the two groups before and after matching, respectively. A summary of the improvement in comparability of the groups achieved by matching is in Table B3. Table B4 shows that matching has reduced the original sample of 83 sales to a smaller sample of 40 sales, consisting of 20 sales in the viewshed group (inside the view shed-Treated) and 20 sales in the control group(outside of the viewshed).

Figure B.1 is a visual display of the imbalance in the attributes between the two groups before matching (raw) and the improvement in the comparability of these attributes caused by the matching process (matched).

The comparison is made on the calculated propensity score for each sale. A propensity score of a property is its conditional probability of falling into the viewshed group given its attributes. It is a single value measure that summarizes all the attributes of any one property. Matching occurs on these propensity scores. It can be said that the propensity score is an overall utility score of the property similarly used in Qualitative and Quantitative analysis within the Direct Comparison Approach used by appraisers using Quality Point.

A comparison of the distributions of the propensity scores between the viewshed and control groups for both the raw and the matched data sets is offered by the histogram plots of Figure B.1. As the plots in the left column show, the distributions of the scores before matching are quite different. This difference disappears after matching, with the viewshed and control groups having similar propensity score distributions in the matched sample.

Figure B.2 below is a dot plot of these propensity scores. In addition to plotting the scores of the matched data set, it also shows the propensity scores of the discarded sales.

Figure B.1: Histogram Plots Comparing Propensity Scores between Raw and Matched Data by Viewshed and Control Groups

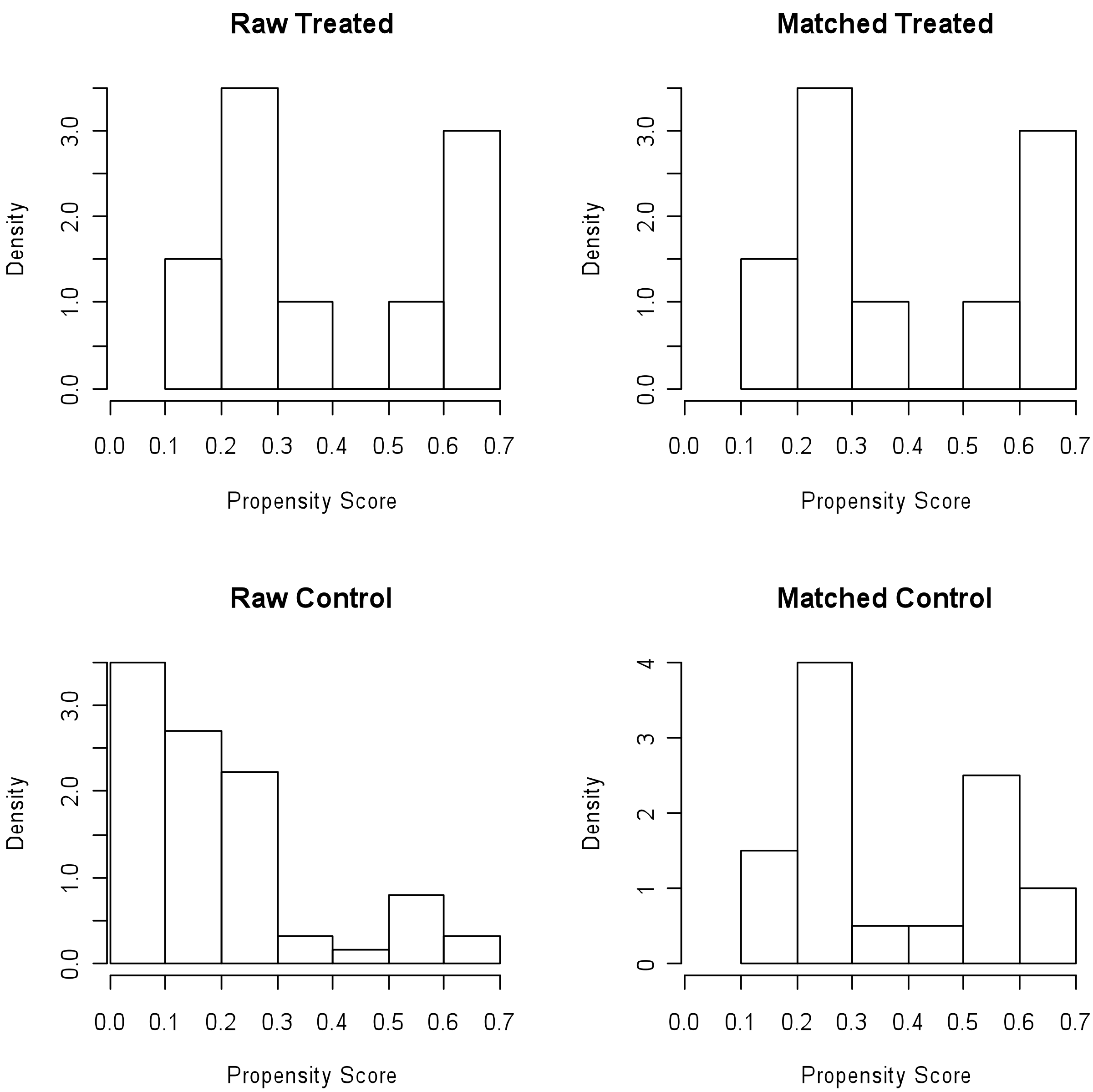
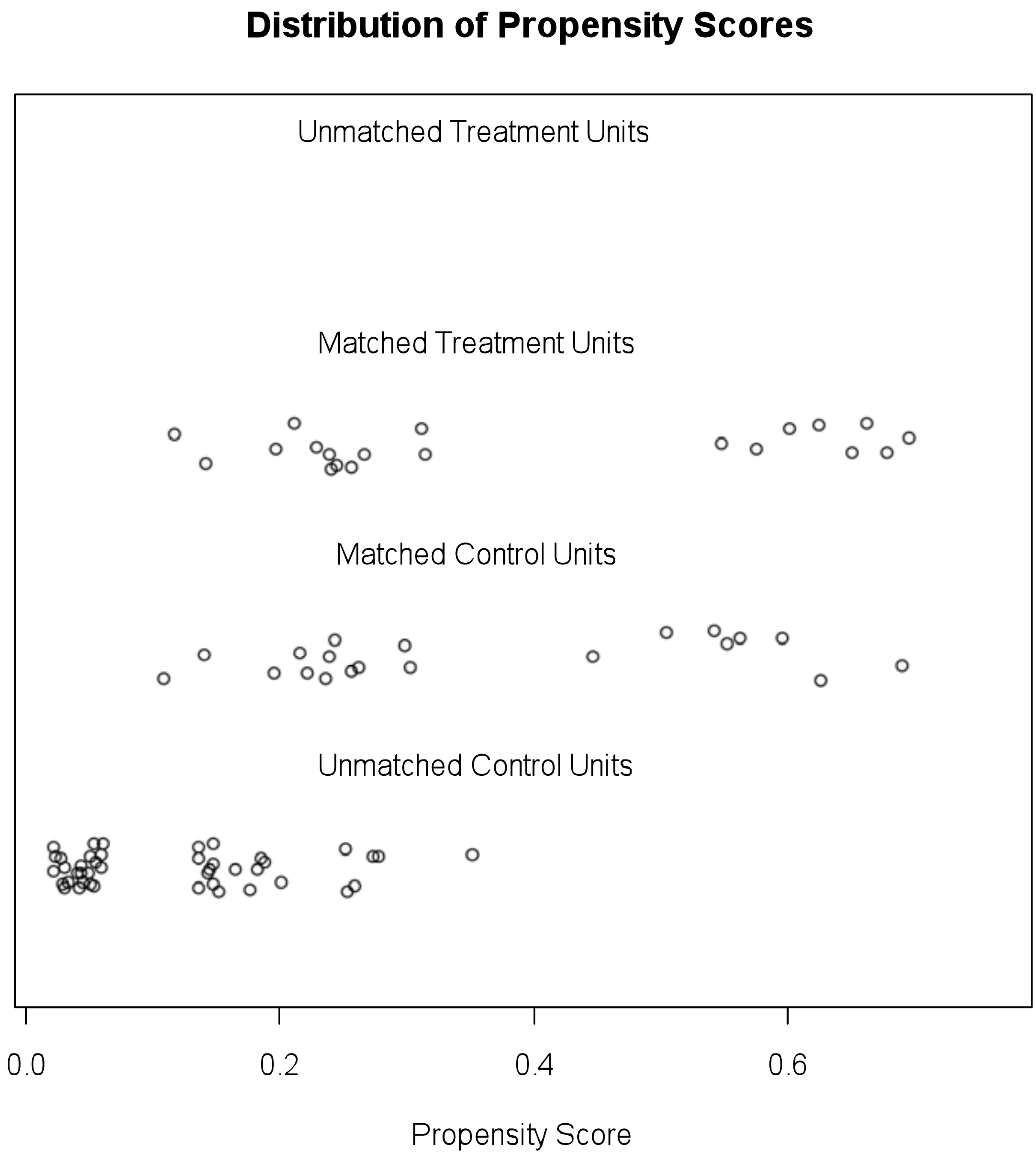


Figure B.2: Plot Comparing Propensity Scores between Raw and Matched Data by Viewshed (Treatment) and Control Groups



After matching, comparability between the groups has improved in the smaller matched data set (mdata). Overall, matching has made the two groups more alike than not.

Tables B.5 is the summary of the regression model built on the matched data set. Besides the viewshed variable, only three predictors were included in this model. These three predictors are helpful in explaining the variation in the log of sale price. The reason why only three predictors were used is because these were significant in explaining variation in the data set. Using too many variables against too small a sample would undermine the basic principles of regression analysis.

Table B:5 indicates that, contrary to the expectation of a statistically important negative coefficient for viewshed obtained from the regression on the full data set (outlined in Panel A), the regression on the smaller matched data sample of 40 sales shows viewshed has no clearly identifiable relationship with sale price. Although the viewshed coefficient has a value of -9%, the standard error is almost 12%. The output shows a probability of 45% of obtaining the coefficient value returned, even if the statement of a zero effect between sale price and viewshed were true. It can reasonably be concluded, therefore, that the model indicates there is no relationship between price and viewshed.

Table B.5 Summary of Regression Model - Data Matched Optimal Method

```
Call:
zelig(formula = log(sp) ~ viewshed + age + hsesf.00s + lotac,
model = "ls", data = mdata, weights = "weights")

Residuals:
Min      1Q  Median      3Q     Max
-0.6559 -0.2388  0.0293  0.2247  0.6321

Coefficients:
Estimate Std. Error t value Pr(>|t|)
(Intercept) 11.27470    0.22463   50.19  < 2e-16 ***
viewshed    -0.08945    0.11594   -0.77  0.44558
age         -0.00626    0.00136   -4.61  5.1e-05 ***
hsesf.00s    0.05082    0.01097    4.63  4.9e-05 ***
lotac        0.11917    0.03048    3.91  0.00040 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.364 on 35 degrees of freedom
Multiple R-squared: 0.634,    Adjusted R-squared: 0.593
F-statistic: 15.2 on 4 and 35 DF,  p-value: 2.72e-07
```

USING THE CEM MATCHING SEQUENCE

As a second matching approach, the CEM package[4] was employed in the R library of analytic functions. The CEM function was chosen from the available matching functions because of its similarity to the matching process traditionally used by property appraisers for variables with continuous values. The basic idea with CEM is to temporarily coarsen continuous variables such as house size so that substantively indistinguishable values are grouped and assigned the same numerical value. It is on these assigned values that matching occurs. Panel C of shows the matching analysis by CEM and final adjustment by regression.

Panel C: Regression Model on Data Matched by MatchIt Package Using Coarsened Exact Matching (cem) Method

```
Cem Matching Call:

library(cem)
todrop <- c("sp", "bsmnt", "outbldgs", "gar", "bsmntfin", "id")

matcem <- cem(treatment = "viewshed", data = wind,
drop = todrop, cutpoints = list(age = 4, hsesf.00s = 3, lotac = 3))

est <- att(matcem, log(sp) ~ viewshed + age, data = wind)
summary(est)
```

Table C.1: Matched Sample Size

```
summary(est)


G0 G1
All       63 20
Matched   11  9
Unmatched 52 11
```

[4] The program implements the Coarsened Exact Matching (CEM) algorithm described in Stefano M. Iacus, Gary King, and Giuseppe Porro, "Matching for Causal Inference Without Balance Checking"

Table C.2 Summary of Regression Model - Data Matched cem Method

```
Treatment effect estimation for data:
(Linear regression model estimated on matched data only)

Coefficients:
Estimate Std. Error t value   p-value
(Intercept) 12.3485988  0.2324106 53.1327 < 2.2e-16 ***
viewshed    -0.0702465  0.2142539 -0.3279  0.747017
age         -0.0082206  0.0028356 -2.8991  0.009982 **
---
 Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

After matching by the CEM method, comparability between the groups has improved (output not shown) in the smaller matched data set of 20 sales. Overall, matching has made the two groups (G0=no viz, G1=avg viz) more alike than not.

Table C.2 is the summary of the regression model built on the matched data set. Besides the viewshed variable, only one predictor (age) is included in this model to explain remaining variation because of the small sample size of the matched data.

Similar to the regression estimate obtained on the matched data by the optimal method (outlined in Panel B), Table C:2 shows the regression on the smaller matched data sample of 20 sales has brought back a strong indication that viewshed has no clearly identifiable relationship with sale price. The viewshed coefficient has a value of -7%, with a very large standard error of 21%.   With this large sampling error, it can reasonably be concluded that the matched data does not refute the hypothesis of no relationship between price and viewshed.

PAIRED SALES ANALYSIS

A common method of analysis by real estate valuers and consultants is the “Paired Sales” or “re-sales”.

The “Paired Sales” method involves the pairing of IDENTICAL sales in every respect with the exception of characteristic under review. “Paired Sales” do not exist in the market place. The confusion by real estate analysts is the difference between the words “identical” and “similar”. Many consultants believe because they have similar sales that they are identical. Unfortunately that is not the case. How consultants analyze similar sales is to make ad hoc adjustments (based upon no evidence) to the data with respect to differences between the paired similar sales to the property characteristic in question. This is a common strategy when trying to group sales that are near or adjacent to wind farms and those that are not. The difficulty with this strategy is that it is subjective in nature, and often very difficult to reproduce.

A closer data match would be “re-sales” that have occurred over a period of time. Thus to measure the effect of wind turbines on real estate values, one should be able to decipher from the “re-sales” the difference in sale prices and the “re-sale” price.

Some “re-sales” of the same property were noted in the data compiled for this analysis. 14 examples of “re-sale” sales were identified for an independent analysis, as shown below. With a view to respecting the rights to privacy of the property owners, and to maintain the confidentiality of purchase price information, the specific property addresses have not been identified. Full details have been retained in the author’s files as required by the Appraisal Institute of Canada, and should they be required for court testimony.

ADDRESS	DATE OF SALE	SALE PRICE	IN THE VIEWSHED	PRICE DIFFERENTIAL
Property A	2008/05	96000	Yes	+$7,000
Property A1	2003/08	89000		
Property B	2009/02	124000	Yes	+$41,500
Property B1	2003/05	82500		
Property C	2008/08	79000	Yes	-$6,000
Property C1	2006/10	85000		
Property D	2007/08	174000	Yes	+29,000

Property D1	2005/03	145000		
Property E	2008/05	99500	Yes	+$9,500
Property E1	2004/05	90000		
Property F	2007/12	131000	Yes	-$4,000
Property F1	2005/06	135000		
Property G	2008/04	152500	Yes	+$12,500
Property G1	2007/11	140000		
Property H	2009/05	79900	Yes	-$5,100
Property H1	2003/09	85000		
Property I	2009/05	70500	Yes	+$6,500
Property I1	2007/01	64000		
Property J	2009/01	65000	Yes	-$52,000
Property J1	2004/12	117000		
Property K	2007/03	95000	No	-$15,000
Property K1	2005/04	110000		
Property L	2007/09	325000	Yes	+$177,000
Property L1	2005/10	148000		
Property M	2007/05	200000	Yes	-$95,000
Property M1	2005/04	295000		
Property N	2008/09	105000	Yes	+$30,000
Property N1	2006/07	75000		

14 pairs of identical properties were found to have sold over the last 5 years. These were in fact re-sale of the same properties. Out of the 14 re-sales, 13 were re-sales that were in the viewshed and 1 re-sale outside of the viewshed. If the "re-sales" are taken at face value, there are 8 re-sales in which their values have increased over time and 6 that have shown a decrease in value. It is interesting to note that the sale that is not in the viewshed showed a decrease in value. Since the element of time is constant and had no effect on sale price, there had to be a reason for the differences in the sale prices within the "re-sales". The interpretation of the "re-sales" has identified some of the reasons for the differences in the sale prices.

Property A sold in 2008 on the MLS®. At that time the home was in good condition and had some updates. There was no MLS® listing on the property when it sold in 2003. However, we did find a 2002 MLS® listing that indicated that the property had received some renovations. In other words, the change in the sale price levels between 2003 and 2005 was not due to a difference in the condition of the home. Everything else seemed identical. So what was the real cause of the increase in value?

Property B sold on the MLS® in 2003. It required updating and it was not in the same condition when it sold in 2009. This might explain the +$41,500 increase between the sale dates 2003 and 2009.

Property C, when it sold in 2006 appeared to be in better condition then when it sold in 2008 at a loss. This could explain the price difference between the sale dates.

Property D revealed no MLS® listing when it sold in 2003. The 2008 MLS® sale indicated that the house was in good repair at the time of the sale. It is not known if there was any difference in the property between the two sale dates.

Property E sold in 2006 and 2008. On both MLS® listings of the property, it indicated that the property had not changed and was in good condition when sold each time. The cause for the property to increase in value by $9,500 is not known.

Property F sold in 2005 and 2007. In both instances the home was in good repair yet it sold for a loss. The rationale for the loss is unknown.

Property G sold in 2007 and 2008. The 2007 sale indicated that the home needed some work. The 2008 sale reflected the improvements made to the property that is why it sold for a profit.

Property H sold in 2003 and in then in 2009 for a loss. Each of the MLS® listings indicated the home was in average condition and no changes had been made to the home. The rationale for loss in value is not known.

Property I sold in 2007 and again in 2009 for an increase of $6,500. When the property sold in 2007 it had some updates and was in a good state of repair. When it sold in 2009, it sold in “as is” condition which suggests some type of a problem. However, it sold at an increased price in 2009.

Property J sold with a loss of $53,000 between 2004 and 2009. There was no 2004 MLS® listing for this property, but there was an expired 2006 listing. According to the 2006 MLS® listing the home appeared to be in average condition. However, when it sold in 2009 the MLS® listing reports the house being sold “as Is” condition which suggests some type of a issue. This could explain a large portion of the loss.

Property K, which was just outside of the viewshed, sold in 2005 and in 2007 for a loss of $15,000. A review of both MLS® listings at the time of these sales, disclosed no evidence of any changes to the property. There is no rationale as to why the property sold for less in 2007.

Property L sold in 2005 and 2007 for an increase of $177,000. The MLS® indicates that the home had been substantially updated at the time of the 2007.

Property M sold in April 2005 for $295,000 and resold in May 2007 for $200,000. This appears to indicate a loss of $95,000. When this property sold in April 2005 it sold under a power of sale and in "as is" condition. When it sold in May 2007 it had a new septic system and was in average condition. The difference in the selling prices between the dates was the result that a lot had been severed off the property after the purchase in 2005. The original lot size of the property in April 2005 was larger than when it sold in May 2007. Thus the price differential was the result of the lot size difference and is not related to the wind turbines.

Property N sold in 2006 and in 2008 for a profit of $30,000. There was no MLS® listing found when it sold in 2006 and the 2008 listing basically showed that it was in average condition. There is no rationale as to why this property sold at an increased price.

Even using “re-sales” as a point of entry in determining the impact of wind farms on property values does not show any casual relationship. With the “re-sales” that were found in the data set, there was more evidence on the outset that property values have increased despite the existence of wind farms. Yet in many instances there was no explanation of why these “re-sales” increased or decreased in value.

The problem of using “Paired Sales” or even “re-sales” as a model for determining the effect on real estate of a given property characteristic is very simple. These types of analysis cannot hold these physical differences between properties constant. In order to understand what groups of data are telling us we need to code the data. The “re-sales” “Paired Sales” methods do not allow for any coding nor do they allow for any levels of measurement.

Discussions with the realtors, buyers and sellers involve tend to be bias and skews results. A tool is required that is capable of holding constant all the variables, is capable of categorizing the variables, and finally, is capable of labeling the characteristics that impede on value.

The only real estate model that can actually hold constant all the variables that interact on price in a given real estate market place is Multiple Regression Analysis. This is the basis of this analysis and the authors have made every attempt to draw any inference, negative or positive, from the data procured from the marketplace as to the relationship of wind turbines and the sale price of nearby rural residential properties.

SUMMARY AND CONCLUSION

Sales prices of property in a given area provide the best source of evidence to establish market value. In attempting to establish the extent of a specific influence on the value of real estate, the available data must be divided and analysed into two groups; those exposed to the influence and those not. In the case of wind farms, it is appropriate to group the available sales data into those within the viewshed of the wind farms and those not.

When residential properties within a viewshed (viewshed group) are compared to those not in a viewshed (control group), there will be differences in selling prices between the two groups that are not related to the wind farms. The authors adopted a basic regression modeling in attempting to rationalize these differences as it allows for the introduction of multiple variables.

An initial exploratory analysis helps to demonstrate that point. On page 41 there is a visual presentation of the average sale prices of data within the “control group” and the “viewshed” group. This graph shows a 7.5% decrease between the average sale prices of each group. On the initial examination it would appear that sales located in the “viewshed” sold “on average” 7.5% lower. It would be wrong to assume that the -7.5% is the result of the wind turbines because the average sale price from each group represents the unexplained functions of all the variables.

Through a review of the MLS® data sheets and other records, as well as ground proofing inspections, the variables were identified and placed into the spreadsheet for regression modeling. These variables include such features as lot size, location, garage, basement finish, house condition, age etc. These variables can help to explain the differences in the selling prices of the dataset to allow for a more probative focus on the influence of the wind farms on those property sales within the viewshed.

The initial regression run showed that the variable “viewshed” returned a negative coefficient of 13%. In regression analysis, a coefficient or value will always be returned in the results. The quantum of the result indicates whether or not the coefficient is statistically significant. In this application, the “viewshed” variable returned, what is commonly referred to as a “Standard Error”, that could be inferred to be fairly wide. The word “Error” may be misleading to some, in that it is not really an error. The error in the sampling is the difference between the data drawn and the total data population. In this case the total population of data is really hypothetical since the "Error" is the calculation of the fact that one is working with a sample not the entire population. There will always be some difference. In the case of the Standard Error in this analysis, it was .059 or 6.0%. Thus the 13% negative coefficient could have returned a value between -19% and -7% which is a very wide spread. It was also noted that the "T" value which measures statistical strength was a -2 which really signifies the weakness of the returned coefficient of -13%. In our opinion, this suggests that there was no consistency in this -13% coefficient being generated by the regression model.

Our exploratory data analysis was not limited to regression modeling on the whole data set. Since we know there are differences between the rural residential sales of each group we were able to segregate the data into closely matched datasets taken from each group. Once they were separated into like datasets, regression analysis could be re-applied to these smaller but more like sales to determine the effect of wind turbines on property values. On page 49 of the report there are four graphs. On the left side of the page are graphs (lower and upper) showing the Raw Treated and Raw Control groupings of data. By matching these sales from the data set as shown on the right side of the page (matched Treated and Control groups) we were able to create a fairly close match or analysis.

The output of the regression modeling on page 47 of the matched data sets using the "optimal" method returned a -9.0% coefficient for the variable "viewshed" with a high standard of error and a very low T value. This suggests that the coefficient returned by this regression run is not statistically significant.

We then extended the matching analysis to include the "CEM" method. The "CEM" method segregates data from two groups using a different technique then the "optimal" method. It must be remembered that both the "CEM" and the "Optimal" method does not consider sale price as a matching variable. The regression run using the "CEM" method is shown on page 52. Once again, a -7% coefficient is found for the variable "viewshed" returned by this model. The "Error" was very wide and the T value was extremely low. The conclusion is that the coefficient that "viewshed" returned is not deemed to be statistically significant.

The last considered approach was to take raw data in the form of paired sales. These paired sales were taken from the data inputs. This data set is located on page 54 of the report. Our examination of this data set was simply to determine the price differences of the same properties regardless of whether or not the residual price was negative or positive. By simply viewing the raw data without any formal analysis, no relationship could be determined between the presence of wind turbines and rural residential properties.

It is of paramount importance to note that any diminution in market value may be as a result of influences other than wind turbines. For example, a vendor may be motivated to accept a price lower that expected or even lower than their own earlier purchase price. Such motivations may be due to job loss, corporate transfer with employer compensation for price loss, ill health, old age or death.

The three regression models in this study returned a similar negative coefficient for the variable "viewshed" supported by a wide Standard Error and low T scores that clearly show that those coefficient results could not be relied upon as being statistically significant. It could not be said that rural residential houses located in a viewshed sold for lower prices.

Recommendations for Future Studies

The study of wind farms and their effect on property values is, and will likely continue to be a subject of debate for many years. Central to any future studies will be the methodology chosen for such a task. As pointed out earlier, the analytical options are limited. Furthermore, the real estate market is not perfect. It is comprised of individuals who hold differing ideals and objectives.

The motivations for buying and selling can vary significantly and can be influenced by numerous factors including, but not limited to financial capabilities, family criteria influences including physical and health limitations, employment etc. It can also be influenced by external factors such as the number of competing listings of properties available for sale, the price of gasoline vis-à-vis travelling distances, and prevailing economic conditions. As a result the data available for analysis will be imperfect, resulting in unpredictable differences and conclusions. Seeking perfection in analytical results can be an elusive and perhaps unattainable objective.

Most competent analysts will acknowledge that a large volume of well researched data, when properly analysed, is more likely to produce a more reliable result than a small selection of data. The commonly used "paired sales" analysis relies on only a few observations and frequently adopts "ad hoc" methods of rationalizing variances. This technique has been used since the 1930's in real estate appraisal practice and can often be proven to be unreliable by rendering biased results due to flawed adjustments and insufficient support. It is for this reason that a "paired sales" analysis, using only a few sales transactions, that are unlikely to be ideally comparable, is a statistically inferior approach.

Some studies on wind farm influences to date have relied exclusively on interviews of area residents. Such interview formats as a basis by reaching a conclusion can be misleading for several reasons. Bias can be built in by the way the questions to be asked are framed. The questions asked are rarely if ever presented with the results for review. The answers given by the respondents may not be truthful for a variety of reasons. Interview format studies are not evidence, they are unsubstantiated opinions, and as such are not empirical or reliable.

The authors believe that the Multiple Regression Analysis technique is the preferred choice in the analysis of data for several reasons. It utilizes a large volume of market derived observational data, and is capable of minimizing the element of bias. MRA can extract a detailed view of the primary influencing variables on price and examined them on a micro level (assuming the data is available).

In future studies of the overall impact of wind farms on nearby property values, the many variables having independent influences must be carefully grouped for analysis. In addition to the usual adjustment for property differences, the following areas are suggested for possible groupings for analysis:

- the distance to a wind turbine;
- the number of visible turbines;
- angle/direction of visibility;
- the influence of visibility of a hilly terrain or bush cover;
- noise measurements at different times of the day;
- noise measurements under different wind conditions;
- the influence of vibrations;
- volume of competing listings of properties available for sale;
- length of exposure time prior to consummation of a sale; and
- the time of year.

Although distance is an important element that needs to be incorporated in any future design program, it must be carefully related to the other influences. If a negative effect becomes evident, then it may be necessary to study the distance at which the impact is no longer measurable. An attempt was made in this study modeling by incorporation this variable into the MRA equation. There was an insufficient volume of sales in order to provide any concrete evidence as to the distance of influence on property prices.

The mandatory minimum noise set back distance, based on the new Ontario guideline from wind turbines to the closest Point of Reception (neighbouring house), is 550 meters. This new set back distance may differ with set backs in other locales. The present suggested setback distance was arbitrarily determined. Absent concrete data gleaned from the market place in terms of the minimal distance of influence (if there is one) it seems unreasonable to some developers that increased boundary lines be set.

A more detailed scoring system to encompass the subtle differences may be required. The site inspection of the sale properties disclosed varying degrees of influence. For example; some had visible views of wind turbines from the driveway and others only from the rear yard. Some had views of wind turbines only when approaching or leaving a property. Some properties were proximate to wind turbines but they were not visible or audible as they were separated by trees. These subtle differences may play a role in analyzing the effect of wind farms on property values. Close proximity to a wind farm development may be a factor, but in future studies the criterion used for scoring the degree of influence requires careful consideration.

If turbine noise is deemed to be a factor to be scored, the relationship of the prevailing winds to the nearby properties may also have to be taken into account. The relationship of wind speed to turbine noise may also need study. Future studies may require mapping the sound measurement results within the viewshed of the wind farms located within the area under study. Wind turbine attributes may also need to be considered in the future.

At a public hearing attended by the authors, a neighbouring complainant suggested that vibrations from the turbines were bothersome. If vibrations are found to be a factor to be analysed, the nature of the subsoil conditions may have to be considered for their influence on the transmission of the vibrations. A clayey subsoil material may have a different influence on the transmission of vibrations than say bedrock.

The proximity of a wind farm development to a property sale may show improvement by using a more comprehensive scoring system, but its reliability is ultimately base in the volume of supporting market driven data.

When a sale property near a wind farm is consummated, an important question in future studies may be the volume of available of competing listings of a similar nature, and their influence on the buyer's decision. Were there a number of listings available to the buyer at the time of the sale within the area of the viewshed, and what influence might they have had on the sale price?

In future wind farm studies specific attention to the influence on the price paid by a buyer of the length of time the property was exposed for sale on the market may be required. The exposure/listing times of the sale properties may need to be examined in the sales groupings, both in and out of the viewshed. As noted earlier in this report, there are many factors that can influence the length of marketing exposure. It may be necessary to consider these factors and determine, if possible, if a lower selling price was related to any specific factor or simply if the property became "stale" on the market. Extended listing times can lead buyers to perceptions of problems that may not exist.

The sale date of the property within the viewshed relative to the time of the year may be worthy of further study. During the summer months property owners and buyers are more mobile or spend more time out of doors. During winter months there can be less tree foliage making the turbines more visible, yet there may be less emphasis on surroundings and a greater focus on other amenities that a given property offers. An analysis to consider if buyers are more sensitive to wind farms during different periods in a given year may be worthy of consideration.

Applicability of Study Results to Other Regions

This study focused only on the influence of wind farm development along the north shore of Lake Erie in the Chatham-Kent area of Ontario. The study results derived from market evidence in this area may not be relevant to other regions of Ontario or Canada. Differences may arise due to variations in:

- socio-economic influences
- Wind directions
- subsoil conditions
- tower heights
- turbine models
- turbine age

- volume of competing listing of properties available for sale
- jurisdictional set back requirements from property lines or neighbouring properties
- area topography
- tree lines and bush lots

As a result of differences in some of these variables there may well be dissimilar study results. Caution should be used before suggesting that similar results would be found in other areas.

CONTINGENT AND LIMITING CONDITIONS

1. This consulting report is not valid unless original signatures are evident.

2. It is assumed that the market considers the sub-soil as good and acceptable. No responsibility has been assumed for the requirements of government, public or private bodies.

3. The presence of any potentially hazardous materials on the properties studied was not apparent or evident during the property inspection. Unless expressly noted, no on-site soil investigation has been undertaken on behalf of the authors, nor are they aware of any test results obtained in the past by others. Unless stated otherwise, the authors assume there are no unusual subsoil conditions or hazardous waste contaminants, which would adversely affect any future use of these sites, or adversely impact on the health of occupants, and no warranty or representation is made as to the environmental integrity of the subject parcels. We are not qualified to detect the existence of such substances.

4. All data used and described herein whether provided for this appraisal or obtained in the market place is assumed to be correct and reliable.

5. Property rights being studied are those of the “Fee Simple” interest. The authors assume no responsibility for matters, which are legal in character. The legal description is assumed to be correct.

6. The authors are not required to give testimony or attendance in court by reason of the appraisal, with reference to this study or the properties analysed therein, unless arrangements have been made previously.

7. Maps, plans, and surveys, etc. that may be in this report are included to assist the reader in visualizing the information and are not warranted as to their accuracy.

8. It is assumed that the properties comply in all material respects with all the requirements of law, including zoning, land classification, building, planning, fire and health by-laws, rules, regulations, orders, Acts and codes of all federal, provincial, regional, and municipal governmental authorities having jurisdiction with respect thereto.

9. It is assumed that, save and except for encumbrances as may be permitted, and explained in this report, there are no easements, rights-of-way, building restrictions or other restrictions so affecting the properties referenced herein as to prevent or adversely affect their operation or so as to materially and adversely affect market value.

10. This report has been prepared on behalf of the Canadian Wind Energy Association. No other third party may rely on this report unless they receive written permission by the study authors. Any liability from unauthorized use is strictly denied. The authors of this report, George Canning and Canning Consultants Inc. and L. John Simmons and John Simmons Realty Services Ltd., accept no warranties, expressed or implied, with respect to the use or interpretation of this report by any third party. Any questions related to this report should be directed to the Canadian Wind Energy Association.

CERTIFICATION

RE: WIND FARM STUDY – IMPACT ON REAL ESTATE VALUES

We certify that to the best of our knowledge and belief:

- The statements of fact contained in this report are true and correct.

- The reported analyses, opinions and conclusions are limited only by the reported assumptions and limiting conditions, and are our personal, impartial, and unbiased professional analyses, opinions and conclusions.

- We have no present or prospective interest in the parcels that are the subject of this report, and have no personal interest with respect to the parties involved.

- We have no bias with respect to the properties that are the subject of this report or to the parties involved with this assignment.

- Our engagement in and compensation for this assignment were not contingent upon developing or reporting of predetermined results, the amount of the value estimates, or a conclusion favouring the client.

- Our analyses, opinions, and conclusions were developed, and this Consulting Report has been prepared, in conformity with the *Canadian Uniform Standards of Professional Appraisal Practice*. The Appraisal Institute of Canada retains the right to review this report.

- We have the knowledge and experience to complete the assignment competently.

- As of the date of this report both, L. J. (John) Simmons, AACI and George Canning, AACI, have fulfilled the requirements of The Appraisal Institute of Canada Mandatory Recertification Program for designated members.

- The undersigned inspected the properties identified herein on various dates in the months of May and June 2009.

By reason of our investigation and by virtue of our experience, we have been able to form and have formed the opinions set out in this report.

Using the time period June 2009, the estimated impact on the property values, as analysed herein simply states that: No empirical evidence can be drawn from the Chatham-Kent market place to suggest that wind turbines have a negative effect on the sale prices of rural residential properties

By reason of our investigation and by virtue of our experience, we have been able to complete a Consulting Report setting out opinions and property sales evidence to assist the addressee herein in considering the impacts on certain property values. This report should ***not*** be construed as an appraisal report setting out an opinion of Market Value, and should ***not*** be relied upon by others for any reason except as provided for herein.

The findings set out in this report are subject to the Critical and Extraordinary Assumptions, as well as the usual limiting conditions and underlying assumptions as outlined herein. The authors reserve the right to revise the opinions in light of any facts and conditions that become known subsequent to the date of this report, which have an impact on the conclusions reached.

John Simmons Realty Services Ltd.

L. J. (John) Simmons, AACI, FRI, CMR, PLE
Dated: February 4, 2010

Canning Consultants Inc.

George Canning, AACI, P.App, PLE
Dated: February 4, 2010

ADDENDUM "A" – PRIVACY STATEMENT

PRIVACY STATEMENT

John Simmons Realty Services Ltd. and **Canning Consultants Inc** have privacy policies in accord with legislation as it affects the **Personal Information Protection and Electronic Documents Act (PIPEDA)**. In general, the firms deal with the collection, use, and distribution of commercial rather than personal information. In the event that personal or sensitive data may be required to properly complete an assignment, the policies recognizes that consent is required for information that:

1. permits someone to learn sensitive, private information;
2. relates to a natural person; and
3. permits the identification of that person.

In accord with corporate policy, therefore, information provided by our clients will be used, secured and maintained based on criteria which include:

- limited use, only the data needed to complete the assignment is required.
- obtaining consent with respect to use of sensitive personal information about an identifiable individual (does not include the name, title, business address, or telephone number of an employee of an organization).
- non-disclosure of files, (subject to Law, or review by authorized representative of ***Appraisal Institute of Canada*****,** the Courts, Provincial or Federal agencies that have appropriate jurisdiction).
- the use of facts in the public domain as part of the appraisal process.
- information retained in our database that is relevant only to the subject property.
- tight control in the production of reports, and distribution only as authorized by the Client.

ADDENDUM "B" – AUTHORS QUALIFICATIONS

Canning Consultants, Inc

The firm has been in existence for seven years. Its principal, George Canning has been in the appraisal/real estate consulting business for 25 years and was a partner in one of the largest real estate firms in Southwestern Ontario. Recognizing that the needs of the clients were not being met by traditional valuation methodologies, this firm was organized to provide specialty consulting services. Solutions to complex real estate problems using modern techniques are now required to address those real estate issues that in the past could not be reliably solved.

Canning Consultants, Inc. is one of a very few fee based real estate consulting Companies that employs modern statistical methods and modeling tools with a common sense approach based upon many years of analyzing real estate.

George Canning, AACI, PAPP, PLE

2006 Designated Ontario Land Economist.

2006 Received designation of DAC.

2005 Elected as Regional Director to the Association of the Appraisal Institute of Canada-Ontario.

2004 Wrote a long distance learning course for the American Institute of Appraisers on Quality Point-a Direct Comparison Approach to Value.

2004 Appointed to the Professional Development Committee for the Ontario Association of the Appraisal Institute of Canada-Ontario for a one year term.

2004 Appointed to the Professional Steering Committee for the Appraisal Institute of Canada to chart the future course of the industry.

2004 Guest speaker at the 2004 world joint AIC/USA Appraisal Conference to be held in Toronto, Ontario June 24-27, 2004.

2004	Guest Lecturer in Kingston on March 5, 2004. Quality Point Analysis, on behalf of the Appraisal Institute of Canada.
2003	Guest Lecturer in Hamilton November 7, 2003. Quality Point, Exploratory Data Analysis, and AMV, on behalf of the Appraisal Institute of Canada.
2003	Guest Lecturer in Ottawa November 21, 2003. Regression Analysis on behalf of the Appraisal Institute of Canada.
2002 to 2004	Elected to the Board of Directors-National Governing Council.
2002	Guest Lecturer in Ottawa, Ontario on the behalf of the Appraisal Institute of Canada. The topic is an Introduction to Regression Analysis and Qualitative and Quantitative Comparative Analysis.
2002	Guest Lecturer in Halifax, Ontario on the behalf of the Appraisal Institute of Canada. The topic is an Introduction to Regression Analysis and Qualitative and Quantitative Comparative Analysis.
2001	Contributed to a new text book on Real Estate Appraising through the University of British Columbia. The material is on Automatic Valuation Models.
2001	Guest Lecturer at Trent University on the behalf of the Appraisal Institute of Canada. The topic is about Qualitative and Quantitative Comparative Analysis.
2000	Teaching 'Introduction to Linear Regression' through Fanshawe College's London and Middlesex Continuing Education Course Program.
1999	Teaching 'Introduction to Linear Regression' through Fanshawe College's London and Middlesex Continuing Education Course Program.
1998-Pres	Teaching 'Investing In Real Estate' through Fanshawe College's London and Middlesex Continuing Education Course Program.
1998 - Pres	Associated Member of the London St. Thomas Real Estate Board

1997 Granted Professional Appraiser by the Appraisal Institute of Canada (P.App)

1997 National Investigations Committee for the Appraisal Institute of Canada (One Year Term)

1996 to 1998 Appointed Executive Director of the London Chapter of the Appraisal Institute of Canada

1994 to Present Provincial Admissions Committee for CRA and AACI candidates (Appraisal Institute of Canada)

1988 to 1998 Certified Instructor for the Ontario Real Estate Association (Real Estate Appraisal Course)

1987 Granted AACI Designation (Accredited Appraiser Canadian Institute)

1983 Granted CRA Designation (Canadian Residential Appraiser)

STUDIES & PUBLISHED ARTICLES

The following list involved studies in which Regression analysis was used:

Studied the Effects of Potential Real Estate Loss on Housing in Cambridge, Ontario as a result of a Gas Spill.

Studied the Impact of Urea Formaldehyde on Residential Housing in London, Ontario.

Determine the Effect on Value over the Loss of On Site Parking of a Dental Building in London, Ontario.

Determined the Impact of the Loss of Front Yard Depth on Residential Housing for Expropriation in London, Ontario.

Determined the Impact of the Loss of Trees on Residential Housing for Expropriation in London, Ontario.

Determined the Impact of the Increase in Traffic Flow as a Result of the Taking of Land for Road Widening in London, Ontario.

Determined the Impact on Value of Subdivision Lots that Back onto Green Space in London, Ontario.

Determined the Impact of Underground Easements on Residential Property Values in London, Ontario.

Determined the Impact of Mutual Driveways on Residential Property Values in London, Ontario.

Determined the Contribution to Old Farm Buildings on Rural Property Values in South Western Ontario.

Contributed to summary results of the impact of tainted water on Walkerton, Ontario.

Determined the Impact of Property Values in Proximity to Garbage Dumps.

Determined the Loss in Value as a result of a new home being hit by an unattended semi trailer truck.

Determined the Impact on Value of Hydro Easements on Farm Properties in the Lambton County.
Determined the Change in Price Levels of Housings with Selling Prices between $400,000 to $600,000 in the City of London between 2001 and 2005.

Completed a province wide study in conjunction with the University of Waterloo on the impact of heritage designations of real property.

In addition,

Co-wrote courses on Data Analysis and Investigation presented through the AIC.

Co-wrote courses on Regression Analysis presented through the AIC.

Published articles include the "Impact on Hydro Lines" and a "20 Year Study of the Apartment Market in the City of London". Other articles have been written for private organizations such as the Canadian Car Wash Association of Ontario and the Ontario Private Campground Association. The topics were valuing car washes, and valuing public recreational campgrounds.

An article was written for the Appraisal Institute of Canada on the" Contemporary Direct Comparison Approach to Value". It was published in the Canadian Appraiser Fall 2000. It was recently published in "Readings in Real Estate", Fourth Edition.

Based upon the application of the multiple regression technique, a major assessment appeal case was won regarding the valuation of many office buildings in London, Ontario. The result was a saving of $1,000,000 in tax for the clients.

L. JOHN SIMMONS, AACI, FRI, CMR, PLE

Memberships and Affiliations

Accredited Member of the Appraisal Institute of Canada #723. (February 1969)

Fellow of the Real Estate Institute of Canada – Marketing. (January 1971)

Charter Member of the Association of Ontario Land Economists. (April 1970)

Active Member of the London & St. Thomas Real Estate Board. (April 1971)

Licensed Real Estate Broker. (April 1971)

Associate Member of the Canadian Association of Real Estate Boards.

Director of the St. Clair Region Conservation Foundation.

Past Regional Vice President of the Ontario Expropriation Association.

Background

Real Estate Appraisal Courses of the Appraisal Institute of Canada at Toronto 1963 to 1965.

Courses in Business Law, Sociology, Industrial Real Estate, at York University, 1967 to 1970.

Obtained Real Estate Sales Licence 1967. Broker since 1971.

Arbitration Courses I & II (AMIO) at University of Western Ontario 1996/97. Has acted as a sole arbitrator.

Past lecturer for Real Estate Appraisal courses at the University of Western Ontario on behalf of the Appraisal Institute of Canada.

Past Chairman and Director of the London & District Chapter of the Real Estate Institute of Canada.

Past member of AIC Professional Standards Investigating Committee.

Past Chairman of the London Chapter of the Appraisal Institute of Canada, 1986.

L. John Simmons – Overview of Professional Experience

Founder of the L. J. Simmons Group and its predecessor companies. President of John Simmons Realty Services Ltd. Has provided Real Estate Consulting and Fee Appraisal services continuously since 1962 for clients, including:

- Federal Government Departments and Corporations;
- Provincial Government Ministries, Departments, and Agencies;
- Various First Nation Councils;
- Power and Utility Corporations;
- Various Conservation Authorities;
- Counties, Cities, Towns, and other Municipal Corporations;
- Various Universities, and Boards of Education;
- Various National and International Corporations, Developers, Lawyers, Industries, Accountants; and
- Banks and financial and lending institutions.

Appraisal and Consulting services provided to the Corporation's clients have included the following:

- expert witness testimony before various courts, boards, and other tribunals;
- case analysis for damage, loss of use and injurious affection claims;
- valuation estimates for property purchase and sale;
- multi property land assembly projects;
- municipal redevelopment and rehabilitation projects;
- natural resource and recreational land valuations;
- utility corridors, right of way and flood easement acquisition and expropriation appraisals;
- subdivision of land;
- public and private institutional property valuations;
- senior citizens housing projects;
- feasibility studies and market analyses;
- investment analyses, benefit and cost studies;
- leasehold valuations and rental property analyses;
- assessment review;
- valuation estimates for relocation and mortgage financing;
- industrial and commercial property valuations;
- valuations of equipment, machinery and industrial assets;
- divorce and estate settlements; and
- property and fire insurance claim appraisals;
- forensic reviews of appraisal reports and purchase agreements; and
- structuring agreements of purchase and sale.

IBI GROUP

ELECTRICAL ENERGY RELATED EXPERIENCE

Enbridge Wind Power Project
In 2006, IBI Group was retained by Enbridge Ontario Wind Power L.P. to undertake land use planning approvals for the Kincardine Wind Farm that involved 120 wind turbines and the production of 181.5 Megawatts of power on 4,100 hectares of farm land located east of the Lake Huron shoreline. This undertaking involved preparing zoning by-law regulations, preparing background reports, and presenting at public meetings. As large scale wind farms are a relatively new land use throughout Ontario, community acceptance of the wind farms has been mixed. As a result, the Kincardine project was appealed to the Ontario Municipal Board for adjudication. For the Hearing, IBI Group undertook and was responsible for OMB Witness Statement, evidence preparation, individual turbine setback analysis, shadow flicker impact analysis, ice throw impact analysis, noise impact analysis, zoning by-law amendment revisions, emergency procedures, and dispute resolution protocol.

Township of Malahide and Municipality of Bayham: Wind Energy Official Plan Policies
The development of electrical wind energy systems is growing in southern Ontario. The prevailing winds along the Great Lakes shoreline are a natural resource with investment opportunity for commercial wind farm development. Wind farm development provides economic and tax benefits to the local municipality. IBI Group has researched wind generation systems for Council, municipal staff and community members of both the Township of Malahide and Municipality of Bayham, and developed Official Plan policies, Zoning regulations and Site Plan Agreements that meet community needs. These planning tools balance the environmental and economic benefits with potential site specific impacts of the turbine.

Ontario Power Authority – Planning for Electrical Infrastructure: A Review of Selected Municipalities in Southern Ontario

IBI Group was retained by the Ontario Power Authority (OPA) in November, 2008 to provide “The Services of An Urban Planner” within the following three streams of work:

Municipal Specific Infrastructure Siting Research;

Advice and Counsel in respect to urban planning issues; and

- Advice and Counsel in the development of a workshop aimed at improving the knowledge of municipal planners in respect to generic electricity infrastructure project siting.

Through a comprehensive evaluation of current Provincial, Regional and local policies and Zoning By-Laws, and planning approval processes, this report is intended to assist the OPA in identifying opportunities and constraints within the overall planning framework for developing a new cogeneration natural gas-fired electrical generation facility and possible transmission upgrades within Study Area 1 (Southwest Toronto, Southern Mississauga, Southeast Oakville) and Study Area 2 (Waterloo, Kitchener, Cambridge, Township of North Dumfries, Township of Woolwich, Guelph).

North Dumfries Energy Centre: Peaking Power Generation Facility

The North Dumfries Energy Centre site is located on Dundas Street South in the Township of North Dumfries. This project is being proposed by CPV Canada Development in attempt to address the increased load growth in the Region of Waterloo. IBI Group's responsibilities include the overall project management of the planning process and planning approvals including Amendment to the Township Official Plan, Amendment to the Township Zoning By-Law, and final Site Plan Approval. IBI Group's responsibilities also included planning and public consultation, on-site analysis with respect to site specific land use compatibility and good planning practices.

Nanticoke Energy Centre: Combined Cycle Facility

The Nanticoke Energy Centre site is located on Haldimand Road 55, north of the Nanticoke settlement area. This project is being proposed by CPV Canada Development in attempt to address the need for an additional supply of electricity, and a renewal of significant components of the province's electricity generation infrastructure. For this project, IBI Group's responsibilities include the overall project management of the planning process and planning approvals including Amendment to the County Official Plan, Amendment to the local Zoning By-Law, and final Site Plan Approval. IBI Group's responsibilities also included planning and public consultation as well as on-site analysis with respect to site specific land use compatibility and good planning practices.

ADDENDUM "C" – REFERENCED STUDIES

Reports Reviewed

1. Noise Radiation from Wind Turbines Installed Near Homes: Effect on Health; Barbara J Frey, BA, MA, and Peter J Hadden, BSc, FRICS, Feb 2007

2. Poletti and Associates, Inc. January 2007 - A Real Estate Study of the Proposed White Oak Wind Energy Center, McLean and Woodford Counties, Illinois.

3. Bard College Study April 2006 Madison New York.

4. Land Value Impact of Wind Farm Development – Crookwell New South Wales (Australia); Henderson & Horning Pty Ltd. February 2006.

5. Impact of wind farms on the value of residential property and agricultural land; RICS survey.

6. Wind Turbines and Infrasound; Howe Castmeier Chapnik Limited, November 29, 2006.

7. Property Value Study: The Relationship of Windmill Development and Market Prices; Peter Bobechko, AACI, P. App, of Blake, Matlock and Marshall Ltd. September 2006.

8. Living with the Impact of Windmills. (Slide presentation) Chris Luxemburger, real estate agent with Sutton Group.

9. Impact of Wind Turbines on Market value of Texas Rural Land. (Slide presentation) Derry T. Gardner of Gardner Appraisal Group Inc. Feb 15, 2009.

10. Property Stigma – Just the latest Fashion : Wind Farms & House Prices in the UK; Sally Sims and Peter Dent (Oxford University) September 2007.

11. Modelling the impact of wind farms on house prices in the UK. Sally Sims & Peter Dent, December 2008.

12. The effect of Wind Development on Local Property Values. Renewable Energy Policy Project study; George Sterzinger, Frederic Beck and Damian Kostiuk. May 2003.

ADDENDUM "D" – ONTARIO GOVERNMENT DOCUMENTS

Documents Reviewed

1. The Green Energy Act, 2009.

2. Noise Guidelines for Wind Farms: Interpretation for Applying MOE NPC Publications to Wind Power Generation Facilities. Ministry of the Environment, October 2008.

3. Noise Modelling Approach for On-Shore Wind Farms; June 2009.

4. Proposed content for Renewable Energy Approval Regulation under the Environmental Protection Act. June 9, 2009.

The Potential Health Impact of Wind Turbines

Chief Medical Officer of Health (CMOH) Report

May 2010

Summary of Review

This report was prepared by the Chief Medical Officer of Health (CMOH) of Ontario in response to public health concerns about wind turbines, particularly related to noise.

Assisted by a technical working group comprised of members from the Ontario Agency for Health Protection and Promotion (OAHPP), the Ministry of Health and Long-Term Care (MOHLTC) and several Medical Officers of Health in Ontario with the support of the Council of Ontario Medical Officers of Health (COMOH), this report presents a synopsis of existing scientific evidence on the potential health impact of noise generated by wind turbines.

The review concludes that while some people living near wind turbines report symptoms such as dizziness, headaches, and sleep disturbance, the scientific evidence available to date does not demonstrate a direct causal link between wind turbine noise and adverse health effects. The sound level from wind turbines at common residential setbacks is not sufficient to cause hearing impairment or other direct health effects, although some people may find it annoying.

1

Introduction

In response to public health concerns about wind turbines, the CMOH conducted a review of existing scientific evidence on the potential health impact of wind turbines in collaboration and consultation with a technical working group composed of members from the OAHPP, MOHLTC and COMOH.

A literature search was conducted to identify papers and reports (from 1970 to date) on wind turbines and health from scientific bibliographic databases, grey literature, and from a structured Internet search. Databases searched include MEDLINE, PubMed, Environmental Engineering Abstracts, Environment Complete, INSPEC, Scholars Portal and Scopus. Information was also gathered through discussions with relevant government agencies, including the Ministry of the Environment and the Ministry of Energy and Infrastructure and with input provided by individuals and other organizations such as Wind Concerns Ontario.

In general, published papers in peer-reviewed scientific journals, and reviews by recognized health authorities such as the World Health Organization (WHO) carry more weight in the assessment of health risks than case studies and anecdotal reports.

The review and consultation with the Council of Ontario Medical Officers of Health focused on the following questions:

- What scientific evidence is available on the potential health impacts of wind turbines?
- What is the relationship between wind turbine noise and health?
- What is the relationship between low frequency sound, infrasound and health?
- How is exposure to wind turbine noise assessed?
- Are Ontario wind turbine setbacks protective from potential wind turbine health and safety hazards?
- What consultation process with the community is required before wind farms are constructed?
- Are there data gaps or research needs?

The following summarizes the findings of the review and consultation.

2

Wind Turbines and Health

2.1 Overview

A list of the materials reviewed is found in Appendix 1. It includes research studies, review articles, reports, presentations, and websites.

Technical terms used in this report are defined in a Glossary (Page 11).

The main research data available to date on wind turbines and health include:

- Four cross-sectional studies, published in scientific journals, which investigated the relationships between exposure to wind turbine noise and annoyance in large samples of people (351 to 1,948) living in Europe near wind turbines (see section 2.2).
- Published case studies of ten families with a total of 38 affected people living near wind turbines in several countries (Canada, UK, Ireland, Italy and USA) (Pierpont 2009). However, these cases are not found in scientific journals. A range of symptoms including dizziness, headaches, and sleep disturbance, were reported by these people. The researcher (Pierpont) suggested that the symptoms were related to wind turbine noise, particularly low frequency sounds and infrasound, but did not investigate the relationships between noise and symptoms. It should be noted that no conclusions on the health impact of wind turbines can be drawn from Pierpont's work due to methodological limitations including small sample size, lack of exposure data, lack of controls and selection bias.
- Research on the potential health and safety hazards of wind turbine shadow flicker, electromagnetic fields (EMFs), ice throw and ice shed, and structural hazards (see section 2.3).

A synthesis of the research available on the potential health impacts of exposure to noise and physical hazards from wind turbines on nearby residents is found in sections 2.2 and 2.3, including research on low frequency sound and infrasound. This is followed by information on wind turbine regulation in Ontario (section 3.0), and our conclusions (section 4.0).

2.2. Sound and Noise

Sound is characterized by its sound pressure level (loudness) and frequency (pitch), which are measured in standard units known as decibel (dB) and Hertz (Hz), respectively. The normal human ear perceives sounds at frequencies ranging from 20Hz to 20,000 Hz. Frequencies below 200 Hz are commonly referred to as "low frequency sound" and those below 20Hz as "infrasound," but the boundary between them is not rigid. There is variation between people in their ability to perceive sound. Although generally considered inaudible, infrasound at high-enough sound pressure levels can be audible to some people. Noise is defined as an unwanted sound (Rogers et al. 2006, Leventhall 2003).

Wind turbines generate sound through mechanical and aerodynamic routes. The sound level depends on various factors including design and wind speed. Current generation upwind model turbines are quieter than older downwind models. The dominant sound source from modern wind turbines is aerodynamic, produced by the rotation of the turbine blades through air. The aerodynamic noise is present at all frequencies, from infrasound to low frequency to the normal audible range, producing the characteristic "swishing" sound (Leventhall 2006, Colby et al. 2009).

Environmental sound pressure levels are most commonly measured using an A-weighted scale. This scale gives less weight to very low and very high frequency components that is similar to the way the human ear perceives sound. Sound levels around wind turbines are usually predicted by modelling, rather than assessed by actual measurements.

The impact of sound on health is directly related to its pressure level. High sound pressure levels (>75dB) could result in hearing impairment depending on the duration of exposure and sensitivity of the individual. Current requirements for wind turbine setbacks in Ontario are intended to limit noise at the nearest residence to 40 dB (see section 3). This is a sound level comparable to indoor background sound. This noise limit is consistent with the night-time noise guideline of 40 dB that the World Health Organization (WHO) Europe recommends for the protection of public health from community noise. According to the WHO, this guideline is below the level at which effects on sleep and health occurs. However, it is above the level at which complaints may occur (WHO 2009).

Available scientific data indicate that sound levels associated with wind turbines at common residential setbacks are not sufficient to damage hearing or to cause other direct adverse health effects, but some people may still find the sound annoying.

Studies in Sweden and the Netherlands (Pedersen et al. 2009, Pedersen and Waye 2008, Pedersen and Waye 2007, Pedersen and Waye 2004) have found direct relationships between modelled sound pressure level and self-reported perception of sound and annoyance. The association between sound pressure level and sound perception was stronger than that with annoyance. The sound was annoying only to a small percentage of the exposed people; approximately 4 to 10 per cent were very annoyed at sound levels between 35 and 45dBA. Annoyance was strongly correlated with individual perceptions of wind turbines. Negative attitudes, such as an aversion to the visual impact of wind turbines on the landscape, were associated with increased annoyance, while positive attitudes, such as direct economic benefit from wind turbines, were associated with decreased annoyance. Wind turbine noise was perceived as more annoying than transportation or industrial noise at comparable levels, possibly due to its swishing quality, changes throughout a 24 hour period, and lack of night-time abatement.

2.2.1 Low Frequency Sound, Infrasound and Vibration

Concerns have been raised about human exposure to “low frequency sound” and “infrasound” (see section 2.2 for definitions) from wind turbines. There is no scientific evidence, however, to indicate that low frequency sound generated from wind turbines causes adverse health effects.

Low frequency sound and infrasound are everywhere in the environment. They are emitted from natural sources (e.g., wind, rivers) and from artificial sources including road traffic, aircraft, and ventilation systems. The most common source of infrasound is vehicles. Under many conditions, low frequency sound below 40Hz from wind turbines cannot be distinguished from environmental background noise from the wind itself (Leventhall 2006, Colby et al 2009).

Low frequency sound from environmental sources can produce annoyance in sensitive people, and infrasound at high sound pressure levels, above the threshold for human hearing, can cause severe ear pain. There is no evidence of adverse health effects from infrasound below the sound pressure level of 90dB (Leventhall 2003 and 2006).

Studies conducted to assess wind turbine noise indicate that infrasound and low frequency sounds from modern wind turbines are well below the level where known health effects occur, typically at 50 to 70dB.

A small increase in sound level at low frequency can result in a large increase in perceived loudness. This may be difficult to ignore, even at relatively low sound pressures, increasing the potential for annoyance (Jakobsen 2005, Leventhall 2006).

A Portuguese research group (Alves-Pereira and Castelo Branco 2007) has proposed that excessive long-term exposure to vibration from high levels of low frequency sound and infrasound can cause whole body system pathology (vibro-acoustic disease). This finding has not been recognized by the international medical and scientific community. This research group also hypothesized that a family living near wind turbines will develop vibro-acoustic disease from exposure to low frequency sound, but has not provided evidence to support this (Alves-Pereira and Castelo Branco 2007).

2.2.2 Sound Exposure Assessment

Little information is available on actual measurements of sound levels generated from wind turbines and other environmental sources. Since there is no widely accepted protocol for the measurement of noise from wind turbines, current regulatory requirements are based on modelling (see section 3.0).

2.3 Other Potential Health Hazards of Wind Turbines

The potential health impacts of electromagnetic fields (EMFs), shadow flicker, ice throw and ice shed, and structural hazards of wind turbines have been reviewed in two reports (Chatham-Kent Public Health Unit 2008; Rideout et al 2010). The following summarizes the findings from these reviews.

- **EMFs**
  Wind turbines are not considered a significant source of EMF exposure since emissions levels around wind farms are low.

- **Shadow Flicker**
  Shadow flicker occurs when the blades of a turbine rotate in sunny conditions, casting moving shadows on the ground that result in alternating changes in light intensity appearing to flick on and off. About 3 per cent of people with epilepsy are photosensitive, generally to flicker frequencies between 5-30Hz. Most industrial turbines rotate at a speed below these flicker frequencies.

- **Ice Throw and Ice Shed**
  Depending on weather conditions, ice may form on wind turbines and may be thrown or break loose and fall to the ground. Ice throw launched far from the turbine may pose a significant hazard. Ice that sheds from stationary components presents a potential risk to service personnel near the wind farm. Sizable ice fragments have been reported to be found within 100 metres of the wind turbine. Turbines can be stopped during icy conditions to minimize the risk.

- **Structural hazards**
  The maximum reported throw distance in documented turbine blade failure is 150 metres for an entire blade, and 500 metres for a blade fragment. Risks of turbine blade failure reported in a Dutch handbook range from one in 2,400 to one in 20,000 turbines per year (Braam et al 2005). Injuries and fatalities associated with wind turbines have been reported, mostly during construction and maintenance related activities.

3

Wind Turbine Regulation in Ontario

The Ministry of the Environment regulates wind turbines in Ontario. A new regulation for renewable energy projects came into effect on September 24, 2009. The requirements include minimum setbacks and community consultations.

3.1 Setbacks

Provincial setbacks were established to protect Ontarians from potential health and safety hazards of wind turbines including noise and structural hazards.

The minimum setback for a wind turbine is 550 metres from a receptor. The setbacks rise with the number of turbines and the sound level rating of the selected turbines. For example, a wind project with five turbines, each with a sound power level of 107dB, must have its turbines setback at a minimum 950 metres from the nearest receptor.

These setbacks are based on modelling of sound produced by wind turbines and are intended to limit sound at the nearest residence to no more than 40 dB. This limit is consistent with limits used to control noise from other environmental sources. It is also consistent with the night-time noise guideline of 40 dB that the World Health Organization (WHO) Europe recommends for the protection of public health from community noise. According to the WHO, this guideline is below the level at which effects on sleep and health occurs. However, it is above the level at which complaints may occur (WHO 2009).

Ontario used the most conservative sound modelling available nationally and internationally, which is supported by experiences in the province and in other jurisdictions (MOE 2009). As yet, a measurement protocol to verify compliance with the modelled limits in the field has not been developed. The Ministry of the Environment has recently hired independent consultants to develop a procedure for measuring audible sound from wind turbines and also to review low frequency sound impacts from wind turbines, and to develop recommendations regarding low frequency sound.

Ontario setback distances for wind turbine noise control also take into account potential risk of injury from ice throw and structural failure of wind turbines. The risk of injury is minimized with setbacks of 200 to 500 metres.

3.2 Community Consultation

The Ministry of the Environment requires applicants for wind turbine projects to provide written notice to all assessed land owners within 120 metres of the project location at a preliminary stage of the project planning. Applicants must also post a notice on at least two separate days in a local newspaper. As well, applicants are required to notify local municipalities and any Aboriginal community that may have a constitutionally protected right or interest that could be impacted by the project.

Before submitting an application to the Ministry of the Environment, the applicant is also required to hold a minimum of two community consultation meetings to discuss the project and its potential local impact. To ensure informed consultation, any required studies must be made available for public review 60 days prior to the date of the final community meeting. Following these meetings the applicant is required to submit as part of their application a Consultation Report that describes the comments received and how these comments were considered in the proposal.

The applicant must also consult directly with local municipalities prior to applying for a Renewable Energy Approval on specific matters related to municipal lands, infrastructure, and services. The Ministry of the Environment has developed a template, which the applicant is required to use to document project-specific matters raised by the municipality. This must be submitted to the ministry as part of the application. The focus of this consultation is to ensure important local service and infrastructure concerns are considered in the project.

For small wind projects (under 50 kW) the public meeting requirements above are not applicable due to their limited potential impacts.

4 Conclusions

The following are the main conclusions of the review and consultation on the health impacts of wind turbines:

- While some people living near wind turbines report symptoms such as dizziness, headaches, and sleep disturbance, the scientific evidence available to date does not demonstrate a direct causal link between wind turbine noise and adverse health effects.
- The sound level from wind turbines at common residential setbacks is not sufficient to cause hearing impairment or other direct adverse health effects. However, some people might find it annoying. It has been suggested that annoyance may be a reaction to the characteristic “swishing” or fluctuating nature of wind turbine sound rather than to the intensity of sound.
- Low frequency sound and infrasound from current generation upwind model turbines are well below the pressure sound levels at which known health effects occur. Further, there is no scientific evidence to date that vibration from low frequency wind turbine noise causes adverse health effects.
- Community engagement at the outset of planning for wind turbines is important and may alleviate health concerns about wind farms.
- Concerns about fairness and equity may also influence attitudes towards wind farms and allegations about effects on health. These factors deserve greater attention in future developments.

The review also identified that sound measurements at residential areas around wind turbines and comparisons with sound levels around other rural and urban areas, to assess actual ambient noise levels prevalent in Ontario, is a key data gap that could be addressed. An assessment of noise levels around wind power developments and other residential environments, including monitoring for sound level compliance, is an important prerequisite to making an informed decision on whether epidemiological studies looking at health outcomes will be useful.

Glossary

A-weighted decibels (dBA)
The sound pressure level in decibels as measured on a sound level meter using an A-weighted filter. The A-weighted filter de-emphasizes the very low and very high frequencies of the sound in a manner similar to the frequency response of the human ear.

Decibel (dB)
Unit of measurement of the loudness (intensity) of sound. Loudness of normal adult human voice is about 60-70 dB at three feet. The decibel scale is a logarithmic scale and it increases/decreases by a factor of 10 from one scale increment to the next adjacent one.

Downwind model turbines
Downwind model turbines have the blades of the rotor located behind the supporting tower structure, facing away from the wind. The supporting tower structure blocks some of the wind that blows towards the blades.

Electromagnetic fields (EMFs)
Electromagnetic fields are a combination of invisible electric and magnetic fields. They occur both naturally (light is a natural form of EMF) and as a result of human activity. Nearly all electrical and electronic devices emit some type of EMF.

Grey literature
Information produced by all levels of government, academics, business and industry in electronic and print formats not controlled by commercial publishing, i.e., where publishing is not the primary activity of the producing body.

Hertz (Hz)
A unit of measurement of frequency; the number of cycles per second of a periodic waveform.

Infrasound
Commonly refers to sound at frequencies below 20Hz. Although generally considered inaudible, infrasound at high-enough sound pressure levels can be audible to some people.

Low frequency sound
Commonly refers to sound at frequencies between 20 and 200 Hz.

Noise
Noise is an unwanted sound.

Shadow Flicker
Shadow flicker is a result of the sun casting intermittent shadows from the rotating blades of a wind turbine onto a sensitive receptor such as a window in a building. The flicker is due to alternating light intensity between the direct beam of sunlight and the shadow from the turbine blades.

Sound
Sound is wave-like variations in air pressure that occur at frequencies that can be audible. It is characterized by its loudness (sound pressure level) and pitch (frequency), which are measured in standard units known as decibel (dB) and Hertz (Hz), respectively. The normal human ear perceives sounds at frequencies ranging from 20Hz to 20,000 Hz.

Upwind model turbines
Upwind model turbines have the blades of the rotor located in front of the supporting tower structure, similar to how a propeller is at the front of an airplane. Upwind turbines are a modern design and are quieter than the older downwind models.

Wind turbine
Wind turbines are large towers with rotating blades that use wind to generate electricity.

Appendix 1: List of Documents on Wind Turbines

Journal Articles and Books

Braam HGJ, et al. Handboek risicozonering windturbines. Netherlands: SenterNovem; 2005.

Jakobsen J. Infrasound emission from wind turbines. *J Low Freq Noise Vib Active Contr*. 2005;24(3):145-155.

Keith SE, Michaud DS, Bly SHP. A proposal for evaluating the potential health effects of wind turbine noise for projects under the Canadian Environmental Assessment Act. *J Low Freq Noise Vib Active Control*. 2008;27(4):253-265.

Leventhall G. Infrasound from wind turbines: fact, fiction or deception. *Can Acoust*. 2006;34(2):29-36.

Pedersen E, Hallberg LR-M, Waye KP. Living in the vicinity of wind turbines: a grounded theory study. *Qual Res Psychol*. 2007;4(1-2):49-63.

Pedersen E, Larsman P. The impact of visual factors on noise annoyance among people living in the vicinity of wind turbines. *J Environ Psychol*. 2008;28(4):379-389.

Pedersen E, Persson Waye K. Wind turbines: low level noise sources interfering with restoration? *Environ Res Lett*. 2008;3:015002. Available from: http://www.iop.org/EJ/article/1748-9326/3/1/015002/erl8_1_015002.pdf.

Pedersen E, Persson Waye K. Wind turbine noise, annoyance and self-reported health and well-being in different living environments. *Occup Environ Med*. 2007;64(7):480-6.

Pedersen E, van den Berg F, Bakker R, Bouma J. Response to noise from modern wind farms in The Netherlands. *J Acoust Soc Am*. 2009;126(2):634-43.

Pedersen E, Waye KP. Perception and annoyance due to wind turbine noise – a dose-response relationship. *J Acoust Soc Am*. 2004;116(6):3460-70.

van den Berg GP. Effects of the wind profile at night on wind turbine sound. *J Sound Vib*. 2004;277(4-5):955-970. Available from: http://www.nowap.co.uk/docs/windnoise.pdf.

Grey Literature

Chatham-Kent Public Health Unit. The health impact of wind turbines: a review of the current white, grey, and published literature. Chatham, ON: Chatham-Kent Municipal Council; 2008 [cited 2010 Mar 5]. Available from: http://www.wind-works.org/LargeTurbines/Health%20and%20Wind%20by%20C-K%20Health%20Unit.pdf.

Colby WD, Dobie R, Leventhall G, Lipscomb DM, McCunney RJ, Seilo MT, et al. Wind turbine sound and health effects. An expert panel review: American Wind Energy Association & Canadian Wind Energy Association; 2009 [cited 2009 Dec 21]. Available from: http://www.canwea.ca/pdf/talkwind/Wind_Turbine_Sound_and_Health_Effects.pdf.

Rideout K, Copes R, Bos C. Wind turbines and health. Vancouver: National Collaborating Centre for Environmental Health; 2010 Jan [cited 2010 Mar 5]. Available from: http://www.ncceh.ca/files/Wind_Turbines_January_2010.pdf.

Wind turbines and Health: a review of evidence. Toronto: Ontario Agency for Health Protection and Promotion; 2009 [cited 2010 Mar 5]. Available from: http://www.oahpp.ca/resources/documents/presentations/2009sept10/Wind%20Turbines%20-%20Sept%2010%202009.pdf.

Environmental Protection Agency, Office of Water. Auxiliary and supplemental power fact sheet: wind turbines. Washington, DC: Environmental Protection Agency; 2007 [cited 2010 Jan 7]. Available from http://www.epa.gov/owm/mtb/wind_final.pdf.

Leventhall G, Pelmear P, Benton S. A review of published research on low frequency noise and its effects. London, England: Department for Environment, Food and Rural Affairs; 2003 [cited 2010 Mar 5]. Contract No.: EPG 1/2/50. Available from: http://www.defra.gov.uk/environment/quality/noise/research/lowfrequency/documents/lowfreqnoise.pdf.

Minnesota Department of Health, Environmental Health Division. Public health impacts of wind turbines.

Saint Paul, MN: Minnesota Department of Commerce, Office of Energy Security; 2009 [cited 2010 Mar 5]. Available from: http://energyfacilities.puc.state.mn.us/documents/Public%20Health%20Impacts%20of%20Wind%20Turbines,%205.22.09%20Revised.pdf.

National Research Council, Committee on Environmental Impacts of Wind-Energy Projects. Environmental impacts of wind-energy projects. Washington, DC: National Academies Press; 2007.

Ontario. Ministry of the Environment. Frequently asked questions: renewable energy approval. Toronto: Queen's Printer for Ontario; 2009. Available from: http://www.ene.gov.on.ca/en/business/green-energy/docs/FAQs%20-final.pdf.

Ontario. Ministry of the Environment. Noise guidelines for wind farms: interpretation for applying MOE NPC publications to wind power generation facilities. Toronto: Queen's Printer for Ontario; 2008 [cited 2010 Mar 5]. Available from: http://www.ene.gov.on.ca/publications/4709e.pdf.

Ontario. Ministry of the Environment. Development of noise setbacks for wind farms: requirements for compliance with MOE noise limits. Toronto, ON: Queen's Printer for Ontario; 2009. Available from http://www.ene.gov.on.ca/en/business/green-energy/docs/WindNoiseSetbacks.pdf.

Pedersen E. Human response to wind turbine noise: perception, annoyance and moderating factors. Göteborg, Sweden: Göteborgs Universitet, Sahlgrenska Acedemy, Department of Public Health and Community Medicine; 2007 [cited 2010 Mar 5]. Available from: http://gupea.ub.gu.se/dspace/bitstream/2077/4431/1/gupea_2077_4431_1.pdf.

Pierpont N. Wind turbine syndrome: a report on a natural experiment [pre-publication draft]. Santa Fe, NM: K-Selected Books; 2009 [cited 2010 Mar 5]. Available from: http://www.windturbinesyndrome.com/wp-content/uploads/2009/03/ms-ready-for-posting-on-wtscom-3-7-09.pdf.

Ramakrishnan R (Aiolos Engineering Corporation). Wind turbine facilities noise issues. Toronto: Queen's Printer for Ontario; 2007 [cited 2010 Mar 5]. Report No.: 4071/2180/AR155Rev3. Available from: https://ozone.scholarsportal.info/bitstream/1873/13073/1/283287.pdf.

Rogers AL, Manwell JF, Wright S. Wind turbine acoustic noise: a white paper. Amherst, MA: University of Massachusetts at Amherst, Department of Mechanical and Industrial Engineering, Renewable Energy Research Laboratory; 2006 [cited 2010 Mar 5]. Available from: http://www.ceere.org/rerl/publications/whitepapers/Wind_Turbine_Acoustic_Noise_Rev2006.pdf.

van den Berg F, Pedersen E, Bouma J, Bakker R. Project WINDFARMperception: visual and acoustic impact of wind turbine farms on residents: final report. Groningen, Netherlands: University of Groningen; 2008 [cited 2010 Mar 5]. Published jointly by the University of Groningen and the University of Gothenburg. Available from: http://www.wind-watch.org/documents/wp-content/uploads/wfp-final-1.pdf.

Whitford J. Model wind turbine by-laws and best practices for Nova Scotia municipalities: final report. Halifax, NS: Union of Nova Scotia Municipalities; 2008 [cited 2009 Apr 21]. Contract No.: 1031581. Available from: http://www.sustainability-unsm.ca/our-work.html.

World Health Organization

World Health Organization, Regional Office for Europe. Night noise guidelines for Europe. Geneva, Switzerland: World Health Organization; 2009 [cited 2010 Mar 5]. Available from: http://www.euro.who.int/document/e92845.pdf.

World Health Organization. Occupational and community noise. Fact sheet no. 258. Geneva, Switzerland: World Health Organization; 2001 [cited 2010 Mar 5]. Available from: http://www.who.int/mediacentre/factsheets/fs258/en/.

Community Concerns about Health Effects of Wind Turbines

Archives and Collections Society. Some health aspects of wind driven industrial turbines. Picton, ON: Archives and Collections Society; c2003-2004 [cited 2010 Mar 5]. Available from: http://www.aandc.org/research/wind_community_health.html.

Gillis L, Krogh C, Kouwen N. A self-reporting survey: adverse health effects with industrial wind turbines and the need for vigilance. London, ON: WindVOiCe: Wind Vigilance for Ontario Communities; 2009. Available from: http://windconcernsontario.files.wordpress.com/2009/04/windvoice__sept__24__20091.pdf.

McMurtry R. Deputation to the Ontario Standing Committee on General Government regarding Bill C-150. Scarborough, ON: Wind Concerns; 2009 Apr 22 [cited 2010 Mar 5]. Available from: http://windconcernsontario.files.wordpress.com/2009/04/deputation-to-standing-committee-mcmurtry.pdf

National Wind Watch: presenting the facts about industrial wind power. Rowe, MA: National Wind Watch; [cited 2010 Mar 5]. Available from: http://www.wind-watch.org/.

Wind Concerns Ontario: bringing sanity to wind development in Ontario. Scarborough, ON: Wind Concerns; [cited 2010 Mar 5]. Available from: http://windconcernsontario.wordpress.com/.

Conference Papers

Alves-Pereira M, Castelo Branco NAA. Infrasound and low frequency noise dose responses: contributions. In: Proceedings of the Inter-Noise Congress; 2007 Aug 28-31; Istanbul, Turkey.

Alves-Pereira M, Castelo Branco NAA. In-home wind turbine noise is conductive to vibroacoustic disease. In: Proceedings of the 2nd International Meeting on Wind Turbine Noise. 2007 Sep 20-21; Lyon, France.

Alves-Pereira M, Castelo Branco NAA. Public health and noise exposure: the importance of low frequency noise. In: Proceedings of the Inter-Noise Congress; 2007 Aug 28-31; Istanbul, Turkey.

Alves-Pereira M, Castelo Branco NAA. The scientific arguments against vibroacoustic disease. In: Proceedings of the Inter-Noise Congress. Istanbul; 2007 Aug 28-31; Istanbul, Turkey.

van den Berg GP. Do wind turbines produce significant low frequency sound levels? In: Proceedings of the 11th International Meeting on Low Frequency Noise and Vibration and its Control. 2004 Aug 30-Sep 1; Maastricht, Netherlands.

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