Landowner Guide

For Wind and Solar Project Development in Ontario

Developed for:

Clean Air Partnership

CLEAN AIR COUNCIL

Purpose of Guide

If you are a landowner, business owner, local decision maker, or other community member, The Landowner Guide for Wind and Solar Project Development in Ontario will help you understand utility-scale renewable energy development, what to expect during such development, operations and decommissioning of renewable energy in Ontario, and what questions to ask developers.

This guide is aimed at large-scale wind and solar projects, often referred to as 'utility-scale' as they are owned and operated by utility companies, as opposed to individuals wanting to put solar on their roofs or a small wind turbine on their property. With this guide, you will have foundational information about utility-scale wind and solar energy development, as well as insights and project development examples. While actual project development will vary by location, this guide offers a starting place for informed conversations, partnerships, and decision-making.

Many studies have found that individuals who are unhappy before a project is completed tend to be the most stressed when it is complete. Landowners and nearby residents should therefore be engaged early and often in the development process to ensure their voices are heard, and concerns are addressed.

The Landowner Guide arose from research, as well as from conversations with project developers, landowners, and communities with renewable energy projects.

While renewable energy development is no longer new, many landowners may find the massive amount of information about it to be overwhelming, and this Guide is meant to provide the latest information and address outdated, incorrect, or scientifically unsupported claims.

Canada as a whole is in the top 10 in wind energy installations globally and the United States is number 2 for both wind and solar (China is number 1). While the focus of this Guide is Ontario, sources from across Canada and the United States are included where they convey information clearly and as they help to illustrate that Ontario is not alone in developing wind and solar projects and landowners across the continent face similar questions and opportunities.

How to Use this Guide

This Guide is accompanied by summary slides to provide landowners with an overview of the key issues related of consideration of renewable project development on their land, while the Guide itself provides more details and references.

Part 1 in this guide provides background information intended to give the basics of how wind and solar technology works, and what is driving its development. This may be useful, to help understand some of the rationale for why developers are interested in designing projects in specific ways as well as how the equipment operates. If your interest is more on the actual development process you can skip to Part 2.

Part 2 focuses on wind and solar project development, timelines and contract types as well as some questions to consider asking developers.

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Glossary

ABBREVIATION	MEANING
AC	Alternating current
CanREA	Canadian Renewable Energy Association
CHA	Community host agreement
CO_2	Carbon dioxide
CVA	Current Value Assessment
dB	Decibels
dBA	A-weighted decibles
DC	Direct current
EROI	Energy return on (energy) investment
GHG	Greenhouse gas
Hz	Hertz
IEA	International Energy Agency
IESO	Independent Electric System Operator
IRENA	International Renewable Energy Agency
J	Joule
kWh	Kilowatt hour
LCA	Life cycle assessment
LDC	Local distribution company
m^2	Square metre
MW	Megawatt
MWh	Megawatt hour
NDA	Non-disclosure agreement
NO_x	Nitrogen oxides
$PM_{2.5}$	Particulate matter with 2.5 nm diametres
PV	Photovoltaic
SO_x	Sulfur dioxide
TW	Terrawatt
W	Watt

PART ONE: WIND & SOLAR BACKGROUND

1. Renewable Energy Growth

1.1 Global Trends

Ontario has recently initiated a request for large-scale (or utility-scale) power, which may include new wind and solar projects[1]. This guide is intended to help landowners understand how and why this development occurs, and how landowners can participate. This guide focuses on utility-scale projects (larger than 5 MW) designed for the purpose of selling electricity to the bulk market as opposed to home and/or businesses looking to develop their own small solar or wind projects on their properties.

Ontario is not alone in expecting wind and solar development. In addition to the need to act to avoid dangerous climate change, reduce air pollution, reduce dependence on finite fuel energy resources, wind and solar are growing rapidly globally due to the fact their costs have fallen dramatically.

In much of the world, wind and solar energy are now the most affordable forms of new electricity generation[2]. Not long ago, some people dismissed wind and solar energy as mere "alternatives" that were much more expensive than conventional options for generating electricity. But recently, that's changed. As wind, solar and now battery costs have fallen rapidly[3] governments and utilities are rushing to adopt these technologies for their economic benefits as much as their environmental ones. In fact, the International Energy Agency (IEA), expects electricity generation from combined forms of renewable energy to generate close to 80 percent of global electricity by the year 2050[4]. In fact, in 2023, the global investment in renewable electricity and power grids overtook fossil fuels for the first time (see Figure 1).

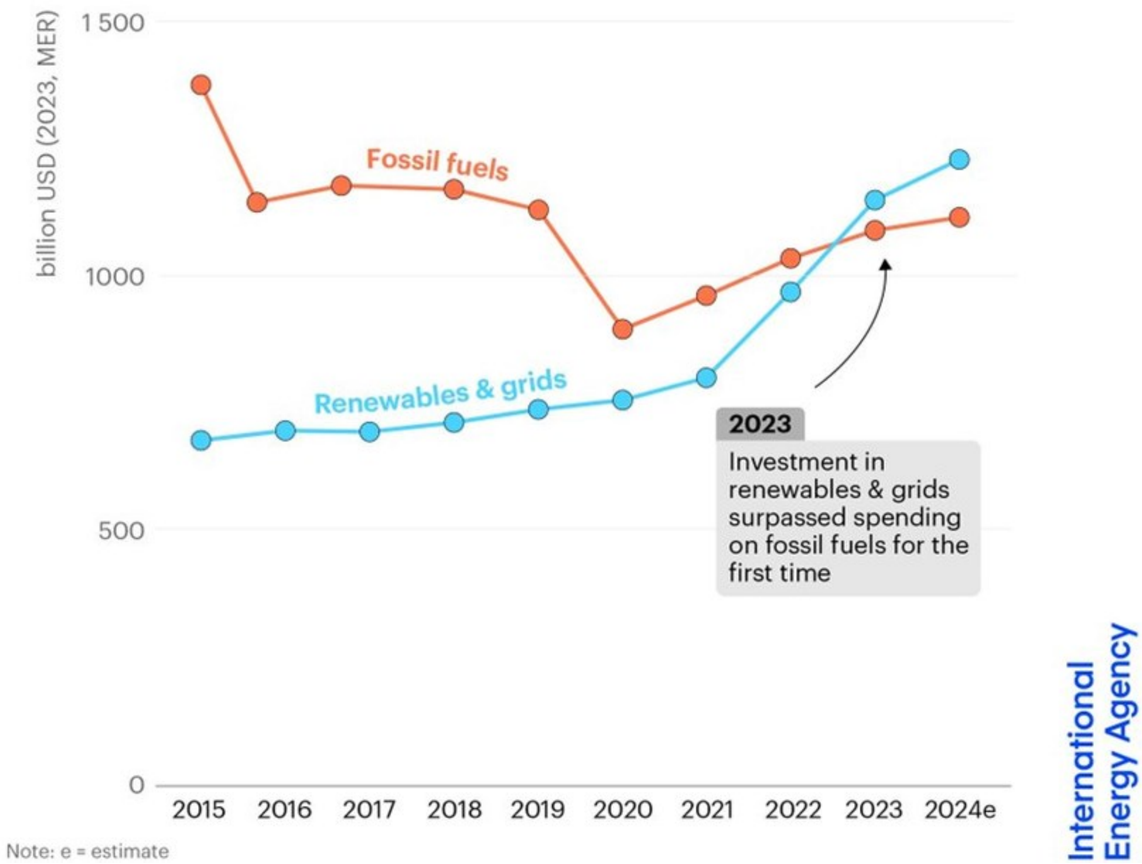


Figure 1: Global investment in fossil fuels compared to renewable energy and power grids[2]

In the United States, renewable electricity, largely generated from hydro, wind and solar, overtook electrical generation from nuclear energy in 2020, and from coal in 2022[5]. The Energy Information Agency reports that it expects solar, batteries, and wind energy to create 94 percent of all new electricity generating capacity in the United States in 2024[6], and that by 2050, wind, solar, and battery capacity could increase by at least 380 percent[7].

Because of the increased adoption of electric vehicles and heat pumps that lower greenhouse gas emissions, the electrification of industrial processes[8], artificial intelligence data centers[9], and a range of other factors, electricity consumption will rise significantly for the foreseeable future. In Canada, and around the world, much of the ability to meet that demand will come from low-cost and efficiently constructed renewable energy generation.

Renewable energy's "worldwide acceleration in 2023 was driven mainly by year-on-year expansion in China's booming market for solar PV (+116%) and wind (+66%). Renewable power capacity additions will continue to increase in the next five years, with solar PV and wind accounting for a record 96% of it because their generation costs are lower than for both fossil and non-fossil alternatives in most countries" [114]

1.2 Renewable Electricity History in Canada

While Canada is home to less than 0.5 percent of the global population, it has the 6th largest electricity system on the planet, ahead of both Germany and Brazil. On a per capita basis, only Bahrain, Qatar, and Kuwait generate more electricity than Canada does. While the Canadian electricity system is large, on average, it results in relatively few emissions. As a whole, Canada has historically generated close to two-thirds of its electricity from hydroelectricity, but that is not the case in every province. Whereas Quebec and British Columbia generate almost all of their electricity from hydro, Alberta and Saskatchewan still heavily rely on fossil fuels for electricity, while Ontario supplies much of its electrical energy from nuclear power.

As of 2022, wind energy accounted for approximately 6 percent of Canada's electricity generation, compared to 13 percent from nuclear power. Wind and solar have been the fastest growing sources of new electricity capacity in Canada for the past decade[10], and all Canadian provinces have wind energy projects, which by the end of 2023 totalled close to 17,000 MW of wind capacity (see Figure 2). Although wind farms began operating across the country in the early 2000s, solar energy has been more expensive until very recently, which is why its development lags behind that of wind in Canada.

However, that might change soon as the cost of solar has declined so quickly, it is expected to become the dominant electricity supply in much of the world by 2050[11].

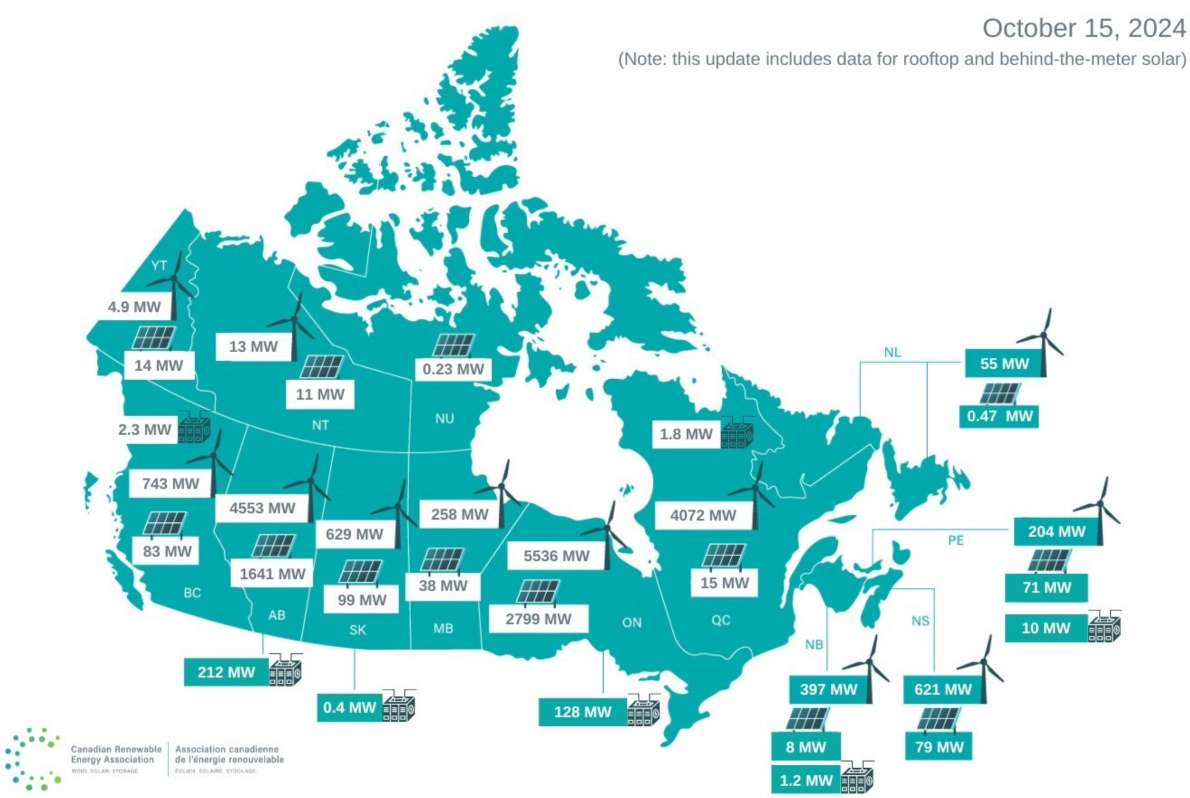


Figure 2: Wind and solar installed capacity in Canada as of December 2023[12]

The early adoption of wind and solar energy in certain European countries has been a major success, generating over 50% of national electricity supply in Spain, 55% in Germany and 67% in Denmark in 2023. Canada has been slower to adopt wind and solar in part due to huge hydroelectricity supplies in much of the country. However, given the massive scale of Canada's electricity system, it still ranks 9th in the world for installed wind capacity and 25th for solar. Recently, Canadian solar has grown to 6,000 MW of capacity in Canada, but on a per capita basis there is three times as much solar in both the USA and China (which had 179,000 MW and 610,000 MW respectively) than Canada in 2023[13].

Canada's first commercial wind farm was built in 1993 in Alberta, but was the only one for many years as significant wind development did not occur until the mid-2000s when Ontario, Quebec and Alberta became the leading Canadian markets. Wind development in Canada has frequently faced 'boom and bust' cycles, often as a result of changes in government policy. Ontario's 2009 *Green Energy Act* resulted in an estimated $12 billion of wind and solar investment in Ontario[14]; it was repealed on January 1, 2019[15], after which new renewable energy development slowed significantly.

Recently, Alberta had been leading Canada in both wind and solar development with $3.75 billion of expected investment in 2023 alone[16], as a result of a growing need for new supply due in part to reduction of electrical generation from coal. However, in late 2023 a moratorium was placed on new renewable development, followed by new permitting rules that have slowed development[17], and reportedly 33 projects have been cancelled since the moratorium was first announced[18].

In 2009 Québec launched a plan to develop 4,000 MW of wind energy capacity by 2015, and while it nearly achieved this goal by 2019, new developments were largely halted until 2023. However in May 2024, Hydro-Quebec announced plans to add 10,000 MW of new wind capacity by 2035[19], a 5-fold increase in a single decade (see Figure 3).

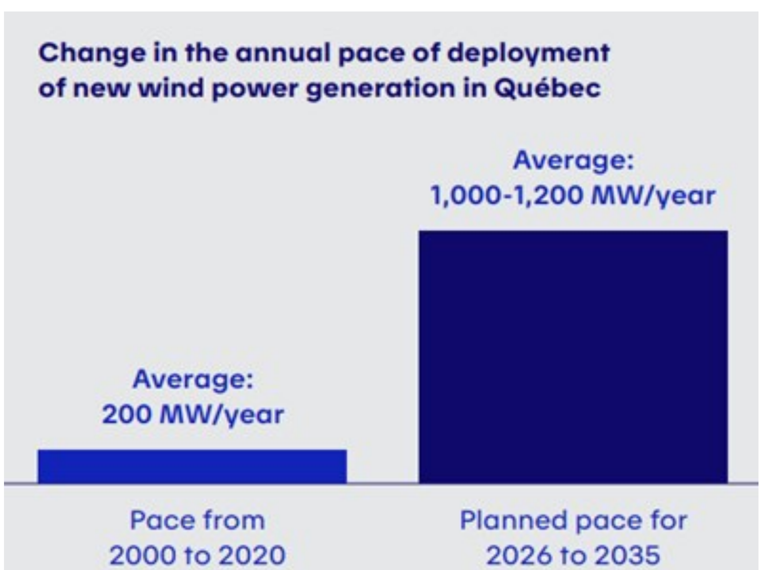


Figure 3: Hydro-Québec anticipated increase in wind energy development over the coming decade[19]

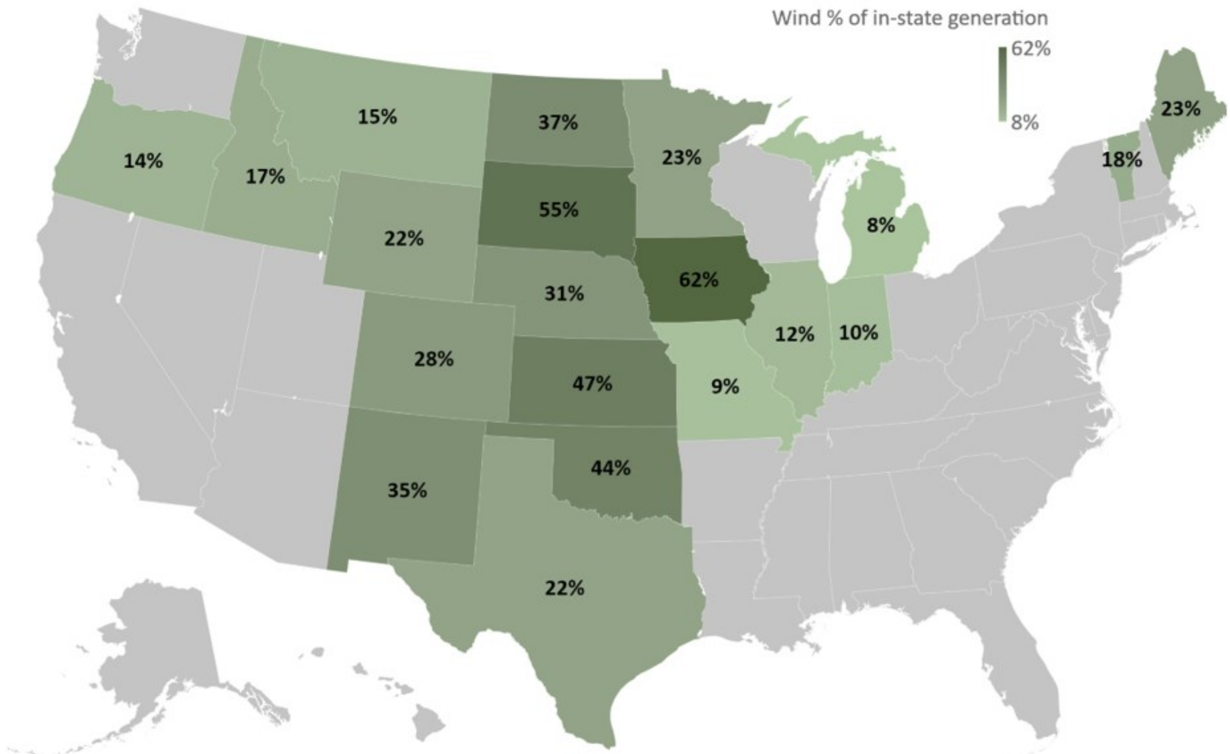


Figure 4: Top 20 states of annual electricity percentage from wind power (2022) Sources: US Department of Energy, AWS Truepower, National Renewable Energy Laboratory (NREL)

South of the border there are several states that generate over a quarter of their annual electricity from wind energy. While Iowa generated over 60 percent of its electricity from wind energy in 2022, Texas leads all states with over 40,500 MW of installed wind energy[20] – more than twice all of Canada's wind energy combined! The highest levels of development have occurred in the prairies, where strong winds and landowners' interest have combined for high levels of development[21], notably often in 'red states', suggesting that wind energy development does not necessarily break along politically partisan lines. In fact, wind energy surpassed nuclear output in Texas in 2014, and coal in 2020[22]. Texas also generated 6 percent of its electricity from solar PV in 2023, while California leads the country in solar energy, with almost 47,000 MW installed, 6,200 MW of which (more than twice all the solar in Canada!) were installed in 2023 alone[23].

Interestingly, wind and solar are growing in California and Texas for different reasons. In California, there is a government lead desire to reduce emissions and increase in-state energy security[24], while in Texas, which has a competitive electricity market, as well as having built transmission lines into the competitive renewable energy zones (CREZ)[25], wind and solar are largely being built because they are cost effective.

1.3 The Future of Electricity in Ontario

In all of Canada, only two provinces have their own nuclear power stations: Ontario and New Brunswick. Ontario's three nuclear power plants, located near Kincardine (Bruce Power), Pickering, and Darlington, have generated over half of Ontario's electricity for decades. Renewable energy from hydro, wind and solar supply over one-third of the electricity generated on Ontario's grid (see Figure 5). Ontario also has a significant supply (over 3,000 MW) of small-scale energy that connects to the lower voltage distribution system, the majority of which is solar energy[26], and about 10% of the total electricity in 2023 came from fossil fuel sources.

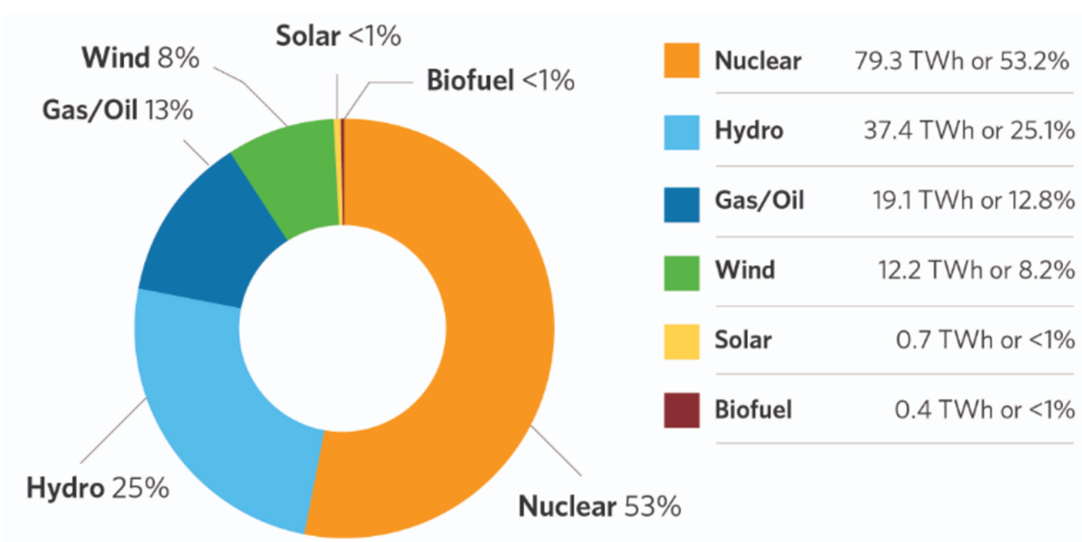


Figure 5: Ontario 2023 transmission connected electricity generation by technology[27]

The IESO recently published its annual planning outlook showing the need for significant amounts of new electricity supply as Ontario's population grows, new demands for electricity increase, and existing generating plants reach the end of their lives (see Figure 6 below). While different types of new supply, including the refurbishment or replacement of existing nuclear plants, may help meet this challenge, the increasingly low-cost of wind and solar will make those sources of electricity generation more attractive as Ontario looks to meet its electricity demand while reducing its emissions.

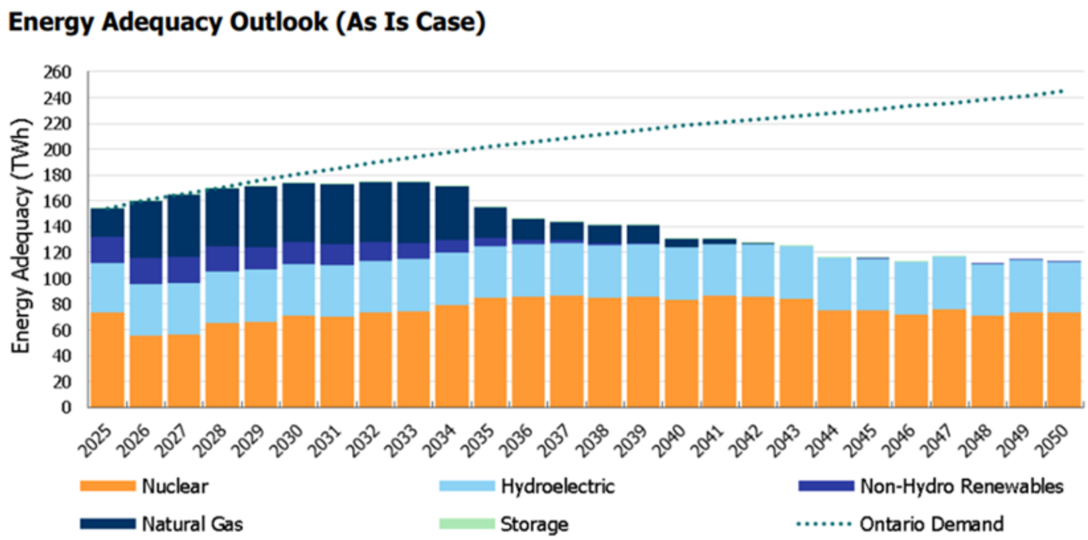


Figure 6: Ontario electricity generation gap[28]

As you can see, Ontario is not alone in expecting to see new renewable energy development, and this Guide exists to help Ontario's landowners understand and constructively participate in how and where new renewables development occurs.

2. Working Principles of Wind and Solar Power Plants

2.1 Variable Output Renewables

Renewable energy refers to generating electricity using a supply that does not get used up, such as a flowing river, tidal currents, wind and sunlight. Each renewable energy source has different advantages, costs, challenges, and limitations on where they can be built. Wind and solar are often discussed together not only because of their low costs, but because they can be built in many more locations than most other renewable sources.

Wind and solar also share the reality that their 'fuel' is not always available. While their fuel does not have a cost, we all know it's not always windy and of course the sun sets at night. Because their ability to generate electricity varies by season and with weather, they are often called *variable output renewable* energy. This guide focuses on variable output solar and wind, and so a few key terms are useful for understanding how variable output renewables operate, why they developed as they did, and the basic principles of how wind and solar plants operate. But don't worry—this guide won't make you do any calculations!

2.2 Terminology

2.2.1 Common Words That Are Often Misused

Energy comes in many different forms, including thermal, electrical, and kinetic, but the easiest way to understand it is as a measurement of accomplishing something. For instance, to heat your home to 20ºC in the winter, or drive a car 100 km, you need a certain amount of energy. To measure energy, we usually use the units of Joules (J). When it comes to electricity, we often use the units of kilowatt-hours (kWh). Both describe a quantity of energy. So, how much energy does a typical homeowner need? In Ontario, that's about 750 kWh per month today[29], but as electric cars and heat pumps become more popular, electricity use is likely to increase for many Ontarians as they decrease gasoline and natural gas consumption.

Power is the rate at which energy is being generated or used, which we measure in Watts (W), or one Joule per second (1 W = 1 J/s). Think of power relating to energy the way speed relates to distance: to know how far you travelled at 100 km/h, simply multiply that rate by how long you drove. For instance, if you drove at 100 km/h for 2.5 hours, you would have driven 250 km. So, one kilowatt-hour (kWh) means consuming 1000 J every second (1 kilowatt), for one hour. As a result, 1 kWh is equal to 3.6 million J, or 3.6 MJ.

Installed capacity is the maximum amount of power that a power system can produce. The maximum generation for an individual solar module is typically around 500 W. For a typical modern wind turbine, the maximum is around 5 megawatts (MW) meaning 5 million Watts. Of course, solar and wind farms contain multiple modules or turbines, so the maximum output of a commercial scale power plant can range from 10 MW to beyond 300 MW.

Capacity factor: All power plants are off for periods of time throughout the year for maintenance, repairs or in the course of normal day-to-day operations they do not operate every hour at full capacity. To conduct annual maintenance, some nuclear and other thermal power plants may cease generation for weeks at a time. While wind and solar output varies based weather and time of day.
In order to be able to predict the total energy a power plant produces we need to understand the average output of a power plant. Capacity factor therefore measures a power plant's total generation compared with the maximum it could have possibly produced over the same period of time.

2.2.2 Examples

Example 1: A wind farm has 20 wind turbines. Each one has a maximum capacity of 3.6 MW. If the average capacity factor for the wind farm is 40 percent, how much energy does the wind farm produce in one year? How does that compare with the average electricity consumption for a typical home in Ontario?

$$(20\ \text{turbines})\left(\frac{3.6\ \text{MW}}{\text{turbine}}\right)(40\%)\left(24\,\frac{\text{hours}}{\text{day}}\right)\left(365\,\frac{\text{days}}{\text{year}}\right) = \mathbf{252,288\,\frac{MWh}{year}}$$

Remember that in an average month, a typical Ontario home uses about 750 kWh or 0.75 MWh every month, which equals 9 MWh every year.

$$\frac{252{,}288\ \text{MWh}}{9\ \text{MWh / home}} = \mathbf{28,032\ homes}$$

So, this wind farm would produce on average around the equivalent amount of energy that just over 28,000 homes would use over the course of one year.

Example 2: The Pickering nuclear power plant has an installed capacity of 3,113 MW, and historically has had a lifetime capacity factor of around 74 percent. New wind turbines can be as large as 6.1 MW[30]. How many wind turbines with a 39% capacity factor would be required to generate as much electricity in one year as the Pickering nuclear plant?

$$1\ \text{wind turbine} = \left(\frac{6.1\ \text{MW}}{\text{turbine}}\right)(39\%)\left(24\,\frac{\text{hours}}{\text{day}}\right)\left(365\,\frac{\text{days}}{\text{year}}\right) = \mathbf{20,840\,\frac{MWh}{year}}$$

$$\text{Pickering} = (3113\ \text{MW})(74\%)\left(24\,\frac{\text{hours}}{\text{day}}\right)\left(365\,\frac{\text{days}}{\text{year}}\right) = \mathbf{2,079,711\,\frac{MWh}{year}}$$

$$\mathbf{\frac{2,079,711\ MWh}{20,840\ MWh} = 968\ wind\ turbines}$$

A large wind farm can be up to 100 wind turbines, and so it would probably take at least 10 large wind farms to generate as much energy every year as the Pickering power plant.

2.3 Why Are Wind Turbines So Big?

Wind occurs in part because the sun heats the earth unevenly (for instance, lakes heat more slowly than land), leading to the rise of hotter air over land that creates low pressure areas over lakes. Because high pressure areas want to equalize with lower pressure areas the movement of high-pressure air into low pressure areas is wind. Therefore, wind is actually another form of solar energy!

The energy that can be extracted from the wind depends on three things:

- the density of the air,
- how much of the air you are interacting with and,
- how fast the air is moving.

A little review of high school physics will be useful to understand why wind turbines are so large, and why they are so tall. Wind turbines can harvest kinetic energy from the air. The equation for kinetic energy is below:

$$\text{Kinetic Energy} = \frac{1}{2}\ \text{mass} \times \text{wind speed} \times \text{wind speed}$$

The first thing we need to calculate is the mass of the air. You can imagine a cylinder of air that is the same diameter as the blades as shown in Figure 7. The thickness of the cylinder depends on how fast the air is moving and how much time we are considering. If we know the density of that air, and the size of the cylinder, we then know the mass.

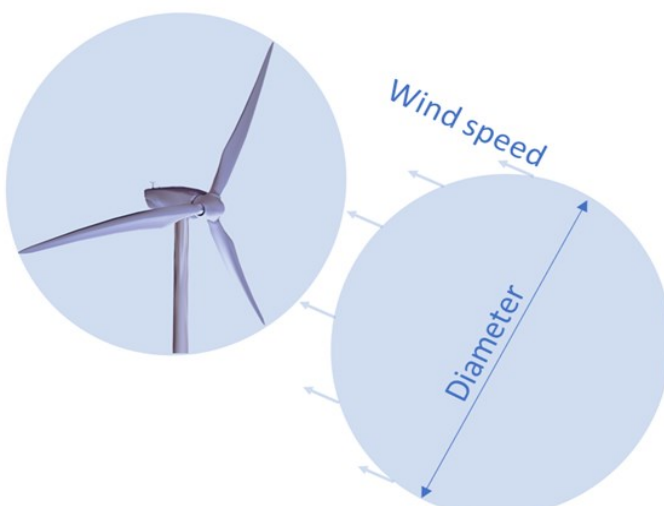


Figure 7: Air about to interact with a wind turbine

Remember, power is simply energy divided by time. So, if we divide by time we get:

$$\text{Power} = \frac{1}{2}\left[\text{air density} \times \frac{\pi}{4} \times \text{diameter} \times \text{diameter} \times \text{wind speed}\right] \times \text{wind speed} \times \text{wind speed}$$

This above formula shows just how important two factors are: diameter, and wind speed. First, the diameter of the turbines affects the power. If you want to generate more power, get bigger turbine blades. Second, the wind speed really, really matters!

Turbines are tall because they are looking for faster winds. Obstacles on the surface of the Earth like buildings or trees, cause friction and turbulence and tend to slow the wind down. The higher the turbine reaches, the fewer obstacles to wind, and the faster it flows (this is why farmer's fields, where there are not a lot of trees, can be ideal locations for wind turbines). In short, higher means faster, which means more power, and so modern wind turbines usually try to be as tall as they can (see Figure 8).

Imagine:

- **A 100 m diameter wind turbine**
- **The air density is 1.2 kg/m^3**
- **The wind is blowing at 5 m/s**

Using the equation above, you can calculate the maximum amount of power in the wind to be 0.6 MW.

If the wind speed were to double, the power in the wind would increase by a factor of 8, to over 4.7 MW!

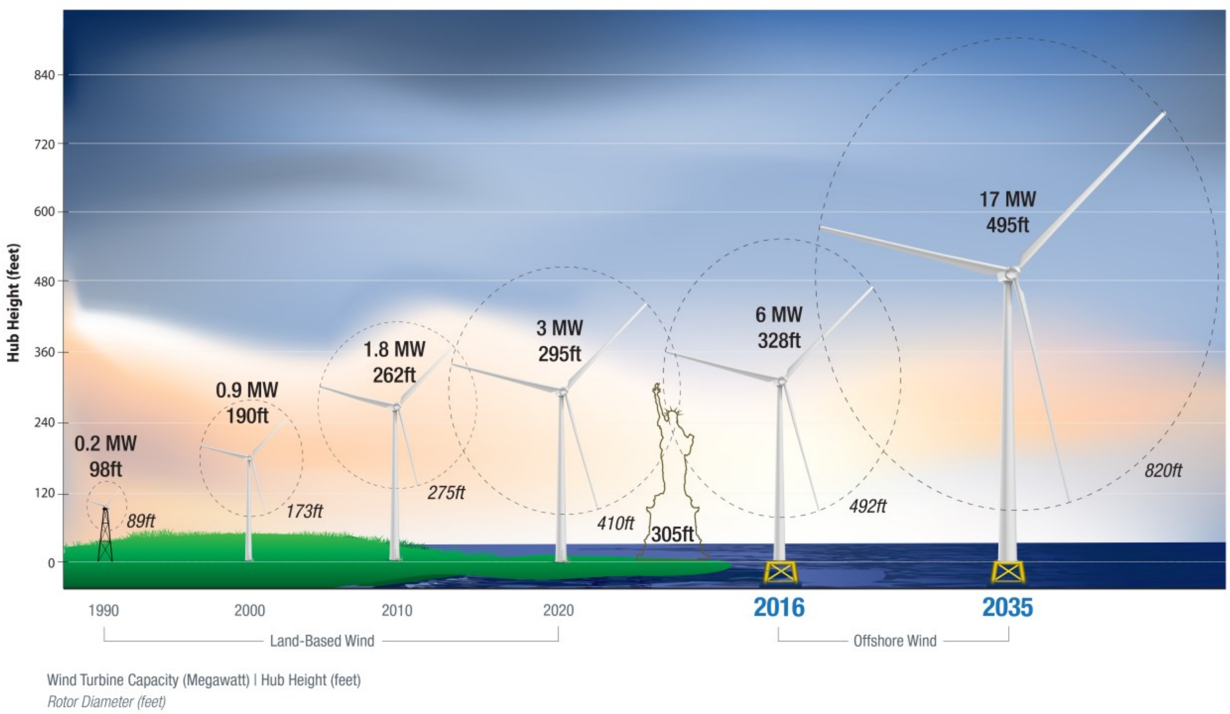


Figure 8: Evolution of commercial wind turbine sizes[31]

The air that moves through a wind turbine is slowed down and it is more turbulent (like the churning waters behind a ship), and so wind turbines need to be at least 6-10 rotor diameters away from each other so they aren't operating too much in each other's wake. More powerful turbines are larger and taller and so a modern wind farm doesn't need as many turbines as older ones, and spaces them further apart, which means multiple land owners typically need to participate jointly in wind energy projects.

2.4 Components of a Wind Turbine

Just as airplanes can come from Boeing or Airbus, and cars come from Mitsubishi, GM, or Fiat, wind turbines come from a range of manufacturers. And just as all airplanes or all cars are similar, wind turbines can vary slightly in appearance and features, but the major components will be mostly the same (see Figure 9 below).

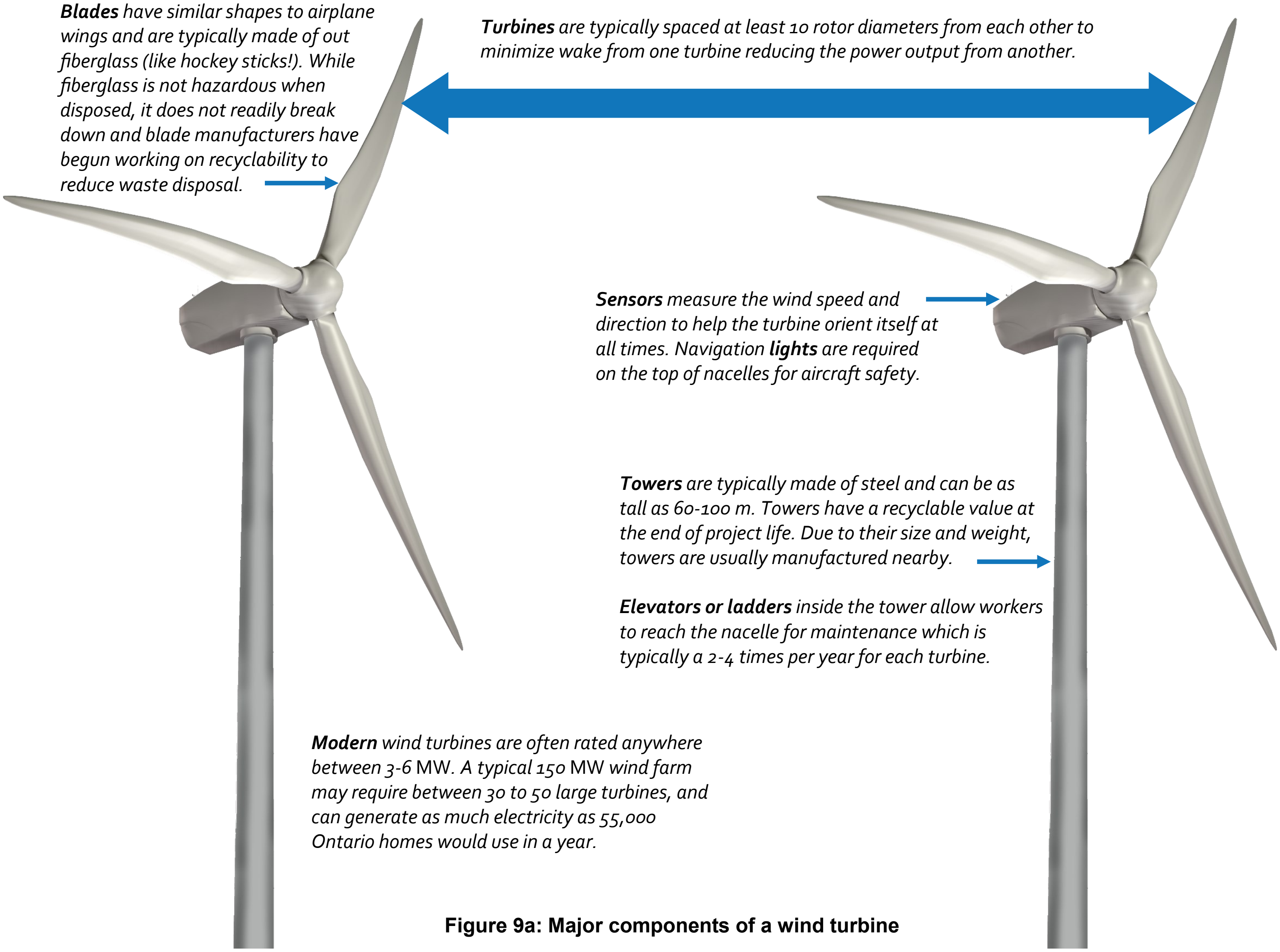


Figure 9a: Major components of a wind turbine

To begin rotating and generating electricity, most turbines need the wind to flow at least 3 m/s (or 11 km/hr) until the wind speed reaches around 25 m/s (90 km/hr). To generate the most power, turbines use sensors to tell them to rotate (or yaw) into the wind even if the wind direction changes hourly. If they need to reduce output, turbines can rotate their blades to change their aerodynamic efficiency (just like a helicopter). to prevent damage in severe storms, they can rotate out of the wind to reduce production or even shut down (which is also useful during maintenance).

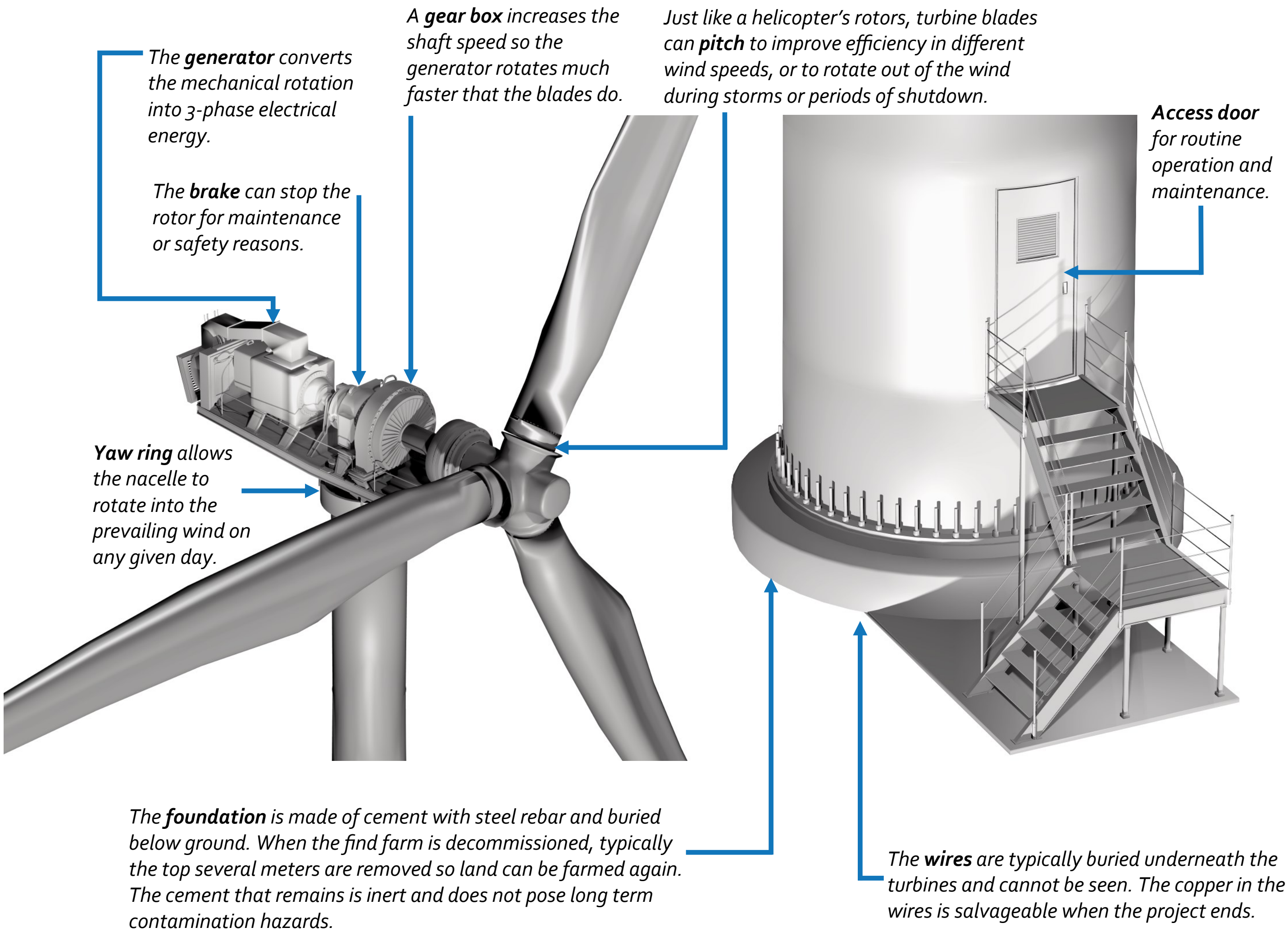


Figure 9b: Major components of a wind turbine

Wind Summary

- **Wind turbines are very tall in order to capture stronger winds available at higher elevations.**
- **The energy in the wind is very sensitive to the speed of the wind, so developers will look for locations and place their turbines to find stronger wind opportunities.**
- **A single modern wind turbine can be 4 MW or more, and is often on a 100 m tower that is typically at least 10 times the rotor diameter from the next nearest turbine.**

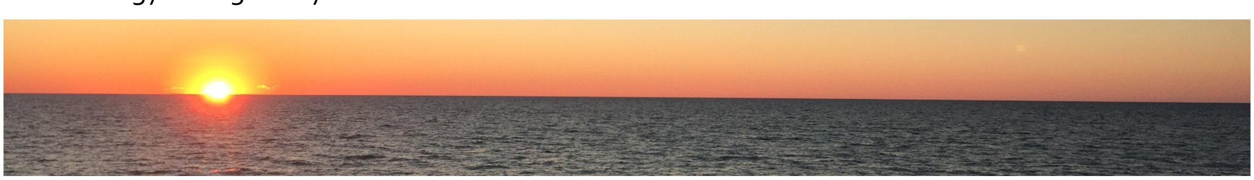
2.5 How Do Solar Photovoltaics Work?

Solar electricity systems are often called "PV" which refers to the photovoltaic effect which occurs in certain materials when they are struck with light. Silicon is commonly used in solar panels because it is abundant (found in sand), and can be treated to enable it to conduct electricity. When the energy in the light strikes the silicon, it gives energy to an electron and temporarily breaks it free from its silicon atom. Solar panels have aluminum wires that run across the silicon and allow the electrons to move from the side where the sun is shining to the back side to fill holes that have been created. This flow of electrons creates electricity.

The amount of electricity generated depends on how many electrons get energized by the light. But not all wavelengths of light energize electrons, and even if they did, no energy conversion process is perfectly efficient.

Nonetheless, commercially available PV systems average 17 to 20 percent light-to-electricity conversion efficiency[32]. This might seem low, but remember a typical car or truck only converts about 20 to 30 percent of gasoline energy to moving your car around, as the rest of the energy is lost as heat, and unlike gasoline or diesel, the fuel for solar PV is free.

Because the photovoltaic effect is slightly sensitive to temperature, cold actually improves efficiency. Ironically, if two days are equally sunny, a solar panel will produce slightly more energy on a cooler day than on a hotter one, and because the wind cools the panels, solar farms will also produce slightly more energy during windy weather.



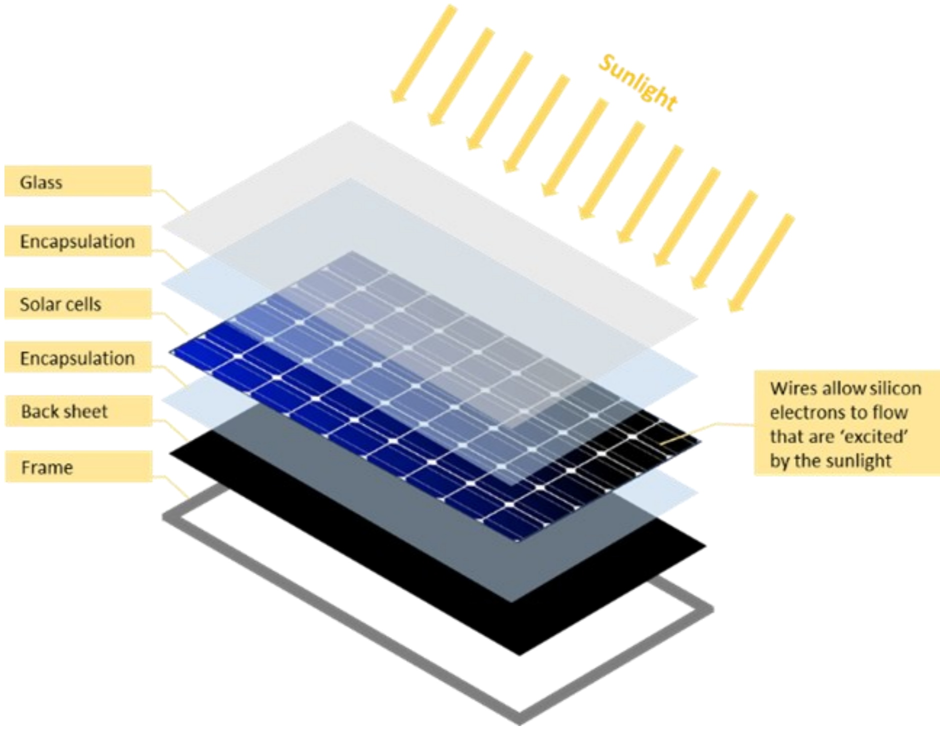


Figure 10: Basic components of a solar module

The basic components of an individual solar module are materials that support and protect silicon cells from the elements, and enable them to be mounted to face the sun (see Figure 10). Silicon cells have become so low cost, that it is now common to also put them on the back of a solar module! This is known as a 'bifacial' solar module. You would not put a bifacial solar module that is mounted flush to your roof, but in a solar farm, the side that is facing away from the sky can use reflected sunlight from the ground or from the row behind them to convert to electricity. While these cells obviously will produce much less energy than the ones facing the sun, it is often still worth the added expense.

The sun bombards the Earth with around 173,000 TW of solar radiation constantly, while global electricity demand is less than 3 TW, so even at current PV efficiency, less than 0.5 percent of the land area of Earth would be needed to generate enough energy to meet global demand.

Unlike most electrical generation equipment that has rotating components that generate alternating current (AC), solar PV systems generate direct current (DC) electricity. The electricity needs to be converted into AC before it is sold to the grid, which is done through a device known as an inverter.

2.6 Why Are Solar Farms So Large?

Solar arrays are made up of many individual modules and are often set up with many evenly spaced rows. It is worth spending a few minutes to understand some key aspects of how modules are oriented to increase their energy output in order to better understand design requirements for a solar farm. The energy that comes from the sun varies a little bit from year to year, and from season to season (the Earth's orbit is not a perfect circle), but on average the sun sends around 1.4 kW/m^2 of radiation to the Earth 24 hours a day, 365 days of the year.

Of course, not all of that energy reaches the Earth's surface as the light needs to get through the atmosphere, as well as any clouds that might be present on any given day, and of course the sun doesn't reach the side of Earth facing away from the sun (also called night time!) The sunlight is spread out across the spherical surface of the Earth as can be seen in Figure 11 below, and so the closer you are to the equator, in general the more direct sunlight you receive.

So, southern Ontario generally has better solar resources than northern Ontario, but clouds that result from being close to the Great Lakes also have an impact. In fact, parts of Saskatchewan and Alberta have better solar resources than southern Ontario despite being further north, because there are typically fewer clouds in the prairies.

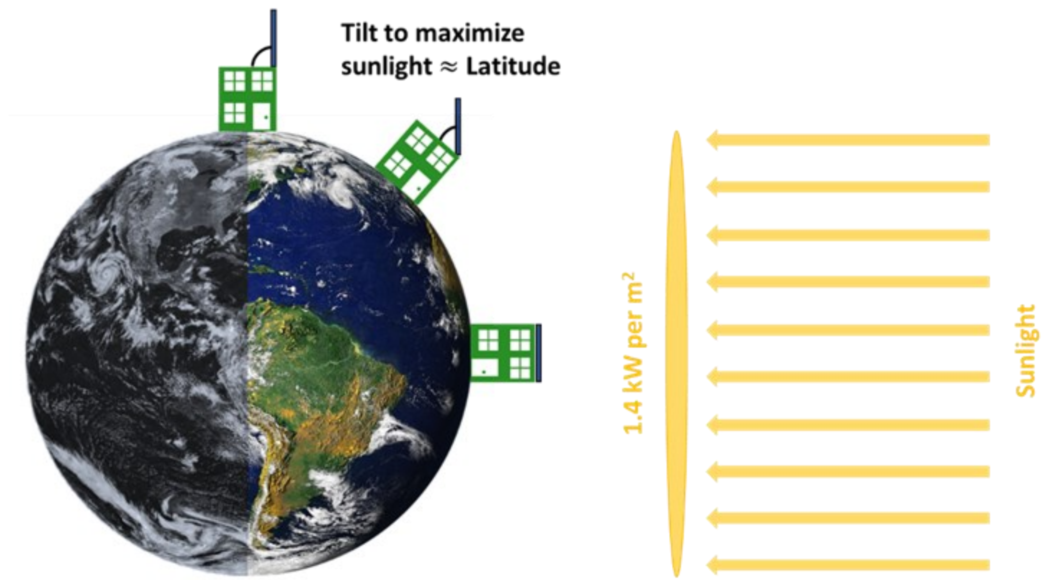


Figure 11: The geometry of a solar system affects the amount of energy it can produce

On a clear day, when the sun's rays are hitting the earth directly, around 1 kW/m^2 of sunlight can reach the surface. If a solar module is around 20% efficient, a 6 x 3.5 foot solar module (approximately 2 m^2), has a rated output around 500 W (even up to 700 W). Solar farms that are often over 100 MW, or 100 million W, might need as many as 200,000 individual solar modules, representing over 400,000 m^2 or close to 100 acres of surface area. But the modules are not simply laid out flat, and so they require more land than just their surface area.

Solar PV installed on the roof of a house or a barn is often attached to the roof at its slope and orientation. Commercial solar farms on the other hand are designed to maximize the amount of energy they can generate year-round and are oriented accordingly. In the northern hemisphere the sun spends most of the time in the southern skies, and so the "azimuth", or the orientation of the face of the modules is to the south. In addition to the azimuth, modules can be tilted to maximize their exposure to direct sunlight as can be seen Figure 12. A tilt close to the latitude is often a starting point for how panels are tilted.

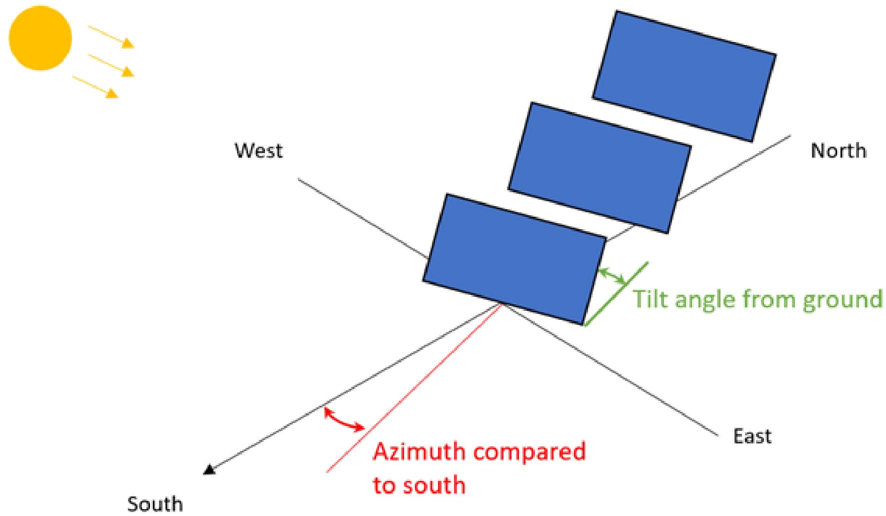


Figure 12: Important solar module design angles

However, there are other design considerations for a solar farm knowing that the sun moves across the sky every day, and also changes its position from season to season affecting the direct sunlight that hits the modules, as well as the shadows one row casts on the next. Solar farm design also considers how reflected light might be collected on the back of bifacial modules, how snow might passively fall off panels, and if the panels are built in a fixed position (see Figure 13 below), or if they are rather designed to track the sun. These decisions all affect the energy the farm will produce, as well as the land that is required to build and maintain a solar farm. Putting this all together, it is common for solar farms to require anywhere between 4 - 7 acres per MW installed[33].

3. Environmental Impacts of Energy Choices

All energy supplies have some impact on the environment, but some impacts are much larger than others, and/or have differing trade-offs. Environmental impacts can include air and water pollution, greenhouse gas emissions, water consumption, habitat impacts and mining-related damages resulting from the extraction of materials that go into the power plants. Overall, wind and solar have much lower environmental impacts than do fossil fuels, but that does not mean they do not have some impacts that should be addressed and minimized to the greatest extent possible.

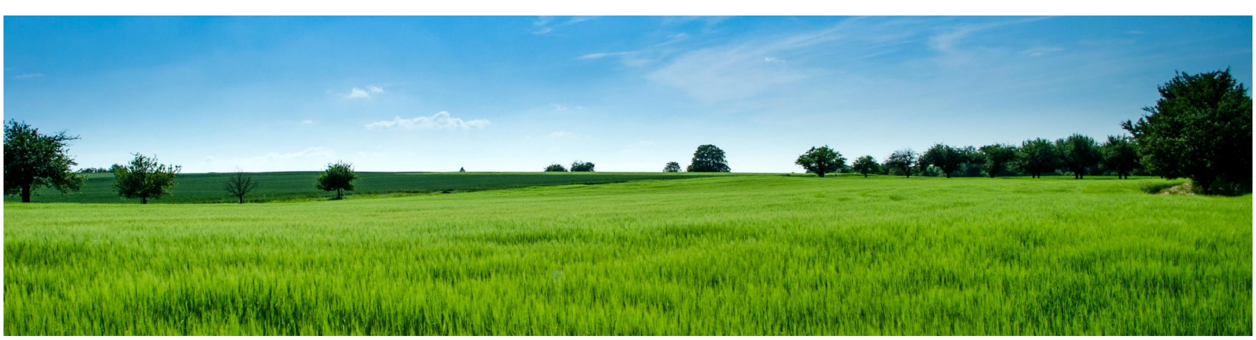


Figure 13: Solar array under construction in Alberta (photo courtesy of BluEarth Renewables)

Solar Summary

- **Solar PV modules convert sunlight directly into electricity.**
- **Solar farms are designed to maximize how much sunlight the cells receive, while minimizing the shadows one row might cast on the next.**

3.1 Air Pollution and Greenhouse Gas Emissions

Every time we flip the switch on the wall somewhere a machine responds to generate that electricity. Traditionally in many parts of North America, that machine is a coal and increasingly a fossil fuel natural gas-burning generator. Even though the lights don't pollute the air inside your house, how the plant generated the electricity will determine how much pollution that electricity causes.

Air pollutants are dangerous to human health. Some of the most common air pollutants resulting from burning fossil fuels to generate electricity are sulfur and nitrous oxides (SO_x and NO_x), carbon monoxide (CO), ozone (O_3), particulate matter (PM) and heavy metals such as mercury. The United States' Environmental Protection Agency notes that there are 188 hazardous air pollutants (HAPs) emitted by fossil fuel power plants, of which mercury from coal plants is of significant concern, but NO_x "contributes to the formation of ground-level ozone and fine particle pollution, which causes a variety of adverse health effects". SO_x contributes "to the formation of acid rain and fine particle ($PM_{2.5}$) pollution, SO_2 emissions are linked with a number of adverse effects to human health and ecosystems"[34]. As air pollution has recently been found to be ahead of tobacco and poor diet to become the 2nd leading global risk factor for death[35], reducing sources of air pollution is increasingly important.

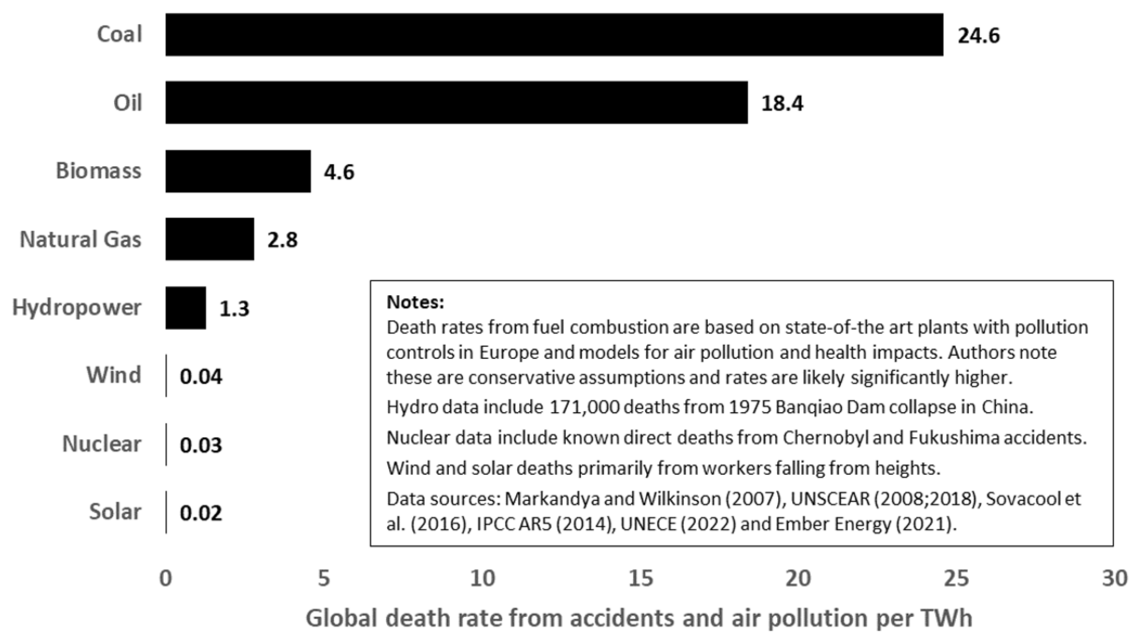


Figure 14: Human death rates attribute to electricity generation sources. Data source: Ritchie and Roser[36]

So, what's a convenient way to discuss the environmental cost versus the electrical benefit? If we add up all of the air pollution that results from all the power plants in a province, and divided that by the amount of electricity that was generated we can come up with an *emissions factor*. This represents the average amount of pollution that occurs for every unit of electricity that is consumed, or on the other hand, the amount of pollutants that are avoided by either not consuming that electricity, or generating it from a non-emitting source.

Another major product of fossil fuel combustion is carbon dioxide, which is well known to be the largest contributor to climate change. While very high concentrations of carbon dioxide are dangerous to human health, we typically do not think of carbon dioxide as an air pollutant in the same way that we do with the previous chemicals; however, the increasing amounts of carbon dioxide accumulating in our atmosphere have the ability to trap the sun's heat, gradually warming up the Earth. This is known as the 'greenhouse effect' and is the same reason that the planet Venus is hotter than Mercury, even though it is further away from the sun.

Climate change poses major economic and long-term health risks, some of which we are already experiencing. In the same way we can create emissions factors for air pollutants resulting from electricity generation, we can do the same for carbon dioxide. The greenhouse gas emissions resulting from generating electricity in different parts of Canada can be seen in Table 1.

Table 1: Electricity consumption greenhouse gas intensity in Canada[37]

Province/Territory	Greenhouse gas emissions factor (g_{CO_2e}/Wh)
Newfoundland & Labrador	25
Prince Edward Island	300
Nova Scotia	680
New Brunswick	300
Quebec	2
Ontario	**28**
Manitoba	1
Saskatchewan	620
Alberta	640
British Columbia	8
Yukon	110
Northwest Territories	180
Nunavut	800

Wind and solar have often been built to reduce emissions resulting from fossil fuel power plants on the system. However, in jurisdictions such as Ontario, the electricity system produces lower amounts of air pollution and greenhouse gas emissions, meaning that using electricity instead of a fossil fuel to heat your home or power a car will avoid both air pollution and greenhouse gas emissions. More renewable electricity will enable the electricity system to support more 'electrification' of energy uses that traditionally relied on fossil fuels.

3.2 Materials and Recycling

The major materials that go into wind and solar systems are commonly used in other aspects of modern life, and do not pose risk to air or water contamination during their construction, operation or removal. While many of the materials are recyclable, concrete is the least likely to be reused. The major materials that go into wind turbines[38] and solar panels[39] are shown below.

Table 2: Common materials and percentage of wind and solar generators

	Typical mass percentage	
Material	**Wind**	**Solar**
Steel	73%	0%
Fiberglass, resin or polymer	13%	10%
Iron	11%	0%
Copper	1%	1%
Aluminum	2%	8%
Silicon	0%	76%
Silver and/or other metals	<0.1%	<0.1%

Both solar and wind systems have foundations underground. Wind turbine foundations are made from concrete with steel rebar, while solar systems can be made of concrete or steel piles. For wind turbines, the foundations can weigh as much as three times as much as the turbine itself[40]. At the end of the project life, enough materials should be removed near the surface so that farming or other land uses can occur.

Like other fiberglass objects including hockey sticks, insulation, car bumpers, and boat hulls, wind turbine blades are rarely recycled. Fiberglass materials do not readily decompose, and so while they do not pose significant concerns to leaching toxins into groundwater, they are often landfilled. This is an issue that is being actively addressed by wind turbine manufacturers[41], as well as other manufacturers that use fiberglass materials[42]. While most Canadian wind turbines are still operating and have not ended up in landfills, there are efforts being made to start thinking about blade recyclability and one of the first blade recycling efforts in North America began in Iowa in 2024[43].

3.3 Life Cycle Impacts

All of the materials that go into the operation and maintenance of an electrical generator, including the machinery itself and the fuels, all need to be extracted, processed and ultimately disposed of. All of these steps involve energy inputs and can be a potential source of pollution and emissions along the way. For electricity generation, life-cycle assessment (LCA) can be used as a tool to sum up the impacts at all stages, and compare it to the final electricity that is delivered to the grid (see Figure 15). LCA is sometimes referred to as cradle-to-grave analysis, and can be done for any type of

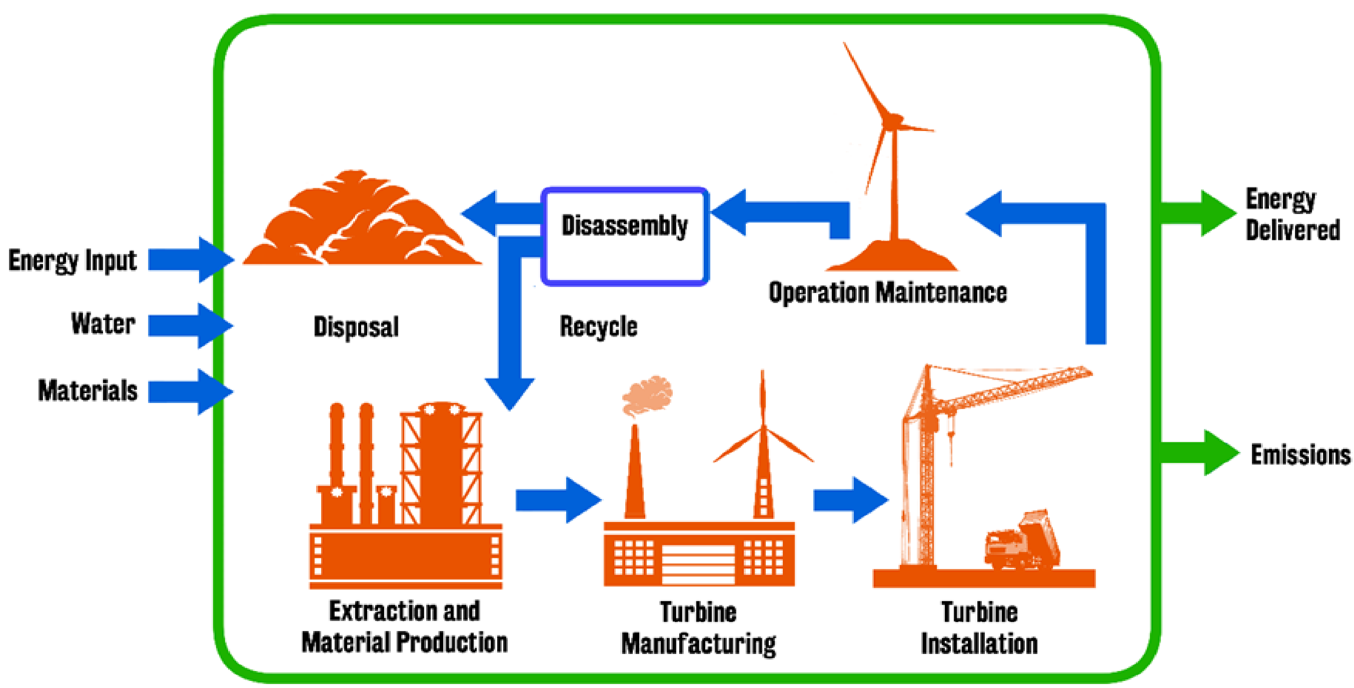


Figure 15: Life cycle of generating equipment

environmental impact whether it is greenhouse gas emissions, air pollution or water. The same analysis can be done looking at all the energy input that is required over the lifespan of a particular technology and comparing it to the energy it ultimately produces. When life-cycle energy input is compared to total energy delivered, it is usually given a special name known as Energy Return on Investment or EROI.

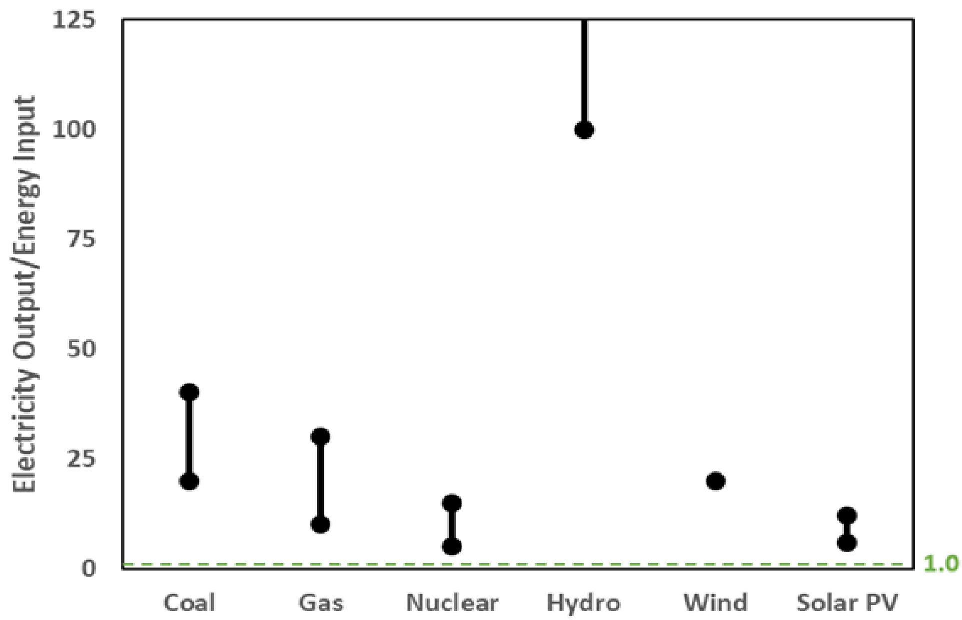


Figure 16: Typical range of energy generated over a power plant's lifetime compared to the energy required to build the plant. Data source: Hall, Lambert, & Balogh[44]

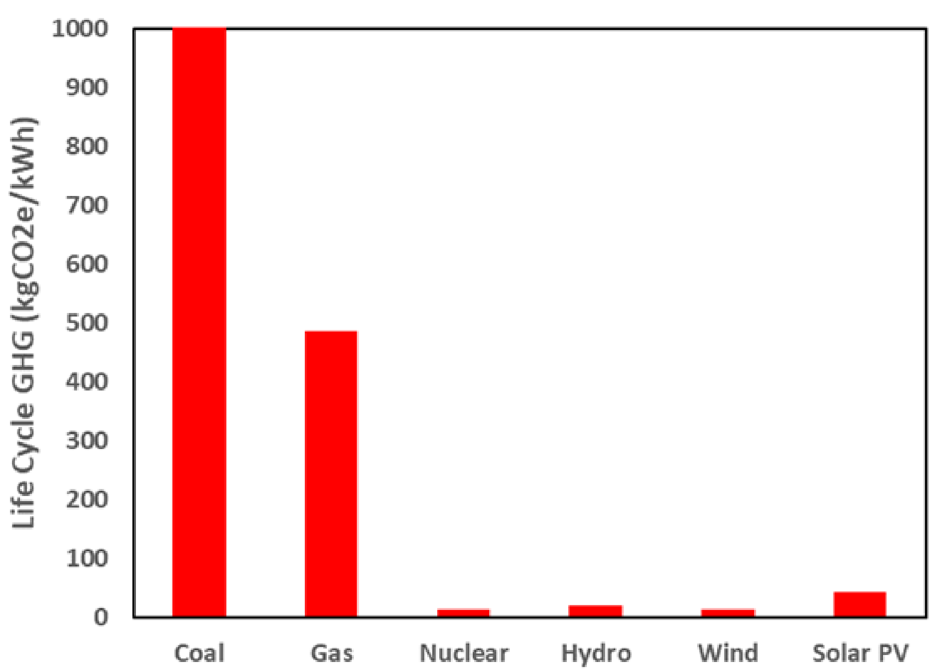


Figure 17: Typical life-cycle GHG emissions for electricity generation types. Data source: NREL[45]

Numerous studies have been done around the world looking at both life cycle assessments and energy return on investment as they are important metrics for society. While the manufacture and installation of wind turbines and solar modules uses concrete, steel and other metals, the results clearly demonstrate that electricity sources that do not rely on fossil fuels have significantly lower greenhouse gas emissions than those that use fossil fuels. The combustion of the fossil fuel is overwhelmingly more significant than the emissions and impacts resulting from the manufacturing and use of the wind turbines and solar panel materials themselves.

If the EROI is larger than 1.0 it means more useful energy is generated for society than was required to input into the power plant over its lifetime. In general, the EROI of renewable energy technologies has been increasing as manufacturing processes and efficiencies improve, while fossil fuels have been decreasing as the easiest fuels to reach have already been extracted. As the world moves towards extracting more and more energy intensive fossil fuel reserves, the EROI will likely continue to decrease[46].

Life-cycle will vary from case to case, and statistics evolve as technologies change, but in general the results are clear: renewable energy generation has consistently lower impacts on health and the environment than fossil fuels.

3.4 Wildlife Impacts

All methods of generating electricity, including wind and solar pose risks to wildlife. But how do the risks from renewable sources compare with those from other options? A 2023 Boston University study using data from 94 wildlife rehabilitation centers across Canada and the USA found the largest direct human-related risks to wildlife resulted from vehicle collisions, fishing-related incidents, avian collisions with buildings and windows, seasonal poisoning from lead ammunition, as well as pesticides[47]. The largest negative impact from energy-related activities is an increase in extreme weather events resulting from a warming planet. Climate change poses a major threat to wildlife conservation[48], and conservation societies such as the World Wildlife Fund[49], and the Audubon Society[50] rank climate change as one of the most significant risks to wildlife biodiversity.

Acute, near-term risks vary depending on the source of electricity generation. Burning coal poses the greatest risks to wildlife because it leads to acid rain, which harms plant life and aquatic ecosystems, and causes mercury accumulation in the food chain. The process of drilling and constructing gas wells requires clearing land, which can lead to habitat loss and fragmentation and can disrupt the natural movement of wildlife and reduce breeding grounds. Large hydroelectric dams cause significant loss of both terrestrial and aquatic habitats upstream and downstream, and can impede fish migration.

Electricity transmission lines also pose collision risks to birds, bats and other wildlife[51], as well as being a significant cause of wildfires[52]. The materials required for wind and solar projects also require mining for steel, copper, aluminum, limestone used in cement as well as rare earth elements used in electronics and magnets. The construction and operation of solar and wind farms can also impact habitats. In the case of wind turbines, avian collisions also need to be minimized.

On balance, the benefits that accrue from wind and solar displacing the need to extract and burn fuels outweigh their impacts. However, that does not mean the impacts of wind and solar energy cannot be scrutinized. Several conservation groups in the United States have been working with renewable energy companies to study and minimize their impacts. In 1994 the National Wind Coordinating Collaborative (NWCC) was initiated as a forum for "government agencies, industry, conservationists, academics, and the general public – to pursue the shared objective of developing environmentally, economically, and politically sustainable commercial markets for wind power in the United States"[53]. Other organizations such as Bats and Wind Energy Cooperative[54] and the Renewable Energy Wildlife Institute[55], can be useful sources for information for constructive measures to balance development while minimizing wildlife impacts.

Many species of bats in North America have had significant population declines from problems ranging from White Nose Syndrome, to loss of breeding and foraging habitat, to changes in farming practices that reduce food options[56]. As a result, there is an elevated concern for wind farms not to add undue additional stresses to bat mortality. Some wind projects have indeed shown higher levels of bat mortality than birds, and bat species that migrate across large distances are put at risk due to cumulative impacts of the aforementioned stresses across their migration ranges[57].

Bat mortality can range from 1 to over 50 bat mortalities/turbine/year, while in Ontario it has been estimated that 4 to 14 is more common[58]. Prior to obtaining approval, bird and bat impact assessments are required, which include outlining efforts that will be made to minimize mortality. Additionally, post-construction monitoring is required after a project has been commissioned to search for carcasses. Wind farms that exceed an estimated mortality of 10 bats/turbine/year are required to curtail their output for wind speeds below 5.5 m/s between sunset and sunrise from 15 July to 30 September throughout the lifetime of the project. While this can have a financial impact on the projects, curtailment has been found to be effective at reducing bat mortality[58].

Birds and bats are not the only species that can be impacted by wind and solar development, but they often get the most attention because flying into infrastructure injures or kills them. Data published from Boston University illustrates the relative impact of wind turbines to other human-caused bird mortality is small (see Figure 18). Nonetheless, all reasonable efforts should be made to reduce risks to wildlife including for wind and solar. In the conclusion to a paper estimating the frequency of bird and wind turbine collisions in the United States, the authors stated: “Despite an apparent lower magnitude of bird mortality at wind turbines compared to other anthropogenic mortality sources … mortality at wind facilities should not be dismissed offhand”[59]. This is especially true for species at risk, as well as species whose habitats might be affected by any particular project. Sensitive habitats and species at risk need to be carefully considered on a case by case basis.

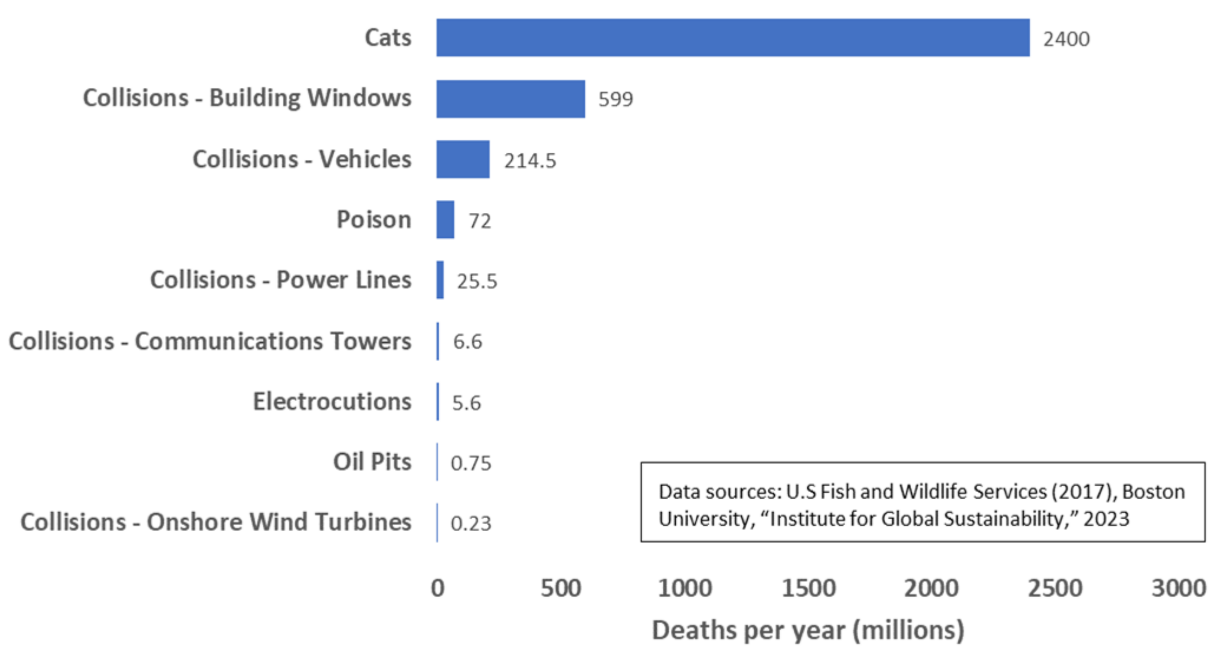


Figure 18: Leading anthropogenic causes of bird mortality in the United States[60]

The U.S. Fish & Wildlife Service published *Land-Based Wind Energy Guidelines* in 2012 to help minimize the impacts of wind energy on wildlife[61]. These guidelines are also often used by solar energy developers. The steps include project planning as well as post-construction and operations. While these are American guidelines, the steps (see Figure 19 below) are similar for development in Ontario.

In Ontario, specific environmental approvals required studies both prior to, and post-construction to minimize, as well as monitor, negative impacts to wildlife. These will be further discussed in section 9.

Figure 19: USFWS wind energy guidelines decision-tree[61]

4. Noise, Health, and Other Impacts

This section deals largely with wind turbines. Solar panels generally have slow, or no moving parts to create repetitive noise beyond the wind blowing over them, although solar panel tracking systems can be audible. Generally solar farm noise levels do not exceed background noise at the fence-line[62], and as trackers and inverters are not operational at night they are not audible during sleeping hours. Wind farms tend to draw more scrutiny when it comes to the impacts discussed here.

4.1 Noise

There are over 500,000 individual wind turbines operating globally, including over 70,000 in the United States alone[63]. As a result, there is a lot of experience of living near and around them.

Wind turbines are not silent. There are two main sources of noise from wind turbines; the aerodynamic noise of the blades as they rotate, as well as mechanical noise from the gearbox in the nacelle. Strong winds moving around the towers can sometimes also be heard. Noise from turbines may be heard up to 1 km away, depending on the terrain, atmospheric conditions, and geological features. Wind turbines are noisier when the winds are stronger, as is the surrounding environmental noise such as trees leaves rustling.

Sound levels are measured on a logarithmic scale with units of decibels (dB). Noise measurements weighted to the human perception are known as A-weighted decibels (dBA), which reduces the impact of very low and very high frequencies, which the human ear is less sensitive to, and emphasizing the mid-range frequencies where human hearing is most sensitive (around 1,000 to 5,000 Hz). According to the US Department of Energy, on average, wind turbines produce sounds 35–45 dBA range from a distance of 300 m, which is less than the 50 dBA a typical refrigerator makes when operating or the 70 dBA from average city car traffic[64].

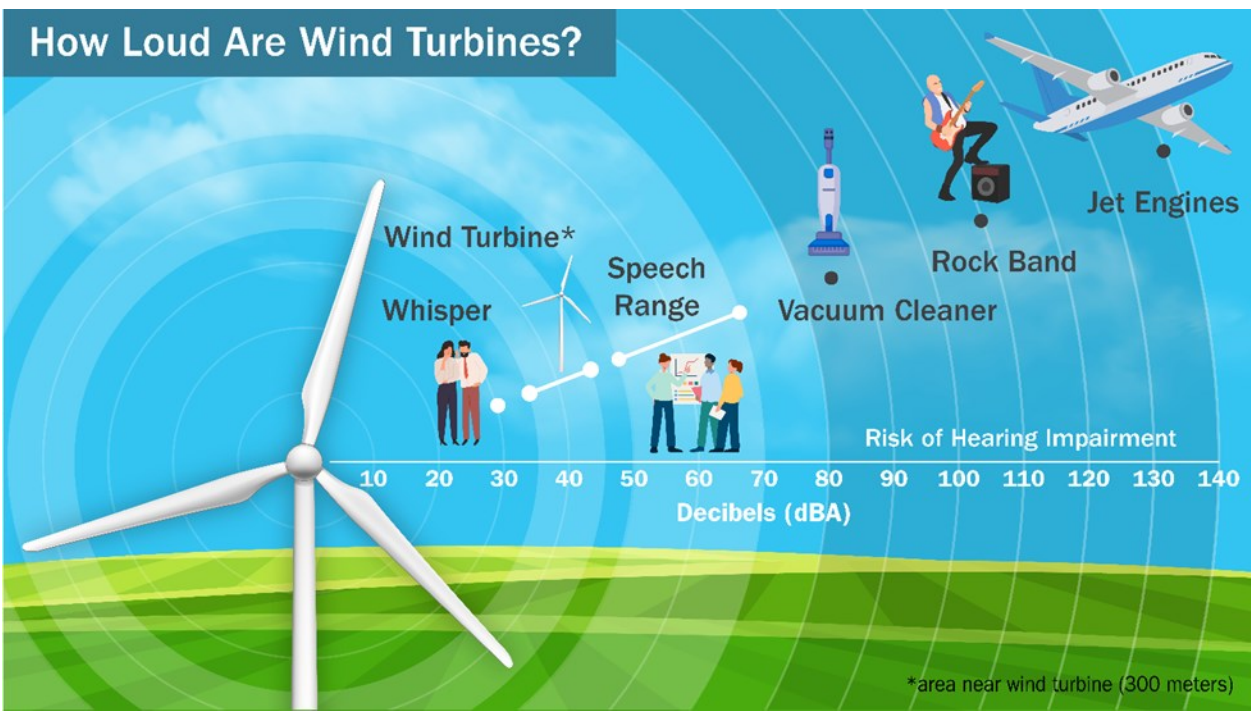


Figure 20: Representation of turbine noise compared other objects at a distance of 300 m (source: Al Hicks, NREL)

Due to the challenges of replicating wind turbine sound levels in controlled environments, it is recommended that people visit a functioning wind farm to experience the potential sound impacts firsthand. The different components of a wind turbine produce various types of sounds, including:

Broadband sound: is often referred to a 'white noise' and is a blend of sound waves with varying frequencies, lacking a distinct pitch (similar to the type of sound from a fan or ocean waves), and for wind turbines is often described as a whooshing, or swishing noise.

Infrasonic sound: occurs at frequencies below the human hearing range (under 20 Hz) and are always present in the environment. Infrasound may come from sources like flowing water or atmospheric turbulence and is typically felt as vibrations or pressure waves rather than being heard. It can sometimes cause structural vibrations, like rattling windows.

Impulsive sound: is characterized by sudden starts and stops, impulsive sounds are brief, lasting only a few seconds or less. These sounds often result from disturbed airflow interacting with the turbine blades, producing swishing noises.

Tonal sound: is produced by the mechanical parts of a turbine, such as shafts, gears, and generators. Tonal sounds can also be created by wind interacting with the turbine, such as airflow over components of the structure. These sounds usually have a distinct pitch, like a musical note.

Noise models are a required component of wind farm planning, and developers need to comply with local regulations regarding noise. Noise levels can be minimized by understanding potential noise sources during project development, maximizing distances between turbines and nearby inhabited buildings, as well as operational strategies. Studying and reducing noise levels continue to be areas of research for manufacturers and government agencies[65].

The Ontario Ministry of the Environment, Conservation and Parks inspects wind energy projects regularly to ensure noise compliance and assesses all complaints about wind turbine noise using a measurement protocol specific to wind turbines to determine if it is complying with its regulatory approval. Noise complaints can be directed to the "Spills Action Centre" at: 1-800-268-6060 (toll-free).

4.2 Health

Wind energy's impact on human health has been studied by multiple governments around the world, including the government of Canada which completed one of the most comprehensive studies in the world.

In collaboration with Statistics Canada, Health Canada completed one of the most comprehensive studies in the world in 2014, which assessed the effects of wind turbine noise (WTN) and low frequency noise (LFN) on human health. This large-scale epidemiological study by Prime Minister Stephen Harper's government arose from residents' concerns living near wind turbines across Ontario and Prince Edward Island. The study sought to:

- "Investigate the prevalence of health effects or health indicators among a sample of Canadians exposed to WTN using both self-reported and objectively measured health outcomes;
- Apply statistical modeling in order to derive exposure response relationships between WTN levels and self-reported and objectively measured health outcomes; and
- Investigate the contribution of LFN and infrasound from wind turbines as a potential contributing factor towards adverse community reaction".[66]

The study included an in-person questionnaire, objective health measurements, and noise measurements at over 1,200 residences categorized by outdoor wind turbine noise levels and randomly selected participants from homes at various distances from wind turbines in the two provinces.

So, what were the results?

The data found no link between WTN levels and health issues like chronic disease or sleep disruption. However, some people's annoyance about wind turbine noise could impact community harmony. Since this study, Health Canada has continued publishing multiple peer-reviewed scientific publications which concluded that there is no evidence connecting wind turbines to illness[67].

In 2022, the Ohio Department of Health published a summary of scientific literature that has been published on public health and wind energy from 2004 to 2018 and their major conclusions were:

> ***"There is no significant body of peer-reviewed, scientific evidence that clearly demonstrates a direct link between adverse physical health effects and exposures to noise (audible, LFN, or infrasound), visual phenomena (shadow flicker), or EMF associated with wind turbine projects.***
>
> ***Epidemiological studies have shown associations between living near wind turbines and annoyance. Annoyance is related to personal factors (such as noise sensitivity) and negative attitudes and expectations towards wind turbines rather than being related to specific physical characteristics of wind turbine projects[68,69] (also known as the 'nocebo effect' where a patient's negative expectation results in negative outcomes). In their 2017 report "Wind Turbine Syndrome: A Communicated Disease", authors Chapman and Crichton conclude based upon a review of studies on Wind Turbine Syndrome available at the time:***

> ***"…that annoyance can sometimes generate health problems consistent with those associated with stress and anxiety, but that there is no strong evidence of direct health effects from turbine exposure. Moreover, [the studies] conclude that pre-existing negative attitudes to windfarms are generally stronger predictors of annoyance than distance from the turbines or recorded levels of noise." (pp. 130-131)***

To summarize, there may be some amount of negative health impact caused by stress and anxiety resulting from annoyance and negative emotions surrounding the construction of new wind installations, but not because of noise, shadow-flicker, or EMFs. In the case of wind farms, it is very likely that education which emphasizes a lack of a proven correlation between noise, visual phenomena, and EMFs and direct health effects will mitigate much of the pre-existing negative attitudes and prevent or reduce stress".[70]

There are numerous peer reviewed studies that generally point to the conclusion that individuals who are unhappy before a project is completed tend to be the most stressed when it is operating. As a result, landowners should ensure they are engaged in the development's processes to ensure their voices are heard, and concerns are addressed.

4.3 Shadow Flicker

The rotation of wind turbine blades cast moving shadows when the sun is positioned behind the turbine. The location of the shadows varies by time of day and season, and the length of the shadows depends on tower height, blade length, terrain, and latitude. As well, the duration of shadow flicker is greater on bright days.

Shadow flicker is generally considered an annoyance and regulations generally exist to minimize it as much as possible. Nonetheless, landowners should inquire about steps that can be taken to minimize it. Shadow flicker rate depends on turbine size and rotational speed. Typically flicker frequency in the range of 0.3–1.0 Hz, which is well below any risk of seizures for those afflicted with photosensitive epilepsy which, according to the American Epilepsy Foundation can occur for strobing frequencies in the range of 3–30 Hz.

Because the sun generally shines from the south in the northern hemisphere, the intensity of the shadow flicker is strongest directly north of the turbine, although the shadow is shortest there. In contrast, the shadow stretches farthest to the east or west, and no shadows are cast directly south of wind turbines in Ontario.

4.4 Falling Ice and Ice Throw

Ice accumulation is not common on wind turbine blades, as cold temperatures often bring dryer air, but it can occur. If ice starts to accumulate on the leading edge of a wind turbine blade it can affect the weight and aerodynamic properties of the blades, which can significantly alter the turbine's performance. As a result, the control system often automatically shuts down the turbine. The turbine typically cannot restart until the ice has completely melted. Some turbines in Canada are equipped with ice removal equipment, but many are not, as even in cold climates ice accumulation is relatively infrequent.

Nonetheless, different types of ice can accumulate on turbine blades. Glaze ice is a clear and solid type of ice that typically forms at temperatures just below freezing, often due to freezing rain. When the sun melts glaze ice, it usually falls straight down from the blades. Rime ice is porous and white in color. Rime ice forms when fog vapor contacts cold surfaces, creating a protruding formation on the front of the turbine blades. Rime ice is less streamlined and forms at colder temperatures than glaze ice, and is more likely to be thrown in smaller pieces as it detaches from the blade. Rime ice formation is more common in humid areas where open bodies of water are present throughout the winter.

Ice falling from the stationary blade of a wind turbine is estimated to land within a combined distance of the blade length and a small (less than 25 m) drift caused by the wind. While wind turbines are designed to shut down if ice is detected, it is possible that ice is thrown from a moving blade. European studies suggest a safe distance of 100-600 m[71], while a U.S. study recommends 230-350 m to limit any strike risk to between 1 in 10,000 and 1 in 100,000. After an icing event, people and livestock should be kept at safe distances.

Snow and ice pose no safety threat for solar PV but can reduce annual production. There is less solar energy to be harvested in the winter months, so the energy that is lost is often relatively small. Nonetheless, project owners often actively sweep snow off solar projects if it is not melted by the sun warming the black modules.

4.5 Catastrophic Failures

As with any industrial equipment, there is always a risk of failure due to extreme weather or other forms of structural damage. Wind turbines were recently damaged in Iowa when they were hit with a tornado[72], while the offshore wind farm near Fukushima, Japan was undamaged and operating within days after the 2011 tsunami which resulted in the catastrophic nuclear failure[73]. Given the weight of the towers, blades and nacelles, in the event of a catastrophic failure of a wind turbine, the distances debris might be thrown is not typically more than a few hundred meters[71] Research in California found the probability of being hit by debris from a wind turbine to be less than 1 in 1,000,000 per year for setbacks of 2-3 overall turbine heights (tower plus the blade length)[74].

4.6 Glare Analysis (Solar)

Glare refers to a sustained reflection of light which can result from solar farms. Glare analysis evaluates the potential for reflected sunlight (glare) to impact surrounding environments, such as roads, airports, and nearby properties. The analysis considers the angle and direction of solar panels, site's latitude, longitude, and solar exposure, seasonal and daily changes in the sun's position as well as nearby sensitive areas such as residential dwellings, highways and airports. The analysis is done to prevent visual hazards to pilots, drivers, and residents caused by the reflections, to regulatory requirements and to minimize complaints from local residents. Geometric changes to the farm's layout as well as the application of anti-reflective coatings can be ways to minimize glare.

4.7 Visual Impacts

While aesthetics do not pose health risks, visual impacts are frequently a significant concern for residents living near proposed projects given that solar farms take up significant land and wind turbines can often be seen from a distance. Studies have shown that perceptions of visual impact can influence how annoyance with respect to new noises are perceived. To address this, developers present residents with still digital paintings and video simulations of how the proposed layout of the project will look when finished. There are often physical or policy limitations on where turbines or solar panels can be placed, but locations can often be adjusted to make the overall impact more acceptable to the local community. Community consultations and input are essential to finding siting solutions that satisfy both developers and the local community.

5. Land Use Requirements

5.1 Wind and Solar Resources

Before looking for land to build a wind or solar farm, it is important to understand the capability for adequate renewable energy potential at a location. The average wind and sunlight will vary from year to year, and so it is important to have long-term data so decisions are not made if one year happened to be particularly windy or unusually cloudy. The first step that most developers take will be to look at publicly available databases which contain long-term weather data, satellite measurements as well as computer models.

There are many freely available wind and solar resource maps and databases from government agencies as well as from private companies. Examples of wind and solar maps that are available for free from the World Bank are shown in the figures below, but other maps are available from NASA as well as the government of Canada. Project developers often consult with resource maps as a starting point for project assessments, and to find potential locations that have reasonable proximity to existing transmission lines. Landowners can also look at them to understand where viable projects might be.

Understanding a solar resource is relatively straightforward, as it is largely a function of latitude and average cloud cover. While the energy varies from year to year, on average it is relatively predictable. Project proponents often use direct satellite data to design and analyze their projects' energy production potential.

Some solar maps denote kWh/kW_p which is an estimate of annual kilowatt-hours of energy production for every kilowatt of solar PV (see Figure 21). It should be noted that these estimates include assumptions around some of the technical terms discussed earlier such as efficiency, tilt angle or how snow coverage may reduce the energy potential of an individual project. Nonetheless the maps still provide a good indicator of the relative quality of a local resource.

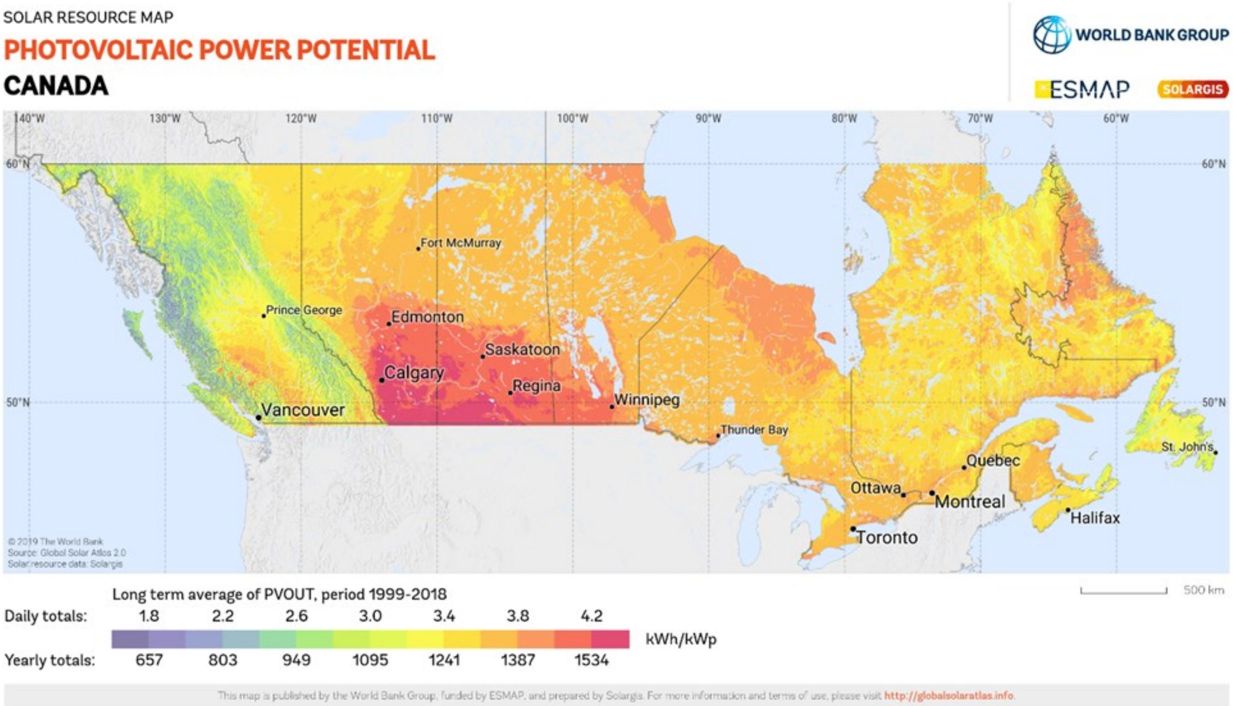


Figure 21: Photovoltaic energy potential in Canada[75]

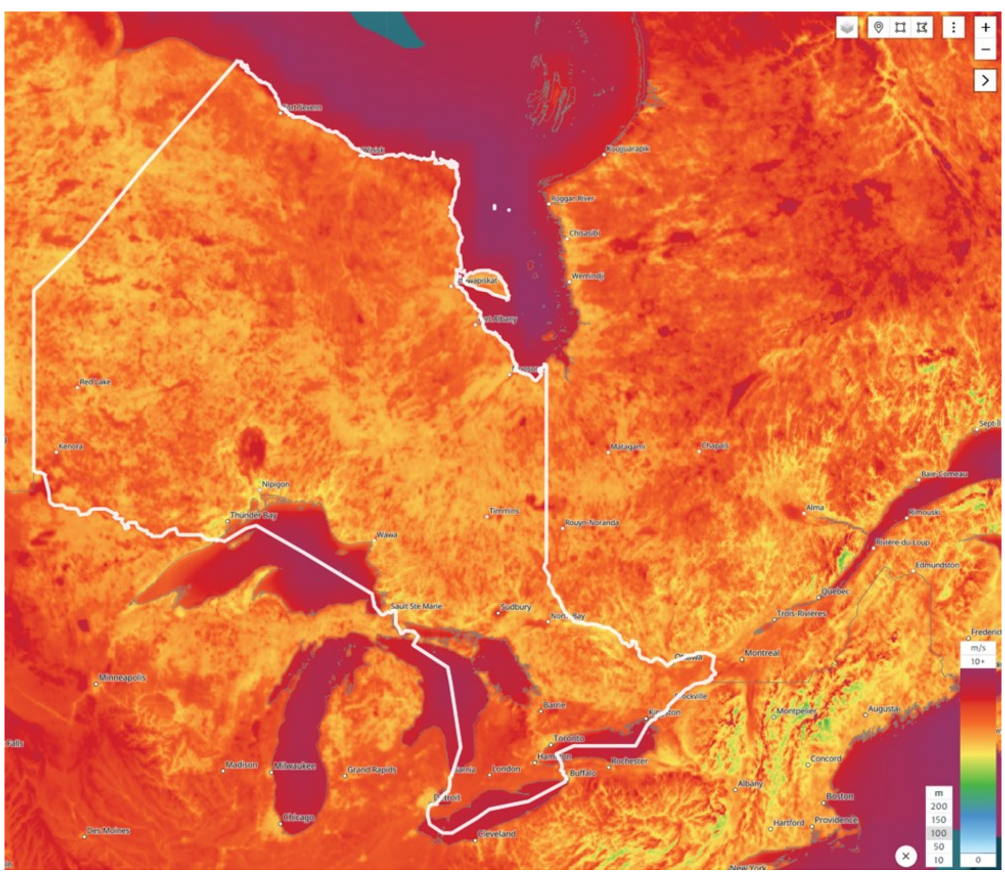


Figure 22: Wind map of Ontario at 100 m height[76]

5.2 Transmission Lines

While the local renewable resource is important, wind and solar projects need to be able to sell their energy, and so they need access to the electricity system. Both technologies can connect to either the high voltage transmission system or the lower voltage distribution system, but larger projects usually connect to the transmission system as not all of the energy can be used nearby and likely needs to be transported elsewhere in the province.

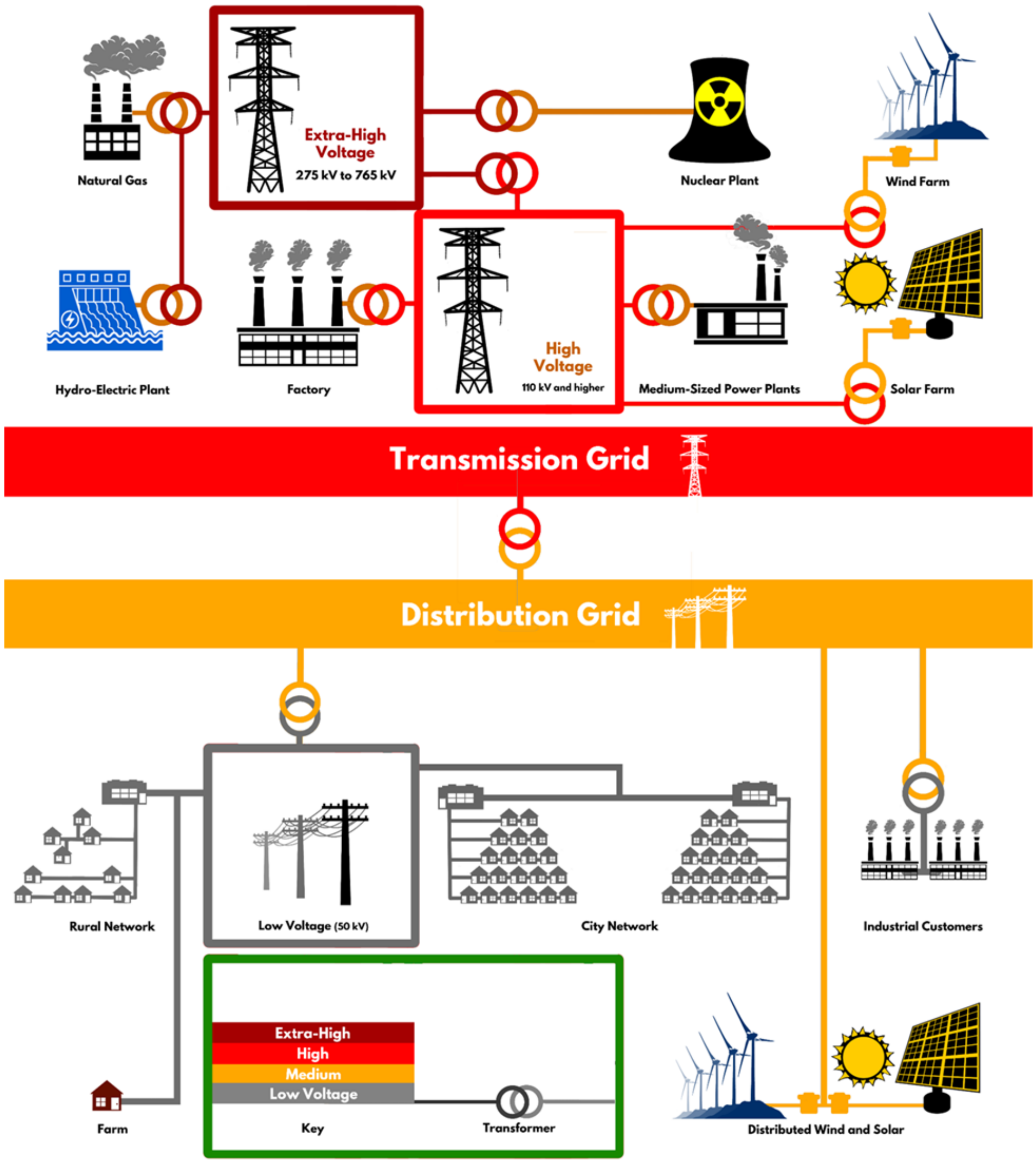


Figure 23: Illustration of typical components of the electricity grid

Distribution connected projects are also referred to as 'embedded generation' and are often relatively small (less than 20 MW). Solar tends to be the most common generation technology that is distribution connected in Ontario because it is readily scalable (see Figure 24).

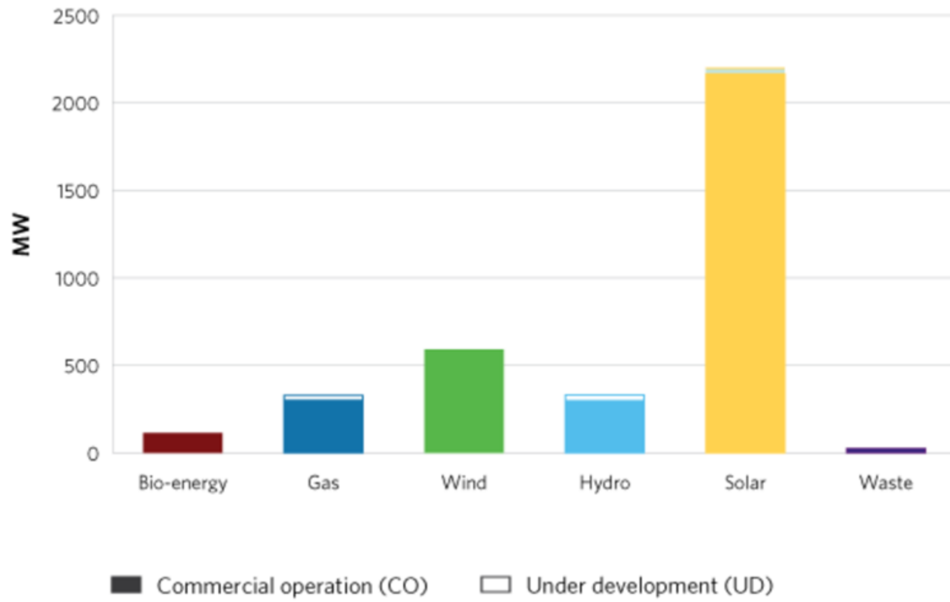


Figure 24: Locations of transmission connected electricity plants in Southern Ontario[77]

Connecting to the distribution system can sometimes be advantageous if transmission lines are far away. However, economies of scale tend to favor larger projects for most electricity generation, including wind and solar. Locations that have high quality wind and solar resources that are also near existing transmission lines are prime targets for development. However, just like a highway that can only handle so many cars at once, transmission lines have limits to the electricity they can handle, so an existing line is not necessarily always capable of handling additional generation.

A map of existing transmission-connected generating stations in southern Ontario can be seen in Figure 25 below and it can be seen that most wind and solar projects are close to existing lines.

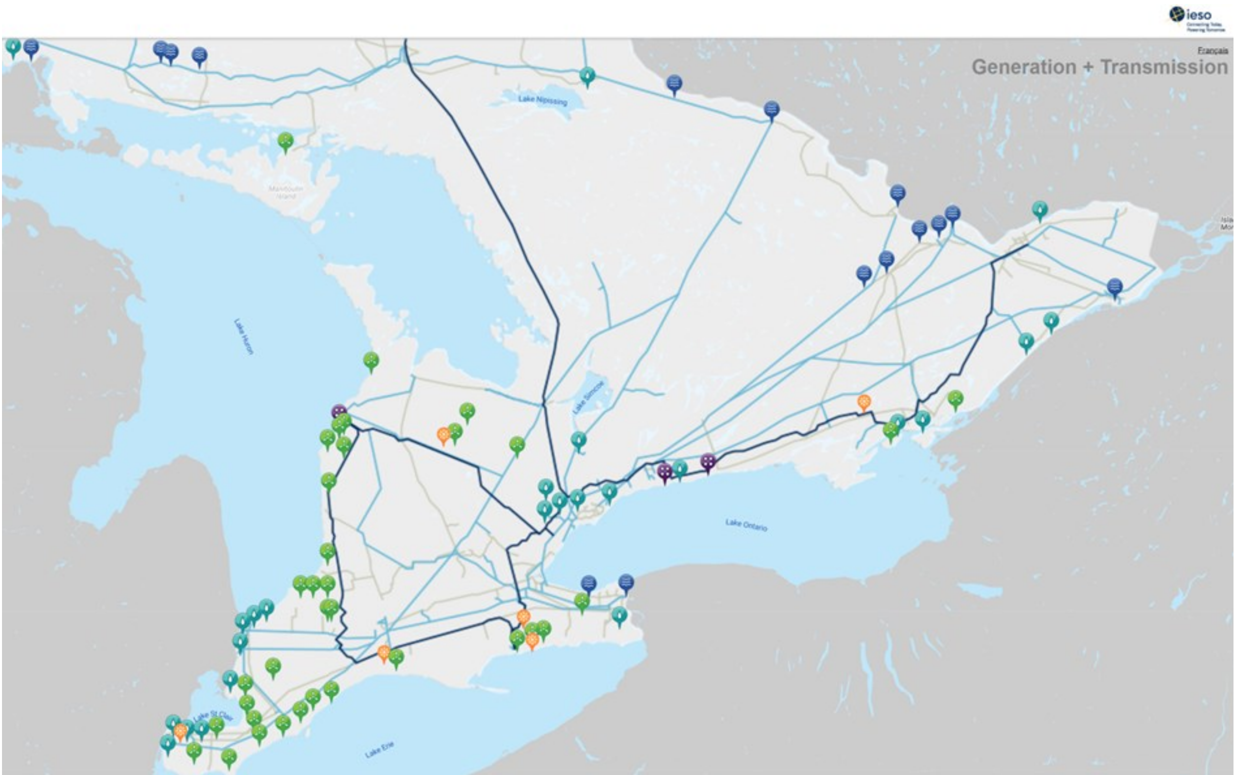


Figure 25: Locations of transmission connected electricity plants in Southern Ontario[78]

5.3 Wind Farm Capacities

How big are wind farms? Their size depends on several factors including location, available land, local wind conditions, and the capacity being developed. In Canada, commercial wind farms often range from 30 to 300 MW. Because wind turbines have grown in recent years, larger wind farms use fewer turbines. A typical wind turbine installed after 2020 is at least 3.5 MW, and can be larger than 6 MW, so wind farms may range from under 10 turbines to as many as 100. 20 to 40 turbines per project is common for recent wind farm projects in Canada.

Historically, Canadian wind farms have required about 125 acres per megawatt of capacity[79]. Even though new farms require fewer machines, the land use remained constant with larger turbines spaced further from each other. The actual land requirement is only about 3 percent of the overall wind farm, which accommodates the turbines and their access roads. Typically, the land around the wind turbines can still be used for farming or animal grazing.

A 2020 database of Canadian wind farms located every wind turbine in the country at the time of its creation[80]. The database includes interactive maps that show that wind farm sizes can range dramatically even where they are close to each other (see Figure 26). Because most wind farms in Ontario are older than 5 years, they will not necessarily resemble new developments with larger turbines, and lower turbine density even for projects with the same overall installed capacity.

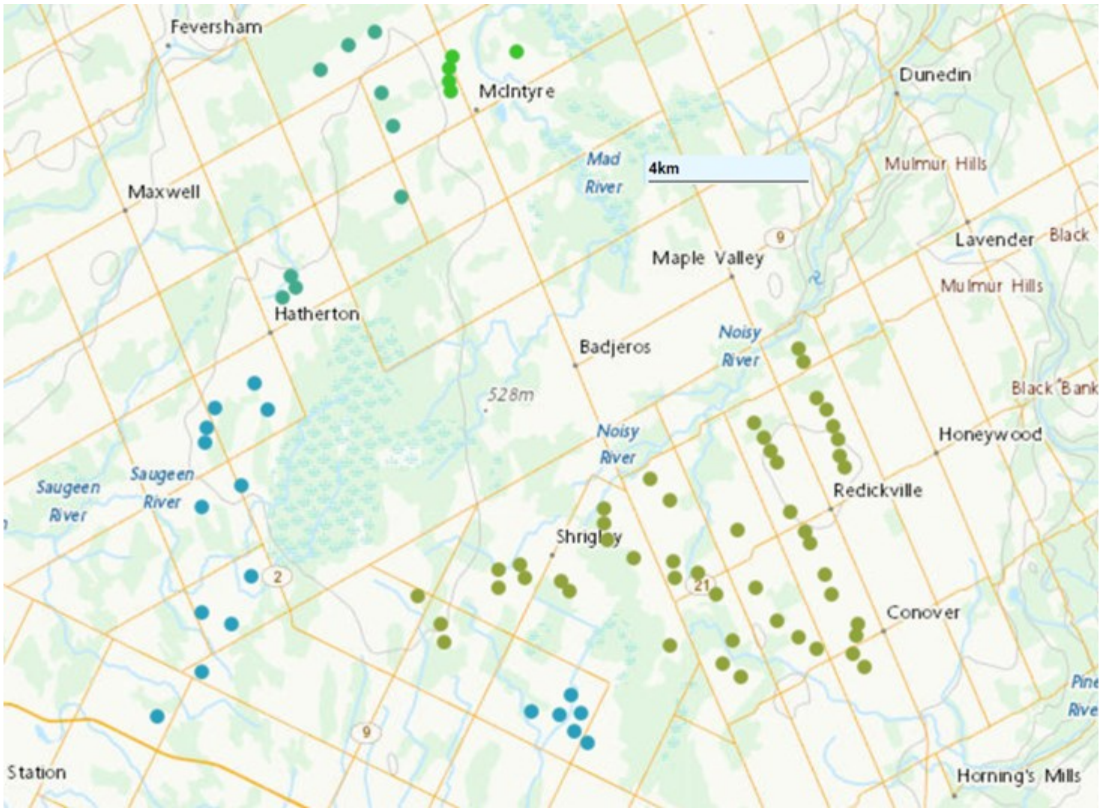


Figure 26: Several wind farms denoted by different colors near Orangeville shown in NRCan database[80]

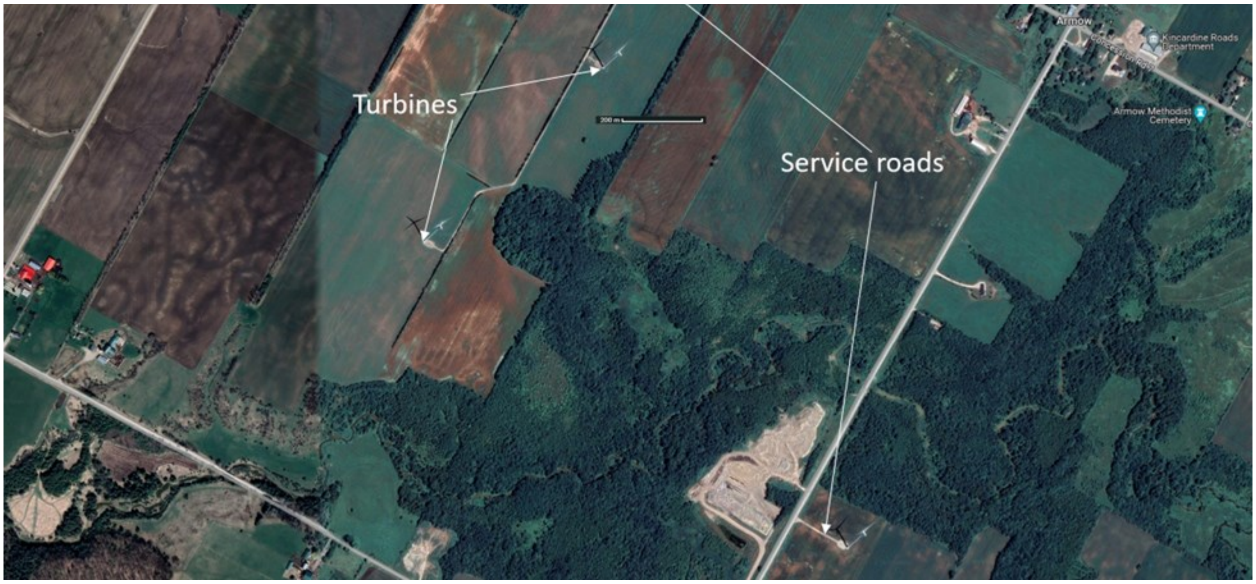


Figure 27: Wind turbines near Armow, ON (Lat: 44.189, Long: -81.531)

Simply using GoogleMaps can show existing wind farms' land use if you know where a wind farm is. Two wind farms near Kincardine are shown below, which demonstrates turbine spacing, the final footprint of the turbine pad, their service roads, and how closely farming can continue near each.

Figure 28: Wind turbines near Ripley, ON (Lat: 44.072, Long: -81.656)

5.4 Size of a Solar Farm

Solar modules are often 2 square metres (2 m x 1 m, or close to 30 square feet), each with a maximum power rating around 500-700 W[81]. A typical Canadian solar farm can generate about 1,000 to 1,800 MWh of electricity annually for every 1 MW installed. While bifacial modules can pick up some of the reflected light from the ground or nearby module, solar panel rows are spaced to avoid excessive shadows being cast on each other. Solar farm sizes can vary significantly and can range from as little as 4 to over 10 acres for every 1 MW of capacity. The largest solar farm in Canada is in Alberta, and has a maximum capacity of 465 MW on 3,330 acres of land (roughly equivalent to 1,600 Canadian football fields), and consists of over 1.3 million individual solar modules[82].

Most solar farms in Ontario are nearly a decade old. While the solar module sizes have not changed as significantly as wind turbines have, they are now more efficient solar panels with larger capacity, and with the addition of bifacial modules, new solar farms require less land while yielding higher capacity than those from a decade ago.

To ensure PV systems operate at peak efficiency, they need to be free from plant shadows. Manual trimming helps keep weeds from casting shadows on the panels and in some cases with grazing livestock[83] such as sheep (see Figure 29). Research from the University of Western Ontario suggests that 'Agrivoltaics' or co-locating certain crops and/or livestock with solar farms can be beneficial to certain crops while keeping weeds from casting shadows on solar arrays[84].

Figure 29: Sheep grazing between the rows of a solar farm (Photo: Shutterstock)

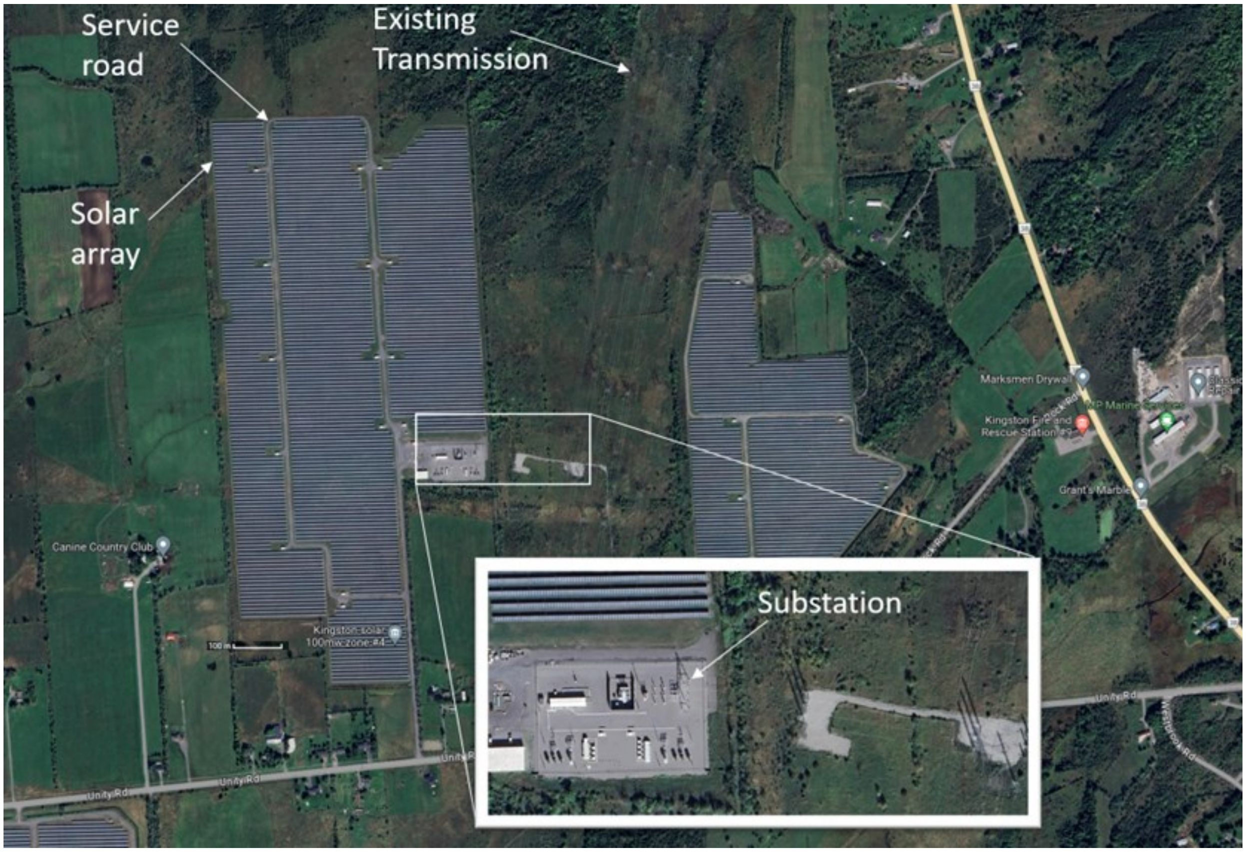


Figure 30: Solar farm northwest of Kingston, ON (Lat: 44.321, Long: -76.640)

Aerial views of existing solar farms can be easily found using GoogleMaps to give an indication of system configurations and land use. An example of a solar farm near Kingston, Ontario is shown in Figure 30 above.

5.5 Agrivoltaics

Agrivoltaics are new in Canada and can range from wider spacing between rows to allow crop farming, to planting shade-tolerate crops under solar panels, to raising the height of the panels to allow animals, and/or machinery to operate beneath them. Emissions Reduction Alberta has recently awarded $3.1 million to establish an agrivoltaics research facility at the University of Calgary[85].

In 2022 the first agrivoltaics conference was held in Canada, at the University of Western Ontario[86], and led to the founding of "Agrivoltaics Canada" an advocacy and research group[87]. Some of the research by members of Agrivoltaics Canada suggests there may be opportunities to increase yields for a range of crops, protect crops from hail damage and excess sunlight, and reduce water consumption[88], while helping to decrease greenhouse gas emissions from agriculture and increasing and diversifying farm revenue. However, adoption of such practices will require more public awareness as well as mechanisms to support non-traditional types of solar farm development[89].

PART TWO: DEVELOPMENT & OPERATIONS

While renewable energy can help reduce air pollution and emissions that cause climate change, they are being developed because they are profitable projects. Landowners and municipalities should ensure they are also sharing in the economic benefits of these projects.

6. Economic Considerations

6.1 Landowner Benefits

Landowners can experience several economic benefits from hosting renewable energy projects, such as direct payments, income diversity and potentially enhanced property values. To maximize the long-term benefits for their properties, landowners should carefully assess any renewable energy proposals by consulting with financial and legal experts. Landowners should also be aware of any increased taxes that may result from additional revenues.

There are different types of arrangements that can be made through land leases and the potential income amounts depend on several factors, including the location, size of the equipment being installed, and the agreement term. In some cases adjacent landowners can also receive payments.

Unfortunately, typically the contracts between private entities and landowners are not publicly available, but it has been reported that individual wind turbines installed in 2006 could result in annual payments ranging from $6,000 to $10,000 in Ontario, resulting in some cases with royalties of 1.75 to 3 percent of annual revenues[90]. However, a number of things have changed in Ontario since this time.

The Green Energy Act guaranteed predictable levels of income for wind energy projects, while new development in Ontario is more competitive. As a result, developers may be looking to reduce all costs, including contracts offered to landowners. On the other hand, wind turbines are larger today, and can produce significantly more energy per turbine than 20 years ago, although the quality of the local wind (and solar) resource also matters.

On average, solar farms (typically on the order of a 20% capacity factor) produce about 50% of the annual energy that a wind farm does (which is often closer to a 40% capacity factor), for the same installed capacity. Energy based royalty rates between wind and solar would vary as a result. A study from the University of Wisconsin Madison reported that per turbine annual payments ranged from 7,000 to 14,000 USD (9,500-19,000 CAD) in 2018[91].

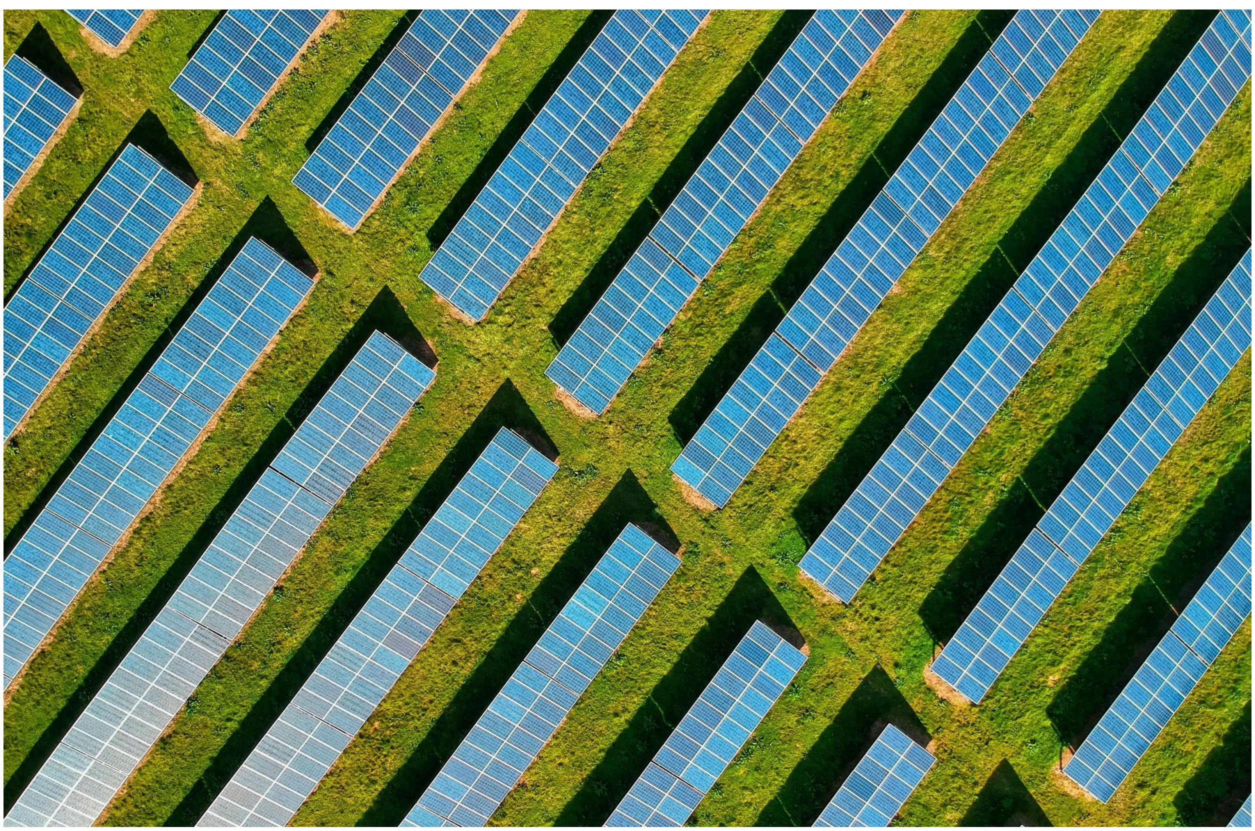
6.2 Leases and Royalty Payments

This section describes some common types of lease structures, but landowners should not hesitate to seek professional advice before signing land options or leases. At early stages of a project, developers will look to sign options for enough land and willing landowners to eventually support a viable project. The option agreement may be as little as 2-5 years, and may have further options for both sides to renew or extend the agreement during that period.

The option agreement gives the developer exclusive rights to the land to develop their project for a certain number of years, and the option can convert that access into a long term lease. Not all optioned land will eventually result in a real project with actual income, and so option values are typically much lower than land leases for actual projects and have been reported to sometimes be on the order of 50 to 200 USD (70-275 CAD) per acre per year[92]. A one-time signing bonus may also be offered in addition to annual option payments.

If the company proceeds to the construction phase, landowners would then negotiate formal land lease terms for up to 20-30+ years. Note that land leases with a term longer than 20 years require municipal consent. There are several types of leases that cover the land on which the renewable energy equipment sits as well as roads required to access it during construction, operation and ultimate decommissioning.

Fixed payment leases offer landowners the predictability of consistent amounts from their wind project income. Landowners might consider negotiating an escalator clause to counteract inflation and preserve the real value of these payments over time. A key advantage of fixed payments is the guarantee of income regardless of the project's operational performance or potential maintenance issues that may decrease electricity production. A drawback to that advantage is that if the project outperforms expectations, the landowner's financial benefits remain capped.



That being said, developers may offer, or you may be able to negotiate, more payment options. Implementing a generation-based compensation model encourages landowners to actively engage in the wind farm's success because increases in the project's electrical output increase their own profit. Such active engagement could include carefully monitoring the maintenance needs of, or preventing damage to, the wind turbines or solar system.

In Ontario, larger renewable energy projects are typically signed for long-term, fixed price contracts, so the value of the electricity is unlikely to increase from year-to-year. Nonetheless, royalty payments might present both higher risk and higher rewards for landowners. These payments are typically a share of the project's revenue, which could include not just electricity sales, but also other commodities such as Renewable Energy Certificates and/or emission offsets. To verify the electricity output and pricing – and their payments – landowners should have audit rights secured in their contracts. Developers are generally open to a mixture of fixed payments and royalties which guarantees minimum payments while still offering the possibility of profit participation in well-

performing projects. This combination balances financial stability with the incentive to maximize the wind farm's efficiency and output.

6.3 Property Values

How do wind turbines affect the value of your property? Recent research in the United States has challenged the belief that proximity to turbines significantly reduces property prices[93]. The study analyzed sales data from 300 million homes near 60,000 wind turbines and discovered that the effect on home values was minimal, with on average only a 1% decrease in value for homes that have turbines visible within a 6-mile (8.4 km) radius.

The findings revealed a more pronounced impact only for homes situated very close to turbines. Properties within 1.2 miles (2 km) of a turbine experienced up to an 8% drop in value. However, this negative impact quickly dropped with distance from the turbines.

The study, published in the Proceedings of the National Academy of Sciences, is unique in its methodology, analyzing both the proximity of homes to wind turbines but also whether the turbines are visible from these homes. Visibility is crucial because it directly correlates with perceived drawbacks by homeowners. It is also worth noting the study found that any decrease in property values peaked at three years following turbine installation and then gradually rebounded.

Several studies have been done in Ontario from the University of Guelph[94], as well as the Municipal Property Assessment Corporation (MPAC) who conducted multiple studies in 2008, 2012 and 2016[95]. The University of Guelph study focused on the Melancthon Township and considered over 7,000 home and farm sales between 2002 and 2010 where 133 wind turbines had been installed between 2005 and 2008, and compared with 10 surrounding townships. During this timeframe, over 1,000 homes and farms were sold. The authors Richard Vyn and Ryan McCullough stated the "turbines have not impacted the value of surrounding properties," across rural residential as well as farm properties[96]. The results were similar to the MPAC which concluded:

> ***Following its review, MPAC concluded that 2016 Current Value Assessments [CVAs] of properties located within proximity of an IWT [Industrial Wind Turbine] are assessed at their current value and are equitably assessed when compared to the assessments of properties that are not in proximity to IWTs. Therefore, no adjustments are required for 2016 CVAs. This finding is consistent with MPAC's 2008 and 2012 base year IWT reports.***

These findings indicate that the economic impact of wind turbines on property values is much smaller than previously feared, but as there can be some small variations the researchers suggest that their results could be used to help landowners as they negotiate leases.

6.4 Property Taxes

Regulation 282/98 under the Primary Property tax statute clarifies property tax treatment of renewable energy. The regulation states for industrial wind and solar projects: "the current value of land that is determined under subsection 19 (5) of the Act continues to be determined under that subsection as if the land was used for farm purposes only. O. Reg. 1/12, s.3, states wind towers are assessed by multiplying $50,460 by the installed capacity in megawatts of the generator attached to the wind turbine tower[97]. Appeals can be made if assessments are made contrary to the aforementioned values.

6.5 Ownership Models

Because large utility-scale projects can easily cost hundreds of millions of dollars, and take many years to develop, individuals, small corporations and even co-ops often face difficulty developing and financing them. Larger companies can not only access lower-cost capital financing to boost their competitive advantage, but can also often have long-term or bulk purchase arrangements with solar and/or wind equipment manufacturers and can receive preferential pricing and priority access to equipment.

There are other paths to equity in such projects that are open to communities, First Nations, and even landowners, although they often require specific government rules or incentives to be able to compete for the aforementioned reasons. Various made-in-Canada community co-operative models exist to develop smaller projects, particularly for solar energy[98] as it is more scalable than wind.

Co-operative ownership models are more common in Europe, notably Denmark, Germany and the Netherlands where landowners own shares in the project that is developed on or near their land and can vote in management decisions and receive a percentage of the returns, as well as the associated business risks. Renewable energy projects are capital intensive, and the lending rate can be a major factor in a project's financial competitiveness. Larger corporations tend to be able to secure lower interest rates than co-ops, and as a result competitive processes tend to favor corporate development and ownership unless there are specific policies in place to foster and support co-operative ownership.

6.6 Community Host Agreements

Renewable energy projects can provide multiple local revenue streams, ranging from an increased tax income for the local municipality, to community host agreements (CHA), to local job creation and of course land lease and royalty payments to landowners. Local businesses may also benefit through

contracts for services such as transportation, food and lodging, as well as labor during construction or offering livestock to graze at local solar farms[99].

Developers often agree to provide annual payments to the local community or municipality through a CHA, which can be a lump sum, an annual payment or a percentage of the revenue generated from the energy project. CHAs often stipulate that developers prioritize hiring local workers for construction and operational jobs. Through a CHA, developers may also support local infrastructure improvements, such as roads or community buildings, schools, health facilities, or cultural projects. Other initiatives can include scholarships, sponsoring local events or even local sustainability efforts such as habitat restoration[98].

Recently the Business Renewables Centre published a map of Alberta showing the different levels of municipal taxes from renewable energy projects which resulted in over $54 million of payments to municipalities in Alberta in 2024. Similar data have not been published in Ontario, but similar sized projects would be expected to deliver comparable tax revenues notwithstanding provincial differences[100].

7. Project Development

Developing any renewable energy projects entails many steps. Because some of them occur concurrently, the following list is not necessarily sequential, but is intended to illustrate how a project moves from its preliminary to final stages.

7.1 Prefeasibility

The initial step in any project is identifying a promising location with a good resource, proximity to power lines, access to construction equipment, and the absence of fatal flaws that might hinder development. After using databases and maps to estimate wind speeds and solar resources, developers will conduct a preliminary economic analysis of the site's viability for further exploration.

7.2 Land Options

Developers typically negotiate option agreements with landowners as discussed in section 6.2 to secure enough land to start the physical assessment, permitting and development process. As the project progresses, the developer will aim to transform option agreements into long-term land lease agreements.

7.3 Resource Assessment

As section 2 described, a wind turbine's performance is very sensitive to the wind speeds where it is operating. The first step in determining the viability of a wind farm is measuring the quality of the locations' wind. While there are many databases (including from weather stations and satellites) having actual on-site information is still critical.

Wind monitoring towers may be installed at heights of up to 100 m, although more commonly ground -mounted equipment that uses laser pulses known as LiDAR (Light Detection and Ranging) to accurately measure wind speeds are used. In either case speeds are measured at various heights off the ground to understand the vertical profile of the wind. In either case, monitoring typically takes place for at least 1-2 years, but can be extended to collect longer term data. This data is then used to estimate the energy generation potential of the wind farm and to evaluate the project's economic viability. On-site data is compared to long-term datasets from nearby weather stations and/or airports. While some projects may collect site-specific solar data, it is not typically required for solar projects. Instead developers use temperature records from 10 or more years, and collect hourly satellite data which are reliable for solar radiation. In addition, local topography is considered for layout and shading analysis.

For both wind and solar projects, developers employ computer simulations to analyze possible layouts and energy generation potential.

7.4 Initial Design and Equipment Location

Once a developer has gathered initial data on wind resources and secured enough land for the project, they generally perform constraints analyses. Using databases and maps, the constraints analysis identifies socioeconomic and environmentally sensitive environmental features such as residences, roads, community halls, wetlands, and other natural habitats. While preliminary work can be done with satellite images, site visits are indispensable for confirming these features. Based on provincial regulations and guidelines, developers enhance their maps to reflect setbacks showing unavailable land, as well as to indicate viable locations for equipment such as turbines, substations, and access roads.

Following the constraints analysis, the developer performs an energy analysis. For solar projects, the analysis typically examines shading, and for wind, enters wind data into a 3D topographical wind farm layout to model wakes, sound impacts, and estimated energy production. Engineers can move individual pieces of equipment in a process known as "micro-siting", as well as model different manufacturers, turbine height, or solar tracking designs. These changes may sometimes result in turbines being moved from one property to another.

7.5 Preliminary Economic Analysis

After comparing the modelled energy production revenue estimates against the costs of turbines, installation, and other factors, the project developer will decide if the site is viable.

7.6 Public Consultations

Throughout the process, developers will continue consulting with landowners who are considering hosting renewable energy projects. Starting from land acquisition stages, developers will seek public involvement and community feedback, through meetings and consultations, particularly after environmental assessments and during initial design presentations. This process is a core feature of the Renewable Energy Approvals (REA) process in Ontario[101].

At the beginning of the process, developers have a federal obligation to engage and secure approval and partnerships with First Nations communities when a project is on reserve lands or recognized traditional territories. All engagements requires sending detailed project descriptions and, ideally, meetings to discuss the project and gather community feedback, and developers must hold a

minimum of two public consultations and notices of each must be distributed at least 30 days before the first meeting, and at least 60 days before the final public meeting.

7.7 Environmental Assessment

Environmental assessments identify potential harm to ecosystems and socioeconomic conditions such as local land use, aviation, and telecommunications. If developers detect such risks, they adjust their plans to reduce them during construction, operation, and decommissioning. They also include monitoring plans for effects on wildlife during construction and operation.

7.8 Detailed Design and Economic Plan

To finalize the project layout, detailed design plans will integrate public input, regulatory requirements, geotechnical findings, environmental considerations, resource data, and illustrate locations of access roads, transmissions lines, substations, and other features. This comprehensive plan includes detailed component schematics and an environmental strategy to guide construction and operational practices.

Before proceeding, developers must secure substantial capital. Detailed cost and revenue estimates must be developed to secure project financing. Projects that are successful in winning a competitive procurement with the IESO, are able to secure long-term (20-year) contracts, known as power purchase agreements (PPA), which they can finance their projects against.

It is not uncommon that projects change hands from the development process to the final investment and operations phase. Companies that buy projects must honor contracts and permits that were negotiated with the original developers.

7.9 Permits and Approvals

The permitting process is described in more detail in section 9. Developers must obtain municipal, provincial, and in some cases federal approvals before commencing construction. A project is ready to proceed only after it has received all necessary approvals and financing.

7.10 Equipment Procurement

Renewable energy components are often manufactured, assembled, and transported to the site from various different locations across the country or around the world. Because renewable energy technology is changing so quickly and globally, new versions of the technology (typically upgrades) may be available by the time a project reaches construction. Significant equipment changes need re-approval and permits.

7.11 Site Preparation, Construction and Commissioning

Before construction begins, developers must coordinate with transportation authorities and local municipalities to plan the large-scale movement of equipment. The site is prepared for construction, including building access roads and laying foundations. A significant increase in local traffic may potentially cause disruptions during construction.

Components are assembled on-site, and the electrical network is connected to the grid. This stage involves substantial logistical coordination and physical construction work. For wind turbines large cranes are required to assemble the towers and blades – in some cases multiple cranes.

Once built, wind and solar farms undergo thorough testing to ensure all equipment and safety systems operate correctly before they start generating power.

7.12 Operation and Maintenance

Ongoing operations include performance monitoring and routine maintenance, which for wind turbines is usually 2-3 times per year. Typically, owners rotate operation and maintenance from turbine to turbine, so for larger wind farms, maintenance may continue regularly throughout the year. Snow removal from solar farms may need to be more frequent in the winter, but otherwise solar farms generally require less on site maintenance. Tracking systems will require regular inspection and maintenance.

Generally, the manufacturer's technicians are contracted for maintenance. If enough equipment is installed in a region, manufacturers may hire and train local staff as permanent technicians.

7.13 Decommissioning, Remediation and Reclamation

Common design life for renewable energy projects is typically 20-30 years. When a project reaches the end of its lifespan, owners must decommission and reclaim the site according to the negotiated terms of removal. In some cases, (particularly common in Europe), developers will look to "repower" prime renewable resource sites, that is re-installing new wind or solar technology on existing sites (in some cases re-using some of the existing infrastructure). Repowering can only be done with local permission and permits and requires restarting the development and approval process.

7.14 Orphaned Projects

In the undesirable event that an operator ceases business operations during a project's lifetime, creditors would assume the responsibility and are typically bound by original agreements. Fully commissioned projects are likely to have a viable business case to continue operations if ownership can be transferred. In the increasingly unlikely event that this is not possible, creditors would be required to decommission and sell the equipment that is on site. Generally speaking the scrap value of equipment is worth more than the cost to remove it.

8. Procurement Processes in Ontario

8.1 New Renewable Energy Projects

Renewable energy applicants must demonstrate their project fulfills a need for the electricity it will produce by meeting one or more of the following[102]:

- Using the electricity on-site for their own use
- Using the electricity on-site and distributing excess into the distribution system for a credit, via a net metering arrangement with their Local Distribution Company (LDC)
- Having an agreement to supply the electricity for a term of 10 or more years with one or more persons
- Intending to sell the electricity at market rates into the IESO administered electricity market as a market participant
- Intending to participate in an IESO procurement.

8.2 IESO Procurements

On December 11, 2023 the IESO announced plans to procure a total of 5,000 MW of new, non-emitting electricity including wind, hydro, biomass and solar. The IESO will look to procure 2,000 MW to be operating by 2030. Two subsequent procurements will occur for 1,500 MW each to be operating by 2032 and 2034 [103]. IESO engagement processes for new procurement processes are available online[104]. The Long-Term 2 request for proposals (LT2 RFP) will seek "long-term" (i.e. 20-year) contracts for 2,000 MW of non-emitting resources that could include new, or re-powered solar, wind, hydroelectric and/or bioenergy projects. Successful projects are subject to receiving municipal support as well as limitations to siting on CLI Class 1-3 Agricultural Lands [104].

It is worth noting that the older FIT program under the Ontario Green Energy Act set fixed prices for projects at the time, while the current procurements are competitive and not open ended. This means that project developers will be seeking to minimize all of their costs (both land and equipment), as well as unsuccessful projects may not be developed until future procurements are announced, or perhaps not at all.

9. Approvals and permitting

9.1 Technical Guides

On December 6, 2018 the government of Ontario repealed the Green Energy Act of 2009 and restored municipal authority over siting renewable energy projects in the Planning Act.

Nonetheless, developers need to obtain approvals from the government of Ontario in order to obtain a Renewable Energy Approval (REA) under Ontario Regulation 359/09 of the Environmental Protection Act. Landowners can become familiar with the details that are required by reviewing the ***Technical Guide to Renewable Energy Approvals*** online[105]. The purpose of this section is not to repeat the contents of this guide, but to highlight some of the important aspects including the steps that are involved as shown on the following page.

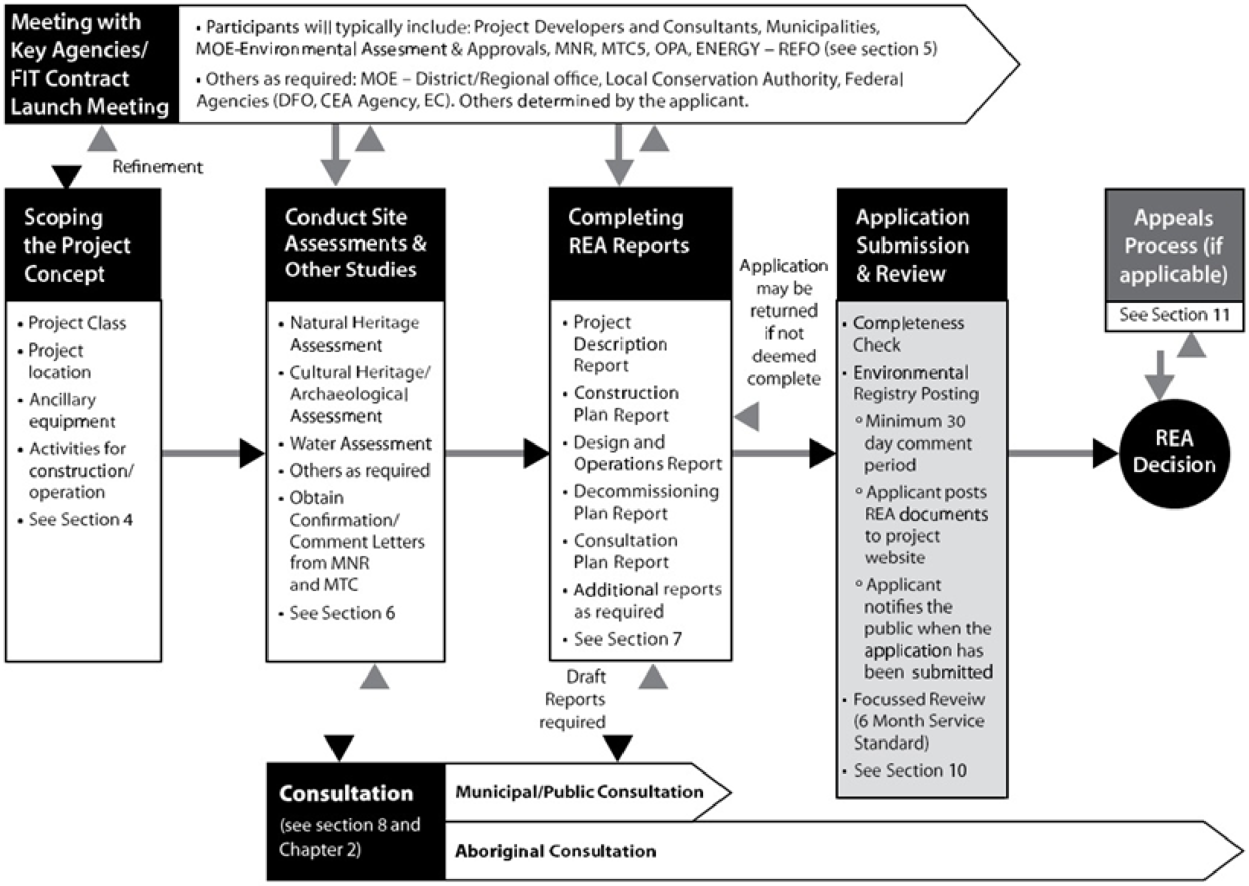


Figure 31: Overview of the principle elements of the REA application process[105]

The following table summarizes how the Government of Ontario defines classes of renewable energy technologies.

Table 3: Solar class definition for REA

Class	Location of PV Modules	Capacity (kW)	REA Required?
1	Any location	≤ 10	No
2	Mounted on a roof or wall of a building	< 10	No
3	Any location other than a wall or roof of a building	> 10	Yes

Table 4: Wind class definition for REA

Class	Capacity (kW)	Max Sound Level (dBA)	Tower Height (m)	REA Required?
1	≤ 3	Any	n/a	No
2	< 3 and <50	Any	n/a	Yes*
3	≥ 50	< 102	< 70	Yes**
4	≥ 50	≥ 102	≥ 70	Yes

* Fewer study, reporting, setback, and consultation requirements

** Fewer setback requirements

Application fees for utility scale projects are over $12,000 for a solar project, and over $40,000 for large wind farms. Not all applications are successful, and a successful application does not mean a project will necessarily get built, but developers only start paying fees when they perceive there is the potential for a project to materialize.

9.2 Elements of Ontario Renewable Energy Approval (REA)

Developers must complete the following steps in order to apply for and receive approval for wind or solar projects. More details of the steps can be found at the Government of Ontario's webpage[106], but these steps include:

- **Renewable Energy Approval (Part IV of O. Reg 359/09)**
  - ◊ Document submission requirements for renewable energy projects.
- **Construction Plan Report**
  - ◊ Details on construction activities, locations, timings, and environmental impacts.
- **Consultation Report**
  - ◊ Information on consultations with the public, aboriginal communities, and local authorities.
- **Decommissioning Plan Report**
  - ◊ Plans for dismantling and restoration post-project.
- **Design and Operations Report**
  - ◊ Specifications and operational plans for the project, including details on setbacks, and environmental protection measures.
- **Project Description Report**
  - ◊ Overview of the energy project, including energy sources, facility operations, and ownership details.
- **Consultation (Sections 14-18 of O. Reg. 359/09)**
  - ◊ Specific requirements for consultations and public notices including number of meetings, accessibility of the information and documentation of the meetings.
  - ◊ Includes consultations with:
    - ⇒ Public
    - ⇒ Aboriginal Communities
    - ⇒ Municipalities, Local Authorities
- **Protected Properties, Archaeological and Heritage Resources (Sections 19-23 of O. Reg. 359/09)**
  - ◊ Guidelines for dealing with properties that have archaeological or heritage value.
- **Natural Heritage (Sections 23.1-28 of O. Reg. 359/09)**
  - ◊ Environmental assessments, impacts on archaeological as well as natural heritage as well as development of an environmental effects monitoring plan.
- **Water (Sections 29-31 of O. Reg. 359/09)**
  - ◊ Assessment of water bodies and their management during the project.

- **Additional Reports (Section 13 of O. Reg. 359/09)**
  - ◊ Additional mandatory reports such as Effluent Management and Emission Summary.
- **Prohibitions (Part V of O. Reg. 359/09)**
  - ◊ Compliance with prohibitions related to project execution.

9.3 Existing Project Approvals

Renewable energy projects that have been submitted for approval can be found online at the Renewable Energy Project Listing site[107], which includes applications that:

- have been approved
- are currently under review
- have been sent back to proponents as incomplete
- have been withdrawn
- are currently being screened for completeness (pre-review).

9.4 Federal Environmental Impact Assessment

The Canadian Environmental Assessment Act may require an environmental impact assessment (EIA) for any project that receives federal funding or requires federal permits. Federal laws that might trigger a federal EA include the Species at Risk Act, the Migratory Birds Convention Act, the Fisheries Act and the Navigable Waters Act. EIAs are led by an independent review panel appointed by the Impact Assessment Agency of Canada[108].

Impact assessments are designed to weigh possible positive and negative impacts of a project on communities, economic well-being, job opportunities, and the environment to help understand them before they start. The goal is to help inform the public and decision-makers about how a projects' impacts can be minimized and opportunities enhanced to protect people and the environment.

EIA's include desktop studies that analyze aerial photographs and maps to identify natural habitats and sensitive sites, investigate the proximity to environmentally significant areas, internationally recognized wetlands, important bird areas, parks, and conserved regions. These also include identifying the locations of homes, community facilities, graveyards, and other important sites or structures. They examine local social and economic conditions; assess the closeness of archaeological and paleontological sites to the project site; evaluate potential disruptions to television and radio signals; and conduct noise simulations.

Field studies might examine birds and endangered species as well as monitoring bat activities to verify the presence and condition of sensitive locations. Studies might also examine the existing environmental conditions of the site(s) and identify the presence of rare plants and sensitive species.

9.5 Municipal Role in Renewable Energy Project Siting

While individual landowners are not directly involved in the municipal permitting process, their support of the project can influence municipal support. Municipalities play an important role in the approvals processes for energy projects as they implement provincial policy frameworks through official plans, zoning by-laws, land division and site plans (see Figure 33 below). The Green Energy Repeal Act restored municipal appeal rights on decisions to refuse requests to amend official plans or zoning by-law permits[109]. As a condition of the Renewable Energy Approval process, planning authorities are required to submit written confirmation that proposed projects' land use is not prohibited by a zoning by-law or Ministerial Zoning Orders. The IESO also requires a Municipal Support Resolution as part of energy procurements.

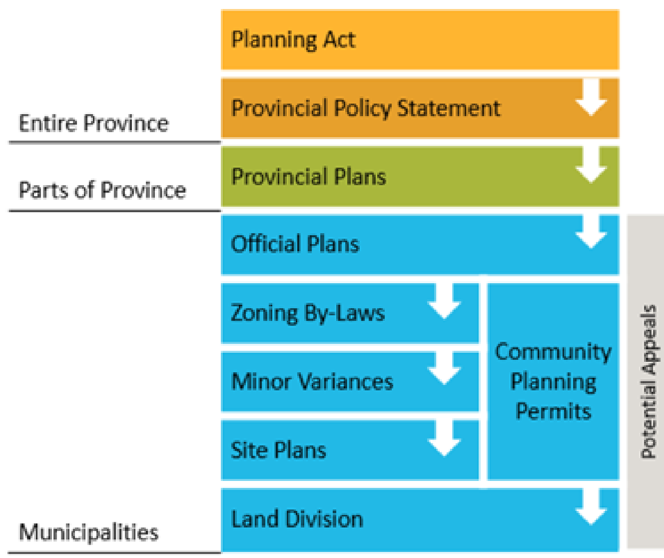


Figure 32: Ontario's Land Use Planning System[109]

Any project that requires approval under the Planning Act such as the creation of a new lot, change in land use or construction of a building may require municipal land use planning approvals such as changes to the official plan, zoning by-law amendments, building permit, consent to sever land, subdivision control, etc. Additionally, renewable energy projects may also involve negotiated agreements between the municipality and the project proponents including contractual obligations during construction, servicing, maintenance, access, etc. The proponent also typically negotiates community host agreements with the municipality.

The Provincial Planning Statement 2024 came into effect October 20, 2024[110]. Section 2.9 of the statement notes that planning authorities need to plan to reduce greenhouse gas emissions, while Section 3.0 requires planning authorities to coordinate, integrate and align infrastructure with land use planning to ensure infrastructure is available to meet current and projected needs. Electricity generation facilities, electricity transmission and distribution systems are included in the definition of infrastructure.

Section 3.8 of the statement states that: "Planning authorities should provide opportunities for the development of energy supply including electricity generation facilities and transmission and distribution systems, energy storage systems, district energy, renewable energy systems, and alternative energy systems, to accommodate current and projected needs"[110].

Section 2.3.2 requires an evaluation of alternative locations to avoid prime agricultural areas (PAA). The LT2 specifically prohibits ground-mounted solar projects from PAAs, while no new electricity generation will be allowed in specialty crops areas[111].

9.6 Ontario Best Practice Guidance for Developers

In its technical guidebook, the Government of Ontario states the following as best practices for project developers to "be a good neighbour"[112]:

- Engaging the public, municipalities and Aboriginal communities - early and often. While Ontario's regulations have minimum consultation requirements, the more you engage the community, the better neighbour you will be. Early engagement will allow applicants to identify issues and opportunities, and allow time to respond or adapt accordingly.
- Getting involved in local community projects. Getting the community involved in the development will lead to greater understanding and can help generate support. You might consider establishing a representative group or "Public Liaison Committee." Having a group that represents local residents, the local municipality and other interested groups early demonstrates your intent to establish long-term positive relations and encourages local participation in the development process.

- Making it easy for community members to express and resolve their concerns. One of the ways you can do this is by establishing a formal complaint resolution process and making it available early in the development process. There are rules in the regulation that require developers to have a plan to respond to the public and to provide information regarding the activities occurring at the project location.
- Eliminating and/or minimizing impacts of the operation on the community by:
  - ◊ Responding promptly to complaints;
  - ◊ Having agreements on operations in place, e.g. voluntary slow-downs or shut-downs under specified conditions;
  - ◊ Working with the community to identify locally valued resources (e.g. heritage resources) and taking measures to identify and mitigate impacts;
  - ◊ Considering provisions for adjusting a project's setbacks/locations or operation practices (e.g. times of operation, turbine speeds) if a sensitive or concerned receptor (human or ecological) is in the area;
  - ◊ Ensuring that tourism implications are considered, both in the location of the project and the project as a whole;
  - ◊ Considering visual barriers between receptors and a project (e.g. tree buffer or berm between road and solar farm); and
  - ◊ Ensuring internal roads to facility components (such as wind turbines and ground-mounted solar facilities) are located in a way that impacts on agriculture are minimized. For example, roads should be placed along property lines or field boundaries to avoid bisecting fields. Width of internal roads should also be considered and not wider than necessary so they do not negatively impact surrounding agriculture.
- Keeping the lines of communication open beyond the development and approvals stages of a project. Establishing continuing dialogue with the local residents for the entire project lifecycle demonstrates an ongoing desire to be a good neighbour by:
  - ◊ Maintaining a website and posting meetings, project reports and notification of any proposed changes to the facility including upgrades and maintenance to ensure the community is aware of workers in the area and reasons for their presence;

    - ◊ Responding to complaints in writing and demonstrating how issues have been addressed;
    - ◊ Maintaining customer service standards (inquiry/response times, complaint resolutions, etc.) and posting information publicly;
    - ◊ Conducting site visits at appropriate times so that the community can see how the project is being maintained and how safety precautions are being taken; and
    - ◊ Providing ongoing information sessions and educational opportunities for local community groups/schools.
- Consider joining an industry association; many developers are members of respective industry associations and commit to codes of conduct and ethics.
- Pro-actively providing a code of ethics to the community can help demonstrate commitment to good environmental and development practices.
- Documenting a Good Neighbour Approach in an agreement and making it publicly available for the local community to view.

10. Negotiating Land Agreements

10.1 Recommendations for Landowners

Renewable energy projects are typically initiated by developers who reach out to landowners in an area where a strong resource has been identified as described in Part One of this document.

Before entering into any kind of lease or agreement, landowners should seek legal counsel (there are many firms that have experience with both the solar and wind energy industry). In addition, there are many landowners in Ontario who have experience with wind and solar projects – speaking to people with direct experience can be valuable as there can be many differing points of view to sift through on the internet.

Good wind sites are attractive business opportunities when there are active procurements. When procurements close, the opportunities might also diminish. Unlike the FIT program, developers are competing against each other for lowest cost projects, and will invariably try to lower their costs where possible, including to landowners, so approach the negotiation looking for a win-win.

This section is intended to give a brief overview of agreement types, which can be a helpful primer before talking to legal counsel. The following advice is summarized from a 2007 Farmers' Guide to

Wind Energy: Legal Issues in Farming the Wind[113] and can be considered as you consider the different types of agreements.

- Think carefully about what you're giving up in exchange for the revenues from the wind project. Are you sacrificing a valuable aspect of your land? Leases and easements should clearly outline which rights are being included in the agreement.
- Ensure compensation is proportional to the rights you're giving up as a landowner.
- Thoroughly assess your options before signing anything. Land that is currently appealing for wind or solar may continue to be attractive in future procurements. However, if your neighbors all agree to work with a developer and you do not, your property might become an isolated "island," making it less appealing (or not appealing at all) to future projects.
- Collaborate with your neighbors to secure a better deal and maintain community satisfaction. A collective of landowners will have more negotiating power than a single individual when it comes to working with developers or marketing land.
- Recognize that different turbines even within the same wind farm might perform better or worse than others, and you may want to consider specific projections based on the contribution of your specific land to the project.
- If royalty payments based on a percentage of revenue are offered, make sure the contract clearly defines your auditing rights, so that you can verify the owner's accounting and that you are sure you are receiving the agreed upon amount.

10.2 Leases and Easements

Even if they do not specifically use the terms, most renewable energy contracts include provisions for leases and easements. A lease grants the lessee—typically the energy developer—exclusive rights to use the land for a defined period. The lessee gains uninterrupted access to the land to harness its energy potential. By signing a lease, the lessor (landowner) transfers control of the property for a set duration in exchange for an agreed upon payment.

An easement grants a party limited use of land for a specific function, while the landowner maintains all other ownership rights. For example, a developer might obtain an access easement to maintain underground electrical lines in a field, even as the landowner continues farming that land.

In general, a renewable energy contract will include a lease for the portions of land designated for turbines and access roads, exclusively reserved for the company's use and typically encompasses easements for transmission lines as well as the right to harness the renewable energy from the site.

A renewable energy contract typically includes three key parts: the option agreement, the operating option, and the option to extend.

10.3 The Option Agreement

An option agreement (also known as a development option or lease option) describes the "rights to develop" of a developer who has secured exclusive rights from the landowner to use or harness the renewable resource(s) on the property for a certain period. The compensation for this is usually modest and based on an acreage rate. The option agreement does not ensure the construction of a project but indicates the company's interest to develop a potential project. It is possible for the landowner to receive small payments for a few years only to see the project eventually abandoned.

Option agreements vary in duration—some may last five, seven, or even ten years, while others could be as brief as one year, with options for renewal. Some options may simply be for the first right of refusal, where a developer secures the opportunity to match any competing offer to lease the land. Option agreements help the company secure enough contiguous land to show management and potential investors the feasibility of a viable project, and in the case of wind energy project in particular, may also include timeframes for resource data collection.

Landowners receiving multiple lease offers from wind developers might explore auctioning their wind rights to the highest bidder. Developer bids can include more than just financial compensation and factors such as contract duration and other non-financial considerations can also be evaluated at the discretion of the landowner.

For wind resource monitoring options, the cost of leasing land for monitoring equipment may be an annual payment, an upfront lump sum, or a fee based on the amount of land used as long as the

equipment is in place which is typically one to three years and grants the developer the right to install equipment and periodically maintain it.

The landowner may negotiate the acquisition, or right of first refusal to purchase the local resource data (and associated analysis) if a developer decides not to proceed with a long-term lease after collecting the data. Resource data is valuable and may benefit the landowner or future parties.

It is important for the landowner to fully grasp the commitments required by the option agreement. Questions to consider include whether agreeing to the option also means consenting to the construction of turbines, the degree of control over the placement of turbines, access roads, and power lines, and what limitations might be imposed on the landowner's use of the property, such as building structures like a tall grain leg or vertical grain dryer. Additionally, it is important to know whether these restrictions apply only during the option period or if they only come into effect during the operational phase.

The project developer may request a non-disclosure agreement (NDA) as part of the initial and/or operating options as a normal course of business. While NDAs are common as developers want to prevent aspects of their business model especially during competitive procurement processes, landowners may want to request the ability to discuss leases with other project participants to ensure there is no animosity among neighbours during the development process.

10.4 The Operating Option

An operating option (also known as an extended option, lease option, or lease) addresses the operational phase of the project, detailing the construction, access roads, and both underground and aboveground transmission lines. The operating option can be triggered if the developer is successful in securing a power purchase agreement (PPA) for the long-term sales of the electricity from the project. This section discusses some details of leases to be thought through when negotiating leases. Additional considerations can be found in the 2005 Ontario Sustainable Energy Association Landowners Guide to Wind Energy[118]. Royalties were discussed in Section 6, and additional questions to consider found in Section 11.

The operating option includes restrictions on how the landowner can use the property and outlines the payment terms for the duration of this phase. Operating options are long-term, typically spanning 20-30 years (and possibly longer). Note that any lease longer than 20 years may be subject to different requirements including consent of the local municipality as well as conditions laid out it the Ontario Planning Act[119].

It is important to note the land use requirements may change from the initial option to the operation phase, which may require more or less land for solar projects, or notably for wind projects parcels of land that may not require wind turbines at all that were originally envisioned. Landowners should ensure that leases provide compensation for every landowner within the project boundary whether or not generating equipment is on their land. Compensation is typically higher for land with project assets due to the impacts and direct loss of land use. If generating equipment (wind turbines or solar panels), are not developed on a location that was originally anticipated by the landowner, he/she may seek other development such as the service building, roads, transformers or substation in lieu. Furthermore landowners with adjoining properties may also be compensated which can help to reduce friction, as well as recognizing any indirect impacts such as dust and noise during construction and visual changes to the landscape.

Any lease signed by the landowner is tied to the land and will remain in effect even if ownership changes, potentially requiring inclusion in the property deed. The renewable energy developer's right to use the land under the lease may be established through a restrictive covenant on the deed itself for the duration of the lease. The landowner should retain the right to conduct normal activities on the property. If any activities need to be temporarily halted during construction, routine or unplanned maintenance, the landowner should receive fair compensation.

All development costs and risk are borne by the developer unless otherwise agreed to. The developer should be fully responsible for any liability related to accidents, injuries, or fatalities occurring during the construction or operation. This includes road accidents involving contractors or operations personnel on the landowner's property. The lease should require the developer and operator to take all reasonable precautions to ensure the safety of their employees, the landowner and their staff, as well as passersby and visitors.

Leases should also include provisions to ensure the site is kept clean from debris and litter as well as any hazardous materials associated with the project and that no toxic or hazardous materials be stored permanently on site. Leases should also detail the responsibility for control of weeds on site of the renewable energy structures as well as access roads.

Leases should also acknowledge any potential crop, livestock or property damages during construction, or maintenance of the renewable energy equipment is the responsibility of the project owner to repair and restore in a timely many and/or provide compensation for reasonable losses incurred as a result. Any new buildings that might impact the renewable energy project should be detailed in the lease including site and size restrictions.

While construction and regular maintenance will typically occur during normal business hours (unless specific exceptions have been discussed), renewable energy operators will require site access 24 hours a day, 365 days per year in case of unplanned maintenance and/or repairs. Accessibility and preferred entry should be mentioned in the lease. Land access rights should be strictly project related unless otherwise specified in the lease.

The lease should also lay out a detailed decommissioning plan at the end of the project's life, as well as the responsibility to remove equipment (non-functioning turbines or solar panels beyond repair). The restoration plan should stipulate the depth of materials to be removed including foundations and wires, as well as replacement of any topsoil that was removed to restore the land to its pre-project productive capacity.

Dispute resolution mechanisms and arbitration rules, including how to chose an arbitrator can also be outlined in a lease.

10.5 The Extension Option

This provision in many contracts allows the wind developer to automatically renew the contract under certain conditions, extending the partnership and operational terms for terms commonly ranging from 5-10 years to extend the operation of an existing project beyond its originally anticipated lifespan.

Repowering extensions may be agreed to for significantly longer periods of time if a site can be re-built with updated/refurbished equipment and put back into service for multiple years/decades if the project owners are able to secure longer term power purchase agreements in the future.

11. Potential Questions for Developers

A project can commit landowners to a relationship of 20-30 years or even more. Everyone will have their own questions and concerns about projects in their area. The Ontario Federation of Agriculture

(OFA) updated its fact sheet for advice before signing a lease in Nov 2024[120]. In addition to the OFA advice, the following list may spark your own specific questions:

- **What are the financial benefits of hosting a renewable energy project on my property?**
  - ◊ How will the developer compensate me? (e.g., lease payments, royalties)
  - ◊ Are the payments fixed, or do they depend on the energy produced?
  - ◊ Are contracts based on a combination of the two or always one or the other?
  - ◊ Are financial supports being offered to my neighbours?
  - ◊ Does the agreement have a clause ensuring treatment is at least as favourable as other landowners who are also participating?
- **What kind of ongoing communication can I expect?**
  - ◊ Do you have other landowners with projects on their land I can speak to about their experience?
  - ◊ Who do I contact if I have concerns about the project during construction or during operations?
  - ◊ Who do I contact during operations?
- **How will my land be accessed and affected during normal operations?**
  - ◊ What are my rights with respect to continued agricultural, recreational and/or other uses of the land?
  - ◊ Am I as the landowner released from any liability incurred as a result of permitted activities in the agreement?
  - ◊ Will the energy project's operations affect pesticide applications?
  - ◊ How will the operator ensure invasive weeds are controlled?
  - ◊ How often does maintenance occur?
  - ◊ Who is responsible for weed controls around equipment and access roads?
  - ◊ Are there chemicals being used for weed control?
  - ◊ How long does post-construction monitoring take place?
  - ◊ Who will be on my land during post-construction monitoring?
  - ◊ How will I be compensated if crops are damaged and/or agreed upon farming practices are interfered with as a result of operations or maintenance?
  - ◊ How are bat and bird impacts being monitored?
  - ◊ How far in advance will I be informed of access for maintenance?
- **What is the expected duration of the land lease?**
  - ◊ How long will the equipment remain on my property?
  - ◊ What happens at the end of the lease agreement?
  - ◊ What happens if you (the developer) sells the project to another developer or operator?
  - ◊ Does the agreement contain a clause that ensures the original agreed upon liability if the new project own defaults.
  - ◊ What happens if I sell my property during the agreement?
- **How will the project affect my property taxes, or insurance?**

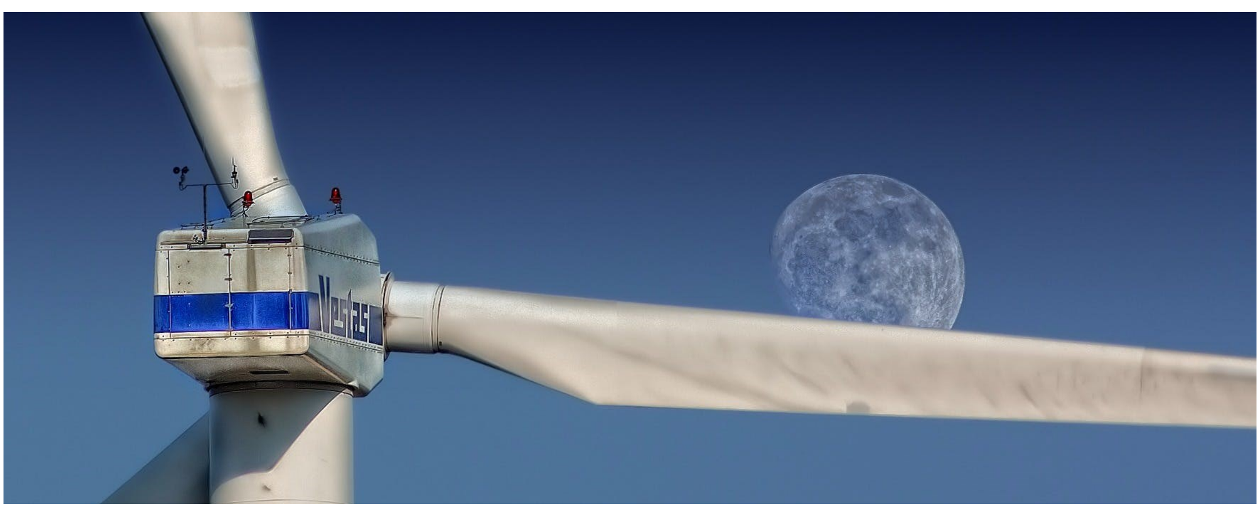
  - ◊ Will hosting equipment increase my property valuation and taxes?
  - ◊ Will I need new insurance?
- **What are the potential effects on my land use?**
  - ◊ How much land will you use?
  - ◊ Will I still be able to use my land for agriculture, grazing, or other activities?
  - ◊ Will access roads be at-grade to avoid disrupting farm operations?
  - ◊ Will the project affect any future construction on my land?
  - ◊ How close to the equipment can I farm?
- **What are the environmental impacts of the project?**
  - ◊ What kinds of wildlife studies or environmental assessments will you or others undertake?
  - ◊ How will you protect local wildlife and habitats?
- **How loud is the project?**
  - ◊ What level of noise should I expect?
  - ◊ How does this noise level compare with other common sounds in a rural environment?
  - ◊ Who do I contact if there is a noise issue?
- **What are the visual impacts?**
  - ◊ How tall are the wind turbines?
  - ◊ How many acres is the solar array?
  - ◊ How will they affect the landscape and views from my property?
  - ◊ Can you develop a model of how the project will look after construction?
- **What happens if there is damage to my property?**
  - ◊ Who is responsible for repairs or compensation if there is damage to my land or infrastructure during construction or operation?
- **What is the decommissioning plan?**

- ◊ Who is responsible for removing the turbines and associated infrastructure at the end of their lifespan?
- ◊ Will you restore my land to its original condition?
- ◊ How long will decommissioning last?

- **What are the safety considerations?**
  - ◊ What safety measures are in place to protect my property and anyone on it?
  - ◊ What models address shadow flicker in my home?
  - ◊ How will you minimize risks such as ice throw?
- **How much time will I have to review the contract with a lawyer before signing?**
  - ◊ What are my legal responsibilities and liabilities?
  - ◊ Is there flexibility in the contract terms?
- **What is the detailed construction schedule?**
  - ◊ How will construction affect my daily operations?
  - ◊ What kind of disruptions should I expect during the construction phase?
  - ◊ How long will construction last?
  - ◊ What is the compensation for any land use that is restricted during construction?

Making informed decisions will help ensure your interests are protected as you negotiate a deal that works for you.

- Set a time and meeting location convenient for you and a friend or partner (always best to have at least two people at the table during negotiations).
- Meetings do not need to be at your property if you do not wish.
- Have all your questions written down. Expect that they all will be answered. Keep track of the ones you are waiting on, and make sure you follow up.
- Talk to a lawyer before you sign anything.
- Ask for compensation even if you do not have a turbine on your land.
- Go to an existing project if there is one nearby to gather information and observations.
- If you are not happy about anything, ask for it to be improved.



12. Online Resources for More Information

Agrivoltatics Canada 2023 conference proceedings (video)	https://youtube.com/playlist?list=PLdeNFYH6Xl-jaVPA24CXivboPsu4VLSYM&si=koMq34MnvIToDbbE
Global Solar Atlas	https://globalsolaratlas.info/map
Global Wind Atlas	https://globalwindatlas.info/map
Health Canada Wind Energy Study	https://www.canada.ca/en/health-canada/services/health-risks-safety/radiation/everyday-things-emit-radiation/wind-turbine-noise/wind-turbine-noise-health-study-summary-results.html
Ontario Federation of Agriculture Fact Sheet	https://ofa.on.ca/resources/agreements-for-renewable-energy-installations-on-your-land/
Ontario Procurement Announcement	https://news.ontario.ca/en/release/1004981/province-launches-largest-competitive-energy-procurement-in-ontario-history
Ontario Technical Guide to Renewable Energy Approvals	https://www.ontario.ca/document/technical-guide-renewable-energy-approvals-0
Ontario Sustainable Energy Association Landowner Guide	https://mail.ontario-sea.org/pdf/LandownersGuideToWindEnergy.pdf
Renewable Energy Wildlife Institute	https://rewi.org/
US Fish and Wildlife Service Wind Energy Guidelines	https://www.fws.gov/media/land-based-wind-energy-guidelines
Who Has Seen the Wind Benefits? Jason Cole, UWO (2020)	https://ir.lib.uwo.ca/lgp-mrps/196

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