An Introduction to Renewable Energy Options for Farmers

Many farmers are becoming increasingly interested in renewable energy sources. Fortunately, there are several renewable or alternative energy options available. Unfortunately, it is often hard to identify which of the technologies are best suited to a specific farm operation.

Wind Energy

Small wind turbines (≤100kW) are suitable for farms and homes as a source of backup power or to supplement power obtained from the electrical grid. The financial viability of small wind turbines mainly depends on the quality of wind resource available at the site. Generally a site needs an average annual wind speed of 4.0 to 4.5 m/s (14.4 to 16.2 km/h or 9.0 to 10.2 mph) before investing in a small wind turbine makes financial sense (OMAFRA 2003). One way to determine if a site is suitable for wind energy is to look at its wind energy potential on a wind resource potential map. The location’s wind roses and wind speed histograms will provide useful information (Fig 1).

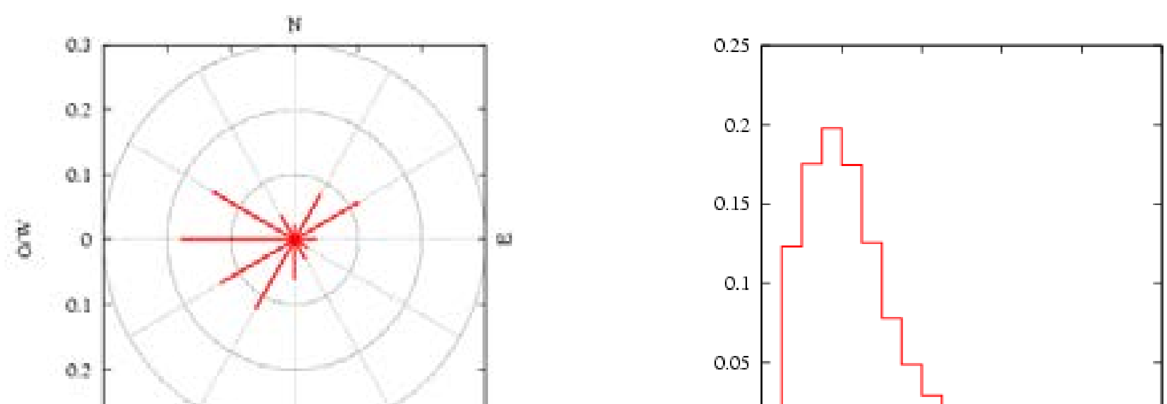

Fig 1. Wind rose and wind speed histogram for Fredericton, NB
(Source: Environment Canada)

Data from local weather stations may also be used. Care must be taken when using this data as the wind energy might be undervalued. Since these stations are close to the ground, consider siting factors (trees, buildings, etc) that might affect the wind measurements. Generally, the most accurate (though expensive) way of measuring wind resource potential is using a wind resource evaluation system. At a minimum an anemometer (cups mounted to short arms connected to a rotating shaft) that rotates with the wind and a recorder (either an odometer or data logger) is required. For best results, at least one year of data at hub height (where the turbine is installed) should be obtained. An important point to remember is that the energy generated by the wind turbine will vary throughout the day.

The siting of the wind turbine is very important. When choosing a location remember the following points:

- wind speeds are higher at the top of a hill, shoreline, and places clear of trees and structures
- surrounding trees will grow but the tower will not increase in height
- avoid areas of high turbulency
- check the local building bylaws and zoning requirements
- attempt to keep the wind turbine 250 to 300 m away from neighbours

The components of a wind energy system include more than just the wind turbine. Either **horizontal axis** or **vertical axis** wind turbines can be used. The more common horizontal axis turbines have to be aimed directly at the wind (achieved by a tailvane). Vertical axis turbines catch wind from any direction but require a large amount of ground space. The basic components of a horizontal axis turbine include the following:

- rotor with aerodynamic blades
- gearbox to match the rotor speed to that of the generator/alternator
- enclosure (nacelle) to protect gearbox, generator, and other components from elements
- tailvane (yaw system) to align the turbine with the wind

Horizontal axis turbines require a tower to mount the turbine. Several types of towers are available:

- guyed lattice towers (radio broadcast towers) are permanently supported by guy wires. These are least expensive but take up a large amount of ground space
- guyed tilt-up towers can be raised and lowered for easier maintenance and repairs
- self-supporting towers have no guy wires (take up little ground space) and are the heaviest and most expensive

The height of the tower is very important as the wind power is proportional to the cube of the wind speed. It is recommended that towers be 24 to 37 m (80 to 120 ft) in height. At a minimum, towers need to be 9 m (30 ft) above any obstacles within 90 m (300 ft).

Solar Energy

Solar energy originates from thermonuclear reactions in the core of the sun. This energy is mostly shortwave radiation that is emitted in all directions. Once the radiation strikes a material, the radiation is either reflected, transmitted, or absorbed (heats the material). The amount of solar energy decreases as the distance from the sun increases, therefore the amount of energy collected varies throughout the year (Fig 2 & 3).

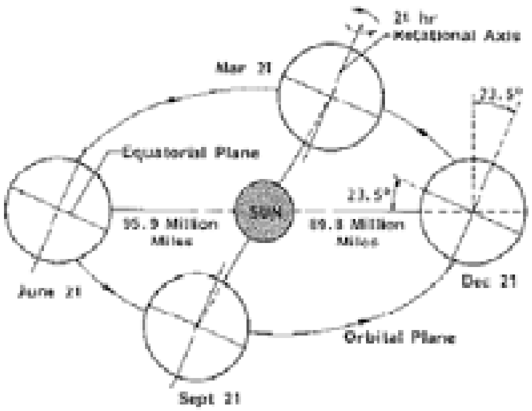

Fig 2. Earth rotation
(Source: MidWest Plan Service)

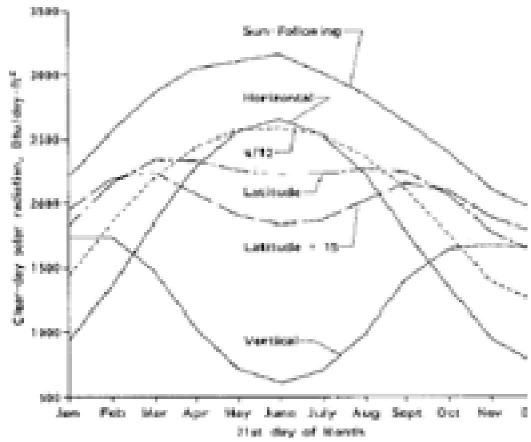

Fig 3. Variability of clear day solar radiation with various tilt angles
(Source: MidWest Plan Service)

The amount of solar energy available depends on the latitude, collector tilt angle, weather, and both the time of day and year. The maximum amount of solar radiation occurs at solar noon (when the sun is at the highest point in the sky) and decreases to zero at both dawn and dusk. It is recommended that fixed solar collectors face due south (up to 20° east or west of due south is acceptable) to receive the maximum amount of solar energy. The ideal tilt angle depends on the time of year when the most energy is required (Table 1).

Table 1. Ideal tilt angles for energy required at three times of the year

Time of Year	Tilt Angle
Year round	Your latitude
Winter	Latitude + 15° **or** vertical*
Summer	Horizontal

*10% decrease in energy

SOLAR HEATING/LIGHTING

Solar heating can either be passive or active in nature. Passive solar heating transfers the heat without the aid of a pump or fan. Instead, natural convection, conduction, and radiation disperse the heat into the environment. This usually involves the appropriate placement of windows. Proper window selection must occur to prevent a net energy loss through the window. The heating capacity can be increased by having the solar radiation strike a substance that stores a large amount of solar radiation. Passive solar heating systems are simple and provide heat at low operating and maintenance costs. An added bonus of passive heating is the natural lighting it provides, which is often preferred to artificial lighting.

Active solar heating involves heating a fluid which is dispersed by fans or by pumping it through pipes. The heating fluid can be either recirculated (water for in-floor heating) or nonrecirculated (ventilation air). The fluid can heat floors, indoor air, or water for consumption on the farm. If the area might be subject to freezing the fluid should contain some type of antifreeze. Solar energy can provide up to 50% of the heating load for heated water required for dairy farms, animal processing and food processing facilities (CanREN 2006). A collector area of 20 to 200 m^2 would be required to supply this heating load (CanREN 2006).

PHOTOVOLTAICS

Photovoltaics can help supplement the electricity needs of a farm but generally cannot handle large loads. This technology can produce approximately 10 to 40% of the electrical need of an individual (BP Solar 2008). Various manufacturers of photovoltaic cells state the cells produce from 54 to 160 W per m^2 (5 to15 W per ft^2) (Kyocera Solar, Inc 2008 and BP Solar 2008). Photovoltaics are well suited for uses involving low loads in remote areas (electric fencers or livestock water pumps). Also, photovoltaics allow the fencer or pump to continue to work during a power outage.

Anaerobic Digestion

Anaerobic digestion systems or biogas systems involve organic matter being broken down by microorganisms in the absence of oxygen in an enclosed structure. These systems provide many potential benefits to farmers:

- reduced odour and pathogen levels in manure
- reduced greenhouse gas production
- production of renewable energy
- increased fertilizer value of manure
- utilization of food byproducts and other organic materials

Anaerobic digestion produces two products, biogas (mainly methane and carbon dioxide) and liquid effluent or digestate. This biogas can be utilized in a number of ways: a) used by a generator to produce electricity and heat, b) burned as fuel in a furnace, or c) cleaned for use as a natural gas replacement. The digestate contains all the water, minerals, and approximately half the carbon of the input materials.

Anaerobic digesters function in one of two ways: **completely mixed** or **plug flow**. Completely mixed systems require a large tank where new material is mixed with partially digested material (Fig 4). This type of system requires an input material with a low dry matter content (4 to 12%). Materials with higher dry matter content can be used if the digestate is recirculated. Plug flow systems require long channels where the input material moves along as a plug (Fig 5). This type of system requires a thicker input material, 11 to 13% or higher dry matter content.

Fig 4. Completely mixed anerobic digester
(Source: OMAFRA)

Fig 5. Plug flow anaerobic digester
(Source: OMAFRA)

Also, these systems can operate at three temperature ranges: thermophylic, mesophylic, or pschrophylic.

Thermophylic systems operate at high temperatures (50 to 60℃). These systems rapidly break down organic matter, resulting in a large volume of biogas. The benefits of these systems include small storage volume requirements, a high level of pathogen removal, and low retention times (3 to 5 days). Unfortunately, thermophylic systems require a large amount of insulation and use a large amount of energy to maintain the high system temperature. Typically larger centralized systems operate at a thermophylic temperature range.

Mesophylic systems operate at medium temperatures (35 to 40℃). These systems have longer retention times (15 to 20 days or more) due to the lower temperature organisms. Mesophylic systems are more immune to temperature upsets, making them more ideal for small and mid-sized agricultural systems.

Psychrophylic systems operate at the lowest temperature range (15 to 25℃) and have been located in Manitoba and Quebec. These systems are very stable and easy to maintain. As a downside, psychrophylic systems have very long retention times to achieve desired gas production and pathogen removal.

Other Renewable Energy Sources

In addition to the energy sources listed above, there are several other renewable energy sources that farmers can explore. These include hydroelectricity, hydraulic ram, gravity (potential energy), stream (kinetic energy), animal (draft), earth energy (ground water heating/cooling), bio-diesel/ethanol, and wood/bio-mass burning. Many of the renewable energy sources are especially suited for pumping water. Depending on the circumstances and conditions on the farm, one or more of these might make financial sense.

Energy Conservation and Efficiency

Although perhaps not as exciting as switching to alternative or renewable energy, increasing the overall energy efficiency of a farm will often make more financial sense, at least in the shorter term. Many proponents of renewable energy sources recommend that an individual consider renewable energy only after all the energy efficiencies possible have been gained on their farm. This is especially true for electricity production, which can be a capital intensive endeavor. Farmers can reduce the energy used on many parts of their farm, such as: lighting, ventilation, refrigeration (produce, milk, eggs, etc.), electric motors, irrigation or vacuum pumps, and machinery. Some energy efficiencies are easily achieved by replacing old or out-of-date technologies (ex. replacing inefficient lighting or fans) or by changing management practices (ex. “gear up, throttle down” and matching appropriate sized tractors to implements). Other efficiencies are more costly or difficult to implement. These changes may require further analysis such as either estimated payback period or a cost-benefit analysis before implementation can be recommended.

Additional Information

Canadian Renewable Energy Network- Natural Resources Canada. **CanREN**.
http://www.canren.gc.ca/

Electricity Resources Branch-Natural Resources Canada. **Renewable and Electrical Energy**.
http://www.nrcan.gc.ca/eneene/renren/index-eng.php

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