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Energy alternatives emerging for 21st Century agriculture

Volatile energy costs and environmental demands are prompting more producers to explore new energy sources.

Wind power, solar power and biodiesel. These are the big three energy alternatives that engineers at the AgTech Centre in Lethbridge believe will help power sustainable agriculture in the future.

"Sustainable, renewable energy sources are the trend of the future and agriculture is positioned to take advantage of them," says Rick Atkins, AgTech Centre Manager and Branch Head of Engineering for Alberta Agriculture, Food and Rural Development (AAFRD).

There are no silver bullets to eliminate fossil fuels, says Atkins. Yet many producers recognize the benefits of shifting to alternative energy for at least part of their energy needs. These benefits can include lower and more stable costs, less impact on the environment and greater energy efficiency.

"The recent trend of high fuel prices and uncertainty in the energy sectors has prompted more farmers to explore alternative energy sources," says Atkins. "Whether it's to heat a hog barn or to light a shop, the key is to look for alternatives that are practical, reliable, cost-effective and environmentally sustainable."

Many options are emerging, but for now the top alternatives for farmers are energy from wind, sun, crops and other resources.

Rating the alternatives

Rating system: 1 - 5 (1 less appropriate - 5 most appropriate)

	Electricity	Heating	Transportation
Biodiesel	3	3	5
Anaerobic Digestion	3	3	1
Wind	5	3	1
Solar	5	4	2
Earth Energy	1	5	1

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Rating the alternatives

Wind power

Wind power is the top-of-mind alternative energy source on the Prairies, especially in southwestern Alberta where strong winds are common. It is generated from turbine systems that convert the kinetic energy of the wind into mechanical energy or electricity.

The amount of power harnessed from the wind hinges on the average annual wind speed, which is influenced by topography and obstacles, says Katrina Lakenman, an AgTech Centre Research Assistant. "It is recommended that at least one year of wind data be collected before selecting a site."

A proven technology. Modern aerodynamics and engineering have improved wind turbines to the point where they can provide reliable, cost-effective, pollution-free energy for individuals and communities. The cost of these systems depends directly on the power output. A 1-kW system costs about $5,000, and a large-scale commercial system that produces 600 kW can cost $1 million.

Consistency is key. Wind systems need a relatively consistent wind flow. A wind power system usually requires an average annual wind speed of at least 15 km/h. An average wind speed of greater than 25 km/h is desirable, over 29 km/h is excellent, especially if the intent is to sell the power. Trees and other obstructions can impede valuable wind flow to the rotors. Rotors should be placed to take advantage of the stronger winds at higher elevations. Towers are typically placed 100 metres from the nearest obstacles. The middle of the rotor is placed 10 metres above any obstacle that is within 100 metres.

Renewable and clean. The forces of nature continuously generate wind energy. "Wind power does not use fuel, produce greenhouse gases or by-products," says Lakenman.

Solar energy

The sun provides an unlimited supply of energy in the form of electromagnetic radiation. Capturing enough solar energy for effective use depends on available solar energy, weather conditions, location, the technology used and the application.

"Solar energy is almost unlimited and is a renewable energy system that can stand alone without connection to a power or natural gas grid," says Sherry Perih, with the AAFRD Engineering Branch.

Economic benefits. "Operating a solar energy system for buildings is much lower in cost than operating a combustion furnace with an air conditioning unit," says Perih. "However, the cost to install a complete solar system can be higher than the cost to install a furnace and air conditioning unit."

On farms, solar energy can be used in a number of ways.

Solar heating of buildings. Buildings designed to harness solar energy for heating typically have large, south-facing windows. Materials that absorb and store the sun's heat can be built into the sunlit floors and walls which collect heat during the day and slowly release it during the night when it's needed most.

Other solar heating design features include sunspaces and trombe walls. Sunspaces, similar in construction to greenhouses, are built on the south side of a building. Sunlight warms the sunspace and a ventilation system circulates the heat throughout the building.

A trombe wall is a thick, south-facing wall painted black and made of a material that absorbs heat. A pane of glass or plastic glazing, installed a few inches in front of the wall, helps hold the heat. The wall absorbs heat during the day and slowly releases it in the building during the night.

"Design features are also available for retaining cool air in the summer," says Perih. "For instance, overhangs can be built to shade windows when the sun is high in the summer and sunspaces can be closed off from the rest of the building. Buildings can also be constructed to use fresh air ventilation in the summer."

Solar water heating. These systems capitalize on the sun's energy to heat water for building heating. Most solar water heating systems for buildings have two main components, a solar collector and storage tank.

Photovoltaic systems. Photovoltaic (PV) cells convert sunlight into electricity. PV cells are often used to power calculators and watches.

"PV cells are usually designed into modules that hold about 40 cells. About 10 of those modules are mounted in PV arrays that can measure up to several metres on a side," says Perih. About 10 to 20 PV arrays can provide enough energy for a household. For industrial applications, hundreds of arrays can be interconnected to form a single PV system.

"The initial cost of solar energy technology is the biggest impediment for producers and others thinking of adopting the technology. For example, a 50 watt panel can cost as much as $600." she says. "But the costs also depend on the application. It has the potential to reduce energy bills considerably when used exclusively or as a complement to other energy sources."

Biodiesel

Producers using diesel-powered tractors need to look no further than the nearest canola field to find a source of cleaner-burning, high-performing fuel. Biodiesel, an exciting new fuel option, is derived from plant or animal oil.

Easy to adapt. "Biodiesel is similar to petroleum diesel," says Kelly Lund, of the AAFRD Engineering Branch. "Using biodiesel does not require changes to existing engines, fuel infrastructure and storage."

Blending with petroleum diesel is also an option, she says. Lubrication is improved even with biodiesel blends as low as one percent, she says. Biodiesel-fuelled engines deliver similar mileage, torque and horsepower. "Winter operating procedures are the same for biodiesel as they are for number two petroleum diesel."

Environmental benefit. Carbon dioxide emissions, total particulate matter and carbon monoxide emissions are reduced with biodiesel. Nitrogen oxide emission, however, seems to increase. But that is mitigated by the fact that biodiesel does not contain sulfur, making catalytic converters more efficient at reducing nitrogen oxide releases. This would not apply to most agricultural diesel engines, which don't use catalytic converters, but even so, there would still be an overall net benefit as far as emissions.

Cost effectiveness. The cost of biodiesel depends on the plant or vegetable oil source. "Producers may be able to obtain sufficient quantities of waste vegetable oil to meet fuel requirements with minimal or no charge," says Lund.

Biodiesel costs

	Biodiesel Waste Oil	Biodiesel Farm Oil	Market Purchased Oil
150 L Batch (Cost of finished biodiesel per Litre)	$.48	$.83	$3.03
450 L Batch (Cost of finished biodiesel per Litre)	$.47	$.82	$3.02

Since biodiesel is currently not available for retail sale, producers must find their own source or produce it themselves, she says. A simple, biodiesel batch reactor that can produce 150 litres of product at a time would cost less than $400 to construct. A 450-litre batch reactor would cost just over $1,100 to build. "However, if a farmer produced three 150-litre batches per week, it would take three and half weeks just to make enough biodiesel to supply a typical day's fuel requirements," she says. "Production can increase with scale, but producers would have to factor in additional storage space for equipment and fuel."

The capital cost of pressing canola seed to obtain its oil on farm is prohibitive, especially for experimenters, she says. An appropriately sized press costs $18,000 to $20,000. "Farm production of biodiesel is viable, but the current economics of farm production don't encourage it."

Commercial biodiesel is widely available in Europe and may be available in Canada later in this decade.

New options on the horizon

The search for energy alternatives continues with innovative options such as biogas and earth energy.

The big three alternative energy sources are just the beginning, says Rick Atkins, AgTech Centre Manager and Branch Head of Engineering for Alberta Agriculture, Food and Rural Development (AAFRD). Researchers are examining several new sources of energy that will further expand the toolbox for building a sustainable agricultural industry. "At the AgTech Centre, we try to find new ways to make agriculture more efficient and clean in its energy use," says Atkins. "With continued research and development in this area, the real societal, environmental and economic benefits of new energy sources will become more viable."

Biogas

One option researchers are exploring is biogas, a fuel produced by the anaerobic digestion of organic material such as manure. This innovative energy can be used for heat or electricity.

"Biogas can be produced on site with a digester," says Brian Sexton, of the AAFRD. "Basically, manure is fed into the digester, where it is heated and kept for several days under anaerobic conditions (no oxygen). Because of our climate, heat usually has to be added for this process to take place. Anaerobic bacteria thrive in these conditions and break down the manure to produce methane or biogas. This biogas can be used to run a boiler for heat or to power a generator for electricity."

Effluent from this process has little odour, and contains fewer weed seeds and pathogens than raw manure, which is a benefit in cropping. "Digestion converts the nutrients found in the manure to a form that is more readily available to crops," says Sexton.

However, anaerobic digestion probably isn't for every operation. "The process works best with liquid manure systems," he says. "As well, biogas production requires a large capital investment, specialized training and weekly upkeep. Proper handling is required, as biogas is explosive. As a result, only a larger dairy, 300 head or over, and swine production operations with over 2,000 animals, could see this as a viable alternative."

To make biogas cost effective, the gas must be used as it is produced, explains Sexton. Matching the energy to heat and electricity demands of an operation, plus being able to sell the excess energy, is the only way to make biogas cost effective. "This is difficult because the energy demands of an operation can vary widely depending on the season. Combination operations, such as a hog operation and greenhouse operation, can make better use of the energy produced."

"Currently there are about 25 systems operating in the U.S. Pilot projects have been conducted in Canada over the years but the economics have not been viable. However, significant advances in anaerobic digestion technology have made today's systems more feasible. As a result, a number of systems are being built in Western Canada."

Earth energy

A more widely available energy source is earth heating and cooling systems. Earth energy systems use temperatures found in the earth or groundwater to heat or cool air and water for buildings.

"For instance, a heat pump can extract heat from the ground to heat a building," explains Sherry Perih, with the AAFRD Engineering Branch. "Reversing the pump in the summer can provide air conditioning by moving hot air out of a building and down into the ground."

Operating costs of an earth energy system are much lower than the costs of operating a combustion furnace with an air conditioning unit, she says. But the cost to install an earth energy system can be higher than the cost of installing a combustion system. "On average though, an earth energy system can save two thirds of the cost of heating and cooling with electricity."

The initial set-up costs are a drawback, but the payback could more than make up those costs, she says. Supplemental heating or cooling may be required if the earth system cannot provide the necessary load. For example a heating/cooling system for a 1200-sq. ft. area can have a capital cost of $10,000. Payback period for this example would be five to 12 years, depending on energy prices.

"This is a readily available technology, and one that could provide many benefits, including the reduction of greenhouse gas emissions," she adds.

Fuel for thought

More energy alternatives are coming online all the time, with varying degrees of practicality for current agricultural operations, says Atkins.

"Farmers are adopting and will continue to adopt economically viable and environmentally sustainable options that fit their operations," he says. "With continued research and development to fine-tune the applications for farmers, this trend is likely to grow in the future."

For producers, the bottom line will be more options for a new century of sustainable production.

More information

AgTech Centre and AAFRD Engineering Branch are committed to the development of information for producers and industry. For more information on alternative energy sources, contact the AgTech Centre directly.

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