BMP OVERVIEW FOR ON-FARM ENERGY PRODUCTION

Green energy production uses on-farm renewable resources and production systems to generate energy.

Federal, provincial and municipal legislation may directly affect the design, construction and maintenance of green energy technologies or structures. Always consult reliable industry professionals to verify requirements for proposed projects.

Wind that blows across rural Ontario can be captured by turbines that convert it into electrical power.

Anaerobic digesters produce biogas by using manure and other organic inputs such as energy crops and food processing by-products. Biogas can be used as a replacement for natural gas to produce heat, electricity and/or transportation fuel.

On Ontario farms, solar panels (photovoltaic cells) can be used to produce electricity, and solar walls can capture heat.

Ontario farmers can grow new energy crops such as switchgrass for on-farm use in biomass combustion systems, or for further processing (e.g. pelletizing) for off-farm use.

SOLAR

Solar radiation is energy that can be harnessed to provide sources of heat, hot water and electricity. Solar heating systems for hot air or hot water are called *solar air* or *solar thermal* systems. Solar electric systems are called *photovoltaic* systems.

Solar air – refers to the solar heating of buildings, either passively (using air movement) or actively (using fans and a circulation system). Heat is absorbed from the sun. Air is passed over the heated surface and circulated around the space to be heated using convection or fans.

Poultry barns require carefully controlled temperatures and proper ventilation to maximize bird health and growth. Well-designed solar space-heating systems can help meet both of these needs.

Solar thermal – refers to solar heating systems that heat a liquid inside a closed-loop system of pipes. Pipes are arranged in boxes under glass. Solar heat is trapped in the box by a flat black plate (plate collector) or by tubes between layers of glass (evacuated tube collectors). Hot water heating systems use fluid that will not freeze in the winter, and pump that fluid to a heat exchanger to heat water for use inside a building.

One type of solar collector for a water-heating system is the glazed flat-plate collector. The water or heat transfer fluid circulates through a network of copper piping attached to a flat black plate inside a glass-covered frame.

BMP*i*

Solar panels should be cleaned regularly to avoid dirt buildup, especially in lower edges. Be careful not to cause damage. Use a low-pressure cleaning system and demineralized water.

Solar electric – refers to the conversion of solar radiation to electricity by photovoltaic cells and modules. The photovoltaic cell uses two semiconducting materials that create an electric current from solar-activated electrons. Electric currents are used as DC or inverted to AC for use as supplemental energy for lights and equipment in barns, workshops or farm homes.

Photovoltaics (PV) can be used to power lighting, electric fencing, small motors, aeration fans, gate-openers, irrigation valve switches, and automatic supplement feeders.

Solar electric energy can even be used to move some sprinkler irrigation systems.

On a larger scale, some or all of the energy produced can be delivered and sold to a local utility through a grid-tie system. This can involve net-metering, where the utility compensates the producer for the net outflow of power (i.e. minus producer use) or a feed-in tariff, where the producer is paid by the kilowatt hour for all the power produced and put onto the grid.

Land in areas with a high proportion of annual sunlight hours may be suitable as solar farms where arrays of photovoltaic modules capture solar radiation. Ideally these systems are located on marginal lands where crops for food are not displaced. Farmstead roofs are an ideal location for solar panels.

You need to ensure the roof is structurally adequate to withstand the panels and any changes to snow loading.

Photovoltaic systems are well-suited to pumping water for livestock in remote streamside pastures, where power lines are unavailable.

SOLAR	
BENEFITS	**CHALLENGES**
• a renewable resource • suitable for remote applications • reduced grid energy consumption • no moving parts unless trackers are used	• some solar systems, e.g. photovoltaic, are a substantial investment • applications limited by sunlight hours and energy generated • if not connected to the grid, energy must be stored for times when solar power is unavailable – batteries are expensive and relatively inefficient

WIND

Not only does the sun supply the earth with direct radiant energy, it also heats the earth and the atmosphere, producing temperature differentials that result in wind. Wind power uses energy from the moving air to turn blades on windmills.

In the past, the motion of the blades was used to grind flour or pump water. Now the blades turn turbines, which rotate generators in order to produce electricity.

Wide open windy spaces are needed in order for these systems to be efficient.

Small wind energy systems come in two sizes:

- micro-electrification or small-capacity wind turbines (100 W–1 kW) – limited on-site or domestic use
- auto production (1–50 kW) – suitable for farm operation needs.

There are several types of wind energy systems:

- **stand-alone –** provides power solely from the wind. In most cases, these systems are grid-connected. Some stand-alone systems may use batteries to store energy when wind conditions are not good.
- **hybrid –** combines wind and photovoltaic (PV) technologies, offering several advantages over just wind or PV. In most locations, wind speeds are low in the summer when the sun shines brightest and longest. The wind is strong in the winter when less sunlight is available.
- **mechanical –** used to aerate ponds or pump water for livestock, irrigation, or household water supplies. More than a million mechanical wind systems are said to be in use in the world today, most of them on farms.

Mini wind power systems are suitable for charging batteries for small electrical loads.

BMP

Wind turbine tower foundations have special requirements depending on turbine type, tower design and size, and local soil conditions. A key BMP is to consult a local engineer or contractor – *before* you start – to determine whether the soil at the site requires special consideration for the foundation type proposed by the manufacturer.

WIND POWER: ON-FARM APPLICATIONS

Wind has been used as a reliable and inexpensive water-pumping power source for generations. Either a mechanical or electric water-pumping system could be ideal for rural and remote locations to supply livestock, a household, or even a small community.

Wind energy systems can do much more than pump water for a modern agricultural operation. Because they are ideal where remote, low voltage power is required, wind energy electrical generators are used for such farm components as electric fences and yard lights.

WIND	
BENEFITS	**CHALLENGES**
• a renewable resource • suitable for remote applications • reduced grid energy consumption	• can be a substantial investment • not operational unless wind speeds are suitable (11–45 km/h or 7–28 mph) • can have high maintenance requirements • small systems may be noisy • some failed technology in recent years

GEOTHERMAL

Geothermal energy is evident on the earth's surface in the forms of volcanoes, geysers, and hot springs. Not far below the ground surface, the seasonal effects of ambient temperatures have little influence, and the internal heat of the earth provides consistent temperatures year-round. One way to tap geothermal energy is *geothermal heat pumps* that provide heat and cooling to buildings.

Also called *ground-source heat pumps,* they take advantage of the constant year-round temperature of about 10 ˚C (50 ˚F) that is just 3 to 5 metres (10–16.5 ft) underground.

In a conventional domestic geothermal system, heat transfer fluid is pumped through pipes that are buried underground, and recirculated into the building. The underground loops of piping act as a heat exchanger. When the heat transfer fluid passes through the loops, it absorbs heat from the ground, which causes it to be warmed.

The heat pump component upgrades this heat to a usable level. Typically for every 1 kWh of electrical power used by the heat pump, you get 4 kWh of usable heat.

This upgraded heat can be used directly in a hydronic or in-floor heating system, or it can be converted to a forced-air system through a heat exchanger.

In summer, the liquid moves heat from the building into the ground. In winter, it does the opposite, providing pre-warmed air and water to the heating system of the building.

Heat pumps can offset greenhouse heating costs.

GEOTHERMAL

BENEFITS	CHALLENGES
• more energy-efficient than most other green energy sources • payback is 5–8 years • heating/cooling and hot water available for all types of farm buildings and homes, potential for hybrids • a heat pump can heat and cool different buildings at the same time, e.g. heating a farm shop and cooling potato storage sheds simultaneously	• initial capital cost • soil limitations – depth to bedrock, stoniness and dry conditions • compatibility with existing heat distribution or hot water systems can be a problem for upgrade projects

MICRO HYDROPOWER

Hydropower is the conversion of energy from flowing water to electrical energy through the use of a turbine.

In the past, water-powered mills played essential roles in rural Ontario – for milling flour, grist and feed, and for saw mills.

Hydropower systems are classified as large, medium, small, mini and micro, according to their installed power generation capacity. (The smaller systems are within the scope of this booklet.)

A **micro hydro** system typically has a generating capacity of less than 100 kW.

A **mini hydro** system has an installation capacity of 100–1000 kW (1 MW).

A **small hydro** system is defined as having a capacity of 1–10 MW.

BMPi

Micro hydro systems are not maintenance-free. Owners should clean out blockages (silt, branches and weeds) from intakes and pipes once a year.

Flowing water can turn a turbine. The turbine then drives a generator to produce electricity.

Existing rural dams can be converted to capture micro hydropower.

MICRO HYDROPOWER

BENEFITS	CHALLENGES
• reduced dependency on grid • accessible in remote areas • less pollution	• suitable site conditions required • cannot be expanded • low power during low-water conditions • some environmental impact – fish and wildlife migration • creating or modifying dams will require permits since this may affect upstream or downstream users

BIOMASS

Biomass materials such as wood, field crops, livestock manure, and other dry organic materials can be used as renewable sources of energy to heat homes and generate electricity.

Biomass is wood or energy crops (e.g. native grass varieties) that can be combusted in high-efficiency systems to produce heat or power, or be converted to bio-oils.

Biomass such as fuelwood has been used for millennia. When burned, biomass converts to carbon dioxide and water, and releases the sun's energy.

Many types of plants can be used for biomass energy production. There are two main approaches: growing plants specifically for energy use, or using the residues from plants that are grown for other purposes.

Grasses – cool-season and warm-season native and introduced grasses can be suitable biomass energy crops.

Grain crops – many farmers have discovered that grain corn may be burned economically in purpose-built burners for affordable domestic heating.

Oilseeds – crops such as soybeans and canola can be processed for oil (biodiesel), and the meal by-products can be used as livestock feed.

Switchgrass, big bluestem, and other native varieties can be harvested for up to 10 years or longer before replanting.

BMP*i*

Harvest less than 30% of crop residue to leave some biomass for soil organic matter.

Biomass wood – on-farm wood materials can be used for biomass too. Sources of on-farm woody biomass include:

- fuelwood – harvested and processed for space heating
- short-rotation woody biomass crops (e.g. willow) – harvested, chipped and burned for heat energy
- waste products from farm woodlot or plantation forest harvest (e.g. limbs, treetops and inferior woody debris) – chipped as woody biomass.

Short-rotation biomass can be harvested for energy production.

APPLICATIONS

- wood heat for farm buildings and greenhouses to replace high-cost fossil fuels
- combustion of low-quality grains for heat
- combustion of sustainable biomass for large electrical power plant

Biomass can be used by large biomass combustion-based electrical power plants.

BIOMASS	
BENEFITS	**CHALLENGES**
• cleaner fuels – fewer greenhouse gas emissions than fossil fuels • renewable resource • alternative land use • opportunities for rural economic diversification • farmers across Ontario can participate by growing biomass crops	• cost–benefit for intensive management • opportunity costs – land for food and feed vs. land for energy • environmental impact of conventional crop systems for growing energy crops • removal of nutrients and organic matter from the farm • increased market for crop products may impact other users (e.g. livestock, food) • some biomass has high mineral (nutrient) concentrations, which can cause challenges such as clinker formation during burning • some outside wood-burning furnaces can cause air pollution (smoke), especially when operating at low capacity • getting paid for the biomass baled and stored on-farm

BIOFUELS

After space heating, transportation and tractor fuels are among the biggest energy needs. Biomass can be converted to transportation fuel. Ethanol and biodiesel are forms of biofuels. Ethanol can be mixed with gasoline and used in gasoline-burning engines. Biodiesel, from the treated oils of oilseed crops, can be mixed with diesel fuel.

ETHANOL

Ontario currently has a 5% ethanol mandate for commercial vehicle fuels. Blending ethanol results in a cleaner-burning fuel that emits an average of 20% less carbon monoxide than unblended gasoline.

Ethanol is currently made from corn or wheat. Research continues on producing ethanol from non-crop biomass to produce what is known as cellulosic ethanol.

Ethanol-gas mixtures can be used for any gas-fuelled farm vehicles such as trucks, ATVs, and small engines.

ETHANOL

BENEFITS	CHALLENGES
• renewable energy from grain crops • ethanol can easily be blended with gasoline, allowing use in conventional engines • domestic energy source • less carbon dioxide emitted (than from fossil fuel combustion) • less MTBE used (this fuel additive is a known carcinogen and water contaminant)	• acreage required to produce ethanol • opportunity costs of growing feed and food • soil degradation from grain-centred cropping systems • risk of increased feed cost for livestock due to global corn ethanol market • loosens “gunk” in the fuel system, which can clog filters

BIODIESEL

Biodiesel is typically made by chemically reacting lipids, such as vegetable oil or animal fat, with an alcohol to create a product with characteristics similar to petroleum-based diesel fuel.

Biodiesel is meant to be used in standard diesel engines, and is thus different from the vegetable and waste oils used to fuel converted diesel engines.

Biodiesel can be used:

- as fuel in diesel engines – trucks, combines, swathers
- in boilers or furnaces designed to use heating oils or in oil-fuelled lighting equipment
- "straight" (100% biodiesel), or blended with petroleum diesel.

Tractors fuelled by biodiesel have lower emissions than tractors using petroleum diesel.

Using waste oil from food processing can result in a biodiesel that is cheaper than conventional diesel. However, competition is developing for the used oil product.

Biodiesel can be used in most on-farm diesel engines, and will usually be blended with diesel.

Oilseed field crops can be processed to produce biodiesel.

BIODIESEL	
BENEFITS	**CHALLENGES**
• safe and easy to handle • no sulphur • odour-free • operates in any kind of basic diesel engine (up to 20% biodiesel) • less air pollution • enhanced lubrication quality of the fuel • blends well with conventional diesel	• backyard brewing is unsafe without proper chemical-handling techniques • low energy content compared to petroleum-based fuels – 11% less energy, which can lead to power loss in engines • long-term storage can result in oxidation and fuel spoilage • hard to use under colder conditions • finding markets or uses for the co-products (e.g. meal and glycerine), which is critical to the economics of on-farm production

ANAEROBIC DIGESTION FOR BIOGAS PRODUCTION

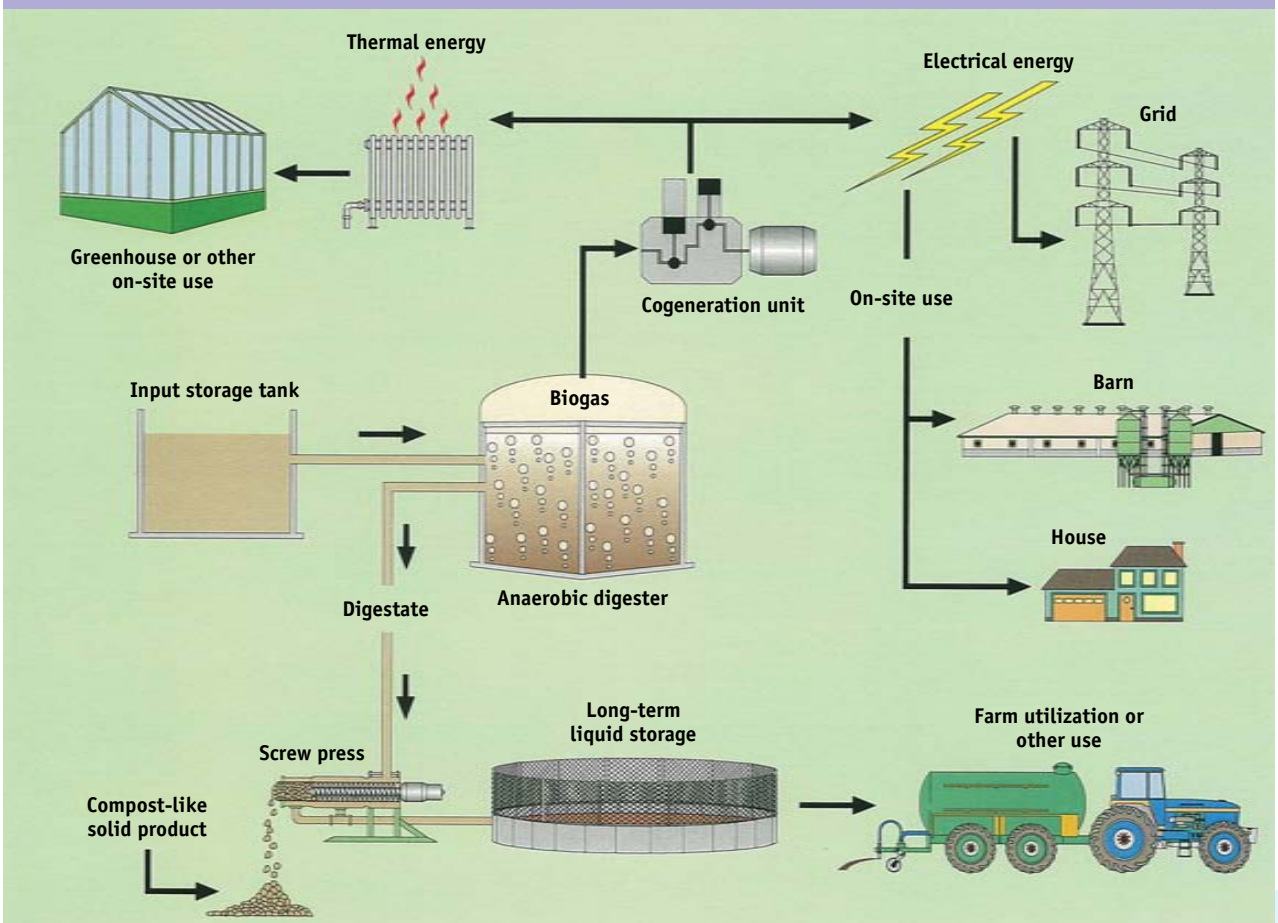
Anaerobic digestion (AD) is the process of micro-organisms breaking down organic materials in the absence of oxygen. Biogas is produced and used as a fuel for generators that produce electricity and for heat. Input material for digesters include manure, energy crops, and food and feed processing by-products.

Completely mixed digester – a completely mixed system, as the name implies, consists of a large tank in which new and old materials are mixed. These systems are suitable for manure with lower dry matter content of 4–20%.

Generally speaking, the completely mixed system has proven to be the most reliable AD technology for Canadian farm conditions.

When manure and other organic materials such as food processing by-products or crop materials are heated and mixed, they can produce biogas, which is mostly made up of methane. The methane can be collected and burned to produce electricity and heat, or used as a fuel replacement.

ANAEROBIC DIGESTION PROCESS



In Ontario, biogas systems are usually built to produce renewable energy. There are also environmental improvements such as eliminating pathogens (e.g. E.coli) and reducing odour from manure.

The biogas is burned in a cogeneration unit that produces electricity and heat. The "digestate" is the nutrient-rich end product that can be used as a crop nutrient.

Some farmers extract a peat-like fibre out of the digestate that they use as livestock bedding to replace straw, shavings or sand.

ON-FARM APPLICATIONS

Biogas can be burned for heat or used to generate electricity. The biogas can also be processed to produce almost pure methane that is equivalent to natural gas. This material, called *renewable natural gas,* could be injected into a natural gas pipeline. As well, cleaned biogas (called *biomethane*) could be used as a fuel source for vehicles.

Most on-farm biogas systems receive off-farm materials like food processing by-products to boost biogas production.

Manure alone has relatively low energy, but has a good range of bacteria that can produce biogas.

Mixing fats, oils and greases, or vegetative materials not only produces lots of gas, but also returns the nutrients in these food by-products back to the cropland.

BMP

Manage off-farm materials in a manner that reduces odour emissions.

ANAEROBIC DIGESTION

BENEFITS	CHALLENGES
• odour reduction • pathogen reduction • energy production • nutrient retention for fertilizer use • reduction in greenhouse gas emissions • effective co-treatment of food processing wastes that may be expensive to manage using other methods	• high capital cost, labour and maintenance • most suitable for large operations • utility connections may be difficult • no decrease in the nutrient content of manure, so the same land base is required for spreading unless further treatment is done • can be difficulties with startup

For More Information

ONTARIO MINISTRY OF AGRICULTURE, FOOD AND RURAL AFFAIRS

OMAFRA offers many helpful resources on energy issues in barns, yards, and in the field.

For information on energy efficiency, conservation and management, see **http://omafra.gov.on.ca/english/engineer/con_energy.htm**

For information on green energy generation, see **http://omafra.gov.on.ca/english/engineer/energy.html**

Get acquainted with the Green Energy Business Information Bundle for Farmers at **http://omafra.gov.on.ca/english/engineer/ge_bib/welcome.htm**

If you have a question regarding farming, agribusiness or rural business, call the Agricultural Information Contact Centre at 1-877-424-1300 or email **ag.info.omafra@ontario.ca**

HOW TO OBTAIN COPIES OF BMP AND OMAFRA PUBLICATIONS

Please order:

- **Online** at **www.publications.serviceontario.ca**
- **By phone** through the ServiceOntario Contact Centre

  Monday–Friday, 8:30 am–5:00 pm

  - 416-326-5300
  - 416-325-3408 TTY
  - 1-800-668-9938 Toll-free across Canada
  - 1-800-268-7095 TTY Toll-free across Ontario
- **In person** at ServiceOntario Centres located throughout the province or at any OMAFRA Resource Centre.

OTHER RESOURCES

Biogas Association
http://www.apao.ca

HydroOne
(energy efficiency around the home)
http://www.hydroone.com/MyHome/SaveEnergy

Natural Resources Canada –
Office of Energy Efficiency
(EnerGuide, Energy Star)
http://oee.nrcan.gc.ca/home

Ontario Ministry of Energy –
Renewable Energy Facilitation Office
(new renewable energy projects)
http://www.energy.gov.on.ca/en/renewable-energy-facilitation-office

Ontario Power Authority
(microFIT Program)
http://microfit.powerauthority.on.ca

Ontario Sustainable Energy Association
(community power projects)
http://www.ontario-sea.org

Canada

Ontario

OFA Ontario Federation of Agriculture

Acknowledgements

The Best Management Practices Program is a partnership of Agriculture and Agri-Food Canada, the Ontario Ministry of Agriculture Food and Rural Affairs, and the Ontario Federation of Agriculture.

Funding for this publication has been provided by Agriculture and Agri-Food Canada and the Ontario Ministry of Agriculture, Food and Rural Affairs.

BMP Technical Coordinators – Ontario Ministry of Agriculture, Food and Rural Affairs: H.J. Smith, Ted Taylor

Task Team and Authors – Ontario Ministry of Agriculture, Food and Rural Affairs: Steve Clarke, Jake DeBruyn, Chris Duke, Ben Hawkins (Chair), Don Hilborn, Helmut Spieser, Ted Taylor

Visuals Coordinator – Ontario Ministry of Agriculture, Food and Rural Affairs: H.J. Smith

Photographers – Agviro Inc.: Katie Gibb, Ron MacDonald; Corporate Photography: Kerry Little; Ontario Ministry of Agriculture, Food and Rural Affairs: Steve Clarke, Jake DeBruyn, Peter Roberts, H.J. Smith; Ontario Soil and Crop Improvement Association: Andrew Graham; University of Guelph: Andrew Gordon, Plant Agriculture

Editor – Alison Lane

Graphic Designer – Neglia Design Inc.

Graphic Illustrator – Ontario Ministry of Agriculture, Food and Rural Affairs: David Rouleau