

# Greenhouse Gases Emissions and Renewable Energy

Number 9

December 2001

## Greenhouse Gases - Things You Need To Know

### What are Greenhouse Gases?

The main greenhouse gases (GHG) from the agriculture sector are nitrous oxide ( $N_2O$ ), methane ( $CH_4$ ), and carbon dioxide ( $CO_2$ ). The ability of each of these GHG to trap heat depends on its capacity to absorb and re-emit radiation and on how long the gas remains in the atmosphere. The majority of scientists agree that increasing levels of GHG are caused by fossil fuel combustion, land use changes, and agricultural and industrial activities, which contribute to changes in temperature, precipitation and weather patterns.

### Fossil Fuel Energy in Agriculture

The main motivation for switching to alternative fuels in agriculture is financial, although reducing GHG emissions is beneficial. Alberta's economy is largely based on fossil fuels. Greenhouse gases are emitted when fossil fuels are burned. The energy, electrical, transportation and mining sectors are responsible for 75 percent of the total GHG emissions in Alberta. The Agriculture and Agri-food processing sectors account for about 12 percent. According to a 1996 emissions inventory, farm fuels account for 10 percent of those emissions (i.e. one percent of total).

### What is Renewable Energy?

Renewable energy technologies convert renewable resources into forms of energy that can complement or replace conventional energy sources such as fossil fuels. Wind, solar, earth energy systems, small-scale hydro and biomass (eg. straw, wood, corn) are all forms of renewable energy.

### Greenhouse Gas Emissions

Wind, solar and small-scale hydro systems have zero GHG emissions. For example, for every kilowatt-hour generated by a wind turbine instead of by burning fossil fuels, about one kilogram of  $CO_2$  is not emitted into the atmosphere. Biomass resources are considered GHG neutral, because the  $CO_2$  generated in producing energy is compensated by the  $CO_2$  used by the growing biomass crop.

**Table 1: Alberta Generation Costs and Carbon Dioxide ( $CO_2$ ) Emissions by Fuel Type**

Fuel	Cents / kWh	~ $CO_2$ t / Mwh
Coal	2 to 3	1
Small Hydro	4 to 6	0
Natural Gas	5	0.5
Biomass	6	0.5
Wind	8 to 10	0
Solar	25 to 50	0

### Wind

Wind turbines capture wind energy and convert it to electricity. Wind energy systems can either be small, stand-alone "off-grid" systems, or connected to the Provincial power grid. Because wind is an intermittent resource, a back-up system is needed.

Wind systems require an average annual wind speed greater than 15 kilometers per hour



Windmill against a sunset



**Alberta Environmentally Sustainable Agriculture Council**

Appointed by the Minister of Agriculture, Food and Rural Development.

Mandated to (1) identify and evaluate environmental challenges and opportunities facing the agriculture and food processing industry; and (2) encourage the industry to proactively address environmental issues.



## Greenhouse Gases - Things You Need To Know

may only be feasible in southern Alberta. Electricity generating costs are reported to have dropped from \$0.25 per kilowatt-hour (kWh) in the 1980's to below \$0.10 per kWh in 2001. One opportunity for farmers is the potential to lease land to wind energy producers.



Solar panels

### Solar

There are three types of solar heating systems that can be used to generate heat or electricity:

- Passive solar – collect and store energy and distribute it by natural processes such as convection and radiation.
- Active solar – uses solar collectors to heat water or air. A typical system will reduce the need for conventional water heating by about two-thirds. Dairy, swine, and aquaculture operations are examples of agriculture businesses using solar systems in Canada.
- Photovoltaic systems – photovoltaic cells (PV) convert sunlight directly into electricity. Photovoltaic arrays (10 to 20 PV modules, each made up of approximately 40 cells) can provide enough power for a household.

### Earth Energy Systems

Earth energy systems provide heating in winter, cooling in summer and year-round hot water for home use. These systems use heat pumps to extract heat from the earth or groundwater to heat or cool air and water. They cost about twice as much as conventional heating systems to install, but on average the

operating cost is about two-thirds less than traditional systems. More than 30,000 earth energy installations in Canada are being used today in residential, commercial, institutional and industrial applications. They are considered to be the most energy-efficient, environmentally clean and cost-effective heating systems available.

### Small-Scale Hydroelectric Power

Small-scale hydroelectric power technologies use free flowing water to produce electricity. Most micro hydros are run-of-stream systems that divert water through a pipe or channel. The water is directed through a turbine, then allowed to flow back to the river or creek. Because they typically don't require a dam, they can be sited, built and operated with minimal environmental impact.

### Biomass

Biomass resources are any plant-derived organic matter available on a renewable basis. This includes agricultural and forestry crops, and animal and municipal wastes. Biomass resources can be burned for heat, produce electricity, or converted to liquid or gas fuels.

Biomass resources are derived from three basic crops:

- cellulosic crops (wood, straw from cereals)
- starch crops (corn, cereal grain)
- oil crops (canola, soybeans)

For biomass resources to be renewable, sustainable cropping practices are necessary. Food crops diverted to produce energy, decrease food production for human and animal consumption.

### Wood

Burning wood instead of natural gas or propane can substantially lower heating costs if it is readily available. Wood is more labour intensive than fossil fuels, which must be taken into account when doing cost comparisons. Depending on the efficiency of the stove or furnace, burning wood emits unburned hydrocarbons, smoke and entrained ash.



#### Alberta Environmentally Sustainable Agriculture Council

Appointed by the Minister of Agriculture, Food and Rural Development.  
Mandated to (1) identify and evaluate environmental challenges and opportunities facing the agriculture and food processing industry; and (2) encourage the industry to proactively address environmental issues.



## Greenhouse Gases - Things You Need To Know

### Straw

Straw can be burned to heat water, buildings or dry grain. It is inexpensive, as most grain farms produce enough to supply a straw-burning system. A straw burning system is economical in meeting demands for large heat loads. Most straw-burning boilers are about 40 percent efficient.



Solar powered recharger in a field

Straw removed for burning and straw residue remaining in the field must be balanced. Alberta Agriculture, Food and Rural Development recommends that 30 percent of the soil surface be covered by crop residue to prevent soil erosion.

### Switchgrass

Switchgrass (*Panicum virgatum*) is a native perennial grass that once dominated the North American prairie. It can grow on marginal lands, and does not require specialized production equipment. A plantation can last from five to 15 years, with an average yield of 10 tonnes per hectare. The grass is harvested annually, then chopped and pelleted for use in specialized stoves and furnaces. Switchgrass is suitable for production in some parts of Alberta.

### Corn

Corn is a starch crop that can either be used as a heating fuel or converted to bioethanol. Clean, dry shelled corn has a high energy per unit weight. New stoves have been developed specifically for burning dry granular fuels such as shelled corn. However, corn may not be a good fuel source because it diverts needed foodstuffs, and requires large fertilizer, herbicide and pesticide inputs for production.

### Biofuels

Biofuels include biogas, alcohols, ethers, esters and other chemicals made from biomass resources. Biofuels can be used as a supplement or an alternative to fossil fuel to produce electricity, heat and transportation fuel.

In the short-term, biofuels can be used as blending agents to dilute CO<sub>2</sub> emissions from fossil-based fuels. In the long-term, technological advances are expected to allow greater use of biofuels in vehicles.

- *Bioethanol* (industrial fuel alcohol) – is made from starch (grain crops, corn), sugar (sugar beet or sugar cane), or cellulose (wood, straw, grass). Bioethanol is the most widely used biofuel today. Ethanol-blended fuels such as E85 (85 percent ethanol and 15 percent gasoline) can reduce net GHG emissions by 37 percent, and E10 (10 percent ethanol and 90 percent gasoline) by four percent.

- *Biogas* – is generated by the anaerobic (no oxygen) digestion of organic material such as animal and municipal waste. It can be burned to produce heat, electricity, or both. The feasibility of on-farm anaerobic digestion depends on type of livestock, manure management system, and heat and electricity requirements. Liquid manure systems work



### Alberta Environmentally Sustainable Agriculture Council

Appointed by the Minister of Agriculture, Food and Rural Development. Mandated to (1) identify and evaluate environmental challenges and opportunities facing the agriculture and food processing industry; and (2) encourage the industry to proactively address environmental issues.



## Greenhouse Gases - Things You Need To Know

best for anaerobic digestion. The installation and operation of an anaerobic digester requires considerable monetary and manpower investments, and the feasibility must be carefully evaluated before proceeding.

- *Biodiesel* – is manufactured from most vegetable oils such as canola or soybean, animal fats, recycled grease, as well as low quality oilseeds and tall oil produced from wood pulp waste. Biodiesel can be blended with conventional diesel fuel or used ‘straight’ (100 percent biodiesel).

Biodiesel is typically added to petroleum diesel in 20 percent blends (B20) for diesel engines, and is a direct fuel substitute for #2 petroleum diesel. Biodiesel-fueled engines deliver similar mileage, torque and horsepower and can be used as a fuel or additive with little or no engine modification. Compared to fossil fuels, biodiesel degrades quickly in the environment and is nontoxic.

### Biopower

Biomass-derived fuels, including bioethanol, biogas and biodiesel can all be used in biopower facilities (cogeneration). Power generation companies are looking at high-efficiency cogeneration systems (heat and power), combined cycle gas turbines and fuel cells, to reduce fossil fuel-derived energy production.

The combination of improved technological efficiencies, scientific advances, increased environmental awareness and environmental protection regulations, have turned biomass conversion into a cleaner, more efficient process. As the biomass energy market grows, so will the market for biomass resources, which may provide farms with another stream of income.

For information on any of these alternative technologies contact the AgTech Centre, Power Pool of Alberta and Alternative Energies at (403) 329-1212 or visit their website at:

[www.agric.gov.ab.ca/navigation/engineering/afmrc/index.html](http://www.agric.gov.ab.ca/navigation/engineering/afmrc/index.html)

**Table 2: A Comparison of Different Fuel Lower Heat Values (LHV) for Burning Different Sources of Energy**

Fuel	Lower Heat Values	
	BTU/lb	MJ/kg
Natural Gas	22865	53.18
Propane	19940	46.37
Gasoline	18831	43.80
Diesel (#2)	18401	42.80
Biodiesel	16251	37.80
Fuel Oil (#1)	15910	37.00
Ethanol	11479	26.70
Coal	10318	24.00
Coal (Sub-Bituminous)	9000	20.93
Flax straw (dry)	8587	19.97
Wood pellets	8512	19.80
Wheat straw (dry)	7680	17.86
*Corn stover (dry)	7540	17.50
*Shelled corn (15% moisture)	7000	16.20
Flax straw (20% moisture)	6635	15.43
Wood (15% moisture)	6450	15.00
Wheat straw (20% moisture)	5908	13.74
Biogas	55159	17.25

Source: PAMI Research Update #719. 1995.

\*Source: OMAFRA Agdex#111.768. 1997.

### Summary

Renewable energy can complement or replace conventional energy and reduce GHG emissions at the same time. Wind, solar and small-scale hydro systems have zero GHG emissions. Biomass resources are considered GHG neutral, because the CO<sub>2</sub> generated in producing energy is compensated by the CO<sub>2</sub> used by the growing biomass crop. Reducing emissions can improve the industry’s production efficiencies, conserve soil and water resources, and contribute to efforts to slow global warming.

### Acknowledgments

In addition to AAFRD staff, we would gratefully like to acknowledge the following external reviewers: Andy Ridge from Climate Change Strategic Direction; Allan Chambers from Alberta Research Council; and Dave Kiely from Prairie Farm Rehabilitation Administration.

To order more copies of this bulletin, contact Conservation and Development Branch, Alberta Agriculture, Food and Rural Development at (780) 422-4385 or check our website at: [www.agric.gov.ab.ca/navigation/sustain/climate/index.html](http://www.agric.gov.ab.ca/navigation/sustain/climate/index.html)



#### Alberta Environmentally Sustainable Agriculture Council

Appointed by the Minister of Agriculture, Food and Rural Development.

Mandated to (1) identify and evaluate environmental challenges and opportunities facing the agriculture and food processing industry; and (2) encourage the industry to proactively address environmental issues.

