Alberta

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RENEWABLE ENERGY TOOLKIT
for Economic Development

Government of Alberta

Finance and Enterprise

Renewable Energy Toolkit for Economic Development

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RENEWABLE ENERGY TOOLKIT
for Economic Development
Part I:

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INTRODUCTION TO THE TOOLKIT

HOW TO USE THE RENEWABLE ENERGY TOOLKIT FOR ECONOMIC DEVELOPMENT

The Renewable Energy Toolkit for Economic Development has been prepared by Alberta Finance and Enterprise to assist communities, to evaluate the potential benefits and risks of renewable energy projects that may provide new economic development opportunities. The Toolkit is designed as a "Self-Assessment" aid that can be used by communities, groups of communities or regions and be integrated with their own economic development structures and strategies. It can be used in a logical sequence working through all of the elements indicated below or simply as a reference for specific planning aspects.

Although the Toolkit attempts to be as complete as possible in suggesting issues that communities need to consider, it is recommended that additional assessments also be considered before deciding to move ahead with any renewable energy project. Each community will need to determine the level of due diligence and additional resources needed for project development.

WHAT IS THE PURPOSE OF THE TOOLKIT?

The purpose of this Toolkit is three-fold:

A. **UNDERSTANDING** - To aid communities in understanding the basics of renewable energy and the types of projects.

B. **COMMUNITY READINESS** - To aid communities in being ready to consider renewable energy projects before specific projects have been presented.

C. **PROJECT SCREENING** - To aid communities in the first level of screening or evaluation of projects, when such projects are presented to them.

WHAT DOES THE TOOLKIT CONTAIN?

The Toolkit contains 13 elements. The first is the Community Action Template for Renewable Energy which provides a suggested sequential approach in using the Toolkit, referencing the other 12 elements.

The 12 elements are organized based on the purpose of the Toolkit:

A. **COMMUNITY UNDERSTANDING AND LEARNING**

- An Overall Profile of Renewable Energy
- A list of the 24 main types of renewable energy projects
- Six profiles of the main sources of renewable energy

B. COMMUNITY READINESS

- CHECKLIST 1 - A Strengths and Weaknesses Checklist to assist communities in determining “best fit” for renewable energy project types for their community
- CHECKLISTS 2 TO 5 – Checklists for Community Receptiveness; Community Capacity; Environmental and Social Impacts; and, Investment Readiness

C. PROJECT SCREENING

- CHECKLISTS 6 TO 9 – Checklists for Developer Viability; Technology; Community Benefit and Developer Business Plan; and, a final Reality Check

WHAT THE TOOLKIT IS NOT

The Toolkit is not a “recipe” for the development of renewable energy projects. It provides a framework that should be used in conjunction with other sources of information and assistance as well as additional resources provided by the network of Alberta Government departments, including:

- Alberta Agriculture and Rural Development
- Alberta Energy
- Alberta Environment
- Alberta Finance and Enterprise
- Alberta Municipal Affairs
- Alberta Sustainable Resource Development

Other agencies, such as Alberta Innovates – Bio Solutions and the Biorefining Conversions Network, can also provide useful direction.

The Toolkit is not meant to be an “advocate” of particular renewable energy projects. Each community that is considering an economic development opportunity must do its own full due diligence to ensure that the particular project is the right fit for the community, its businesses and its residents.

Finally, the Toolkit is not a source of information on existing or proposed policies or incentives of the Government of Alberta with respect to renewable energy development. Such information needs to be fully current and should be accessed independently of the Toolkit.

COMMUNITY ACTION TEMPLATE FOR RENEWABLE ENERGY

The ***Community Action Template*** provides a suggested sequential set of steps in using the other 12 elements of the Toolkit.

The level of understanding and readiness will vary by community and so the process of using the Toolkit should be adapted to each potential user's needs.

For understanding and learning, some communities or regions may already have developed their own renewable energy publications which should be used in conjunction with the Profiles of the Toolkit. Some communities may have already moved further ahead with community readiness and will only need to use the Investment Readiness Checklist as a "double-check" of their level of preparedness to consider projects. Some communities will already be in the phase of project development and may have already developed a process of project screening, in which case the Checklists provided here will simply provide a point of comparison.

A.

COMMUNITY UNDERSTANDING AND LEARNING

Step	Description	Content	Toolkit Element
A.1	**Review the basics of renewable energy**	Generation of electricity; Production of heating and cooling; Production of biofuels; Key drivers of Renewable Energy; Contribution to economic development; Community role	Overall Renewable Energy Profile
A.2	**Understand the main types of renewable energy projects**	24 main projects described with Alberta examples	Types of Renewable Energy Projects
A.3	**Review the individual renewable energy profiles.**	Wind for electricity generation; Solar PV for electricity generation; Enhanced Geothermal for electricity; Bioenergy and Combined Heat and Power (CHP); Heating and cooling using solar thermal, geothermal heat pumps and bioenergy boilers; Biofuels and Biorefineries	6 Profiles with referenced websites for further information

B.

COMMUNITY READINESS

Step	Description	Content	Toolkit Element
B.1	Conduct Community Strengths and Weaknesses analysis to determine which types of renewable energy projects might be the best fit for your community or region.	Input from General Public and Civic Groups; Business Community; Municipal Government Leaders; Educational and Research Institutions	Checklist B.1 Strengths and Weaknesses Analysis
B.2	Ensure Community Receptiveness to renewable energy project development.	Input from General Public and Civic Groups; Business Community; Municipal Government Leaders; Educational and Research Institutions	Checklist B.2 Community Receptiveness
B.3	Assess your community capacity for renewable energy projects.	Organizational; Development Strategy; Support Programs; Land Use and Availability, Utilities, Transportation and Communications; Feedstocks for Bioenergy; Human Resources	Checklist B.3 Community Capacity
B.4	Assess the potential environmental and related impacts of renewable energy development in your community.	Emissions and site contamination; Biodiversity Protection; Worker Health and Safety; Public Opinion	Checklist B.4 Environmental and Social Impacts
B.5	Assess the Investment Readiness of your community for renewable energy projects. This builds on the Community Capacity and Environmental and Social Impacts Checklists and provides a final checklist to ensure that you are ready to move forward with screening of specific renewable energy projects.	Review Community Receptiveness, Capacity and Environmental and Social Issues; Consider other issues such as Active Business Recruitment, Local Investment Capacity.	Checklist B.5 investment Readiness

C.

PROJECT SCREENING

Step	Description	Content	Toolkit Element
C.1	**Screen the reputation and viability of any developer who approaches the community with a project proposal.**	Corporate Information; Project History; Project Elements; Project Financing; Type of Agreement	Checklist C.1 - Developer Viability
C.2	**Screen the renewable energy technology that a developer is proposing to use.**	Technology Readiness; Output of the Technology; Technology Requirements; Operational Performance; Components Supply; Feedstock Supply	Checklist C.2 - Technology
C.3	**Before moving forward with a project, screen it against the background of the Community Benefit and the elements that should be addressed in the Developer's Business Plan.**	Community Benefit; Technical Feasibility; Management Feasibility; Economic Feasibility; Market Feasibility; Financial Feasibility; Environmental Feasibility	Checklist C.3 - Community Benefit and Developer Business Plan
C.4	**Before proceeding with an agreement do a "Reality Check" to ensure that you are satisfied with the due diligence that you have undertaken to ensure a successful project outcome.**		Checklist C.4 - Reality Check

OVERALL PROFILE OF RENEWABLE ENERGY

Conventional energy in Alberta is energy that comes from oil, natural gas and coal – the fossil fuels. The Province is rich in these sources of energy. In other countries (e.g. France) where nuclear energy is used extensively, it would be included in "conventional".

Alternative Energy is defined as anything that is not "conventional". So, for Alberta, wind, solar, biomass, geothermal, hydro, peat, sewage sludge, manure and municipal solid waste (MSW) can be added to the list. As technologies advance, other Alternative Energy sources will emerge, such as hydrogen fuel cells.

Renewable Energy is a narrower concept. It includes all sources of energy that, if used, can be "renewed" and never fully "used up". Solar, geothermal and wind energy are really unending sources and humans do not really have to do anything to "replace" them[1]. Bioenergy from agriculture and forestry is only renewable if humans actively grow and replace the biomass that is used in energy production. Biomass waste such as sewage sludge, manure and MSW can be considered renewable if it is organic (i.e. plant waste rather than fossil-based plastics etc.).

Renewable energy will not replace conventional energy in the short or even medium term. The demand for oil, natural gas and coal will continue well into the future and will continue to be the predominant source of energy in Alberta, Canada and the world for many years to come. 75% of Canada's primary energy comes from these fossil fuels. The International Energy Agency (IEA) forecasts that – even in the optimistic scenario - supply from these fossil fuels would decline from 82% in 2007 to 67% by 2030.

Renewable energy can replace fossil fuels but, at present, is used primarily in a "complementary" fashion to fossil fuels. For instance, electricity that is fed into the Alberta grid is predominantly fossil-fuel based but is supplemented by electricity from renewable sources such as wind farms. Ethanol is used as a blend with gasoline. Renewable energy heating systems often have a fossil-fuel based backup system.

HOW CAN RENEWABLE ENERGY BE USED?

This Toolkit provides profiles of the main sources and uses of Renewable Energy

- Wind energy for electricity
- Solar photovoltaic (Solar PV) energy for electricity
- Enhanced geothermal energy for electricity
- Bioenergy for electricity and combined heat and power (CHP)

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1 Hydro power (electricity generation from flowing water) is also considered to be renewable energy. While hydro power is not prominent in Alberta, it is in other provinces such as Ontario. In Ontario, since it has been part of the standard energy mix for a considerable length of time it can also be considered as "conventional" energy.

- Heating and cooling using solar thermal energy, geothermal heat pumps and bioenergy boilers
- Biofuels (for transportation) and biorefineries

The world's most significant use of energy is for heating and cooling purposes (about 50% with 20% for electricity and 30% for transportation).

Wind, solar PV and geothermal energy can be used for the production of electricity. Solar thermal panels, geothermal heat pumps and bioenergy boilers can be used to produce heating and cooling.

In addition, bioenergy can be used to produce transportation fuels (biofuels) and can be further processed in a "biorefinery". A biorefinery – which is just beginning to come on the scene - is a facility that integrates biomass conversion processes and equipment to produce a range of foods, fuels, chemicals, feeds, materials, heat and power in proportions that maximize economic return (similar to today's petroleum refineries).

Generation of Electricity from Renewable Energy

The demand for electricity in Alberta is growing rapidly, creating possible opportunities for new generation projects.

An electricity grid transmission system ensures that people throughout a jurisdiction have access to electricity no matter where the generation occurs or how it is produced. In many provinces of Canada, the grid is owned and managed by the provincial government. However, in Alberta no part of the system is owned by the government. Alberta's grid is a mixture of privately and municipally-owned facilities. The electricity marketplace supports electricity generation from many different power sources. Producers choose which type of fuel and technology will be used to provide electricity supply. Since 1998, generation from renewable resources (including hydro) has increased by 63%[2]. A key factor in developing power from renewable energy is the ability to connect to the grid.

Alberta's electricity system is a network of generation facilities, transmission lines, wholesalers/retailers and regulators. The key players are:

- The Alberta Electric System Operator (AESO) which is independent from the government and is responsible for system planning, such as critical transmission infrastructure projects. The AESO operates in the public interest in accordance with the Electric Utilities Act.
- The Alberta Utilities Commission (AUC) which regulates the utilities sector, natural gas and electricity markets to protect social, economic and environmental interests. It regulates the transmission of electricity and is responsible for making decisions about

[2] This section is based on several Alberta Energy publications such as "Electricity and You", and "Talk about Alberta's regulated electricity transmission system" available at **www.energy.alberta.ca**

transmission facilities and lines. All new generation projects must be approved by the AUC. However, own-use electricity generation is exempt from the system.

- The Independent System Operator, part of the AESO, which ensures an open-access, competitive market place.

Grid-connected electricity can come from wind power, solar photovoltaic power, geothermal power and bioenergy (including biogas). Wind power is the most commercially developed renewable electricity source in Alberta.

Production of Heating and Cooling from Renewable Energy

Heat is required for space heating in buildings and for process heat to drive equipment in industry.

In Canada, 70% of energy used in residential, commercial and institutional buildings is used for heating.

Renewable energy can be used to generate electricity which can, in turn, provide heating, cooling and lighting. But solar thermal, geothermal and bioenergy can be used directly to produce space heating, hot water and cooling for individual homes, commercial or institutional buildings, for groups of buildings and for entire communities (district heating and cooling). This is referred to as “low heat” that is under 180 degrees Celsius.

Some jurisdictions – in particular Europe – intend to phase out fossil fuel energy sources for new buildings and are already making a certain percentage of energy from renewables mandatory.

At the same time, many are working on making buildings more efficient users of energy and are developing ways to “integrate” renewables into the structure and cladding of buildings. By 2030, buildings may be the most prominent focus for renewable energy systems.

Production of Biofuels

Transportation is the single largest source of Greenhouse Gas Emissions (GHG’s) and demand for fuel is expected to grow more rapidly than any other sector up to 2020. Thus replacing or blending fossil fuels with biofuels is a priority in most countries. The main biofuels are biodiesel and ethanol. Biogas is also treated as a biofuel although it can also be used to produce heat and electricity. The biomass used for biodiesel and ethanol is predominantly agricultural (canola, sunflower, tallow for biodiesel; corn, wheat, and sugarbeets for ethanol). The main Alberta biofuel sources are wheat and canola. Biogas is mainly produced from landfill sites and from animal and food processing wastes.

Second-generation biofuels are those that can be produced from ligno-cellulosic materials which includes both forest and agriculture feedstocks. Plant demonstrations of the technologies involved are underway.

Ligno-cellulosic biofuels come from a wider variety of non-food feedstocks, provide greater environmental benefits and will eventually be cheaper to produce than current processes. Examples of second generation feedstocks are switchgrass, camillina, willow and wood chips. Canada is a leader in second generation ethanol technology.

Biofuels is the most common pathway to biorefineries, but equally important is the expansion or conversion of pulp mills to biorefineries.

WHAT IS DRIVING RENEWABLE ENERGY?

The key drivers of renewable energy development are the following:

Conventional Energy is Ultimately Finite

Conventional energy sources are finite and will eventually be depleted, even if this is far in the future. They are only renewable through millions of years in the evolution of the earth. But with continuously growing energy demand, new sources of energy must be developed. Renewable energy can contribute to meeting this growing demand.

Sustainability

There is a growing commitment at individual, community, national and global levels to ensure that development activities are undertaken in a sustainable manner. A significant contributor to this effort is the development of energy sources which are renewable and can contribute towards a balanced energy future. The use of solar, wind, geothermal and biomass as energy sources work towards achieving this balance.

From an industry point of view, renewable energy holds the potential to open up new sources of employment through the development of "green" industries in Alberta. This is particularly true in light of the provincial expertise in the areas of agriculture, forestry and petrochemicals. As well, this emerging sector of the economic presents opportunities for international investment opportunities within Alberta.

HOW CAN RENEWABLE ENERGY PROJECTS CONTRIBUTE TO ECONOMIC DEVELOPMENT?

Countries of the European Union have set a binding target of a 20% share of renewable energy by 2020. In Europe renewable energy technologies already have sales of nearly $30 billion annually and are estimated to provide over 300,000 jobs. One million jobs are expected by 2020[3], a significant number of which will be in rural areas.

Similar economic development opportunities can emerge for Canada and for Alberta, particularly for communities with abundant forest and agriculture resources. Alberta is fortunate within

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[3] Commission of the European Communities – COM (2008) 30 final

the Canadian context to have expertise[4] within the fossil fuel industries and in petrochemical processing that can be used to leverage new renewable opportunities in partnership with new renewable technology partners.

One pathway of economic development opportunities from renewable energy can be characterized as follows:

- Initiation of projects that use renewable energy technology and equipment, perhaps initially from outside Alberta.
- Initiation of demonstration projects by investors and local communities based on the resource and expertise advantages of Alberta.
- Opportunities for local installation, maintenance and professional services such as engineering and project management.
- Local manufacturing of components for renewable energy equipment.
- Further research in Alberta on how improvements to processes and equipment can be made, particularly based on the Province's expertise in oil, gas and coal as well as forestry and agriculture.
- Design and manufacturing of components and full renewable energy systems.
- Based on expertise gained in design, installation and project management, export of systems and services to other jurisdictions.

WHAT IS THE ROLE OF COMMUNITIES?

For larger renewable energy projects communities will act as hosts to private sector investment. They may in some cases be part of a formal, legal partnership with a private sector developer or a consortium of developers. However, the more common case is that the community (municipal corporation) will be part of an informal partnership. This means that an understanding will be reached with a developer with respect to the provision of certain municipal infrastructure services, land and/or other professional services. The community may also act as a facilitator for the developer in accessing government-based incentive programs.

For the successful implementation of a project, the partnership should be as open and strong as possible with full knowledge of the expectations and obligations of each party within a defined time-line.

In other cases, usually smaller projects, the community (municipal corporation) may act as a renewable energy project initiator. This could happen, for instance, with the development of a district energy system or the application of renewable energy to specific municipal buildings. But even in these cases, the community may still entrust the operation of an initiative to a private sector company or to a local cooperative (common model for district energy in Europe).

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4 As an example, for every 500 people in the labour force in Alberta, 8.4 are Engineers. This is the highest ratio of all Canadian Provinces - 6.1 in Ontario and 4.7 in each of Quebec and British Columbia. (Source: derived from Statistics Canada 2006 Census data). The situation is similar for other technical occupation categories, such as geologists.

In all cases, the spirit of a renewable energy project that is going to be successfully implemented in a community is an active partnership between all of the key players – from both the private and public sectors.

TYPES OF RENEWABLE ENERGY PROJECTS

Following is a list of the twenty four major types of renewable energy projects organized under the headings of the six Awareness Profiles for sources and uses of renewable energy. The key factors for successful implementation are listed along with examples of communities in Alberta where projects have been initiated. Projects in communities may focus on one type of renewable energy source but generally the aim is to develop projects from several renewable energy sources that can act in a complementary fashion to create "renewable energy clusters". The list is presented to assist communities and should not be considered as a complete list of all project considerations.

	TYPE OF PROJECT	KEY FACTORS	EXAMPLES OR POTENTIAL
WIND FOR ELECTRICITY PRODUCTION			
1	Small-scale for own use	• Sufficient wind speed • Moderate investment • Batteries for storage	◦ *Several examples throughout Alberta*
2	Commercial wind farms	• Sufficient wind speed • Grid connection essential • High investment • Technology is commercially ready	◦ *Many wind farms in Southern Alberta – may be local opportunities in other regions*
SOLAR PHOTOVALTAIC (PV) FOR ELECTRICITY PRODUCTION			
3	Off-grid residential and commercial application	• Sufficient sunlight • Batteries for storage	◦ *Applicable to remote areas with no or limited grid connection*
4	Off-grid communications application *(telecom relays, navigational aids etc.)*	• Sufficient sunlight • Batteries for storage	
5	Grid-connected single or multiple buildings	• Sufficient sunlight • Grid connection essential but not generally a problem • Technology is commercially ready	◦ *Alberta Solar Municipal Showcase* ◦ *Vulcan County farm* ◦ *Potential opportunities throughout Alberta*
6	Centralized Photovoltaic (PV) power plants	• Sufficient sunlight • Grid connection essential and not available everywhere • Technology is commercially ready	◦ *No examples so far, but potential for development*

	TYPE OF PROJECT	KEY FACTORS	EXAMPLES OR POTENTIAL
ENHANCED GEOTHERMAL FOR ELECTRICITY PRODUCTION			
7	Geothermal that taps into reservoirs of hot water and steam in the ground	• Thermal reservoirs	◦ *Only sites are within boundaries of Jasper National Park and Banff National Park (not available for development)*
8	Enhanced deep wells for power plants	• Technology not yet commercial • Closeness to "hot spots" desirable • Grid connection essential • Link to oil and gas industry drilling technology • High investment	◦ *No projects so far* ◦ *Potential to use end of life oil/gas wells or coal mines* ◦ *Potential to combine with carbon capture*
BIOMASS FOR ELECTRICITY PRODUCTION - And Combined Heat and Power (CHP)			
9	Industrial CHP systems that use heat directly for industrial processes and supply excess electricity to the grid	• Conversion or enhancement of pulp and paper operations • High investment	◦ *Forest product-based facilities in Drayton Valley, Whitecourt and Grande Prairie* ◦ *Others proposed* ◦ *Other industries proposed or considering*
10	Dedicated biomass power plant	• Generally uses wood chips, wood pellets and municipal solid waste (MSW)	◦ *Examples in USA and Europe* ◦ *Gasification facility in Dapp*
11	Biomass co-fired power plant *(e.g. with coal)*	• Technology well-developed and easily applied • Needs coal fired power plant owner/operator to take lead	◦ *Common in Europe* ◦ *No examples so far in Alberta, but potential development*
12	Waste-to-energy that uses biomass, municipal solid waste(MSW) and garbage	• Technology is commercially ready	◦ *Common in Europe* ◦ *Red Deer with 20 other municipalities awaiting building of gasification plant to handle MSW* ◦ *Edmonton building gasification plant to handle MSW* ◦ *Southern Alberta Energy-from-Waste Alliance*

	TYPE OF PROJECT	KEY FACTORS	EXAMPLES OR POTENTIAL
13	Pellet production *(most of Canada's production exported to Europe for electricity generation)*	• Requires access to wood biomass • Technology is commercially ready • High investment for larger plants	◦ *Plants in Slave Lake, La Crete and Grande Cache*
HEATING AND COOLING			
14	For individual or several residential and commercial buildings	• Suitable buildings • Investment moderate • Technology is commercially ready	◦ *Opportunities throughout Alberta*
	Solar hot water	• Suitable sunlight • Technology is commercially ready	◦ *Drake Landing Solar Community* ◦ *Turin Hutterite Colony*
	Geothermal heating and cooling	• Moderate investment • Technology is commercially ready	◦ *General applicability in Alberta*
	Biomass heating	• Wood pellets or wood chips • Technology is commercially ready	◦ *Common in Europe and some parts of USA*
15	District heating and cooling	• Density of buildings and residences to reduce pipe needs • Usually initiated by municipality • Uses wood pellets or wood chips • Moderate to high investment	◦ *Systems common in Europe* ◦ *District energy systems exist in Alberta (Calgary) but are not biomass-based*
BIOFUELS – And Biorefineries			
16	Biodiesel *(small)*	• Access to biomass • Moderate investment	◦ *Operation in Barons based on used cooking oils*
17	Biodiesel *(commercial – first generation)*	• Access to biomass *(tallow and canola most in use)* • Access to water for processing • Technology is commercially ready	◦ *Plants at Aldersyde and Lethbridge*

	TYPE OF PROJECT	KEY FACTORS	EXAMPLES OR POTENTIAL
BIOFUELS – And Biorefineries (cont'd)			
18	Ethanol *(commercial - first generation)*	• Access to agriculture biomass *(wheat and triticale most in use as well as imported corn)* • Access to water for processing • Technology is commercially ready	◦ *Plant at Red Deer* ◦ *Applicable wherever agriculture biomass available*
19	Ethanol *(commercial - second generation)*	• Technology not fully commercially ready • Access to water for processing • Access to biomass *(wood based)*	◦ *Drayton Valley gasification* ◦ *City of Edmonton (proposed gasification)* ◦ *Applicable wherever wood biomass available*
20	Biogas *(commercial)*	• Access to biomass *(mainly manure and food processing wastes)*	◦ *Iron Creek Hutterite Colony* ◦ *Others proposed*
21	Pyrolysis oil	• Technology emerging for wood biomass to energy	◦ *No projects yet in Alberta and still limited application elsewhere*
22	Tarped sewage lagoons fueling boilers	• At conceptual stage	◦ *No sites yet in Alberta*
23	Biorefinery biofuel pathways	• Complex projects • Substantial investment required • Not yet widespread application	◦ *Hairy Hill project combines ethanol, biogas, heat production, electricity production, and organic type fertilizers*
24	Biorefinery pulp pathways	• Emerging but substantial opportunities	◦ *Several pulp and paper operations in Alberta considering projects*

What about wind for electricity?

Wind energy is the fastest growing renewable energy source throughout the world with installed capacity doubling every three to five years. It is also the most rapidly deployable. The leading countries in installed capacity are Germany, United States, Spain, India and China. In Denmark, wind supplies over 20% of total electricity demand.

Canada's first commercial wind farm was built at Cowley Ridge, Alberta in the early 1990's. Southern Alberta is one of the strongest wind power regions in Canada with many wind farms now established and others proposed. Installed capacity in 2009 was over 500 MW providing 4% of Alberta's electricity needs (from "Talk about Wind Power", Government of Alberta).

HOW DOES IT WORK?

Everyone is familiar with windmills. The wind turns the blades creating mechanical power. A modern wind turbine directs mechanical power to a turbine to produce electricity.

HOW IS IT USED?

While single wind turbines can be installed with the electricity used locally and directly, the usual configuration is a wind farm with multiple turbines supplying electricity to the Alberta electrical grid. The mid-size range of a farm is 20 to 50 MW. Some very large farms in United States are over 500 MW. The investment required is $1.5 million to $2 million per MW installed. Turbines are getting larger and taller, more efficient and with generally declining investment costs per MW.

As wind blows intermittently, not all of the installed capacity is used on a continuous basis. Electricity generation is between 25% and 35% of installed capacity. At 35% efficiency, one MW produces enough electricity for 300 homes, with each home using about 10 Megawatt-hours (MWh) per year (not including electric heating).

Intermittency can be addressed through energy storage systems and complementary electricity systems to supplement wind generation.

HOW DOES IT CONTRIBUTE TO ECONOMIC DEVELOPMENT?

The installation of wind-power often leads to expertise in technology development and component manufacturing capability. The large European turbine manufacturers are establishing facilities around the world. As each turbine has over 8,000 components, the supply chains are extensive.

Manufacturing opportunities can include control systems, generators, castings, towers, blades, bearings and gearboxes. A wind farm also requires installation (foundations and towers) as well as ongoing maintenance and repair. Local expertise can also be built up in services such as legal, financial and engineering.

The local human resource skills required are in relation to the installation, maintenance and repair of wind turbines. Lethbridge College is the Canadian leader in wind turbine technician and teacher training certification.

WHO ARE THE PLAYERS IN ALBERTA?

"Harness the wind of Southern Alberta", a publication by the Southern Alberta Renewable Energy Partnership (SAAEP) notes:

- Major wind generators/developers in the region include TransAlta Wind, Enmax, Suncor Energy and Enbridge Inc.
- Equipment suppliers from international manufacturers such as Acciona Windpower (Spain), Vestas (Denmark), GE Wind (USA) and Enercon (Germany).

WHAT NEW TECHNOLOGY IS COMING?

The research and development focus for the future is on

- New turbine designs with the use of new materials (enabling turbines to turn more slowly and more efficiently).
- Component manufacturing processes and mass manufacturing (to meet the growing demand).
- Best methods of grid integration (to enable growth in wind power).
- Battery storage systems.

WHAT RESOURCES ARE NEEDED?

Wind energy projects require

- Locations with sufficient wind speed – usually 18 km/hour or more.
- Proximity to the Alberta electricity grid and the regulatory authority to integrate into the grid.

In Alberta, as in many other jurisdictions, the limiting factor on the growth of wind power is the capacity of the electricity grid to accept more hook-ups. However, Alberta is planning for an additional 4,000 MW of wind power by 2020 and undertaking a multi-billion dollar grid upgrade, mostly in the southern region. The Southern Alberta Renewable Energy Partnership (SAAEP) estimates that 11,500 MW of “wind interest” applications are in the pipeline throughout Alberta. In 2008 the Alberta Government introduced a micro-generation regulation allowing small wind turbines to sell excess electricity into the grid.

Projects do not use any local natural resources other than wind and land. They do not need water.

HOW DO PROJECTS GET STARTED?

The initial task in moving a wind energy “idea” forward is to ensure a suitable site with adequate wind and to ensure that connection to the grid will be permitted at that site.

The Canadian Wind Association suggests the following eleven steps in moving a wind power project forward. The steps can require 12 to 36 months to complete and would be undertaken by a project developer/investor with assistance from local partners.

1. Wind assessment
2. Farm design
3. Environmental study
4. Land acquisition
5. Permitting and public consultation
6. Economic and financial analysis
7. Manufacturing
8. Site preparation
9. Construction
10. Commissioning
11. Operation and maintenance

WHAT ABOUT THE ENVIRONMENT?

The overall environmental impact is very positive as electricity production from wind power is clean with no emissions, particularly so when compared to electricity from coal or natural gas.

Public reaction to the development of wind power projects can vary significantly by location. Social acceptance is crucial for successful development.

The siting of the wind farm is the most important element in limiting the environmental impact. The type, size and speed of the turbines used are also important. The main concerns that have come to light include:

- Visual impact (need to consider impact up to 10 km range and particularly within first 2 km).
- The perceived noise impact from the aerodynamic movement of the blades.
- The use of the land on which the turbines are situated and incompatible competing uses.
- Impact on birds, bats and wildlife habitat.
- Potential electromagnetic interference.

WHERE TO GET MORE INFORMATION

1. Alberta Energy www.energy.alberta.ca
2. Southern Alberta Renewable Energy Partnership www.saaep.ca
3. TransAlta Corp. www.transalta.com
4. Canadian Wind Energy Association www.canwea.ca
5. Wind Energy Institute of Canada www.weican.ca
6. Canadian Wind Energy Atlas www.windatlas.ca
7. The Global Wind Energy Council www.gwec.net
8. European Wind Energy Association www.ewea.org
9. American Wind Energy Association www.awea.org

What about Solar Photovoltaic (PV) for electricity?

A solar photovoltaic (PV) cell converts the sun's energy into electricity by causing a voltage flow between the positive and negative layers of the cell.

About one-half of the world's 14,000 MW of PV energy is installed in Europe and one-half in the rest of the world.

The leading PV power countries are Germany, Spain, Italy, United States, Japan and Korea. In Europe, about 3% of the total electricity supply is expected to come from PV by 2020.

Canada is far down the list with only 33 MW installed at the end of 2008. Nevertheless, annual growth is impressive and Ontario, with its Green Energy Act (October 2009) and generous feed-in tariffs has become one of the fastest growing PV markets in North America. Feed-in tariffs provide a guaranteed, subsidized purchase price for renewable energy electricity.

The application of PV systems in Alberta is growing, particularly in the grid-connected distributed market.

HOW DOES IT WORK?

PV cells are made of a semi-conducting material, generally silicon. When the cell is exposed to the sun, the photons generate electrical charges inside the material.

HOW DOES IT CREATE POWER?

A PV module is made up of many individual PV cells. Modules are normally connected together to form a PV array. The modules produce direct current (DC) which is turned into alternating current (AC) by an inverter. The modules, inverter and all ancillary control and management equipment make up the PV power system. Systems can also incorporate storage batteries.

PV power systems have no moving parts. They are silent, require only minimal maintenance and are often self-cleaning. More power is generated when the sun shines brightly but modules will still generate some electricity on overcast days.

As the sun shines only intermittently, not all of the installed capacity is used on a continuous basis. Intermittency can be addressed through energy storage systems and complementary electricity systems to supplement solar generation. Battery technology development will be important in the future.

For a system with a rated power of 1 kW in Alberta, the actual electricity production would range from 600 kWh to 1,000 kWh per year depending on the amount of sunlight available and the technology used – 7% to 23% efficiency. The practical limit of conversion efficiency is about 30%.

WHERE IS THE TECHNOLOGY USED?

The most common technology is wafer based crystalline silicon, as normally seen on rooftop panel systems. With "thin film" technology, which is growing fast, modules are constructed by depositing extremely thin layers of semi-conductor materials onto a backing such as glass, stainless steel or plastic.

Concentrating PV (CPV) and dye-cells are also emerging technologies.

GRID-CONNECTED AND OFF-GRID

Two main PV market segments exist: Off-grid systems with no grid connection and Grid-connected systems.

The market initially developed with off-grid systems and, in Canada, 85% of capacity is off-grid. However, the grid-connected market has shown growth of 40% annually since 2000 and will increasingly be the focus of attention. In the USA, nearly 90% of the market is grid-connected.

OFF-GRID SYSTEMS ARE:

- Domestic systems for individual homes or other buildings or for rural application where no grid exists.
- Non-domestic systems used for single applications in telecommunication relays, water pumping, navigational aids and highway information panels.

GRID-CONNECTED SYSTEMS ARE:

- Distributed systems including single or multiple buildings that can provide electricity to the grid and use electricity from it. This includes Building Integrated PV systems (BIPV).
- Centralized PV power plants, whose sole objective is to provide electricity to the grid, in a size range of 10MW to 100 MW.

The grid-connected distributed systems are likely to be the growth focus for Alberta. Howell-Mayhew Engineering of Edmonton estimates 100 grid-connected systems on buildings in Alberta (BIPV) with thousands of small residential/rural off-grid systems.
In 2008, the Alberta Government introduced a micro-generation regulation allowing PV systems up to one MW to sell excess electricity into the grid. Residential PV systems are usually less than 10 kW.

Examples include:

- Two Alberta PV-based sustainable housing projects under the Canada Mortgage and Housing Corporation's (CMHC's) EQuilibrium™ Sustainable Housing Demonstration Initiative.
- The Avalon Discovery Equilibrium house in Red Deer, using PV integrated roofing tiles generates more energy than it consumes, supplying the excess to the Alberta grid.
- The Alberta Solar Municipal showcase demonstration project involving PV systems on buildings in 20 municipalities.

Centralized PV power plants as found in Europe and the USA do not yet exist in Canada. Ontario's Green Energy Act has definitely stimulated interest in large-scale PV power plants. However, their development in other provinces will depend on whether or not some market support measures are introduced.

HOW DOES PV CONTRIBUTE TO ECONOMIC DEVELOPMENT?

Opportunities for Alberta communities exist in both PV applications and in manufacturing and services related to this rapidly growing industry. About 40% of the costs of a system are for local installation, mounting, design and regulatory compliance.

In its 2008 report to the International Energy Agency (IEA), Natural Resources Canada's (NRCan) Canmet Energy estimated the Canadian PV market to be worth CAD 500 million. This represents over 300 solar energy companies (sales companies, wholesalers, product manufacturers, project developers, private consultants, systems installers and industry associations) in Canada.

The leading silicon producer is Timminco Limited, based in Quebec. Several Canadian leaders in cell and module production are based in British Columbia. It is important to note that nearly 75% of Canada's PV sales are for the export market.

The world leader in PV system production is China, followed by Europe, Japan and Taiwan. Major companies include, Q-Cells (Germany), Suntech (China), First Solar (USA/Germany/Malaysia) and Sharp (Japan). Other market leaders in terms of supply and installation include Renewable Energy Corporation (REC) from Norway, BP Solar, Gintech, Mitsubishi and Deutsche Solar AG

Canmet estimates that about 2090 people are employed in the industry in Canada.

WHAT RESOURCES ARE NEEDED?

The only resource needed for the application of PV systems is sunlight. Even though some areas of Alberta receive more sunlight than others, PV systems can be applied almost everywhere either on or integrated into buildings that have exposure to the sun.

HOW DO PROJECTS GET STARTED?

The Alberta Solar Showcase, involving 20 municipal organizations across the province, is a good example of how projects get started. New grid-connected solar PV systems were installed on highly-visible municipal buildings around Alberta.

It has helped inform and educate municipal leaders, administrative staff, facility maintenance personnel, electrical inspectors and utility providers, and assisted in building capacity and experience within the local solar industry.

WHAT ABOUT THE ENVIRONMENT?

During their electricity generation lifetime of more than 25 years, PV modules have no adverse impact on the environment.

While the purification process in silicon PV cell manufacturing is energy-demanding, advances in technology are making continuous improvements in energy reduction.

WHERE TO GET MORE INFORMATION

1. Solar and Sustainable Energy Society of Canada www.sesci.ca and Northern Alberta Chapter http://solaralberta.ca
2. Alberta Solar Municipal Showcase www.lassothesun.ca
3. Climate Change Central www.climatechangecentral.com
4. PV Potential and Insolation Map of Canada https://glfc.cfsnet.nfis.org/mapserver/pv/
5. Canadian Solar Industries Association www.cansia.ca
6. Canadian Solar Building Research Network www.solarbuildings.ca
7. Ontario Sustainable Energy Association www.ontario-sea.org
8. International Solar Energy Society www.ises.org
9. Solar Energy International www.solarenergy.org
10. European Photovoltaic Industry Association www.epia.org
11. United States Solar Electric Power Association www.solarelectricpower.org

What about Geothermal electricity?

While wind, solar and bioenergy are renewable sources of energy from above the ground, geothermal energy taps into the energy beneath the ground. This is why it is sometimes called “heat mining”.

In the 6,000 kilometers from the surface of the earth to its centre, the temperature of the molten rock can reach 5,500 degrees Celsius. The USA Geothermal Energy Association states that, “the heat continuously flowing from the Earth’s interior is estimated to be equivalent to 42 million MW of power and is expected to remain so for billions of years to come, ensuring an inexhaustible supply of energy.”

Geothermally-generated electricity is distinct from ground-source heat pumps (GSHP). Heat pumps use either the earth or groundwater, mainly for space heating and cooling, not generating electricity.

HOW DOES IT WORK?

Traditional geothermal energy taps into reservoirs of hot water or steam in the ground, drawing it to the surface through a wellhead. The hot water or steam then drives a turbine to produce electricity. Wastewater, after passing through a condenser is reinjected back into the ground through a second wellhead, prolonging the useful life of the system. This is commonly referred to as an “open loop” system.

Enhanced Geothermal Systems (EGS) drill wells much deeper into the ground. Instead of tapping into existing reservoirs of hot water or steam, they inject water from the surface through a wellhead and use the heat from the ground to produce hot water or steam. As in traditional geothermal, the wastewater is reused in a continuing cycle. This is commonly referred to as a “closed loop” system

HOW IS IT USED?

Centralized electricity power plants are located directly at the wellhead sites. As with other sources of centralized electricity generation, connection to the electricity grid is a requirement.

In contrast to wind and PV generated electricity, geothermal electricity contributes to the base load needs as it can provide a constant energy source as opposed to an intermittent one.

WHAT IS THE TECHNOLOGY USED?

Traditional geothermal reservoirs are located closer to the earth’s surface where the rock is porous (less than 3 km). While such reservoirs occur in British Columbia and the Yukon, they only occur in Alberta within the boundaries of Jasper National Park and Banff National Park (not available for development).

The best conditions for tapping into EGS are where a temperature of 150 degrees Celsius can be obtained at less than 7 km underground. Alberta Innovates – Energy and Environmental Solutions (AIEES) has undertaken an initial mapping of potential EGS sites in Alberta (study by Jacek Majorowicz and Michal C. Moore commissioned by the former Alberta Energy Research Institute). Best sites are at a depth of less than 7 km and are located primarily in northwestern Alberta and in central-eastern Alberta (based on available mapping).

WHAT RESOURCES ARE NEEDED?

The technology and drilling techniques for EGS are similar to existing drilling practices in the oil and gas industry.

HOW CAN GEOTHERMAL ELECTRICITY CONTRIBUTE TO ECONOMIC DEVELOPMENT?

EGS is still in the research and development stage with demonstration projects located in a number of countries. It is not yet cost-effective.

For Alberta, potential opportunities cited include:

- Unconventional" EGS which co-produces hot water from oil and gas production.
- Use of carbon dioxide (in carbon sequestration) to fracture the rock to enable water to be pumped in.
- Utilization of end-of-life oil and gas wells for EGS.
- Utilization of end-of-life coal mines (e.g. Crowsnest Pass Region).
- Production of power for oil sands projects, replacing natural gas.

The Canadian Geothermal Energy Association (CanGEA) has set a target of 5,000 MW of geothermal electricity by 2015 in Alberta, British Columbia and the Yukon.

The US Geothermal Energy Association cites the following economic development parameters for each 1,000 MW of geothermal energy produced:

- $4 billion capital investment
- 6,000 person-years of manufacturing and construction employment
- 1,800 permanent jobs

Skills for geothermal energy are transferable from the oil and gas industries.

Resources needed for EGS are:

- A good location with adequate temperatures at a reasonable depth.
- The ability to connect to the grid to supply base-load power.
- The availability of sufficient water to pump into the well.

Additional mapping is required to determine specific sites.

HOW DO PROJECTS GET STARTED?

All projects are at the research and development or demonstration phases. They involve serious private sector companies, usually with government financial assistance for development projects.

In Alberta, the most likely private sector initiators will come from the oil and gas industries in cooperation with companies that have geothermal expertise.

WHAT ABOUT THE ENVIRONMENT?

A landmark study on EGS was undertaken by an Massachusetts Institute of Technology (MIT) panel and released in January 2007. The study evaluated the environmental impact as follows:

"The panel also evaluated the environmental impacts of geothermal development, concluding that these are "markedly lower than conventional fossil-fuel and nuclear power plants."

"This environmental advantage is due to low emissions and the small overall footprint of the entire geothermal system, which results because energy capture and extraction is contained entirely underground, and the surface equipment needed for conversion to electricity is relatively compact.

The report also notes that meeting water requirements for geothermal plants may be an issue, particularly in arid regions. Further, the potential for seismic risk needs to be carefully monitored and managed.

WERE TO GET MORE INFORMATION

1. Alberta Innovates - Energy and Environment Solutions (www.albertainnovates.ca) – to access study, “Enhanced Geothermal Systems in the Alberta Basin”, Jacek Majorowicz and Michal C. Moore.

2. Canadian Geothermal Energy Association www.canGEA.ca

3. USA Geothermal Energy Association www.geo-energy.org

4. www.geothermal.inel.gov/publications/future_of_geothermal_energy.pdf) to access MIT study of January 2007.

5. International Geothermal Energy Association (www.geothermal-energy.org)

What about electricity from Biomass?

Biomass can be used to produce energy in the forms of electricity, heat and fuels. This profile deals with electricity generation and combined heat and power (CHP). Other profiles consider heat from biomass, biofuels for transportation and biorefineries that have the potential to produce multiple products.

WHAT IS BIOMASS?

Biomass is a biological material that comes from forests, agriculture and organic community waste. Alberta has both forest and agricultural biomass – particularly hay, straw and forest residues.

Biomass used for energy is often a “residue” from other operations such as forest harvesting, wood product manufacturing and agriculture. But it can also be an “energy crop” – a forest or agriculture crop harvested for the sole purpose of energy development.

Biomass sources can differ substantially in how they can be used for bioenergy. The main factors are:

- Moisture content
- Ash content
- Energy value
- Size and texture
- Levels of contamination with other materials

Biomass usually originates as a solid form. It can be turned into other solids (wood pellets from wood chips), liquids (oils from crops) or gases (methane from landfills).

WHAT TECHNOLOGIES ARE USED?

The main technologies to transform biomass into energy are thermal conversion technologies (combustion, gasification and pyrolysis), anaerobic digestion and fermentation.

Most power plants use the source of heat to produce electricity only and do not fully use the excess heat that is co-produced with the electricity. Systems that make full use of both electricity and heat production are called Combined Heat and Power plants or Co-generation plants. When the heat is fully used efficiency can be as high as 85%.

In Europe the trend is to convert power plants (or to construct new ones) as Combined Heat and Power Plants (CHP).

Alberta has the largest CHP electricity plant in Canada – the Joffre Cogeneration Combined Cycle Gas Turbine facility. The plant generates all the electricity and process heat needed to operate a nearby petrochemical plant with substantial surplus electricity sold into the electricity grid. While the technology to integrate biomass into gas turbine plants is not yet commercial, the presence of strong leaders in CHP technology in the province could be a major benefit in future applications that can include biomass CHP.

For electricity generation from biomass the current main technology is the combustion of wood chips or pellets as well as hay/straw. Gasification (syngas) of forest and agricultural biomass is emerging.

HOW IS BIOMASS USED NOW IN ELECTRICITY GENERATION?

Basically three configurations exist to transform biomass into electricity:

1. **Industrial applications** that produce electricity from biomass (and usually also heat) for their own purposes, selling the excess to the grid.

   In Canada, the pulp and paper industry has been at the forefront in the generation of electricity and process heat from biomass (hog fuel) and "black liquor" a by-product of the pulping process. The industry is responsible for the majority of the biomass electricity generating capacity in Canada. Leading provinces are BC, Ontario, Quebec, Alberta and New Brunswick.

   Forest product-based combined heat and power (CHP) facilities are located in Drayton Valley, Whitecourt and Grande Prairie.

2. **Power plants** that can run entirely on biomass or fossil-fuel plants that are co-fired with biomass.

   In the USA, about 40 dedicated biomass power plants using forest and agriculture residues, mainly in California, Maine and Michigan supply electricity to the grid. In Europe, coal plants co-fire with wood pellets (using over 80% of Canadian wood pellet production). In Alberta, a biomass gasification facility exists in Dapp.

3. **Waste-to-energy incinerators** installed in communities, mainly in Europe and Asia, which take biomass and produce heat and electricity.

   In Germany, advanced combustion technology systems take all forms of municipal waste, even toxic waste imported from other countries.

HOW ELSE COULD BIOMASS BE USED FOR ELECTRICITY?

Small amounts of electricity can be produced by the extraction of methane from landfill sites and many municipalities are developing that option with connections to the grid. There is significant potential to use a complementary generation system within coal fired plants.

Electricity generated at power plants relies on some form of heat source to drive a steam turbine or a gas turbine (or a combination of both in a "combined cycle". In Alberta, 90% of the electricity is produced from coal and natural gas.

Biomass that is combusted can act as a supplementary or alternate source of heat for the production of electricity.

HOW CAN BIOMASS ELECTRICITY CONTRIBUTE TO ECONOMIC DEVELOPMENT?

In the event of the development of biomass co-firing in coal-fired electricity plants, the main opportunity for rural communities would be in the supply of biomass to the power plants. If a 400 MW coal plant is co-fired at 5%, the biomass requirement would be about 125,000 bone-dry-tonnes (BDT) per year (about double the amount when wet)[1].

If the power plant is using wood chips, this involves the harvesting, chipping and transportation of the chips to the power plant, usually in a wet state. Dedicated biomass power plants in United States generally use chips, other wood residues and sometimes agricultural feedstocks like hay and straw.

But usually, for convenience of handling, biomass co-fired power plants use or plan to

1 Based on estimates contained in, *Feasibility Study: Identifying Economic Opportunities for Bugwood and Other Biomass Resources in Alberta and BC*, prepared by Levelton Consultants Ltd. for the Alberta Energy Research Institute

use wood pellets. The economic development opportunity then is the establishment of a pellet mill to produce the pellets.

As a basic rule of thumb, biomass is most cost-effective in chip or other wood residue form if it does not have to be transported more than 100 km. Wood pellets can support much higher transport distances (e.g. export to Europe from Canada) as their sales price is three to five times higher than wood residues. While wood pellets dominate the market, pellets from agriculture, which have higher ash content, are under development.

The production of biomass for electricity generation is of primary benefit to entrepreneurs and existing lumber mills in the wood products industry. At present, Alberta has a limited capability in pellet production. In a pellet plant operation, skills from the wood harvesting and yard handling processes are directly transferable. However, new skills related to the operation of the pellet mill would be required.

British Columbia is recognized as the province with the greatest expertise in pellet production, sales and transportation.

WHAT RESOURCES ARE NEEDED?

For the supply of biomass for the production of electricity or for heating, the greatest need is access to wood fibre resources. When the wood products sector is strong, lumber mills have a surplus of residues that can be used for biomass combustion and/or pellet production. However, when fewer mills are operating and the demand for pulp and paper is low, wood residues and wood chips for the production of pellets are in short supply (low production).

This means that any new biomass operation needs access to direct forest resources and needs such access on a long-term basis to justify new investment and to secure sales contracts. In Alberta, as in many other provinces, access to forest resources for new industry participants is often a limiting factor. In several Canadian provinces, forest tenure reform is actively being considered to allow greater access for bioenergy feedstocks.

Nevertheless, local solutions working with existing forest industry players (licence holders and logging contractors) should be explored.

HOW DO PROJECTS GET STARTED?

The development of biomass co-firing of coal electricity plants in Alberta will depend on four factors:

1. The pressures across Canada and from United States for a reduction in coal-fired generation and the negative emissions impact on the environment.
2. The incentive measures that might be put in place by the Government of Alberta to encourage co-firing.
3. The availability of biomass primarily in the form of wood residues and/or wood pellets.
4. And, most importantly, the decisions by the private sector coal power plants to incorporate biomass co-firing.

Communities that are within 100 km of coal plants in Alberta can take some pro-active steps to determine the likely availability of and capacity to supply biomass within the plant catchment area.

WHAT ABOUT THE ENVIRONMENT?

Co-firing with biomass is not an alternative but a complementary action to further reduce emissions of sulphur dioxide (SO2), nitrogen oxide (NOX) and carbon dioxide (CO2) from electricity generation processes. The use of biomass can make a significant contribution to the reduction of these emissions. For instance, the carbon dioxide that biomass gives off when it is burned is counterbalanced by the amount absorbed when the plant/ species in question is replaced after harvesting.

Nevertheless, combustion of biomass does create some concerns for emissions – particularly nitrogen oxide (NOX) and particulates so the integration of biomass combustion with coal must be carefully planned.

WHERE TO GET MORE INFORMATION

1. Alberta Forest Products Association
   www.albertaforestproducts.ca
2. Forest Products Association of Canada
   www.fpac.ca
3. Alberta Innovates – Energy and Environment Solutions
   www.albertainnovates.ca – to access the footnoted “Bugwoood Study”
4. USA Biomass Power Association
   www.usabiomass.org
5. International Energy Agency (IEA)
   www.iea.org – See Biomass for Power Generation and CHP
6. Capital Power
   www.capitalpower.com – joint owners of Genesse 3 with TransAlta
7. PowerScorecard
   www.powerscorecard.org

What about heating and cooling with renewable energy?

The world's biggest use of energy is for heating and cooling purposes (about 50%). Electricity uses 20% and transportation 30%. In Canada, furthermore, 70% of energy used in residential and commercial institutions is used for heating.

Renewable energy can be used to generate electricity which can, in turn, provide heating, cooling and lighting.

But solar thermal, geothermal and bioenergy can be used directly to produce space heating, hot water and cooling for individual homes, commercial or institutional buildings, for groups of buildings and for entire communities. This is referred to as "low heat" that is under 180 degrees Celsius.

The focus of renewable heating and cooling is the building. Some jurisdictions – in particular Europe – intend to phase out fossil fuel energy sources for new buildings and are already making a certain percentage of energy from renewables mandatory.

At the same time, many are working on making buildings more efficient users of energy and are developing ways to "integrate" renewable energy production into the structure and cladding of buildings. Some predict that by 2030, the "Building" will be the most common energy system.

HOW IS IT USED?

Bioenergy requires the combustion of biomass to produce hot water which can then be used directly for heating in radiators and hot water tanks.

Solar thermal energy and geothermal energy do not require combustion. They "collect" heat from the sun or from the earth and use it to heat hot water.

All three technologies can use heat exchangers to transform heat from hot water to hot air, which can then be used similarly to forced air furnaces. Also all can use condensers to transform heating to cooling.

The three most common ways in which renewable heating and cooling is used are:

1. In individual homes or larger multi-family buildings.

   The use of solar thermal to produce hot water is probably the widest use, followed by geothermal for heating and hot water, and solar for heating. Bioenergy boilers using pellets, chips or logs are slowly being introduced to the market.

2. In commercial and institutional buildings.

   In Canada, the use of geothermal for this sector is more widespread than for individual homes. Solar thermal is developing. In Europe and United States the use of bioenergy is much more common in this sector than in Canada.

3. In District Heating and Cooling systems that can service a group of buildings and even entire communities.

   All three forms of renewable energy can work in a District Heating system.

The Drake Landing Solar Community in Okotoks, Alberta is a good example of a solar thermal district energy system providing space heating for about 50 homes. The system also uses a borehole to store heat in the summer for use in the winter.

A fourth market sector is applications to industrial processes. At present, only bioenergy is applicable but research is ongoing for solar thermal and geothermal.

Strathcona County also has a District Energy system fired by fossil fuels but envisages using renewable fuels, such as biomass, in the future.

WHAT IS THE TECHNOLOGY USED?

Solar thermal

- Solar collectors (dominated by flat plates on roofs) filled with water or glycol carry water to a heat exchanger that then heats water.
- Canada leads the world in solar air collector technology that does not use a liquid. The main application, so far, is for air heating in commercial buildings. This technology includes "solar walls".

Geothermal

- A continuous loop of pipes 10 to 30 feet underground or in water extract heat from the ground. A "heat pump" concentrates the heat and transfers it to water or air for space heating. Heat can also be returned to the earth for storage as a way of air conditioning homes and buildings.

Bioenergy

- Bioenergy boilers produce hot water for heating by combusting biomass (usually pellets at the residential level). A heat exchanger can transform the hot water into hot air, as in a traditional forced air furnace.
- Larger bioenergy boilers that can combust a greater variety of biomass can produce hot water in district heating systems and in industrial applications. Often such systems are configured to produce both heat and electricity (Combined heat and power) with the power usually sold to the electricity grid.

All three of the technologies can be used in combinations. For instance, many new houses in Germany combine a biomass pellet boiler with a solar water heater. Increasingly, in Europe biomass district heating systems are adding solar thermal arrays. The use of solar thermal panels (heat) and solar PV panels (electricity) on the same building is another possibility.

Common areas of further technology development relate to energy storage, advancement in cooling, building integration and district systems.

HOW DOES HEATING AND COOLING CONTRIBUTE TO ECONOMIC DEVELOPMENT?

In contrast to the large projects for the generation of electricity, heating and cooling from renewable energy used in building applications relies upon a host of small and medium sized companies for installation, maintenance and sales – heating equipment sales companies, heating and cooling contractors, pellet distributors etc.

Training specific to renewable energy heating and cooling is required for all of these positions. Engineering education at the engineering professional level is offered by the University of Alberta and specific training related to the sales, installation and trades positions is offered by several Community Colleges.

In Europe about 30,000 to 40,000 people are employed in the solar thermal industry which has annual sales of $4.5 billion (Can). As Europe has been the leader in solar thermal and bioenergy technology development, most of the larger manufacturers are based there. However, Canadian manufacturing capability is developing.

WHAT RESOURCES ARE NEEDED?

In the case of solar thermal and geothermal, no natural resources are required other than exposure to sunlight or access to the heat of the earth. As such, solar and geothermal heating and cooling systems can be installed almost anywhere. As nearly all of these systems have electronic controls, some electricity is required.

For bioenergy systems, access to biomass is required. For residential and most small commercial systems this usually means access to wood pellets. As pellets can absorb higher transport costs than wood chips, their availability is increasing – even in areas where pellets are not produced. To heat a typical house, about five tonnes of pellets would be required annually. Availability of wood chips will depend on geographic location and on the ability of a community or investor to secure a long-term local supply.

For district heating and cooling systems, insulated pipes must be laid in the ground for both the collection and distribution systems (water). The depth is not below three feet, but their installation can create some temporary disruption to pedestrian and automobile traffic.

HOW DOES A PROJECT GET STARTED?

The installation of renewable hot water and heating systems in individual residences can be undertaken directly by the owners in a retrofit but are more usually installed in new buildings at the time of construction.

The same is true of commercial and institutional buildings such as schools, hospitals or municipal buildings.

District energy systems are a more complex undertaking and are either lead by a municipality or by a project developer. For instance, the Drake Landing Solar Community involved a developer, a builder, a utility operator, an engineering company and equipment suppliers. The municipality was involved in the standards and approvals process.

In Europe, it is not uncommon for district energy projects to be initiated by a municipality but then operated by either a cooperative or by a private company.

The District Energy system in Calgary, while using natural gas, has an investment requirement of about $30 million.

WHAT ABOUT THE ENVIRONMENT?

As a general rule of thumb, each home that uses electricity and/or some form of fossil fuel produces about six to seven tonnes of Greenhouse Gas Emissions (GHG's) every year. So any application of renewable energy for heating and hot water will provide a reduction in emissions – the actual amount depending on the system used and on the percentage of energy use replaced. When the Drake Landing Solar Community is at full operation (90% energy replacement) each home will save over five tonnes in GHG emissions.

Very few environmental issues arise in connection with the use of renewable energy for heating, hot water and cooling. However, the most efficient bioenergy boilers for residential and commercial/institutional application that come from Europe must be certified for use in North America. Even though European technology usually exceeds North American standards, the certification process can be long and expensive.

WHERE TO GET MORE INFORMATION

1. Solar and Sustainable Energy Society of Canada www.sesci.ca and Northern Alberta Chapter http://solaralberta.ca
2. Climate Change Central www.climatechangecentral.ca
3. Alberta Geothermal Energy Association (www.agea.ca)
4. Drake Landing Solar Community www.disc.ca
5. Canadian GeoExchange Coalition www.geo-exchange.ca
6. Canadian Bioenergy Association (Canbio) www.canbio.ca
7. Canadian Solar Industries Association www.cansia.ca
8. Canadian Solar Building Research Network www.solarbuildings.ca
9. Natural Resources Canada – Canmet Energy http://canmetenergy-canmetenergie.nrcan – rncan.gc.ca
10. Ontario Sustainable Energy Association www.ontario-sea.org
11. International Solar Energy Society www.ises.org
12. Solar Energy International www.solarenergy.org
13. European Solar Thermal Industry Federation www.esttp.org

What about Biofuels?

WHAT IS BIOMASS?

Biofuels are produced from biomass. Biomass is a biological material that comes from forests, agriculture and community organic waste. Alberta has both forest and agricultural biomass – particularly hay, straw, wheat, and canola and forest residues.

Biomass used for energy is often a “residue” from other operations such as forest harvesting, wood product manufacturing and agriculture. But it can also be an “energy crop” – a forest or agriculture crop harvested for the sole purpose of energy development.

Biomass sources, referred to as feedstocks, can differ substantially in how they can be used for bioenergy. The main factors are:

- Moisture content
- Ash content
- Energy value
- Size and texture
- Levels of contamination with other materials

Biomass usually originates as a solid form. It can be turned into other solids (wood pellets from wood chips), liquids (oils from crops) or gases (methane from landfills).

WHAT ARE BIOFUELS?

Transportation is the single largest source of Greenhouse Gas Emissions (GHG’s) and demand for fuel is expected to grow more rapidly than any other sector up to 2020. Thus replacing or blending fossil fuels with biofuels is a priority in most countries.

The main biofuels are biodiesel and ethanol. The biomass used for both is predominantly agricultural (canola, sunflower, tallow for biodiesel; corn, wheat, and sugarbeets for ethanol). The main Alberta biofuel sources are wheat and canola. Biogas is also considered as a biofuel here, although it can be used for the production of heat and electricity.

WHAT TECHNOLOGIES ARE USED TO PRODUCE BIOFUELS?

Biodiesel

Biodiesel is made primarily from vegetable oils by reacting the oil with an alcohol (usually methanol) in the presence of a catalyst. The resulting chemical reaction (called transesterification) produces biodiesel and glycerine as a byproduct. Biodiesel represents under 2% of the global diesel market. Biodiesel can be blended up to 25% with hydrocarbon fuels for use in today’s vehicles.

Ethanol

Ethanol is water-free alcohol produced by the fermentation of sugar or starch contained in grains - primarily wheat in Alberta - and corn in Eastern Canada. About four million bushels of wheat are needed to produce 40 million litres of ethanol.

Ethanol is also blended with gasoline, but currently only up to a maximum of 10% (E-10). Some specifically designed commercial vehicles can use a blend up to 85% ethanol (E-85). Ethanol represents less than 4% of global gasoline consumption.

Second-generation biofuels

Second-generation biofuels are those that can be produced from ligno-cellulosic materials which includes both forest and agriculture feedstocks. While plant demonstrations of the technologies involved are underway, the market is not expected to be fully commercial before 2015. Second generation biofuels will usually involve the co-generation of electricity.

Ligno-cellulosic biofuels come from a wider variety of non-food feedstocks, provide greater environmental benefits and will eventually be cheaper to produce than current processes. Examples of feedstocks are switchgrass, miscanthus and wood chips.

Canada is a leader in second generation ethanol technology. Third generation biofuels are algae-based and are likely to become commercial only after 2015.

Other biofuels

Biogas is mainly methane produced by anaerobic digestion using manure, sewage, organic municipal waste and energy crops. It can be compressed like natural gas and used to power vehicles. More usually, it is used as a fuel for a combustion process.

Pyrolysis oil (also referred to as bio-oil) is currently produced from wood residues and is slowly entering the biofuel market. It can be blended with hydrocarbon fuels or upgraded to make green gasoline or diesel. Two Canadian companies who are leaders in this technology are Dynamotive and Ensyn.

Syngas produced from biomass is an emerging technology.

Biorefineries

The concept of a biorefinery is to achieve economies of scale in combining several technological processes to produce multiple green energy and related products. The pathway to biorefineries is predominantly through the production of biofuels but also through the process of producing pulp in the pulp and paper industry.

For instance, the Growing Power Hairy Hill project in Alberta will produce ethanol from wheat. The byproduct of distillers grain will be used as a cattle feed. The manure from the cattle will go through an anaerobic digester to produce biogas which, in turn, will produce hot water and electricity needed to power ethanol production, with excess electricity being sold into the Alberta grid. The anaerobic digestion will also produce organic fertilizers as a commercial byproduct. The Permolex plant in Red Deer is already in operation.

The concept of a full biorefinery is to replicate an oil refinery that is capable of producing a wide range of chemical and related products just as oil does today. While progress is substantial, the concept is unlikely to be fully realized in the near future.

HOW CAN BIOFUELS CONTRIBUTE TO ECONOMIC DEVELOPMENT?

The main beneficiary of biofuels is the agricultural sector as forest biomass can only be used once second generation biofuel technology comes to market.

The Alberta agricultural sector is already prominent in the production of crops that are used in biofuels and has also developed downstream activities in processing, such as oilseed crushing. The production of biofuels is a natural extension of these activities.

Alberta has a number of biodiesel and ethanol production plants in operation and many more are in the planning and feasibility stages.

Biodiesel plants have been established in Aldersyde and Lethbridge with a number of other plants proposed. An ethanol plant is located in Red Deer with others being proposed for Alberta. As well, ethanol gasification projects are planned for Drayton Valley and the City of Edmonton.

About five biogas operations exist, with others planned.

WHAT RESOURCES ARE NEEDED?

The main resources needed are the crops required to produce the biofuels as well as animal residues (for biodiesel). The requirements for large-scale biogas are proximity to a dairy or hog operation or food processing plant. The blending of feedstocks is also possible.

A major issue in biofuel production is the need for substantial amounts of water in the current processes used. While water recycling (non-consumptive) is growing, consumptive water use is in the range of two to six gallons of water needed for each gallon of biofuel produced. Water use for biofuels is higher than water used in fossil-fuel gasoline refining. Water use is also an environmental concern in areas where water consumption is already high compared to availability[2].

HOW DO PROJECTS GET STARTED?

Projects get started usually by those entrepreneurs and investors who are already present in the agricultural sector or in biofuels development elsewhere. Many projects are in the hundreds of millions of dollars, although some smaller scale projects are possible. Alberta biofuel project listings and locations can be found on the government website (www.agric.gov.ab.ca).

WHAT ABOUT THE ENVIRONMENT?

The production and use of biofuels has a definite environmental benefit in reducing the amount of fossil fuel based products used in transportation. Biofuels can make a significant reduction to GHG emissions and several of the feedstocks of Alberta show an increased benefit compared with other biofuel feedstocks.

The recent concern with the production of biofuels is the claim that they have led to food price increases and shortages resulting from the competition of biofuels for food crops. The Alberta Biodiesel Association website provides a full briefing that deals with this issue.

Nearly all biodiesel projects existing or proposed in Alberta are based on manure and food processing wastes which can lead to odour control challenges.

With respect to ethanol production, the energy balance of producing ethanol from corn has been questioned, as the energy input required can be equal to or greater than the energy provided by the resulting ethanol. Quebec has banned any new ethanol from corn.

This is not an issue for Alberta as the production of ethanol from wheat feedstock has a much better energy balance. The situation is similar for biodiesel production in Alberta.

A limiting factor when considering many biofuel projects, is the availability of a reliable source of water for various production processes.

As second generation biofuels develop and other uses of biomass for energy advance, the use of dedicated forest and agricultural crops will also grow (as opposed to just residues from other activities). In this case the balance of land used for biofuels and food production will likely be an increasingly important issue for the public.

2 Water Implications of Biofuels Production in the United States, National Research Council, 2008 – ISBN 0-309-11362-8

WERE TO GET MORE INFORMATION

1. Alberta Biodiesel Association
   www.albertabiodiesel.org
2. Alberta Ethanol Association
   (currently being formed)
3. www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/bdv11362
   for Alberta biofuel project listings
4. Alberta Research Council
   www.biofuels.arc.ab.ca – for biodiesel testing
5. The Canadian Renewable Fuels Association www.greenfuels.org
6. Canola Council of Canada
   www.canola-council.org
7. United States Dept. of Energy Renewable Fuels Data Centre
   www.afdc.doe.gov
8. International Energy Agency (IEA)
   www.iea.org

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