Emerald Hills Urban Village

FOUNDATION RESEARCH BULLETIN

Design Centre for Sustainability at UBC

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CARBON

1.0 Why is carbon a key theme?

Increased levels of carbon dioxide in our atmosphere from burning fossil fuels has been linked to climate change and global warming. As a result, global temperatures are predicted to rise to unprecedented and unsustainable ranges over the next century. The impacts of this climate change are wide and varied.

Heating, cooling, lighting and other power demands of our buildings all represent significant sources of carbon dioxide emissions. This is in part related to the amount of energy being consumed, and in part to the source from which energy is derived. Thus, any sustainable urban neighbourhood must consider where energy is coming from, and how much energy from fossil fuels is being used.

Sustainable communities optimize the economic, social and ecological impacts of buildings and infrastructure. Innovative development standards and practices will reduce community and environmental emissions impacts as well as private, public, and taxpayer costs of development and infrastructure. Low impact solutions such as green infrastructure and natural drainage systems will save money over the longer-term, ensuring the sustainability of economic growth. Such designs will reduce carbon emissions to conserve valuable resources.

Carbon, as defined in this project, refers to carbon dioxide emissions associated with fossil fuel consumption.[1] This technical bulletin outlines strategies and technologies to reduce carbon dioxide emissions on a building and neighbourhood scale by minimizing energy demand and using renewable energy sources to offset the need for fossil fuel.

It should be noted that lifestyle decisions such as food and transportation choices contribute significantly to our carbon footprint. Opportunities to mitigate the carbon footprint of these factors are discussed in the Food and Transport technical bulletins.

2.0 Why is carbon important to Emerald Hills Urban Village?

The Alberta government has promised to reduce GHG emissions from government operations to 26% below 1990 levels by 2005, and has committed to use renewable energy for 90% of its needs.[2] Although the Alberta government has made some strides towards lowering the greenhouse gas emissions from its own operations, there is still much to do. Alberta has the highest greenhouse gas emissions of all of the provinces, and its 2002 climate change plan has not been updated. Instead of absolute emission reduction targets, Alberta's plan uses greenhouse gas intensity targets that allows GHG

[1] One Planet Living, 2006, p. 19.
[2] David Suzuki Foundation, 2006, p. 9.

emissions to rise with economic growth. The plan predicted that emissions would be 39% above 1990 levels by 2010, however between 2000 and 2004, actual emissions rose twice as fast as they were anticipated to. It is expected that emissions will rise by as much as 83% by 2020![3]

The greatest source of GHG emissions in Alberta is from the oil and gas sector. The second highest emitting sector in the province is electricity production. Reliance on coal-fired power plants for the majority of electricity production in the province is largely responsible for these emissions which have increased to 31% from the 1990 level.[4]

Carbon dioxide emissions from human actions have been linked to rising global temperatures. Global climate change will affect different areas in different ways. For Alberta, the most likely climate change scenario as estimated by Climate Change Central is increased occurrences of drought. Drier conditions will be detrimental to food production, lead to an increase in forest fires, and an increase in air-borne particulate matter. The health implications of drought episodes will be an increase in respiratory disorders, as well as mental distress in the farming community.[5]

According to the Office of Energy Research and Development, Alberta's energy is predominately derived from natural gas and petroleum, with lesser amounts coming from hydro, biomass, and coal. Overall, 1169.8 PJ of useful energy is consumed in Alberta, 870.2 PJ of energy is lost, and electrical system energy losses consume 447.1 PJ of energy. Of all the energy consumed in Alberta, the commercial and residential sectors accounts for 17%.[6]

The Emerald Hills area is subjected to extreme temperature variations throughout the year. According to the Climate Normals from 1971-2000, there was over an 80°C temperature difference between the extreme maximum and minimum temperatures for the year. Given these harsh temperature extremes, it is not surprising that over half of the energy consumed in Canadian residential and commercial sectors is used for space heating (see figure 1[7] and 2[8]).

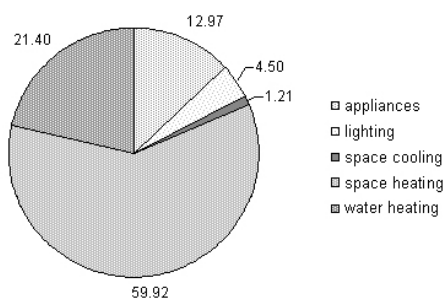

Figure 1: Breakdown of Residential Energy Consumption in Canada (by percentage)

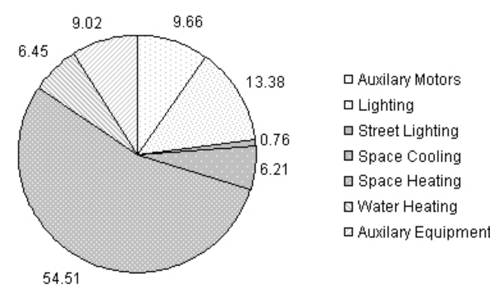

Figure 2: Breakdown of Commercial Energy Consumption in Canada (by percentage)

[3] David Suzuki Foundation, 2006, p. 9.
[4] Ibid. p. 10.
[5] Climate Change Central, 2002.
[6] Natural Resources Canada, Office of Energy Research and Development, 2006, p. 24.
[7] Ibid, p. 9.
[8] Ibid, p. 10.

3.0 How can EHUV impact on this theme?

The second draft of Strathcona County Municipal Development Plan outlines several policies that explicitly deal with energy conservation. Including:

"5.11 Collaborate with development/building industries and community organizations to facilitate the development of more sustainable housing criteria such as... c) Reduced energy use and the positive benefits on the atmosphere through the use of renewable energy and green power;"[9]

"8.42 Aid in the reduction of greenhouse gas emissions by: ... c) Encouraging energy efficiency in subdivision and building designs; and d) Providing education, regarding energy efficient alternatives in development."[10]

There are two basic methods to reduce the carbon footprint associated with the development: reduce energy consumption through demand side management practices and source new supplies of energy based on non-fossil fuel sources through supply side management practices.

3.1 What Strategies are relevant for EHUV?

Figure 3[11] illustrates the cost verses relative benefit of carbon strategies that can be applied on the building and block scale. It is a useful reference for selecting the most effective design strategies that can be implemented within a set budget.

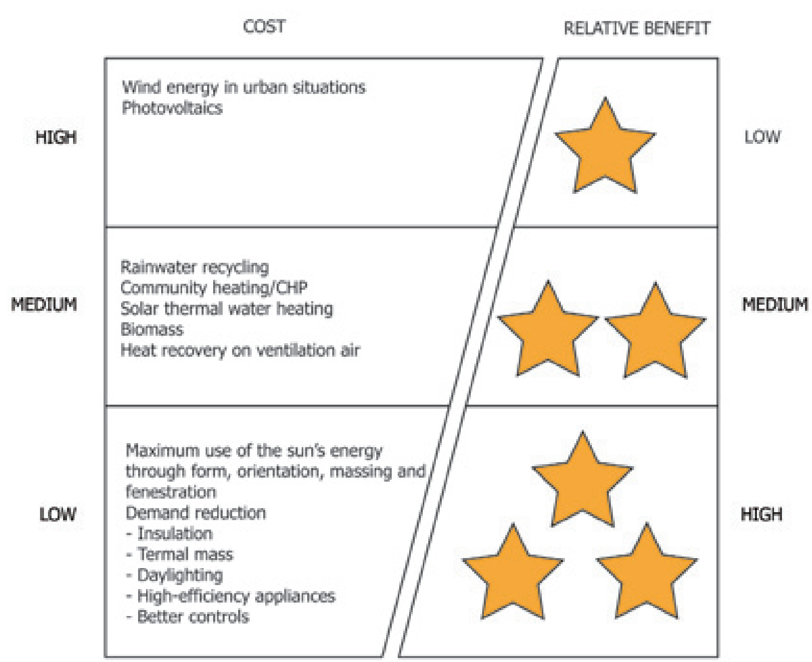

Figure 3: Cost and relative benefit of carbon design strategies

[9] Strathcona County, 2006, p. 5.2
[10] Ibid, p. 8.6
[11] Lewis, 2005, p. 25

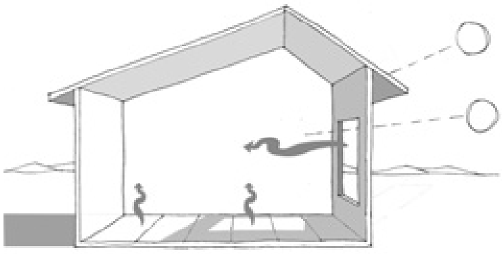

Figure 4: Illustration of how passive solar heating works

Optimize solar design

The most important thing from a site design perspective that can be done to reduce the carbon footprint is to plan street networks to create building sites that optimize opportunities for passive solar design. Working with the sun to help passively heat and cool buildings is something that has been understood since ancient Greece, when whole cities where planned to capitalize on solar access. Proper site orientation and passive design strategies not only offset heating and cooling costs, but they enable daylighting and active solar strategies such as photovoltaics and solar hot water heating. Through proper passive design, it is possible to offset up to 25 per cent of a building's heating costs.

Design Measures

Align street network to the cardinal points, which will enable buildings to be oriented with their long axis facing due south. To facilitate passive design, buildings should have a thermally efficient building envelope with high performance windows, an air vapour barrier, and adequate insulation. Buildings should be designed with windows along their southern façade, and minimize windows to the northern and western exposure. A ratio of roughly 8% window to floor area is needed to facilitate passive solar heating. To facilitate daylight harvesting, buildings should be designed with a narrow floorplate. Materials with a high thermal mass, such as stone floors, brick, concrete, and double layers of gypsum walls, will retain solar energy and reradiate that heat back into the space when the sun is gone. Generous roof overhangs and strategic placement of deciduous vegetation can help to eliminate unwanted solar gain in the summer, while allowing the sun's rays to penetrate into the house in the winter when needed. Exterior light shelves and building shading will help to bounce daylight into interior spaces while mitigating the potential for glare.

Optimize wind access for natural ventilation

With proper site design and building form, it is possible to offset the need for mechanical ventilation by harnessing the prevailing winds. This technique, known as natural or passive ventilation, reduces heating and cooling loads and maximizes fresh air intake resulting in a healthier indoor environment.

Design Measures

Wind creates high pressure on upwind facades and low pressure on downwind facades. This pressure differential drives air flows from areas of high pressure to areas of low pressure. To create the greatest pressure difference between the windward and leeward faces, buildings should be orientated with their long facade and most openings perpendicular to the prevailing winds. In the study area, the prevailing summer winds are from the west, so proper site orientation for natural ventilation would have the long axis facing north-south. As the optimal building orientation for natural ventilation conflicts with the optimal orientation for passive solar design, the design team will have to assess all tradeoffs in order to choose the most appropriate solution.

Construct buildings with thermally efficient envelopes
Reduce the energy demand of new buildings by designing thermally tight building envelopes. New residential units should be constructed to R-2000 energy standards or the EnerGuide for Homes rating of 80 or more. Commercial buildings should be designed to conform to Natural Resource Canada's Commercial Building Incentive Program compliance targets which stipulate that buildings should be designed to be 25% more efficient than a reference building designed to the Model National Energy Code for Buildings (MNECB).

Design Measures
Strategies to achieve this include the use of air vapour barriers, high performance windows, and higher insulation levels for walls, roofs, and floors.

Include water conservation strategies
Over 20% of residential energy consumption is used to heat water.[12] Implementing design strategies that reduce water consumption will lead to a corresponding reduction in energy use.

Design Measures
To achieve this goal, low flow faucets, showerheads, and water conservation appliances such as dishwashers and clothes washers should be utilized. Advanced technologies such as greywater heat recovery systems that extract waste heat from waste water and use that energy to preheat cold water should also be considered.

3.2 What technologies are appropriate for EHUV?

Renewable Energy Systems
The second draft of Strathcona County Municipal Development Plan explicitly supports the use of renewable energy systems through policy statements such as: "Reduce dependence upon fossil fuels by promoting utility facilities that employ renewable energy sources (eg. district energy or geothermal systems)[13]" and "Promote alternative utilities such as innovative heating and energy systems (eg. ground source heating).[14]"

Renewable energy, such as photovolatics, creates power without contributing to global climate change, poor air quality, or resource depletion.

Photovoltaics & Solar Water Heating
Photovoltaics convert sunlight to electricity. In northern climates, these systems work best in the summer when the sun is higher in the sky, but power is still generated during the winter months. Photovoltaics are a feasible technology for the Edmonton area and the Edmonton based firm Eti Solar energy technology inc. has been installing photovoltaics throughout the area. One of their retrofit projects includes the 1.65 kW array on the Strathearn House in Edmonton. The installed costs of photovoltaics are approximately $10 per watt of capacity. Using that value, the 1.65 kW array at the Strathearn House was budgeted at $16,500.

Next to space heating, the second largest use of energy within residential units is hot water heating. Through solar hot water heating, it is possible to reduce energy consumption associated with hot water heating by 50-75%.

The cost associated with photovoltaics can be reduced by replacing building components

[12] Natural Resources Canada, Office of Energy Research and Development, 2006, p. 24.
[13] Strathcona County, 2006, p. 16.2
[14] Ibid, p. 16.1.

Figure 5: Strathearn House, a grid tied array, installed in November 2005, has been working well and in August 2006 the electricity bill for the house was $2.

Figure 6: An active solar hot water system at the City of White Rock's Green Operations Building serves as the primary source of heat for the building.

Figure 7: A SolarWall system installed at an apartment building in Calgary

such as shingles, roof overhangs, and windows with photovoltaics. This strategy, known as building integrated photovoltaics (BIPV) lowers costs by reducing the requirement for the building components the PV is replacing.

Instead of a full installation of a solar water heater or a photovoltaic array, it is possible to pre-wire the buildings during construction to facilitate their installation down the line. This strategy was used at Koo's Corners in Vancouver, where residential units were pre-wired for solar hot water at a nominal cost of approximately $250 per unit. Making buildings solar ready passes the cost of the installation onto the resident, and is one way to differentiate the product in the marketplace.

Renewable energy options such as solar hot water and photovoltatics can be marketed as upgrade package for potential homeowners.

Design Measures

Proper site orientation is required in order that photovoltaic and solar water heating will work. Buildings should be oriented due south, roof areas should be free of penetrations (to eliminate shading of the panels and to create a larger surface area for arrays), and roofs should be designed with an angle as close to the latitude of the site as possible, which is 53 degrees in the Edmonton area.

Solar Air Heating and Ventilation - Transpired Solar Collector

Although residential versions are available, solar air heating and ventilation systems are best suited for industrial, commercial and institutional applications. Created by Conserval Engineering in Toronto, Solarwall is a solar air heating system generally known as a Transpired Solar Collector. Consisting of a metal cladding system attached to a south facing wall, a SolarWall system preheats ventilation air, reduces energy costs and associated $C0_2$ emissions. At night and on cloudy days, the air cavity in the SolarWall system provides an extra layer of insulation. When heating is not required, a damper is opened, allowing the solar collector to be bypassed while providing fresh air. In the summer, the wall also acts as a heat shade, preventing unwanted heat gains from the main wall. SolarWall costs approximately $14/sq. ft. SolarWall systems work particularly well in the presence of snow, where the high albedo can improve performance by 50-70%.[15]

Design Measures

The metal cladding that comprises the SolarWall should be mounted 6-12 inches from the exterior south-facing wall.

Ground Source Heat Pumps

Efficient, renewable space heating can be achieved through ground source heat pumps (GSHP). Ground source heat pumps

[15] SolarWall, no date.

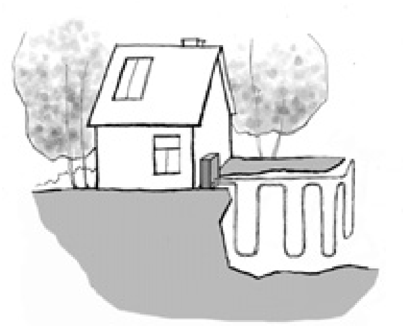

Figure 8: An illustration of a vertical, closed loop ground source heat pump.

are electrically powered systems that capitalize on the constant temperature of the earth to provide heating, cooling and hot water for buildings. GSHPs can be installed horizontally, vertically, or in a pond/lake. The type chosen depends on the land areas and bedrock conditions of the site. GSHPs are either closed or open loops. With close loop systems, water is circulated through pipes buried beneath the surface of the earth. In the winter, the water collects heat from the surrounding earth bringing that heat into the building. In the summer, the water collects waste heat from the building, depositing it into the ground. Although GSHP have a high initial capital cost, their payback period is relatively short. GSHP are a good solution for multi-residential, commercial, and institutional building typologies.

<u>Design Measures</u>
In situations when lot site is limited, a vertical closed-loop arrangement (see Figure 8) is the most appropriate GSHP system to use. Depending on soil conditions and the size of the system, 150 mm diameter pipes are inserted into holes bored to a depth of 18 to 60 m. The amount of piping required is dependent on the size of the system being installed. Typically, 23 to 31 m of piping is needed for every kW of heat pump capacity.[16]

Biomass
Biomass is an umbrella term that refers to organic matter such as plants, trees, agriculture waste (i.e. corn stalks and wheat straw), organic waste from municipalities, wood waste (i.e. sawdust, timber slash and mill waste), animal waste and even garbage. Biomass can be converted into energy using several methods: direct combustion, anaerobic digestion, co-firing, pyrolysis, and gasification. Biomass can also refer to biofuel such as ethanol and biodiesel. In Canada, biomass supplies 5.9% of the primary energy demand.[17]

Biomass is renewable energy source. It is considered a greenhouse gas neutral energy source since the only carbon dioxide released to the atmosphere when it is converted into energy is the carbon dioxide sequestered growing.

Biomass can be easily incorporated into a district energy system or a combined heat and power system, or can be used as a fuel in engines.

Alberta has large resources of biomass, both forest and agricultural resources that should be looked at as alternative fuel sources.

Direct Combustion refers to burning of biomass directly to produce energy in the form of heat or electricity. This is the most direct method of producing energy from biomass.

Anaerobic Digestion is the process by which organic matter is broken down by bacteria in anoxic conditions. The results of this process is that waste is converted to a gas, primarily methane and carbon dioxide and is known as biogas. This gas can be

[16] Natural Resources Canada, 2005.
[17] Pollution Probe, 2003, p. 42.

captured and used in an electrical generating plant.[18] At the Clover Bar Landfill Site just east of Edmonton, methane is captured for electricity generation. Each year this plant produces 41,300,000 kW-hr of energy or enough for approximately 3,600 homes.[19]

Co-firing is introduction of biomass into coal-fired electricity plants. This is a useful process to reduce the use of coal.

Pyrolysis is a thermo-chemical process that converts solid biomass into a liquid, hydrocarbon rich fuel. This is achieved by heating biomass in an oxygen-free tank, then quickly cooling it into an oil-like liquid. The advantage of pyrolysis is that it produces a renewable liquid fuel that can be easily stored, transported or burned. One form of pyrolysis is gasification. *Gasification* uses more air than pyrolysis creating a gas that is a mixture of carbon monoxide, hydrogen, methane, carbon dioxide, and nitrogen. This gas, known as producer gas, can be used to produce electricity in gas turbines, or burned to produce steam.[20]

Ethanol is a fuel source created by fermenting corn, grains, potatoes, sugar beets, or sugar cane. Ethanol is used as an additive in gasoline in a blend of ten percent ethanol to 90 percent gasoline. More than 130 million litres of grain-based fuel ethanol is produced each year in Canada.[21]

Similarly, *Bio-diesel* is a fuel source made from renewable sources, such as vegetable oils from canola seeds, corn seeds, sunflower seeds or flax seeds. Bio-diesel is clean burning. It is produced extensively throughout Europe and the US, however bio-diesel is in the development stages in Canada.[22]

District Energy System

District energy systems use insulated pipes to deliver hot water from a central source to heat buildings. These systems are typically used on a neighbourhood scale and feature a centrally located energy centre that houses the boilers and equipment.

Figure 9: The City in the Park development within Sherwood Park includes a district energy system that serves the Strathcona County Hall, Festival Place, the Kinsmen Leisure Centre, and buildings constructed in Centre in the Park by Christenson Developments. Natural gas boilers are used to heat the water in the City in the Park district energy system.

There are many benefits of a district energy system. They are adaptable. Instead of replacing every individual furnace as new technology or fuel sources become available, it is only necessary to modify the central system. District energy systems are efficient. With district energy systems, it is possible to transfer heat loads between buildings that have a large cooling requirement (i.e. arenas) to buildings that have a large heating requirement (i.e. swimming pools). In this way, maximum utility is derived from the energy that is typically wasted.

<u>Design Measures</u>

Urban form is an essential factor in energy efficiency measures. Residential developments with densities over 30 dwellings per hectare (12 dwellings per acre) are suitable for similar energy distribution systems.[23] Energy transfer between buildings and occupancies as well

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[18] Ibid, p. 46.
[19] Environment Canada, 2003.
[20] Pollution Probe, 2003, p. 48.
[21] Ibid, p. 49.
[22] Ibid.
[23] Miller, 2006, p. 46.

as the internal efficiency of buildings, are highly dependent on compact development. This is because the resource use per unit for buildings and utilities increases rapidly as development spreads, and because local energy distribution systems are costly to install and difficult to insulate over long distances.

Figure 10: Greenwich Millennium Village uses a combined heat and power system to provide central heating, hot water and electricity to its occupants. It was the first UK private housing development to utilize CHP

Combined Heat and Power

Combined Heat and Power (CHP) or Cogeneration is an energy conversion process in which more than one form of usable energy is derived from one fuel source. For example, electricity and heat is produced by the combustion of natural gas or biofuel. Combined Heat and Power facilities are more efficient than electricity generation or heat only production systems as they capitalize on waste heat generated through the electricity production process. Benefits include a 30-40% fuel savings, reductions in carbon dioxide emissions, and reduced energy prices.[24]

CHP can be used in conjunction with a distributed energy system, or used to provide heat and electricity for industrial processes. They can utilize a diversity of fuel sources, including biomass, fossil fuels, geothermal or solar energy.

Design Measures

To assist in choosing the most appropriate CHP system, RETScreen International has developed software that can be downloaded for free off its website.

Specify energy efficient infrastructure

To reduce energy consumption from public infrastructure such as street lights and traffic lights, energy efficient models should be specified.

Design Measures

Street lighting should avoid light trespass by using energy efficient light standards that employ downlighting and LED lights an energy efficient solution for traffic lights.

Include energy meters

Studies have shown that if energy meters are placed within an obvious location within the home (i.e. the front hallway), that homeowners will modify their behaviour to reduce the amount of energy that they consume. Energy meters inform the occupant about the direct effect that their activities have on the energy consumption.

Include programmable thermostats

Programmable thermostats enable homeowners to automatically adjust temperature settings within their home, which helps to save energy at night or when they are away. They contain no mercury, are more accurate than conventional thermostats, and improve comfort.[25]

4.0 What policies and/or programs will add value?

Introduce Policy to Adopt a Green Building Rating System

The second draft of the Municipal Development Plan mentions that

[24] Environment Canada, 2004.
[25] Energy Star, no date.

institutional and community facilities should include "Lifecycle costing perspective; that utilize regenerative energy heating and cooling sources which are alternatives to fossil fuels; and are designed to meet green building design standards such as LEED (Leadership in Energy and Environmental Design), wherever possible.[26]"

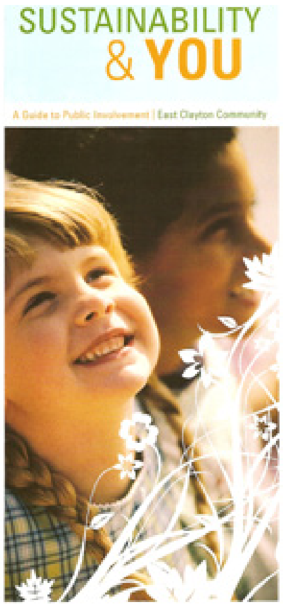

Figure 11: "Sustainability & You" pamphlet distributed to educate residents of East Clayton about the natural stormwater management practices used in the community

Strathcona County should consider taking that statement one step further by instituting a Sustainable Building Policy. One suggestion is to legislate that all new municipal facilities must meet a LEED Canada Gold Certification. The City of Vancouver[27] and Public Works and Government Services[28] both require new buildings to achieve a LEED Gold Certification, whereas the Government of Alberta[29] and the City of Calgary both have policies in place that stipulate that new buildings must meet a LEED Silver certification.

Purchase Green Power Certificates for Shared Infrastructure

Alberta is a Canadian leader in wind energy production with an installed capacity of 384.15 MW[30]. To support this industry, and reduce the carbon footprint of municipal operations, Strathcona County can purchase green energy certificates to cover the energy cost of shared infrastructure and community facilities.

Homeowner Energy Conservation Education Campaign

To ensure that homeowners know not only how to use their energy efficient appliances, but also how to optimize their behaviour to reduce their energy consumption, Strathcona County should embark on a homeowner education campaign in partnership with the developers.

Carbon Neutral Policies

Strathcona County can adopt a policy to set targets towards achieving carbon neutrality. This was involve benchmarking carbon dioxide emissions throughout the County and enacting strategies and education campaigns to lower carbon emissions. Alternatively, the municipality's carbon emissions can be offset through a planting program, or by purchasing carbon offset certificates from organizations who invest in renewable energy. Two cities in the UK who have embarked on this ambitious course, and can serve as an example, are Ashton Hayes and Newcastle.

5.0 What other resources are available?

Foundation Research Bulletins:
#1 Land, for more on reducing carbon footprint through building layout and design.
#5 Transportation, for more on reducing greenhouse gasses.
#6 Food, for more on relocalizing food production.
#7 Materials, for information on embodied energy of building components.

Ashton Hayes Going Carbon Neutral Project
www.goingcarbonneutral.co.uk

Canadian Green Building Council
www.cagbc.org

Canadian Renewable Energy Network (CanREN)

[26] Strathcona County, 2006, p. 11.1
[27] City of Vancouver, 2004.
[28] Public Works and Government Services, 2006.
[29] Government of Alberta, 2006.
[30] Canadian Wind Energy Association, 2006.

www.canren.gc.ca/renew_ene/index.asp

ENMAX Renewable Energy Solutions
Offers renewable energy produced from wind to Alberta residents and businesses.
www.enmax.com/Energy/Whats+New/Renewable+Energy+Solutions.htm

R-2000
www.r2000.chba.ca

RETScreen International
The RETScreen International Clean Energy Project Analysis Software is a decision support tool developed to evaluate the energy production and savings, life-cycle costs, emission reductions, financial viability and risk for various types of energy efficient and renewable energy technologies (RETs). www.retscreen.net

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Figure 1: Natural Resources Canada. (2005).
Figure 2: Natural Resources Canada. (2005).
Figure 3: Lewis, S. (2005). *Front to back: A design agenda for urban housing.* Oxford: Elsevier. p. 25.
Figure 4: Design Centre for Sustainability.
Figure 5: Eti Solar Energy Technology Inc.
Figure 6: Design Centre for Sustainability.
Figure 7: SolarWall.
Figure 8: Design Centre for Sustainability.
Figure 9: Strathcona County. http://webpub3.strathcona.ab.ca/Strathcona/Departments/Planning+and+Development+Services/Centre+in+the+Park/Community+Energy+Centre+photos.htm
Figure 10: Countryside Properties. http://www.countryside-properties.com/homes/new-homes/local-area/london/greenwich/parkside.aspx
Figure 11: Surrey Parks Recreation and Culture.

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