Smart Growth on the Ground

FOUNDATION RESEARCH BULLETIN: Squamish

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ENERGY MANAGEMENT IN SQUAMISH

1.0 Introduction

This technical bulletin examines the energy situation within the District of Squamish. An overview of current energy supplies, the potential for renewable energy sources and a breakdown in energy use within Squamish contextualizes the need to incorporate demand side management measures where they can have the most impact – within buildings. Opportunities to reduce energy use within residential and commercial buildings are highlighted by increasing order of effectiveness and design strategies that can ease the transition to anticipated new technologies – such as fuel cells and photovoltaics – are discussed. Opportunities for incorporating distributed energy networks are identified. In this context, methods to conserve energy and prepare for new technology on a block and district scale are also explored.

Energy Supply in Squamish

BC Hydro's total electrical generation capacity is 13,900 MW, with 94% of that power derived from hydroelectric sources. However, BC Hydro is near its maximum capacity and is now becoming aggressive about conservation while looking for new energy supplies. Although renewable energy will be developed, many of these new sources are likely to be thermal (gas fired generation) or large hydro dams – both of which carry high environmental impacts.

The majority of natural gas used in Squamish is extracted from Northeastern BC or Alberta and piped to the site. Terasen Gas is the main natural gas supplier in Squamish, with the average customer consuming 80 GJ/year.[1] Prices are subject to market pressures and have doubled (from 21.8 ¢/m^3 to 44.5 ¢/m^3) between 1997 and 2002.[2] Gas price instability has been driving more consumers toward electric heating, which aggravates existing regional supply problems. High gas prices and instability are likely to be new facts of life for the future.

2005 Local Electricity Sources:
Capacity (MW) by generating stations in the Squamish area:

- Cheekamus – 140 Cheakamus (dam hydro)
- Mamquam – 50 (run of the river hydro)
- Brandywine Creek – 7.6 (run of the river hydro)
- Furry Creek – 10.5 (run of the river hydro)
- *Ashlu Creek – 42 ('green' hydro, online by 9/2006)*
- Total – 250.1 MW

Squamish Region generating capacity:

- 1998 annual domestic energy use per capita : 42 GJ
- 2016 potential energy demand: (42 x 22,900) = 961,800 GJ
- 2031 potential energy demand: (42 X 33,100) = 1,390,200 GJ

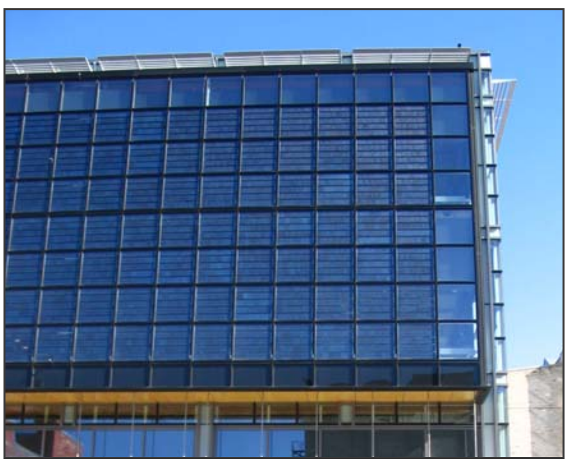
The Potential for Green Energy Sources in Squamish

With an array of green energy sources potentially available for development, Squamish is well positioned to become a centre for alternative energy solutions in British Columbia. Already local governments are investigating renewable energy opportunities through Request for Proposals[3] and broad policy statements such as:

"The Squamish-Lillooet Regional District endorses a goal of regional sustainability and supports the development of green energy projects in the region when those facilities:

- *Have been properly evaluated and are shown to be technically sound, environmentally sensitive and socially responsible;*
- *Are located, designed, constructed and operated in a manner that is consistent with the overall vision for the region and do not negatively impact on its primary economic activities (e.g. tourism in the Sea to Sky corridor);*
- *Can be connected into the existing transmission and distribution infrastructure with minimal impact and do not require the development of any new major transmission corridors; and*
- *Provide tangible community benefits comparable to projects constructed since 2001"*[4]

Future energy production will not rest solely with one technology. Instead it will be achieved through a complement of energy sources. A selection of renewable energy sources that show potential in Squamish are discussed below.



Figures 1 & 2: The 12.8 kW Building Integrated Photovoltaic array incorporated into the curtain glazing of Red River College's Princess Street Campus (The photo on the right shows this system from the inside).

Photovoltaic

Within Howe Sound, solar potential is limited during the winter months, however, incorporating the basic elements of passive solar design, including careful orientation and choice of insulation levels are always worthwhile. Photovoltaic electricity (PV) costs are now around \$0.30 - \$0.80/kWh, or 5 to 13 times the cost of Hydro in 2004 – making BIPV unfeasible as a source of green power from a utility standpoint. Replacing various building materials with photovoltatics (also know as Building Integrated Photovoltaics or BIPV) offsets some of the costs associated with this technology. Photovoltaic electricity (PV) is an emerging technology that will someday become cost competitive, however the low costs of electricity in BC, and the lack of financial government subsidies currently prevents the wide scale application of this technology. That being said, BIPV can be considered an effective energy and cost saving measure for building owners.

The total potential generating capacity from BIPV in BC is estimated at 280 MW for the residential buildings (detached or semi-detached homes), and 160 MW for commercial buildings. However, given the unfavourable economics, uptake is assumed at 2.5%, resulting in a potential generating capacity of 7MW and 4 MW for residential and commercial sectors.[5]

Figure 3: A small-scale wind turbine at Sir Sanford Fleming College in Lindsay, Ontario

Wind Energy

Squamish has a reputation for being a very windy place. In fact, the very name "Squamish" is a First Nations term that roughly translates into "Mother of the Great Wind." The District of Squamish has recently undertaken a three phased approach to examine the feasibility of developing wind power at the local level. These phases include: Pilot Project Strategy and Public Consultation, Wind Assessment and Analysis, and Project Development. Phase 1 was completed in April 2004, showing widespread community support for the initiative (85% of surveyed residents were in favour of wind power in Squamish).[6] The project is now in the second phase and the quality of the wind resources in Squamish are being explored in greater detail. This involves directly measuring wind using anemometers in several key locations, and then simulating wind patterns. To create accurate wind pattern simulations requires at least one year of data, therefore the completion of phase two is not anticipated until early 2006.

Currently wind projects can produce power at $0.04 to $0.055/kWh, and a financial incentive of $0.01/kWh is offered by the federal Wind Power Production Incentive (WPPI) for qualifying wind turbines. It is estimated that the potential for wind power production in British Columbia from small-scale turbine installations (turbines that range in size from 1kW to 50kW and are suitable for residential, small business or farm applications) is 25 GWh per year. [7]

For Small Scale Hydro Study:

Flow – mean annual flow
Power – estimated installed capacity
Cost – estimated total capital costs (including transmission lines)
Energy – annual generation using mean annual flow and capacity factor
Green Energy – annual generation considering fish flow factor
Green Energy Cost – average cost of power production

Small Scale Hydro

Small scale hydro projects include run-of-the-river hydro power facilities of up to 50MW in size. With these systems, the stream flow passing through the powerhouse is essentially the flow that naturally occurs in the stream. This implies that there is no (or minimal) storage reservoir, and flows downstream of the powerhouse are virtually identical to pre-development flows.

In a report of undeveloped micro-hydro opportunities in British Columbia, BC Hydro has identified four watercourses in Squamish that have power generating potential. These four watercourses, Cheekye River, Fries Creek, Monmouth Creek, and Stawamus Creek, have an estimated annual green energy generation of 52.4 GWh.[8]

Table 1: Selected Attributes of Potential Small Scale Hydro Sites in Squamish[8]

Stream Name	Flow (m^3/s)	Power (kW)	Cost ($1000)	Energy (GWh)	Green Energy (GWh)	Cost $/kWh
Cheekye River	1.7	1,600	4,279	7.7	6.9	0.058
Fries Creek	1.6	2,300	4,017	11.1	10.0	0.038
Monmouth Creek	0.59	2,200	4,010	10.6	9.5	0.039
Stawamus Creek	2.8	6,000	11,029	28.9	26.0	0.040
Total		**12,100**		**58.3**	**52.4**	

Figure 4: Solar tubes at the City of White Rock's Green Operations Building

Figure 5: 2211 West 4th Street (the Capers Building) in Vancouver that is heated by a ground source heat pump (*Source:* SmartGrowth BC)

Figure 6: A 214 m^2 (2300 ft^2) SolarWall installed on Centennial School's gym in Coquitlam provides fresh air at a rate of 6,000 CFM (*Source:* SolarWall)

Solar Water Heating

Solar water heating (or solar thermal) is the capture of solar energy to heat water. Solar water heating systems are safe, reliable, and emission-free. Some pumping energy is often required, but it is marginal compared to the solar energy generated. This technology is efficient – and not just in warm climates. In Vancouver, it is estimated that hot water energy savings of up to 43% is possible through the installation of a solar domestic hot water system (DHW). DHW can be used to preheat domestic hot water or integrated with a radiant floor heating system to heat the house. DHWs typically cost $800-$1,400 per person installed.[9]

Solar hot water heating provides the base heating for the City of White Rock's Green Operations Building. Along with natural ventilation, solar heating provides an annual cost savings of $4,785 when compared with a conventional building.[10]

Ground-source heat pump (GSHP)

A ground-source heat pump provides heating and cooling for a building by taking advantage of the earth's relatively consistent temperature. This system consists of pipes that are buried beneath the earth's surface and connected to the home. Water or antifreeze solution is circulated through these pipes, collecting heat from the earth in the winter which is then 'pumped' to the building. In the summer, this process is reversed as heat is gathered from the building to be released in the ground. GSHP systems are a proven, efficient technology that can replace a forced air furnace in a dwelling, thereby offsetting energy use and reducing CO2 emissions. Installation for these systems can be costly, due to the necessarily to bore deep holes into the earth. Given the high capital costs associated with GSHP, these systems are well suited to a multi dwelling units where the capital cost is widely distributed.

Completed in 1993, 2211 West Fourth Street in Vancouver, better known as "The Capers Building", was the first commercial application of a ground source heat pump system in Western Canada. The heat pump provides free heating and cooling for commercial and retail spaces, while heating the water for the entire building.[11]

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 C02 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.[12]

Geothermal
Geothermal power generation produces electricity by using a high-temperature geothermal resource (i.e. steam or hot water reservoirs with temperatures higher than 170 C) to drive steam driven turbines. These types of geothermal resources are generally limited to recent volcanic terrains, such as those found near tectonic plate boundaries (west coast of North America, Iceland, New Zealand, Japan).

Sixteen prospective geothermal sites were identified in British Columbia for potential power production based on their geologic setting (volcanism, faults), evidence of repeated volcanism and the occurrence of hot springs and other geothermal manifestations. Six of these sixteen sites offer the greatest potential for commercial development based on currently available data on their resource characteristics and their location relative to the power grid and market. The fourth most promising site is Mount Cayley in Squamish, which was identified as promising but with severe terrain, offering a production potential of 100 MW.[13]

Biomass
Biomass is organic material derived from plants. Created through photosynthesis, biomass contains chemical energy that can be extracted through combustion to produce energy that can be used as heat or power. The most abundant source of biomass fuel in British Columbia is wood residue, a by-product from sawmills and other forestry operations. Other major sources of biomass fuel include municipal solid waste, demolition and land clearing waste, and agricultural waste – most of which is disposed of in landfills. Anaerobic decomposition of organic material in landfills produces another source of biomass fuel, landfill gas.

A report by BC Hydro estimated the energy potential of biomass projects for BC at approximately 240 MW (1935 GWh per year) with capacity factors between 65% and 100%, and production costs between 4 and 10 cents per kWh.[14] Biomass can be part of a local solution for energy production by converting local "waste" resources from agricultural and forestry operations into useable energy.

Hydrogen Fuel Cells
Although hydrogen fuel cells are still under development, they represent a promising technology that will play a prominent role in the future. Fuel cells, which are devices that produce electricity through chemical reactions, are cleaner and more efficient than power plants and internal combustion engines. The hydrogen fuel used in fuel cells is derived from water and as long as it is produced using a renewable energy source such as photovoltaics, it is considered renewable.

BC is the epicenter for hydrogen and fuel cell development in Canada, boasting 65% of Canadian hydrogen and fuel cell businesses. This hydrogen cluster also includes two world class research facilities, the NRC Institute for Fuel Cell Innovation at UBC and the Institute for Integrated Energy Systems at the University of Victoria.[15]

With the proposed 'Hydrogen Highway' (H_2) that will link the Vancouver Airport to Whistler for the 2010 Olympics, in a very literal sense Squamish is well positioned to take advantage of the coming hydrogen economy. This H_2 project is the first demonstration project of its kind in Canada and will consists of seven nodes, complete with hydrogen fueling infrastructure as well as transportation and stationary applications.[16]

2.0 Demand Side Management

Energy Use in Squamish

In BC, the building sector accounts for 25% of total energy use, comprised of 15% residential and 10% commercial. Transportation accounts for 33% of all energy use and business and industry accounts for 42%. *Of the transportation factor, 24% of that energy is used in residential commuting*. Therefore, building use and commuting together account for 33% of total energy use. [17]

With one-third of the energy used within British Columbia consumed by buildings or associated transportation, improving the energy efficiency of building infrastructure and building complete communities that reduce the need for travel will help Squamish achieve its energy targets.

An Approach to Energy Conservation in Buildings

Generally the most effective priorities for energy conservation in buildings are:

- Energy demand reduction by building design
- Advanced technology and equipment
- Energy recovery and recycling

These priorities will shift and different strategies emerge depending on the building type and site. They will also vary between the building scale or block and district scale.

In the mild climate of Howe Sound it is relatively easy to create buildings that consume less energy through the use of natural ventilation, effective insulation and daylighting. Synergistic energy opportunities can be uncovered by looking at buildings, blocks and districts as integrated systems (for example, energy can be captured from commercial buildings and used in residential).

Furthermore, there are design approaches and present technology choices that will make buildings and district utilities more adaptable to future technologies. These “future ready” solutions ease the transition to solar devices, fuel cells and co-generation (combined heat and power).

3.0 Residential Demand Side Management

Energy Use Profiles

Even in the mild climate of Squamish, space heating and ventilation account for the largest energy use in homes. Water heating is the second largest user of energy with appliances falling third, dominated by the refrigerator. Lighting and electronics make up a relatively small energy use factor in homes but this trend has been growing steadily as consumers acquire more electronic devices and space and water heating equipment has become more efficient. The second residential chart shows an R-2000 standard home designed to use about 30% less energy than the code home. In this home the space heating and lighting are smaller factors due to better insulation and more efficient equipment, but this shift makes water heating and refrigeration & appliances more prominent. These are more difficult to improve because they are highly dependent on consumer behaviour and preferences.

One third of space heating in older homes can be lost through windows. By upgrading old single glazed windows to modern sealed units, it is reasonable to reduce total energy use in the Lower Mainland by 20%.

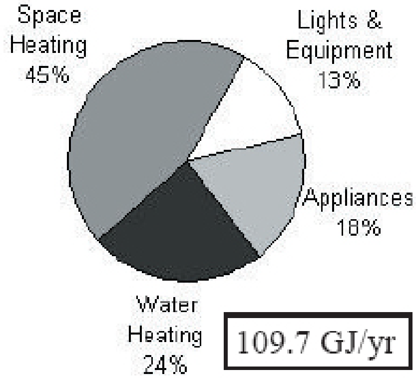


Figure 7: Code Residential Energy Use Profile[19]

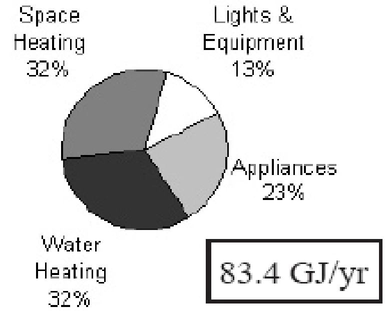


Figure 8: R-2000 Residential Energy Use Profile[20]

Table 2: Residential Building Scale Energy Strategies

← Increasing Priority

Increasing priority ↑

Strategy	Feature 1	Feature 2	Feature 3	Feature 4
Demand Reduction	Insulation	High perform. windows & draft sealing	Solar design & orientation	Hot water conservation (1)
Advanced Technology & Equipment	High efficiency heating and hot water systems	Combined heating systems (2) & efficient lighting and motors	Solar water heat devices	Solar electrical devices (PV's)
Energy Recovery	Energy recovery ventilation	Wastewater heat recovery		

1. Though hot water is a major component of residential energy use, it is highly dependent on occupant habits and is therefore less amenable to conservation through design and technology improvements.
2. Combined systems are very compact units that use the same high efficiency components to produce both space heat and hot water. They may also provide ventilation and heat recovery.

"Solar ready" pre-plumbing was installed in all dwelling units at Koo's Corners, a multi-family residential green townhouse development in Strathcona. The pre-plumbing, which cost $200/unit, enables homeowners to easily install a roof-mounted solar hot water heater at any time in the future.[18]

Residential New Technology Readiness

Residential buildings that use low temperature heating systems – such as radiant heated floors – are highly adaptable to any type of heating supply. These systems integrate well with Ground Source Heat Pumps (GSHPs) and can be easily adapted for other nascent technologies such as stationary fuel cells and bio-fuel systems.

Solar system readiness can be provided by allocating south facing wall areas and roofs for future solar devices, including the pre-installation of pipes and wiring conduits. An approximate allocation is:

- An opaque, unobstructed wall area oriented within 45 deg. of south, with an area equal to at least 7% of the dwelling floor area.
- A roof area oriented within 60 deg. of south, with an area of at least 10 m2 (110 sq.ft.)

4.0 Commercial Buildings

Energy Use Profiles

Commercial buildings use almost twice the energy per unit of area of residential. This is primarily due to the large lighting loads, pumps and fans, and computers. The large glass area of many commercial buildings can also lead to high heating and cooling loads. A C-2000

A small (1000 m2) C-2000 commercial building saves enough energy to operate more than nine R-2000 detached homes.

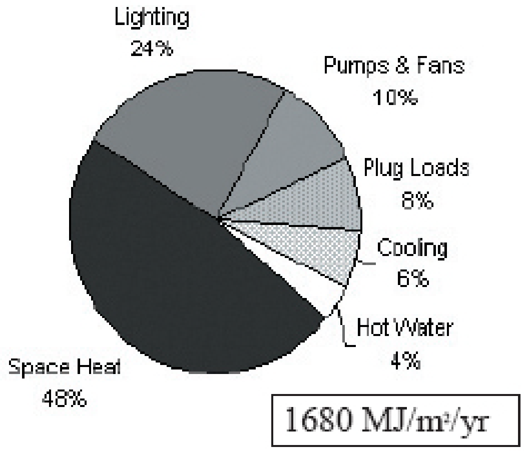


Figure 9: Code Commercial Energy Use Profile[21]

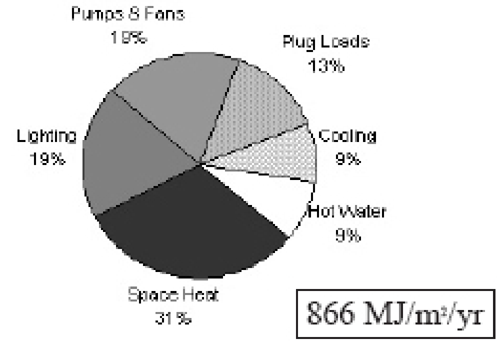


Figure 10: C-2000 Commercial Energy Use Profile[22]

Solar heat rejection strategies and efficient lighting have reduced energy costs by 42% at Crestwood Corporate Centre Building 2 in Richmond, BC.

commercial building is designed to use 50% less energy than a code building. This is primarily achieved by better solar control, insulating glass, more efficient lighting, energy recovery ventilation and efficient motors. Natural ventilation and cooling may also be an effective energy measure in Squamish. Reducing solar gain and improving heating and cooling equipment makes the energy use by computers, office equipment, fans, elevators and the like much more prominent. These plug load energy uses are more difficult to improve because they require larger capital investment as well as changes to workplace behaviour and expectations.

Energy Reduction Strategies for Commercial Buildings

Richmond City Hall saves 2,850 GJ of energy a year by using efficient lighting and HVAC systems, resulting in cost savings of $32,700 a year.

Table 3: Commercial Building Scale Energy Strategies ← Increasing Priority

Increasing Priority →

Strategy	Feature 1	Feature 2	Feature 3	Feature 4
Demand Reduction	Solar heat rejection by shading and glass selection	Daylight utilization and advanced lighting control (1)	Natural cooling and ventilation	Insulation (2)
Advanced Technology & Equipment	High efficiency lighting and office equipment (1)	High efficiency cooling equipment	High efficiency motors, e.g. pumps, fans, elevators.	Building-integrated renewable energy systems
Energy Recovery	Heat collection and transfer from chillers (3)	Energy recovery ventilation (4)	Wastewater heat recovery (5)	

1). Improved lighting system and office equipment efficiency reduces both cooling demand and direct electricity usage.
2). Though thermal insulation is generally not a high priority for commercial buildings in a mild climate, reflective (radiant type) insulation can help reduce cooling demand, especially for small buildings.
3). Cooling of building areas is a major energy use in large office buildings. Food and beverage retail services use product coolers. Heat rejected from both can be collected and distributed as hot water.
4). Pools and spas have a large capacity to benefit from energy recovery exhaust systems since ventilation is necessary for humidity control. Office buildings can reduce cooling loads by using energy transfer between supply and exhaust air streams.
5). Most commercial-office buildings use very little hot water. However specialized uses such as fitness and recreation centres and laundries have high usage.

Natural ventilation and daylighting strategies used at Terasen Operations Centre saves $150,000/yr in operating energy.

Commercial New Technology Readiness
Medium to large scale commercial buildings have the capability to use Combined Heat and Power (CHP) systems, also called co-generation. These systems use gas turbines (and may use fuel cells in future) to produce electricity and heat. Since heating is usually a minor demand in this occupancy type, it may be best transferred to an adjacent user. However with the current high cost of gas and low cost of electricity, they are not yet economical. Ground Source Heat Pumps, are also highly effective cooling systems applicable to commercial uses. If heat is exchanged between cooling uses and heating uses in the building or adjacent buildings, the size and cost of the earth collection system can be reduced. To facilitate the future uptake of BIPV, commercial roof and wall areas can be allocated now for future solar installations, and service conduits can be pre-wired.

5.0 Opportunities for Distributed Energy (DE)

One of the emerging trends in the energy industry is a shift from large centralized power plants to smaller, often higher efficiency plants located at the point of consumption. These smaller energy resources are called “distributed generation” sources because they are distributed throughout the grid.

Market forces are beginning to favour the smaller scale, fuel flexible energy systems that distributed energy permits – developed and used close to their point of use. Thus, the future of energy production will probably involve local community and individual household generation.

Distributed energy can be grid connected and operated in parallel to the system, or operated independently. DG encompasses a wide range of technologies, including turbines, reciprocating engines, renewables and storage systems, which are available today, as well as advanced or emerging technologies, like fuel cells, microturbines and other systems now on the drawing board.

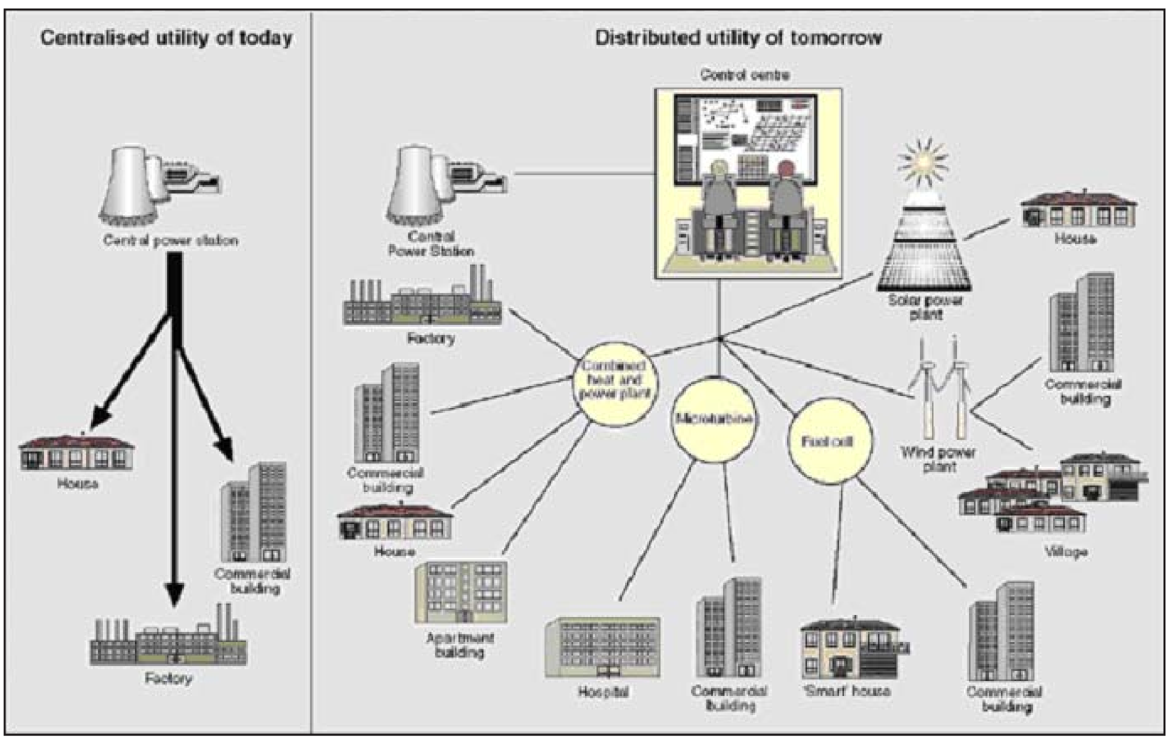


Figure 11: The shift from centralised to distributed energy systems. (*Source:* CSIRO Energy Technology.)

The benefits of distributed energy can be considered from a range of perspectives. From an environmental perspective, distributed energy generally replaces grid power, and electricity from the grid affects the environment in a variety of different ways. At each stage of the process - from the generation of electricity to the high voltage long-distance transmission of that electricity to the final low voltage distribution to customers-there are a number of real or potential impacts.

Utilities increased the size of central plants throughout the 20th century seeking economies of scale to lower installed cost per kW of capacity and often achieving small increases in plant efficiency. The goal was to produce electricity over the life of the plant at less cost. However, as electric use expanded, we saw the number of plants, and their size, greatly increased. The end result has been a major increase in total fuel consumed and emissions.

From an economic perspective, a decision to employ DE technologies would have to incorporate other economic factors such as the value of reliability, which is an extremely important factor to which high cost value is often applied, and power quality, or include non-economic factors like the preference for renewable or environmentally benign power. Using current technology, the cost to produce a kWh of electricity for the average small user, such as the residential and small business customer, will be higher than utility supplied power unless heat recovery is employed. Compared to the average small energy user, commercial and small industrial customers have a wider range of technologies from which to choose as well as lower fuel costs and somewhat lower electric rates. Thermal requirements allow the DE economics to improve with the capture of waste heat and resultant reduction in gas usage by reducing use of boilers or chillers on site. The availability of new technologies such as microturbines and fuel cells, which have a higher recoverable heat value for smaller scale systems than reciprocating engines, will expand the potential for combined heat and power. Reliability and power quality add greater potential value to DE resources for this market segment as well.

Large industrial customers have a wide array of available technologies with lower capital costs than those available for the smaller-scale customers. At the same time, the larger customer can often purchase fuel at prices close to those realized by electric utilities. Further, there are many more heat recovery applications. DE is easy to justify for these customers on a payback basis alone. For this reason, a significant DE market currently exists for large industrial customers.

DE Technologies

Each DE technology has its own environmental characteristics. The following charts highlight the environmental benefits while allowing comparison among technologies.

Table 4: Zero Emissions Technologies (Source: http://www.deforum.org/environmental.htm)

	Solar (PV)	Wind	Fuel Cells
Land Use	Minimal - can be placed on roofs, integrated into building designs.	Small "footprint," but needs space. Previous problems with harming or killing birds, but newer designs minimize harm. Some complain turbines diminish aesthetic appeal of landscape. Whir of rotors audible.	Usually contained in buildings or vehicles. Can be as small as a shoebox or can be "stacked" to much larger sizes.
Emissions	Zero emissions.No greenhouse gas effect.	Zero emissions.No greenhouse gas effect.	Zero emissions or no greenhouse gas effect while running on hydrogen (H2). Arrays that use natural gas for H2 conversion may release emissions.
Fuel Impacts	Fueled by the sun.100% renewable.	Fueled by wind.100% renewable.	If H2 comes from water, it is renewable. If H2 comes from a fossil fuel (natural gas, gasoline), it is not renewable.
Comparison to Grid Power	Superior emissions profile. Slightly better land use. Superior fuel impacts.	Superior emissions profile. Land use impact for both equally intrusive.Superior fuel impacts.	Superior emissions profile. Superior land use impact.Fuel impacts dependent on H2 conversion process.
Comments	Excellent environmental profile. Limited by sun exposure and costs.	Very good environmental profile. Limited by intermittent wind flows and location.	With H2, an excellent environmental profile. Conversion from fossil fuels lowers profile, but still superior to combustion technologies.

Table 5: Technologies for Gaining Greater Efficiencies
(Source: http://www.deforum.org/environmental.htm)

	Microturbines	Stirling Engines	Combustion Engines
Land Use	Minimal - can be placed on roofs, integrated into building designs.	Minimal - can be placed on roofs, integrated into building designs.	Small to Medium footprint - can be placed in basements, on roofs, or integrated into building designs.
Emissions	Zero SOx and low Nox emissions due to low firing temperatures. Moderate release of CO2.	Low SOx, Moderate Nox and CO2 emissions.	Moderate to high NOx emissions.
Fuel Impacts	Natural gas, non-renewable.	Natural gas, waste gases or spectrum of liquid fuels.	Liquid fuels (gasoline, diesel). Non-renewable.
Comparison to Grid Power	Emissions profile roughly equal to grid, unless using CHP or CC, where profile becomes much better. Less land use impact.Marginally better fuel impacts.	Emissions profile roughly equal to grid. Less land use impact.Equal fuel impacts.	Worse emissions profile. Less land use impact.Generally worse fuel impacts, except where utility is highly reliant on coal.
Comments	Good environmental profile. With CHP or CC, becomes excellent environmental profile.	Good environmental profile.	Bad environmental profile except for land use impacts.

Table 6: Innovative Configurations **(Source: http://www.deforum.org/environmental.htm)**

	Fuel Hybrids	CHP	Combined Storage
Land Use	Minimal - can be placed on roofs, integrated into building designs.	Small to medium footprint - can be placed on roofs, integrated into building designs, or placed in an adjacent facility.	Varies depending on the size of the system. Is one of the largest DE systems on a kW per square foot. Battery based systems can be very large. Flywheel systems are smaller.
Emissions	Very low NOX.	Very low NOx due to dry low NOx combustion systems. Natural gas use produces half the CO2 of the equivalent of coal per unit of fuel input.	By providing peak power, allows offsetting the use of old high emissions and inefficient peaking turbines.
Fuel Impacts	Most fuel combinations are possible.	Generally natural gas.	None.
Comparison to Grid Power	Very good emissions profile where high efficiencies are achieved. Land use varies.Fuel impacts dependent on fuel choices.	Superior emissions profile. Better fuel use impacts.	By providing peak power, assists in deferring the use of old high emissions and inefficient peaking turbines.
Comments	Potentially excellent environmental profile	Very good environmental profile.	Good environmental profile during operation. The battery system does require hazardous waste disposal procedures.

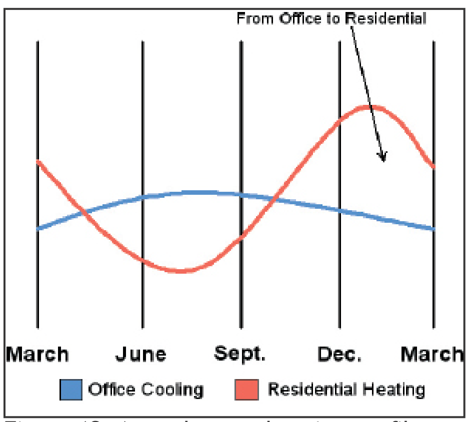


Figure 12: Annual space heating profiles for commercial and residential, showing opportunities for heat transfer

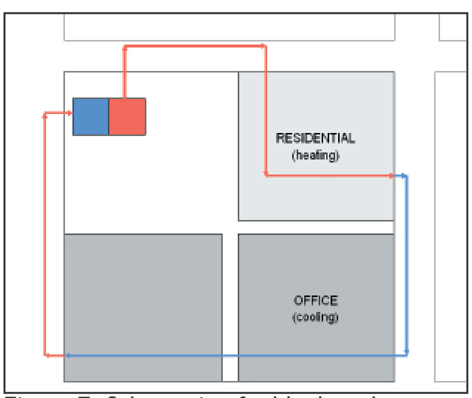


Figure 7: Schematic of a block scale energy exchange system that transfers heating and cooling between commercial and residential buildings.

Energy Opportunities at the Block and District Scale

Several possibilities for energy efficiencies, energy recovery and innovative technology exist at the block and district scale. These opportunities work in conjunction with the concept of distributed energy systems.

- Some occupancies, such as food service and commercial offices, produce constant heat rejection from cooling equipment. This heat can be used for seasonal space heat and hot water by adjacent residential uses.
- Local energy systems are possible at a particular scale. The capital cost and distribution costs must be rationalized against more centralized systems.
- Innovative systems such as ground source heat pumps and fuel cells have a high capital cost that makes them prohibitive for small buildings. However at a larger scale serving several buildings, the capital cost per unit drops substantially.

Urban form is an essential factor in energy efficiency measures. Energy transfer between buildings and occupancies as well 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. Furthermore, *compact development* and *complete community design* reduce commuter trips that account for one quarter of the energy used in buildings and related transportation.

Urban form is an essential factor in energy efficiency measures. Compact development is inherently more energy and resource efficient. It also makes district energy supply and exchange more feasible.

Three conventional detached homes use the same energy as five R-2000 townhouses

Table 3. Block and District Scale Energy Strategies ← Increasing Priority

Increasing priority ↑

Strategy	Feature 1	Feature 2	Feature 3
Demand Reduction	Compact development	Building form and landscape design for residential solar access and commercial shade	
Energy Recovery	Mixed use; adjacent commercial and residential uses	District hot water and chilled water loops (1)	
Advanced Technology & Equipment	High efficiency heat pump cooling	Central CHP designs	District renewable energy systems

1. These may combine heat pump technology with earth collection and storage systems and high-efficiency boilers to produce a complete energy system. Also CHP systems and district loops can be combined.

New Technology Readiness

Block and district scale systems require good access for future flexibility. Designing a "utility corridor" into the block, using a service tunnel system, or a shallow, linear "utility room" attached to buildings is an effective strategy. Generally the most flexible distribution methods are, again, low temperature hot and chilled water since they are adaptable to any kind of energy supply. In addition to heat pumps, both combustion equipment and fuel cells should be planned for, allowing for fuel choices including natural gas, liquefied gases, liquid bio-fuels (e.g. methanol and bio-diesel) and hydrogen.

6.0 Additional Resources & Funding Sources

BC Sustainable Energy Association
http://www.bcsea.org/sustainableenergy/

The C-2000 Program for Advanced Commercial Buildings
The Buidlings Group, Natural Resources Canada
http://www.buildingsgroup.nrcan.gc.ca/projects/c2000_e.html

Canadian Renewable Energy Network (CanREN)
Natural Resources Canada
http://www.canren.gc.ca/

EnerGuide
The Office of Energy Efficiency, Natural Resources Canada
http://oee.nrcan.gc.ca/energuide/home.cfm

Hydrogen Economy Portal
http://www.hydrogeneconomy.gc.ca/home_e.html

R-2000 Program
The Office of Energy Efficiency, Natural Resources Canada
http://www.oee.nrcan.gc.ca/r-2000/english/public/index.cfm?PrintView=N&Text=N

The Distributed Energy Forum
http://www.deforum.org/environmental.htm

Funding Sources:

Commercial Building Incentive Program
http://oee.nrcan.gc.ca/newbuildings/cbip.cfm

Industrial Building Incentive Program
http://oee.nrcan.gc.ca/newbuildings/ibip/ibip.cfm

Renewable Energy Deployment Initiative (REDI)
http://www2.nrcan.gc.ca/es/erb/erb/english/View.asp?x=455

Wind Power Production Incentive (WPPI)
http://www.canren.gc.ca/programs/index.asp?CaId=107&PgId=622

Notes

[1] http://www.terasengas.com/_AboutTerasenGas/Newsroom/SquamishRateIncrease.htm
[2] http://oee.nrcan.gc.ca/neud/dpa/tableshandbook2/res_00_9_e_1.cfm?text=N&printview=N
[3] District of Squamish. (January 23, 2004). *Request for Proposals For An Alternative Energy Project.*
[4] SLRD. (July, 2003). *Independent Power Project Development in the SLRD*
[5] www.bchydro.com/rx_files/ environment/environment3927.pdf
[6] Sea Breeze Power Corporation and Dillon Consulting. (April 7, 2004). *Draft Report: Phase One - Squamish Wind Energy Project.*
[7] www.bchydro.com/rx_files/ environment/environment3927.pdf
[8] BC Hydro and Power Authority. (March 2000). *Inventory of Undeveloped Opportunities at Potential Micro Hydro Sites in British Columbia.* (Prepared by Sigma Engineering Ltd.)
[9] http://www.bcsea.org/sustainableenergy/solarhotwater.asp
[10] City of White Rock. (N.D.) Leading by Example. http://www.city.whiterock.bc.ca/2005City-Operations/pdfscityoperations/leadingbyexample.pdf
[11] http://www.greenbuildingsbc.com/new_buildings/case_studies/2211_West.pdf
[12] http://www.bcsea.org/sustainableenergy/solarair.asp; www.solarwall.com
[13] www.bchydro.com/rx_files/ environment/environment3927.pdf
[14] www.bchydro.com/rx_files/ environment/environment3927.pdf
[15] http://www.bcsea.org/sustainableenergy/hydrogen.asp
[16] http://www.nrc-cnrc.gc.ca/highlights/0405hydrogen_e.html
[17] Environment Canada, Canada's National Greenhouse Gas Emissions 1990-1999, http://www.ec.gc.ca/press/2001/010711_b_e.htm
[18] http://www.cmhc-schl.gc.ca/en/imquaf/himu/upload/Koo-s-Corner.pdf
[19] Cooper, Ken, Life Cycle Assessment of House Assemblies. Natural Resources Canada, CANMET Buildings Group, 2004, Ottawa
[20] Natural Resources Canada & Canadian Home Builders Association, The R-2000 Technical Standard. http://oee.nrcan.gc.ca/r-2000/english/standard_tofc.cfm
[21] Natural Resources Canada, Commercial and Institutional Building Energy Use Survey (CIBEUS), 2000, Ottawa http://www.statcan.ca/english/sdds/2943.htm
[22] Natural Resources Canada, Commercial Building Incentive Program (CBIP) http://oee.nrcan.gc.ca/newbuildings/buildings/casestudies-etudesdecas/

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