District Energy Consultation Paper

Prepared for:
The District of Squamish

Prepared by:
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Compass Resource Management

Introduction

- The District of Squamish's Community Energy Action Plan includes a 5-10 year Master Action Plan for practically implementing and monitoring a series projects intended to reduce energy consumption and GHG emissions
- Several "catalyst" projects were identified. These projects are intended to change how buildings are connected to each other, and to relevant infrastructure systems. These catalyst projects will explore enabling policies and innovative institutional arrangements to achieve these ends.
- One of the proposed catalyst projects is the creation of a district energy system (DES) that evolves in parallel with the waterfront developments, and that begins by providing buildings with hot water from natural gas boilers, and evolves into electrical co-generation powered primarily by biomass.
- Compass Resource Management was commissioned to examine opportunities to develop a DES at the Waterfront Landing development, provide ToRs for a detailed feasibility study should there be cause for moving forward, and identify partners and funding sources for the feasibility study.
- This screening analysis summarizes major findings and recommendations. It includes an evaluation of the potential for district energy within the Waterfront Landing development, compares the district energy potential in Squamish with other systems and applications in B.C., describes promising technologies and scope (heating only vs. heating and cooling), and examines potential heat source technologies.
- Based on favourable results from the screening analysis, a draft Terms of Reference for a feasibility study is provided as a separate document
- A summary of the proposed Terms of Reference and potential partners/funders are identified in this report.

Background on District Energy

- District energy systems use alternative energy technologies to supply the space heating and domestic hot water needs of a neighbourhood via an underground network of pipes. Cooling needs can also be met depending on the magnitude of cooling loads and type of technology adopted.
- The in-building heat distribution systems are usually the responsibility of individual developers, and requires one of three general approaches at the discretion of the developer: 1) hydronic radiant floor heating; 2) fin type baseboard convectors / perimeter radiators, and 3) fan coils.
- Rationale for pursuing district energy:
  - Reduced costs – Centralization of heating offers possible cost savings through reduced equipment requirements (due to load diversification) [1] , economies of scale in equipment costs, savings in operating costs from more efficient equipment and optimized operations.
  - Improved quality of service – Hydronic heating (if used) is generally considered more comfortable than other forms of space heating and a utility can normally undertake more timely and regular maintenance of equipment than individual building owners.
  - Improved environmental performance – Economies of scale and other cost savings from centralization of heat sources can facilitate the use of more efficient technologies.
  - Reduced risk and increased flexibility – Distributed systems also put more risk on individual building owners, even if they do not own the actual equipment. Financial and operating risks can be pooled across a larger number of customers in a utility model; implementation of more efficient and alternative technologies can further reduce customer exposure to fluctuating fuel prices; hydronic heating systems are also more adaptable to new technologies over time. A centralized utility will also typically have a higher level of design and operating standards, and professional management. In addition, a centralized utility will have less overall (rotating) equipment, which reduces risks.

[1] Load diversification refers to the fact that the peak demand in different buildings will typically occur at slightly different times. As a result, the peak demand on the central system will typically be lower than the sum of the peak demands for individual buildings.

Potential Alternative Technologies

- **Ocean heat recovery** extracts heat energy from ocean water and "lifts" the temperature with the use of a heat pump.
- The **Geoexchange** concept involves extracting heat energy from heat available within the ground or in groundwater, either indirectly by a vertical closed loop heat exchange system (ground-source), or directly by pumping ground water to a heat pump (ground-water).
- **Sewer heat recovery** can take two forms: (1) diverting stable flows from a sewer pump station to a heat exchanger (heat pump evaporator), and (2) using a special sewer pipe with internal heat exchanger built in, such as Rabtherm technology from Switzerland.
- **Biomass combustion** involves the combustion of wood residues (hog fuel) or wood pellets to produce hot water for distribution
- **Biomass gasification** is a thermo-chemical process that uses heat to convert any carbon-containing fuel into a clean burning gas commonly referred to as syngas. The syngas can be fed to heat recovery equipment (e.g., a boiler) and/or an engine or turbine (for electricity production, with or without heat recovery).

Factors Influencing Viability

- Economic viability can depend on:
  - Energy density and intensity – Energy intensity is the amount of annual and peak heating and cooling demand per unit of floor space (MW/m2 or MW.h/m2). Energy density is the amount of annual and peak heating and cooling demand per unit of land area (MW/ha or MW.h/ha). Energy density is a function of both energy intensity (building efficiency) and floor area density. High energy density improves the economics of centralized energy because it reduces distribution costs and limits distribution heat losses (thereby improving system efficiency and thus economics).
  - Availability of alternative heat sources – Availability of low cost alternative heat source affect economic viability.
  - Nature of development – A new development allows system to be installed in tandem with other infrastructure and ensures new buildings are compatible, vastly improving the economics.
  - Rate of development – Threshold energy demand and intensity is required. Higher rates of development tend to improve economics because slow build-out results in slow and insufficient returns necessary to recover an acceptable overall return given the large, initial capital outlay.
  - Phasing – Developing buildings with typically larger energy demands early in the phasing process can help provide sufficient revenues early in the system's operation and thus improve economics.

- Factors that can enhance economic viability:
  - District incentives – e.g. property tax exemptions for the Energy Centre and distribution assets can greatly reduce operating costs and strengthen otherwise marginal returns. Exemption would be for the energy system only, not the buildings connected to the system.
  - Securing government grants can offset the large, initial capital outlay that is a large determinant of the economic viability of DES.

Examples of District Energy Systems

Installed and Future Systems

- Lonsdale Energy Corporation
  - Natural gas mini-plants, no cooling
  - Owned by Lonsdale Energy Corporation, a wholly-owned subsidiary of the City of North Vancouver
- South East False Creek
  - Central sewer heat and natural gas boilers for peak demand and back-up, no cooling
  - Will be operated as utility by City of Vancouver
- Dockside Green
  - Biomass gasification with natural gas boilers for peak demand and back-up, no cooling
  - Owned and operated by Dockside Green Energy – partnership between Vancity, Windmill developments, Corix and Terasen
- Sun Rivers
  - Example of a distributed energy utility – parcel scale ground source heat pumps are organized into a district system under a utility ownership model (residents billed monthly access fee to ground loop, provides heating and cooling
  - Owned and operated by Corix Utility
- Drake's Landing
  - Solar PV with seasonal storage and natural gas boilers for peaking and backup, no cooling
  - Owned and operated by Drake Landing Company (non profit partnership run by ATCO Gas, United Communities (the developer), Town of Okotoks, Sterling Homes (builder)
- Whistler Athlete's Village
  - Waste heat from sewage plant and natural gas boilers for peak demand and back-up
  - Utilizes ambient loop and heat pumps in individual units, heating and cooling

Recent Feasibility Studies Completed

- East Fraser Landing
  - Biomass and waste heat recovery from Burnaby Waste Incinerator Plant shown viable. Proceeding with waste heat recovery from Burnaby Waste Incinerator.
- Fraser Mills
  - Biomass shown to be most economically viable option. Ground water heat pump and waste heat from Catalyst industrial facility also analysed.

Background and Objectives of Screening Analysis

Background

- Pridham Developments Ltd. agreed to allow Waterfront Landing development to serve as the test case for a district energy system pre-feasibility analysis.
- The site was thought to be worth consideration for a number of reasons:
  - It is a brownfield site in Downtown Squamish that has significant size and projected units.
  - There is sufficient development detail to conduct the analysis.
  - There may be potential to extend the service to adjacent sites.
  - Findings may be applicable to other sites.

Objectives

- Define core boundaries of the Waterfront Landing development and discuss any other "expansion" nodes if relevant; describe features of study area (size, area, energy density, development timeframe, etc.) and compare to others in B.C.
- Discuss the pros/cons of heating only or heating and cooling
- Examine potential heating/cooling sources and competitiveness of those sources
- Discuss the energy system phasing issues
- Provide summary conclusions on value of further study

Methodology for Screening Analysis

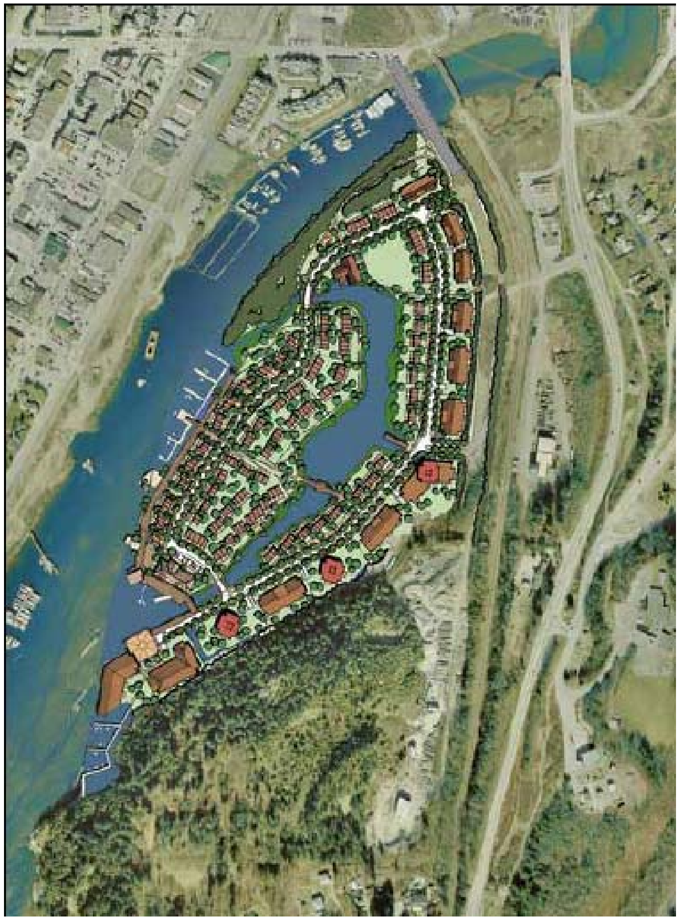
- Establish current and projected 20-year energy demands.
- Identify potential heating and cooling alternatives.
- Identify policy / institutional issues related to viable and promising alternatives.
- Identify precedents, where applicable.
- Prepare recommendations.

Waterfront Landing

- The policy direction of the 2006 OCP Review supports a Sub Area Plan and redevelopment of the former Interfor Landing.
- In October 2005, the District completed a Smart Growth on the Ground (SGOG) process with endorsement from District Council. The comprehensive residential redevelopment of the former Interfor Landing will illustrate the District's commitment to Smart Growth on the Ground. Principle 4 "Buildings and Infrastructure are Greener, Smarter and Cheaper" provides the rationale for a District Energy screening analysis:

> *The Waterfront Landing neighbourhood will incorporate green and sustainable development standards, such as narrower road widths, innovative stormwater management measures, implementation of energy efficient building design techniques, including extensive use of glass to maximize natural illumination, building orientation, building insulation, <u>alternative clean energy techniques</u>, sustainable roofing technology and incorporation of energy efficient servicing infrastructure strategies that collectively create sustainable communities over the long term.*

Features



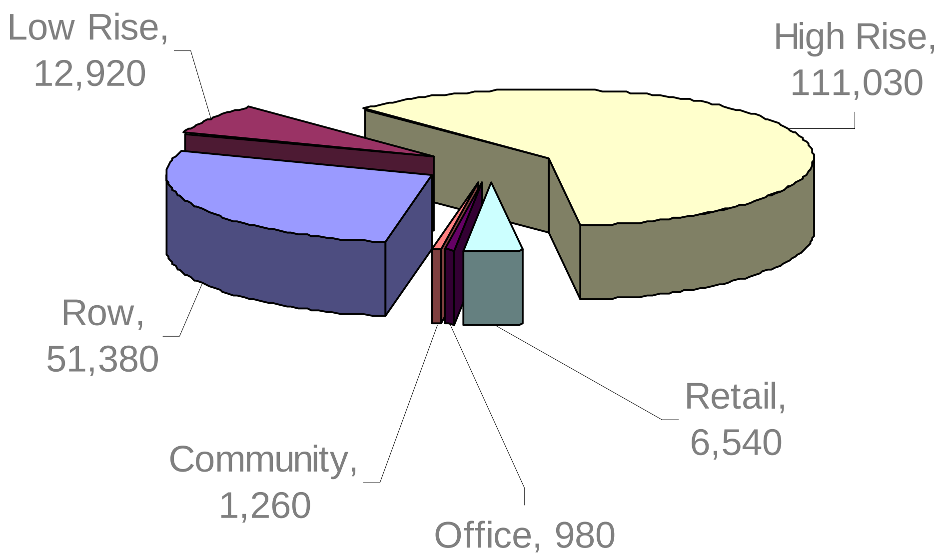
- Approximately 53.1 acres in size.
- 11.2 ha of park / lagoon space
- Mix of residential, retail, commercial, office
- Bordered by Blind Channel to the west and north, the railway to the east, and a rock escarpment to the south
- Sub area plan is currently at 3rd reading, and the development is likely to proceed as detailed in that plan.

Projected Development Mix (at Buildout)

Land Use / Unit Type	Site Area (Ha)	FAR	m2
Row	1.94	1.00	19,400
Stacked Townhouse	2.46	1.30	31,980
Total Row			51,380
Low Rise	0.68	1.90	12,920
High Rise (up to 8 stories)	2.85	2.50	71,250
High Rise (above 8 stories)	1.53	2.60	39,780
Total High / Mid Rise			111,030
Commercial	0.21	1.40	2,940
Retail	0.36	1.00	3,600
Office	0.07	1.40	980
Community	0.21	0.60	1,260
		Total	**184,110**

Development yields derived from Table 1: Land Use Distribution, Waterfront Landing Neighbourhood Sub Area Plan (November 6, 2007). The sub area plan was in its third reading at the time of this analysis.

Projected Development Mix (at Buildout)



Total Floor Area: ~ 184,000 m^2

Energy Demand

- To calculate energy demand projections two factors are required: 1) floorspace projections, by building type and 2) energy intensity multipliers.
- Floorspace estimates were derived from Table 1 of the Waterfront Land Sub-Area Plan, now entering its third reading before council. We assumed developers would build to maximum FAR (see slide 11). Future floorspace scenarios are the subject of public consultations and have not been approved by Council.
- Energy intensity multipliers are derived from Neighbourhood Energy Studies prepared for Fraser Mills (Coquitlam) and East Fraser Lands (Vancouver). Multipliers are adjusted for Squamish's heating and cooling degree days. Multipliers are also adjusted for the expected new 2008 Green Building Code -- EnerGuide for New Houses 77 and ASHRAE 90.1 2004.
- Energy intensity multipliers are multiplied by floorspace estimates to determine annual and peak energy demands.

Floorspace and Preliminary Energy Projections

Floorspace (m2)		
Residential (m2)		175,330
Commercial (m2)		8,780
	Total (m2)	184,110
Energy Consumption		
Natural Gas (GJ)		46,675
Electricity (MWh)		6,892
Energy Demand		
Space heat (MWh)		9,778
DHW (MWh)		5,385
Cooling (MWh)		1,418
	Total (MWh)	16,581
Peak Load (Non-Diversified)		
Residential heat (MW)		8.7
Residential cooling (MW)		1.5
Commercial heat (MW)		0.3
Commercial cooling (MW)		0.6
	Total Heating (MW)	9
	Total Cooling (MW)	2

* 9 MW of peak heat demand requires about 3 MW of base load capacity, or about 18,000 MW.h of annual energy capacity

Business as Usual GHG Emissions

- Current and future Business as Usual (BAU) GHG emissions depend upon assumptions about the electricity emission factor.
- BAU is the expected level of emissions if development proceeded as planned (i.e. without a DES).
- Four scenarios are considered:
  - Scenario 1 uses marginal emission assuming 100% of new supplies from green electricity sources.
  - Scenario 2 uses current average emission rate for BC Hydro (direct and indirect).
  - Scenario 3 uses a marginal (incremental) emission rate assuming new electricity from a combined cycle gas turbine
  - Scenario 4 uses a marginal emission rate assuming 50% of new electricity from green sources and 50% from new combined cycle gas turbines.
- In addition to emission considerations, there is also the issue of whether it is appropriate to use a high quality energy form such as electricity for a low quality energy use (heating) even if the source of electricity is green.

Emission Factor Assumptions

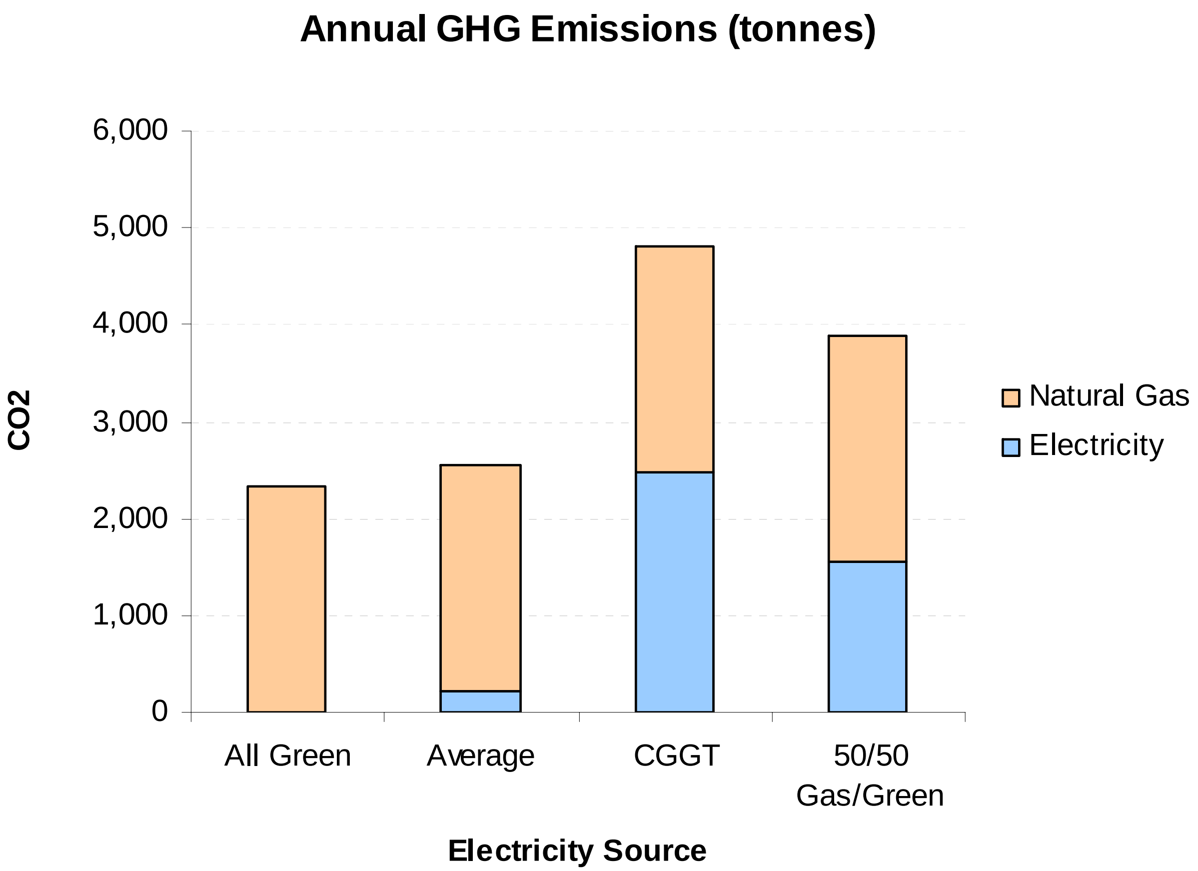
Electricity		
100% Green Electricity	0	kg/MWh
BC Hydro Average	30	kg/MWh
CGGT Electricity	360	kg/MWh
50/50 Gas/Green Split Electricity	225	kg/MWh
Natural Gas	50	kg/GJ

BAU GHG Emissions

- Emission forecasts are based on emissions factors for each fuel type, energy use per m2 and estimated fuel splits.
- The table at the side shows our assumptions about fuel splits for Squamish.
- The splits are based on BC Hydro's 2003 Conservation Potential Review for the Lower Mainland and expert opinion.

Building Types	Space Heating Electric/gas Floorspace Split	Hot Water Electric/gas Floorspace Split
Row		
Row New Electric	33%	14%
Row New Gas	67%	85%
Low Rise	Electric w/ Gas MAU	Gas
High Rise	Electric w/ Gas MAU	Gas
Retail	Gas	Gas
Office	Gas	Gas
Community	Gas	Gas

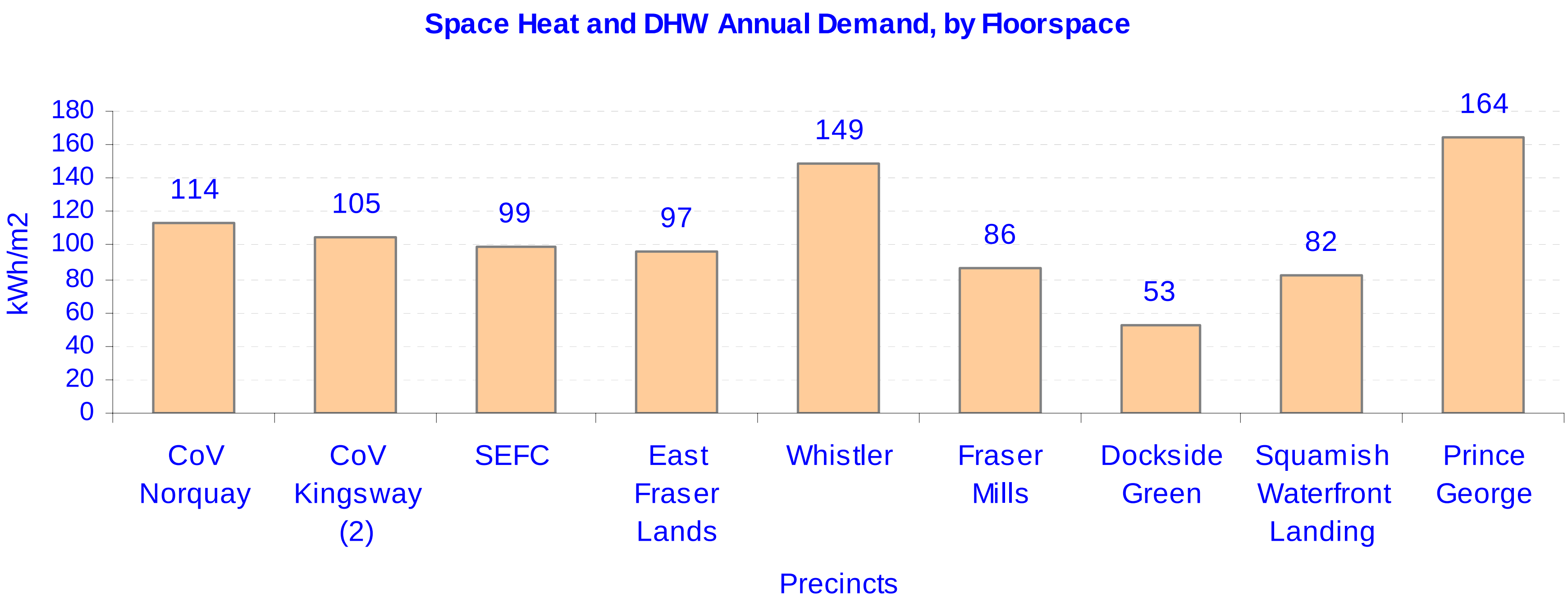
BAU GHG Emissions



Comparisons with other Precincts

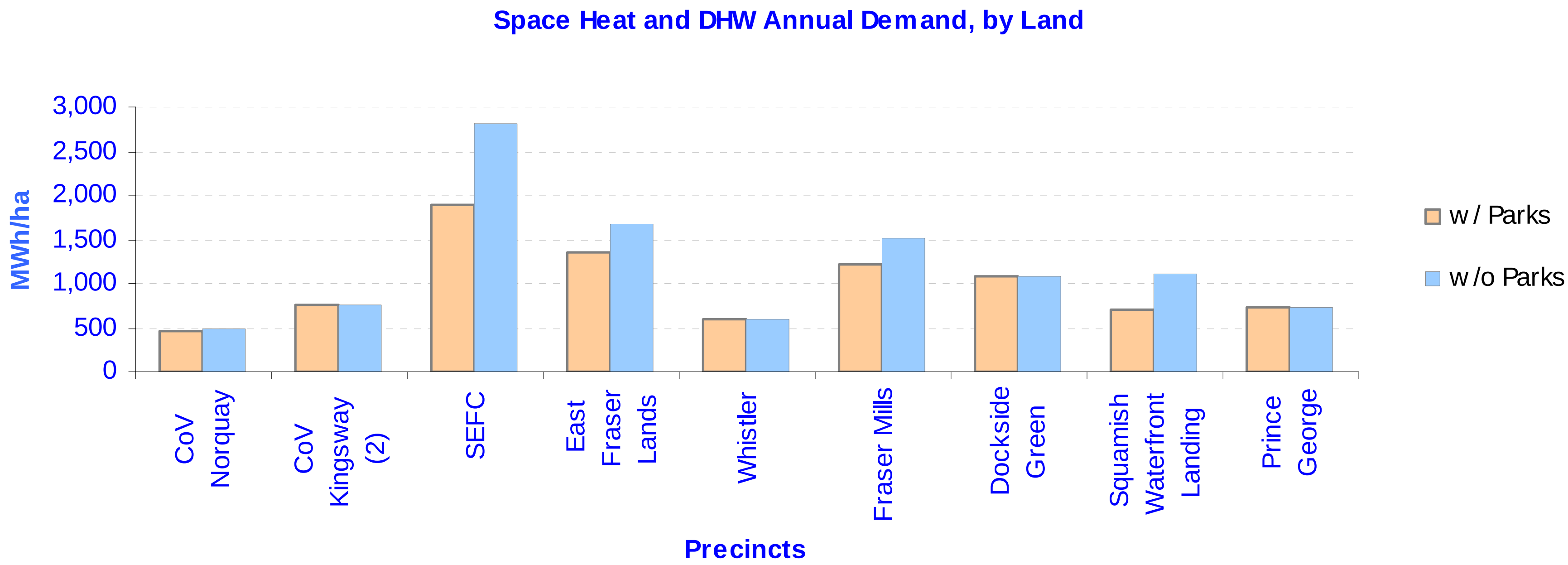
Precinct	Floorspace (m2)	Mix	Land Area (ha)	Status
Norquay Village (Vancouver)	592,083	95/5 res/com	150	Not proceeding. Low density, existing development too costly to retrofit, no economical source of central heating.
Kingsway Rezoning Area (Vancouver)	248,724	80/20 res/com	35	Not proceeding. Low density, existing development too costly to retrofit, no economical source of central heating.
Waterfront Landing	184,110	95/5 res/com	21	TBD
Southeast False Creek	613,977	80/20 res/com	32	Proceeding with sewer heat DES.
East Fraser Lands (Vancouver)	720,000	93/5/2 res/com/inst	52	Proceeding with waste heat recovery from GVRD waste to energy plant.
Whistler Olympic Village	93,125	Mostly residential	23	Proceeding with waste heat recovery DES.
Fraser Mills (Coquitlam)	463,467	84/3/2/9 res/com/inst/ind	33	Biomass DES marginal.
Dockside Green	125,560	85/15 res/com	6	Proceeding with biomass gasification DES (thermal only).
Prince George	55,000	Institutional buildings	~13	Proceeding with biomass system.

Annual Demand Comparison, by Floorspace



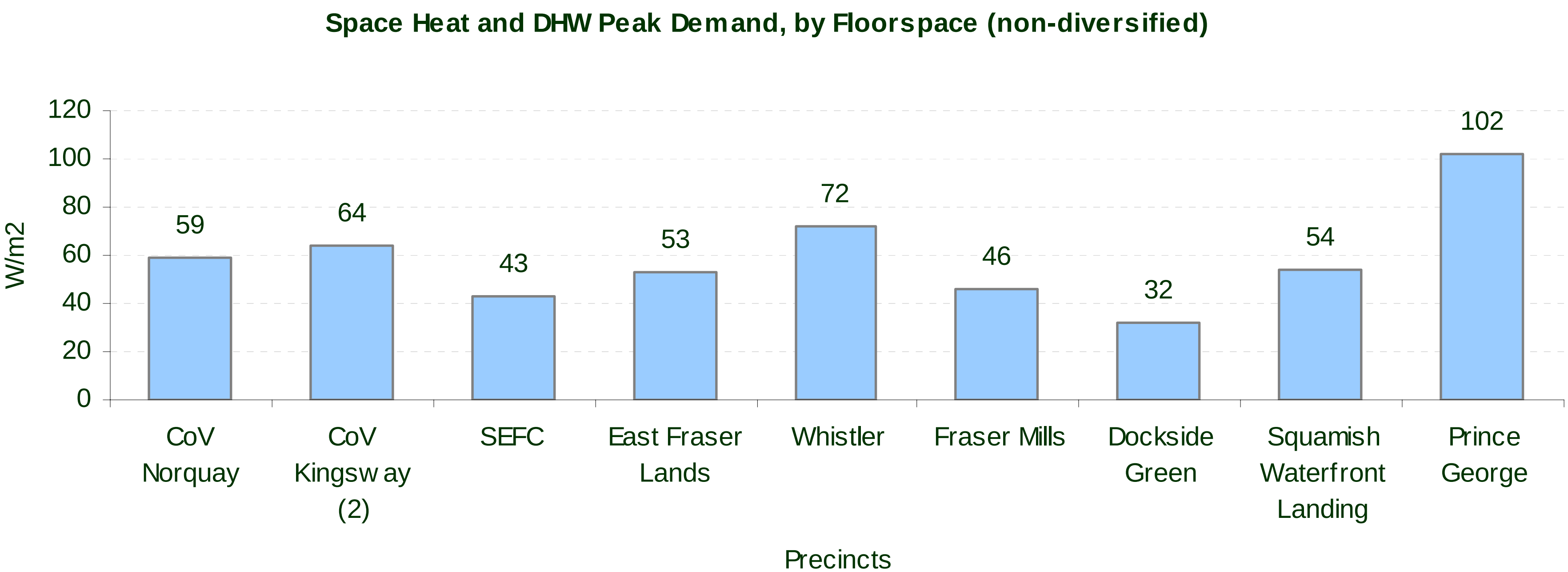
- This figure compares the annual floorspace intensity (kW.h/m2) of Waterfront with other precincts. Squamish's relatively low floorspace energy intensity is attributed to building code improvements expected to take effect in 2008. The 95/5 res/com floorspace mix at Oceanfront is comparable to other precincts.

Annual Demand Comparison, by Land Area



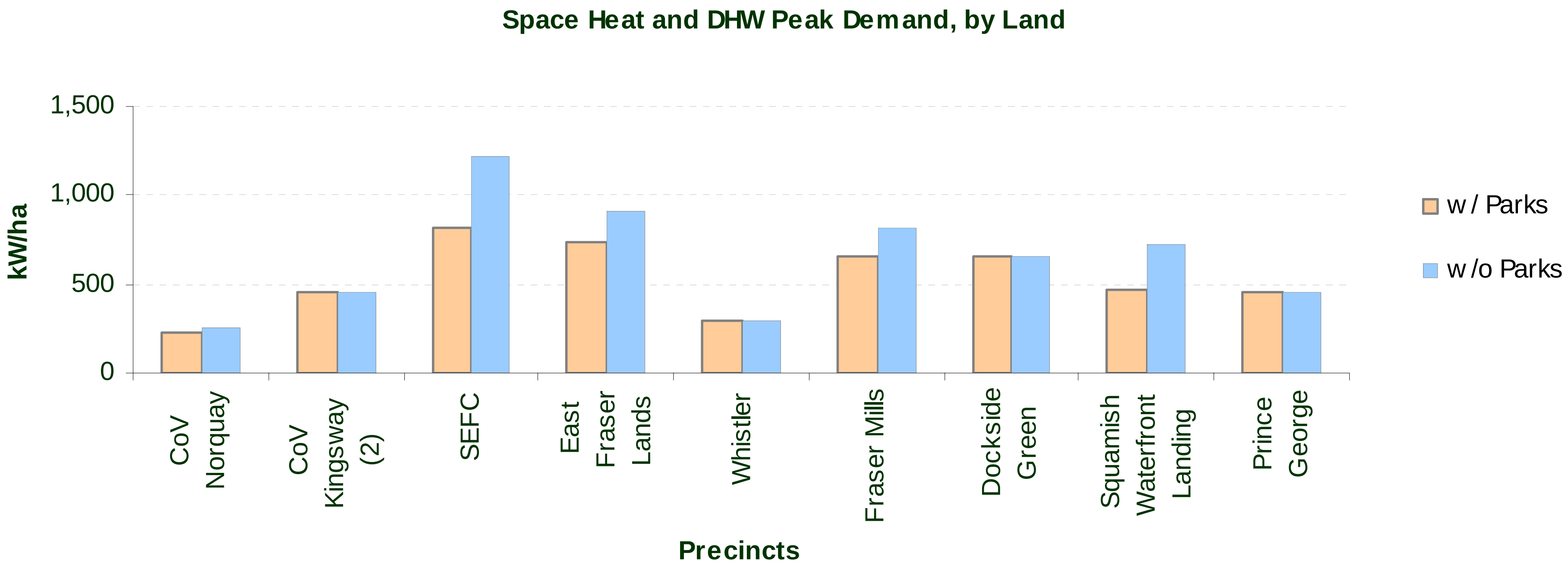
• This figure compares the annual energy density (MW.h/ha) of Oceanfront with other precincts. The two bars provide a comparison of energy density with parks included in the total land area and parks excluded. Excluding parks increases energy density, but this should only be used where parks will likely not affect distribution costs (the majority of the cost of district systems). Annual energy density with parks is comparable to Kingsway Rezoning Area, Whistler and Prince George whereas annual energy density without parks is comparable to Dockside. Whistler, PG and Dockside are all proceeding with DES systems.

Peak Demand Comparison, by Floorspace



• This figure compares the peak floorspace intensity (W/m2) of Waterfront with other precincts. Waterfront is comparable to EFL, Fraser Mills and SEFC. This is attributable to higher Building Code standards expected in 2008.

Peak Demand Comparison, by Land Area



- This figure compares the precinct peak energy density (kW/ha) of Waterfront with other precincts. The two bars provide a comparison of density with parks included in the total land area and excluded. Peak density is much higher when parks are excluded, but should only be used where parks will not impact distribution costs. Energy density with parks included is comparable to Kingsway Rezoning Area and Prince George whereas peak energy density without parks is comparable to Dockside Green (which is proceeding with a DES system) and Fraser Mills (where the viability of a DES system is marginal, though possible).

Discussion – Energy Intensity of Floorspace

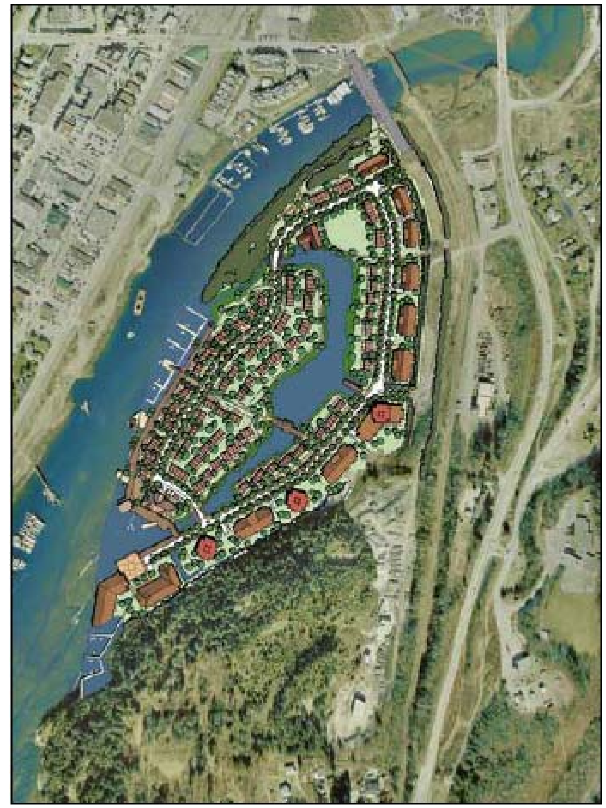
- Energy Intensity is measured two ways: 1) the annual energy demand per square metre of floorspace (kW.h/m2) and 2) the peak energy demand of floorspace (w/m2).
- The Waterfront Landing development is comparable to other developments that were screened for DESs or proceeding with DESs. Whistler and Prince George are much higher due to the higher number of heating degree days in Whistler/Prince George compared to Squamish, Victoria and the Lower Mainland.
- It would seem the Waterfront Landing development should have a higher intensity because it has more heating degree days (i.e. Squamish is colder) than the Lower Mainland and Vancouver Island locations it is compared to. But the Waterfront Landing is similar because we included efficiency gains expected with the introduction of the new BC Green Building Code. The efficiency gains more or less offset the higher energy use from the colder winters.

Discussion – Energy Density/Intensity

- Energy Density is also measured in two ways: 1) the annual energy demand per ha of development (MW.h/ha) and 2) the peak energy demand per ha (MW/ha).
- The greater the energy density, the more likely a potential DES will be economic, all things being equal. Energy density is a key indicator of how a potential DES compares to other systems that are either being built or in the design/feasibility stage.
- A key consideration is whether to include park space in the total land area. For most developments, excluding park space is likely the more accurate measure. The reason is that park space is not 'livable' space and is generally fairly concentrated on a site. Thus, it does not increase distribution costs of the district system.
- However, if parks are distributed throughout the site, they will likely increase total distribution costs, a key factor in DES economics.
- In summary, if the parks are concentrated and/or located on the periphery, then Energy Density <u>excluding</u> parks may be the more accurate indicator of likely distribution costs. If parks are widely disbursed throughout the site or centrally located, then Energy Density <u>including</u> parks may be the more accurate metric.
- The previous slides demonstrate the effect including parks has on the overall Energy Density. Note that Waterfront's Energy Density is comparable to Dockside Green, Prince George, Fraser Mills and Whistler when <u>excluding</u> parks but comparable to Prince George and Kingsway Rezoning Area when <u>including</u> parks. Dockside Green, Prince George and Whistler are proceeding with DESs and Fraser Mills in being considered.

Discussion

- The site concept plan for Waterfront Landing shows a large lagoon in the centre of the site.
- This suggests a low energy density.
- However, the development surrounding the central lagoon has a compact shape and reasonable energy density, which could make a DES viable, depending upon the type and location of the heat source.



Land Area (Ha)	21.24
Public Realm / Lagoon / Park Space (Ha)	11.18
Total Area (less Public Realm / Park Space)	10.06

Centralized vs. Decentralized Applications

- Some alternatives must be centralized (e.g., biomass) whereas some alternatives can be centralized or decentralized (e.g., geo-exchange).
- Centralized applications require a neighbourhood distribution system to distribute heat from central source(s) to customers. Degree of centralization can range from several parcels to much larger nodes or entire study area.
- The cost of a neighbourhood distribution system is a key consideration. Cost-effectiveness depends upon:
  - Energy density (affects linear length of pipe required per unit of demand),
  - Mix of uses (helps improve utilization rate of pipe and other centralized equipment),
  - Cost of installation (will be lower where installation can be coordinated with other infrastructure)
  - Cost of centralized heat source (the cheaper the centralized heat source, the more distribution piping that can be justified).
- The Waterfront Landing site may support a centralized system:
  - If park space is excluded from the total land area, energy density is comparable to Dockside Green.
  - The site has a large central lagoon but relatively compact development surrounding the lagoon, which may improve the economics of distribution (e.g., a single distribution loop with short interconnections may be possible).
  - Because the site is a brownfield, installation of distribution system can be coordinated with other infrastructure.
  - Low cost heat sources may be possible.
- Nodal/decentralized systems with limited distribution infrastructure may be possible:
  - Horizontal GX systems in parks or lagoon serving groups of adjacent row houses.
  - A vertical GX system serving several contiguous parcels with high density and mix of uses.
  - A Rabtherm sewer heat recover system serving a nearby apartment or townhouse complex

Note: The viability of any centralized or nodal system requires non-electrically heated floorspace.

Possible Heating and Cooling Sources

- The following heating and/or cooling alternatives are possible at the Waterfront site:
  - Geo-exchange systems (ground source, ground water)
  - Ocean heat recovery
  - Sewer heat recovery (pump station, Rabtherm)
  - Biomass Combustion
  - Biomass Gasification
- Other potential heating/cooling sources include industrial waste heat recovery and chiller heat recovery. Neither are suited to this site because of the absence of a major industrial facility in close proximity and absence of large cooling loads (for chiller heat recovery).
- A major distinguishing factor among technologies is whether they provide space heat and domestic hot water (DHW) or space heat and cooling.
- For technologies that provide space heat and DHW mechanical cooling is required (i.e. electric chillers and cooling towers).
- For technologies that provide space heat and cooling, additional DHW supply may be required.
- Space heating and cooling also typically requires a four-pipe distribution system, unless the system uses distributed heat pumps (similar to Whistler's system).
- In a typical new predominantly residential, large-scale development in coastal B.C., space cooling accounts for about 10% of the total demand whereas space heat accounts for about 60-70% and DHW accounts for about 20 - 30% of total demand. Technologies that satisfy space heat and DHW generally satisfy a larger share of demand.
- At Waterfront Landing cooling accounts for 8%, DHW for 32% and space heating for 60% of total demand. See slide 14.

Heating Only vs. Heating and Cooling

	Heating and DHW Only	Heating and Cooling
Potential Technologies	Sewer, co-generation, biomass, geo-exchange, waste heat recovery, ocean heat recovery	Geo-exchange, chiller heat recovery, ocean heat recovery
Distribution	Low-temperature (65 degree), 2-pipe insulated system	Four to six-pipe system if technologies are centralized
Energy Centre	Centralized OR decentralized (on-site or mini-plants)	Centralized OR decentralized (on-site or mini-plants)
Conventional Energy Requirements	Electricity used for chillers (for cooling). Only use electricity if heat pump used. Natural gas peak/back up.	More electricity used. Natural gas or electricity used for peak/back up heating. Additional natural gas typically required for DHW.

- There are pros and cons to each. Based on the low cooling loads on the site we recommend focusing on technologies and configuration that address heating and DHW.

Sizing and Phasing

- Total estimated heating load is about 9 MW.
- Based on experience at other sites, the optimal size of an alternative energy system for this site would be 3 – 4 MW. The remaining peak capacity would be most economically supplied by natural gas boilers, which would also provide back-up in the event of any outage of the alternative supply capacity.
- This amount of alternative energy capacity could supply 60 – 80% of the annual energy requirements for the site.
- Given a phased development, it is often most economical to install the natural gas boilers first, followed by the alternative energy supply when load reaches an adequate size to ensure a high level of utilization of the more expensive alternative energy supply capacity.
- The alternative energy supply could also be implemented in phases, although there are often economics of scale associated with larger installations.
- Co-generation (e.g., with biomass) could also be implemented in phases, depending upon market conditions.

Geo-exchange

- Geo-exchange configurations typically rely on energy stored in the earth or water to heat and cool buildings. A geo-exchange system still requires external energy sources (usually electricity) to recover energy, but total external energy requirements are greatly reduced compared with conventional heating systems.
- A typical geo-exchange system consists of three main components: a) a ground heat exchanger (GHX); b) a heat pump; and c) an energy distribution system. In this assessment, we focus on space conditioning only. We do not address water heating applications. Because the buildings in the study area are heat load dominant, adding water heating loads may not improve the economics of the entire system
- Two geo-exchange configurations are possible at this site (ocean heat recovery will be treated separately):
  - Ground-source Heat Pumps (GSHPs) - use the ground as a heat source and sink, either with vertical or horizontal Ground Heat eXchangers (GHXs);
  - Groundwater Heat Pumps (GWHPs) - use underground (aquifer) water as a heat source and sink
- Geo-exchange may be used for heating and cooling. Cooling load can reduce size of vertical GSHP fields but will have limited effect on sizing of horizontal GSHP fields of GWHPs.
- GX may be centralized (i.e., single field serving multiple developments via a distribution network) or decentralized (individual systems within each parcel). Both are considered.
- Precedents:
  - Sun Rivers, Kamloops (vertical GSHP distributed systems).
  - Wilden Estates. Kelowna (vertical GSHP distributed systems).
  - Drake Landing, Okotoks (vertical GSHP, centralized and combined with solar thermal).
  - Richmond Olympic Oval (Centralized loops integrated with waste heat recovery from skating oval) – IMPLEMTATION IS UNCERTAIN.

Ground Source Heat Pump – Resource (centralized)

- The ground source and ground water geo-exchange options at the scale desired and in a centralized district heating application are essentially unproven in Canada, although they have some history in Europe. Typically, GSHP/GWHP are implemented at the building scale where both heating and cooling is required, and preferably coincidently.
- Centralized GSHP and GWHP were assessed for the Fraser Mills site in Coquitlam, B.C. Fraser Mills is a much larger development but of roughly a similar mix of uses. For GSHP, the required land area is 1.5 to 12 m2/kW. Based on the Waterfront Landing sub area plan, there appear to be two potential fields: the Public Waterfront Park and the Public Playfield. Assuming similar ground conditions as Fraser Mills and 75% of the parks are available to accommodate a vertical GHX field, approximate capacity would be:

Site	Size (Ha)	Accessible Area (m2)	Range of Capacity (MW) @:		
			1.5m2/kW	6m2/kW	12m2/kW
Public Waterfront Park	1.5	11,250	7.5	1.9	0.9
Public playfield	0.46	3,450	2.3	0.6	0.3

- About 3 MW of capacity is required for base load. There would likely only be adequate capacity at the Public Waterfront Park using the more optimistic range of assumptions. For comparison, at Fraser Mills a 8,000 m2 (.8 Ha) park was capable of 2 MW of heating capacity (assuming 4m2/kW).

Ground Water Heat Pump – Resource (centralized)

- For GWHP, the capacity of the system depends on groundwater flow rate. Required ground water flow rate is about 0.05 l/s/kW.
- Westmar Consulting dug a testpit as part of its analysis for the tidal lagoon. At 6m, flow rate is 9.46 l/s. However, there is a silt layer at about 7.5 m which could impede flow rates vertically. Data is not available for deeper depths.
- A 9.5 l/s flow rate translates to about 200 kW per well, i.e. 10 wells to produce 2,000 kW.
- Typically, about 50 m buffer is required between 'producing' wells and 'injecting' wells. About 6 m radius spacing is required between 'producing' wells. Given the available park space, the following capacity may be possible (but completely depends on site-specific ground conditions).

Site	Size (Ha)	Accessible Area (m2)	# of producing wells	Capacity (MW)
Public Waterfront Park	1.5	11,250	32	6.4
Public playfield	0.46	3,450	5	1.0

- About 3 MW of capacity is required for base load. The Public Waterfront Park may have enough potential heating capacity for the development and may warrant further analysis.

GSHP/GWHP – Cost (centralized)

- The ground source and ground water options at the scale desired and in a centralized district heating application are essentially unproven in Canada.
- However, we are able to provide recent cost estimates for centralized GSHP and GWHP at Fraser Mills in Coquitlam, B.C. These costs are specific to Fraser Mills and so should be interpreted with caution. The economics of geo-exchange are highly sensitive to ground conditions, which can vary significantly from site to site. Also, Fraser Mills is a much larger development, so the geo-exchange system benefits from economies of scale on the one hand but the system is subject to greater distribution costs on the other hand.
  - GSHP - ~$2,100/kW
  - GWHP - ~$1,900/kW
- These are installed unit capital costs and do not include land/building costs or operating costs.

Decentralized Vertical GSHP/GWHP – Resource

- For decentralized vertical systems, surficial and bedrock geology influences the performance and installation cost of the ground heat exchanger (GHX). To our knowledge there are no site-specific studies that can be used to determine drilling conditions, ground thermal properties, and the potential influence of groundwater flow at Waterfront Landing. University Heights' ground conditions (granite) are very different than the Oceanfront Lands (sand, marine silt, bedrock). Site-specific study is required. Using Fraser Mills as a rough guide, between 1.5 and 12 m2 of space is required per kW of heating capacity. See previous slide for range of resource potential in parks.
- Decentralized GWHP resource is similar to the centralized option (slide 32).

Decentralized Vertical GSHP - Cost

- The table below demonstrates the range of capital costs for vertical geo-exchange systems in the Lower Mainland. The majority of the up front costs are attributed to the ground loop. The cost of the loop is dependent on the type of configuration, the length of pipe required and the drilling conditions.
- We assumed an installed vertical GHX cost of $1,200 per kW of heat pump capacity, though costs can range between $1,000 and $1,400 in the Lower Mainland. Waterfont Landing-specific engineering analysis was not available, so these figures should be interpreted with caution.

Building type configurations	Heat pump size (kW)	Heat pump cost per kW	Heat pump cost	Installed GHX cost	Total installed cost	Total installed costs per kW
SFD	4	$1,000	$4,000	$4,800	$8,800	$2,200
	9	$500	$4,500	$10,800	$15,300	$1,700
	17	$300	$5,100	$20,400	$25,500	$1,500
MURB and commercial	10	$375	$3,750	$12,000	$15,750	$1,575
	60	$175	$10,500	$72,000	$82,500	$1,375
	110	$150	$16,500	$132,000	$148,500	$1,350

- Due to economies of scale associated with larger systems, there is a non-linear relationship between heat pump size (in kW) and the cost of the heat pump per kW. For example, a 10 kW heat pump for a commercial building costs $375/kW whereas a 110 kW heat pump costs $150/kW. The result is the total installed cost per kW decreases as the size of the configuration increases.

Decentralized Vertical GWHP - Cost

- The installed unit cost of a decentralized GWHP system depends on water flow and well depths. Cost details of centralized GWHP also apply for decentralized GWHP. For comparison, the Lyn Valley Care Centre in North Vancouver installed a 105 kW ground water (open loop) system to provide heat for the facility. Installed unit capital costs for that system were about $1150/kW, aligning it more with vertical systems in terms of costs.
- According to an industry expert at Geothermax, a geo-exchange consulting firm in Ontario, the City of Welland, Ontario is considering a surface water geo-exchange district system. The system would use the Welland Canal as a heat source/sink and provide space conditioning to civic and private buildings via a district loop. This project is in the concept stage so specific information is not available yet.

Decentralized Horizontal GSHP – Resource

- For decentralized horizontal systems, approximately 40 m2 of area is required per nominal ton of heat pump capacity. The sub area plan shows a public waterfront park and a public play field as the most promising options. We assume 60% of this space is available for a horizontal loop.
- Using these assumptions, both parks combined could provide about 860 kW of heating/cooling capacity. Fairly balanced heating/cooling loads are assumed.

Site	Size (Ha)	Accessible Area (m2)	Nominal tons	Heat potential (kW)
Public Waterfront Park	1.5	7,500	188	660
Public playfield	0.46	2,300	58	202

Decentralized Horizontal GSHP - Cost

- There are two parks that may be suited to horizontal geo-exchange, the Public Waterfront Park and the Public Playfield. Based on the resource potential on slide 34, rough cost estimates are provided. Heat pump costs assume $400/kW of heat pump capacity. Installed GHX costs assume $400/kW of capacity.

Site	Heat potential (kW)	Installed GHX cost	Heat pump cost	Total installed cost	Cost per kW
Public Waterfront Park	660	$ 262,500	$ 264,085	$ 526,585	$798
Public playfield	202	$ 80,500	$ 80,986	$ 161,486	$798

Ocean heat recovery – Resource/Cost

- The tidal lagoon and blind channel are candidate sites for an ocean heat recovery system. However, further study would be required to ensure minimum water level and the effect of tidal inflow/outflow on surface water temperatures. The tidal lagoon is about 4 metres deep. Blind channel is expected to be dredged to a depth of 4.5 metres.
- There are two options: closed loop and open loop. Open loop circulates sea water from an inlet pipe to an outlet pipe via a heat exchanger. Closed loop circulates antifreeze through the pipes.

<u>Open loop</u>

- It is assumed the tidal lagoon replenishes sea water regularly. Assuming a required base load capacity of 3MW, then about 18,000 MW.h is required, of which about 2/3 would come from the water, or 12,000 MW.h.
- To get about 3MW of heat requires pumping about 500 m3/h, which will require about 50-75 Hp pumps assuming 25 m of static and dynamic head. The same holds true for Blind Channel.
- For ocean loop heat recovery, a pump station and associated piping estimate including intake from water is about $500,000. The Heat Pump plant for 3 MW is about $3.5 million. Installed unit capital costs are therefore about $1,350/kW.

Ocean heat recovery – Resource/Cost

Closed loop

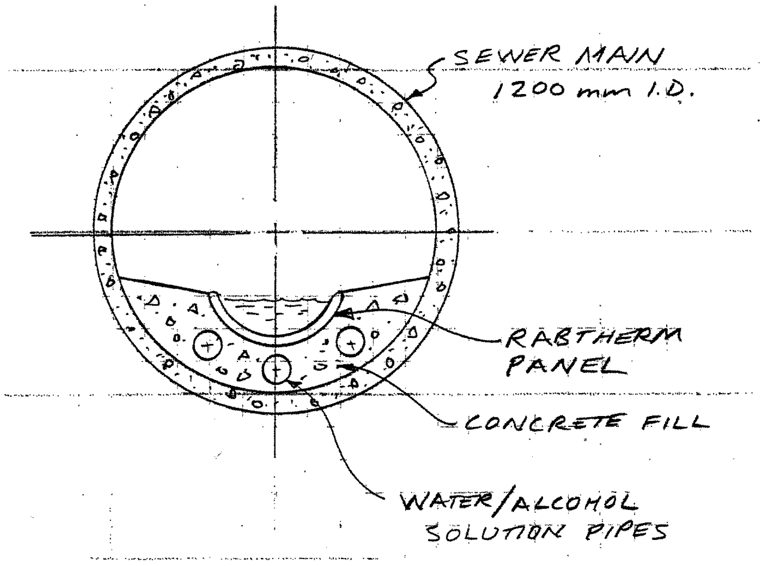
- A closed loop would suit a smaller scale application. We consulted with a geo-exchange contractor who is designing and installing closed loop systems. Approximately 4 m2 of floor area of ground loop is required per kW. A 35 kW system would require about 140 m2. There is a linear relationship between ground loop area and heat potential. A 350 kW system would require about 1,400 m2 of floor area.
- The tidal lagoon is about 2.1 ha. Assuming 30% of the floor area can accommodate a loop, there is about 1.5 MW. The low available floor area is to allow for low depths at the edge of the lagoon and the habitat bench expected to be created.
- We only have costs for smaller systems. A 10 ton (35 kW) system was roughly estimated to cost $25,000 installed. A 100 ton system would benefit from economies of scale of about 20%. Assuming the heat pump is $400/kW the unit cost of a 100 ton (350 kW) closed loop system is about $1,000/kW.
- These costs are very general. Precise costing/capacity estimates requires site specific analysis. These estimates should be interpreted with caution.
- A lease for use of the seabed floor would be issued by BC Integrated Land Management Bureau. The application would be referred to DFO. Processing times is at least 4-5 months, assuming no impacts on fisheries. DFO could stall this processing time considerably.

Sewer Heat - Resource

- There are two potential approaches to sewer heat recovery: 1) heat recovery from sewer inverts (Rabtherm technology); or 2) sewer heat recovery at a pump station (SEFC).
- At the pump station, heat exchangers capture the heat within sewage then 'lift' the temperature using heat pumps. The heat is then distributed to the end user in the form of hot water.
- Sewer heat recovery systems using a pump station and heat pump at this scale have been successfully implemented in Norway and Japan, but generally is not a common solution. The City of Vancouver is implementing this concept at Southeast False Creek. The viability of a centralized system likely depends on there being a pump station on or very close to the site.
- Currently, there is a small on site pump station at the south end of the site. A forcemain crosses the site northwards draining into a main hole where a gravity system delivers sewage to a larger pump station at the Scott Road crescent. Scott Road crescent sits at the northern end of the site across Highway 99 (approx. 150m from the north tip of the Waterfront site).
- The October 2006 "Impact Statement and Servicing Strategy" report (R.F. Binnie and Associates) proposes two options: 1) expand the onsite pump station and force main systems and 2) develop 2 separate force main and pump station systems to service a broader area. This option would involve building a new Scott Crescent Pump station and forcemain.
- It is not possible to provide an estimate of available capacity in the absence of specific details (type of sewer (force main/gravity flow), temperature and flow, water quality, load coverage, pressure/pressure drop, etc)
- A new pump station at Scott Crescent is a very good option for a district heat source and warrants further analysis. The current Scott Crescent pump station has a capacity of 65 l/s. This would likely increase. For comparison, projected sanitary flows for the SEFC Olympic Village and interim development in the area increased the average day flow of the Cambie Street pump station to 92.9 l/s. However, flow rate is not the only consideration. Temperature of sewage is a key factor and would have to be examined in greater detail.

Sewer Heat - Resource

- The other main option is a more distributed system called Rabtherm. Heat exchangers are installed in the invert of the sewer pipe itself (i.e. Rabtherm technology) and distributed to the end user via a heat pump.
- Rabtherm is a proprietary technology from Switzerland that uses heat transfer panels embedded directly in the sewer inverts. Minimum requirements for technical viability are:
  - Minimum inside main diameter of 500 mm.
  - Concrete or brick mains.
  - Average sewage volume of 15 l / s.



An illustration of Rabtherm technology

Sewer Heat - Resource

- Without knowing the details of the sanitary network on the site, it is not possible to provide an accurate resource assessment of the potential capacity. The table below gives a sense of the available capacity of different diameter sewer channels.

Channel Diametre (mm)	Required Min. Average Flow (l/s)	Max. Recoverable Heat (kW/m)	Area of Heat Exchanger (m2/m)
500	12 to 20	2.8	0.75
675	20 to 40	5	1
750	40 to 50	6.5	1.15
900	50 to 60	8	1.3
1050	60 to 80	10	1.6
1275	80 to 150	13	2.1

- To illustrate, a 750 mm sanitary line (a fairly large arterial line servicing a large area) with a 200 linear metre Rabtherm installation is capable of recovering 1.3 MW of heat, enough heat for about for about 600 SFDs (assuming 65% capacity factor and an average consumption of 12,000 kW.h per SFD).

Sewer Heat – Costs

- For sewer pump station heat source, the SEFC sewer heat system has an installed unit capital cost of about $2,500/kW ($7 million/ 2.7 MW).
- For Rabtherm, costs are uncertain due to proprietary nature of the system and the lack of existing applications in the region. Cost-effectiveness depends upon distance of the end user to the sewer channel. There are also economies of scale in the application. Implementation must coincide with installation or retrofit of existing pipelines, otherwise cost is definitely prohibitive.
- There are several existing Rabtherm applications in Europe, where energy prices are much higher. There are currently no applications in North America. However, systems are being considered for Sapperton (GVRD), Harvard and Montreal.
- A 2003 Sandwell Enginnering study provides cost estimates for a 106 kW benchmark system. The cost estimate found the total upfront costs of the benchmark system to be $239,700, or $2,261/kW. Above 106 kW, costs are roughly linear, meaning that cost per unit of heat delivered would be the same for larger systems. Below 106 kWs unit costs rise in a non-linear fashion.
- Credible data was not available for the unit cost per kW of smaller diameter installations, but unit costs would likely be higher.

Biomass Combustion/Gasification - Resource

- Biomass based district heating plants are common in Scandinavia and have been implemented in some recent district heating projects in Canada, including Revelstoke BC (2005), Oujebougamou QC (1994), and Charlottetown PEI (1986).
- Biomass DESs convert wood waste into energy in a variety of ways. The waste (in the form of biomass residue or pellets) can be burned directly to produce steam or hot water or burned in a cogeneration facility to produce electricity and heat.
- There are two dominant technologies: biomass combustion and biomass gasification.
  - Gasification - Wood waste or pellets are converted to 'syngas', which can be burned to produce hot water or electricity. The main benefit of gasification is that the gas can be used in a multitude of end devices such as boilers to produce heat and reciprocating engines and gas turbines to produce power. The big disadvantage to co-gen gasification is high first costs. This technology is still not used commercially and it about 5 years away from commercialization.
  - Combustion – This system simply burns wood waste to produce hot water or steam. The main benefits are the confirmed effectiveness of the technology and its widespread use in other district systems. The main concern tends to be local air emissions (particulate matter) but with advances in post-combustion emissions clean up PM levels are greatly reduced. Combustion-based co-generation systems are less common at small scale.
- There are two dominant forms of biomass fuel supply:
  - Wood residue – Forestry and construction wood waste that is processed off site to boiler specification grade. More than 6.1 million tonnes of wood residue are generated annually in the mainland region of BC. About 74% of the total is consumed in pulp mills, cogeneration plants, power plants and other facilities.
  - Pellets – generally made from compacted sawdust. The pellet fuel industry is growing in BC, with about 90% of production being exported. It relies on the Forestry Sector for whitewood residue for pellet production, hence is faced with some similar pressures as biomass residue fuel. Future opportunities may include pellets from agricultural residues or from native grasslands production. Pellet are a cleaner fuel to combust.
- There is growing demand for wood waste. Competition includes particle board and pulp manufacturers, European pellet-based DESs, and other biomass operators as a result of BC Hydro's call for bioenergy.
- Other promising "biofuels" is methane gas from landfills and municipal solid waste. The decay of biomass in landfills produces biogas which contains about 60% methane gas that can be burned to produce heat and power. Municipal solid waste can be incinerated to produce heat and power. Both are emerging, capital intensive technologies that don't yet compete with wood-based biomass feedstock.

Biomass Combustion/Gasification - Resource

- Locating and securing a long term supply of wood residue is critical for a viable biomass DES. Dockside Green Energy in Victoria recently filed an Application for a Certificate for Public Convenience and Necessity (CPCN) with the B.C. Utilities Commission. According to the Application, biomass for the proposed gasification plant will be supplied from local sources on Vancouver Island. At the time of the Application there was a draft 20-year supply agreement between DGE and Three Point Properties to supply wood-waste from land clearing operations at Bamberton, a property being developed to the south of Mill Bay on the Saanich Inlet.
- Potential sources of wood residue include: land clearing operations from large developments, park waste facilities, community forests, construction recycling facilities, and importing wood residue from outside the area.
- We learned there has been ongoing interest in Squamish to acquire a community forest tenure for the Brohm Lake area. If tenure application was successful, the woodlot could be a steady, reliable supply of biomass residue, the major cost being the opportunity cost of the material.
- Woodlot licenses held locally by private individuals and the Squamish Nation are also potential fuel sources.

Biomass Combustion/Gasification - Cost

- Cost of biomass depends on the price and availability of the fuel source and utilization of the energy system. For comparison, a biomass combustion heat plant for Fraser Mills has an estimated unit capital cost of $1,200/kW. This estimate is for a larger system (6 MW). Waterfront Landing would likely require a 3 MW system and therefore higher unit costs (due to diseconomies of scale).
- Dockside Green DES utilizes Nexterra technology but only for thermal energy, as cogeneration is not economical. Installed capital costs of for this heat plant are about $6 million. With 2 MW of capacity, installed unit capital costs are about $3,000/kW. These costs are before grants. Dockside received a $1.5M grant from the federal government’s Technology Early Action Measures (TEAM) program.

Summary of Heat Sources

Heat Source	Scope	Applicable Scale	Capacity	Cost*	Comments
Centralized Geo-exchange	Space heating and cooling (potential to to capture some DHW)	Vertical GSHP/GWHP possible at centralized scale.	Significant	GSHP – ~$2,100/kW GWHP - ~$1,900/kW	Requires electricity input. Precinct-scale systems unproven.
Ocean heat	Space heating and cooling (DHW potential)	Centralized scale possible.	Significant	Open- ~$1,350/kW Closed ~$1,000/kW	Potential DFO regulatory process. Requires electricity input. Large scale unproven.
Decentralized Geo-exchange	Space heating and cooling (DHW potential)	Vertical and Horizontal possible at decentralized scale.	Moderate	Vertical - ~$1300-2200/kW Horizontal - ~$800/kW	Requires electricity input.
Sewer heat – Pump Station	Space heating (potentially cooling and DHW)	Centralized heat source serving precinct.	Could be significant	~$2,500/kW (SEFC)	Requires electricity input.
Sewer heat - Rabtherm	Space heating (potentially cooling and DHW)	Decentralized could serve part of development.	Could be significant.	~$2,260/kW	Requires electricity input, well suited to new development.
Biomass – combustion	Space heating and DHW	Centalized heat source serving precinct.	Could be significant	~$1,200/kW	Securing long term fuel supply is critical.
Biomass - Gasification	Space heating and DHW	Centralized heat source serving precinct.	Could be ignificant	Co-gen N/A Thermal only ~$3,000/kW	Securing long term fuel supply is critical.

Comment on Heat Sources

- It is important to note that unit capital costs are only one screening criterion. Systems also vary in terms of their operating costs. This would be examined in greater detail during a feasibility analysis.
- All heat source costs are before grants.
- All unit capital costs are before the land and building costs that would be associated with the energy centre.

Most Promising Options

Centralized

- Sewer heat recovery at proposed Scott Crescent pump station
- Ocean loop in tidal lagoon
- Biomass combustion
- Longer-term – biomass gasification with cogeneration

Decentralized

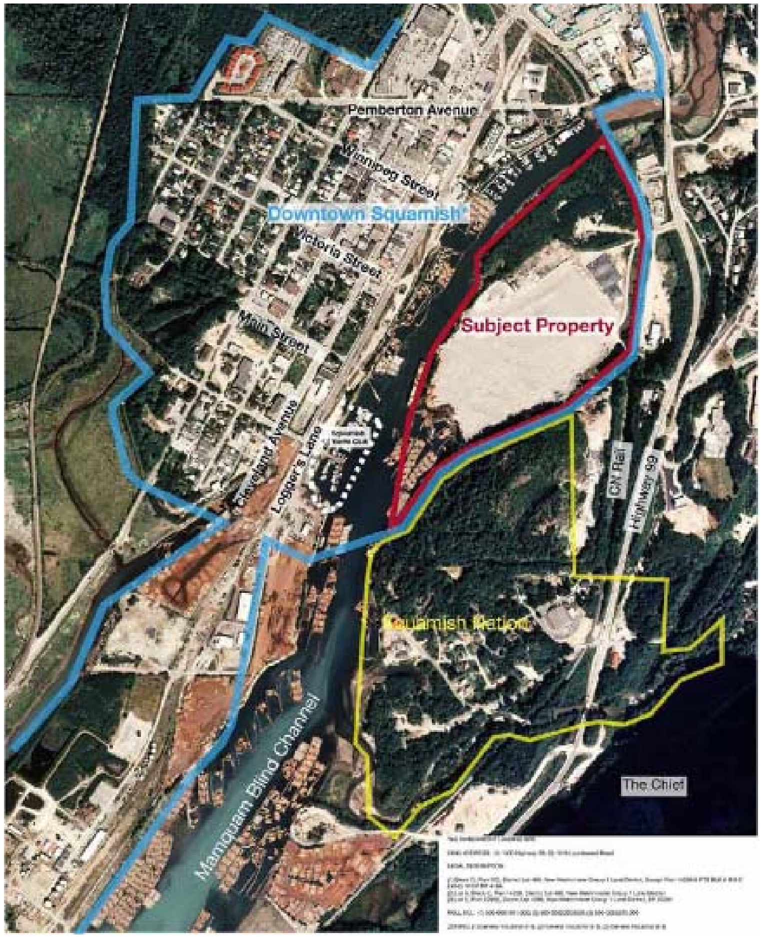
- Horizontal GX loops in parks serving adjacent rowhouse and apartment complexes with or without solar thermal for DHW.
- Sewer heat recovery at on-site pump station / forcemain
- Vertical GX loops for individual rowhouse and apartment complexes with or without solar thermal for DHW.
- Limited potential under right conditions: Sewer heat recovery node for a large mixed use development.

Related opportunities

- Minimize electric resistance heat in new construction to allow future adaptation of alternative technologies (future proof).
- Minimize active cooling, particularly in low-rise construction.
- Provide rough-in for solar thermal systems to allow future adaptation.

Expandability

- Blind Channel serves as a barrier to the distribution system, so the energy centre would likely have to be at the north end of Waterfront site and the pipes would need to cross the channel at Hwy 99 bridge.
- The proposed Scott Crescent Pump Station could serve the Waterfront Lands and an expanded area on the east side of Hwy 99.
- The District expressed interest in expansion to other developments in the downtown area. The Blind Channel serves as a major obstacle and would likely make expansion uneconomical.
- Any proposed sewer heat expansion near the Oceanfront development is a valuable potential heat source and should be considered for an Oceanfront DES.



Conclusions and Next Steps

- Total heating peak demand is about 9 MW. About 3-4 MW of alternative energy capacity could satisfy base demand and meet 60 – 80% of annual energy needs. The remaining demand (representing the peak) would likely be met with natural gas boilers.
- Total annual heating demand is about 17,000 MW.h.
- Annual cooling accounts for less than 10% of total demand. For this reason, we suggest a pursuing a district system that aims to meet most of space heating and DHW demand.
- We suggest minimizing cooling requirements through passive design features and meeting residual cooling needs with conventional chillers.
- Depending on the degree to which the tidal lagoon affects distribution costs, Waterfront Landing may be a viable site for a centralized DES
- Potential heat sources for a centralized district system include:
  - Scott Crescent sewer pump station (off-site)
  - Ocean loop heat recovery using the tidal lagoon as a heat source/sink (though could involve considerable regulatory hurdles, i.e. DFO)
  - Ground water heat pump using wells located in Public Waterfront Park as the heat source/sink
  - Biomass combustion (long-term potential for biomass gasification with cogeneration)
- Decentralized (nodal) systems are also possible. Potential decentralized heat sources (that could satisfy part of the demand) include:
  - Horizontal ground source heat pump system in the Public Waterfront Park and/or Public Playfield
  - Vertical ground source heat pump system in open areas and individual parcels
  - Sewer heat at on-site pump station
  - Rabtherm sewer heat using sanitary pipes < 500 mm
- Blind Channel serves as a significant physical barrier to expanding the system to the southern part of Downtown Squamish. Distribution costs would likely make expansion cost-prohibitive.
- Detailed feasibility study is required to confirm technical and economic viability.