University of Victoria
Sustainable Site Requirements Study

DRAFT

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1. INTRODUCTION

The University of Victoria (UVic) is updating their campus plan and would like to identify potential locations and space requirements for future sustainable, low and zero carbon systems and technologies. Previous reports have identified the following technologies as having the best potential for the university:

- Solar Photovoltaics,
- Biomass,
- Municipal Solid Waste Combustion,
- Biomass Combustion,
- Anaerobic Digestion,
- Campus Waste Energy Recovery, and
- Geo-exchange.

The space requirements and preferred location for each of the above technologies has been assessed and is discussed in the relevant sections below. The maps in appendix A provide a graphical representation of this information.

For additional and specific information on how each technology operates and the campus's energy demand, refer to the previous studies identified below, specifically the Integrated Energy Master plan.

2. BACKGROUND

2.1 Previous Studies

A number of reports and studies have previously been prepared for the University of Victoria (UVic) discussing the GHG targets and the feasibility of energy efficient and low/zero carbon technologies that could help meet the university's established targets. These documents include:

- University of Victoria Strategic Plan (2007)
- University of Victoria Sustainability Action Plan (2008)
- Integrated Energy masterplan (Integral, 2011)
- Condensing boiler study (Integral, 2014)

2.2 Existing District Energy System

The majority of buildings at UVic's Gordon Head Campus are currently served by a high temperature hot water loop that provides space heating and domestic hot water heating energy to 32 buildings on campus. The heating loop is served by one large central heating plant located at the Engineering Laboratory Wing (ELW) as well as three smaller ancillary plants distributed across the campus (in the Clearihue, McKinnon and Commons buildings).

The existing hot water DES has been considered when identifying the preferred and alternate locations for technologies that have a synergy with the DES.

3. METHODOLOGY

When selecting potential sites for the different sustainable technologies, this report used the following criteria to assess and rank each site:

- The available land area, it's current use and its proximity to residential areas,
- The accessibility of the site and the impact of potentially increasing traffic to the area (fuel delivery),
- The proximity of the site to existing campus infrastructure (electrical and district heating), and

- Any site specific features that may impact the system's efficiency (for example shading on the PV array sites).

Once a preferred site was selected, the capital cost premium of developing the other sites was calculated. For the photovoltaic array sites, the capital cost premium is based on the cost of installing trenched electrical infrastructure in addition to what would be required for the preferred site. For all other options the capital cost premium is based on the cost of installing trenched pipework to connect the site to the to the existing high temperature district heating system or the cost of installing an additional low temperature district heating system.

	$/m
Trenched electrical infrastructure	$3,500
Trenched pipework	$2,500

Table 1: Cost of Installing Additional Infrastructure

Finally the potential GHG emissions reductions that could be achieved by the different sustainable technology system was calculated, using the university's 2010 GHG emissions baseline (calculated in the Integrated Energy Masterplan) as a reference year.

	Tonnes GHG /MWh
BC Hydro Electricity	0.014
Natural Gas	0.179

Table 2: GHG Coefficient

4. SOLAR PHOTOVOLTAICS

Solar photovoltaic (PV) systems utilize the free, renewable energy of the sun by converting solar radiation energy directly into electricity. This electricity can either be fed back into the grid or used in a nearby building. Photovoltaic panels are considered a carbon neutral source of energy.

There are two main applications of PV panels applicable at UVic; building mounted and large ground arrays. The primary difference between the two is that building mounted PV systems typically only have the capacity to serve the building to which they are mounted and connect to the building's electrical distribution. Large ground arrays, on the other hand, can have sufficient capacity to serve numerous buildings and requires connection to the campus electricity infrastructure. PV panels are very scalable, meaning demonstration projects can be developed for both installation scenarios and expanded as required.

Figure 1: Example of a photovoltaic system integrated into car park shading

Since the purpose of this report is to identify the space requirements for potential new renewable energy technologies, it will focus on large scale, ground mounted PV systems. It is recommended that the feasibility of incorporating photovoltaics be considered for all new buildings and future major renovations of existing buildings.

4.1 Site Requirements

The following potential sites were identified for large scale, ground mounted PV arrays. Refer to Photovoltaic Array Sites Map in appendix A for the advantages and disadvantages of each site.

Site Name	System Scale	Projected Capacity (MW)	% Annual Electrical Demand	Site Area Available (m^2)	GHG Reduction %	Cost Premium
Car Park 1 (Preferred Site)	District Scale	3.8	7%	20,000	<1%	N/A
Car Park 2	District Scale	2.3	5%	12,500	<1%	-
Car Park 4	District Scale	1.9	4%	10,300	<1%	-
Car Park 5	District Scale	2.0	4%	10,800	<1%	$350k - $550k
Car Park 6	District Scale	2.5	5%	13,500	<1%	$150k - $250k
Car Park 8	District Scale	1.4	3%	7,200	<1%	$150k - $250k

Table 3: Photovoltaic Array Sites

5. HIGH TEMPERATURE HEATING

As previously discussed, UVic currently operates a high temperature district heating system. Integrating other technologies that produce high temperature heat, such as municipal solid waste, biomass and anaerobic digestion (biogas) combustion, therefore offers both the benefit of low carbon technologies and minimizes the need to upgrade existing campus infrastructure.

5.1 Biomass

Biomass combustion involves the burning of biomass fuels (wood chips, hog fuel, wood pellets) to generate hot water that can be used for space heating, domestic hot water etc. These fuels are typically waste wood products from the forestry and agriculture industries and are considered a carbon neutral fuel source. The premise of this argument is that the carbon released in extracting energy from biomass is equivalent to the carbon absorbed by the plant material in its lifetime. Burning fossil fuels, in contrast, releases CO2 that wouldn't otherwise enter the atmosphere.

UVic currently generates 60 tonnes of waste wood each year. This is a very low quantity and would be able to meet less than 1% of its annual heating demand. A facility of this size would therefore be considered a demonstration project. In order to operate a district scale biomass plant, the university would need to source biomass fuel from other local sources.

Figure 2: Example of biomass fuel

5.2 Anaerobic Digestion

Anaerobic digestion is a biological process that utilizes high energy content organic waste (i.e. waste with proteins, fats and sugars) to produce a useable fuel gas called biogas that can be used to power equipment the same as conventional fossil fuels. UVic currently generates approximately 480 tonnes of organic and food waste each year. Based on this quantity, if relying solely on its own organic waste stream the university would only be able to generate 816 GJ/year of biogas or the equivalent of <1% of its annual heating energy demand. A facility of this size would therefore be considered a demonstration project and would not significantly alter the university's annual fuel demand or greenhouse gas emissions.

In order to use anaerobic digestion to meet a significant portion of the campus's annual heating demand the university would need source fuel from the local community. This could involve a contract with the Capital Regional District of Victoria (CRD), which produces 48,000 tonnes of organic waste each year.

5.3 Municipal Solid Waste

Like biomass combustion, Municipal solid waste (MSW) combustion involves the burning of the combustible portions of MSW to generate hot water for space heating, domestic hot water heating etc. UVic currently generates 660 tones of MSW each year. At this rate the university would be able to generate 1,800,000 kWhs of thermal energy each year. This is approximately 3% of its annual heating demand. A facility of this size would therefore be considered a demonstration project and would not significantly alter the university's annual fuel demand or greenhouse gas emissions. In order for MSW combustion to meet a significant portion of the campus's annual heating demand the university would need to source fuel from the local community.

It's important that, unlike biomass combustion, there is significant debate about whether or not MSW combustion should be considered a renewable fuel source and if so under what circumstances. As such Table 4 refer to the estimated GHG emissions reductions from using either biomass or anaerobic digestion as fuels sources.

5.4 Site Requirements

Biomass, anaerobic digestion and MSW combustion systems all require larger site areas than conventional fossil fuel systems. While the plantroom area required is similar, these technologies also require fuel storage, handling and in the case of anaerobic digestion processing space. Fuel transportation also needs to be considered, with fuel typically delivered to site by truck. For these reasons biomass, anaerobic digestion and MSW facilities are ideally located on major roads.

As shown in the University of Victoria Biomass, Natural Gas and MSW Sites Map (see Appendix A), the following potential sites for district scale and demonstration biomass, anaerobic digestion and MSW plants are:

Site Name	System Scale	Projected Capacity (MW)	% Annual Heating Demand	Site Area Available (m^2)	GHG Reduction %[1]	Cost Premium
Biomass/MSW/Anaerobic Digestion Location 1	District Scale	4	67%	1,200	47%	$1M - $1.5M
Biomass/MSW/Anaerobic Digestion Location 2	District Scale	4	67%	1,200	47%	$600k - $850k
Biomass/MSW/Anaerobic Digestion Location 3 (Preferred Site)	District Scale	4	67%	1,200	47%	N/A
MSW Location 4	Demonstration Plant	0.2 (200kW)	3.5%	600	-	-
MSW Location 5	Demonstration Plant	0.2 (200kW)	3.5%	600	-	$1M - $2M
Biomass/Anaerobic Digestion Location 4	Demonstration Plant	0.025 (25kW)	<1%	600	<1%	-
Biomass/Anaerobic Digestion Location 5	Demonstration Plant	0.025 (25kW)	<1%	600	<1%	$1M - $2M

Table 4: Biomass/Anaerobic Digestion/MSW Plant Sites

[1] Refers to the predicted GHG emissions reductions from using either Biomass or Anaerobic Digestion.

6. LOW TEMPERATURE HEATING

6.1 Geoexchange

Geoexchange (GHX) heat pump systems use the constant temperature of the earth as a heat source/sink to generate low temperature heating water. As an electrically powered system, meeting a building's annual heating demand with a GHX heat pump system will result in significantly less greenhouse gas emissions than a traditional natural gas heating system. They can also be installed beneath buildings or parking structures offer an advantage over other technologies.

While GHX systems utilize a naturally occurring, carbon neutral energy source, they typically require large amounts of land in order to generate significant amounts of thermal energy. The Integrated Energy Master Plan found a GHX field of 20,000m2 would be needed in order to meet the campus's base load heating demand alone. It's important to note, however, that GHX is a scalable technology that can be installed in stages in tandem with the construction of new buildings.

Figure 3: Installation of GHX Borehole Field

6.2 Enterprise Data Centre – Waste Energy Recovery

Similarly to GHX systems, data centres can also be a source of low temperature heating. Data centres typically have high cooling loads and reject significant amounts of low grade waste heat. If this heat can be captured it can be used to provide space heating and make up air heating to other buildings.

6.3 Site Requirements

While both GHX systems and heat recovery from the Enterprise data centre offer significant GHG emissions savings for UVic, it's important to remember that both can only generate low temperature heating water. UVic currently operates a high temperature district heating system. In order to utilize either technology significant upgrades to the existing district heating system and buildings, or the construction of a new low temperature district heating system would be needed.

As shown in the University of Victoria Geoexchange and Heat Recovery Sites Map (see Appendix A), the following potential sites for GHX and heat recovery plants are:

Site Name	System Scale	Capacity (MW)	% Annual Heating Demand	Site Area Required (m^2)	GHG Reduction %	Cost Premium ($)
Heat Recovery/ GHX Site	Demonstration Plant	Heat Recovery 0.3 GHX System 0.34	Heat Recovery 12% GHX System 3%	HR Plantroom 200 GHX Heat Pump Plantroom 200 GHX Field 1,700	10%	Low Temperature District Heating System $1M - $2M
GHX Site – 2	District Scale	4	67%	GHX Heat Pump Planntroom 200 GHX Field 20,000	21%	Connecting to Existing District System $250k - $500k

Table 5: Heat Recovery and GHX Sites

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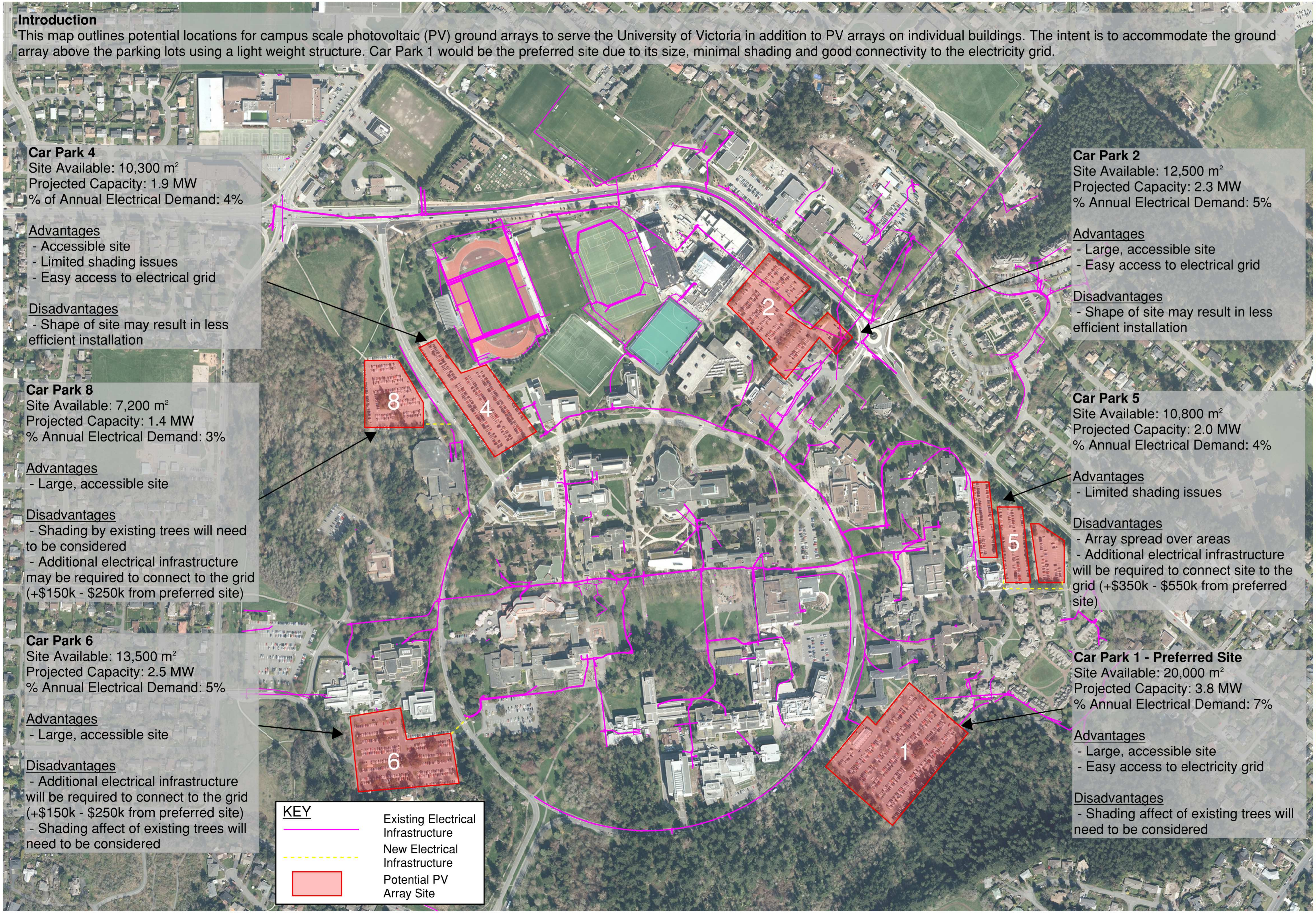
APPENDIX A – CAMPUS RENEWABLE TECHNOLOGY MAPS

Introduction

This map outlines potential locations for campus scale photovoltaic (PV) ground arrays to serve the University of Victoria in addition to PV arrays on individual buildings. The intent is to accommodate the ground array above the parking lots using a light weight structure. Car Park 1 would be the preferred site due to its size, minimal shading and good connectivity to the electricity grid.



Car Park 4
Site Available: 10,300 m²
Projected Capacity: 1.9 MW
% of Annual Electrical Demand: 4%

Advantages
- Accessible site
- Limited shading issues
- Easy access to electrical grid

Disadvantages
- Shape of site may result in less efficient installation

Car Park 8
Site Available: 7,200 m²
Projected Capacity: 1.4 MW
% Annual Electrical Demand: 3%

Advantages
- Large, accessible site

Disadvantages
- Shading by existing trees will need to be considered
- Additional electrical infrastructure may be required to connect to the grid (+$150k - $250k from preferred site)

Car Park 6
Site Available: 13,500 m²
Projected Capacity: 2.5 MW
% Annual Electrical Demand: 5%

Advantages
- Large, accessible site

Disadvantages
- Additional electrical infrastructure will be required to connect to the grid (+$150k - $250k from preferred site)
- Shading affect of existing trees will need to be considered

Car Park 2
Site Available: 12,500 m²
Projected Capacity: 2.3 MW
% Annual Electrical Demand: 5%

Advantages
- Large, accessible site
- Easy access to electrical grid

Disadvantages
- Shape of site may result in less efficient installation

Car Park 5
Site Available: 10,800 m²
Projected Capacity: 2.0 MW
% Annual Electrical Demand: 4%

Advantages
- Limited shading issues

Disadvantages
- Array spread over areas
- Additional electrical infrastructure will be required to connect site to the grid (+$350k - $550k from preferred site)

Car Park 1 - Preferred Site
Site Available: 20,000 m²
Projected Capacity: 3.8 MW
% Annual Electrical Demand: 7%

Advantages
- Large, accessible site
- Easy access to electricity grid

Disadvantages
- Shading affect of existing trees will need to be considered

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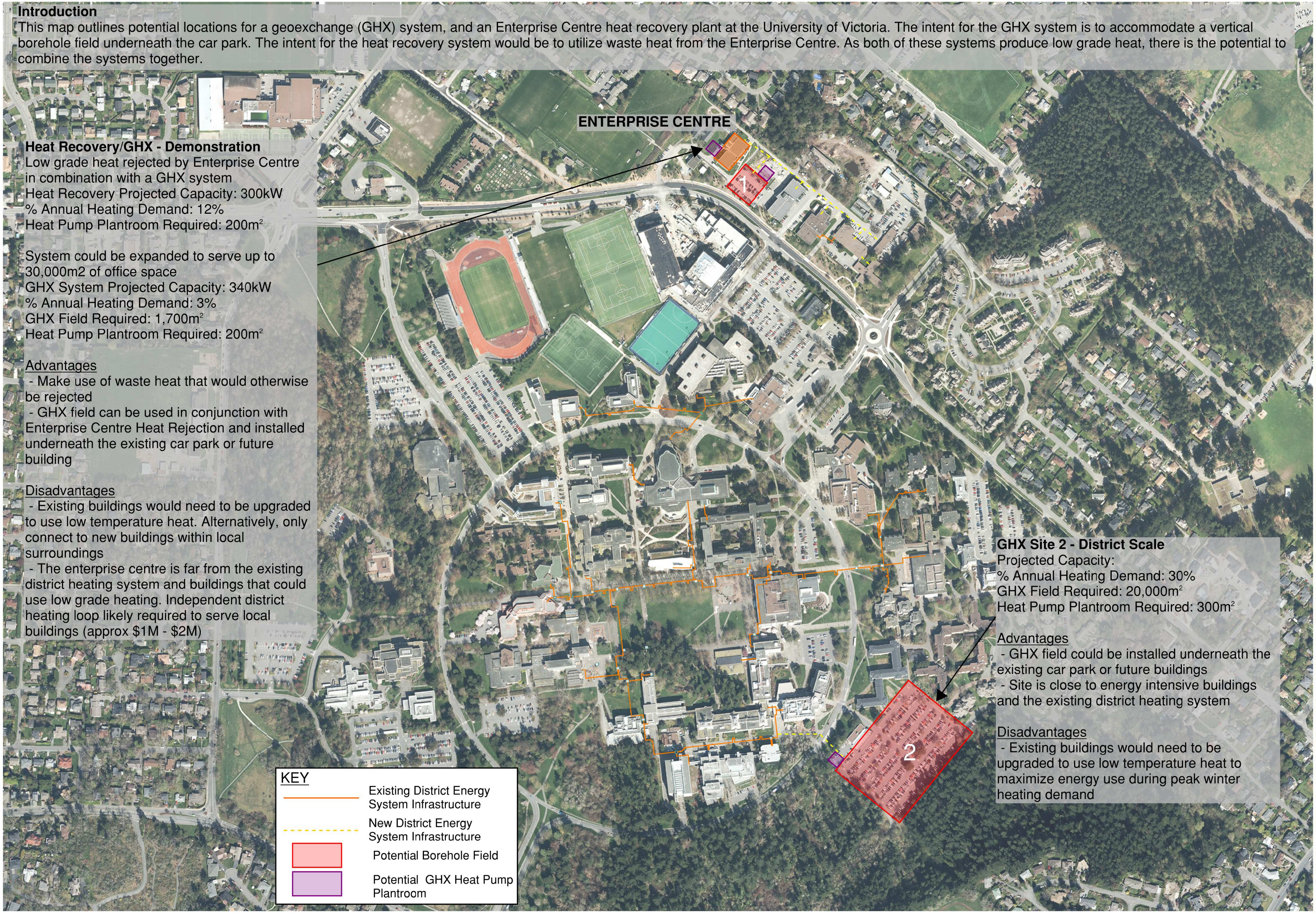
PHOTOVOLTAIC ARRAY SITES

UNIVERSITY OF VICTORIA SUSTAINABLE SITE REQUIREMENTS

DRAWN BY: HT & NB **CHECKED BY:** CD **DATE:** 6/10/2015

Introduction

This map outlines potential locations for a geoexchange (GHX) system, and an Enterprise Centre heat recovery plant at the University of Victoria. The intent for the GHX system is to accommodate a vertical borehole field underneath the car park. The intent for the heat recovery system would be to utilize waste heat from the Enterprise Centre. As both of these systems produce low grade heat, there is the potential to combine the systems together.



Heat Recovery/GHX - Demonstration

Low grade heat rejected by Enterprise Centre in combination with a GHX system

Heat Recovery Projected Capacity: 300kW

% Annual Heating Demand: 12%

Heat Pump Plantroom Required: 200m^2

System could be expanded to serve up to 30,000m2 of office space

GHX System Projected Capacity: 340kW

% Annual Heating Demand: 3%

GHX Field Required: 1,700m^2

Heat Pump Plantroom Required: 200m^2

Advantages

- Make use of waste heat that would otherwise be rejected
- GHX field can be used in conjunction with Enterprise Centre Heat Rejection and installed underneath the existing car park or future building

Disadvantages

- Existing buildings would need to be upgraded to use low temperature heat. Alternatively, only connect to new buildings within local surroundings
- The enterprise centre is far from the existing district heating system and buildings that could use low grade heating. Independent district heating loop likely required to serve local buildings (approx $1M - $2M)

GHX Site 2 - District Scale

Projected Capacity:

% Annual Heating Demand: 30%

GHX Field Required: 20,000m^2

Heat Pump Plantroom Required: 300m^2

Advantages

- GHX field could be installed underneath the existing car park or future buildings
- Site is close to energy intensive buildings and the existing district heating system

Disadvantages

- Existing buildings would need to be upgraded to use low temperature heat to maximize energy use during peak winter heating demand

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GEOEXCHANGE AND HEAT RECOVERY SITES

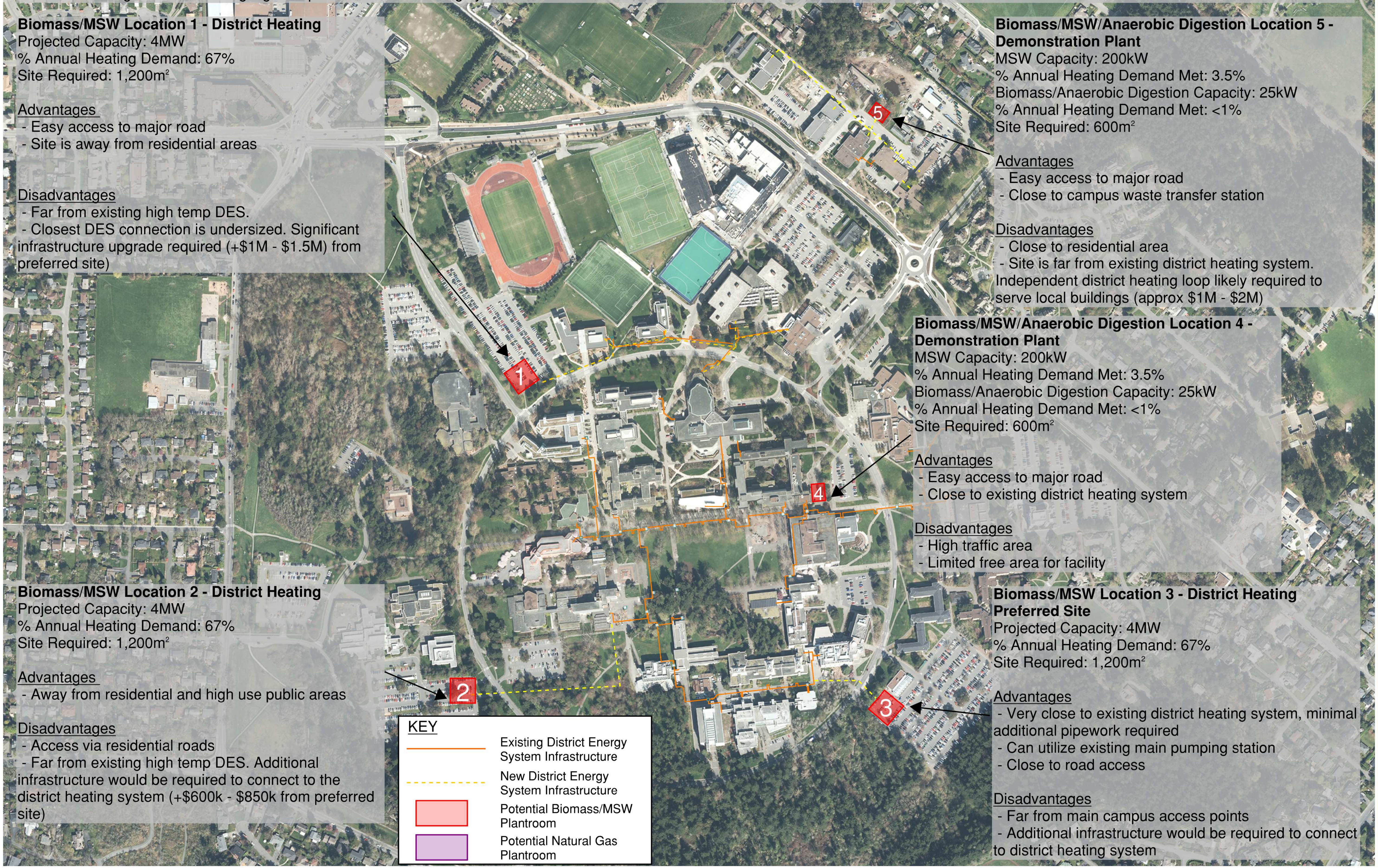
UNIVERSITY OF VICTORIA SUSTAINABLE SITE REQUIREMENTS

DRAWN BY: HT & NB CHECKED BY: CD DATE: 6/9/2015

BIOMASS, NATURAL GAS AND MSW SITES
UNIVERSITY OF VICTORIA SUSTAINABLE SITE REQUIREMENTS

Introduction

The following map outlines potential locations for thermal energy generation plants that utilize combustion to create hot water, including Biomass / SynGas / Municipal Solid Waste plants for the University of Victoria. Two potential plant types have been identified: plants sized to provide district heating and demonstration plants. The intent for the district scale plants is to meet a significant portion of the campus's annual heating demand. The demonstration plant would showcase renewable technology and promote research. Biomass/MSW Location 3 is the preferred site due to it's proximity to energy intensive buildings and the existing high temperature district heating system.



Biomass/MSW Location 1 - District Heating
Projected Capacity: 4MW
% Annual Heating Demand: 67%
Site Required: 1,200m²

Advantages
- Easy access to major road
- Site is away from residential areas

Disadvantages
- Far from existing high temp DES.
- Closest DES connection is undersized. Significant infrastructure upgrade required (+$1M - $1.5M) from preferred site)

Biomass/MSW/Anaerobic Digestion Location 5 - Demonstration Plant
MSW Capacity: 200kW
% Annual Heating Demand Met: 3.5%
Biomass/Anaerobic Digestion Capacity: 25kW
% Annual Heating Demand Met: <1%
Site Required: 600m²

Advantages
- Easy access to major road
- Close to campus waste transfer station

Disadvantages
- Close to residential area
- Site is far from existing district heating system. Independent district heating loop likely required to serve local buildings (approx $1M - $2M)

Biomass/MSW/Anaerobic Digestion Location 4 - Demonstration Plant
MSW Capacity: 200kW
% Annual Heating Demand Met: 3.5%
Biomass/Anaerobic Digestion Capacity: 25kW
% Annual Heating Demand Met: <1%
Site Required: 600m²

Advantages
- Easy access to major road
- Close to existing district heating system

Disadvantages
- High traffic area
- Limited free area for facility

Biomass/MSW Location 2 - District Heating
Projected Capacity: 4MW
% Annual Heating Demand: 67%
Site Required: 1,200m²

Advantages
- Away from residential and high use public areas

Disadvantages
- Access via residential roads
- Far from existing high temp DES. Additional infrastructure would be required to connect to the district heating system (+$600k - $850k from preferred site)

Biomass/MSW Location 3 - District Heating Preferred Site
Projected Capacity: 4MW
% Annual Heating Demand: 67%
Site Required: 1,200m²

Advantages
- Very close to existing district heating system, minimal additional pipework required
- Can utilize existing main pumping station
- Close to road access

Disadvantages
- Far from main campus access points
- Additional infrastructure would be required to connect to district heating system

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