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Renewable Power Generation Conceptual Plan for Ogden Point, Victoria

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Synopsis

This report examines, with a 5, 10, and 20-year outlook, the potential for renewable energy generation at Ogden Point using solar, wind, tidal, wave, ocean-thermal, biomass, and geo-exchange technologies, based on available information. Consideration was given to capital and operational costs, implications for master planning, emissions of greenhouse gases (GHGs) and conventional air pollutants; discussion of other considerations relevant to stakeholders is included.

It was found that solar, geo-exchange, and biomass are likely viable energy technologies for this site over the time period considered, and that wind, tidal, wave, and ocean-thermal are not. Geo-exchange has significant potential to provide economically competitive space heating and domestic hot water. Further information about what will be built on site is required to undertake a more detailed assessment; it is recommended that such assessments be integrated with master planning efforts going forward. Solar photovoltaic panels (PVs) are not currently competitive from a financial perspective, but if current trends of increasing energy costs and decreasing technology costs continue it will become viable in the next 10-20 years. It is recommended that master planning incorporate “future-readiness” so this technology can be taken advantage of in the future. Biomass is very attractive from a technical and financial perspective, but it has the potential for other significant concerns on this particular site that should be fully considered before the technology is investigated further. Wind energy is technically feasible but the site conditions are marginal and costs would be very high. The other technologies were not thought to be at all viable for this site.

Table 1, below, gives a conceptual overview of the various renewable energy technologies examined in this report. It describes the type of energy they produce (heat, electricity, or both), the potential quantity of energy they could generate on the site (high, medium, or low), cost (with more “$” symbols indicating the total expected costs are higher), the timeline over which the technology may become feasible, and the degree of other potential concerns for using the technology at this specific site (high, medium, or low). These include aesthetics, noise, and other issues that may be of concern to stakeholders.

Table 1: Technology Summary

Technology	**Energy Type**	**Potential Quantity**	**Cost Magnitude**	**Other Potential Concerns**	**Feasibility Outlook**
Geo-exchange	Heat	Moderate	$$	Low-Moderate	Immediate
Solar PV	Electric	Low-Moderate	$$$$$$ (⇓[1])	Low	10-20yrs
Biomass	Electric & Heat	High	$	High	Immediate
Wind	Electric	Low	$$$$$$$$$$$$$$	Med	Not foreseeable
Tidal	Electric	NA			
Wave	Electric				
Ocean-Thermal	Electric				

If electrical energy were to be generated on site it would likely be most appropriate for this power to be sold to BC Hydro through the Standing Offer Program. Also considered was the potential for renewable energy infrastructure to be used as the source of power for cruise ships, should shore power infrastructure be developed. Due to the enormous energy demand of the ships relative to the capacity to generate power on site, and the intermittency of this demand (and in most cases supply), attempting to use renewable energy generated on site to power ships would be impractical.

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[1] The ⇓ symbol indicates that the price of this technology is rapidly declining

Plan Overview and Objectives

This report examines the potential for renewable power generation at Ogden Point with a 5, 10, and 20-year outlook. It addresses the potential for a broad range of renewable energy technologies including solar, wind, tidal, wave, ocean-thermal, biomass, and geo-exchange. Each was assessed to determine whether it was likely to be a good fit for Ogden Point given the site conditions and available technology. While this assessment is intended to be at a conceptual level, more detailed information has been presented where available.

Capital and operational costs, and potential for energy production, were estimated based on available information. The quantity and timing of energy production, and the ability to make use of this energy on or off-site, is also discussed. From this information, and assumptions about equipment life, and discount and escalation rates, levelized energy costs were determined. This allowed for a comparison to energy prices to ascertain whether potential revenues (or savings) made renewable energy technologies attractive from a financial perspective. Considerations of potential issues for larger site planning are also discussed. Master planning efforts are already well underway at Ogden Point, though it is not yet known what will be built. This report provides guidance to inform the planning process and maximize the chances that renewable energy can be incorporated into site development in both the short and long term.

Renewable energy solutions were also considered in light of their implications for GHG emissions and air quality. While a true “triple bottom line” assessment is beyond the scope of this report, other considerations for renewable energy technologies are discussed where appropriate. These include aesthetics, noise, and other potential stakeholder concerns. The report provides guidance to the Greater Victoria Harbour Authority (GVHA) that will help them make decisions about renewable energy going forward. The level of effort (and cost) that would be required to do a complete assessment of all potential renewable energy strategies would be prohibitive. This report provides GVHA direction on where to focus limited resources when undertaking more detailed analysis and planning efforts so there is maximum chance of success.

Planning Process

This report was prepared by Jordan Fisher and Associates Ltd. (JFA) in collaboration with EA Energy Alternatives Ltd. (EA) and the Sustainable Systems Design Lab, Institute for Integrated Energy Systems at the University of Victoria (UVic). Jordan Fisher, of JFA, was the prime consultant overseeing the project. EA, led by Kevin Pegg, provided wind and solar analyses and a variety of background information. UVic provided comparative wind and solar analyses and a variety of information on other technologies. Eric Hoevenaars conducted this work under the supervision of Dr. Curran Crawford. Hummingbird Urban Biomass Ltd. provided information on biomass systems and related costs and revenues. JFA conducted background research, supervised the technical analysis, synthesized all information, conducted the financial analysis, and produced the report.

JFA began by working with GVHA to define the scope of the report and the process used to produce it. It was originally planned that this project would be completed in conjunction with master planning efforts, though due to delays in those efforts the consulting team was unable to participate as part of the larger master planning team. Specific information was not yet available regarding what will be built on site so a more generalized approach was used where necessary. This report can inform future planning efforts and it is recommended that as the master planning process moves forward an integrated planning, design, and management process be used to ensure renewable energy (and other) considerations are effectively integrated.

Trends in Renewable Power Generation

Renewable Energy has been of increasing interest to a wide variety of energy users in part due to concerns about a broad range of environmental impacts associated with non-renewable energy (e.g. fossil fuels), including GHGs and air pollutants. Increasing demand for energy both locally and globally, and the limited availability of new energy sources, has resulted in increasing energy costs, a trend that is expected to continue.

BC Context

The BC Energy Plan, released in 2007, features 55 policy actions to address climate change and energy security. BC also established a new Innovative Clean Energy Fund to help develop clean and renewable energy technologies for British Columbians in areas such as solar, geothermal, tidal, wind, and bioenergy.[2] BC Hydro's Bioenergy Call for Power focuses on converting biomass into clean, cost-effective and carbon-neutral electricity. In 2007 the BC Government also announced a commitment to reduce province-wide GHG emissions to 33% below current levels by 2020 and 80% by 2050. Known as Bill 44, the Greenhouse Gas Reduction Targets Act[3] legally binds the Province to achieve these ambitious targets. Since that time, the BC Government has begun to develop plans and policies that will require and support all sectors of the province to contribute to this commitment.

At current levels BC already uses more electricity than it produces, requiring costly energy imports from other regions to satisfy 10-15% of electric needs. The BC Energy Plan mandates energy self-sufficiency by 2016. With energy demand projected to grow between 20-40% over the next 20 years, it is clear that a reduction in energy use and the development of new sources of energy are high priorities.[4]

Energy prices are generally expected to rise rapidly, though they can be difficult to predict, especially over the long term. This is especially true of fossil fuels, as prices fluctuate continually and are affected by a range of global issues that can be hard to foresee. Electricity prices are regulated in BC and somewhat easier to predict, at least in the shorter term. In March of this year BC Hydro announced plans to increase rates by about 10%/year over the next five years, though the Province has challenged this and

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[2] The BC Energy Plan. http://www.energyplan.gov.bc.ca/

[3] Greenhouse Gas Reduction Targets Act (2008). http://www.env.gov.bc.ca/epd/codes/ggrta/

[4] Forecasting Growth, BC Hydro.
http://www.bchydro.com/planning_regulatory/meeting_demand_growth/forecasting_growth.html

it is currently uncertain exactly what will happen to rates. Nonetheless, it is reasonable to expect that in the coming years rates will increase significantly.

There is often a perception that the cost of renewable energy will decrease significantly in the near future. This may be true in some circumstances, though this notion often does not account for the fact that energy infrastructure costs are not just made up of technology that is continuously improving, but also raw materials (e.g. concrete, steel, copper) and soft costs (e.g. engineering, permitting), all of which are increasing. Of all the renewable technologies being considered solar photovoltaic panels (PVs) are most likely to see significant cost decreases. This technology is rapidly evolving and the panels themselves, which have dropped in price roughly 50% since 2007, make up a large portion of total system costs. Despite this, PVs are still very expensive relative to today's energy prices, but given that energy costs are increasing while PV costs are decreasing there is growing interest in designing buildings to be capable of easily incorporating PVs in the future.

In contrast to PVs, wind turbines are a fairly mature technology. While there is room for innovation, the cost of raw materials has gone up and turbine prices have actually increased slightly in recent years. As described in the Wind Energy section of this report, a large portion of costs for small wind sites relate not to the turbines themselves but to the associated infrastructure and soft costs. Geo-exchange and biomass technology are also improving, though these too have significant material and soft costs associated with their infrastructure. Nonetheless these technologies are seeing rapid uptake, as they can be very cost competitive and reduce reliance on fossil fuels.

There is an increasing trend towards better monitoring of energy use and production, which enables organizations to use energy more efficiently and make more effective use of renewable energy systems. While energy efficiency is not part of the scope of this report, no discussion on renewable energy would be complete without noting that the first priority should always be to maximize efficiency through good design and efficient equipment. Simply put, it is generally much cheaper to save energy than to produce it. It is highly recommended that an integrated design process be utilized as planning moves forward to ensure efficient and effective solutions are developed.

Solar Energy

Solar energy can be harvested in a number of ways, though the most common type of energy generation involves the use of photovoltaic panels (PVs). These panels are sometimes arranged in large "farms" to create power stations, and are often used on building rooftops for smaller scale generation. For the purposes of this report, a rooftop application of PVs is considered.

Solar panels have the advantage of not requiring any input of materials during their operation (unlike biomass). They have no moving parts (unless more complex systems that rotate the panels to track the sun are used), and therefore have relatively low operation and maintenance requirements. They do not produce any GHG or air pollutant emissions in their operation. They produce no noise and are not generally considered to present aesthetic issues. These are all characteristics that make PVs an attractive option for renewable energy. Figure 1, below, shows an example of a rooftop PV array.

Figure 1: Rooftop PV Array

Analysis was done to estimate the potential for solar generated electricity at Ogden Point. First, modeling was done based on resource data obtained from the NASA Surface Solar Energy Data Set[5], which estimates the amount of solar energy falling on the site. This allowed for an estimate of the amount of energy that could be produced by PVs. Using assumptions on the capital and operating costs, and a 5% discount rate, a levelized cost of energy per kWh was determined. No cost for the use of the rooftop space (e.g. a lease) is included. This assessment was then compared to a more detailed study that was done in 2007 for a building at a nearby location, The Legislature.

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[5] NASA Atmospheric Science Data Center. Surface Meteorology and Solar Energy. [Online] http://eosweb.larc.nasa.gov/sse/.

The modeling done for Ogden Point suggested that for each 1MWp of PV panels installed, between **1.27 GWh/yr** and **1.42 GWh/yr** can be generated, depending on the derating factor assumed (i.e. losses due to dirt, fog, shading, etc.). Costs were roughly estimated at about **$6.5 million per MWp** including installation. Using First Solar thin film modules, a popular model for PV plants, estimates were made on the amount of energy that could be generated over a given area. These panels have a footprint of 111 W_P/m^2, though they cannot all be placed side-by-side in practice and it was estimated 83 W_P/m^2 would be a more realistic estimate (conventional PV panels would produce more energy per m^2, though would not necessarily be cheaper per kWh). Based on these figures, we can expect generation between 105.8 $kWh/yr/m^2$ and 118.3 $kWh/yr/m^2$ at Ogden Point. Therefore, 1MWp of thin film PVs would occupy about $12{,}000m^2$ of roof area. For comparison, the existing warehouse on the site is approximately $9{,}100m^2$. Based on the above figures, a $5,000/yr operation and maintenance budget (escalating at 2%/year) and a 25 year equipment lifetime, the estimated levelized cost for photovoltaic generated energy on the site would be between **$0.33/kWh** and **$.37/kWh**.

The above figures can be compared with those from the 2007 Legislature study. That study found that for a system with 200kWp of photovoltaic panels about 246MWh/year could be generated. Therefore for each 1MWp, 1.23GWh/yr was expected, which is fairly close to the figures found in this analysis. The installed cost for the Legislature system in 2007 was estimated to be $2 million, or $10 million/MWp. While this figure is substantially higher than the $6.5million/MWp assumed in this study, as noted in the above section on Trends In Renewable Power Generation, the costs of PVs/MWp has been reduced by about 50% since 2007, though this would apply only to the panels themselves and not the installation costs. Given this, the $6.5million/MWp used in this study seems reasonable.

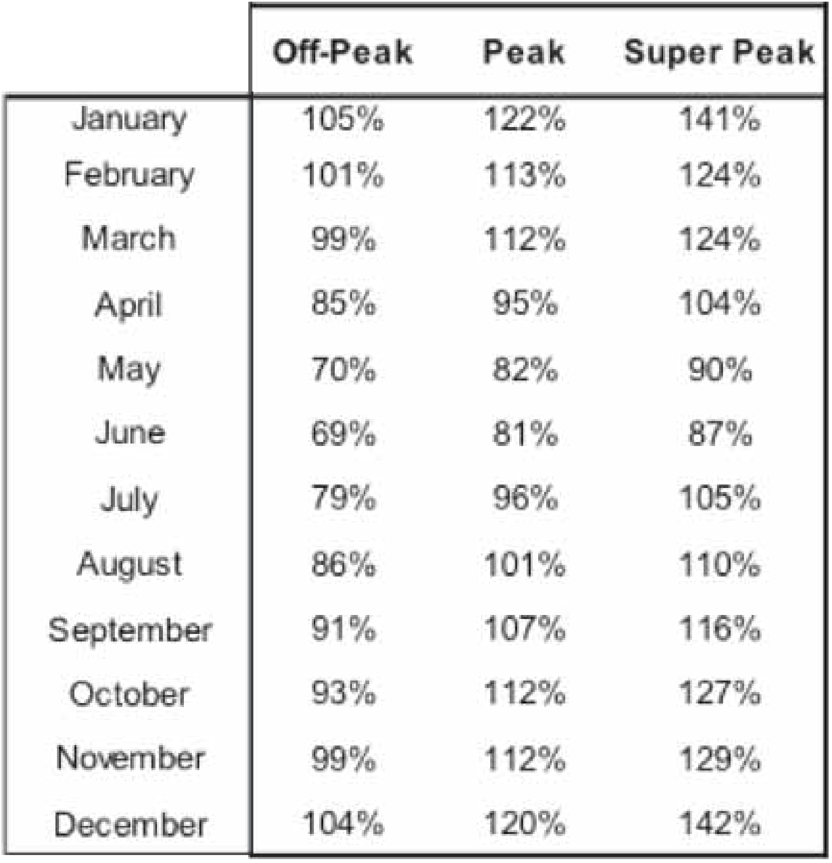
If photovoltaic panels were installed at Ogden Point the energy produced could either be used on site or sold back to BC Hydro. The exact costs of electricity that will be used at Ogden Point in the coming decades are difficult to estimate. Rates depend on the characteristics of the user and much uncertainty remains as to what site uses will be in the coming decades and what the energy use profile of those users will be. To complicate matters further BC Hydro's rates are changing rapidly and are difficult to predict over the long term. Currently, rates for residential users (who pay the highest rates for electricity) are less than $0.09/kWh. Rather than simply using energy on site, another option, with greater financial advantage, is to sell the energy to BC Hydro. Energy can be sold to BC Hydro either through the Standing Offer Program or the Clean Power Call (intended for larger producers). In this situation the Standing Offer Program is likely more appropriate. The Standing Offer Program is described by BC Hydro as follows:

"BC Hydro implemented a Standing Offer Program to encourage the development of small and clean or renewable energy projects throughout British Columbia. The program was developed to streamline the process for small developers selling electricity to BC Hydro, simplify the contract and decrease transaction costs for developers while remaining cost-effective for rate payers. The Standing Offer

Program embodies the principles and policies set out in the BC Energy Plan and the Clean Energy Act."[6]

Under this program energy producers are paid a base price, which is adjusted for the time of delivery and escalates yearly with the consumer price index. Energy delivered during periods of higher demand is purchased at a higher rate than during periods of lower demand. The rates consider the time of day that the energy is delivered as well as the month in which it is delivered. In general, rates are highest in the winter and lowest in the summer, and highest between 4pm and 8pm and lowest between 10pm and 6am. For the Vancouver Island region, the base price for 2010 was $101.25/MWh, or about **$0.10/kWh**. Table 2, below, outlines the off-peak, peak, and super peak rate adjustments from the base price for each month.

Table 2: BC Hydro Standing Offer Program Rate Adjustments



	Off-Peak	Peak	Super Peak
January	105%	122%	141%
February	101%	113%	124%
March	99%	112%	124%
April	85%	95%	104%
May	70%	82%	90%
June	69%	81%	87%
July	79%	96%	105%
August	86%	101%	110%
September	91%	107%	116%
October	93%	112%	127%
November	99%	112%	129%
December	104%	120%	142%

Source: BC Hydro

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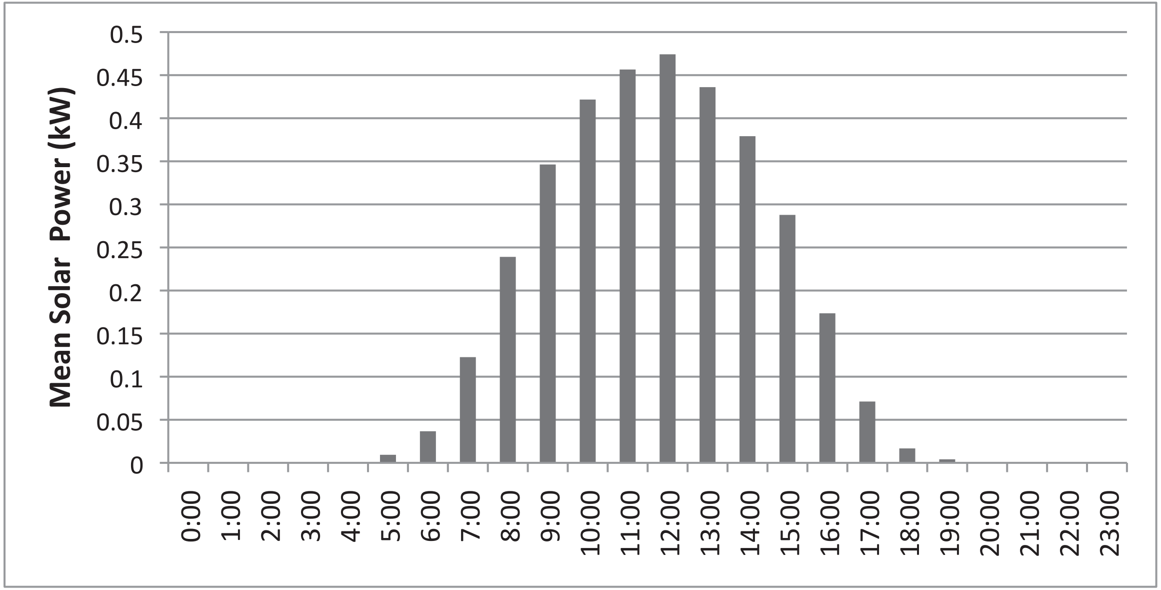
[6] http://www.bchydro.com/planning_regulatory/acquiring_power/standing_offer_program.html

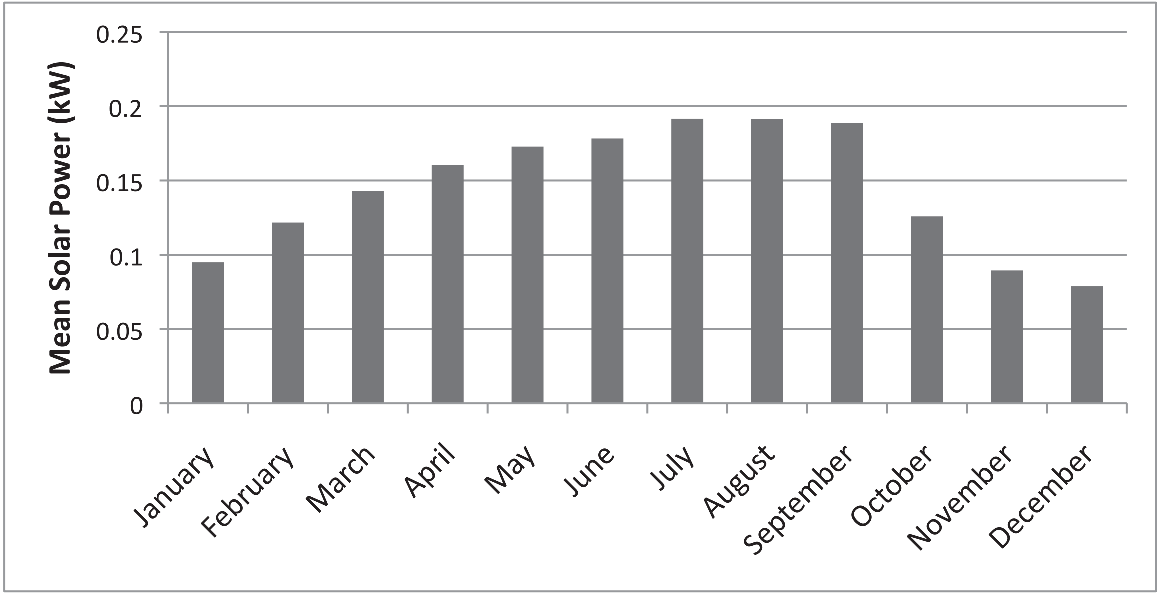
Figures 2 and 3, below, show the diurnal (i.e. daily) and monthly distribution of solar energy on the site.

Figure 2: Diurnal Distribution of Solar Energy



Source: analysis based on data from the NASA Surface Solar Energy Data Set[7].

Figure 3: Monthly Distribution of Solar Energy



Source: analysis based on data from the NASA Surface Solar Energy Data Set[8].

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[7] NASA Atmospheric Science Data Center. Surface Meteorology and Solar Energy. [Online] http://eosweb.larc.nasa.gov/sse/.

[8] NASA Atmospheric Science Data Center. Surface Meteorology and Solar Energy. [Online] http://eosweb.larc.nasa.gov/sse/.

In general, the highest energy production would occur mid-day, and in the summer. Therefore, the time of day when most energy would occur would be during peak hours, with a small amount of energy generated during super peak hours and almost no energy generated during off-peak hours. In contrast, from an annual perspective, the greatest energy production would occur during the summer months, when rates are lower. Detailed analysis to estimate the portion of power that would be generated during each rate period is beyond the scope of this report but could be undertaken as part of a more detailed feasibility study.

It is unknown what pricing may be used for future programs but the 2010 rate for Vancouver Island is about 15% higher than original pricing when the Standing Offer Program was introduced in 2008. The 2010 rate is based on the Clean Power Call. The Clean Power Call is an RFP process and is geared towards larger projects. Given the relatively small size of a PV project one might expect at Ogden Point it is likely that the Standing Offer Program would be more appropriate.

It is clear that the value of grid electricity is substantially less (about 4 times less) that the levelized cost for photovoltaic energy based on *today's* figures. In March of this year BC Hydro announced plans to increase rates by about 10%/year over the next five years, though the Province has challenged this and it is currently uncertain exactly what will happen to rates. Nonetheless, it is reasonable to expect that in the coming years rates will increase significantly and the cost of PV panels will decrease significantly. If both these trends continue it is reasonable to assume that the levelized cost of installing PV panels will become competitive in the foreseeable future. If the value of electricity were to double from where it is today and the cost of photovoltaic electricity were to drop by 50%, this option would become very attractive. So, while photovoltaic electricity production would not be economical today, or in the next 5 years, it may become appealing in the next 10-20 years.

Given the fact that the cost of photovoltaic electricity is not currently competitive, but has a good chance of becoming competitive in the foreseeable future, it is recommended that GVHA incorporate considerations for "future-readiness" into the development of Ogden Point. "Future-readiness" means developing the site and its buildings in a way that will enable the project to more easily adapt to future conditions. From the perspective of PVs, this would mean designing buildings so their rooftops can accommodate solar installations when energy pricing and PV costs justify doing so. Considerations include the placement of mechanical equipment and vents, roof orientation and aspect, connectivity with the electrical distribution system, minimizing shading from other structures, and structural strength. One study done on "solar-ready" strategies noted that the most common reasons for rejecting a building as a candidate for rooftop photovoltaic installations were roof obstructions (40%), bad orientation (25%), and bad roof profile or design (15%).[9] Ensuring that the master planning process effectively integrates these considerations will be critical to future success.

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[9] Bryan, H. et.al, 2010 "Solar Ready Roof: Establishing the Conditions for a High-Performing Solar Installation", American Solar Energy Society National Conference

Wind Energy

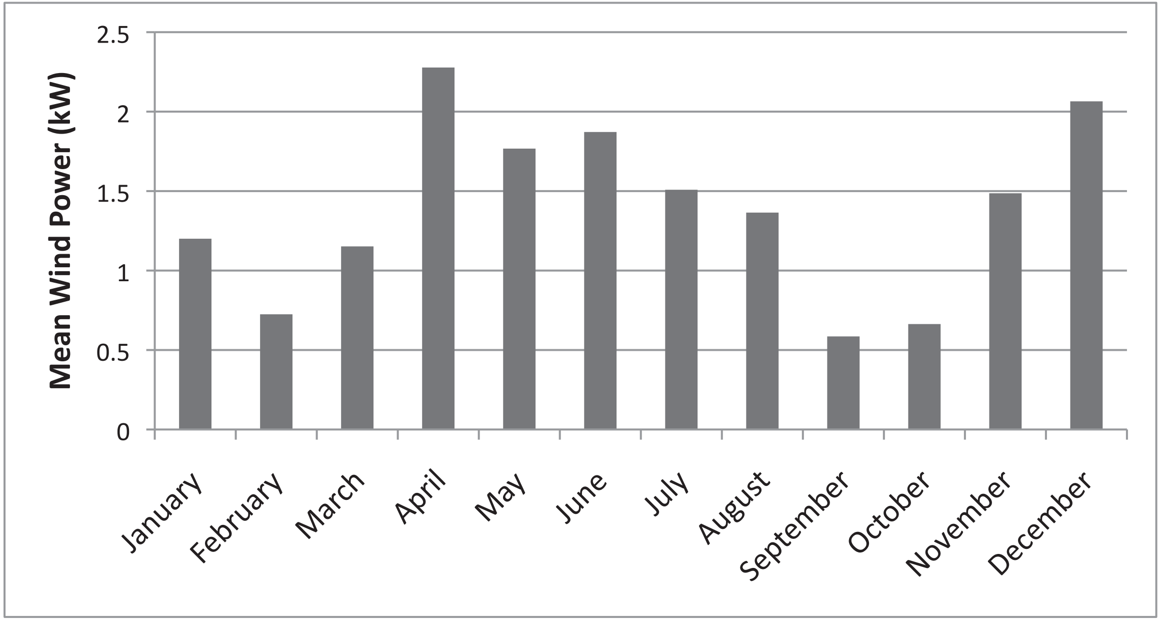
Figure 4: 10kW Bergey Wind Turbine

Wind energy is harvested using turbines, usually placed on top of a pole or tower. Wind turbines are a fairly mature and well-proven technology. They function best in areas with strong, and constant wind. Winds are typically stronger with increased elevation above the ground so wind turbines work best at higher heights. There is debate about the impacts of turbines on the surrounding environment. While they are generally considered to be an environmentally friendly technology, and produce no GHGs or air pollutants in their operation, there are some potential risks to avian life. People in close proximity to wind turbines sometimes complain about noise, and some people find them unsightly, while others welcome them in the visual landscape. Figure 4 shows a picture of a 10kW Bergey wind turbine.

The potential for generating electricity from wind energy at Ogden Point was assessed in two separate analyses, one completed by EA and one by UVic. The analyses were based on data collected by GVHA from sensors at the end of the breakwater at Ogden Point at a height of about 15m. The analyses then estimated the wind speeds at higher heights based on local conditions, as a wind turbine would typically be located at a height in excess of 30m. Based on the wind profile, the amount of energy that could be generated using a 10kW Bergey Excel turbine was estimated. Each study then estimated related costs and, using a 5% discount rate, a levelized cost was determined.

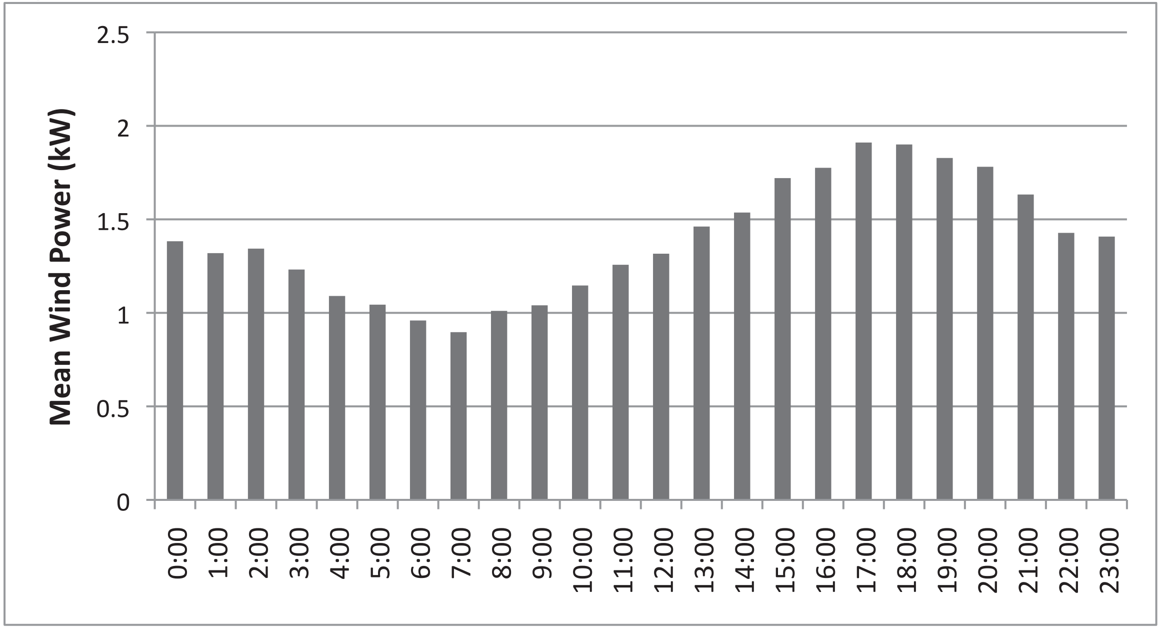
The studies used slightly different methodologies but produced similar results in terms of estimates of energy generation potential. The EA study synthesized wind speeds at 35m, and estimated an average of 4.79m/s. The UVic study synthesized wind speeds at 30m, and estimated an average of 4.99m/s. Figures 5 and 6, below, show the monthly and diurnal (i.e. daily) wind power profiles.

Figure 5: Monthly Wind Power Distribution



Source: analysis based on data from GVHA sensors at the Ogden Point breakwater.

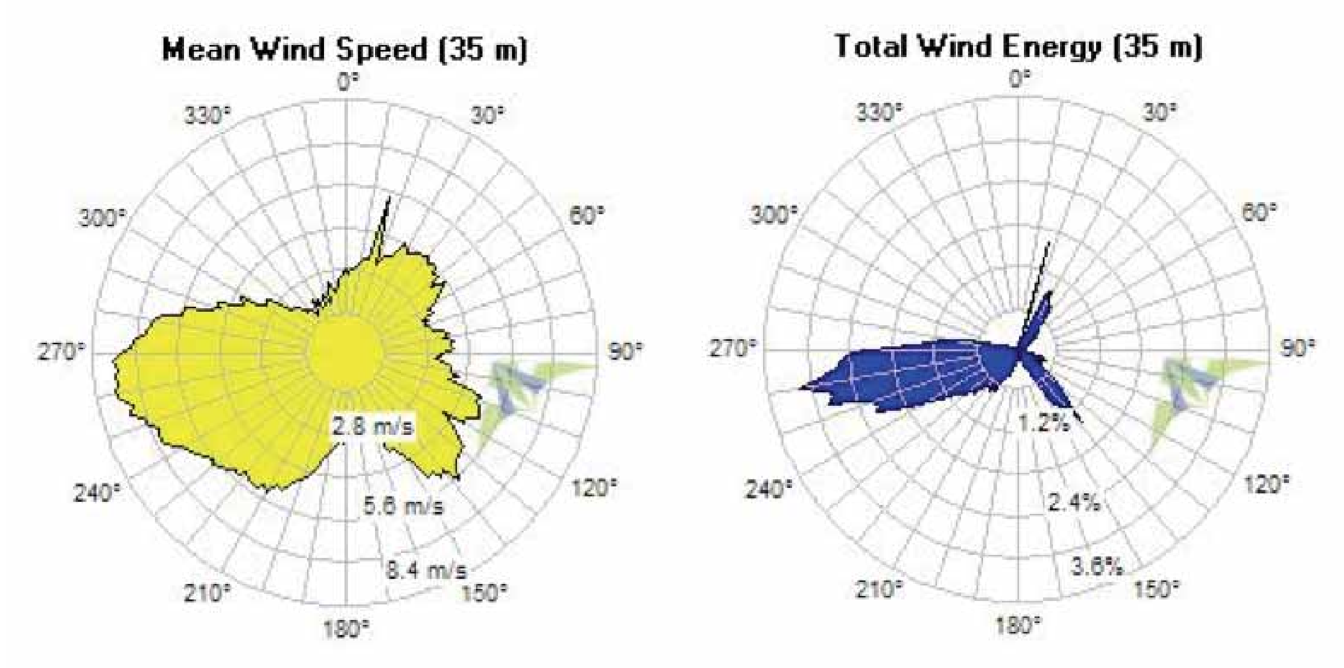
Figure 6: Diurnal Wind Power Distribution



Source: analysis based on data from GVHA sensors at the Ogden Point breakwater.

Wind roses are used to illustrate the direction and magnitude of wind at Ogden Point. Figure 7, below, shows the mean wind speed and total wind energy.

Figure 7: Mean Wind Speed and Total Wind Energy



Mean Wind Speed (35 m)

Total Wind Energy (35 m)

Source: analysis based on data from GVHA sensors at the Ogden Point breakwater.

The site was found to be of marginal quality for wind energy. It has a sufficient wind resource to be technically feasible, but not enough to warrant commercial application. The EA analysis estimated that a 10kW Bergey Excel turbine would produce about **11MWh/yr** of electricity on this site. The UVic analysis estimated that the same turbine would produce about **12MWh/yr**. These differences are relatively small and are likely a result of minor differences in methodology (e.g. how errors or gaps in the data were handled, differences in extrapolating wind speeds with height). Where the studies differed greatly was in their estimates of the installed cost of the turbine. The UVic study estimated that the installed cost would be **$60,000** (including the turbine, the tower, and installation). This assumes that a tilt-up lattice tower would be used, which is a relatively inexpensive tower that is structurally sufficient but generally thought to be less aesthetically pleasing. The EA study estimated that costs would be **$130,000**. This assumes that a more aesthetically pleasing freestanding monopole would be used, which is much more expensive, but thought to be more appropriate for this site. EA also believed a more conservative estimate was appropriate to fully account for costs associated with engineering, wiring, shipping/crating, foundation, crane, permitting, and tie-in to electrical service.

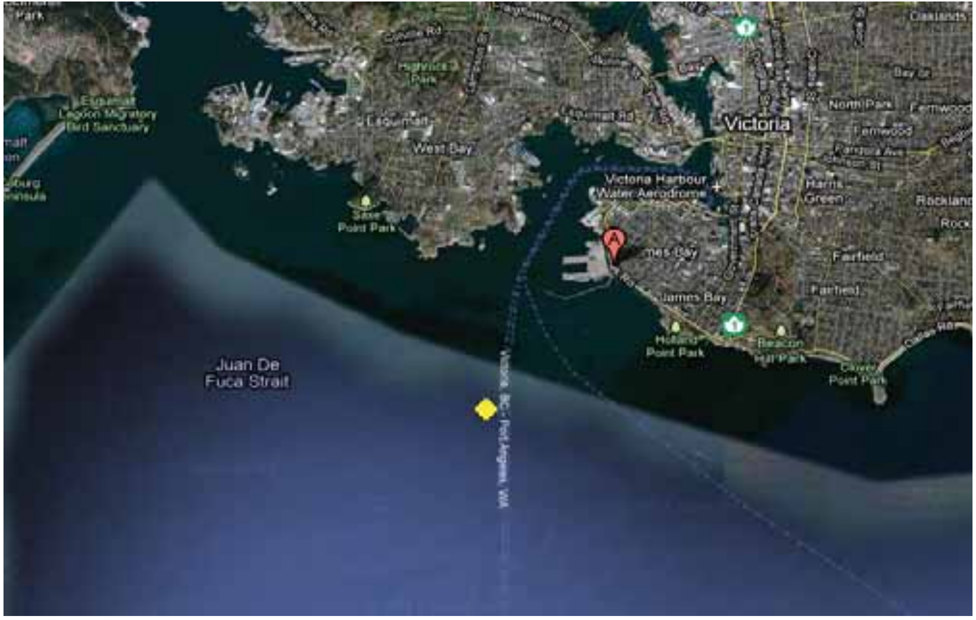
Based on the above figures, and assuming a 25 year equipment lifetime, a $5,000/yr operation and maintenance budget (escalating at 2%/year), the levelized cost of electricity is estimated at **$0.87/kWh** based on the UVic figures, and **$1.42/kWh** based on the EA figures. Even if the figures presented here are overly conservative, the costs are clearly very high. While energy prices are likely to increase, the total cost of installing wind turbines are not likely to decrease as discussed in the section on Trends In Renewable Power Generation. As a result, the site is considered to be a very poor candidate for wind energy both today, and over the next 5, 10, and 20 years.

Tidal Energy

Tidal energy is harvested using turbines that capture energy from the raising and lowering of water levels, primarily resulting from the interplay of the gravitational forces of the sun and moon. Tidal conversion technologies can be categorized as either 'tidal current energy' or 'tidal range energy' systems. 'Tidal current energy' relies on some sort of horizontal or vertical axis turbine concept, with or without ducts. This technology is still in a relatively early stage of development and many designs are in the works by different companies. 'Tidal range energy' uses a similar process as hydroelectric power plants. A barrage separates a tidal bay from the sea, and gates and turbines are installed along the dam. As the sea level changes with the tides, the gates on the barrage are opened when the difference in water level between the two sides of the barrage is sufficiently large. The hydrostatic head causes the water to flow through the turbines turning a generator (this technology would not be applicable at this site).

Tidal current data was obtained from the nearest location available from Fisheries and Oceans Canada[10], south west of Ogden Point, shown in figure 8 below.

Figure 8: Tidal Current Data Location



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[10] Fisheries and Oceans Canada. Pacific Region. [Online] Institute of Ocean Sciences Data Archive. Ocean Sciences Division. [Cited: 03 07, 2011.] http://www-sci.pac.dfo-mpo.gc.ca/osap/data/default_e.htm.

The most recent data (from 1995-1996) provided average and maximum current speeds at different depths during three different time periods, which is illustrated in table 3 below.

Table 3: Current Speeds

Start Date	End Date	Depth (m)	Average Speed (m/s)	Maximum Speed (m/s)
May 6 1995	October 5 1995	35	0.154	0.872
May 6 1995	October 5 1995	55	0.232	0.803
October 5 1995	April 25 1996	34	0.219	0.827
October 5 1995	April 25 1996	54	0.231	0.732
April 25 1996	October 10 1996	27	0.211	0.721
April 25 1996	October 10 1996	47	0.185	0.798

Source: Fisheries and Oceans Canada. Pacific Region. Institute of Ocean Sciences Data Archive. Ocean Sciences Division.

While there is a lot of variability in tidal currents with location, this data was used as a starting point as it was the best data available and the cost of undertaking on-site analysis of currents in locations directly around Ogden Point would be significant.

According to the Research Institute for Sustainable Energy (RISE), peak tidal current velocities below 2 m/s are generally uneconomic[11]. Clean Current's tidal turbine technology has been designed to rotate only when the current velocities exceed 1 m/s.[12] The average current velocity for the best dataset shown above is 0.232 m/s and the maximum velocity from all datasets is 0.872 m/s. Given this, it appears that tidal flow is insufficient to be feasible for energy generation. While it is possible that speeds are somewhat greater immediately adjacent to Ogden Point it believed that it is highly unlikely that conditions would be sufficient to make tidal current energy a viable option. Given these site conditions, it is unlikely that viability will change significantly over the next 5, 10, or 20 years.

Race Rocks, a site approximately 16km southwest of Ogden Point, was home to a demonstration project for tidal energy done in partnership with ENCANA, Pearson College, and Clean Current. In recent discussions with Pearson College (a not-for-profit private school in Metchosin) it was learned that they retained the equipment necessary to measure tidal currents and offered to lend it to GVHA if there was an interest in more detailed analysis of the tidal energy potential of the site. Even if this equipment were obtained at no charge, Pearson College estimated that it would cost at least $10,000 to undertake the analysis. Given the low likelihood of feasibility, and the lack of maturity of the industry, it is not recommended that further analysis be undertaken.

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[11] Research Institute for Sustainable Energy. Tidal Barrage & Tidal Turbines. [Online] [Cited: 03 07, 2011.] http://www.rise.org.au/info/Tech/tidal/index.html.

[12] Clean Current. Clean Current and the Environment. [Online] http://www.cleancurrent.com/technology/environment.htm.

Wave Energy

Wave energy capturing technology is in a very early stage of development. To date, there are only a few pre-commercial installations in the world, with approximately 50 companies working on various concepts, and various associated research institutes and offshore testing centers being set up. Most wave energy conversion technologies are based on a floating structure interacting with incident waves. The most common type resembles a surface-piercing bobbing buoy in appearance, although others are articulated "snake" like devices on the surface, and some are bottom mounted directly interacting with the pressure field of the passing waves. Still other approaches directly harness the kinetic movement of the water particles with some type of fin or rotor, while other at-sea or land-based devices impound the waves and use resulting air pressure in a driven cavity to power a bi-directional turbine. The majority of the concepts however use some type of hydraulic or direct-drive linear electric motor for power takeoff. The lack of convergence in design in the wave energy arena points to the early state of the technology.

As Ogden Point is not exposed to open-ocean swells, the wave energy at the site is limited to locally generated wind waves. The location of Ogden Point near a busy shipping channel and harbor entrance limits the possibilities for floating structure deployment unless a much more detailed study was to be conducted into navigational constraints and/or integration into harbor defense structures. In addition, no readily accessible data source to analyze the resource was available; significant costs would be required to undertake site-specific analysis. It is not believed that wave energy warrants further investigation at this time and it is unlikely to make sense over the next 5, 10, or 20 years.

Ocean-Thermal Energy

Ocean thermal energy conversion (OTEC) is an energy-harvesting concept whereby the temperature differential between ocean surface water and deep waters is harnessed to drive a thermal cycle and produce electricity. Even in the tropics, this temperature differential is on the order of 20-25°C, which is extremely small compared to conventional power plants and hence inherently limits the thermodynamic efficiency theoretically available. In Victoria, the temperature differential is considerably smaller than in the tropics, further limiting possible application of OTEC. As with wave energy, OTEC is only just at the prototype stage, requiring work to maximize efficiency of the specialized Rankine cycles used in the devices to maximize possible energy extraction towards the thermodynamic limits. Additionally, significant challenges remain with respect to biofouling and offgassing of the seawater in the heat exchangers and the large pipes required for water circulation. It is not believed that further investigation is warranted now, and it is unlikely to be a competitive energy source for Ogden Point in the next 5, 10, or 20-years. Note that OTEC is a technology to produce energy from the thermal gradient in the ocean. It is therefore distinct from ocean geo-exchange heat pumps, which can provide heating and cooling functions to buildings, and may be a viable source of renewable energy at Ogden Point at present. This is discussed further under the Geo-Exchange section of this report.

Biomass Energy

Biomass energy is produced from organic material that was recently living. An urban biomass plant would typically run on organic waste such as woody yard and garden waste or organics that are source separated from businesses or households (e.g. food waste). If these organics are left to break down anaerobically in a landfill, they produce large quantities of methane, a greenhouse gas that is approximately 20 times more powerful that $CO_{2.}$ Another potential input for biomass plants are biosolids that are output from wastewater treatment processes. These "biosolids" actually contain a large amount of water and first need to be dewatered before they can be used to generate energy.[13]

Biomass energy plants typically convert their waste inputs into a higher-grade fuel, and then convert that fuel into electricity, heat, or both.[14] This is commonly done using a gasification process, where the waste is converted into "syngas", which is combusted, thus generating heat. This heat can either be used directly for space heating or domestic hot water (e.g. as done in the Dockside Green project in Vic West) or used to drive a steam turbine to generate electricity. If used to drive a steam turbine, some heat can be recaptured and used for space heating or domestic hot water, a process known as combined heat and power (CHP). Some biomass plants can also produce biofuels that can power vehicles, and output fertilizers that can be sold.

This report does not attempt to give a complete description or analysis of all possible options for biomass energy but provides an example of a biomass system that can be used to produce heat, electricity, or both. The figures for capital and operation costs, energy produced, and site area requirements, were provided by Hummingbird Urban Biomass Ltd., a Victoria based company currently working in Phoenix, Arizona. Figure 9, below, provides an overview of their technical process and is based on a plant the company is developing at Arizona State University.

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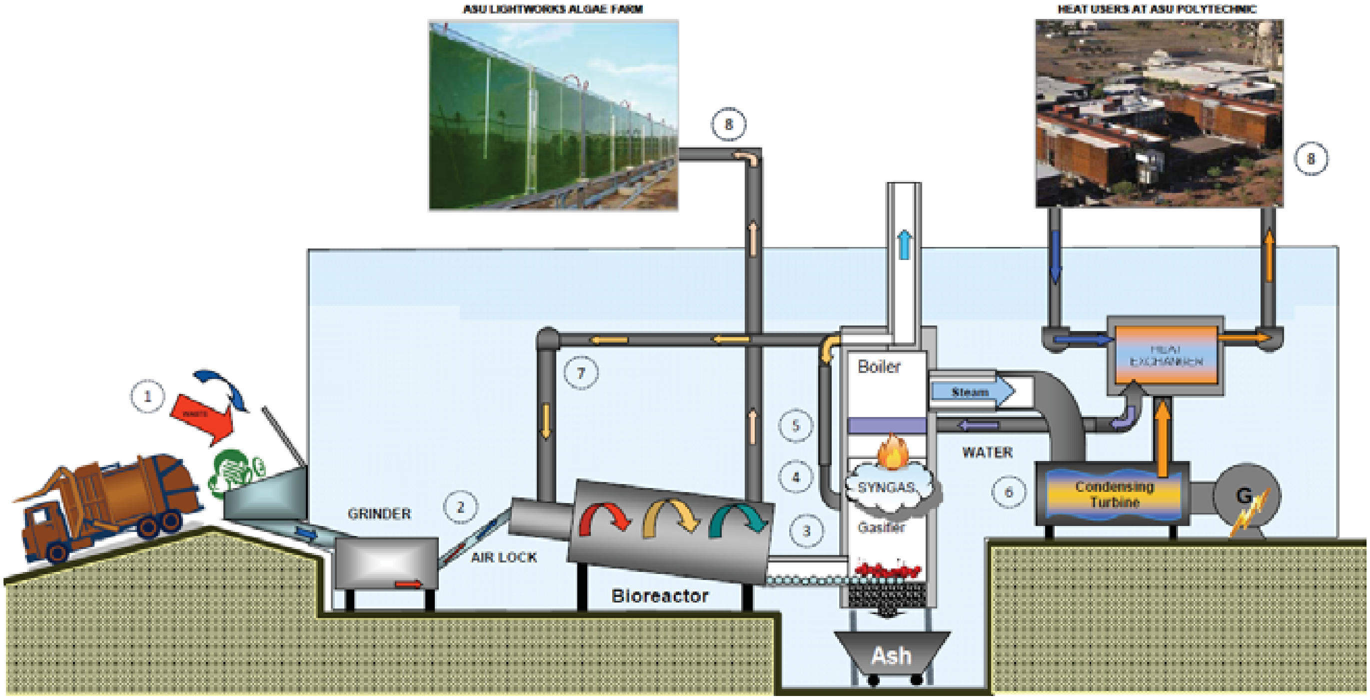
[13] It is interesting to note that the CRD is planning a sewage treatment plant at McLaughlin Point, several hundred meters NW of Ogden Point and the sewage main that will supply that plant will run through the Ogden Point site. The CRD currently plans to transport the biosolids to the Hartland Landfill (approximately 15km road distance from the treatment site) unless another suitable site can be found where these materials could be processed and, ideally, harvested energy could effectively be made use of.

[14] Systems that directly combust organic material to produce energy would also be considered biomass energy, but this report focuses on systems that first convert this waste into a cleaner fuel.

Figure 9: Overview of Hummingbird Urban Biomass Ltd. Biomass Energy Plant



1. Source Separated Organic Waste, in the form of food waste and green yard and garden waste is delivered to the urban biomass facility.

2. The waste is mixed and ground then sent through a bioreactor dryer to create clean, dry, and uniform biomass fuel.

3. This fuel is then fed into a pyrolyzer where it undergoes a state change that generates heat and decomposes the organic material in a matter of minutes.

4. During the decomposition, carbon monoxide and hydrogen gas are produced. These gases (syngas) are safely exhausted from the pyrolysis zone.

5. Additional oxygen is introduced into the syngas in a separate part of the chamber where it combusts at temperatures in excess of 1200 degrees Fahrenheit.

6. The heat is used to generate electricity through a condensing steam turbine.

7. The heat recovered, is available to be used in the drying process inside the bioreactor dryer.

8. Exit flu gas can be used in algae production, and remaining heat can be utilized in a nearby heat loop.

The emissions from such a plant would have a relatively low particulate count. The basic emissions profile based on the type of fixed bed updraft gasifier being used is:

Particulate (mg/m3) = 10
SOx (mg/m3) = 34
NOx (mg/m3) = 17
CO (mg/m3) = 170

Biomass plants of this type perform well from a greenhouse gas emissions perspective. In BC, biomass energy is generally considered to be GHG neutral. If not used to produce energy in the plant the waste would otherwise decompose, thus producing methane.

The figures in this report are based on a plant that produces **1.55MW** of electricity and **4.5MW** of useable heat at a facility that would require approximately 2 acres (including buildings, vehicle access, etc.). For comparison, this is approximately the same size as the existing warehouse at Ogden Point (not counting vehicle access, surrounding site area, etc.). It is assumed that the plant would have 8,000 operating hours per year, producing a total of **12,400 MWh** of electricity and **36,000 MWh** of heat, though it is unlikely that all this heat could be utilized in practice. Such a facility would typically earn the majority of its revenue from tipping fees (i.e. fees paid by people disposing of source separated waste), as well as earning substantial revenue from energy sales.

The plant described here would require approximately **$14 million** in capital costs and **$1.4 million** per year in operations and maintenance costs (escalating at 2%/year). The plant is assumed to have a lifespan of 20 years and, for the purposes of this report, a 5% discount rate is used to estimate the levelized cost of energy. It is important to note that the first set of levelized costs that are presented are based solely on the capital and operational costs of the plant; any revenues from tipping fees would be additional and could be very substantial (tipping fee revenues are accounted for in the second set of levelized costs).

If it is assumed that only electricity were to be produced from such a plant (i.e. none of the heat was utilized) the levelized cost of energy would be about **$0.23/kWh**. This cost is substantially less than the cost of electricity that would be generated by wind or solar energy on this site, though substantially more than the current price of grid electricity. If one assumes that the heat energy is also utilized (e.g. by way of a heat loop that provides space heating and/or domestic hot water), the costs are considerably lower. In order to properly assess the ability for heat energy to be utilized more information is required as to what will be built on the site so that heating loads can be determined. Once site planning is further advanced there will be more certainty in this regard. In addition to on site heating needs, it is possible that some heat could be sold to offsite users if there was a user with such a need and interest in relatively close proximity (i.e. existing or future buildings). For example, Dockside Green's biomass plant provides heat to the nearby, and previously existing, Delta Ocean Pointe Resort.

As mentioned above, it is unlikely that all heat could be used in practice (unless there was a very large user that needed as much heat as the plant could produce year round). For illustration purposes, if 50% of this heat was utilized the total levelized cost of energy of the plant would be under **$0.10/kWh**. If only 25% of heat was utilized the levelized cost of energy would still be under **$0.14/kWh**. As mentioned above, a biomass plant would also have substantial revenues from tipping fees. Hummingbird estimates that these revenues would be above **$2 million/year** (escalating at 2%/year), significantly more than operations and maintenance expenses. Such revenues, if realized, would allow for such a plant to generate substantial profits. Looking at it another way, if one deduced the tipping fee revenues from the sum of the annuitized capital cost and levelized operation and maintenance costs, the resulting levelized energy costs would be extremely low (far lower than BC Hydro's rates). In other words, most of the costs of the plant would be covered by tipping fee revenues leaving a small cost easily justified by the significant energy generation. Viewed in this manner, even if the plant only generated electricity, the levelized cost would be less than **$.03/kWh**. If it also utilized 25% of the available heat the levelized energy cost drops to less than **$.02/kWh**, and if 50% of heat is utilized the figure drops to about **$.01/kWh**.

From a technical and financial perspective, biomass energy has a number of advantages for Ogden Point. It has the potential to generate a substantial amount of "green" energy (with relatively low emissions of air pollutants) and revenue using renewable materials that are essentially waste products. Unlike some other renewable energy technologies (e.g. solar, wind) biomass provides continuous rather than intermittent power output. From a utility's perspective this is very attractive as incorporating large amounts of intermittent renewable energy sources into a grid poses great challenges for balancing loads. Given this, utilities may be willing to pay more for biomass energy than intermittent sources of renewable energy. Therefore, it may be possible for the developer of a biomass plant to negotiate a better rate with BC Hydro than would otherwise be available. The Ogden Point site is of sufficient size to accommodate such a plant and has both road and water access to allow for the delivery of organic materials. The location of Ogden Point is also in close proximity to the planned CRD wastewater treatment plant at McLaughlin Point, a potential source of biomass, with one pipe already planned between the two sites. If this option were considered, master planning efforts would have to account for such a plant in the site layout, though some of the infrastructure could likely be built underneath other uses to maximize site utilization and allow the plant to remain partially hidden from view. It would be possible to build a smaller plant than the one described here, though doing so would lose economies of scale and likely result in significantly higher levelized energy costs.

While biomass has a number of advantages, there are other important considerations. While a complete triple bottom line assessment is beyond the scope of this report, a few considerations are highlighted here. Ogden Point is an established working harbour with a history of uses that include industrial activities, cruise ships, air and marine transportation, etc. At the same time, the site is located within a primarily residential neighbourhood and many residents already have concerns about the amount of noise, odour, traffic, and air quality impacts associated with Ogden Point. For example, the GVHA engaged the James Bay Neighbourhood Association (JBNA) to get their feedback on elements of the master plan that is under development. JBNA recommended that a number of uses be prohibited, such as power generation plants, bulk good transfer/storage, wastewater treatment, as well as a number of other uses, and expressed concern about traffic (including from heavy weight vehicles), noise pollution, etc.

The development of a biomass plant would require a large amount of material to be transferred to the plant, either by ship/barge or truck (or by pipe in the case of biosolids from wastewater treatment). The plant described above would require about 135 tonnes of material per day, equivalent to 6-14 truckloads (depending on truck capacity). Some or all of this material could potentially be barged, though barging has its own challenges (e.g. it must be ensured that no waste materials are inadvertently blown into the water). While biomass technology has come a long way from simple combustion of organic materials, and produces relatively few air pollutants, some stakeholders would likely object to even the cleanest of biomass technologies in this location. While trucking issues would not apply to biosolids piped from a nearby wastewater treatment plant, there would likely be other concerns about such a facility (e.g. potential for odours), even if aesthetic concerns were sufficiently addressed.

Biomass has tremendous potential as a renewable energy source and, in the right location, can be an excellent way to produce “green” energy (and revenue) from waste products, and can perform well with regard to emissions (both conventional and GHG). The nature of the neighbourhood surrounding Ogden Point and stakeholder concerns raise questions about whether this is an appropriate site for such a use and whether requisite approvals are likely to be obtained. If GVHA is interested in investigating biomass energy further it is recommended that these broader issues be fully considered prior to undertaking more detailed technical analysis.

Geo-exchange

Geo-exchange, sometimes called geothermal, involves capturing heat from the surrounding environment and using it to provide space heating or domestic hot water to buildings. Geo-exchange systems can be either closed or open loop. In closed loop systems a water and anti-freeze solution runs through a closed pipe in the ground or a water body and absorbs surrounding heat, which is then transferred into buildings using heat pumps. The pipes can either be horizontal or vertical. Horizontal pipes are typically cheaper but require a large area, whereas vertical pipes require more expensive drilling but a smaller area. Most applications require vertical pipes as there typically isn’t enough area surrounding buildings to meet heating needs. Where possible, heat can be extracted from the water rather than the ground, which avoids drilling costs. This requires that the water body be sufficiently large in order to provide enough heat without significantly changing the temperature of the water body. Open loop systems involve actually drawing water out of the ground or a water body, extracting heat from the water, and then discharging the water back into the environment. The heat pumps use electricity to run but output 3-4 times as much heat energy as they use in electrical energy. This is because they are utilizing the heat energy from the surrounding environment that has been delivered through the pipes. Typically, geo-exchange systems rely on natural gas as a back up and for peak loads, though most of the energy a system uses in a given year can be obtained from the geo-exchange system itself.

Geo-exchange systems can also be used for cooling by running the process in the other direction. In other words, they can use heat pumps to draw heat out of a building and discharge the heat into the environment (this is the same way a refrigerator works). In our climate, most of our energy needs relate to heating rather than cooling, though by using hydronic (i.e. water based) loops in a district geo-exchange system it is possible to transfer heat from users that want to discharge it to those that want to use it. For example, facilities with a lot of refrigeration equipment (e.g. grocery stores) or computer server centers are continuously discharging heat, which could be transferred to nearby users that require space heating in the winter or hot water all year round (e.g. for domestic purposes or swimming pools).

Geo-exchange systems have attracted great attention in recent years as they can provide a very cost effective solution for space heating and domestic hot water, as well as cooling. The exact costs are very situation specific and depend both on the natural site conditions (e.g. ground conditions, accessibility of a water body) as well as the heat loads of the user. Given that it is not yet known what will be built at Ogden Point it is not yet possible to assess heat loads and undertake an analysis of the feasibility of a geo-exchange system, though general guidance can be given at a conceptual level with some reference to other local examples of geo-exchange systems.

The Westhills Development in Langford features a district geo-exchange system made up of a network of vertical wells, though it is designed to accommodate other heat sources in the future. These could include a limited amount of fresh-water heat exchange, heat from a future wastewater treatment plant, or excess heat from buildings connected to the district system (e.g. grocery stores). Currently, the system is entirely used for residential purposes but it is intended to accommodate large amounts of commercial space in the future. The system is operated by Sustainable Services Limited, a private company created for the purpose of operating an on-site renewable energy utility. As the system is privately owned financial information is not available, however, the company provides thermal energy at the same rates that BC Hydro charges for electricity. Given that, it is reasonable to assume that the costs associated with the system are competitive with BC Hydro’s rates. Other private developments also use geo-exchange systems, such as the Aquattro Development in Colwood, which uses vertical wells to heat four-story condominiums. The Sidney Pier Hotel & Spa uses an ocean geo-exchange system. Unfortunately costs for this system were not available for review, though it is reasonable to expect that the capital costs of such a system were lower than costs would have been to drill vertical wells. The District of West Vancouver is investigating a large ocean geo-exchange system to provide heating and cooling to municipal buildings and high rises, and is considering partnering with FortisBC to develop it. They anticipate that the system will be more efficient than ground-geo-exchange due to the stable temperature of the ocean. There are also a number of waterfront homes in Vancouver that are using ocean geo-exchange systems.[15]

Ogden Point’s proximity to the Juan de Fuca Strait suggests there is an opportunity to use an ocean-based geo-exchange system for future development. Such a system could be either open or closed and would benefit from the enormous thermal mass of this water body. Using a closed system could be done

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[15] Seyd, Jane. West Vancouver looks to ocean for heat. [Online] 03 02, 2011. http://www.globaltvbc.com/technology/West+Vancouver+looks+ocean+heat/4372526/story.html.

by submerging coils of pipe, protected using fencing materials, or by using “SlimJim” technology, a plate heat exchanger that can be mounted underneath a pier. For seawater use SlimJims would need to be titanium, as would most equipment used in an ocean application.[16] The Coast Guard Chicago Marine Safety Station installed a 32 ton SlimJim heat exchanger in 2005 to heat and cool their 12,000 ft^2 (1115 m^2) structure.

Open loop systems would require that water be drawn through intake pipes to a titanium heat exchanger and then out through discharge pipe(s). About 160 gpm of flow would be required to produce 200 kW of power.[17] Regulatory criteria would need to be considered in the design stage for specifications such as volume of water intake/discharge, temperature of water discharge, potential pollutants in discharge, dimensions of infrastructure, etc. A Canadian Environmental Assessment Agency screening would be necessary and marine traffic issues would have to be considered.

Another similar option is the use of sewer heat exchange technology. Essentially, this involves using heat exchangers inside sewage pipes to extract heat from raw sewage and transfer it into buildings in the same way as described above. Vancouver’s Olympic Village uses sewage heat exchange to provide space heating. Detailed system costs are not known but the on-site utility provides this energy at $.084/kWh, which is competitive with BC Hydro’s rates. There will be a new sewage main that will carry raw sewage through the Ogden Point site to the CRD’s McLaughlin Point wastewater treatment plant. One challenge may be that in order for wastewater treatment plants to operate effectively the sewage must be above a certain temperature. Given the close proximity of the plant withdrawing too much heat from the sewage prior to it entering the treatment plant may be a concern. Discussions with CRD would be necessary to assess whether this is an option at Ogden Point.

Further investigation would be needed into the above heat exchange technologies to assess feasibility at Ogden Point. If ocean geo-exchange is possible it is expected that this would be of greatest interest out of the three options discussed in this section (heat exchange from the ground, ocean, or sewer main). Investigations should be done in conjunction with master planning efforts and ensure that the heat loads of different development options are considered. While further study is needed, it is believed there is excellent potential for heat-exchange technology on the site. These technologies would not involve unsightly infrastructure, would not have negative impacts on air quality, have very low GHG emissions, and are likely to be very competitive from a financial perspective.

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[16] Personal communication, Aaron McCartie, DEC Design Mechanical Consultants Ltd., January 12, 2011.
[17] ibid

Technology Summary

Table 4, below, gives a conceptual overview of the various renewable energy technologies examined in this report. It describes the type of energy they produce (heat, electricity, or both), the potential quantity of energy they could generate on the site (high, medium, or low), cost (with more "$" symbols indicating the total expected costs are higher), the timeline over which the technology may become feasible, and the degree of other potential concerns for using the technology at this specific site (high, medium, or low). These include aesthetics, noise, and other issues that may be of concern to stakeholders.

Table 4: Technology Summary

Technology	Energy Type	Potential Quantity	Cost Magnitude	Other Potential Concerns	Feasibility Outlook
Geo-exchange	Heat	Moderate	$$	Low-Moderate	Immediate
Solar PV	Electric	Low-Moderate	$$$$$$ (⇓[18])	Low	10-20yrs
Biomass	Electric & Heat	High	$	High	Immediate
Wind	Electric	Low	$$$$$$$$$$$$$$	Med	Not foreseeable
Tidal	Electric	NA			
Wave	Electric				
Ocean-Thermal	Electric				

The technology summary table indicates that biomass energy is likely the most attractive from a financial perspective, has the potential to produce the greatest quantity of energy, and is the only option capable of producing both heat and electricity. Conversely, it has the greatest amount of other potential issues for this site, which may be of significant concern to key stakeholders. Geo-exchange systems can likely produce a moderate amount of energy (heat only) at a relatively low cost, and other potential concerns are likely to be low-moderate in significance. These are unlikely to be a major problem, but there will be considerations for potential environmental or marine transportation impacts of infrastructure that must be evaluated. Solar PV can produce low-moderate amounts of energy (electric only), and has costs that are not currently competitive, but it is reasonable to expect they could become competitive in the next 10-20 years; it is the only viable technology that is also likely to decrease in cost rapidly. Other technologies may also decrease in cost in some respects (e.g. turbines and heat pumps will likely become more efficient), but as a large portion of their costs relate to infrastructure or soft

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[18] The ⇓ symbol indicates that the price of this technology is rapidly declining

costs that are likely to increase over time, they are not likely to experience a decrease in overall costs the way solar PV may. Solar PV also has the advantage of having the lowest number of other potential concerns. PVs have little impact on the surrounding environment, do not make noise, are not generally considered to be an aesthetic issue, do not require a constant input of materials (and the associated traffic), have no odour, etc. Wind turbines can produce a small amount of energy (electric only), but the site conditions are marginal for wind and costs would be very high. Wind turbines likely have moderate other potential concerns; some people find them unsightly, they produce some noise, and there are concerns about some potential impacts for avian life. Tidal, wave, and ocean-thermal technologies (OTEC, not geo-exchange) are not thought to be feasible either because site conditions are not favourable or technologies are not near maturity (or both). While it is always possible that a major breakthrough can be made in any of these technologies at any time, based on the information available, these technologies are not thought to be worthy of further investigation for Ogden Point.

The ability for the energy produced to be used on or off site was also considered. For the heat producing technologies (biomass and geo-exchange) more information is required about what will be built on site to make a proper assessment of heat loads, though there is a good chance that new (and potentially existing) buildings can make effective use of these technologies. System design must be completed in conjunction with site planning efforts. For electricity generating technologies the on-site electricity demand will of course also depend on what is built, but there is the potential to sell this energy to BC Hydro at rates above what consumers pay, so if a significant amount of energy is generated this is likely the preferred option (if only a very small amount of energy were produced one would have to assess whether it was worth the effort of connecting to the grid and entering into an agreement with BC Hydro).

One other issue that has been discussed is the potential for electricity produced on site to be used to power ships while in port, in the event that shore power infrastructure were developed. GVHA did a preliminary study on shore power at Ogden Point, which noted that shore power will significantly reduce air emissions associated with the burning of marine fuels at berth, including reductions in nitrogen oxides (NOx), sulphur oxides (SOx), particulate matter (PM), and volatile organic compounds (VOCs). In addition, when ships use shore power, they are significantly reducing emissions of GHGs. In these respects, shore power would be a great benefit, though the costs would be significant (early estimates suggest costs would be in the range of $10-11 million to upgrade the electrical grid and $5-9 million for shore power infrastructure).[19] GVHA is working towards the creation of a detailed feasibility study that will more fully consider the costs and benefits. The preliminary study did not outline the amount of power that would be used by ships while in berth, but the average electrical load of a cruise ship connected to shore power was estimated at 7MW in a study done on the Port of Los Angeles.[20] For comparison, the highest output of any technology considered in this report is 1.55MW, far less than the draw of even one ship, and there can be up to three ships berthing at any given time. The ships are also only present for a small portion of the year, and while there would only use shore power for an average

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[19] Shore Power For Ogden Point: Pre-Feasibility Study, Greater Victoria Harbour Authority, 2011

[20] Use of Shore-Side Power For Ocean-Going Vessels White Paper (Draft), prepared by Tetra Tech, Inc. for the American Association of Port Authorities, May 1, 2007

of 5.5hrs per call.[21] Due to the sheer magnitude of the ship's energy usage, and the intermittency of this use, one must conclude that attempting to use renewable energy generated on site to power ships would be impractical.

Conclusion

Geo-exchange technologies are likely the most favourable overall, and could produce a significant amount of renewable heat energy. Further investigation into system feasibility, in conjunction with site planning efforts, is highly recommended. Solar PV has a good chance of becoming a viable option in 10-20 years and it is recommended that planning efforts incorporate considerations for "future-readiness" to take advantage of future conditions. Biomass, while very attractive from a technical and financial perspective, has the potential for other significant concerns on this site that should be fully considered before the technology is investigated further. Wind turbines are technically feasible but this site is a very poor candidate for wind energy, costs would be very high, and further investigation is not recommended. The other technologies discussed are not thought to be worthy of further exploration based on current information.

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[21] Shore Power For Ogden Point: Pre-Feasibility Study, Greater Victoria Harbour Authority, 2011