Harnessing low carbon pathways to thermal energy provision: A multi-case study of Metro Vancouver, B.C.

by

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Abstract

This research will explore the drivers and barriers that affect the implementation of renewable fuel sources in thermal energy provision in the Metro Vancouver region of B.C. Through a multi-case study methodology employing a grounded theory approach, district energy systems (DES), and discrete on-site thermal energy solutions (TES) in Metro Vancouver will be examined. The purpose of this research is to explore the economic, ecological, and social imperatives that affect the growth, and choice of fuel sources, of the DESs and TESs that will be analysed. As the population of our larger cities continues to grow, civic policy drivers are striving to build increasingly densified, transit connected urban nodes; innovative DES and TES technologies are an effective means of providing low carbon heat while growing synergistically within their communities. Cumulatively, the effect of carbon abatement by population dense urban centers globally will play a vital role in mitigating the severity of climate change. Through examining the growing low carbon thermal energy industry within Metro Vancouver, this research will extrapolate viable policy options that local governments can implement to encourage the development of locally sourced renewably generated thermal energy.
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Introduction

The climate change imperative

In this new millennium humanity collectively will have no shortage of intractable social and environmental issues to address; our rampant growth both in numbers of shear population and in industrial capacity is beginning to threaten the very biosphere that underpins this growth (IPCC, SPM 1.2, 2014). It is the contention of this researcher, however, that the penultimate issue will be how humanity responds to the ever escalating global crisis of climate change, how quickly our societies adopt new technologies that can arrest this impending climatic disruption will be key to our shared future. It is now a widely accepted fact amongst the vast majority of climate scientists that this alteration of our climatic system is being propelled by humanity, through anthropogenic emissions of greenhouse gases (GHG’s) that are being released, to a large extent, through our profligate burning of fossil fuels, resulting in the carbon loading of the Earth’s atmosphere (IPCC, SPM 1, 2014). Meanwhile, humanity is also undergoing the largest demographic reorganisation in history, with the majority of the Earth’s population shifting from a rural subsistence based agricultural lifestyle that consumes very little energy inputs, to an urban populace striving to raise their living standards, and ergo consuming more energy (UN, world urbanisation prospects, 2014). As these two macro issues evolve, there will be ample opportunity for environmental stressors such as ocean acidification, atmospheric carbon loading, and freshwater scarcity; alongside climate related disturbances that will result in human dislocation due to changing sea levels, drought cycles, and heat waves; to exert enormous strains upon the already fractious and tenuous geo-political balance (IPCC, SPM 1.3, 2014). In order to adapt to these changes within our systems, and mitigate the impacts of this growing influx of urban migrants and climate refugees, technological
innovations must be implemented at the city scale to accommodate the added load that this growth will exert on the already burdened energy systems of our global cities.

Although these very real environmental and social problems can be viewed as a fait accompli, there is nevertheless ample opportunity to make changes in how we interact with our environment through implementing innovative technologies and re-designing the provision of energy and services within our increasingly densified cities. It is in cities where long-term urban planning and energy efficient building codes can facilitate this transition. Part of this transition will involve shifting some of our energy provisioning from an outdated and inefficient energy model whereby large central generating facilities far removed from the load centres transmit energy over vast distances. In a report commissioned by the Quality Energy Systems of Tomorrow (QUEST), and written by Bataille et al. (2010), it was found that, “if all electricity was made in conjunction with industrial heat needs, and industry was within 10km of our commercial and residential buildings, virtually all net industrial and buildings heating energy requirements could be eliminated.” (p.12). It is certainly not the contention of this research that all electricity production infrastructure be moved adjacent to these load centres, that would neither be economically feasible, nor would it be likely to secure the requisite social license; but, it merely illustrates the vast opportunities that are possible in synergizing our energy portfolio. The contention of Bataille et al.’s report is that we must exploit integrated community energy solutions (ICES), this concept effectively speaks to the need to link the capacity of land use decisions and urban planning to influence how we build, and power our urban spaces. Through integrating some energy generation within the cityscape and exploiting synergies between electricity production and thermal needs, by capturing previously wasted heat recovery opportunities, in conjunction with
denser, transit connected or electro-mobile neighborhood hubs or nodes, cities can eventually become carbon neutral, or even potentially carbon sinks (Lund et al., 2014, p.2).

The purpose of this research is to explore the opportunities in further developing our production, transmission, and consumption of thermal energy within our urban areas – please note, for the purposes of this thesis, thermal energy refers to indoor space heating, and domestic hot water, but not indoor air cooling. Herein, emphasis will focus on the current attempts to reduce GHG emissions through incorporating low carbon energy sources that can be sustainably procured in our thermal energy systems. Through examining the growing confluence of district energy systems (DESs), and other discrete on-site thermal energy solutions (TES) in the Metro Vancouver region of British Columbia, this research will seek to extrapolate viable policy recommendations that can enable this sector. Likewise, this analysis will seek to identify any barriers that are retarding, or impeding the continued scaling out of smarter, more efficient thermal energy provision.

Broadly speaking, this thesis intends to identify, and cogently argue for, the need to align our urban development planning objectives, with the energy requirements of our modern cities. More specifically, the finer grained focus will be on how policy can enable, or conversely impede, the scaling out of these thermal energy networks that are more efficient in their generation and transmission, more adaptable to fluctuating energy markets, and more resilient to exogenous perturbations.

By way of illustrating each of the objectives, a case study approach will explore the evolving low-carbon DES and TES sector in Metro-Vancouver. Beginning with an examination of thermal
energy consumption patterns, and the innovative technologies that are revamping them, this research will then trace the development of DESs both domestically and abroad, and outline their merits. Next, focusing in on a local Vancouver perspective, a brief exploration of provincial policies, local energy portfolios, and regional growth strategies continues to build the rationale for why people may want to advocate for, and incent the growth of low-carbon thermal networks.

Through the analysis section, the regulatory regime that governs much of the thermal energy sector will be discussed and explained, next the ensuing market place where these systems must compete for, and secure access to, sufficient customers to make their systems both financially viable, and operationally effective is described. In their striving to achieve these objectives, attention will be paid to how this sector must forge strategic partnerships with municipal governments, as well as the crucial relationship with developers and the general public who ultimately will consume the heat that is transmitted from these systems. Furthermore, analysis will scrutinize how the district energy (DE) sector can increase public literacy of DE, and why it is important to embed these systems within the urban cityscape. Finally, the conclusions of this research will be stipulated, along with several recommendations that highlight how policy decision-makers can effectively remove barriers that are hampering the growth of these low-carbon thermal energy providers.
Methodology

The DE and TESs sectors in Metro Vancouver are developing and expanding, to a large extent, because of public policy drivers that are grounded in the effort to mitigate the effects of climate change. As much of the innovation and use of new technologies in this industry has developed and grown over the last ten years, and could be thought of in its nascent stage of growth, this research seeks to explore and analyse this expansion from the perspective of a multiple case study approach. The case study approach allows the researcher to examine real world issues from a local context, and since this research focuses on policies, events, and actors that are endogenous to the industry in Metro Vancouver, this methodology is appropriate (Yin, 2009). This particular industry has a wide breadth of diversity both in terms of governance structures, as well as diverse technologies that generate the heat, due to these factors, “Every case should serve a specific purpose within the overall scope of inquiry” (Yin, p.47, 2009). Fundamentally, this thesis seeks to examine how and why DE has proliferated in many municipalities of Metro Vancouver in a relatively short time span, and what, if any, barriers are hindering its continued scaling out.

The policy drivers that have stimulated the growth in this industry locally have cascaded down from the Provincial climate change mitigation legislation, as stipulated in the section entitled B.C.’s legislative mandate; but likewise, municipal policies, and even internal organisational goals, have a profound effect on the DESs locally. Due to this diversity of objectives and policies, this research has drawn data from DESs operating in 4 local municipalities: the city of Vancouver, the city of North Vancouver, the city of Surrey, and the city of Burnaby; as well as two Universities: The University of British Columbia (UBC), and Simon Fraser University (SFU). By drawing data from these diverse areas, it is possible to control for, and mitigate any potential irregularities among sites that may skew research
results (Bryman, n.d.). Through drawing data from a spatially diverse area, and interviewing key stakeholders from multiple regimes, along with a thorough document review, it is possible to achieve convergent validation and thereby provide a more rigorous data set (Bryman, n.d.).

**Interview Participants**

In order to solicit interview participants, each respondent was sent a standardized letter of invitation that was approved by the Royal Roads ethics committee. In collecting data, 18 interviews were conducted over a 5 month period using a purposive sampling of critical stakeholders (Collins, Onwuegbuzie and Jiao, 2006). In addition to certain pre-selected interview respondents, a snowball sampling technique was used to query respondents as to other knowledgeable stakeholders who were then invited to participate in interviews (Carter & Little, 2007). All interview respondents were guaranteed anonymity in order to encourage candour, and also because anonymity provided respondents the comfort of knowing that their answers would not impact their professional careers in any way. Another method that was used to build trust and rapport between the researcher and respondents was accommodating face to face meetings, this was accomplished for all but 2 respondents.

In order to account for the diverse technologies and business models deployed in this industry, interview respondents were equally diverse, and were associated with: 7 separate DESs, 3 consulting firms, 2 private utilities, 1 public utility, 2 members of the provincial government, 1 member of the regulatory commission, and 1 representative from an industry association. The respondents collectively represented 4 municipalities, 2 universities, one regional governing body, the British Columbia Utilities
Commission (BCUC) and the provincial government. As previously mentioned, a technique of snowball sampling (Yin, 2009) was used until conceptual saturation (Newing, 2011, p.75) was achieved, this point became self-evident as interview responses became more repetitive and no new data was emerging.

Prior to constructing the research questions an extensive literature review of academic articles was conducted, along with a thorough internet based review of the DE sector in Metro Vancouver, finally this was supplemented by attending a DE trade conference hosted by quality energy systems of tomorrow (QUEST) over a two day period in Vancouver that focussed primarily on DE. Once properly informed, the crafted interview questionnaire comprised a set of 14 questions designed and administered by the researcher. During the interviews, all respondents were provided their own copy of the questions so that they could read and digest them, and have the ease and ability to re-visit them should they have had any supplementary comments. The interviews as such, followed a semi structured pathway, with open ended questions that encouraged emergent themes, and the exploration of tangential commentary. Although all questions were directed at a specific query, at the end of each question was a bold heading that related to the macro-issue at the core of each question, in this way respondents felt comfortable to steer responses in any direction that they felt was appropriate.

With the permission of each respondent, 13 interviews were recorded and subsequently transcribed, while 3 were recorded by the researcher using hand written notes, and 2 respondents who were often inaccessible wrote their own answers to the standardized questionnaire.
Limitations and biases

The research underpinning this thesis is qualitative, and in this way can be affected by researcher or respondent bias, leading questions, and other limitations including time, resources, and researcher knowledge. In order to account for these corrosive tendencies, a wide array of research techniques were used to triangulate data as way of mitigating these influences. According to Bryman (n.d.) these limitations and biases can be mitigated through: data triangulation, in which diverse data sources are exploited, including varied people, settings, and times; investigator triangulation, using more than one researcher; theoretical triangulation, interpreting data from multiple theoretical lenses; and methodological triangulation, in which a mixed methods approach of verifying qualitative data by sourcing quantitative references is used (Bryman, n.d.). In this thesis, data triangulation has been employed extensively to in order to reduce the possibility of bias affecting the research conclusions.

Data Collection and Analysis

As specified, the data set collected included interviews of a robust sampling of key stakeholders; literature review, including, academic articles, web-based searches, and BCUC archives; an industry conference administered by QUEST; and tours of several local DESs. By sourcing a vast repository of diverse information it is possible to achieve convergence and validity from a multiplicity of sources, over prolonged temporal periods, and from a spatially diverse area (Yin, 2009; Bryman, n.d.). By utilising these sources of triangulation, the theories and conclusions that are extrapolated from this data can be accepted as sufficient based upon the tenets of confirmatory evidence (Yin, 2009).
The data collected from the qualitative interviews were analysed from the perspective of grounded theory, in which the researcher revisits the data frequently and builds theories and abstract categories as way of representing, organising, and drawing meaning and conclusions from the data (Charmaz, 2006). Analysis and review of data commenced immediately after the interviews in order to retain and represent the full sensory experience; but it was also reviewed and revisited many times over several months. During this time the data was coded and recoded until a stable and cohesive data set emerged that would be replicable and credible.

**Research Context**

**Thermal energy consumption**

Thermal energy consumption within our built environment presents an opportunity to reduce our GHG emissions both incrementally and cumulatively, and will also allow the re-allocation of higher quality energy to maximize the exergy embedded therein (Bataille et al., 2010). In order to fully grasp this concept one must have a cursory understanding of the second law of thermodynamics, which deals with the degradation of energy through entropy. The term exergy refers to energy and its relationship with its environment, that is to say, in order to maximize the exergy you must exploit the energy to the maximum of its potential (Rosen, 2001, p.208). Using electricity to power resistance baseboard heaters for indoor space heat is akin to a Neanderthal building his fire outside of his cave to cook his meat, rather than bringing the fire inside and exploiting its full utility for providing lighting and capturing its heating potential. Through prioritizing the usage of renewably generated hydroelectricity in B.C., we can
effectively direct this high grade energy towards machines that require electrical power, and exploit a wide array of other feedstocks in order to produce thermal energy to heat and cool our built indoor space (Bataille et al., 2010). Recognizing that using our highest grade of energy to satisfy our most low-grade of energy requirements - that is to say, utilising hydroelectricity to produce in indoor temperature of 22 degrees Celsius - is a critical first step on the path to making wiser decisions about how and where we allocate our primary energy; and we can thereby more fully exploit the exergy embedded in the energy we produce.

District energy systems and other novel thermal energy solutions are an increasingly viable strategy that cities should exploit if they are to direct their high exergy energy to its most appropriate uses, and to meet the challenges of the new millennium (Lund, Möller, Mathiesen, & Dyrelund, 2010). DESs as discussed in this research, are fundamentally producers and transmitters of thermal energy - though it must be noted that DESs very often are utilised in tandem with thermal electricity production in order to capture waste heat opportunities, in systems known as combined heat and power (CHP), however these systems are not utilised locally, and are therefore outside of the scope of this research. DESs, for the purposes of this research, are most often comprised of three main subsystems: a centralised heat generator that can be powered by a variety of fuel sources, an underground piping infrastructure that transmits the heat within the bounded system, and lastly the end consumer of the heat, either residential, commercial or institutional indoor space (Rezaie & Rosen, 2012). The other thermal energy solutions (TES) referred to, generally consist of high efficiency, or renewably generated, single site thermal generating systems that are not interconnected to a broader DE network. The technologies often used by these on-site discrete systems are geo-thermal loop fields, ground source heat pumps, or adjacent waste heat recapture opportunities.
Given that, “Space and water heating account for 60–80% of the energy consumed in the residential, commercial, institutional, and public administration sectors” (Ghafghazi, Sowlati, Sokhansanj, & Melin, 2010, p.1134), efficiencies that can be achieved through DESs: scalability, nodal design principles, innovative renewable fuel sources, and professionally constructed, maintained, and operated systems must be realised (Lund et al., 2014). Furthermore, significant reductions in GHG emissions can be achieved through shifting the energy sources of DESs from fossil fuels such as coal, oil, or natural gas, to renewable fuels like biomass, geothermal heat exchangers, sewer gas heat recovery, or other industrial waste heat recovery opportunities (Dalla Rosa, Boulter, Church, & Svendsen, 2012). In jurisdictions that produce electricity from combustion, there are vast opportunities to recapture the resultant waste heat and transmit it through a DES, or even to leverage a city’s steady production of solid waste through incineration, waste heat recovery, and its subsequent transmission (Dalla Rosa et al., 2012). Through using these renewable fuel sources or cogeneration opportunities in large scale DESs, or even in onsite discrete renewable energy systems, GHG emissions in cities can be significantly reduced through displacing the traditional model of onsite fossil fueled thermal energy generation within the majority of built indoor space.

Many countries globally have taken a leadership role in extensively implementing DESs as a means to mitigate GHG emissions, while also diversifying their energy portfolios; North America, meanwhile, has been slow to encourage their expanded use. According to Rezaie & Rosen (2012),

For instance, Sweden has installed a 40 TWh (Terra watt) district heating system which supplied more than half of the heating capacity of the country in 2000 [30]. The percentage of district-heated homes is around 65% in Latvia and Lithuania. Due to use of district energy networks, the use of oil and hydroelectricity has dropped about 10% in Norway. (p.3)
While many Scandinavian and Baltic states source half or more of their thermal energy needs from DESs, many of which are fueled by renewable energy inputs, Canada sources only a paltry 7% of our heating requirements from DESs, and the bulk of these use fossil fuels as their energy source (Rezaie & Rosen, 2012). There are a myriad of reasons why national policy makers in Canada have not actively encouraged the expanded use of renewably fueled DESs, and these range from the low price, abundance, and availability of fossil fuels in our country, to the huge geographically diverse expanse of a relatively small population across Canada (Rezaie & Rosen, 2012). Further exacerbating these national macro issues that hamper the expansion of DE, there is also the reality of the path dependence and technological lock-in inertia that facilitates a status quo approach to energy generation and provisioning (Dale, Newman, 2009). As an explication of the concepts path dependence and technological lock-in, one must bear in mind that energy infrastructure projects are often highly capital intensive, and, as such, energy utilities and their investors are reluctant to adopt new, innovative technologies until they have fully recovered their return on investments, and that the time frames to achieve this are often decades long. At a subnational level, however, there is interest from municipal governments, universities, and even environmentally conscious businesses to expand the use of renewably fueled DESs, since these groups see the opportunity to align themselves with a sustainable, locally sourced, and scaleable technology for space heating requirements.

The Evolution of DE

The fundamental concept behind DE, the centralised production and subsequent distribution of thermal energy through an underground piping network, is not new, nor is it revolutionary; rather, it has been in use since the times of the Roman greenhouses and hot baths (International district energy
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association (IDEA), 2009). These rudimentary systems evolved over the centuries to the point where sprawling DESs were installed in several North American cities in the late 19th century that utilised steam to convey the heat from a generating plant, through the piping infrastructure, to the end consumers (Henrik Lund et al., 2014, p.2). Today, those steam systems that remain are considered to be legacy systems that will be converted to a hot water based delivery medium at the end of their lifecycles. This is because hot water systems operate at significantly lower temperatures and pressures, benefiting in reduced corrosion and risk of explosions within piping networks, but most importantly, the lower input temperatures can facilitate novel lower grade fuel inputs (Lund et al., 2014).

The benefits of District energy

As discussed, DE and other renewable thermal energy options have become an increasingly important municipal objective in order to reduce our reliance on, and exposure to, fossil fuels, alongside the imperative to improve resiliency in our energy systems. The rationale for this is to not only achieve the collective benefit of reduced GHG emissions, but also because re-designing our production and provision of thermal energy will aid in insulating our cities from fuel price volatility through the flexibility and potential to switch DE’s fuel inputs, while still utilizing the same piping infrastructure that is in the ground. The very nature of the distributed generation model of DE with its embedded generation nodes dispersed throughout cities, will provide the robust and resilient energy infrastructure to achieve the redundancy within our energy portfolios that can better withstand the impacts of severe weather or other disruptions within the traditional gas and electricity grids (international district energy association, 2009, FAQ). Moreover, the growth of a de-carbonized energy economy provides an important hedge
against the looming possibility of a comprehensive carbon pricing regime either nationally or internationally in the years and decades to come.

Many of the benefits that flow from building DE infrastructure are collective in nature, and are not always direct, often they involve co-benefits, and since many of the benefits are to public goods and are communal in nature, it requires careful collaboration and co-ordination by both the public and private sector in order to generate the requisite inertia to bring these projects from pre-feasibility studies through to operational producers of thermal energy (Berry, 2014). In order to foster these conditions it is critical, if not imperative, to have strong political leadership that will champion and cultivate the enabling conditions. By having strong champions within political elites, both municipally and provincially, it encourages the growth of a technical and analytical expertise within the civil service that can collaboratively craft regulations, zoning variances, and bylaws that are necessary in order to build new TES and DE capacity, while also providing flexibility enough to retrofit existing building stock to become DES compatible. This high level political clout underpinning the drive to create the conditions where DE and other TES can be successful, is important in developing policy and regulations that mandate energy efficiency targets that these technologies can help achieve. Moreover, deliberate urban planning integrated with an overarching energy plan for a city will also direct development and growth in denser nodes that will provide the aggregated customer loads that DE requires in order to flourish.
British Columbia context

DE fundamentals locally

In particular, British Columbia is emerging as a continental leader in developing the enabling legislative and policy tools that are fostering an aggressive expansion and reorganisation of the provision, transmission and consumption of thermal energy within the province. Although DE has been, and continues to be, the preferred choice for providing thermal energy to institutional space and other sprawling one owner sites both domestically and globally (Berry, 2014), it is only within the past 10-15 years that it has become a municipal priority locally in Metro Vancouver. DE provides many advantages and efficiencies in terms of its operational and lifecycle costing versus a business as usual scenario (BAU) (Ristimäki, Säynäjoki, Heinonen, & Junnila, 2013), however a major hurdle in order to secure a customer load is the requisite co-ordination between municipalities, developers, system operators, and individual consumers (Elenchus Research Associates Inc., 2010; Ostergaard, 2012).

Implementing DE involves accessing and leveraging patient and risk tolerant pools of capital in order to physically construct the underground piping infrastructure that is the transmission network (Ostergaard, 2012). In order to aggregate a sufficiently dense heat load of end consumers to satisfy the business case aforementioned, DE systems must have comprehensive agreements with the municipality(s) in which they are located (Elenchus Research Associates Inc., 2010). This imperative is most often satisfied in one of three ways, either a municipality will itself be the driving proponent who owns, operates, and self-regulates the system; or the municipality will provide a franchise area with a guaranteed customer load to a private DES operator, regulated by the British Columbia utilities commission (BCUC), and often enforced through compulsory connection and/or hydronic building
bylaws; or thirdly, a concession agreement in which a public/private agreement is crafted that delineates the shared ownership and operational responsibilities of the parties to the system, depending on the details of the ownership structure, a concession agreement may or may not be subject to BCUC oversight.

**B.C.’s legislative mandate**

In a research study commissioned by Natural Resources Canada and conducted by the Canadian District Energy Association published in June 2011, B.C. was highlighted as having strong supportive policy towards DE by the 200 industry stakeholders who were polled. In fact,” Frequently, references were made to the successful provincial level policy initiatives in British Columbia, which have set sustainability priorities in which DE has been identified as a critical solution” (p.31). This same study concluded that no fewer than 60 local communities in B.C. have identified DE as a strategy to achieve reduced GHG emissions (CDEA, 2011, p.66). These policies were crafted and passed into provincial law by the Gordon Campbell government in the mid 2000’s. By having a strong champion for climate change reform in the then Premier Campbell, several critical bills were passed that have resulted in the thermal energy renaissance that is currently underway within the province.

Beginning with the Greenhouse Gas Reductions Targets Act (GGRTA), passed in 2007, the provincial government set aggressive targets, “Under the Act, B.C.’s GHG emissions are to be reduced by at least 33 per cent below 2007 levels by 2020. Interim reduction targets of six per cent by 2012 and 18 per cent by 2016” (B.C. Ministry of Environment, 2015). As of the most recently released data in 2012, the provincial emissions inventory stated that GHG emissions were 6% lower than the 2007 baseline;
this coincides precisely to the targets set out in 2007 (Horne, 2014). As a supportive policy to achieve these targets, this same government implemented a revenue neutral carbon tax,” The carbon tax was implemented on July 1, 2008, with tax rates equal to $10 per tonne of carbon dioxide equivalent (CO\textsubscript{2} e) emissions. The rates were increased by $5 per tonne annually until reaching $30 per tonne of CO\textsubscript{2} e on July 1, 2012.” (B.C. Ministry of Finance, 2015). This carbon levy, though arguably not a high enough pecuniary penalty in order to incent the reductions sought after, has provided a strong evidentiary record that carbon pricing can have a reductive impact on carbon emissions while also retaining a strong economy (Dale et al., 2015). As a complimentary measure designed to demonstrate leadership and commitment to the above policies, the Campbell government then implemented the carbon neutral government program in December of 2008. This program, “is about achieving net-zero greenhouse gas (GHG) emissions. This commitment covers the entire provincial public sector including schools, post-secondary institutions, government offices, Crown corporations and hospitals.” (B.C. Ministry of Environment, 2015). In order to comply with this statute, all public sector organisations must measure their emissions portfolios, attempt to reduce these as much as practicable, purchase carbon offsets through the B.C. climate action secretariat, and lastly must produce a carbon neutral action report that is publically available online (B.C. Ministry of Environment, 2015).

Since these provincial policies resulted in an effective downloading of much of the economic burden on local municipal governments, the local governments (green communities) amendments act was also instituted. The intent of this act is to provide a centralised supportive infrastructure through the B.C. climate action secretariat to assist municipalities in their efforts and plans to achieve reduced emissions and carbon neutrality. As a codified agreement, the B.C. climate action charter stipulates the anthropogenic stimulus for climate change, and provides a framework for how local communities can collaboratively craft plans and policy to ameliorate this situation; to date,” out of 190 BC Local
Governments (including the Islands Trust) 182 or 96% have signed the British Columbia Climate Action Charter.” (B.C. climate action, 2015).

**Shifting the load**

As highlighted above, there are a myriad of reasons why DE and other non-traditional TESs provide collective benefits to its customers, as well as society at large; however, when considering the case for these technologies, they cannot be analysed in the absence of considering the region’s, and the province’s, overall energy portfolio. DE can efficiently provide space heating from waste heat sources, or under-exploited feedstocks, such as biomass, when stipulated policy objectives are to reduce GHG emissions and to utilise local energy sources in a corollary effort to build a sustainable and liveable region.

When planning a regional energy strategy it is imperative to, “match energy quality with end-uses, e.g., use electricity to run computers and machine drives, and waste heat for home heating with district energy systems, thereby preserving exergy; “(Bataille et al., 2010, p.iii). Embedded in this erudite statement is the acknowledgment that all energy is not created equally; that is to say, some forms of energy have more inherent utility within them than others. Electricity is considered one of the highest forms of energy in terms of its utility, and demand for it will only grow as the market increases for personal electronic devices, and as electro-mobility options increase. Commensurate with the notion that electricity is a high value energy form, is the fact that certain forms of electricity generation are more desirable and beneficial than others in terms of their environmental impact, and their utility. At the pinnacle is renewably generated hydroelectricity; this is because it produces very low GHG emissions from an electricity generating standpoint. According to BC Hydro estimates
The GHG intensity — a measurement of how many tonnes of emissions are emitted for every gigawatt-hour (GWh) of electricity generated by BC Hydro and independent power projects in B.C. — has ranged from about 10 to 30 tonnes per GWh in recent years. That’s significantly lower than the average electricity generation intensity of 160 to 200 tonnes per GWh for Canadian provinces and territories, many of which do not have a resource mix so favourable towards hydroelectricity.

(BC Hydro, Greenhouse Gases, 2015)

Also of critical importance, is that hydroelectricity can be stored and dispatched to match demand extremely quickly. It is therefore wise that we as a society deliberately consume this commodity as efficiently as possible, and when practicable an alternative energy source should be utilised in order to produce space heating. The resulting surfeit of hydro-power would provide an enviable problem, among other options, it would enable us to sell our hydroelectric power to neighboring jurisdictions in order to displace coal-fired thermal electricity generation, and realise real GHG reductions since GHG emissions are a trans-national problem that respects no borders.

The provincial government of B.C. is cognisant of some aspects of this salient reasoning, and has included some of these fundamental principles in Bill 17, the Clean Energy Act of 2010. The following is an excerpt from part 1 this act.

The following comprise British Columbia's energy objectives:

(a) to achieve electricity self-sufficiency;
(b) to take demand-side measures and to conserve energy, including the objective of the authority reducing its expected increase in demand for electricity by the year 2020 by at least 66%;

c) to generate at least 93% of the electricity in British Columbia from clean or renewable resources and to build the infrastructure necessary to transmit that electricity; ...

(g) to reduce BC greenhouse gas emissions

(i) by 2012 and for each subsequent calendar year to at least 6% less than the level of those emissions in 2007,

(ii) by 2016 and for each subsequent calendar year to at least 18% less than the level of those emissions in 2007,

(iii) by 2020 and for each subsequent calendar year to at least 33% less than the level of those emissions in 2007,

(iv) by 2050 and for each subsequent calendar year to at least 80% less than the level of those emissions in 2007, and

(v) by such other amounts as determined under the Greenhouse Gas Reduction Targets Act; ...

(j) to reduce waste by encouraging the use of waste heat, biogas and biomass;

In order to achieve these legislated objectives BC Hydro will use a wide array of new generating options, as well as aggressive demand side reduction strategies promoted through their Powersmart division. One effective strategy to meet these objectives, would be to encourage a shifting of the future
load growth from the space heating demands from electrical resistance baseboard heaters in higher density developments, to either a DE network, or to another on site TES.

Of course, there are many socio-economic factors that will affect whether or not a particular building can or would connect to a DES, so it is difficult to predict with any confidence how much load could or would be shifted. With that being said, in a 2012 report done by the load analysis department at BC Hydro that analysed residential electricity trends in the time period 1996-2012, found that 56% of all accounts sourced their space heat from electricity (Nelson, Albrechtsen and Berrisford, 2013, p.8). With that being said, the lion’s share of those accounts are single family dwellings, and these accounts would not qualify as the target demographic market for DESs or other TES; but, within this sample 20% of accounts are within the multi-family, and higher density categories that could feasibly connect to DES or other TES of: row houses, high rises, and low rises (Ibid). Looking at the account numbers more closely, one can see that within the target market for DES or TES, the high rise and low rise apartment sectors, that 68% of accounts are serviced by electrical space heating; one must bear in mind, however that these two categories consumed only a paltry 6.8% of the total load in 2012 (Ibid).

It is crucial when analysing these load trend numbers, and when extrapolating potential load shifting to DES or other TES, to examine the growth forecast models for Metro Vancouver. This is because buildings that are currently constructed with electrified space heating are unlikely customers for DE or other TES, as retro-fitting existing building stock to be hydronically compatible would not be cost effective. What is reasonable, is to plan that new construction of high density residential units are built to facilitate hydronic heating. Within Metro Vancouver’s 2040 growth model forecast, released in 2011, there will be 1 million additional people living in the region in 574 000 new dwelling units. Of these new dwelling units, 162 000 will be located within either the Vancouver metropolitan core, or the
Surrey metropolitan core, and it should be noted that both of the areas currently have, and plan to actively expand, one or more large DESs (Metro Vancouver 2040 growth model, 2010).

Since space heating can be produced and delivered utilising a wide variety of alternative feedstocks, it is seems desirable that B.C.’s access to hydroelectricity not be squandered on space heating. In order to ensure that this is possible, it seems to be a reasonable recommendation that all new multi-unit developments within Metro Vancouver be built with a hydronic heat delivery system installed throughout new buildings in order to be compatible with DE and TES.

Energy Diversification

“The new normal” according to pronouncements from the World Energy Council is that, “Energy leaders see energy price volatility and the future of a climate framework as their top critical uncertainties” (World Energy Council, 2015). This statement has proven its truth many times over, and it has again shown its veracity in the context of the current global surplus of oil production that has resulted in sharply lower prices for this seemingly indispensable global commodity. And, although, in this instance a highly sought after energy feedstock has surprised forecasters by reaching and staying at a lower than anticipated price, the reverse can, and has at many times, been true. DE, with its ability to switch fuel inputs, can provide an effective hedge against this kind of type of energy price volatility. Here in B.C. we are blessed with an abundance of energy resources: from a wealth of hydroelectric capacity and opportunities, to vast natural gas reserves, an abundance of urban wood waste and forestry residuals for usage as bioenergy, alongside wind potential and other still developing technologies. This, however, does not preclude the possibility that global commodity price fluctuation could affect the
prices we pay, and even the availability, of certain feedstocks for generating thermal heat or any future CHP projects.

An instructive case study in this vein is to look at the development of the Swedish DES industry, and to plot how and why they adapted their energy feedstocks the way they did. First of all, it should be noted, that the Swedish DES industry dwarfs that of Canada’s, and in fact it provides 57% of the nation’s space heating requirements (Di Lucia & Ericsson, 2014). Its growth follows three distinct phases, and each of these was shaped and propelled by macro-issues that were far removed from the control of the DE regimes themselves. At the inception of the growth phase of DE networks in Sweden in the 1950, the nation was reliant mainly upon its domestic hydroelectricity and also on large imports of foreign oil, mostly imported from the Middle-East, and utilised very little natural gas, as they were not connected to a supply pipeline. As these DESs grew during the 1960’s they became more reliant on these foreign oil imports. By the early 1970’s geo-political events conspired to instigate the first oil crisis, this resulted in a tripling of the cost of oil imports, and by the end of the decade the oil price had then doubled again (ibid, 2014). These exogenous events resulted in an extended period of re-organisation in the DES sector, and a period throughout the 1980’s through the early 1990’s where these DE networks effectively switched out generating technologies as they shifted and experimented with a number of fuel input alternatives. By the mid 1990’s government policy again affected fuel choices for DESs, as Sweden embarked on an aggressive GHG reduction platform guided by an escalating carbon tax, as well as a tradeable renewable electricity certificate that compelled utility companies to procure a share of their electricity generating portfolio from renewable sources (Ibid). As these new sustainability minded principles trickled down, DESs found a number of thermal generating strategies that were effective for the area’s they were situated, however, biomass has become the pre-dominant fuel choice, and as of 2011 accounted for 45% of DE fuel inputs (Ibid).
Although we here in B.C. are fortunate to have a plethora of energy options, any wise investor realises that markets and commodity prices are cyclical in nature, and that exogenous events are often unpredictable and capricious; DESs are one viable strategy to add diversity to our local energy infrastructural mix.

**Energy Resiliency**

As an often parallel objective to energy diversification, energy resiliency has become a critical deliverable for major utilities, and is rapidly becoming a top priority for regional governments. Energy resiliency speaks to the need to build redundancies within our energy infrastructure and supplies, and moreover, it requires that some generating capacity be installed within load centres. It is the opinion of the International Energy Agency that, “Climate change could affect our energy systems, and thereby our energy security, in several ways: by altering energy demand, disrupting energy supply and damaging energy infrastructure” (IEA, 2015). By incorporating integrated community energy systems, including DES, within our urban load centres, we can provide some degree of insulating back-up energy should there be any interruptions of the gas or electricity transmission or distribution networks (Bataille et al., 2010).

As a way of illustrating the pragmatic utility of this concept, it is again instructive to look at a real world example of where DE has provided this redundancy that has maintained islands of power and heat amid widespread outages. During the 2013 Hurricane Sandy “superstorm”, there were large areas that were without power along the Eastern U.S. seaboard, largely in New York, New Jersey and Connecticut. The islands of power that remained were from combined heat and power (CHP) installed
mainly on university campuses such as Princeton and New York University (IDEA, micro grids, 2013). As
a result of these, as well as other examples of resilient micro grids, there has been considerable
investment and interest in further expanding CHP in these hurricane prone areas (ibid).

Fortunately for the people of B.C., we are not located in an area that is prone to intense
seasonal storm activity, although we do live in a seismically active zone. The possibility of natural
disasters exists anywhere, as does the possibility of deliberate and targeted infrastructure attacks,
although these possibilities may seem remote. By integrating some energy systems within our more
dense cities, we can proactively plan and take steps to mitigate the impact of these infrequent, yet
severe events.

**Compact liveable communities**

Metro Vancouver is a sprawling geographic region that is comprised of 21 municipalities that
stretches from the village of Lions Bay on Howe Sound, out to its easternmost fringe in Maple Ridge,
then across the Fraser River to the city of Langley, and then abuts the Canada-U.S.A. border all the way
to the cities of Tsawwassen and Richmond that that lie on the Coast of the Pacific ocean (Metro
Vancouver, 2015). As an electoral area, it has as its core mandates the regulation of the regional airshed,
the provision of solid and liquid waste services, management of regional parks, and managing the
region’s overall growth strategies (Metro Vancouver, 2015).

In 2010 Metro Vancouver released *Shaping the future*, its 30 year growth strategy for the region
in a comprehensive report that stipulates its main goals, and the pathways to achieve these objectives.
These broad goals are as follows.
GOAL 1 Create a Compact Urban Area

GOAL 2 Support a Sustainable Economy

GOAL 3 Protect the Environment and Respond to Climate Change Impacts

GOAL 4 Develop Complete Communities

GOAL 5 Support Sustainable Transportation Choices

Alongside these five goals, DESs are an excellent synergistic strategy to symbiotically grow and achieve these objectives, as the Metro 2040 growth strategy intends to strongly encourage the region’s residential growth to targeted urban centres (Metro Vancouver 2040 growth model, 2010). The core tenets of the Metro Vancouver growth strategy, are to create dense urban cores throughout the region within a specific urban containment boundary. Commensurate with that, they, in conjunction with Translink, intend to direct,” 28% of residential growth to Frequent Transit Development Areas (FTDAs). FTDAs are anticipated to be identified along the frequent transit network (FTN), concentrating growth in close proximity to transit” (Metro Vancouver 2040 growth model, 2010). This mandated growth strategy, will create the dense aggregated heat loads that are sought after by large sprawling DESs. Moreover, if adequate coordination and cooperation between DES operators and transit infrastructure projects can be achieved, there will be the opportunity to lay DE piping infrastructure in the ground, and this will not only reduce the cost burden on both parties for the construction, but of equal importance, lengthy traffic delays can be reduced for the road-users. This final point is not something to be underestimated, as was seen when the Cambie corridor skytrain installation occurred, where there were significant impacts upon the local residential and commercial occupants adjacent to these projects. This
led to subsequent litigation, and arguably a reticence from some parts of the public to accept these large scale infrastructure projects in their areas. It must be recognized, that these capital intensive and potentially disruptive large-scale infrastructure projects will proceed only if there is public acceptance, and what has come to be known as “social license to operate”.

More than simply promoting the kind of compact, dense heat loads that DE seeks to exploit, Metro Vancouver as an organisation is actively looking at leveraging energy generating potential from both their sewage treatment plants, as well as at their solid waste incinerator. In their 2014 climate actions report, they have identified several opportunities for leveraging their operations through liaising with energy utilities to exploit the energy potential therein. Looking specifically at thermal generating and transmitting synergies that Metro Vancouver is currently exploring, these include the following.

- Effluent heat recovery from the Lions Gate secondary wastewater treatment facility, and a subsequent purchase agreement with a nearby DES.
- Effluent heat recovery from the Iona wastewater treatment, and a subsequent purchase agreement with Vancouver international airport (YVR).
- Effluent heat recovery from the Lulu Island secondary wastewater, and a subsequent purchase agreement with a nearby DES.
- Heat recovery from the Burnaby waste to energy facility that currently generates electricity that is fed on to the grid, and future purchase agreement with a DES.

(Quan, 2014)

These initiatives are undoubtedly rooted in the knowledge that space heating requirements in the local Metro Vancouver municipalities were directly responsible for 42% of GHG emissions, and over half of these were from burning natural gas, as reported in the 2010 community energy and emissions

**Local Jobs**

As highlighted previously, DE offers many benefits to jurisdictions who invest the time, capital, and social resources into building both the physical DE networks, but also the requisite socio-technical expertise that underpins system growth. DE not only acts as a direct employer for professionals to manage business development, regulatory compliance, technical/mechanical engineering, as well as communications and community outreach programs, but can also act as an attractor for other sustainability and energy efficiency industries; in effect it can act as a catalyst to develop a local hub for sustainability and innovation.

In analysing the local capacity in the DE sector in Metro Vancouver it is difficult to reference exact numbers of both direct and indirect local jobs generated by the industry, since it is in a period of rapid growth, but has not yet reached a critical mass where there is a large industry association locally that tracks these figures. However, in a 2014 report compiled by the Canadian Industrial Energy End-use Data and Analysis Centre (CIEEDAC) it states that there were 25 DES in British Columbia that were providing thermal heat (Nyober, Murphy, Melton & Wolinetz, 2014). According to their research, 58% of these systems employed 5 or fewer employees, while 35% employed 10 or more while the remaining 7% used between 5 and 10 employees; using these statistics as a reference point, DES in B.C. directly employs roughly 175-200 people. These numbers do not account for the sub-contractor demands for
consulting engineers, building contractors, material and fuel suppliers, as well as all other services that are purchased or consumed by DESs and their employees in the local economy. In order to fully appreciate the potential jobs in a mature DES industry in B.C., it is useful consider the DE industry in Norway. Norway has a population of roughly 5 million people, while B.C. has a population of just over 4.5 million; whereas the direct employment from DES in B.C. may be around 200 people, Norway’s more mature DES industry provides 1350 full time jobs (UNEP, DE in cities, 2015, p.12).

Although any estimated number of local jobs created thus far, or anticipated job growth, would be a specious guess at best, there is nevertheless a palpable groundswell of activity in the DES sector in Metro Vancouver. This is related to, and affected by the overall sustainability drive that has cascaded down from provincial and municipal policies, in much the same way as it has permeated up from the desire of the populace to take steps to mitigate the impact of climate change.

Analysis

**BCUC Regulatory Oversight**

In order to have a fulsome understanding of the marketplace in which DESs operate, it is critical to examine the role that the regulatory mandate of the British Columbia Utilities Commission (BCUC) plays in the provision of energy in B.C.; the commission’s influence is pervasive throughout the energy utilities sector, and influences even DESs that do not fall under its purview. The commission’s mandate is derived from the statutory authority accorded to it through the Utilities Commission Act (UCA), and in
this act rests the reasoning behind why some DESs are subject to BCUC regulatory oversight, and why some are not.

“The commission’s mission is to ensure that ratepayer’s receive safe, fair, and non-discriminatory energy services at fair rates from the utilities it regulates, and that shareholders of those utilities are afforded a reasonable opportunity to receive a fair return on their invested capital” (BCUC, organisational profile, 2015). As implied in this mission statement, the BCUC does not regulate all utilities in B.C., the reason for this is because within the UCA, it explicitly states that the BCUC’s authority does not extend to, “a municipality or regional district in respect of services provided by the municipality or regional district within its own boundaries.” (UCA, definitions, 2015). Therefore, if a municipality decides to develop a DES within its own boundaries, it will not have to apply for BCUC approval to do this, which is known as a Certificate of Public Convenience and Necessity (CPCN); however, a private utility must.

The purpose of a CPCN is to, “ensure that utilities are not making unwise investments, the cost of which they will later expect to recover in rates from their customers” (BCUC, Understanding Utility Regulation, 1999, p.38). The CPCN process must be undertaken for private DESs that hope to establish new thermal networks, but likewise, an established system must also apply for a CPCN for major extensions to existing systems (ibid, 1999).

The rationale behind providing this kind of publically transparent energy regulation, is that large energy utilities have the hallmarks of “natural monopolies”, in that they operate as a vertically integrated enterprise that most often controls the generation, transmission, delivery, and sale to the public of their commodities, moreover, they are often at the scale at which normal market competition mechanisms rarely apply (BCUC, Understanding Utility Regulation, 1999, p.2). The Commission does, and
has, recognized that as markets change, the need for regulation must evolve in lock step in order to ensure that competitive market forces are not stifled through rigid regulation (ibid, 1999, p.3).

With this rationale in mind, the Commission amended the regulations surrounding the emergent DES and TES sector in late 2014 in their Thermal Energy Systems (TES) Regulatory Framework (TES Framework). Under this new regulatory framework, the commission stipulates the thresholds for what constitutes a thermal provisioning network that requires the filing of a CPCN, as follows is a brief description.

- **Micro TES**: A TES with a capital cost of $500,000 or less is exempt from Part 3 of the UCA other than sections 42, 43 and 44.
- **Strata Corporation TES 4**: A TES owned or operated by a Strata Corporation, or the Strata Corporation’s lessee, trustee, receiver or liquidator, that supplies the Strata Corporation’s owners, is exempt from Part 3 of the UCA other than sections 42, 43 and 44.
- **Stream A TES**: An On-Site TES with an Initial Capital Cost above $500,000 but less than $15,000,000 is exempt from sections 44.1, 45-46 and 59-61 of the UCA. TES Providers are required to register Stream A TES prior to building or otherwise acquiring the Stream A TES.
- **Stream B TES**: All other TES will be regulated similar to other Public Utility systems. An application for a CPCN5 and a rate approval application are required.

(BCUC, TES Regulatory Framework Guidelines, Appendix A, 2015, p.7)

It should be noted that this new classification of DES and TES has provided a more streamlined regulatory process, and has given operators much needed clarity, and has thus lessened the risk profile of many projects. Most importantly, it has provided a clearer path for land developers whose projects
do not fall within the bounds of an existing DES, but who nevertheless, want to develop an on-site renewable, or low-carbon TES in partnership with a private utility provider. Whereas in the past, each time a private utility paired with a developer to build an on-site system a CPCN application process needed to be made, a process that often takes between 3-6 months, or perhaps more if there is need of lengthier public hearings involving multiple interveners, under the new regulatory framework, this process has been expedited to require only the filing of a four page registration with the commission. To quote one interview respondent who works on stream ‘A’ projects,

...the new regulatory framework model in place with the commission, really it has greatly streamlined the regulatory process for the stream ‘A’ [projects], because we only need to register the projects, and that means filling out a four page form. They don’t review the rates, or require a CPCN, or a long-term resource plan.

With these basic foundational tenets in mind, an exploration of respondent’s views, perceptions, and opinions of the BCUC regulatory process can now proceed. Of the 18 interview participants polled, 14 individuals agreed that the BCUC process was beneficial to maintaining a public perception of oversight and accountability within their industry. Within the sample, of the four outliers, 2 operate outside of the province in jurisdictions that do not regulate thermal energy, and instead favour competitive market forces to self-regulate, and therefore promote well-managed systems. While of the two domestic outliers, one stated the BCUC model is effective only within the marketplace of B.C., while the other felt that unregulated municipal systems scrutinized by elected council members was the most ideal model. Frequent mention was made that operating under the scrutiny of the BCUC provides assurances to heat consumers that their best interests are being maintained, and that an evidentiary record of CPCN documentation, and rate setting hearings, are publically available through the
Commission. Furthermore, that consumers of DES or TES do have the same protections as all other energy consumers in the province.

Another recurrent issue amongst the sample, was that unregulated systems had the potential to set rates that did not conform to the standard low-risk benchmark rate of return on equity (ROE) of 8.47% (adjustable by a sliding scale of 75 basis points based on rate of return on 30 year Canada savings bonds) plus a negotiated risk premium that is arbitrated based upon a project’s risk profile. This is negotiated between the BCUC and the applicant (BCUC, Low-Risk Benchmark Utility for the Year 2009, 2008, p.3). This potential for inconsistencies in rates can raise the possibility that rate payers may feel unjustly charged; though this would likely just be a public perception issue, and not necessarily based in fact, it nevertheless could bring disrepute upon the sector as a whole. It was also noted by several respondents, that if a non-regulated system that set its own rates also had a mandatory connection bylaw within their municipality, that there is a possibility of friction and acrimony with local developers who may have to explain to new residents why their thermal energy rates are non-standardized to industry norms.

As a way of alleviating public concerns surrounding equity of rates for non-regulated municipal DESs, many voices pointed to the independent advisory board that the South East False Creek (SEFC) DES- known by the city moniker of, Neighbourhood Energy Utility (NEU)-operated by the City of Vancouver (COV) employs. The mandate of this expert, external review panel is to objectively validate and vet the NEU rate setting process, its cost estimates, and its market competitiveness (COV, 2013, Appendix E, p.E2). Furthermore, the SEFC NEU publishes publically available annual financial reports that exhaustively stipulate all relevant financial information, as well as future cost estimates and future NEU objectives.
The Business Case

DE, like any other business venture, must generate sufficient revenue from its end consumers to cover its capital expenditures and its operational responsibilities, and if the system is privately owned, it will also need to provide an acceptable return on the equity provided by its investors in order to attract them to the project initially. Although oversimplified, this statement is nonetheless true for building a strong business case for DE; by analysing the variables that will affect how this business case is developed, including a project’s inherent diverse circumstances that will affect risk profiles, alongside critical governance and ownership structures will elucidate how and where financing is sourced, and how and when it will be deployed.

Several prominent themes emerged from the interview data as respondents were queried as to where, and from whom DE looks to source its financing. It was generally agreed by all that DE requires access to patient, risk tolerant pools of capitals in order to grow the transmission networks and build new generating facilities; furthermore, widespread agreement centered on the need to conserve capital during the early growth years, and to mitigate risk through employing a phased in approach to deploying capital in system expansion. Since much of the growth in DE in Vancouver is centered on new construction development within infill projects in denser urban nodes, it was noted by many that care must be taken to match system extensions and expansion to the rates of this growth. Another area of convergence preferred by most all respondents, is the use of revenue deficiency deferral accounts in order to levelise customer rates. This financial tool is utilised because revenues during the first several years of system development are often outstripped by expenses. This is because of the large capital expenditures in building a generating plant, and then interconnecting it through the under-ground piping to the initial customer load, and during this time is when aggregate heat loads have not
developed to their desired targets. Where respondent answers diverged, was whether DESs are best owned and operated by private utilities, or by the municipal government, roughly 50% of respondents supported one over the other; not surprisingly, respondents generally supported the business model on which they, or their organisations, work on.

Paradoxically, it is the wholly publically owned DES that have greater flexibility in financially structuring their systems, since privately held systems are beholden to negotiating with the BCUC for debt to equity ratio’s, its rate of return on equity, capital expenditures allocated to system extensions, as well as customer rates; whereas unregulated municipally owned systems are not compelled to emulate these procedures, though some do.

In Metro Vancouver we have many systems currently developing that provide relevant case studies of how operators have tried to manage risk and develop novel financial mechanisms in order to further the drive towards providing low-carbon heat at rates that are competitive with traditional on-site natural gas fired boilers, or electric baseboard heat. In so doing, it is essential to bear in mind that low carbon heat sources must compete in the marketplace with traditional fossil fuel heat sources that do not internalise the full cost of their carbon emissions, though B.C.’s carbon tax does to a certain extent attempt to remedy this. Further exacerbating this competition deficit, is that the fossil fuel industry has vast economies of scale in terms of production, transmission, and distribution networks; not to mention the much debated, but nevertheless present, value of subsidies that this industry receives both domestically and globally. With these constraints in mind, by briefly examining one of the local examples of a recent CPCN application for a new low carbon fueled DES, we can see how some system proprietors are trying to build successful business cases.
UBC Neighbourhood District Energy System (NDES)

UBC as a responsible corporate citizen, who is fundamentally committed to sustainability and innovation, has taken a leadership role in developing and demonstrating the utility of low carbon DE on its Vancouver campus. As a corollary benefit to its sustainability goals, some GHG emissions that the institution would have had to have purchased carbon offsets for as a public sector organisation (PSO) according to the 2010 carbon neutral deadline for PSO’s under the GGRTA have been significantly reduced. Not to be confused with the gasified biomass fueled academic DES that has helped in achieving these reductions- and in operation since 2012, which produces in excess of 8 Megawatts of thermal energy (UBC, energy and water, BRDF, 2015), and has helped the University in reducing its GHG emissions by 21.7% during 2014 (UBC, energy and water, stats and metrics, 2015)- this section will provide commentary on the business case being developed for the new NDES being developed by UBC in concert with Corix multi utility services (CMUS).

Under a 20 year infrastructure agreement between UBC and CMUS, a new independent DES is being developed in the Westbrook mall area of the campus where UBC intends to direct significant new development and residential growth (CMUS, CPCN, 2014). Since this DES will be predicated on new development bringing a growing heat load density to the service area, the parties applied for BCUC approval to grow the system in two distinct phases. Over the first phase of service (2015-2023) the heat will be generated by two “temporary energy centres” consisting of two 2.9MW natural gas boilers housed within converted shipping containers (ibid, p.6). During this initial phase, in order to reduce the risk profile as the intended heat loads grow, the parties intend to use the traditional natural gas boilers as a low risk and cost effective bridging strategy. By 2024, however, the intention is to integrate waste heat from the adjacent TRIUMF particle accelerator as the main base load source for the space heating
and domestic hot water needs of the system’s end consumers (ibid, p.7). The financial structuring of the
system is as follows.

- Total capital costs of Phase 1 (in 2014 $) : 11,193,073
- Deemed capital structure of 57.5 percent debt and 42.5 percent equity
- Equity risk premium of 75 basis points over the benchmark low risk utility return on equity
  for a total of 8.75 percent
- 20 year levelized rate structure utilizing a revenue deficiency deferral account

(ibid, p.9 & p.16)

It should be noted that this financial breakdown is fairly standard across the regulated DE sector.

There were, however, two novel amendments made to the rate structure that CMUS and UBC
asked The Commission to grant as part of their CPCN request for phase 1. The first request for an
additional charge to be added on to the end consumer’s bill was for what they termed a “carbon
emission rider” (CER), stipulated to be $25/tonne CO\textsubscript{2} to offset the phase 1 combustion of natural gas;
the intention being to hold these funds in trust until such time as the low-carbon energy is incorporated
(ibid, p.18). The rationale behind this requests was to accrue funding during the early years of the
project to offset some of the cost of integrating the low carbon energy in phase 2, but also as a way of
educating the public as to the full cost of emitting carbon, and implementing a price signal that would
incentivized the fuel switch (ibid, p.27). The Commission ultimately decided that the CER bore too much
likeness to the already imposed provincial carbon tax, and that furthermore, this additional fee being
charged only on consumers of phase 1 could result in instances of “intergenerational equity”, and finally
that it is possible that the phase 2 low carbon fuel switching may not occur; and as such, The
Commission denied the request for a CER (ibid, p.30). It is interesting to note that the recently applied
for CPCN request for the North-East False Creek DES by Creative Energy Platforms Vancouver has included a similar request for a carbon surcharge during the initial phase of their new system extension, so it remains to be seen how The Commission will revisit this issue (NES NEFC CPCN, 2015, p.75).

The second additional surcharge that UBC and CMUS applied for Commission approval to implement, is for what they termed a “connection credit” (CC). The purpose of this surcharge is to compensate developers for their increased incremental costs of having to build their low rise wood framed buildings hydronically, since their BAU scenario is to install electric resistance baseboard heaters because the equipment is less expensive, but also because the build time is far less than installing hydronic piping (ibid, p.18). The cost structure for the CC is proposed, “at a rate of $4.50 per square foot of completed floor space from 2015 through 2017, and then proposes to reduce the rate by $0.90 per square foot each year thereafter, resulting in a rate of nil by 2022.” (ibid, p.18). The underlying implication behind this surcharge is that if developers are forced to build hydronically, and not compensated for their increased costs above BAU, that this economic disincentive could impact the rates and timing of development, and thereby imperil the entire timeline and objectives of the DES. The Commission approved of the arguments put forth by the applicants, and approved the connection credit; however, to mitigate the issue of intergenerational inequity between phase 1 and phase 2, The Commission declared the recovery costs be amortized over the first 10 years (ibid, p. 33).

DE Governance and Ownership

The term governance is widely used in many different contexts, and in this way it can be amorphous, but for the purposes of this analysis governance will follow the broad definition provided by Stocker (1998) in that, “governance is ultimately concerned with creating the conditions for ordered rule
and collective action” (p. 17). Ergo, the term governance refers to the interplay between influential actors, both in the public sector and in the private sector, and how the shared delineation of power can be exercised in order to facilitate a desired outcome (ibid).

Though technical in nature, DE and its deployment, like any human activity, is affected by the decisions and policies of influential actors within relevant regimes and governing institutions; and can be thus analysed through the lens of socio-technical transition theory (Smith, Stirling, & Berkhout, 2005). For the purposes of this section, analysis will focus on how an, “energy system exists within a governance structure – a framework of decision making rules and the institutions that administer them on which the energy system relies” (Fri & Savitz, 2014). Moreover, analysis will elucidate how governance arrangements can effectively drive the deployment of DE, and how the inherent capacity, and aptitudes within both public and private ownership structures can be leveraged synergistically to enhance the growth of low carbon DES or TES.

As has been stressed previously in this thesis, revamping the way in which thermal energy is created, transmitted, and consumed has become a priority for many municipal governments in B.C., and they have seized upon the opportunities for its creation through low carbon sources as a viable platform by which to achieve some of the GHG reductions that they are tasked with. Also examined previously, in the section that dealt with regulatory oversight of the BCUC, were some of the intrinsic differences between the aptitudes and capacities that are available to wholly publically owned DESs, as opposed to privately owned systems. These governing bodies bring diverse advantages to a particular project; public systems with their financial structuring flexibility, access to subsidy and grant programs, access to low interest public capital, and ability to manipulate zoning, bylaws, and taxation to benefit their DESs; and private utilities with their vast in house experience and technical capacity developing energy
infrastructure projects, ability to access large pools of private capital, familiarity with material suppliers and installation contractors, and experience in managing risk. Each of these assets are integral to the success of a project, and in most cases synergies are leveraged and collaboration and co-ordination occurs between the public and private realm.

Through the discussion with interview respondents no less than one third stressed that this diversity in governance and ownership is beneficial to DE, and allows projects to follow the path of governance that most facilitates achieving the desired goals and objectives of that project. While nine other respondents made reference to municipalities as being strong drivers for DE, and many of this sample cited a municipality’s ability to pursue “sustainability goals” and a desire to implement innovative demonstration projects. Many respondents also stressed the benefit to an unregulated wholly owned municipal DES of employing an independent, expert advisory board as a third party monitor; frequent mention was made to the success and transparency of the SEFC NEU who employ such a board. However, there was the other half of the sample who felt that private utilities are best suited to managing the financial risks associated with developing DES or TES, and that their experience in developing large scale energy projects is better suited than is a municipality who may have scant experience in providing energy services to the public. This is not too imply that half of respondents felt that municipalities should play no role whatsoever, rather that they should collaborate, and co-ordinate policy, and provide service area to private utilities, who can then build, finance and operate these systems through either a concession agreement or based on a franchise area fee. There were however, a small minority who did feel that municipalities should only set policy goals, perhaps with specific energy performance guidelines, or by specifying what share of renewable energy needs to generated, and then leaving it to private utilities to compete for business.
Subsidies and Grants

DE energy, as long lasting energy provisioning infrastructure, provides collective benefits to communities in many ways as has been expounded upon in earlier sections. As such, it is reasonable that some amount of public funding be used to incent its deployment and scaling out. Since many of the benefits ascribed to DES affect public goods, specifically by its ability to reduce GHG emissions through utilizing previously wasted energy feedstocks to provide space heating and domestic hot water to consumers, there is the tendency for these benefits to be undervalued in the marketplace. In order to account for these marketplace failures, many believe the public sector should leverage its considerable influence by providing access to funding opportunities, co-ordinating load aggregation, connecting public buildings, and other enabling policy measures that can offset this under valuation.

Not surprisingly, in discussions amongst the research sample whether or not the current funding avenues that are available to DESSs were effective or not, opinions varied considerably based upon whether or not the respondent’s own work history included accessing any of the public funding opportunities. That is to say, those involved with a wholly owned public DES, or a hybrid public/private venture that was able to successfully navigate the subsidy/grant channels, believed that the current model was effective. In particular, many respondents involved in projects governed by the municipal business model reported that the Federation of Canadian Municipalities (FCM) Green Municipal Fund (GMF) was leveraged effectively and provided added capital to several local systems. Grant and subsidy programs were also available and effectively used by the systems at the two local universities, both as way to incentivize innovative demonstration projects, such as UBC’s bioenergy gasification plant, and also to shift some load from BC Hydro. In much the same way, a significant amount of public money was also effectively accessed and used in developing the SEFC NEU, which is also an innovative
demonstration project that recycles heat from a sewer trunk line. It was noted by all respondents, that these programs are not available to private utilities who are not directly allied with a municipality; this is perhaps reasonable given the likelihood that public perception would not be favourable to taxpayer money being channelled into profitable private corporations. One astute respondent made note that accessing public funding involves competing for scarce funds with many other worthy public infrastructure projects, and that many of these competing priorities are not discretionary in nature, as is a DE investment, but rather involves upgrading infrastructure in order to comply with regulations. In pointing this out, the respondent suggested that it would be beneficial to synergize infrastructure spending when possible to provide energy feedstock availability to DE; for example, when upgrading liquid or solid waste disposal systems and plans, deliberate incorporation of DE potential should be scrutinized and harnessed when possible.

**Bylaws**

As a complimentary policy tool to subsidy and grant programs, municipalities have the ability to implement bylaws that can influence and enhance the success of DE. Favourable bylaw enactment can take diverse forms, from implementing mandatory connection to DESs, to strengthening building codes and energy efficiency requirements, to requiring new developments to build hydronically; however, it should be noted that only the city of Vancouver has the statutory authority to make amendments to the provincial building code.

Through querying the respondents as to whether or not they felt that implementing mandatory connection bylaws to DES was good municipal policy, only two individuals dissented and believed rather that connection decisions should not be compelled, and instead, that the marketplace should determine
connections based upon a value proposition. However, the lion’s share of respondents felt mandatory connection bylaws were critical in reducing risk to system developers, and thereby lowering their weighted average cost of capital (WACC), through providing secure access to consumers, and are thus important enabling measures. Furthermore, one respondent made mention of his belief that developers, in the absence of a mandatory connection bylaw, or a requirement to build hydronically, would opt to heat their buildings instead by the more inexpensive and quicker to install, but more costly to operate, electric resistance baseboard heaters. One other respondent, who did favour mandatory connection, referred to the fact that this policy is necessary under the BCUC cost of service rate setting paradigm, but elsewhere, where rates are based upon a cost avoidance model, the marketplace value proposition is enough to incent new connections.

**Role of Developers**

Cities are constantly changing and in flux, and can be viewed as a palimpsest on which new technologies are built over the foundations of their predecessors. The decisions we as a society make in planning how this constant process of growth occurs will ultimately affect the health, vibrancy and sustainability of our modern cities. In order to build a city that conforms to these ideals and objectives, there needs to be widespread engagement, coordination, and collaboration between diverse stakeholders; the lack of such a fulsome discourse and process of consensus building can lead to a fractured pathway that is prone to short-sighted policies that will revolve and shift according to electoral cycles.

One of the most critical stakeholders that will shape the built environment in any city is its land developers. The decisions they make in designing and building the new low-rise, mid-rise, and high-rise
multi-family dwellings that will house much of the anticipated growth in this region will dictate not only the aesthetic of our city, but will also have a large influence on the amount, and type of energy that is consumed. Of course, developers must adhere to the building codes and zoning requirements that are legislated and enforced by municipal, and the provincial government- it should be noted that only the city of Vancouver has the authority to amend the provincially mandated B.C. building code.

The decisions that developers make in building and installing their heating, ventilation, and air conditioning (HVAC) mechanical systems in their properties are sunk costs, and this makes it extremely unlikely that these mechanical systems will be wholly changed until the end of the building’s lifecycle. If a building is built to be heated by electric baseboard heaters, it would never be compatible with a DES that transmits its heat via hot water. This is because the hydronic piping in a building is analogous to a vascular system in a plant or animal, in order to replace electric wiring with hydronic piping would be an enormous, expensive, and disruptive task. Furthermore, developers can quite rightly claim that electrified heating here in B.C. is low in GHG emissions and is renewably generated; the veracity of this statement is not debated, rather it is a misallocation of a high exergy energy source, and does not encourage the harnessing of many already produced waste energy feedstocks.

Through the interview discussion with respondents a common and recurrent theme emerged, that there is a fractured and sometimes adversarial relationship between DE and much of the development community. Since building hydronically is more expensive than installing electrified space heating, the BAU scenario for many local developers, the added cost and longer build time acts as a disincentive, and also a point of friction between some developers and municipalities that have mandatory connection policies within a DESs service areas. In fact, as an example, one interview respondent, who works for a large consultancy firm that has a wide breadth of experience of working on
the DE file, shared a prime example of the kind of issue that can arise between DE and developers. He related, that oftentimes developers will build the heating and ventilation mechanical equipment on the roof of their buildings because in that location the space used will not impact, or reduce, the amount of allowable square footage available for merchantable building space. As follows is a direct quote explaining how this situation occurred on a project that the respondent worked on,

“We were eliminating all the chiller and boiler plants that they had on the roof, but we were taking three or four parking spaces in the parking lot to put the energy transfer station. So, that was actually a disadvantage for the developer, because the roof space was free, it didn’t cost them anything, they had to pay to build it, but didn’t lose anything in terms of development [potential]… so district energy was actually a disadvantage because parking spaces were actually very valuable, but the space on the roof wasn’t valuable at all

An exception to this perceived acrimony came from a private utility who prefers to work on the more loosely regulated “stream A” TES projects in close collaboration with developments that choose to install their own on-site heating and/or cooling systems. This stream ‘A’ business model, however, assumes that all developers will make the progressive decisions to install a high efficiency, low carbon HVAC system, and this is certainly not always the case. This the reason that the diversity of business models, both stream ‘A’ projects, as well as municipally mandated DES connection policies, each have a part to play within the growing low carbon thermal energy sector.

Frequent mention was also made as to the different classes of developers and developments, in that, certain projects will support the low carbon DES or TES, while some do not. It is unclear if the reason for this is an economic differentiation within the marketplace, that is to say, that the higher end commercial and residential development sector seek a higher environmental performance to satisfy a
marketplace demand; or whether some developers are trying to push the marketplace in this direction in concert with municipal policy. While another class of developers are merely concerned with building as inexpensively as possible. An oft cited remark was that building codes that require elevated environmental performance standards and energy efficiency targets can be strong enabling policies for both DES and TES.

As for requiring developers to contribute financially to DES or TES, many respondents believed that it is reasonable to expect some level of contribution under certain circumstances. The mechanism for assessing how much a project should contribute, who should collect and administer the funds, and how the funds should be dispersed was unclear, and as such it is an area that would warrant further research and discussion. However, in a scenario of more stringent energy performance standards within the building code, such as those in the city of Vancouver that requires new building to be built to a LEED Gold standard (city of Vancouver, sustainable zoning, 2012), the argument can be made that it is essential, and economically advantageous, to connect to a low carbon DES, and, therefore, developers should provide some level of financial contribution to the capital cost of their connection.

**Achieving Public Support for Alternative Feedstocks**

Much discussion thus far has focussed on the ability of DESs to incorporate alternative feedstocks as their energy source for producing heat. The myriad of benefits range from an increased fuel supply diversity and resilience, to the ability to incorporate already produced heat from waste sources, to leveraging the energy available in the liquid and solid waste streams, and finally to produce less GHG emissions from our thermal energy requirements. Although harnessing these synergies would seem to be advantageous and valuable to all, it nevertheless would require widespread support from
the regional populace – a notion that has come to be known as social license, as well it could displace some vested interests in a BAU scenario.

In any analysis of novel DE feedstocks to be used within this region, it is critical to speak to each potential feedstock based upon its own particular circumstances, both in terms of its benefits and drawbacks. A discussion such as this could easily dominate the entire breadth of this thesis and far more. As such, what follows will encompass a brief overview of what each feedstock is, how it can be used, any projects specific to the region, and how difficult interview respondents believe gaining social license to use these feedstocks locally will be.

**Waste Heat Recovery**

It was widely noted by all interview respondents that public acceptance of utilising novel feedstocks in order to produce thermal heat followed a spectrum: from almost completely acceptable through to not acceptable to a vast majority of the public. At the top of virtually all respondents’ list of non-contentious socially acceptable feedstocks, is the harnessing of already produced waste heat. Since waste heat recovery opportunities do not require any new combustion, a very small and often innocuous heat transfer station, and provide an efficient recovery of an already produced energy source, most all interview respondents believed that obtaining social license is a non-issue. As follows is a list of some of the DES and TES projects that utilise waste heat sources.

- Telus Garden: “The $750 million, one million square foot TELUS Garden development in the heart of Downtown Vancouver will incorporate a LEED Platinum 24-storey signature office tower, a LEED Gold 53-storey residential tower with more than 425 green homes, and retail
space along Robson and Georgia” (Telus, news centre, 2015). Developed by Westbank properties in concert with Telus, this DES is operated by FortisBC and claims to reduce CO$_2$ emission by one million kg/year through harnessing waste heat from a Telus data centre.

- **SEFC NEU**: As previously described, a COV owned DES that claims to reduce GHG emissions by 60% from a BAU scenario, and sources 70% of this energy from sewer waste heat recovery (COV, SEFC NEU, 2014).

- **UBC NDES**: As previously described, a joint project between UBC and CMUS slated to be built in 2024 to harness waste heat from the TRIUMF particle accelerator.

**Biogas Recapture**

Biogas recapture technology is the anaerobic digestion of organic waste, such as garbage in landfills, sewage and liquid waste, and agricultural waste, and its subsequent collection and use as a “renewable natural gas”. In terms of its scalability, a 2014 article for UBC’s Sauder School of Business referenced a report that asserted that through harnessing the biogas opportunities from all waste water facilities in Canada, CO$_2$ emissions could be reduced by the equivalent of 560 000 cars/year (Forrest, 2014). Most commercially available biogas is sold through FortisBC as a premium product to those customers who choose to pay the additional cost. Most all interviewee’s believe that biogas is also a non-contentious feedstock. The sole issue mentioned involved potential locations of anaerobic biodigesters, many believed that as long as they are located at a current site, such as a waste water treatment plant, there would be no issue. However, if a bio-digester was to be installed into an urban area, for example to digest local compost, the resultant odour would likely be a cause for contention.
Geoexchange

Geoexchange technologies involve harnessing the differential in heat between the underground temperature and the ambient temperature above ground. This is achieved through pumping a refrigerant fluid through pipes beneath the ground, the fluid is warmed by soil beneath the frost line and flows back into a heat exchanger in a building, it can also operate in the reverse to cool a building, by pumping heat from a building back into the cooler soil in the summer (Canadian Geoexchange, 2015). These geoexchange systems are most often used in on-site TES or small scale DESs. Two notable systems locally include, but are not limited to the following.

- Delta school board in partnership with FortisBC uses Geoexchange loop fields along with some natural gas boilers to provide heating and cooling to 19 buildings, resulting in a 45% reduction in energy usage and saving the PSO $100 000/year in offset costs. (FortisBC, media centre, 2012)

- Marine Gateway development in partnership with Fortis Alternative Energy Services (FAES), services two residential towers and one mixed use tower through a Geoexchange loop field and natural gas boilers. GHG emissions are reduced from a BAU scenario by 50%, as well it integrates 70% renewable energy. (BCUC, final decision, p.4, 2012)

Biomass

Biomass as defined by the BC Bioenergy Network, “is derived from organic materials including wood waste, agricultural crops, animal manure, food waste, and municipal green waste. Through conversion processes, this organic material can be transformed to produce electricity, heat, valuable
biofuels, and specialty chemicals” (BC bioenergy network, our work, 2015). B.C.’s access to bioenergy resources is vast, a 2007 report by the GLOBE foundation claimed that if exploited to its highest potential, it could satisfy half of this province’s 920 petajoule consumption of fossil fuels (BC bioenergy network, 2010); although this figure is theoretical, and not likely to be logistically practicable, it nevertheless illustrates the reserves available. Many of the biomass conversion to energy plants currently operating in B.C. produce electricity that is fed onto the BC Hydro grid, while others are used for the domestic thermal needs of the producers. However, there are several noteworthy biomass fired DESs locally that are used for heating purposes, among these are:

- UBC Academic DES, as briefly mentioned earlier, converts roughly 2 truckloads (80yds) of woodchips per day by way of a Nexterra designed gasification plant into 8 megawatts of thermal energy (UBC, energy and water, BRDF, 2015), and has helped the University in reducing its GHG emissions by 21.7% during 2014 (UBC, energy and water, stats and metrics, 2015);
- UNBC DES utilising a similar Nexterra gasification plant that uses an adjacent sawmill’s residue to power a hot water DES that reduces fossil fuel inputs by 85% for space heating needs on campus. (UNBC, green energy, 2015), and
- SFU University biomass combustion plant in partnership with CMUS, not yet built, but the threshold for connected units has been reached and final negotiations are underway to construct a new generating plant.

While biomass energy does have the potential to provide a scaleable feedstock to a large urban DES, there are also some serious concerns, both in terms of securing a consistent and economically viable supply of the feedstock, and also in securing the social license necessary to build and operate a
biomass to energy facility within a dense urban area. In terms of where biomass combustion or
gasification resides on the spectrum of social acceptability described by the majority of interview
respondents, these concerns raised the likelihood of attaining social license to questionable, depending
on the success of the public outreach and education strategy that is deployed to build support. It was
virtually unanimous that any proponent interested in building such a facility would have to engage in a
significant and prolonged program of public outreach and education aimed at building the public literacy
surrounding the benefits to biomass energy, while also mitigating concerns surrounding air quality,
facility aesthetics, and feedstock delivery concerns. The basis of these campaigns it was said, need to
focus on dispelling some outdated notions of what modern combustion technologies can achieve in
terms of air emissions, while also quelling fears that an industrial scale generating plant would
negatively impact local property values.

This very scenario was acted out in the COV before the 2010 Winter Olympics; as part of hosting
the games the organising regime made significant promises in terms of sustainability targets for the
venues. One such venue, the athlete’s village in the COV, committed to building a low-carbon,
renewably fueled DES to provide low GHG derived thermal energy to the new development. During the
planning phase a feasibility study investigated a range of options for powering this new DES. After
weighing four different options, including: biomass, natural gas boilers, geoexchange, and sewer waste
heat recovery, in a multi-criteria assessment, the optimal feedstock was found to be biomass. In an
article that examined this case study, the authors concluded that, “Despite advantages of utilizing
biomass in the considered district energy system, such as low capital cost, advanced and low risk
burning technology, and GHG neutrality, it was not chosen as the best option since the concerns of local
groups were not addressed properly during the feasibility study phase.” (Ghafghazi, Sowlati, Sokhansanj,
& Melin, 2010). To be fair, the project proponents were operating under a time constrained
environment due to the pressure of the Olympic Games; and their final product, the SEFC NEU is widely heralded as an excellent demonstration project for sewer waste heat recovery, and its transparent public governance structure is also well regarded. As a real world example of the sometimes irrational fear that some people can have of new technologies, one interview respondent who lives in Vancouver related the following story,

There is no doubt that the public is willing to accept one technology over another, and the South East False Creek [district energy system] is probably the best example we have of that. Because I live in that community, and I know at the time [of the system’s feasibility study] there was a proposal for biomass combustion, and I had neighbors who were knocking on my door because they knew that I was involved in district energy, and that I was an engineer. I remember one young couple that said to me, “will it be safe for our children to play outside”. I had lived in Denmark, and Danes have one of the highest safety cultures in the world and they are recognized for that, and Danes aren’t worried about their children being exposed [to biomass combustion], because they understand that there is all this technology that makes biomass very safe, but perception is perception.

The notion of utilizing biomass in a DES in the COV may be revisited presently. Although there has been no official pronouncements, Creative Energy Vancouver Platforms, a DE utility that is owned by the Vancouver development firm Westbank Properties, who has recently purchased the legacy natural gas powered, and steam conveyed DES in downtown Vancouver, has announced that it is investigating the possibility of a fuel switch. One of the options being explored is a large scale biomass combustion facility. According to a statement filed with the BCUC,
Creative Energy is currently conducting a detailed feasibility study for a larger fuel switch that would serve both existing customers, and the growth attached to the core system. This is a large and complex project that is intended to address City policy drivers, provincial policy drivers, and market needs. The study is being co-funded by the Federation of Canadian Municipalities (through a grant program) and the City of Vancouver. The results of this study will be available towards the end of this year. Separate studies are underway for supply options to serve new DE systems not connected to the core.


**Solid Waste Incineration**

According to Environment Canada, “Incineration is a type of thermal treatment that is recognized as an effective and environmentally sound disposal method for a wide range of wastes, and is used in facilities across Canada.” (Municipal solid waste and the environment, 2014). Although utilising municipal solid waste (MSW) to produce thermal energy is very effective in terms of producing heat for DE, as well addressing landfill related issues, all interview respondents resoundingly stated that they felt that the requisite social license would be very hard to achieve. Furthermore, mention was made of the need to implement a ban on MSW being hauled out of the region in order to ensure a secure resource stream for any future MSW incinerator, this same respondent also made mention of the strong lobby from the waste disposal sector to maintain waste hauling contracts status quo.
Property Tax

The final barrier to be examined in this analysis, is how property taxes can hinder the growth of the low carbon DES. Property taxes are determined according to the assessed value of land and improvements as determined by BC Assessment, a crown corporation mandated by the BC Assessment Act (BC Assessment, our business, 2015). Although all property owners in BC are responsible for paying annual property taxes, there are some instances when this financial liability can be overly onerous for some DES. In particular, DES that are trying to build new generating plants, that are likely low-carbon fueled, can be subject to hefty property taxes during the initial phase of high capital outlay in the years when aggregated heat loads are still developing. The combination of high capital deployment on a parcel of land and the construction costs of a generating plant alongside still developing revenue streams can affect the timing of switching from natural gas, to low carbon energy sources.

For many thermal energy providers in the Metro Vancouver marketplace, property taxes would not be considered a barrier. For those providers who operate under the “steam A” model, in which the thermal generating equipment is located on site, most often within the parking level of a building, the property tax liabilities lie with the building’s owners. Likewise, many municipal DES operate either through a tax exemption granted by the municipality, or they pay a lessened amount, or they will often have their generation nodes located in existing buildings, as is the case with the Lonsdale Energy Corporation (LEC) in the City of North Vancouver. Another similar situation that is quite common, is for developing DESs to house their initial generation boilers within what is often termed a “temporary energy centre”, these are most often natural gas boilers housed within converted shipping containers. Since they are temporary portable containers often on municipal land, they are also not subject to paying property taxes.
In the COV, however, there are strong municipal policy drivers that are trying to convert the legacy steam system within the downtown core to a low-carbon system. Among options that are being explored, is the construction of a large scale biomass fired generation plant on a separate parcel of land from where the current natural gas generating plant is located. According to several interview respondents who are familiar with this project the utility mil rate within the COV that is applicable to DE utilities is between 5-5.5%, and if a new generating plant is to be built costing tens of millions of dollars, the property tax liability would be as one respondent termed it “quite harsh”. These same respondents conceded that there is on-going discussions between the system proponents, the COV, and BC Assessment about how they can best mitigate the impact of this financial burden. One potential solution is to phase in the tax burden over a longer time period, and this is already possible for utilities, “Where in the opinion of the Board of Directors, there has been a substantial change in the rate from one taxation year to the next, the Assessment Authority may phase in the rate change over up to a three-year period” (BC Assessment, regulated rates, 2015). Through phasing in this financial obligation over a longer time frame we can reduce the impact that these costs would have on customer rates; it is crucial to bear in mind that regulated DESs in B.C. operate on a cost of service rate model, ergo higher costs to system operators are passed on as higher rates to heat consumers.
Conclusion

Throughout this thesis a myriad of benefits have been highlighted that provide a strong evidentiary record for why DES should be deliberately encouraged and implemented wherever feasible across Canada. This is not to say that DES or TES are a panacea to the plight of climate change, far from it, rather they are one measure that can be deployed to both incrementally and cumulatively reduce anthropogenic GHG emissions from our increasingly densified urban centres, while also imparting valuable fuel input flexibility, and energy resiliency. Through exploiting novel energy generation and transmission technologies, as exemplified by DES, cities can also realise the co-benefits of more effectively leveraging their production of primary energy, harnessing the waste heat potential from their heavy industries and waste streams, and exploit a variety of previously wasted biogenic energy sources. These available synergies will move our urban centres closer to the goal of being net zero waste societies’, and will provide a pathway for closing the loop between our production, consumption and disposal streams.

It is widely acknowledged by many scientists and scholars that our societies require aggressive transformative change in our energy systems, transportation systems, agricultural systems, as well as urban design and building technologies, in order to avert some of the more dire ecological changes, and social dislocations that are predicted to occur over the next century (Potvin et al., 2014; Dale, Robinson, Herbert and Shaw, 2013). Achieving this kind of fundamental change is made all the more difficult as there are powerful vested interests with formidable investments mobilized in order to maintain the status quo; through their deliberate campaigns, a concerted effort has been mounted to obfuscate and misinform the electorate as to the true consequences of our current energy technologies. Over time as people become better informed of the eventual outcomes of our cumulative impacts, it is hoped they
will elect political leaders who will push industry to transition to more sustainable practices, and that more people will make the individual behavioural changes that are required; in this way, true transformative changes can be realised.

In order to create this envisioned liveable and sustainable society, however, it is incumbent upon all citizens to educate themselves about the true impact humanity is exerting on our foundational ecosystems, and to actively choose to make behavioural changes to reduce their own carbon footprint; this may well be true, but it is also deceptively difficult to achieve. Through harnessing efficiencies at a system wide level, as happens with DE or a TES, it lessens the burden on the individual to make all these requisite changes within themselves. It is imperative that efficiencies be made at the system level in all the major categories that were previously listed.

However, from the narrow view of this thesis, changes within the thermal energy system generation and provisioning are advocated. It is for this reason -system level change- that municipalities are actively pursuing DESs as a means to achieve some of their requisite GHG reductions. It was widely mentioned during the research interviews that end consumers of heat are largely indifferent or unaware of how or where their thermal energy is sourced, so long as their desired temperatures are delivered to their indoor space at reasonable cost, they are content. Therein lies the utility of these systems, desired outcomes are achieved, both in terms of lowering carbon emissions and in providing desired indoor temperatures, without having to change the behavioural patterns of individuals. In terms of incremental costing to consumers, sourcing centrally delivered low carbon thermal energy would pale in comparison to granite countertops, stainless steel appliances, and tropical hardwood flooring in the new construction that is planned in the Metro Vancouver area.
What is still debated, and is an area that warrants further scholarly scrutiny, is who is responsible for educating the general public as to the benefits of combusting previously wasted feedstocks, such as urban wood waste, forestry residuals, and municipal solid and/or refined liquid waste to produce thermal energy in the urban core. Furthermore, who also is responsible for promulgating the science based evidence that shows that the resultant urban air quality would be little worse than under a BAU scenario. Whomever assumes the reigns of this outreach campaign, be they political elites, system proponents, traditional utilities, or NGO’s, it is critical that there be coordinated collaboration. These low carbon thermal energy proponents must standardize a message across these diverse organisations so as to ensure the educational outreach campaign does not further cloud what is an already highly technical subject matter.

However the above questions are resolved, it would be beneficial for all players in the thermal energy sector to have clear regulations that stipulate energy performance targets for new development projects, and ideally, precise targets for renewable energy integration that are equitable across the region, with reasonable and achievable timelines, as opposed to a pastiche of opaque and inconsistent policies that differ from development to development, and neighborhood to neighborhood. In order to achieve these desired outcomes, it will take a strong commitment from the hands that hold the levers of control within the Provincial government. It is important to remember that low carbon thermal energy provisioning, either from a DES or an on-site TES, are developing in close alignment with civic policy objectives, and that they will ultimately confer public goods benefits on all citizens of this region. For this reason, it is important that general public become well informed, and educated as to the rationale, benefits, and science associated with low carbon energy sources.
Discerning readers may note, that within this thesis there has been scant mention of the role of the Canadian Federal government in directing the national energy discourse towards more innovative and sustainable energy policy. This has been done quite deliberately, although this researcher does feel there is urgent need for a reformed national energy strategy in Canada promulgated from the Federal government that pays heed to the peril that climate change could pose, this analysis is beyond the scope of this thesis. In order to accommodate a thorough and detailed analysis and discussion of the DE industry in Metro Vancouver, it was decided that this thesis would restrict its content to factors that are within the sphere of influence of British Columbia.

As follows is a list recommendations of some of the more important changes that could be implemented in order to streamline and further drive the expansion of this sector.
Recommendations

- Implement a comprehensive national plan for pricing carbon, either through a carbon tax, similar to B.C’s, or a cap and trade system as operates between Quebec and California.

According to the report, Acting on climate change, from the Sustainable Dialogues Canada, a group of 60 leading scholars across this country,” Widespread agreement nevertheless exists among climate policy analysts that carbon pricing should be a key component of any comprehensive climate change policy. There is less agreement on which carbon pricing mechanism (a carbon tax, or cap and trade) provides the best balance” (2014). By creating a uniform carbon pricing system across Canada, or North-America wide, the low carbon and renewable energy alternatives will be incented to grow on a larger scale, and as this scale grows, costs to consumers will drop inversely. Through pricing the market distorting effects of carbon externalities into carbon based fossil fuels, individuals, organisations, and governments can receive the right price signals, and thereby choose the optimal technologies. This will not only incent the further scaling out low carbon fueled DES s, but will also incent jurisdictions that produce thermal electricity to incorporate CHP into their generation facilities and thereby greatly increase the efficiency of the primary energy inputs.
Strengthen energy efficiency guidelines within the provincial building code.

Although the provincial building code is not lax by North-American standards, and as of, “April 2013, B.C. adopted both the 2011 National Energy Code for Buildings (NECB) and ASHRAE 90.1 (2010) as compliance options in the B.C. Building Code for large residential, industrial, commercial and industrial buildings effective December 20, 2013” (BC government, buildings and safety standards, 2015) if B.C. is to continue in its leadership role on climate change mitigation it must continue to escalate standards.

It should come as no surprise that the nexus of the growth within the DES and TES sector in B.C. is occurring within the COV. The reason for this is that under the political regime of Mayor Gregor Robertson, the COV has aggressively set GHG reduction targets of its own under its Greenest City 2020 Action Plan that seek to reduce GHG emissions in the COV by 33% below 2007 baseline levels (COV, 2012). As highlighted in a list of the 3 highest priority actions to achieve these goals, DES can play a significant role.

- Work with partners in the city to build new neighbourhood-scale renewable energy systems
- Work with partners to convert large-scale steam systems to renewable energy
- Develop a policy framework that clearly articulates when the City will or will not consider different renewable energy sources for district energy systems

(Ibid)

Further to specific targets, the COV has mandated as of 2011 that all new buildings on re-zoned sites be constructed to LEED Gold standards; the stringent energy efficiency targets mandated therein encourage connection to a low-carbon DES or TES on site. As a reiteration, the COV has the authority
under its charter to make amendments to the Provincial building code, while other local municipalities do not.

- **Explore the possibility of allowing low-carbon fueled DES to market their GHG reductions as a carbon offset.**

Trying to develop a low carbon fueled DES is a capital intensive and potentially high risk investment, and therefore increases the cost of accessing financing through a project’s WACC. By creating new revenue streams for these projects, such as selling GHG reductions to the BC climate secretariat as carbon offsets, the likelihood of these new projects being built can be increased. In a report done by the Delphi group in 2011 titled *GHG QUANTIFICATION PROTOCOL: FUEL SWITCHING FROM FOSSIL FUEL-FIRED ENERGY GENERATION TO LESS GHG-INTENSIVE FOSSIL FUEL OR RENEWABLE ENERGY SOURCES V2.1*, this scenario is explored; though the report is premised on electricity generation, it also stipulates that it is applicable to, “Generation of heated air or water (e.g. for industrial process use, space heating, domestic hot water) (Ibid, 2.2.1). However, in order to be considered as an acceptable GHG offset, each project proponent must pass the “barriers test” for additionally. The concept of additionally revolves around the viability of a project, in that, if a project were going to be built without the incentive of the carbon offset, then it would fail the barriers test and not qualify as requiring the top up of the offset to proceed. The basic criteria for a barrier that is preventing a project from proceeding is as follows.

- **Capital Cost:** A higher capital cost in either the baseline or the project may present a barrier depending on access to credit or capital.

- **Operating Cost:** Operating costs associated with energy generation may present a barrier for certain types of generation
- Technical Expertise: The project or baseline may require technical expertise that is not readily available and hence barriers could be present either through cost of training, timing of expertise availability, etc.
- Infrastructure: Lack of infrastructure may present a barrier in terms of type of fuel available at the site, transmission and distribution equipment, necessary structures etc.
- Institutional/Political: Resistance to the project or baseline at an institutional or political level may present a barrier.
- Fuel Procurement: Challenges in procuring or cost of obtaining a reliable supply of certain types of fuel may present a barrier Social/Cultural: Social acceptance of particular technologies or energy generation solutions may be a barrier

(ibid, 2011)

- **Implement a ban on electric baseboard resistance heaters in all new high density developments, and instead mandate hydronic building.**

  This recommendation is tightly aligned with the notion that we must consider the principles of maximizing the exergy within our energy portfolios. Although we are fortunate to have a plethora of hydroelectric potential within the province of BC, we should nevertheless be sourcing our space heating requirements from lower grade energy sources, as have been described elsewhere within this thesis. As a further rationale, we must begin to consider our energy assets from a wider, more comprehensive lens, which is to say on a more national, or even continental perspective. Climate change is a global problem, as are GHG emissions; through exporting some of our renewably generated hydroelectricity to neighboring jurisdictions that currently generate electricity from thermal coal, significant GHG reductions can be achieved. This possibility could be enhanced through shifting new space heating and domestic hot water requirements from being electrically sourced, to being sourced from a DES or TES;
this can only happen if new building stock is constructed hydronically. As is evidenced form the UBC NDES connection credit requirement, left to their own discretion many developers will choose the more economical to install electrified heating systems. To reference the salient commentary of one of the interview respondents,

At the end of the day, if B.C. still thinks that they can continue on with [electric] baseboard heaters, then don’t bother continuing with district energy... basically, they haven’t built an electric baseboard heated building in Ontario for twenty-five years.

- Increase public literacy of the benefits and rationale for encouraging DES and TES within our cities

Although Vancouver has had a large scale, and successful, DES operating within the downtown core since 1968, DE has low profile within the minds of the general public. This assertion was repeated many times throughout the interview process, though it may be anecdotally sourced, it nevertheless remains widely held. Since many municipalities are hoping to expand DE within their denser core areas, and they plan to leverage alternative feedstocks that are low carbon, some of which may require new combustion, it is critical that a clear, cohesive, and comprehensible public outreach strategy be implemented. As Ghafghazi et al. (2010) reference in their article chronicling the lead up to the SEFC NEU, gaining social license to build these new DES can be a large hindrance, and as happened in that instance, proponents may not be able to utilize their desired feedstock. This is particularly true of biomass, which is one of the most bandied about options in any local DES. In order to build the public acceptance that is required, civic official in concert with local utility providers should standardized a
public educational campaign to designed to promulgate the benefits that DE will confer upon its communities, and dispel some of the outdated notions that people have regarding modern combustion technologies.

- Improve access to, and supply of biomass resources

As stated, biomass is an attractive feedstock for DE, both locally, but also globally. BC’s wood pellet export industry, for example, is valued at 300 million dollars annually (Vancouver Sun, 2015), and is actively expanding in order to fill market needs in Europe and Asia. In order to ensure a secure and available supply of this resource, changes need to be made to regulations that dictate stumpage rates for logging residuals. Logging residuals refers to the remainder of the trees after merchantable logs are harvested. Currently producers have to pay the same stumpage rates for harvested logs as they would for harvested residuals, since residuals are of a much lower economic value, this incents logging companies to leave these resources on site (Ibid). Further compounding this egregious waste, is that these residuals are most often burned on site in order to reduce fuel loading to mitigate forest fire hazards (Ibid). This creates a system where not only is a valuable resource wasted, but it also results in more GHG emissions when they are burned and resultant waste heat is not harvested. The applicable regulations that have created this situation need to be re-visited in order that they can updated to meet with current market demand for this increasingly valued resource.
• **Strengthen the relationship between DE and local developers**

Since developers are an integral part of building cities, it is important that their concerns and issues surrounding DE be addressed. Obviously it is not possible to make any blanket statement regarding the status of the relationship between DE and local developers since each circumstance has its own variables. It was apparent, however, throughout the interview process that most respondents felt that this is a confrontational and often adversarial dynamic. Determining how the bonds between these two communities can be strengthened is an area that warrants further study.
References


Fortisbc. (2012, October). News release. *Fortisbc to deliver thermal energy to schools within delta school district*. Retrieved from


Request for interview

Date, 2015

To whom it may concern,

My name is Reg Martin, I am a second year student at Royal Roads University enrolled in the Master of Sustainable Environmental Management program. I am writing you this letter to introduce to you a research study I am undertaking as part of my thesis project. The broad topic of the research is to examine the barriers, in terms of regulatory regimes, governance structures and economic realities, facing district energy and its scaling out in the Metro Vancouver area. My research will be qualitatively based and will involve a purposive sampling of 15-20 critical stakeholders in this sector, ideally including representation from DE, as well as from the major utilities (FortisBC, BC Hydro), the regulatory regime (BCUC), and members of both municipal and provincial governments. The interviews will require one hour or less of time commitment on the part of participants, and all parties involved with this research will remain anonymous. Through engaging in these interviews, I hope to be able to aggregate recurrent themes into specific recommendations that can be of utility to all stakeholders. Guiding me in this research is my thesis supervisor, Dr. Ann Dale, a foremost academic researcher in climate change adaptation and mitigation and a holder of a Canada Research Chair in Sustainable Community Development.

Ted Sheldon from the climate action secretariat has graciously offered to forward my thesis research to many of you in order to facilitate the solicitation of interview participants. I hope all will consider participating in the research, and adding to the robustness of the data collected.

I will be seeking to engage in these qualitative interviews early in 2015. My formal document is to be submitted to my academic advisory council for review by September of 2015. Pending its approval by my thesis committee, the document will be made available to all research participants, and it will also be accessible to the public.

Thank you for taking the time to consider my request. Please feel free to contact me at your convenience for further information or clarity.

Sincerely,

Reg Martin, xxxxx@shaw.ca
Interview Questions

1. How long have you been working in the district energy sector in Metro Vancouver? What is your position within this industry?

2. District energy (DE) requires high upfront capital costs, both in the pre-planning phase as well the construction phase, and therefore requires patient and high risk capital, do you believe that there is enough literacy, with regards to DE, on the part of financial institutions, and is there a need to better communicate the long term benefits to financing DE projects? SEED CAPITAL

3. Many DES have sourced a portion of their initial financing from government subsidies or incentive programs (Federal gas tax, Prov. Innovative clean energy fund, FCM green communities grants, Olympic grants...etc.) Is this model of subsidies effective? If not, what incentives would be more effective? SUBSIDY/GRANTS

4. Many of these government subsidies are only available to municipally owned utilities, and are not equally accessible to private developers, do you feel that this creates any inequality in the marketplace, and if so what should be done? ACCESS TO FUNDING

5. How long did the preconstruction planning and zoning process take to obtain the requisite municipal approvals? Do you feel as though this was a reasonable amount of time, or is there anything that government could or should do to expedite this? PERMITTING

6. DE have a variety of governance structures, from municipal ownership, private investor ownership, and mixed public/private. What do you think about this diversity of governance structures? GOVERNANCE

7. Based upon whether a DES is municipally owned, and operating within its bounded municipality, it is not subjected to BCUC oversight, whereas most others are subjected to BCUC regulatory oversight. Does this inconsistency create the potential that unregulated systems may be perceived to lack oversight and perhaps accountability? BCUC OVERSIGHT

8. Some municipalities locally, and other jurisdictions nationally and internationally, have bylaws that compel connections to DE, do you believe these bylaws are good policy? Are there any other bylaws that local government should consider in order to encourage DE? BYLAWS
9 Given developers have made financial gains through densifying our urban environment, should they pay into a fund that can be made available for community energy initiatives such as DE? If not, what other ways can developers contribute to DE? **ROLE OF DEVELOPERS**

10 DES and other community energy initiatives are relatively new endeavours in our local and national marketplaces, in what way is this a barrier to this industry? **LOCAL CAPACITY**

11 Do you feel that the public is willing to accept biomass, biogas, or waste incineration within the urban centres of Metro Vancouver, and if not, why not? **PUBLIC BUY-IN**

12 How can we build greater literacy in both the public and political decision makers about the advantages of incorporating these locally produced feedstocks into our community energy systems? **PUBLIC LITERACY**

13 Are the local property tax rates well-structured for DE systems? Should municipalities make any amendments to their property tax regimes to help accommodate the economic challenges faced by DE systems? **PROPERTY TAXES**

14 Given the undervalued costs of carbon fueled energy’s negative externalities- and recognising that BC’s $30/ ton carbon tax is not a high enough pecuniary leveling mechanism- is it reasonable that low carbon thermal energy should be able sell at a premium price for customers who desire this option? Or, should DES’s powered by low carbon fuel sources be able to sell carbon offsets equal to the amount of GHG avoided from a business as usual baseline (natural gas boilers). **LOW CARBON**