FUTURE ECONOMY

CASE STUDY

INNOVATIVE APPROACHES TO LOW-CARBON URBAN SYSTEMS: A CASE STUDY OF VANCOUVER'S NEIGHBOURHOOD ENERGY UTILITY

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EXECUTIVE SUMMARY

The City of Vancouver's Neighbourhood Energy Utility (NEU) is a low-carbon urban system that hits a sweet spot of clean energy, local control, and stable prices at competitive rates. The NEU arose as part of a vision for redevelopment of former industrial land into a mixed-use community in the Southeast False Creek area of Vancouver. The first phase included construction of the False Creek Energy Centre and service to the Athletes' Village for the 2010 Winter Olympic Games.

At the core of NEU operations is a hybrid system of sewage heat recovery (SHR) backed up by natural gas boilers to deliver thermal energy to buildings in the service area. The NEU targets a key GHG mitigation opportunity in buildings through shifting away from fossil fuels for space and water heating.

While the system is not fossil fuel free (due to the natural gas component), GHG emissions were reduced by approximately 56-77% in 2012 and 44-61% in 2013 relative to development that did not include the NEU. This decline in performance between 2012 and 2013 is due to new buildings being added to the existing system, which increase the system's reliance on natural gas. Planned new SHR capacity is added in 2018. Future mitigation opportunities for the NEU could include biomass as a substitute for natural gas.

Capital costs were supported by a federal grant, low-interest loans and self-financing from the City. The NEU's rates are modeled on a traditional regulated utility, with revenues obtained entirely from its customer base. Because the eventual customer base will be built out over more than a decade, the city implemented a rate structure that under-recovers capital costs, running deficits in the early years. Cost competitiveness is a key objective, and the NEU rate structure compares favourably to other DE systems and energy providers.

The NEU is a modern example of public sector innovation. It challenges a paradigm of centralized energy distribution, and links and expands municipal services in a novel way. To reduce risk and achieve economies of scale, the City requires mandatory connection of all buildings in the service area.

As a highly capital-intensive utility, most of the job creation occurs during the construction phase, which involved approximately 50 FTE jobs over a three-year period. Ongoing expansion of the network to new buildings ensures continuing construction work. In NEU operations, there are 3.5 FTE jobs, and these are highly-skilled engineering jobs. While these numbers are relatively small, it represents only 24 buildings and a very small percentage of total energy demand in the city.

The NEU has environmental and economic attributes that could be replicated in other cities (and it is already having an influence in other parts of Metro Vancouver). A key challenge is upfront capital costs, which could be ameliorated by senior government support and through the development of green bonds. But the NEU case also shows how a public utility model can be developed for low-carbon district energy, even in the absence of subsidies.

Future constraints on carbon and increases in the price of emitting carbon would clearly improve the economics of this innovation. Future gains could also arise from the addition of new energy centres to a growing NEU network using SHR and/or other renewable sources.

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About E3 Network's Future Economy Initiative

In communities across the US, new economic institutions are emerging to challenge business-as-usual. These bold innovations respond to rising inequality, environmental degradation, economic decline. They may forge the foundation for a more resilient and equitable economy of the future. Despite their potential significance, there is a general lack of awareness of these innovations and their impacts and there has been little systematic economic analysis of these innovations and their contribution to a potential future economy.

The Future Economy Initiative[1] is bringing rigorous economic analysis to these emerging innovations. Our goals are to document and study their social, economic, and environmental impacts and identify factors which contribute to their emergence, success, and limitations. We assembled a team of researchers to design a framework for analyzing future economy innovations and awarded grants to teams of researchers across the country to apply the framework to varied case studies. This case study report is one of seven presenting results of those efforts. We encourage you to explore the other completed case studies and to apply the framework in your own research and share your findings

For questions or comments on E3 Network's Future Economy Initiative, please contact Robin Hahnel at E3 Network, robinhahnel@comcast.net.

For more information regarding this particular case study, please contact Marc Lee, Senior Economist, at Canadian Centre for Policy Alternatives, BC Office, 1400 - 207 West Hastings Street, marc@policyalternatives.ca

[1] The Future Economy Initiative is a program of Economics for Equity and the Environment Network (E3 Network), a national network of economists developing new and better arguments for protecting people and the planet. Through applied research and public engagement, we seek to improve decision making and further understanding of the relationship between economy and ecology. More information available online at: http://www.e3network.org/future-economy-initiative.html.

1. INTRODUCTION: DISTRICT ENERGY 2.0

Around the world cities have asserted a leadership role in climate action at a time when progress among national actors and in international negotiations has been painfully slow. For example, an umbrella group of local governments, the International Council for Local Environmental Initiatives (ICLEI) has been a key forum for sharing and linking urban mitigation actions.[2] Cities ostensibly have a more limited policy toolbox than senior governments, yet decisions on land use planning, buildings and urban infrastructure can have a powerful long-term impact on their carbon footprint.

A central greenhouse gas (GHG) mitigation challenge common to all urban areas is the energy used for transportation and buildings. For urban planners, an ideal of *complete communities* emphasizes low-carbon structural change, with walking, biking and transit modes of transportation supplemented by car-sharing, plus greater proximity of homes to work, shops, entertainment, parks and public services.[3] Efforts to design green buildings and energy-efficiency retrofits of existing buildings have also been widespread.

The concept of *community energy management* goes a step further to integrate energy into urban planning "in order to exploit the synergies between urban design objectives for livable cities and energy management objectives of minimizing energy use and its associated environmental effects for a given standard of living."[4]

In this paper, we consider these dynamics in evaluating the City of Vancouver's Neighbourhood Energy Utility (NEU), a district energy system in operation since 2010, and built for modern challenges of sustainability and energy security. The NEU arose as part of a vision for redevelopment of former industrial land into a mixed-use community in the Southeast False Creek area of Vancouver. The first phase included construction of the False Creek Energy Centre and service to the Athletes' Village for the 2010 Winter Olympic Games.

The NEU repurposes district energy as a key ingredient in urban planning and greenhouse gas mitigation. District energy is primarily the use of centralized boilers to provide heat and hot water to multiple buildings, although it can also include cooling services and co-generation of electricity. It is a well-established technology, with many examples of steam systems (powered by fossil fuels) in downtowns, universities and hospital campuses across North America going back more than a century.[5] In Northern Europe, district energy has achieved greater penetration, originally a response to oil price shocks, with Sweden an exemplar for having pushed its district energy to shift to renewables.

The NEU displaces fossil fuels through the capture of heat from sewage waste, the first example of its kind in North America. This was inspired by two such facilities in Norway (another is in Japan), adapted to the Vancouver context. It is also an excellent example of public sector innovation at a time when the conventional wisdom is that innovation is best left to private sector actors. The NEU model challenges us to rethink what we consider to be municipal public services to include energy, and integrates energy and sewage services.

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[2] For example, see "ICLEI: Cities Show Surge in Climate Action," http://newsroom.unfccc.int/green-urban/cities-show-surge-in-climate-action/ based on ICLEI, carbon*n* Cities Climate Registry 2013 Annual Report, http://www.iclei.org/fileadmin/PUBLICATIONS/Annual_Reports/cCCR-annual-report-FINAL_20140610.pdf

[3] Patrick Condon, Eric Doherty, Kari Dow, Marc Lee, Gordon Price, *Transportation Transformation: Building complete communities and a zero-emission transportation system in BC*. Vancouver: Canadian Centre for Policy Alternatives, 2011, https://www.policyalternatives.ca/transportationtransformation.

[4] Jaccard, M., L. Failing and T. Berry (1997). "From Equipment to Infrastructure: Community Energy Management and Greenhouse Gas Emission Reduction" in *Energy Policy* 25(13): 1065- 1074.

[5] There are over 6,000 district energy systems in the United States (about one-third in each of universities, medical complexes and other facilities) and 116 in Canada. D Harvey, A Handbook on Low-Energy Buildings and District-Energy Systems: Fundamentals, Techniques and Examples. London: Earthscan, 2006. And J Nyboer, R Murphy, N Melton and M Wolinetz (2014). District Energy Inventory for Canada 2103. Canadian Industrial Energy End-use Data and Analysis Centre, Simon Fraser University, Burnaby, BC.

We can think of the NEU as a case study in low-carbon urban systems that use modern technology to hit a sweet spot of clean energy, local control, and stable prices at competitive rates. These "district energy 2.0" systems are compatible with a variety of renewable energy technologies beyond sewage heat recapture. They may also do more of the heavy lifting of greenhouse gas mitigation: space and water heating account for most of the energy used in buildings, and almost all of the GHG emissions.[6] With many city centres experiencing a revival, the resulting higher density patterns of development align well with district energy systems.

The next section looks closely at the NEU model and how it evolved. Then we analyze a range of economic, environmental and governance dimensions. Whether the NEU is scalable and replicable is an essential question, and we consider challenges and barriers alongside some evidence that the NEU model is already influencing energy planning and greenhouse gas mitigation in other parts of the city and in the Metro Vancouver region.

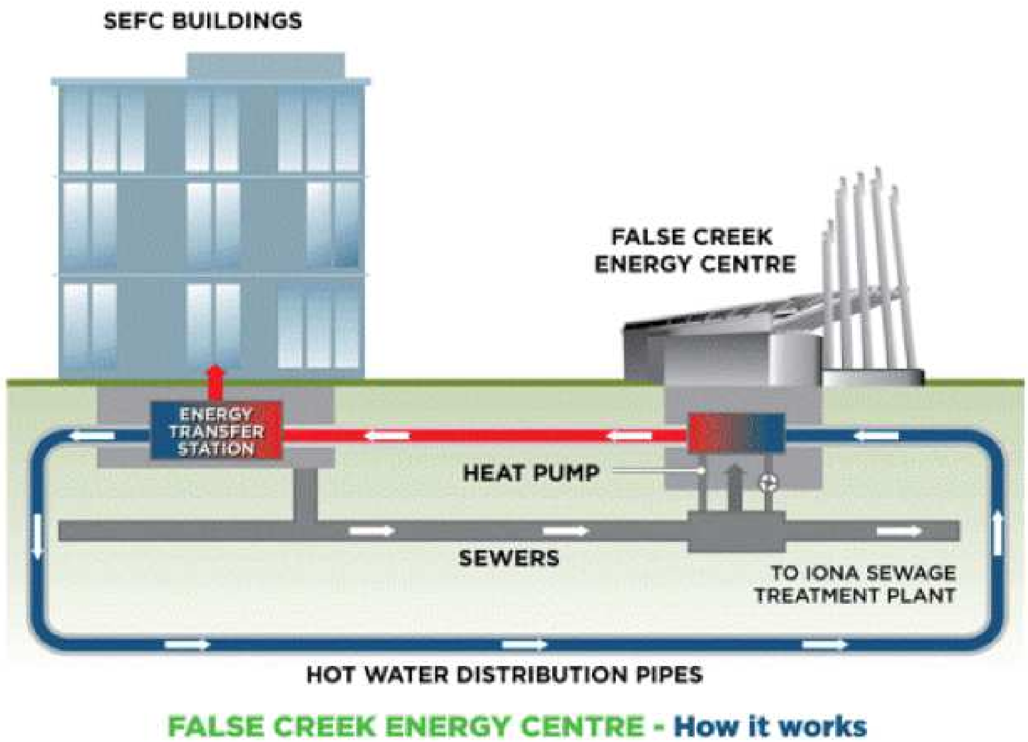
2. THE EVOLUTION OF THE NEU: BACKGROUND AND CONTEXT

The key objectives of the NEU are to provide low-carbon energy (space heating and hot water) in its service area, and to do so in a way that is cost-competitive for consumers and that makes a financial return for the city. Instead of individual buildings having their own dedicated equipment for heat and hot water, each building is required to connect to a centralized facility. Like other utilities, the NEU overcomes a collective action problem by investing in capital infrastructure that is repaid by consumers over time.

At the core of NEU operations is the False Creek Energy Centre, which uses a hybrid system of sewage heat recovery and natural gas boilers to deliver thermal energy to buildings in the service area via 3.7 km of pipes (Figure 1). Outgoing hot water ranges in temperature from 65°C in summer to 95°C in winter, and is cycled back to the energy centre with return temperature of 50°C for all seasons. The NEU provides another piece of infrastructure, energy transfer stations, which connect to each building's heat and hot water pipes (called a hydronic system). For space heating, individual units can heated by either radiant floors/ceilings, perimeter baseboards/radiators, or fan coils using forced air.

[6] 78% of energy use and 99% of GHG emissions for residential buildings in BC in 2011. Natural Resources Canada, Office of Energy Efficiency, Comprehensive Energy Use Database Tables, Residential Sector – British Columbia, Table 2: Secondary Energy Use and GHG Emissions by End-Use, http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/trends_res_bc.cfm

Figure 1: How the NEU Works



Source: City of Vancouver

Sewage heat recovery provides 3 megawatts (MW) of baseload capacity.[7] Sewage is diverted to the False Creek Energy Centre, where it is screened, and its low-grade energy is extracted through heat pumps and converted to high-grade energy (sewage does not itself flow through the NEU's hot water network; only the heat is harvested). Electricity is a major input to run the heat pumps, but they yield 3.2 times in energy output. The NEU is not fossil fuel free – the False Creek Energy Centre also has 16 MW of natural gas capacity for back-up and peak (e.g. winter) capacity needs.

Intensive planning for the NEU began in March 2006, and it was launched less than four years later to power the Athletes' Village the 2010 Winter Olympic Games. Geographically, False Creek is an inlet of the Pacific Ocean that penetrates into the heart of Vancouver. Completely industrial in use a century ago, False Creek's transformation into several mixed-use neighbourhoods has occurred in stages, beginning in the 1970s. Redevelopment of the 80 acre (32 hectare) SEFC site is the final piece, and is still underway (the Athletes' Village development was phase one).

Service to the original Athletes' Village development comprised 1.2 million square feet of residential, commercial and institutional space. As of 2014, 3.8 million square feet have been connected, with a projected 7.4 million square feet connected by the time the Southeast False Creek area is fully built out.[8]

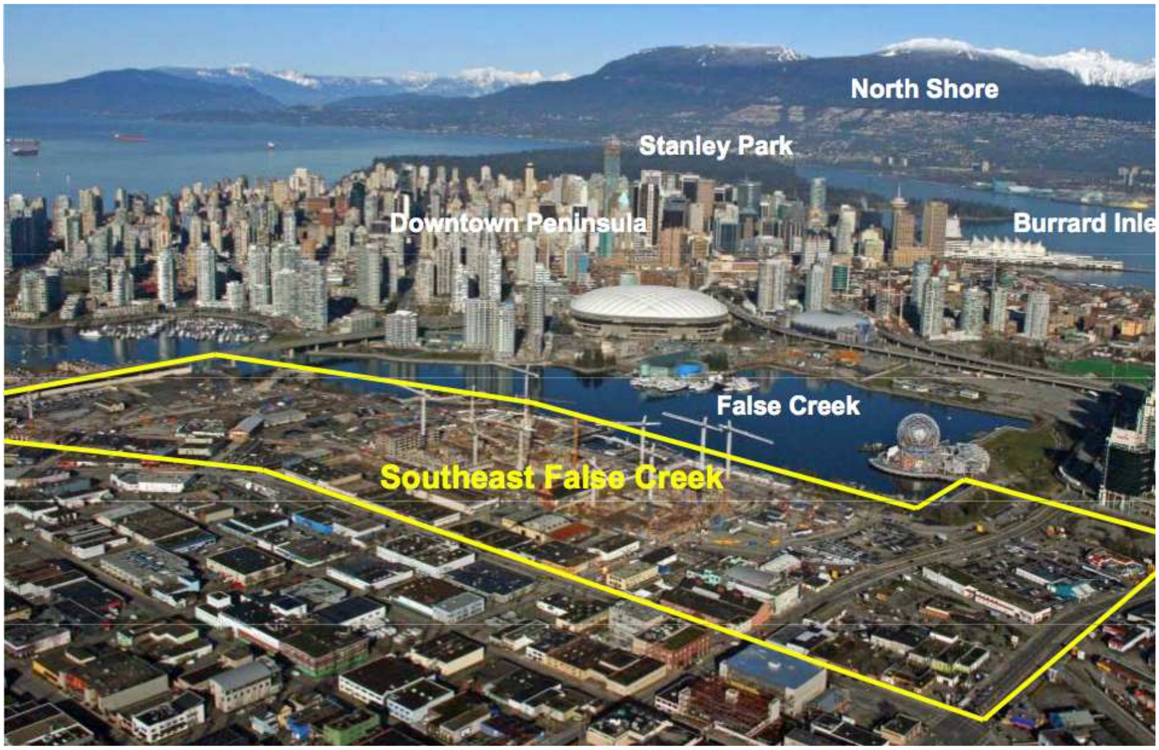
The neighbourhood will eventually house approximately 16,000 people. The City plans to add new sewage heat recovery capacity in 2018, with an increase of an additional 5.8 MW to service the growing development. As the network expands there are also opportunities to connect to other district energy

[7] Capacity is a measure of the instantaneous ability to generate energy, like the size of a car's engine. Baseload refers to the fact that this is the foundational or dependable power for the system. Energy consumption measures capacity over a unit of time, such as a megawatt for one hour, a megawatt-hour (MWh).

[8] City of Vancouver, Southeast False Creek Neighbourhood Energy Utility (SEFC NEU) 2014 Customer Rates, Administrative Report, December 10, 2013, *http://former.vancouver.ca/ctyclerk/cclerk/20131210/documents/ cfsc1c.pdf*

systems in the City (such as a legacy steam system in downtown Vancouver and hospital systems to the south) and could also tap other low-carbon energy sources.

Picture: Bird's Eye View of Southeast False Creek (2009)



Source: City of Vancouver

The NEU's roots go back a quarter century, with the articulation of a vision for the redevelopment of industrial land in the Southeast False Creek (SEFC) area as a sustainable community. This vision itself resulted from the City of Vancouver being one of the first municipal governments in the world to investigate local responses to climate change. The City's *Task Force on Atmospheric Change* reported in June 1990 – some seven years before the signing of the Kyoto Protocol, and two years before the *United Nations Framework Convention on Climate Change* (UNFCCC) was signed at the historic Earth Summit in Rio. Among the Task Force's 35 recommendations was a call for an international design competition for SEFC to "facilitate energy efficient land use policies" on the grounds that it would "motivate the architectural, design and building industries, as well as the public, to encourage energy-efficient land development."[9]

In 1991, Vancouver City Council directed that "the residential development in SEFC should provide a significant amount of family housing" and "that SEFC should be developed to incorporate principles of energy-efficient community design in its area plan and that the City should explore the possibility of using SEFC as a model for "sustainable development."[10] Development of a low-carbon district energy system

[9] Clouds of Change, Final Report of the City of Vancouver Task Force on Atmospheric Change reports, Volume One, June 1990, accessed at http://www.sfu.ca/content/dam/sfu/continuing-studies/forms-docs/city/Clouds-of-Change-Volume1-and-Volume2.pdf. The Task Force recommendation was subsequently adopted (and amended) by Vancouver City Council as Recommendation #17: "That Council direct the City Planning Department and the Housing and Properties Department to develop and planning and design process aimed at achieving an energy-efficient development on the southeast shore of False Creek between Main and Cambie and that this process be reported to Council early in 1991."

[10] Cited in City of Vancouver, Southeast False Creek Policy Statement: Toward a Sustainable Urban Neighbourhood and a Major Park in Southeast False Creek, adopted by Vancouver City Council, October 1999.

came about in subsequent planning work, and was articulated in the SEFC Official Development Plan, passed in 2005.

Innovation was an important aspect of NEU development from the outset, and included choice of energy source, engineering options, and development of the business model. The City engaged a team of consultants to investigate technology options, capital costs, strategies and GHG reduction goals. Two potential energy sources for the NEU met the twin tests of low carbon and affordability: biomass and sewage heat recovery (SHR). SHR became the eventual winner in the city's multi-criteria assessment, even though biomass was determined to result in both lower costs and greater GHG reductions.

Considerations about local air quality became the deciding factor. While SHR was perceived to have some technical risks, due to the small number of real-world examples, biomass was deemed to be more challenging because of uncertainty and timing for receiving air emissions permits from the regional government, as well as public perceptions about air quality impacts. Indeed, at one point when biomass appeared to be the likely technology, public hearings expressed concerns about local air quality, as well as the impact of transporting fuel into the neighbourhood.[11]

This choice was set against the impending deadline of the February 2010 Olympics. Had more time been available to get permits and address public concerns about air quality (the role of emission control technologies, for example), the NEU might be a biomass-based system today. This is an example of how the time pressure of the Olympics drove strategic decisions about SEFC development and the NEU in order to minimize delays. The SHR system came online just two days before the Olympics, although it was only after the area was occupied in Winter 2011, and there was sufficient demand on the system to function efficiently, that the SHR system stabilized.[12] Time pressure from the Olympics also worked in favour of the public sector model. Going with a private operator would require time for a Request for Proposals, evaluation and selection, and would later require regulatory approval from the BC Utilities Commission. Thus, the two most salient features of the NEU, sewage heat recapture and a public utility model, were driven by a tight timeline in the form of the Olympics.

Choosing SHR meant extensive learning about systems developed elsewhere, and adapting that knowledge to the Vancouver context. Legacy district energy systems across North America, including those in Vancouver, are generally powered by fossil fuels. For low-carbon inspiration, the City looked to Northern Europe, with Sweden in particular having evolved district energy to increasingly include renewable sources. These systems can be very large, with almost every building in Stockholm connected to the system, which has a variety of energy sources. Norway was also of interest, with two facilities using sewage heat recovery (Japan was the only other example of SHR prior to the NEU). In addition to learning what was possible in terms of technology, lessons were also taken on their business model and rate design.

These learnings were refined through an iterative process, linked to political approvals at city council and two rounds public consultations, into specific infrastructure design. The conception of SHR changed as this learning occurred. For example, heat exchangers in the sewer mains were originally proposed but this was deemed to be theoretically but not pragmatically possible. Instead, the NEU model focused on the use of a single energy centre to which sewage pipes are diverted, with energy harvested through heat pumps, and backed by natural gas. SHR itself is a product of advancements in heat pump technology and use of heavily-insulated pipe, which mean hot water systems are more efficient than older district energy systems using steam.

A second round of public consultation occurred prior to Council's approval of the False Creek Energy Centre to be located under the Cambie Street bridge, but across the street from existing housing to the

[11] There was some wavering on council. SHR was the preferred option when council approved the NEU in March 2006. That shifted to biomass after a report on energy sources in December 2006, then back to SHR once it was clear that permit delays were significant and public consultations showed concern over the biomass option.

[12] Personal communication with Chris Baber, Manager of Neighbourhood Energy, City of Vancouver, and the original project manager hired in 2006 for the NEU.

west. After a more challenging public process around technology choice, the City took a more proactive approach to engage citizens on the energy centre. Before any designs were made a committee of local neighbourhood representatives was formed to participate in design charrettes and share their thoughts, and open houses were held, co-hosted with the False Creek Neighbourhood Association.

A concern arising out of this public process was around the stacks needed for the natural gas boilers. This led to hiring a public artist, and an iconic and visually-appealing design that serves as public art. In the evening the stacks are lit with LED lights showing in colour system usage. The result was a high level of support – the part of the NEU local residents liked the most was the stacks – albeit at a cost of about $1 million. When the City went to the development permit board for approval, the neighbourhood association provided a letter of support.[13]

The NEU's project manager since 2006, Chris Baber, comments on the organic nature of the process from concept to built form: "Early on it was really hard to visualize how it would look. The product is the output of a large number of people, including architects and residents."[14]

3. LOOKING UNDER THE (NEIGHBOUR)HOOD: EVALUATION OF THE NEU

District energy requires a large upfront investment spanning multiple buildings, and is ideally suited for a new development with planned high densities like SEFC. There are potential economies of scale to be achieved through the centralization of heating: (a) at a technical level, as larger equipment tends to have lower costs per unit of energy produced, and is better optimized to overall load conditions; (b) through operating efficiency gains from professional maintenance of systems; and (c) from integration across many customers, which smoothes out peak demand, and thus requires less (15-25%) total capacity.[15]

While those are well-known features of district energy, in this section we consider the NEU case study for its distinct environmental, economic and governance dimensions. Because greenhouse gas mitigation was a central policy objective, we start with an assessment of how the NEU achieves its GHG reductions. Next we consider how the NEU works as utility business model, with its higher up-front capital costs and ongoing rate structure. Public ownership is also a critical aspect of the NEU. As a more technocratic development, social benefits and costs are somewhat less evident, but we examine employment and local economic benefits associated with the NEU.

Table 1: Key NEU Stats

2014 Stats		
Total Pipe Length	3.7 km	
Connected Buildings	24	
Total Floor area (square feet)	3,853,476	
Residential Floor area (sf)	3,476,740	
Commercial & Institutional Floor area (sf)	376,737	
Performance Data (MWh)		
Inputs	**2012**	**2013**
Electricity for Heat Pump	4,246	4,534

[13] Personal communication with Chris Baber.

[14] Personal communication with Chris Baber.

[15] T Berry, 2010, *Neighbourhood Infrastructure: Doing More with Less*, Compass Resource Management and Portland Sustainability Institute, http://goo.gl/9XEWJ6

Electricity for distribution pumps, HVAC, controls, lighting, etc	1,022	1,133
Natural gas	3,896	8,778
Total energy input	**9,164**	**14,445**
Outputs		
Sewage heat recovery	13,554	14,560
Natural gas boilers	3,422	7,672
Total thermal output	**16,976**	**22,232**
Share of SHR in total output	79.8%	65.5%
Heat pump efficiency (coefficient of performance)	3.2	3.2

Source: City of Vancouver.

3.1. GHG Mitigation

In general, buildings in Vancouver use both electricity and fossil fuels to meet energy needs (i.e. lighting, powering appliances, heating/cooling and hot water). The NEU targets a key GHG mitigation opportunity in buildings through shifting away from fossil fuels for space and water heating. Together these two areas account for a large proportion of the energy used in buildings: 78% of residential energy demand, and 55% of commercial/industrial demand in BC.[16] Fuel switching for space and water heating applications is the principal means by which GHG emission reductions from buildings could be achieved, as most of the electricity generated in British Columbia is already low-carbon and relatively low-cost hydropower.[17]

The NEU's use of sewage heat recapture (SHR) is akin to recycling and composting activities – a shift from linear to circular systems ("closing the loop"). The NEU's heat pumps capture energy from waste water, mostly water heated up to room temperature while sitting in the toilets and pipes of buildings.[18] On an annual basis, the NEU met 80% of demand from sewage heat recovery in 2012 and 65% in 2013.[19] This drop is due to new buildings being added to the existing system, which increase the system's reliance on natural gas and thus reduce the relative GHG reduction arising from SHR.

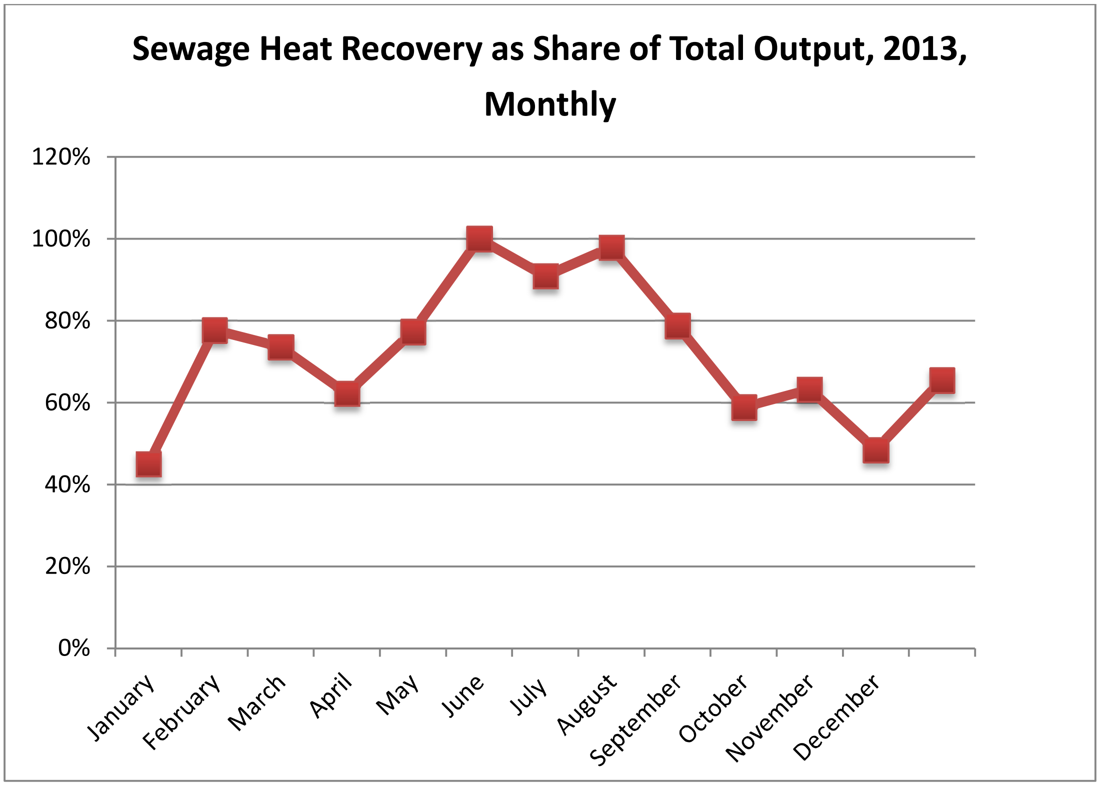
Figure 2:

[16] Data for 2011 year. For residential buildings, 53% is for space heating, hot water 25%, and space cooling 0.3% of total energy use. For commercial/institutional buildings, figures are 48%, 7% and 1% respectively. Note that Vancouver has a milder climate, with less heating demand in winter and less cooling in summer relative to other parts of BC. Natural Resources Canada, Office of Energy Efficiency, Comprehensive Energy Use Database Tables, Table 2: Secondary Energy Use and GHG Emissions by End-Use, for each of Residential and Commercial/Institutional, British Columbia, http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/comprehensive_tables/list.cfm?attr=0

[17] For the time being. BC Hydro rates are now rising after limited increases over many years. Higher rates, in part, reflect the marginal cost of new power supply.

[18] The heat is not from chemical processes within the sewage itself.

[19] Data provided by City of Vancouver Engineering Department.



Source: City of Vancouver Engineering Department

Figure 2 shows the SHR share of system output (i.e. consumer demand) in 2013 at different times of the year. Vancouver has a milder and wetter climate when compared to other parts of Canada and the northern US states. In summer, SHR is sufficient to meet total demand, meaning the system is close to fossil fuel free (occasional exceptions might include downtime for system maintenance). In the coldest months of the year, demand for heating is greater and the heat of the incoming sewage resource is less. Nonetheless, SHR met about half of demand in December and January.[20] This shows some limitations in use of SHR by itself as a renewable energy input: system run entirely on SHR would require substantial additional capacity (and capital cost) to meet loads in winter, which would then sit idle for much of the remainder of the year.

Overall, there is a net increase in GHG emissions, as SEFC is new development. Natural gas used by the NEU led to GHG emissions from operations of 723 tonnes of CO2 in 2012 and 1,628 tonnes in 2013.[21] Electricity from BC Hydro, which powers heat pumps, has negligible GHG impact.[22]

Figure 3 shows estimates of GHG impacts based on energy use data from the NEU and constructing counterfactual scenarios about averted GHG emissions – that is, if the SEFC development had occurred without the NEU. Averaged across 2012 and 2013, SHR led to averted GHG emissions of about 2,450 tonnes per year if all thermal capacity for the system had been entirely from natural gas. This represents

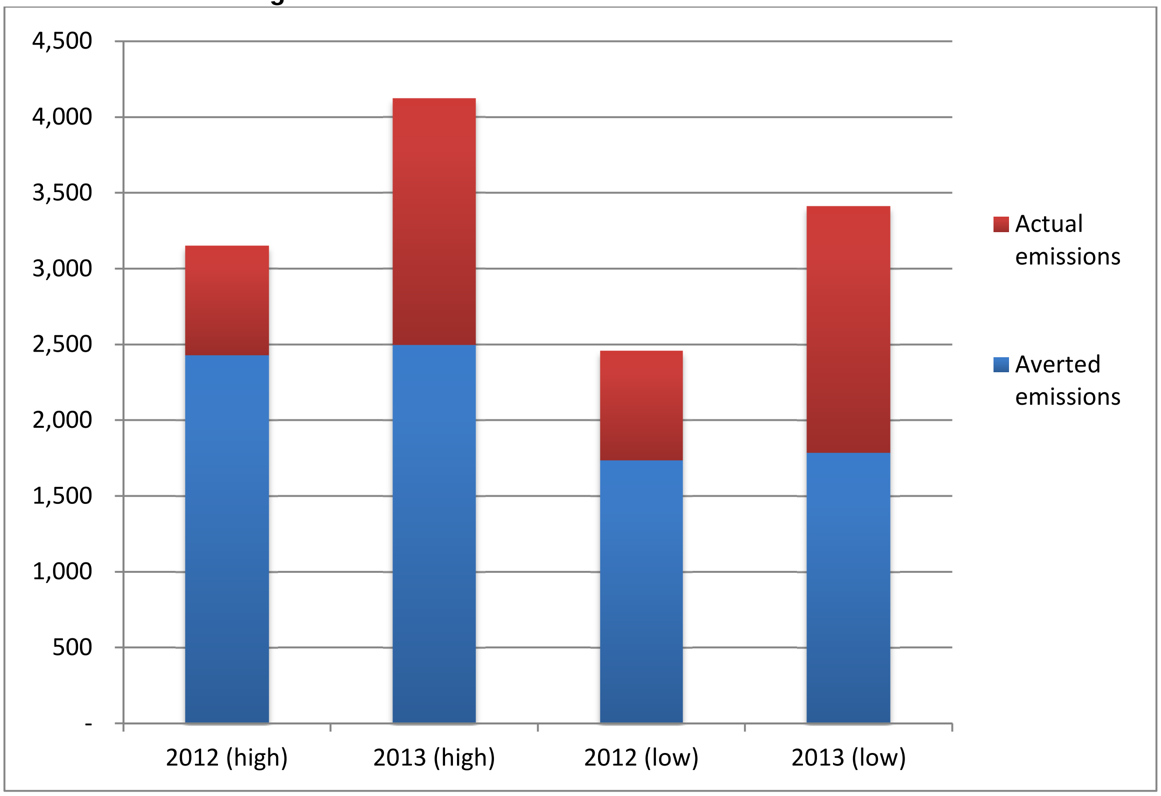
[20] NEU operators note there was significant heat pump downtime in January 2013 due to a failure of the sewage screen.

[21] A significant issue for natural gas (methane) is leakages from wellhead to final combustion because methane is a much more potent greenhouse gas than carbon dioxide (35 times more heat trapping over a 100-year period, and 86 times more over a 20-year period). This calculation assumes no leakage, and therefore understates the climate impact of using natural gas. In the same manner, this also understates the averted GHG emissions from utilizing SHR.

[22] A small amount of natural gas, mostly for back-up purposes, is used in BC, while 94% of electricity generation is from hydroelectricity and other renewable sources. On a lifecycle basis, there is still some GHG impact arising from construction and flooding land.

a 77% reduction in 2012 and 60% in 2013 (high scenario in Figure 3). Averted GHG emissions are less in the low scenario, about 1,800 averted tonnes per year, if we assume 30% of this energy would have come from electric water and baseboard heaters (the average for multi-unit buildings in Vancouver). This represents reductions of 56% in 2012 and 44% in 2013 (low scenario in Figure 3).[23]

Figure 3: GHG Emissions and Averted Emissions



Source: Author's calculations based on data from City of Vancouver.

As with energy demand, the relative impact of SHR in GHG mitigation is forecast to decline over the next few years as new buildings are added, and additional peak demand in colder months is met with natural gas. This will occur up until planned new SHR capacity is added in 2018, with an estimated 75-85% reduction in GHG emissions compared to natural gas boilers in each building.

In terms of pricing, low natural gas prices in recent years have made SHR (and all renewable technologies) relatively less attractive. Importantly, the market price for natural gas does not consider the externalized costs associated with its consumption. While attributing costs to emissions can be challenging, a recent study on the external costs of GHG emissions (known as the "social cost of carbon") put them in a range of $150-500 per tonne of CO2, although some high-end estimates reach just under $900 per tonne.[24] BC's $30 per tonne carbon tax addresses some portion of this amount, and adds to NEU costs for using gas for back up and peaking. Future constraints on carbon and increases in the price of emitting carbon would clearly improve the economics of this innovation.

Over a longer timeframe, there are other mitigation opportunities for the NEU. Biomass, in particular, would be an ideal companion to substitute for natural gas, and would reduce the NEU's carbon footprint

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[23] A small amount of natural gas, mostly for back-up purposes, is used in BC, while 94% of electricity generation is from hydroelectricity and other renewable sources. On a lifecycle basis, there is still some GHG impact arising from construction and flooding land.

[24] F Ackerman and E Stanton (2011). *Climate Risks and Carbon Prices: Revising the Social Cost of Carbon, published by Economics for Equity and Environment network,* http://www.e3network.org/social_cost_carbon.html.

to near zero. Biomass is widely viewed as carbon neutral, although actual results depend on any net deforestation as well as fossil fuels used in production and transport. Using high efficiency boilers and emission control equipment, an equivalent NEU facility powered by biomass would not have an adverse effect on local air quality, according to the City.[25]

Future gains could also arise from the addition of new energy centres to a growing NEU network using SHR and/or other renewable sources (could include geo-exchange, geothermal, anaerobic digestion, and recovery of waste heat from data centres and commercial buildings). This would add redundancy and resilience to account for system downtime for maintenance, as well as improved GHG reduction performance. The NEU interconnects with solar hot water systems on three buildings, which enables net metering of energy. For the most part this is for demonstration purposes, as it is more efficient to use the NEU's centralized boilers.

In terms of GHG emissions and other environmental factors, the NEU is ultimately one part of a larger tapestry. The overall SEFC neighbourhood is, by design, aspiring to reduce the carbon footprint of urban living, such as high densities, and being well suited to walking, biking and transit options. Building codes have become increasingly strict, and BC will adopt a new building code in 2015 that has greater focus on building envelope air tightness and reducing losses due to thermal bridging (e.g. concrete balconies or walls that lose heat energy to the outside).

3.2. Financing and Utility Model

The City of Vancouver's investment in the NEU overcomes collective action problems associated with developing district energy in general and achieving GHG reductions in particular. District energy requires a large upfront investment spanning multiple buildings, and as a result is common in situations where there is a single owner of buildings (e.g university and health care campuses). The efficiency of district energy depends on a number of factors, such as capital costs, ongoing costs for fuel and electricity, the size of customer base and the density of the service area.

For a new development like SEFC, the challenge lies in developing a utility model that makes economic sense, and that networks buildings with different owners, all coming on stream at different times. A core policy to achieve this, and dramatically reduce risk for the city as the utility provider, is a mandatory connection requirement – that all new buildings in SEFC be connected to the NEU (more on this in governance below).

As of 2010, when the NEU came online, total capital costs were $32 million, and includes the False Creek Energy Centre, the initial pipe network, and energy transfer stations in each building. Costs accumulate each year as new buildings are connected, with total capital cost to date of $36 million, and a projected total of $47 million by 2022 when the system will be fully built out. The SHR upgrade planned for 2018 is anticipated to cost about $8 million for an additional 5.8 MW of capacity. [26]

Some key factors behind the NEU's financing of capital costs up to its 2010 launch include:

- A federal grant of $10 million. Interestingly, this grant was funded out of a federal-provincial agreement on the transfer of federal gas tax revenues. Through an Innovations Fund, federal grants are available for projects including innovative approaches to GHG reduction.[27]

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[25] City of Vancouver, Neighbourhood Energy Utility – Evaluation of Heat Source Options, Administrative Report, November 27, 2006, RTS no. 06419, http://former.vancouver.ca/ctyclerk/cclerk/20061214/documents/ csb3b.pdf

[26] Baber.

[27] City of Vancouver, Innovations Fund Application, Administrative Report, April 29, 2008, RTS no. 7395, *http://former.vancouver.ca/ctyclerk/cclerk/20080513/documents/a7.pdf*

- The Federation of Canadian Municipalities provided a $5 million loan at a rate of 1.7%, which lowered the overall cost of borrowing. [28]
- The remainder was self-financed through the City's Capital Financing Fund at a rate of 5%.[29]
- A sewer pump station in SEFC was already slated for an upgrade, so integrating these planned capital costs eased the economics of the NEU construction, as did coordination with all of the other new infrastructure planning for SEFC development.

The NEU's revenues are obtained entirely from its customer base.[30] The rate structure is modeled on a traditional regulated utility, with estimation of revenue requirements necessary for operations. As a municipally-owned entity, however, it is not required to be regulated itself.[31] In place of regulatory review, the NEU has established an independent rate review panel (more on this below in governance).

One particular challenge the NEU's rate structure sought to overcome is that the eventual customer base will be built out over more than a decade. This led to some innovative self-financing on the part of the city through the creation of a Rate Stabilization Reserve,[32] and a levelized rate structure, which means rates under-recover capital costs in the early years, something that could only have happened under the auspices of a public enterprise. Rates for the existing customer base (the early movers-in) are adjusted so that they are not absorbing a disproportionate share of the capital costs (in particular, the energy centre).

Annual rate increases are approved by city council, and include an inflation component plus step increases.[33] Rates are broken down into two components: a "fixed capital levy" to cover capital costs of $0.50 per m2 per month; and a "variable energy use charge" for operating costs of $42 per MWh in 2014. The NEU's rate review panel recommended a shift to applying rate increases exclusively to the variable energy portion of the bill rather than the floor area charge to improve the price signal for conservation. Such a measure was approved by city council and is under development for 2015.[34]

Overall, cost competitiveness is a key objective, and the NEU rate structure is intended to compare favourably to other district energy systems and energy providers. The City estimates an effective rate of $97 per MWh for 2014.[35] This is 11% higher than the estimated rate for natural gas from Fortis BC at $87 per MWh, which is at very low prices by historical standards. Rates are roughly comparable to BC Hydro grid electricity.[36] The NEU rate is estimated to be lower than other new district energy systems, but is a lot higher than the legacy steam system in downtown Vancouver.

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[28] City of Vancouver, Southeast False Creek Neighbourhood Energy Utility (SEFC NEU) 2011 Customer Rates, Administrative Report, December 2, 2010, RTS: 08880, *http://former.vancouver.ca/ctyclerk/cclerk/20101202/documents/ csbu3-SoutheastFalseCreekNeighbourhoodEnergyUtility-SEFCNEU- 2011CustomerRates.PDF*

[29] Ibid. The Capital Financing Fund is a source of internal financing for city projects, and had an accumulated surplus of $254 million at end of 2013, according to the City's Annual Financial Report.

[30] The NEU bills buildings not individual units, so decisions about how to allocate NEU costs within a building are made by the building's strata council. NEU units still purchase their electricity (lighting, appliances) through BC Hydro.

[31] In BC, the British Columbia Utilities Commission regulates private utilities and the Crown corporation, BC Hydro.

[32] The Rate Stabilization Reserve is essentially a line of credit established by the City, and financed by the Capital Financing Fund. See note 32.

[33] According to the December 2013 staff report, rates are estimated to increase at 3.22% up to 2015 and then 2% thereafter.

[34] City of Vancouver, *Southeast False Creek Neighbourhood Energy Utility (SEFC NEU) - Transition to a Stronger Conservation Rate Signal*, Administrative Report, April 11, 2014, RTS no. 10418, http://former.vancouver.ca/ctyclerk/cclerk/20140429/documents/a1.pdf

[35] City of Vancouver, Dec 10 2013.
[36] BC Hydro has a two-tier rate structure for residential customers, with a lower rate of $75.20 per MWh for consumption up to a 1,350 bi-monthly threshold, and $112.70 for consumption above the threshold. In practice, rates may depend on quality of building energy performance, unit size, and amount of consumption at the second tier rate. See https://www.bchydro.com/accounts-billing/customer-service-residential/residential-rates.html

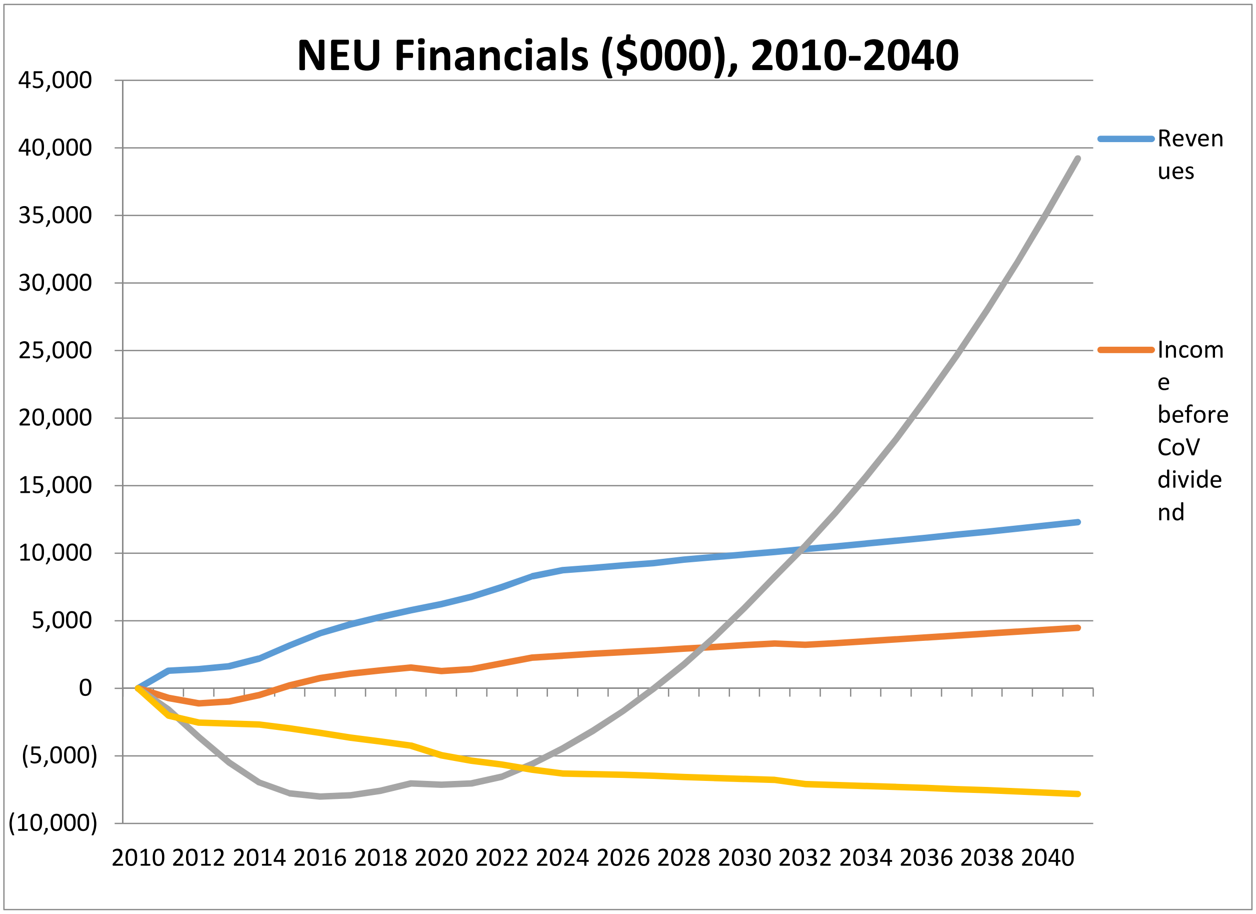
The utility model has its risks associated with how quickly the customer base is built out. For example, revenues in 2013 were 18% lower than budgeted, due to demand uncertainties in bringing new buildings on-line. Economic downturns can also have a major impact on the housing market, although this has yet to happen in central Vancouver.

On the cost side of the ledger, about two-fifths of NEU expenditures are operating costs for staffing, maintenance, insurance, and energy inputs (natural gas and electricity). The remainder represents depreciation and repayment of debt, including a return to the City of Vancouver of about $1 million per year. On this basis, the NEU had expenditures of $3.6 million in 2013 and revenues of $2.2 million, for a deficit of $1.4 million. The NEU's cumulative deficit as of end of 2013 was almost $7 million.[37]

It is important to note that this picture is of a utility still in its early years. Over time, the NEU's finances are projected to improve dramatically. If we remove the dividend flowing back to the City, the NEU is already profitable (revenues exceed costs) as of 2014. Figure 4 shows these actual and projected revenues and costs, and net income before the dividend paid to the City of Vancouver. The closing balance (cumulative deficit/surplus) for the NEU includes the payment of the City's dividend, and is estimated to reach a maximum deficit in 2016 at just under $8 million (the ceiling approved for the Rate Stabilization Reserve). It then shrinks in subsequent years as more buildings are connected, before becoming a growing surplus as of 2027. At that point the NEU surplus could be used for further capital investment to grow the network or to lower rates.

Figure 4: NEU Financials ($000), 2010-2040

[37] City of Vancouver, Southeast False Creek Neighbourhood Energy Utility (SEFC NEU) 2014 Customer Rates, Administrative Report, December 10, 2013, *http://former.vancouver.ca/ctyclerk/cclerk/20131210/documents/ cfsc1c.pdf*



Source: City of Vancouver.

Of note, the projected cumulative surplus exceeds $10 million by 2031. This is the amount of the capital grant provided by the federal government. Thus, while federal grant funding was seen as a key to getting the NEU off the ground, including SHR technology in particular, the utility model shows that the NEU could have been developed in the absence of that federal funding, and without any impact on the rate structure.

Utilizing sewage heat recovery (SHR) requires additional upfront capital investment but lowers operating costs associated with natural gas or other fuel. Comparative research by the City found that the levelized cost per MWh of SHR and biomass to be similar, but both options are more costly than a natural gas system.[38] However, SHR reduces exposure to fluctuations in fossil fuel prices. In practice, better-than-expected performance of the SHR system has reduced operating costs for natural gas relative to projections.[39]

There is still some vulnerability to future price increases for both electric and gas inputs. As new buildings are added, natural gas costs increase from $269,000 in 2013 to an estimated $1.2 million in 2018. After new SHR capacity comes online, costs for natural gas fall back down to an estimated $265,000 in 2019. Natural gas prices have been extremely low in recent years, but as the "polar vortex" winter in 2013/14 shows, price spikes can arise. Overall, natural gas has much greater risks around fuel price volatility and

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[38] City of Vancouver, Neighbourhood Energy Utility – Evaluation of Heat Source Options, Administrative Report, November 27, 2006, RTS no. 06419, http://former.vancouver.ca/ctyclerk/cclerk/20061214/documents/ csb3b.pdf

[39] City of Vancouver, Southeast False Creek Neighbourhood Energy Utility (SEFC NEU) 2011 Customer Rates, Administrative Report, December 2, 2010, RTS no. 08880, *http://former.vancouver.ca/ctyclerk/cclerk/20101202/documents/ csbu3-SoutheastFalseCreekNeighbourhoodEnergyUtility-SEFCNEU- 2011CustomerRates.PDF*

security of supply. Pressures on the electricity utility, BC Hydro, are driving rate increases in coming years.[40]

3.3. Governance and Public Ownership

The NEU is a modern example of public sector innovation. It challenges a paradigm of centralized energy distribution, and links and expands municipal services in a novel way. But while publicly-run, it is not customer- or community-run either. The NEU is run as part of the City's Engineering department, and is governed by the City's own formal processes. In particular, rates are approved annually by city council, a process supplemented by advice from an independent External Rate Review panel. The City is the owner of the NEU, but also its de facto regulator in the absence of the BC Utilities Commission review that would be required of a private system.

Some complaints have come from residents and developers about higher prices relative to comparable buildings not connected to the NEU, although these lack substantiation, and do not appear to be making an apples-to-apples comparison. NEU rates are likely to be more reflective of the total cost of ownership, including amortization of capital costs, insurance, and staff time for operations and maintenance, while the comparator may only be considering the basic cost of gas.[41] For consumers/owners, the absence of independent heating equipment in each building leads to lower annual operating and maintenance costs. In this regard, independent review through the BC Utilities Commissions could be a preferred way of addressing such concerns.

To move ahead with the NEU, the City required a legislative change to the Vancouver Charter, the provincial legislation that sets out powers of the local government. This change enabled the city to develop an energy utility. The resulting Energy Utility System By-Law featured a mandatory connection requirement of all buildings in the service area. As noted above, this is viewed as a keystone policy that greatly reduces the risk for the city in investing the upfront capital necessary to achieve improved environmental performance by guaranteeing a customer base.

Most developers want assurance that the system is going to be reliable and affordable. Mandatory connection is resented by some developers, who argue that this leads to higher purchase costs for provision of hydronic heating systems. However, the NEU's provision of heat exchange units within each building connected reduces costs for developers, and these heat exchange units are small, meaning additional space in buildings is freed up for other (profitable) uses. The Urban Development Institute (an industry association for developers) argues for a hybrid approach that would use district energy for common areas but with electric baseboard heaters in individual units.[42] Such a system would likely be more costly to end users, however, and future use of electric baseboards may be inconsistent with meeting BC's new building code. UDI also expresses concern about uncertain costs that will arise from future conversion to low-carbon sources (e.g. natural gas to biomass), and potential delays in having district energy systems up and running alongside new units ready to be occupied.

Could the NEU be privatized and would this matter? The NEU rate structure was designed to emulate the decisions of a private operator and the requirements of the regulatory process. In this regard, the impact of privatization on the rate structure for consumers may be limited by regulatory process. While private energy utilities are currently regulated, changes to policy could affect this relationship in the future.[43] Vancouver's public model is to be reviewed every 3 years, and it is not implausible a future council would privatize the NEU.

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[40] J Calvert and M Lee. *Clean Electricity, Conservation and Climate Justice in BC: Meeting our energy needs in a zero-carbon future*. Vancouver: Canadian Centre for Policy Alternatives, June 2012, https://www.policyalternatives.ca/electricity-justice

[41] Trent Berry comments at Community Energy Symposium, September 2014.

[42] Presentation by Jeff Fisher, UDI, at Community Energy Symposium, September 2014.

[43] This has been the case with a number of controversial energy projects in BC, which have been exempted from BCUC regulation by the provincial government.

The NEU demonstrates benefits from public ownership beyond what is captured in a utility model. Community energy management objectives include the integrated planning of future developments, and ensuring that new district energy systems are standardized and coordinated with other city investments in water and wastewater systems. Public ownership keeps money in the local economy, and given the importance of energy to well-being, there is value in carving out this space from a trajectory of capitalist development centered on growth, profit maximization and absentee ownership. Insulation from swings of market prices in global energy markets is another consideration beside environmental performance. Moreover, public ownership has provided the City with valuable intellectual capital about renewable energy development, best practices and innovation that can be leveraged to new projects.

The reasons for Vancouver's choice of a public sector model, however, may have less to do with these factors than pragmatic ones. The deadline imposed by the Olympics was driving the timetable for development. In BC, district energy systems run by the private sector require regulatory approvals from the BC Utilities Commission, whereas municipal ones do not. A staff report to Council on ownership options concluded that public ownership had some important financial advantages, as the NEU would not be subject to income taxes, and would be able to access senior government grant funding. In addition, the city would retain direct control over rates, future expansion of the utility, and technology decisions.[44]

If the City was to divest, one interesting model could be for the consumer base to collectively purchase the NEU instead of sale to a for-profit company. This element of local control is consistent with the concept of "energy democracy," which emphasizes direct ownership and control of distributed energy generation, more typically for electricity generation from solar and wind sources. Naomi Klein notes such a shift in Germany, for example, with "roughly half of Germany's renewable energy facilities ... in the hands of farmers, citizen groups, and almost nine hundred energy cooperatives."[45] Improvements in the economics of renewable energy, and discontent with traditional private utilities, have led to interest in energy democracy in the United States,[46] although concept has not been applied to district energy.

3.4. Employment and Local Economic Benefits

In terms of both absolute numbers and the nature of jobs, the NEU is not a significant provider of permanent jobs, nor does it overtly target employment opportunities for traditionally disadvantaged groups. As a highly capital-intensive utility, most of the job creation occurs during the construction phase, which involved approximately 50 FTE jobs over a three-year period, although the number of jobs at any one time varied. Ongoing expansion of the network to new buildings ensures continuing construction work. In NEU operations, there are 3.5 FTE jobs, and these are highly-skilled engineering jobs.

While these numbers are relatively small, context matters: it represents only 24 buildings and a very small percentage of total energy demand in the city. An expanded network across the city in areas that met minimum density requirements, along with new energy centres, has the potential to create local and green jobs from the expansion of green infrastructure.

Importantly, consumer expenditures on NEU energy have a greater propensity to stay in Vancouver and in the public sector, repaying the initial investment and ongoing operating costs. Capital equipment for the NEU was imported from outside BC, so there are some leakages. Gas in BC is domestically-provided, so there is no reduction in imported fossil fuels.

There is, however, a transfer of revenue to the City of Vancouver from a private natural gas utility, Fortis BC, a subsidiary of a Canada-based corporation with utility interests in Canadian provinces, the US,

[44] City of Vancouver, Neighbourhood Energy Utility – Evaluation of Ownership and Operating Options for the City of Vancouver, Administrative Report, November 27, 2006, RTS no 06323, *http://former.vancouver.ca/ctyclerk/cclerk/20061214/documents/csb3a.pdf*

[45] N Klein. *This Changes Everything: Capitalism vs the Climate*. 2014, p. 131.

[46] See, for example, J Farrell, *Beyond Utility 2.0 to Energy Democracy*, December 2014, Institute for Local Self-Reliance, http://ilsr.org/report-energy-democracy/

Caribbean.[47] Fortis BC is transforming itself into a broader energy company including the provision of district energy in new developments in Vancouver. And Fortis is still the source of the gas purchased by the utility, a cost of $269,000 in 2013. In addition, the NEU paid $412,000 for BC Hydro (a public enterprise called a Crown corporation) electricity in 2013. Gas and electricity were a combined 19% of operating costs. Such costs in a private utility context elsewhere may drive greater leakages from the local economy.

There were no explicit social objectives built into the original NEU plan. One additional outcome is improved resiliency to natural disasters. In earthquakes and ice storms, district energy facilities have continued to provide power, even when blackouts occurred in the electricity system, by virtue of being off-grid and more localized systems.[48] There is an additional social and economic benefit associated with more stable rates arising from the use of SHR.

Equity concerns come more at the level of the type of development being built in the service area. Much of the development area has been turned into luxury condominiums, although through inclusionary zoning, there is an official target of 20% social housing in the mix (three buildings are owned by the City and managed by the Cooperative Housing Federation of BC). As a centrally-located community, a key benefit is a dramatic reduction in the need to own a private vehicle. Those who live in the area have abundant walk, bike, transit and car-sharing mobility options.

4. SCALABILITY AND REPLICABILITY

In light of the economic and environmental benefits of the NEU, to what extent can the district energy 2.0 model – low carbon emissions, competitive pricing and public ownership – play a role as a core technology for sustainable and low-carbon cities?

For district energy in general, the cost of laying pipe may not make economic sense is low-density areas, although there are also small town examples (e.g. Revelstoke, BC has a district energy system supplied by wood waste from the local mill). At the other extreme, the size of a district energy system is limited only by the number of buildings that can economically connect to the network. In large European cities the network can be more than 50 km long.[49]

Once built, a district energy network can grow over time and rely on a number of energy sources, which provides greater resilience as downtime of any one energy centre (whether due to a disruption or for routine maintenance) can be offset by others in the network. Sewage heat recovery is obviously a notable renewable source of energy, one that is easy to emulate (all cities have sewer pipes), but could also cover other renewable sources. Combined heat and power (CHP) systems can also go a further step and co-generate electricity (for local use or for sale to the grid) along with heat.[50] In BC, there is little financial incentive for this due to abundant and relatively low-cost hydroelectricity.

There are some unique features about Vancouver that shaped the choice and evolution of the NEU. The NEU arose in an urban context shaped by strongly held environmental values. Vancouver has enjoyed strong support for climate action and other green goals, from the 1990 Task Force on climate change to the 2011 Greenest City Action Plan. Perhaps remarkably, the NEU has enjoyed continued support spanning city councils representing three different political parties. Past Vancouver Mayor Gordon Campbell became premier of BC, and led a province-wide focus on climate action between 2007-09,

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[47] Fortis purchased its BC assets from US corporation Kinder Morgan in 2007.

[48] T Berry, 2010.

[49] B Bradford, 2014, "Under their own power: District energy systems enable self-reliant, resilient communities" in *ReNew Canada: The Infrastructure Magazine*, http://renewcanada.net/2014/under-their-own-power/

[50] About 10% of US district energy systems have combined heat and power (CHP), according to D Harvey, *A Handbook on Low-Energy Buildings and District-Energy Systems: Fundamentals, Techniques and Examples*. London: Earthscan, 2006.

including a BC carbon tax, a carbon neutral government initiative, and a push for climate action plans at the local level.

While this background is essential to why Vancouver became a pioneer, the economic, environmental and engineering features of the NEU described above suggest that the model can be replicated and customized in a variety of contexts. The upfront costs associated with district energy can be a substantial barrier to implementation, particularly for cash-strapped municipal governments. But the NEU case shows how a public utility model can be developed for district energy. Grant funding from senior governments would clearly catalyze the development of new district energy systems.

The challenge of raising capital could be ameliorated through emerging financing vehicles such as green bonds, which could pay a steady rate of return based on future revenues from customers. Green bond issues may also enable borrowing at lower cost to the extent that the private sector is willing to lend at lower interest rates for green infrastructure. A Fall 2014 green bond issue from the Government of Ontario, in support of transit infrastructure, was almost five times over-subscribed, which suggests some support for the idea.[51] As calls for divestment from fossil fuels grow, that capital needs a place to go.

Expanding low-carbon energy systems like the NEU would be a logical replacement, and align well with the needs and long-term horizons of pension funds and endowments.

Vancouver's Neighbourhood Energy Strategy

Within the City of Vancouver, the NEU has sparked greater interest in district energy as a means of reducing the carbon emissions from buildings. The City's July 2011 Greenest City Action Plan argues for the "development of economically viable opportunities for the large scale deployment of sustainable energy systems for high-density, mixed-use neighbourhoods." Attention to carbon reduction objectives has been a top priority in Vancouver (and the overall region), but the case could also be made in terms of providing low-cost, reliable and locally controlled energy.

In Fall 2012, Vancouver council passed a Neighbourhood Energy Strategy to expand the service areas for existing district energy systems, require new major developments to connect to a district energy system, and seek conversion of legacy district energy systems to renewables. While large parts of Vancouver do not meet the minimum density for district energy to be efficient, the Strategy identifies three major areas of Vancouver for action: downtown, central Broadway (a high density east-west corridor) and Cambie corridor (undergoing redevelopment post-installation of a new transit line).[52]

This strategy reflects complexity at ground level that did not exist in the brownfield development of SEFC; in particular, the issue of ownership (private sector, and public but non-municipal institutional) arrangements, and ensuring the provisions encompass both new developments and older buildings. In the downtown area, for example, Central Heat is a private-sector operator of a legacy steam system, powered by natural gas, which services more than 200 buildings. Its GHG reduction potential is estimated at 70,000 tonnes CO2 per year. However, the city does not have direct control to make this happen, and so they are considering a series of incentives and supportive policies plus some regulation pertaining to new buildings. In the other areas, the legacy systems are two major hospital campus natural-gas-powered networks, which are owned by the provincial public sector not the municipal government.

The Cambie corridor encompasses several neighbourhoods along a new rapid transit line (which also opened in 2010 in conjunction with the Olympics. The 2012 official development plan envisions higher density development along the corridor linked to both transit and community energy. Brent Toderian, then Director of Planning, comments:

[51] See B. Critchley, "Ontario adds to US$32-billion of green bond issuance this year" in *Financial Post*, October 9, 2014, http://business.financialpost.com/2014/10/09/ontario-adds-to-us32-billion-of-green-bond-issuance-this-year/

[52] City of Vancouver, Vancouver Neighbourhood Energy Strategy and Energy Centre Guidelines, Administrative Report, October 3, 2012, RTS No. 9772, *http://former.vancouver.ca/ctyclerk/cclerk/20121003/documents/ ptec1.pdf*

> We've prided ourselves for years in Vancouver on integrating land use and transportation thinking better than most cities, and I think this Plan takes that to a new level. Beyond that though, this Plan signifies for us a new definition for success – the robust integration of land use, transportation and energy. In particular, district and neighbourhood energy sources and systems that take heating off-the-grid, on top of building and transportation-related energy use considerations. This is a huge piece to our "Greenest City" aspirations, building on the great success and lessons from the neighbourhood energy utility at the Olympic Village.[53]

A similar mandatory connection requirement to SEFC is being applied in the Cambie corridor. All new buildings with greater than 2,000 m3 of heated floor space must connect to a district energy system or be designed for connectivity in the future. Moreover, the city's Sustainable Large Sites Rezoning Policy requires completion of a Low Carbon Energy Supply Feasibility Screening Study, applicable to all rezoning with land area greater than 2 acres in size and/or 45,000 m3 in floor area. If feasibility is assessed positively the district energy system connectivity would be required as a condition of development.[54]

Two existing hospital complexes (Vancouver General Hospital and Children and Women's Hospital) already have legacy district energy steam systems, and they are envisioned as sources of energy for the new development, converted to renewable sources. However, the city also issued a Request for Proposals for a private utility provider to build and operate a district energy system. [55] Low-carbon attributes and cost competitiveness are addressed in this approach, but public ownership has not. The private operator would have to seek regulatory approvals from the BC Utilities Commission, rather than being directly run as a utility by the city.

The City seeking a private operator relates to risks around customer uptake and concerns about total amount of borrowing being taken on by the City (and impact to the City's credit rating and capacity to borrow for other capital work). Yet, there is no reason why the city could not have gone ahead with a public sector model for the Cambie corridor. New development always requires new and upgraded infrastructure, and in Vancouver the city requires amenity contributions for child care centres, schools and parks. District energy need not be any different. The utility model means capital costs can be paid from operating revenues over 20-25 years.

Surrey's District Energy Plan

The nearby City of Surrey, a fast-growing suburb of Metro Vancouver south of the Fraser River, has emulated the NEU in several respects for anticipated high-density developments in the central part of the city. Development of a municipal utility, Surrey City Energy, was approved in 2011, and like Vancouver it is modeled after a private regulated utility, with an external rate review panel. The first building will be connected to the system in Spring 2015, in what the City envisions as a 30-year plan to build out its network.

Also like Vancouver, a mandatory connection requirement was established for new developments over a certain size within the service area. This is seen as an essential policy tool for the development of municipal district energy. The city had previously worked with developers to assess interest in district energy, but found that perceived risk was a barrier to moving ahead, and the city could not get the buy-in needed to move ahead with the first phase of infrastructure. In the absence of secured customers, the financial risk to the city was perceived as too high. Mandatory connection eliminates this aspect of risk

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[53] Spacing Vancouver, "Vancouver's Cambie Corridor Plan selected for 2012 Award for Planning Excellence!" http://spacing.ca/vancouver/2012/06/27/vancouvers-cambie-corridor-plan-selected-for-2012-award-for-planning-excellence/

[54] City of Vancouver, Neighbourhood Energy Connectivity Guidelines, March 2014, http://vancouver.ca/files/cov/neighbourhood-energy-design-guidelines.pdf

[55] Interview with Jason Owen, District Energy Manager, City of Surrey.

and creates a viable investment proposition (although there is still risk that the number of units coming online does not meet expectations).[56]

The Surrey city centre area has some similar attributes to the areas of Vancouver identified in its NES. It is fast growing, with substantial new high density development anticipated in coming years. These are ideal conditions for the use of district energy infrastructure to be implemented. For the low-carbon aspects, however, the City is taking a different tack than Vancouver. Its plan is to build out the first phase of infrastructure using natural gas as fuel, then converting to a large biomass plant within a decade.[57] In this way, the initial capital costs are less, then down the road the larger customer base can support the investment in renewable capacity. The city envisions a number of nodes of energy sources that can power the network, bringing in the city's hospital, schools and others.

Metro Vancouver

The particular location of the NEU positively shapes its ability to use the SHR resource. Sewage comes into the NEU from two different sources: from SEFC and the surrounding area into the pump station (primary source); and from a sewer main line that runs from downtown under False Creek. One of the challenges of sewage heat recovery is to have constant flow of sewage – between 100 to 120 litres per second – even during the night when people are not producing as much sewage.[58] The NEU uses control valves that open to increase the sewage flow in the night.

The cities of Vancouver and Surrey participate in governance of the Greater Vancouver Regional District (commonly called Metro Vancouver), which coordinates infrastructure operations and planning for water, sewers, and solid waste for 21 member municipalities. In the case of sewage heat, municipalities own sewer infrastructure in their areas, but trunk lines are owned by Metro Vancouver. Because of the larger flows accumulated in the trunk lines, there is great potential for SHR. Metro Vancouver is also examining heat recapture at a new wastewater treatment plant in North Vancouver.[59]

Metro Vancouver adopted a Sewer Heat Policy in September 2014, with a top stated priority to contribute to reduction in regional GHG emissions. In the staff report it cites research on the sewer network, noting potential capacity of 105 MW in winter and 430 MW in summer, with the former equivalent to the energy requirements of 50-75,000 homes.[60] The staff report notes that "there is sufficient amount of recoverable heat from Metro Vancouver's sewer collection systems to heat approximately 700 high rise buildings without negatively impacting treatment processes at the wastewater treatment plants."[61] The policy establishes terms for both public and private utilities to access sewer heat as a renewable resource for district energy systems. Access is on a first-come first-served basis, a cost-recovery fee for tie-in but no cost for the sewer heat itself (and linked to long-term contracts).

[56] Interview with Jason Owen, District Energy Manager, City of Surrey.

[57] This same approach using natural gas as a transition fuel is being used in a couple new private district energy developments in Metro Vancouver (River District and Simon Fraser University's UniverCity).

[58] Personal communication with Chris Baber.

[59] J Deacon, "Wastewater energy plan would be B.C. first" in 24 Hours, Vancouver, http://vancouver.24hrs.ca/2014/10/21/wastewater-energy-plan-would-be-bc-first

[60] Data from presentation by Linda Parkinson, Metro Vancouver, to Community Energy Symposium, September 11, 2014.

[61] Greater Vancouver Regional District Utilities Committee, Agenda, Thursday, July 10, 2014, p. UC-13, http://goo.gl/V1pYb5. Note that this is only the potential from assets owned by the regional government and does not include those owned by member municipalities.

5. CONCLUSION

A major 2014 report on The New Climate Economy comments that cities "generate around 80% of global economic output, and around 70% of global energy use and energy-related GHG emissions. ... As pioneering cities across the world are demonstrating, more compact and connected urban development, built around mass public transport, can create cities that are economically dynamic and healthier, and that have lower emissions."[62]

The NEU model of energy infrastructure is one important piece of the puzzle for sustainable communities, but the full environmental impact must also consider density, built form, building energy efficiency, proximity to work and other places of interest. Modern district energy systems are complementary to rooftop solar and high-efficiency design in the development of low- to zero-emission buildings. More distributed forms of renewable energy generation have also experienced improved economics vis-a-vis conventional fossil fuel sources, in doing so challenging the business model of centralized electricity utilities.[63]

The NEU also points towards the benefits of community energy management to achieve public benefits (reduced GHG emissions). Expansion of the platform could include fuel switching to further reduce GHG emissions to near zero, addition of new energy sources to the growing network, and interconnection with other historical and emerging district energy networks. Cogeneration of electricity could be considered (St Paul is a notable example).

In a world that desperately needs to reduce GHG emissions, the NEU model offers a real world example of how things can be done differently. It builds on an old idea, district energy, and adds a sustainability lens, but it also reimagines the public and local provision of energy services. The NEU is an example of system-wide approach to the development of truly sustainable cities, driven by a vision of SEFC as a sustainable community, and pushed by Vancouver's ambition to become the "greenest city" in the world.[64]

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Appendix A.

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