Transforming the Cogswell Interchange: An Opportunity for District Energy

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CONNECTING LANDSCAPES

Foreward

Quality Urban Energy Systems of Tomorrow (QUEST) and students from the College of Sustainability at Dalhousie University addressed the need for a feasibility study of a district energy (DE) system for the redevelopment of the Cogswell Interchange in Halifax’s urban core. This report is the result of research conducted by Connecting Landscapes, an interdisciplinary team with a sustainability focus. The report was commissioned by QUEST NS and took place between September 2014 and May 2015.

Acknowledgements

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Executive Summary

In light of the Cogswell Interchange redevelopment scheduled for 2016, an unprecedented opportunity to integrate a district energy (DE) network into the Halifax urban core exists. The source of the thermal energy is located immediately adjacent to the Cogswell Interchange at the The Harbour Solutions Sewage Treatment Plant (STP). Instead of continuing to waste and divert this energy source into the harbour as is currently being done, a unique opportunity exists for Halifax to utilize this energy for the Cogswell redevelopment as the effluent contains a substantial amount of heat relative to what would be required for Cogswell redevelopment. An urban project such as this can complement already existing DE infrastructure owned by the universities, hospitals, and military base. In accordance with the Environmental Goals and Sustainable Prosperity Act (EGSPA), Nova Scotia has set ambitious 2020 greenhouse gas reduction and renewable energy targets for the province. To achieve the targets established in EGSPA, improving the heating and cooling infrastructure on the Halifax peninsula is necessary. Environmental energy legislation and access to local renewable energy technologies are increasing. The expansion of DE supports this modern shift and will strategically position Halifax to implement smart energy systems today and into the future.

ENVISIONING AN ENERGY-SECURE, SUSTAINABLE, CITY FOR THE FUTURE

The Halifax Harbour STP has the energy potential to provide base-load heating to all of the buildings in the Cogswell redevelopment as determined by the feasibility analysis. As well, the project has the potential to expand to additional buildings and residences in the future. The construction of the DE system would occur simultaneously with the Cogswell redevelopment. This provides ample opportunity to implement DE as the installation of other networks, such as water, sewage, and electricity will also be occurring. DE provides the opportunity to shift to a renewable energy source, which reduces domestic greenhouse gas emissions. The abatement of emissions has the potential to set a precedent for Atlantic Canada in accordance with a global awareness of the adverse impacts of climate change.

REUNITING THE NORTH AND SOUTH ENDS OF THE PENINSULA

Since the Cogswell Interchange was constructed, it has acted as a social and economic barrier between the North and South ends of the Halifax peninsula. This report discusses how a DE network can be integrated into the Cogswell redevelopment and also reconnect the North and South ends of the city.

CONCLUSIONS AND RECOMMENDATIONS

The opportunity to implement DE into the Cogswell Interchange has been highlighted based on case studies and a feasibility report below. A presentation to

the Environmental and Sustainability Standing Committee (ESSC) was made at HRM Council on April 2nd, 2015 in order to capture the attention of the municipality. To carry the project forward, a stakeholder roundtable on district energy for the Cogswell Interchange was held on April 22nd, 2015 at Dalhousie University to plan for the implementation of district energy at the Cogswell Interchange.

Introduction

DE systems are used for the production, transmission, and distribution of heat from a fuel source. The role of DE throughout many European, and Canadian jurisdictions highlights the effectiveness of this well-developed technology.

In combination with the upcoming land redevelopment at the Cogswell Interchange and close proximity to the thermal energy source, an important opportunity for Halifax to plan and implement more efficient and secure energy solutions undoubtedly exists. The municipal council of Halifax is also interested in exploring the opportunities for the use of DE in the Cogswell redevelopment[1]. As a response to the councillors' interest in DE, Connecting Landscapes and QUEST NS hosted a DE roundtable with stakeholders on April 22nd, 2015 at Dalhousie University.

WHAT IS DISTRICT ENERGY?

DE provides hot water, space heating, and cooling from a central facility. DE is capable of transferring energy through steam or hot water by utilizing heat exchangers, heat pumps, boilers, and chillers. The hot water or steam is sent through a network of insulated, underground pipes to buildings where it passes through a direct use for domestic hot water, or space heating. There is also the potential to extract water from the ocean and feed chilled water through the system during warmer months of the year to provide cooling to buildings. DE systems remove the need for buildings to have heating, venting, and air conditioning equipment on-site. DE systems create a more usable space, while also buffering against the volatility of foreign energy prices by achieving local energy security.

SETTING THE STAGE IN THE COGSWELL INTERCHANGE

In the early 1960s, proposals for the development of the Cogswell Interchange were initiated by the city of Halifax. The Cogswell Interchange was intended to provide a multi-lane highway to cater to an expected increase in urban density, known as the 'Harbor Drive Project.' During the planning process, the project was met with considerable public resistance, halting the completion of the project just one year after its construction phase in 1970. The Cogswell Interchange is classified as a "collapse-o-scape" which is defined as[2]:

> **"A landscape of collapse and fragmentation, but it is of a scale that meets the needs of the productive city and of-**

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[1] Davenport, R. (Feb 5 2014). Halifax committee orders up smart energy options for cogswell redevelopment. Halifax Metro. Retrieved from: http://metronews.ca/news/halifax/1280951/halifax-committee-orders-up-smart-energy-options-for-cogswell-redevelopment/

[2] Stremke, S., van den Dobblesteen, A. (2014). Sustainable Energy Landscapes: Design, planning, and development. Boca Raton, FL: CRC Press.

> **fers a new landscape that will increase sustainability and urban resilience by hosting new functions for the city that help to close material and energy cycles in an effective way, by improving the metabolism of the city".**

In 2006, the city of Halifax released a plan identifying the Cogswell Interchange lands as a prioritized redevelopment site. Following this decision, efforts to engage the public on the renewal of the Cogswell Lands were made. The municipality hosted a public consultation on May 16th, 2013 called the "Cogswell Shake-Up" to provide discussion about the future of the Cogswell lands. Technical studies were also conducted to assess the Cogswell lands. These processes have accelerated efforts towards planning future infrastructure in the downtown core of Halifax. The Ekistics Planning & Design report[3], "Cogswell Transformed," also explores the opportunity for DE in the Cogswell redevelopment. Their report advises Halifax to consider the potential for a centralized DE network supplied by waste heat from the STP.

The Opportunity for District Energy in the Cogswell Interchange

The municipality has decided to redevelop the lands in the Cogswell Interchange. This will result in reduced upfront capital costs associated with construction of the DE system. The majority of the Cogswell redevelopment falls within a 500-meter buffer of the STP. Therefore, capital costs associated with a complex, large radius DE piping network can be minimized. Reductions in upfront capital costs due to ideal timing and close proximity reinforce the potential for DE to be implemented in the Cogswell redevelopment strategically.

According to EGSPA[4], Nova Scotia is committed to reducing greenhouse gas emission levels by 10 per cent below 1990 levels by 2020. As DE is capable of reducing greenhouse gas emissions in high-density urban cores, development of this system in Atlantic Canada could set a precedent for sustainable and efficiency focused energy development. As well, Nova Scotia is currently vulnerable to the volatile cost of global energy prices. Nova Scotia generates 60% of energy from coal that is imported from Colombia and the United States[5]. DE provides a local and reliable alternative to foreign energy. DE at the Cogswell Interchange can assist Nova Scotia in meeting its EGSPA targets and achieve local energy security.

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[3] Ekistics. (2014). Cogswell Transformed. A Plan for the Redevelopment of the Cogswell Interchange. Retrieved from: http://www.halifax.ca/council/agendasc/documents/140513ca1141att1.pdf

[4] Environmental Goals and Sustainable Prosperity Act, SNS 2007, c 7, <http://canlii.ca/t/5225x> retrieved on 2015-03-22

[5] Nova Scotia Power. (n.d.). Tomorrow's Power. Retrieved from http://tomorrowspower.ca/answer/310/

IDENTIFYING ASSETS AND BARRIERS

The primary asset to the implementation of a DE system in the Cogswell interchange is the nature of the space in which the redevelopment is planned to occur. A GIS map is a key tool that provides an analysis of the spatial characteristics within study area proximity to thermal energy source (See Appendix A). The GIS map displays that the STP is located within the identified Cogswell redevelopment zone. A large area of redevelopment zone is contained within a 500 meter buffer around the STP. The close proximity of the redevelopment zone to the STP is ideal as piping costs are reduced. The proposed DE network also provides the flexibility to expand the system to adjacent developments.

Another key asset to the implementation is that the Cogswell redevelopment will be occurring. Other lines and pipes connecting to the new buildings for the proposed redevelopment will also be under construction and the timing is ideal to install piping infrastructure that will establish the thermal grid for a DE system. Retrofitting options are extremely expensive and proactive installation of this critical infrastructure can ensure potential utilization as the Cogswell redevelopment progresses.

Despite the key assets, an inherent lack of analysis and collaborative planning serve as key barriers to the timely incorporation of the DE project into the Cogswell redevelopment. The project must have an adequate rate of return on investment for it to be worthwhile and must live up to infrastructure standards, and the concept must be effectively adopted into municipal government plans. In order to combat a perceived planning barrier, a DE roundtable will be hosted on April 22nd, 2015. The purpose of the roundtable is to serve as capacity building event to allow multidisciplinary stakeholders to converge to design a roadmap for a DE project in Halifax. The roadmap will be integral in guiding the planning and implementation phases of DE for the Cogswell redevelopment.

EXISTING DISTRICT ENERGY INFRASTRUCTURE IN HALIFAX

DE is an energy strategy that has already been implemented in Halifax. Dalhousie University is an example of a pre-existing DE system in Halifax. Dalhousie is a local model of success that provides heating to 95 buildings to the Carleton, Sexton, and Studley campuses. This system is the largest in Halifax as it produces a thermal power load of 47 MW. There are several other district heating systems on the peninsula. The Victoria General Hospital (VG) has the second highest load at 31 MW[6]. The map of DE infrastructure in Halifax illustrates the six heating systems on the peninsula; Dalhousie University (DAL), Dalhousie Sexton Campus (Sexton), Saint Mary's University

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[6] QUEST NS. (2014). The Role of District Energy in Making Nova Scotian Communities Energy Resilient. Retrieved from http://www.questcanada.org/sites/default/files/files/QUEST%20NS%20Caucus%20_%20-MAR182014_V3_LowRes.pdfhttp://www.questcanada.org/caucus/ns

(SMU), Victoria General Hospital (VG), Halifax Infirmary Hospital (Infirmary), Department of National Defense (DND) and Canadian Forces Base Halifax (CFB) (see Appendix B). DE infrastructure has already been incorporated into large developments within the city. Cogswell provides an unprecedented opportunity for Halifax to add another system to the city core, providing energy security to a more interconnected municipal heating system.

District Energy Models of Success

Comparable DE projects were analyzed to gain insight into their capacity, operations, and structure. The case studies are used as models of success. Benchmark case studies were chosen for the type of heating source, the heating or power demand for the district, the opportunity for expansion, financial return and the ability of the system to provide equal or better heating relative to conventional sources.

SLEEMAN CENTRE, GUELPH, ONTARIO

Case Study 1

Cost	$3.8 million
Fuel Source	Hot water system: Natural gas (2 boilers) Chilled water system: Electric (1 chiller)
Capacity	3.8 MW
Building Area	13,378 m^2
Building Types	Sports and entertainment complex
Ownership	Owned and operated by Envida Community Energy Inc - A subsidiary of Guelph Hydro Inc. and the City of Guelph

The Sleeman Centre DE system is located in the downtown core of Guelph and came into commercial operation in the fall of 2013. The Sleeman Centre is a hockey arena with an internal thermal energy plant that provides heating and cooling to the Sleeman Centre, a city-owned building, and other buildings in proximity including a condominium and an arts centre. The system uses pre-insulated steel pipes that are 6-8 inches in diameter. It is an 80-meter, four-

pipe system that supplies and returns hot and chilled water to the buildings. The Guelph system is a success story that demonstrates the viability of DE as both a heating and cooling mechanism. Guelph has plans to supply at least 50 percent of the city with DE heating in the next thirty years, reducing GHG emissions by 60 percent for each resident[7].

FALSE CREEK, VANCOUVER, BRITISH COLUMBIA

Case Study 2

Cost	$33.8 million
Fuel Source	70% Sewage heat recovery and 30% Natural Gas
Capacity	3.2MW
Building Area	557,418.2 m^2 (projected - 2020)
Building Types	Residential and Commercial
Ownership	Community Owned (Neighbourhood Energy Utility)

The False Creek Energy Centre provides heat and hot water to the Southeast False Creek community and the Olympic Village in Vancouver, BC. It is integrated with a sewage pumping station and recovers heat from untreated sewage effluent. Heat pumps are used to transfer the energy to a hot water distribution system. During the colder months of the year, heat pumps are supplemented with natural gas boilers to ensure all buildings receive secure and reliable heating. Heat pumps use a small amount of electricity to upgrade the wastewaters' low-grade thermal energy (averaging 20°C) to a higher-grade temperature of 65°C that can be used for residential space heating and domestic hot water. The facility is also used to enhance the city's urban architectural design with LED lights on

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[7] Envida (2013). District Energy Strategic Plan for the City of Guelph. Retrieved from: http://guelph.ca/wp-content/uploads/011514_DistrictEnergyStrategicPlan_web.pdf

top of the exhaust stacks that change colour depending on consumption levels. The utility is monitored by STP operators and also an independent firm[8].

DALHOUSIE UNIVERSITY, HALIFAX, NOVA SCOTIA

Case Study 3

Cost	$33 million
Fuel Source	Natural Gas
Capacity	47 MW
Building Area	430,742.6 m^2
Building Types	Institutional buildings, Sports facility, and Residential
Ownership	Dalhousie University

The central heating plant at Dalhousie University uses two 1971 central steam boilers with a total capacity of 170,000 PPH or 47 MW. Dalhousie's heating demands in 2010-2011 were 162,000 PPH for which the system was working close to its maximum capacity. The boilers distribute steam to approximately 95 of the buildings on Dalhousie's main campus. The use of a DE system has been a sustainable and efficient means to serve the campus and allow for expansion, while ensuring long-term energy security.

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[8] CIBSE (2014). Case Study: Heat Recovery from sewage waste treatment plant. Retrieved from: http://www.cibse.org/Knowledge/Case-Studies/CIBSE-Case-Study-Heat-Recovery-from-Sewage-Waste-T

CHARLOTTETOWN, PRINCE EDWARD ISLAND

Case Study 4

Cost	$25 million to $30 million for all upgrades
Fuel Source	Combination of wood-chips (36,000 tonnes annually), Municipal solid waste (26,000 tonnes annually), and Fuel oil
Capacity	35 MW heating and 1.2 MW electricity
Building Area	418,063.7 m^2
Building Types	Institutional buildings, Commercial, and Residential
Ownership	Private - PEI Energy Systems

The Charlottetown DE system was developed in 1986 and serves a variety of buildings including the city's provincial government offices, the University of Prince Edward Island, the Atlantic Veterinary College, the Queen Elizabeth Hospital and other mixed-use facilities. The system is privately owned by PEI Energy Systems and was previously owned and operated by Countryside Power Income Fund. The DE system provides heat to around 125 downtown buildings, including a nearby hospital, and uses the electricity internally while selling excess power back to the grid. Approximately 1 million litres of hot water is distributed through 17km of thin-wall steel piping. Each building that receives the hot water has two heat exchangers. One heat exchanger is for the building to circulate hot water at 80°C, while the second is for domestic hot water and operates at 50°C. The boilers produce high-pressure steam that is converted to high-temperature hot water for a district heating system. The supply of the system is 40 thermal MW, which effectively avoids the use of 16 million litres of petroleum per annum. The DE system solves provincial energy concerns and municipal waste management issues[9].

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[9] Biomass Energy Resource Center (2009). In Prince Edward Island's Capital City, a Biomass Pioneer Just Keeps on Working. Retrieved from: http://www.biomassinnovation.ca/pdf/Case%20Studies/CaseStudy_CharlottetownDH2.pdf

The Charlottetown DE case study highlights several key lessons:

- ☑ Engage local stakeholders and regulatory bodies from the outset to help establish a broad base of support and limit the impact of regulatory hurdles encountered
- ☑ Scan for municipal fees and tax implications to assess cost-effectiveness
- ☑ District energy systems in small communities can be integrated into existing urban environments and used as part of an economic retention and growth strategy
- ☑ Optimizing the use of existing infrastructure assets can contribute to the development of a viable and profitable DE system[10]

Feasibility Analysis

Topics examined in this feasibility analysis include the energy potential at the STP, the energy demand within Cogswell redevelopment, the proposed redevelopment area, a piping network cost analysis and a breadth of energy cost case studies. Each of these pieces demonstrates the feasibility of a DE project for the Cogswell Interchange.

THE HALIFAX HARBOUR SOLUTIONS WASTEWATER TREATMENT PLANT

Table 1: Annual data, values for the wastewater effluent at the STP

Total Annual Flows	37,500,000 m^3
Daily Flow	114,000 m^3/day (heating season average, September to April)
Average Annual Temperature	15.8*C
Maximum Annual Temperature	25.1*C

In order to calculate the total amount of energy contained within the wastewater effluent stream at the STP, the energy content of the source can be calculated using:

$Q = m \text{ x } c \text{ x } \triangle T$

where,

Q = thermal energy in kilojoules

m = mass (kilograms) = volume (m3) x density (kilograms/m3)

c = specific heat capacity of effluent (4.193 kilojoules/kilogram/°kelvin)

ΔT = temperature differential of effluent (°kelvin)

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[10] Godken, D. (2007). PEI Energy Systems: Consolidation leads to economic benefits. Retrieved from: http://www.districtenergy.org/assets/CDEA/Case-Studies/PEI-Energy-Systems9-25-07.pdf

According to Halifax Water[11], the energy contained within the wastewater effluent on an average daily basis for 2012/2013 is equal to:

Q= [(114,000 m3/day) x (999.8 kg/m3)] x 4.193 kJ/kg/°K x 1°K
= 113,977,200 kg/day x 4.193 kJ/kg/°1K x 1°K
= 477,906,399.6 kJ/day
or
≈ 478,000,000 kJ/day
or
≈ 478,000 MJ/day

The electrical energy and thermal power equivalence contained within the wastewater effluent is obtained by multiplying Q by a conversion factor and converting this energy to power, respectively:

478,000 MJ/day x (2.778 x 10-4) = 132 MWh/day
or
132 MWh/day ÷ 24 hours/day = 5.5 MW

Therefore, for every 1°C change in the temperature differential of the effluent, an additional 5.5 MW of power is contained within the source of energy. The total amount of power available was calculated by multiplying the amount of power available per 1°C differential by the temperature of effluent. At an average yearly temperature of 15.8°C - there is an immense amount of thermal power that can be utilized relative to the Cogswell redevelopment requirements'.

PROPOSED BUILDINGS

In their analysis of the Cogswell Interchange, Ekistics[12] labels the proposed buildings as Blocks A through E and S for simplification purposes. Blocks A through S will consist of mixed use buildings as primarily residential and retail space. Table 2 indicates the total area of the proposed Cogswell redevelopment[13]. In total, the proposed redevelopment at this stage will create 158,037 m² of space that will need to be provided with energy.

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[11] Halifax Water. (2013). Halifax wastewater treatment facility, wastewater effluent heat recovery-basic facts.

[12] Ekistics. (2014). Cogswell Transformed. A Plan for the Redevelopment of the Cogswell Interchange. Retrieved from: http://www.halifax.ca/council/agendasc/documents/140513ca1141att1.pdf

[13] Ibid.

Table 2: Total square meters in the proposed Cogswell redevelopment

Building Block	Building Footprint (m^2)	Number of Floors	Total Area per Building Block (m^2)
A	1347	20	29,940
B	1768	18	31,824
C	1606	21	33,726
D	1362	20	27,240
E	2109	15	31,365
S	834	7	6,672
			158,037

For the following calculations, the total of 158,037 m^2 of floor area is used as an estimation to represent the total redevelopment area (as seen in Table 2). In order to calculate the total heating demand, the following consumption factors have been taken from Ret Screen's benchmark database[14]:

1.Retail/Commercial building types in Atlantic Canada: 29 W/m^2
29 W/m^2 represents an average of four data values from the benchmark database

2.Residential building types in Atlantic Canada: 28 W/ m^2
28 W/ m^2 represents a single data value from the benchmark database

The values above are published by Natural Resources Canada[15]. As building energy efficiency improves, the published values above may be overstated for the Cogswell redevelopment which is scheduled to begin demolition in 2016 with new construction following. Therefore, 2014 values that are used in this feasibility analysis should be considered as high-end demand estimates.

Table 3: Average heating demand per unit of floor area

Building Type	Demand (W/m^2)
Retail/Commercial	29
Residential	28

Given these demand estimates and the total redevelopment area of 158,037 m^2, the total amount of power required for the Cogswell buildings blocks will be 4.4 MW and 4.6 MW for residential and retail/commercial, respectively. By assuming that

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[14] Natural Resources Canada. (2013). RetScreen4 [Computer Software]. NRCan, CanmetENERGY

[15] Ibid.

the Cogswell redevelopment will consist of retail and commercial space, the feasibility analysis suggests that for a 1*C change in the temperature differential of the effluent, the entire Cogswell redevelopment load (158,037 m^2) can be satisfied by the 5.5 MW.

UNDERSTANDING THE ROLE OF HEAT PUMPS IN DISTRICT ENERGY

A heat pump must be used to convert the relatively low temperature effluent into a high temperature flow that can be used to heat buildings. Heat pumps are a simple and proven technology that effectively add energy to low-grade heat and are still considered to be an environmentally proactive solution to conventional natural gas boilers. The use of heat pumps for wastewater has become increasingly popular because of the advantages such as higher energy efficiency, environmental protection, and reduced operating expenses[16]. The following table of case studies provide typical costs for heat pumps among various other system variables:

Table 4: Parameters of heat pump technology

Case Studies*	Cost of Pump (CAD**/ Capacity/Heating Delivered)	Season Efficiency/Type***
Stuttgart/Echterdi - Germany	$111,042/1803.8 MW/2,712 MWh	310%/Single Fuel - Electric
St. Hubert Airport - Canada	0/239 kW/526 MWh	400%/Single Fuel - Electric
Ottawa International Airport - Canada	($20,000)***/30.3 kW/65 MWh	320%/Single Fuel - Electric

***Case studies were taken from RetScreen 4[17]**
****Based on average 2014 EUR to CAD exchange rate[18]**
*****See Appendix C for more information**

PIPING NETWORK

A number of different pipe options exist for DE systems as defined by Diameter Nominal (DN) and Nominal Pipe Size (NPS). The piping analysis used Dalhousie University's DE piping network as a proxy to estimate sizing . The data was strategically chosen as future development could see the system in the Cogswell attached to the system at Dalhousie University. The Dalhousie University DE piping network consists mainly of 8"and 12" NPS piping. Therefore, it was assumed that DN 200 and DN 300 insulated piping will be used for the Cogswell redevelopment[19]. Cost estimates

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[16] Hepbasli, A., Biyik, E., Ekren, O., Guherhan, H., & Araz, M. (2014). A key review of wastewater source heat pump (WWSHP) systems. Energy Conversion and Management, 88, 700-722.

[17] Natural Resources Canada. (2013). RetScreen4 [Computer Software]. NRCan, CanmetENERGY

[18] Bank of Canada (2014). Year average exchange rates. Retrieved from http://www.bankofcanada.ca/stats/assets/pdf/nraa-2014-en.pdf

[19] The Engineering Toolbox. (n.d.). NPS – Nominal Pipe Size and DN – Diametre Nominal. Retrieved from: http://www.engineeringtoolbox.com/nps-nominal-pipe-sizes-d_45.html

are listed in the table below. As European DE expert Urban Ziegler[20] suggests, pre-insulated pipes experience typical heat loss of two to three percent annually.

Table 5: Total piping cost estimates based on type and length

Piping Size (DN/NPS)	Cost Estimate* (CAD/m)	Total Cost of Piping for 50m (CAD)	Total Cost of Piping for 100m (CAD)	Total Cost of Piping for 200m (CAD)	Total Cost of Piping for 300m (CAD)	Total Cost of Piping for 500m (CAD)
200mm/8”	$750/m	37,500	75,000	150,000	225,000	375,000
300mm/12”	$1000/m	50,000	100,000	200,000	300,000	500,000

***See Appendix D for more information**

ENERGY COST CASE STUDIES

Another factor in determining the feasibility of a DE system is the price per unit of energy relative to conventional sources of energy. Two case study templates highlight a reduction in a cost of energy shifting from a conventional system to a DE system[21]:

Table 6: RetScreen DE case studies showing changes in the cost of energy by utilizing DE

Case Study	Total Energy Delivered/Annual System Costs* (Conventional System**)	Cost per unit of energy	Total Energy Delivered/Annual System Costs	Cost per unit of energy
Ottawa International Airport	1,705 MWh/ $205,380	~$12/MWh	1705 MWh/ $145,431	~$8.5/MWh
Charlottetown Airport	2,083 MWh/ $124,077	~$6/MWh	2,083.4 MWh/ $21,796	~$1/MWh

***Ottawa International Airport used diesel and electricity for space heating, while Charlottetown Airport used a diesel system exclusively - a conventional system**
****Annual costs for a conventional system include fuel costs, while annual costs for a DE system include fuel costs, operation and maintenance costs, and debt payments for the life of the system**

Both of the case studies demonstrate that the cost per unit of energy decreases from a conventional energy system to a district energy system. Therefore, adoption of a DE system has the potential to reduce costs associated with energy uses such as heating. In terms of the Cogswell Interchange, the load capacities required for retail/commercial and residential are stated in the table below. The cost of generating a unit of energy at the Cogswell Interchange by using natural gas or

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[20] Ziegler, U. (2013, January 23). Daniels B.E.S.T. lecture. [Youtube Video]. Retrieved from: https://www.youtube.com/watch?v=eeAOFdiiIdw

[21] Natural Resources Canada. (2013). RetScreen4 [Computer Software]. NRCan, CanmetENERGY

electricity can be determined by converting the load capacities to potential energy demand:

Table 7: Conversion of power load to consumption depending on building types

Scenario	Conversion to Energy Consumption	Total Energy Demand (Consumption)
Retail/Commercial @ 4.6 MW	4.6 MW x 8765.81 hours	~40,323 MWh
Residential @ 4.4 MW	4.4 MW x 8765.81 hours	~38,570 MWh

Based on the two total energy demand scenarios it is possible to compare the costs of consuming energy through the price of natural gas, electricity, while also determining the potential amount of greenhouse gas emissions that can be abated through the adoption of a DE system. Energy prices per unit are as follows:

NATURAL GAS[22]

$61.865/MWh (as of May 16, 2015) as the Homeowner rate or Class 1 Commercial rate (Up to 1,388.9 MWh)

$39.981/MWh (as of May 16, 2015) as the Class 2 Commercial rate (1,389 MWh to 13,389 MWh)

$34.819/MWh (as of May 16, 2015) as the Class 3 Commercial rate (Over 13,389 MWh)

ELECTRICITY[23]

$149.47/MWh (as of May 16, 2015) as the Residential Domestic Service Tariff

15.774¢ for the first 200 kWh (as of May 16, 2015) as the Small General Tariff (Commercial) and 13.960¢ for every additional kWh

11.841¢ for the first 200 kWh (as of May 16, 2015) as the General Tariff (Commercial) and 8.562¢ for every additional kWh

Using the total energy demand values from Table 7, the total cost of energy was calculated based on the residential rates above. Greenhouse gas intensities per unit of consumption for natural gas and electricity are 0.196 tonnes of CO_2/MWh

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[22] Heritage Gas. (2015). Rates and rebates for homeowners. Retrieved from: http://www.heritagegas.com/residential/rates-rebates/

[23] Nova Scotia Power. (2015). 2015 electricity rates. Retrieved from http://www.nspower.ca/en/home/myaccount/billing-and-payments/2015-electricity-rates/default.aspx

and 0.526 tonnes of CO_2/MWh[24], respectively.

Table 8: Total cost of energy production annually with potential GHG abated

Cost Scenario 1 - Natural Gas @ $61.85/ MWh	Total Cost of Energy Production, Annually (CAD)	Potential Greenhouse Gas Offset* (tonnes of CO_2)	Cost Scenario 2 - Electricity @ $149.47/MWh	Total Cost of Energy Production, Annually (CAD)	Potential Greenhouse Gas Offset (tonnes of CO_2)
Natural Gas for 40,323 MWh	$2,494,582.395	7,903.308	**Electricity for 40,323 MWh**	$6,027,078.81	21,209.898
Natural Gas for 38,570 MWh	$2,386,133.05	7,559.72	**Electricity for 38,570 MWh**	$5,765,057.9	20,287.82

***Represents the approximate amount of greenhouse gas emissions that can be abated from the atmosphere by not burning conventional fossil fuels to generate the required energy**

Based on the feasibility analysis, DE is a viable energy solution for the Cogswell redevelopment. There is a unique opportunity for Halifax to utilize a secure and local source of energy. After analyzing a variety of data, the feasibility analysis demonstrates that there is a substantial amount of energy that can be used to heat the new buildings in the Cogswell redevelopment cost-effectively.

Looking Forward

A presentation to the Environment and Sustainability Standing Committee (ESSC) was made at Halifax Municipal Council on April 2nd, 2015. The presentation to the ESSC captured the attention of the municipality and introduced the strategic opportunity for this DE project in Halifax (See Appendix E). The presentation was met with interest by the ESSC and has proved a successful first step to the implementation of DE for Cogswell redevelopment. The next step in planning and implementing a district energy project involves a capacity building exercise, which through brainstorming ideas brings together the expertise necessary for Halifax to develop this project moving forward (See Appendix F).

The next step involves the stakeholder roundtable aimed at building capacity for DE in the Cogswell Interchange which will occur on April 22nd 2015. The event is aimed at providing a networking space for key players to combine knowledge and form a DE community in Halifax. The outcome of the roundtable will be a roadmap that illustrates the process of implementing DE into the Cogswell redevelopment. The roadmap will be presented to Halifax City Council. This is intended to be a capacity building exercise to raise awareness about DE, provide a collaborative open space

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[24] Natural Resources Canada. (2013). RetScreen4 [Computer Software]. NRCan, CanmetENERGY

for discussion, and create a network of key stakeholders who can lead planning and implementation phases moving forward (See Appendix F).

CREATING CHANGE: DYNAMICS WITHIN THE COGSWELL INTERCHANGE

To create change and implement the DE system in the Cogswell Interchange, we have identified key decision makers and stakeholders. The Mayor and Municipal Council are important decision makers and stakeholders for the city of Halifax as they have the ability to support the development of a district energy project in a variety of ways. Halifax can support this project by implementing planning policies that streamline environmentally friendly projects, while creating incentives for innovation and better cost-effectiveness. Halifax and the Halifax Water Commission can support the financing of this project while overseeing changing ownership relative to short-term and long-term interests as the project evolves. Developers and engineering firms are also vital to the implementation of DE and are also regarded as major stakeholders for this project. We invited the relevant decision makers and stakeholders to the roundtable event in an attempt to create a cohesive dynamic whereby every individual would be focused on how to plan and implement DE into the Cogswell redevelopment. By bringing together the required expertise found in the decision makers and stakeholders we've identified, the roundtable event will provide a capacity building platform for a potential DE project in Halifax.

PROPOSED METHODOLOGY

The roundtable used an Open Space Technique for the DE roundtable. Open Space is most effective when the work to be done is complex, the people and ideas involved are diverse, and there is a passion for resolution[25]. The roundtable discussion is an opportunity for the participants to get together in an informal setting to examine DE issues as they relate to their specific industry and/or business process. This event will act as a tool to guide the implementation process for DE in the Cogswell Interchange.

The process of road mapping develops visualizations for actions in multi-year project by identifying relevant components along a timeline. For this specific DE project, some examples of such components used are ownership structure, policy and funding, system design, and project implementation (See Appendix G). After setting the stage for DE and the Cogswell Interchange, participants will be broken down into smaller groups. Each small group will be given a different component of the DE project and attendees will map out a rough timeline in the span of x years. All attendees will have time to visit each table. This will allow all the different stakeholders to interact and it will create a visual output to show how the different timelines overlap or diverge. The visual will be a DE roadmap, which attempts to simplify all

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[25] Herman, M. (1998). Open space world. Retrieved from http://www.openspaceworld.org/cgi/wiki.cgi?AboutOpenSpace

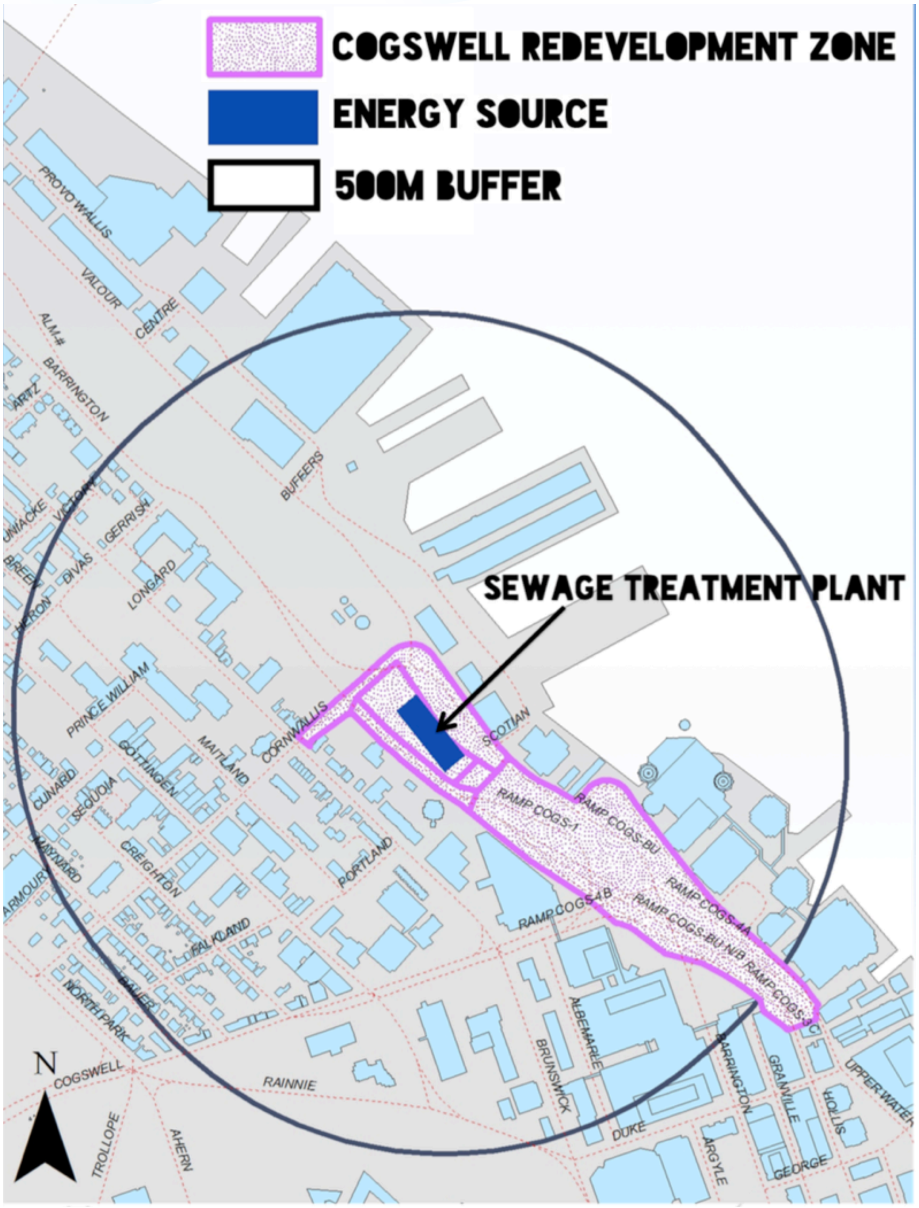
the complexities of DE in a way where it is accessible for engineers, planners and politicians.

ROUNDTABLE DELIVERABLES

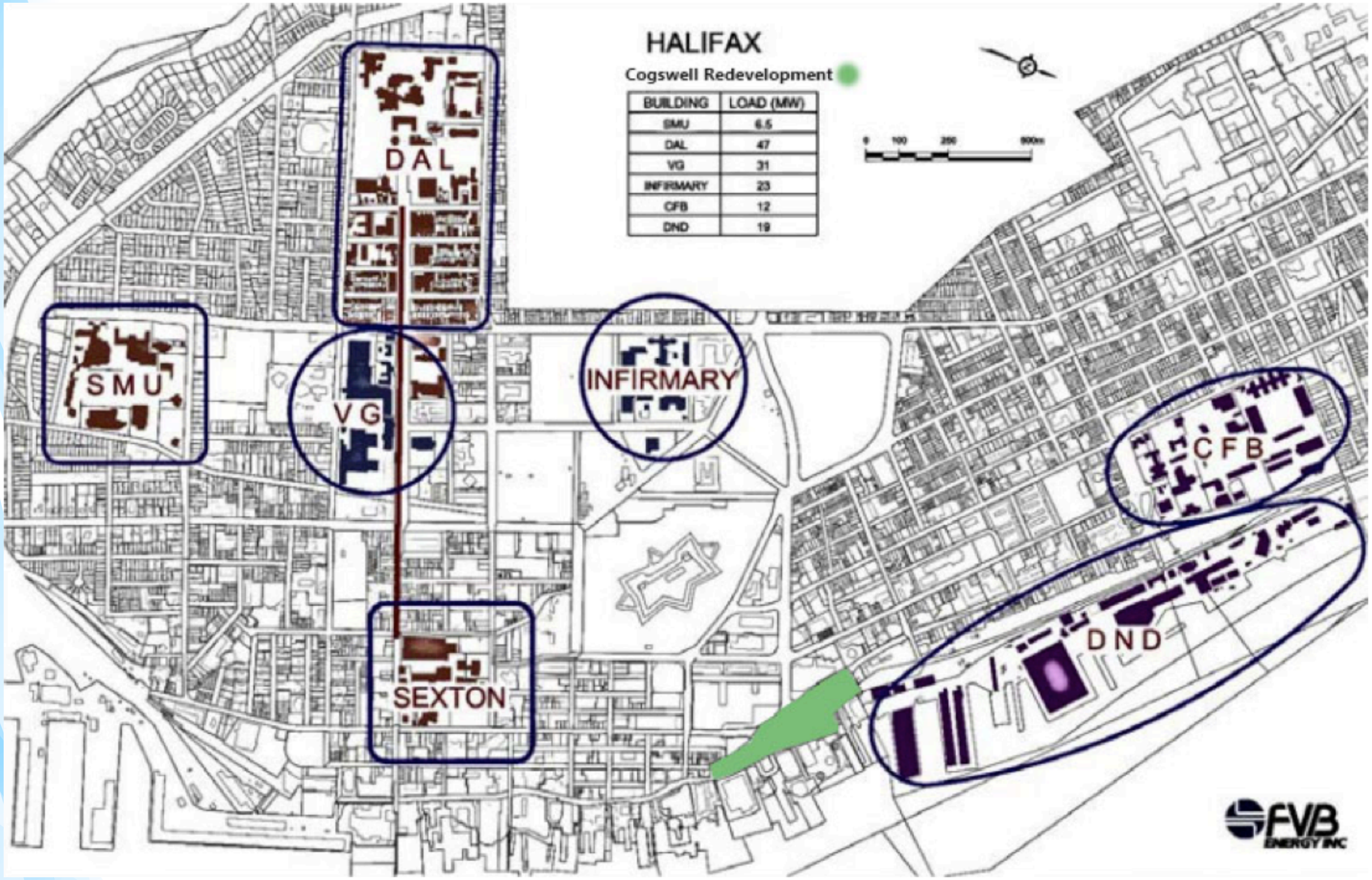
The key output of the stakeholder round table is a road map. The ideas, discussion, data, recommendations, conclusions, questions for further study, and plans for immediate action were documented by the facilitation team in one comprehensive and complimentary report. After the event, the road map and any other additional items will be prepared and distributed amongst roundtable participants and to ESSC at Halifax City Council.

Appendices

APPENDIX A: GEOGRAPHICAL INFORMATION SYSTEMS

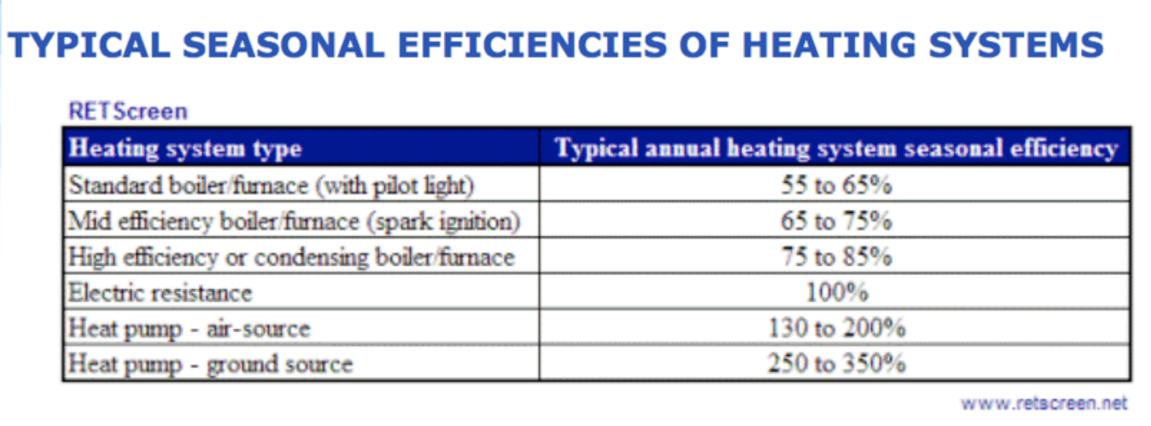


APPENDIX B: DISTRICT HEATING INFRASTRUCTURE IN HALIFAX, NOVA SCOTIA (2015)



BUILDING	LOAD (MW)
SMU	6.5
DAL	47
VG	31
INFIRMARY	23
CFB	12
DND	19

APPENDIX C: SEASONAL EFFICIENCIES FOR HEAT PUMPS[26]



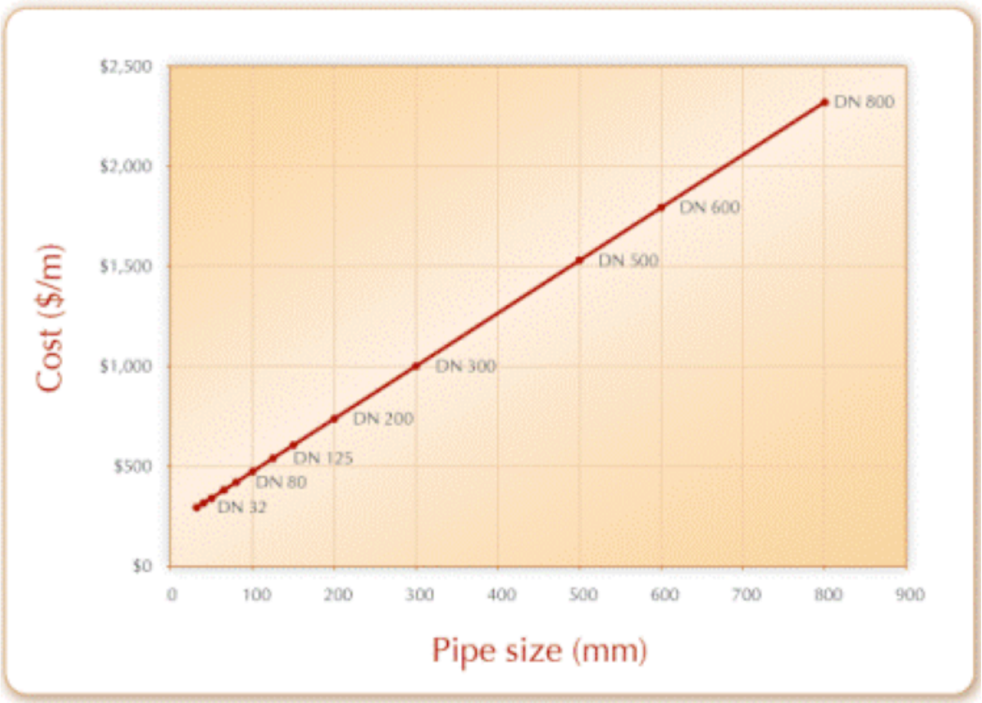
TYPICAL SEASONAL EFFICIENCIES OF HEATING SYSTEMS

RETScreen

Heating system type	Typical annual heating system seasonal efficiency
Standard boiler/furnace (with pilot light)	55 to 65%
Mid efficiency boiler/furnace (spark ignition)	65 to 75%
High efficiency or condensing boiler/furnace	75 to 85%
Electric resistance	100%
Heat pump - air-source	130 to 200%
Heat pump - ground source	250 to 350%

www.retscreen.net

APPENDIX D: PIPE COSTS BASED ON DIAMETER NOMINAL AND NOMINAL PIPE SIZE[27]



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[26] RETScreen. (2013). Typical Seasonal Efficiencies of Heating Systems. Natural Resources Canada. Retrieved from http://www.retscreen.net/ang/typical_seasonal_efficiencies_of_heating_systems_image.php

[27] RETScreen. (2008). Typical Costs for Heating Distribution Line Pipes. Natural Resources Canada. Retrieved from www.retscreen.net/ang/typical_costs_for_heating_distribution_line_pipes_image.php

APPENDIX E: STANDING COMMITTEE ON ENVIRONMENT AND SUSTAINABILITY AGENDA TEMPLATE

On April 2, 2015, the Connecting Landscapes team presented the findings of the feasibility analysis to the HRM council Standing Committee on Environment and Sustainability (SCES). The goal in presenting a case for the DE project to the committee is to capture the attention of the municipality and promote DE as a viable an environmentally sound energy source.

Plan for presentation:

1. Introduction
2. Communicate that timing is ideal
3. Discuss benefits
   i) Consistent with EGSPA goals
   ii) Promotes local energy security within Halifax
4. Feasibility Analysis
   i) The power is available to satisfy the heating demand for the buildings in the proposed Cogswell redevelopment.
5. Concluding remarks

The presentation highlighted the ideal timing for the implementation of a district energy system in the Cogswell, the sustainability benefits and feasibility of the opportunity. Connecting Landscapes hopes to present the DE project as a vital component in the redevelopment plans of the Cogswell Interchange.

APPENDIX F: THE INTEGRATED DESIGN PROCESS

THE INTEGRATED DESIGN PROCESS

> **"The Integrated Design Process (IDP) is a method for realizing high performance buildings that contribute to sustainable communities. It is a collaborative process that focuses on the design, construction, operation and occupancy of a building over its complete life-cycle. The IDP is designed to allow the client and other stakeholders to develop and realize clearly defined and challenging functional, environmental and economic goals and objectives"**

The Integrated Design Process (IDP) approach assisted with framing the methodology for the DE roundtable at Dalhousie University. IDP uses a holistic approach to building design and construction and relies on every stakeholder sharing a vision of sustainability to work collaboratively to implement sustainability goals[28]. In order for IDP to be effective, the stakeholders must come from multiple disciplines. IDP is not an exclusive organizing tool in principle and can be used for variety of design and decision-making projects[29]. IDP is crucial for the coordination and execution of the DE project.

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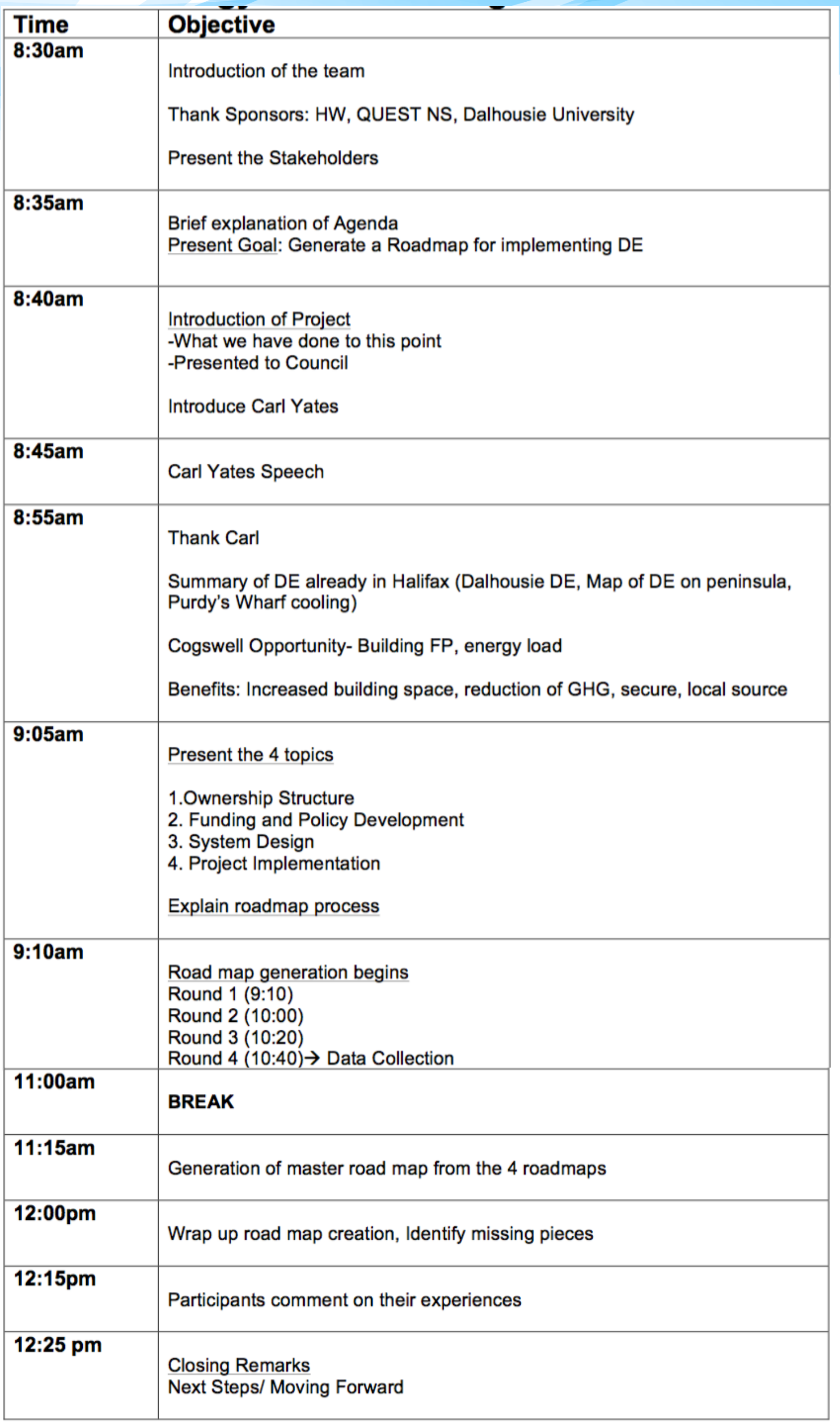
[28] Natural Resources Canada. (2014). Integral Design Process. Retrieved from http://www.nrcan.gc.ca/energy/efficiency/buildings/eenb/integrated-design-process/4047

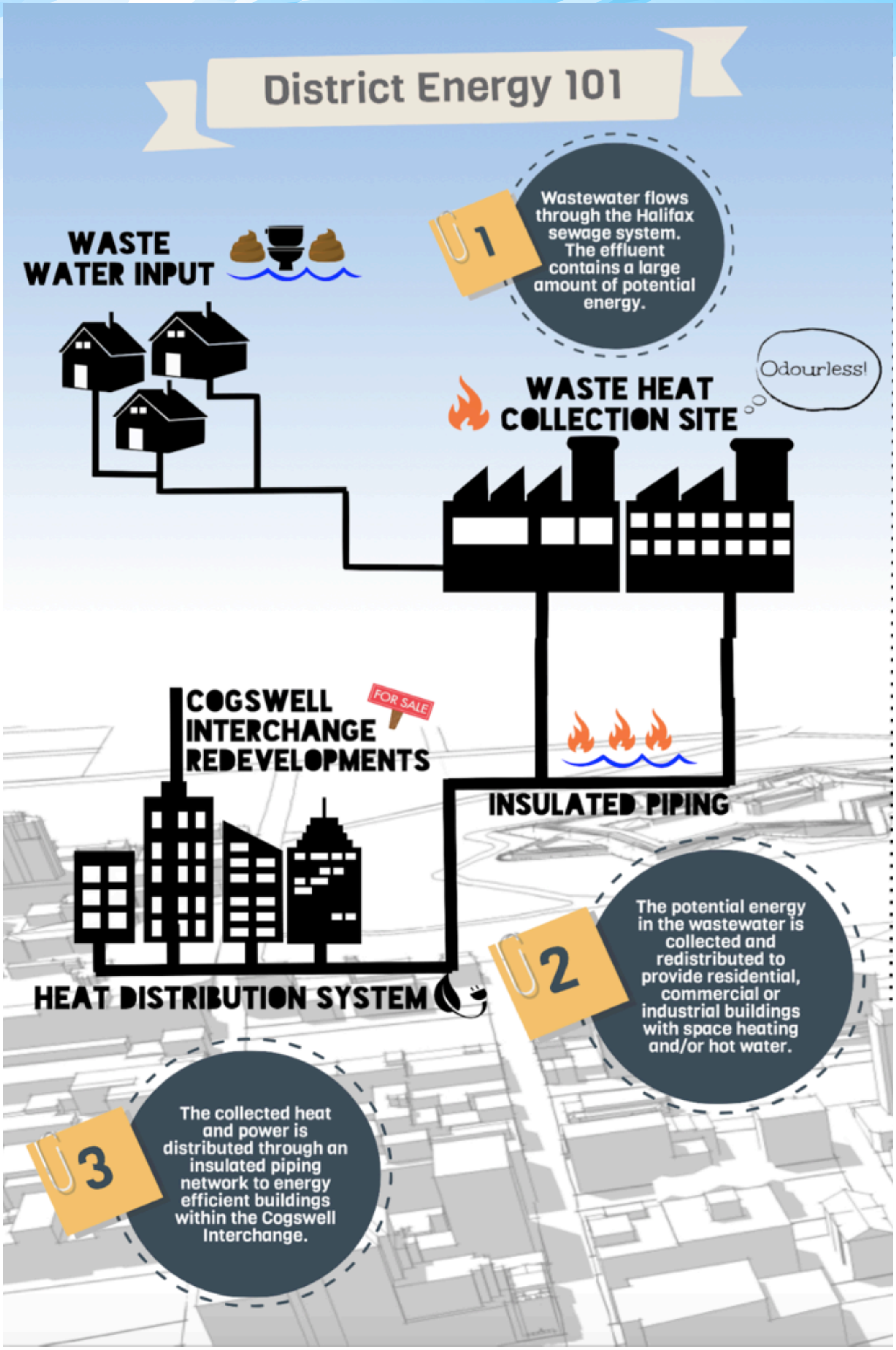
[29] BC Green Building Roundtable. (2007). Roadmap for the Integrated Design Process. Retrieved from http://cascadiapublic.s3.amazonaws.com/Large%20Cascadia%20Files/RoadmaptotheIDP.pdf

APPENDIX G: ROUNDTABLE AGENDA FOR APRIL 22ND, 2015



Time	Objective
8:30am	Introduction of the team Thank Sponsors: HW, QUEST NS, Dalhousie University Present the Stakeholders
8:35am	Brief explanation of Agenda Present Goal: Generate a Roadmap for implementing DE
8:40am	Introduction of Project -What we have done to this point -Presented to Council Introduce Carl Yates
8:45am	Carl Yates Speech
8:55am	Thank Carl Summary of DE already in Halifax (Dalhousie DE, Map of DE on peninsula, Purdy's Wharf cooling) Cogswell Opportunity- Building FP, energy load Benefits: Increased building space, reduction of GHG, secure, local source
9:05am	Present the 4 topics 1.Ownership Structure 2. Funding and Policy Development 3. System Design 4. Project Implementation Explain roadmap process
9:10am	Road map generation begins Round 1 (9:10) Round 2 (10:00) Round 3 (10:20) Round 4 (10:40)→ Data Collection
11:00am	**BREAK**
11:15am	Generation of master road map from the 4 roadmaps
12:00pm	Wrap up road map creation, Identify missing pieces
12:15pm	Participants comment on their experiences
12:25 pm	Closing Remarks Next Steps/ Moving Forward

APPENDIX H: DISTRICT ENERGY INFOGRAPHIC



1 Wastewater flows through the Halifax sewage system. The effluent contains a large amount of potential energy.

2 The potential energy in the wastewater is collected and redistributed to provide residential, commercial or industrial buildings with space heating and/or hot water.

3 The collected heat and power is distributed through an insulated piping network to energy efficient buildings within the Cogswell Interchange.

APPENDIX I: STAKEHOLDER ASSESSMENT