DISTRICT HEATING AND COOLING AT SYDNEY HARBOUR

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ENWAVE – DISTRICT HEATING AND COOLING AT SYDNEY HARBOUR

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1. INTRODUCTION

This report presents a preliminary design of a district heating and cooling (DH&C) network including production facilities at Sydney, Nova Scotia.

The purpose of this report is to present the concepts under consideration for an energy network in Sydney. No detailed design has been undertaken and results and costs set out here are based on conceptual assessments only. A high-level economic assessment has been carried out to identify the preferred scenario for more detailed development. Cost estimates in this report are based on the assumptions laid out herein and are intended for use by Enwave as part of this study project only.

Heating and cooling consumption per building is estimated based on building reports complete by FC Scriven, O'Neill. Costs for buildings conversions were also provided by FC Scriven, O'Neill.

A Preliminary DH&C network was developed based on hydraulic analysis to ensure that demand can always be supplied on the coldest and hottest days of the year respectively. The capacity of each production unit in the scenario analysis is not optimized, this would be carried out as a future detail stage of work.

The assumptions and technical information on which the project analysis is based are presented in Section 3, which includes the building information, heat demand, cooling demand, a technology catalogue with cost estimates on production technologies, the prices of DH&C pipes, fuel prices, an evaluation of available heat sources and the possibility for utilizing air and seawater cooling.

Section 4 outlines the DH&C network development based on the building thermal demand, and an assumed location of the new energy center. An analysis of different scenarios for the project was carried out where different supply options for both heating and cooling were evaluated. The production distributions and investment costs may be used in a subsequent economic analysis.

Section 5 outlines the initial economic results for the preferred scenarios. Results are presented as EBIDTA values (earnings before interest, depreciation, taxation and amortization).

1. Ebidta Real (inflation applied) NPV
2. GHG emissions savings

2. CONNECTED BUILDINGS AND ENERGY DEMAND

Several buildings were selected as candidates for inclusion in the study. These candidate buildings were selected by Enwave based on consultation with CBRM, FC Scriven O'Neill, building owners and Ramboll.

The buildings are located along the Sydney harbourfront and into the town as shown in Figure 2-1 below.

Figure 2-1: Candidate Buildings

The existing buildings considered as candidates are set out in Table 2-1 below. Each building was assessed for connection based on total potential connected load (heating and cooling), distance to the central plant and cost for conversion. A decision was then made on the feasibility of connecting each building based on experience from previous projects.

Table 2-1: Existing Building Summary

Building	Included (Y/N/Partial)	Reason	Estimated Cost for Conversion
Cruise Pavilion	N	Distance to the central plant and relatively low connected load.	*$250,000*
Sydney GOCB	N	Distance to the central plant and high cost of conversion.	*$789,000*
Justice Centre	Y	Relatively close to the central plant and other clustered connected buildings. Balance between connected load and cost for conversion.	*$440,000*
Commerce Tower	Y	Relatively close to the central plant and other clustered connected buildings outweighing the relatively high cost for conversion.	*$836,000*
Holiday Inn Sydney Waterfront	Partial	Additional demand in the building considered to be too costly and disruptive to connect. Remaining demand considered as straightforward to connect and close to the central plant.	*$582,900*
Vista Heights	Partial	Additional demand in the building considered to be too costly and disruptive to connect. Remaining demand considered as straightforward to connect and close to the central plant.	*$80,000*
CBRM Civic centre	Y	Close to the central plant, building requires substantial work to renovate the existing HVAC system offering an excellent opportunity for the network.	*$1,770,000*
Cambridge Suites	Y	Relatively straightforward connection to district energy system, close to the central plant. Building energy plant	*$375,000*

		due for renewal in the short term.	
YMCA of Cape Breton	N	Low energy demand and relatively high conversion cost compared to distance to the central network.	*$549,200*
Centre 200	N	Low energy demand compared to distance to the central network. Heat recovery opportunity not considered suitable for connection to the network.	*N/A (screened out before conversion cost estimates)*
		Total	$5,122,900

Full Building reports are contained in Appendix 4 of this report. Please note that most of these costs are considered to be accurate to +/- 30%.

Of these 10 existing buildings only 6 are included for connection in the final project base case, these are indicated above.

Future developments in Sydney are also included in this assessment, these are the new College (potential) and the Water Front Renewal Project. There are significant uncertainties associated with each of the large-scale new development connections, however initial discussions have been encouraging.

The final location for the College is not yet fixed, for the purposes of this report the harbourfront location is assumed. A size of 236,000ft^2 has been assumed based on guidance received from CBRM.

No energy demand information was available at the time of writing for the college, the new harbourfront renewal project or the library building, benchmarks have been used as placeholders for the purposes of this initial concept development phase.

2.1 Energy Demand Assessment

The heating and cooling demand benchmarks are shown in Table 2-2. These are used for buildings which are planned for construction in the coming years.

Building energy demands and conversion costs were assessed by local advisors and information provided is based on discussions with building operators and utility bills provided.

Table 2-2: Heat demand and cooling demand per building type

	Heat demand	Cooling demand
Unit	MBTU/ft^2	MBTU/ft^2
New building	*49*	*33*

Information on the existing buildings can be found in the building reports in Appendix 4. The heat demand (HD) and cooling demand (CD) per building is shown in Table 2-2.

Table 2-3: Heat demand and cooling demand per building

Building	Connected	Building Floor area (1)	Total HD	Total CD
		ft²	MBTU/year	MBTU/year
Cruise Pavilion	*Not Connected*	*39,300*	*1,562,340*	*1,242,393*
Sydney GOCB	*Not Connected*	*75,000*	*1,805,115*	*1,347,173*
Justice Centre	*Connected*	*69,600*	*3,114,590*	*1,787,844*
Commerce Tower	*Connected*	*42,000*	*2,395,838*	*1,489,870*
Holiday Inn Sydney Waterfront	*Connected*	*76,000*	*3,939,597*	*653,053*
Vista Heights	*Connected*	*94,900*	*1,426,170*	*0*
CBRM Civic centre	*Connected*	*18,500*	*2,479,487*	*1,387,697*
Cambridge Suites	*Connected*	*86,000*	*3,782,101*	*3,761,912*
YMCA of Cape Breton	*Not Connected*	*55,600*	*2,263,401*	*1,127,657*
Centre 200	*Not Connected*		*0*	*0*
Waterfront Develop-ment Casino & Hotel Tower	*Connected*	*113,000*	*5,537,000*	*3,729,000*
Waterfront Develop-ment Residential Apartment Tower	*Connected*	*85,600*	*4,194,400*	*2,824,800*
Waterfront Develop-ment Marine Inter-pretive Recreation Centre	*Connected*	*18,000*	*882,000*	*594,000*
Waterfront Develop-ment Regional Li-brary	*Connected*	*37,865*	*1,855,385*	*1,249,545*
Waterfront Develop-ment Commercial Of-fice Space	*Connected*	*74,900*	*3,670,100*	*2,471,700*
New College	*Connected*	*236,000*	*11,564,000*	*7,788,000*
		Total MBTU/year	***50,471,523***	***31,454,642***
		Total MWh/year	***14,803***	***9,225***

(1) Please note that this is the total building floor area and does not represent the total heated and cooled floor area in all cases as some buildings are only partially connected to the system.

New buildings are highlighted as shaded rows in the above table.

2.2 Thermal demand profiles

The DH&C demand profiles are estimated based on a temperature profile for Sydney from the Climate Forecast System Reanalysis 2 (CFSR 2) database, as plotted on Figure 2-2.

We have estimated the DH&C demand profiles based on a temperature dependent demand of 80 % for both heating and cooling. The heat demand profile can be seen in Figure 2-3, the cooling demand profile is shown in Figure 2-4.

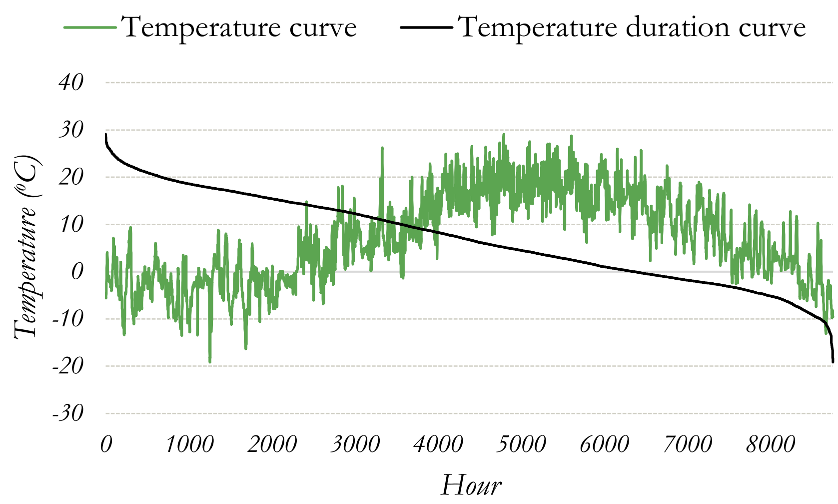


Figure 2-2: Temperature profile

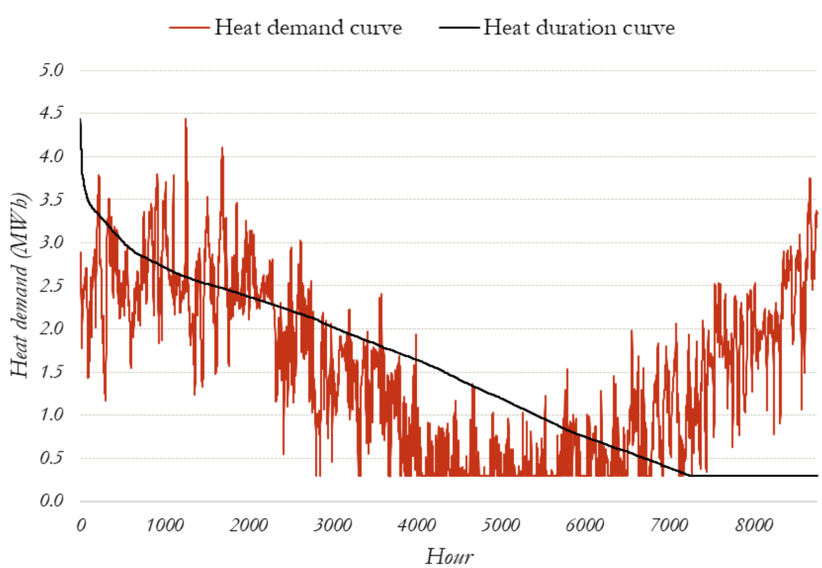


Figure 2-3: Heat demand profile

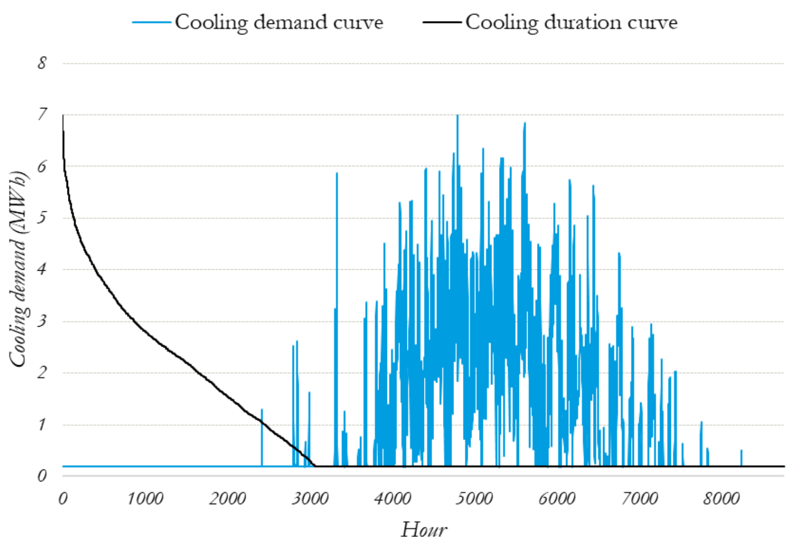


Figure 2-4: Cooling demand profile

3. TECHNICAL AND COST ASSUMPTIONS

In this section, the assumptions and technical information on which the project has been carried out are outlined.

3.1 District heating and cooling network temperatures

The district heating and cooling networks are sized based on the temperatures in Table 3-1. The amount of heating and cooling that can be carried by the pipes is determined by the supply and return temperature in the networks. Because this network is intended to supply a mixture of existing and planned buildings the operating temperatures of the building heating and cooling systems will have a big impact on the network design.

Should the final design temperatures of the system vary there will be a corresponding change in pipe diameters and subsequent costs. The efficiency and scale of the supply technology will also change.

The temperatures below are based on temperature information provided in the building reports and experience of similar buildings where temperature reductions were achieved through changes to the central mechanical spaces and controls.

Further assessment and design work are required to determine achievable supply and return temperatures per building. It is also advisable that planned future buildings are designed with the district energy system in mind.

Table 3-1: District heating and cooling network temperatures

	District heating		District cooling	
	ºC	ºF	ºC	ºF
T_{supply}	*74*	*165*	*13*	*56*
T_{return}	*52*	*125*	*6*	*42*
ΔT	*22*	*40*	*8*	*14*

3.2 District heating and cooling pipe cost estimates

An estimate on investment cost for DH&C pipes can be found in Table 3-2. The cost estimates are based on our experience in North America and includes material, excavation and installation costs. Construction management and design, as well as any unforeseen costs, are not included in the values below.

The network is responsible for 10% of the total capex for the project and any savings that can be made by reducing pipe diameters and excavation costs will help the project economics.

Table 3-2: District heating and cooling pipe cost estimates

Type of dig		Low
DN	Inches	$/m
DN 20	3/4	*493*
DN 25	1	*546*
DN 32	1 1/4	*553*
DN 40	1 1/2	*576*
DN 50	2	*554*
DN 65	2 1/2	*624*
DN 80	3	*736*
DN 100	4	*898*
DN 125	5	*1062*
DN 150	6	*1223*
DN 175	8	*1304*
DN 200	10	*1384*
DN 250	12	*1626*
DN 300	14	*2273*
DN 350	16	*2675*
DN 400	18	*2916*
DN500	20	*3079*
DN600	24	*3241*
DN700	28	*3403*
DN800	32	*3565*
DN900	36	*3728*
DN1000	40	*3890*

Based on a cross reference exercise carried out with information provided by CBRM for ductile iron water pipe installation, the local costs in Cape Breton are expected to be similar to those presented above.

3.3 Fuel and electricity prices

The fuel and electricity prices are shown in Table 3-4 and Table 3-5.The fuel oil price is based on local values, and the electricity price is from Nova Scotia Power [2]. The wood chips price is based on local information, it is expected that fuel prices for wood chips could be negotiated locally at potentially lower rates. Initial prices are based on 2018 values.

Ongoing fuel costs are a key driver for the project economics and sensitivity around these costs has been included in Section 5.3.

The district energy network would have a higher electricity consumption than individual buildings and will likely have a higher load factor than individual buildings, this is reflected in the rates shown in Table 3-4.

Table 3-3: Fuel prices

	Fuel price	Fuel price (metric)
Wood chips	*85 $/ton*	*43 $/MWh*
Fuel oil	*1.05 $/l*	*105 $/MWh*
Propane	*0.9 $/l*	*127 $/MWh*

Table 3-4: Electricity prices

	Electricity price
District Energy Plant	*121.7$/MWh*
Customers	*145.4 $/MWh*

3.4 Carbon Intensity of Fuels and Electricity in Nova Scotia

Carbon intensity values are taken from Tables 4-2 and 4-3 in Standards for Quantification, Reporting, and Verification of Greenhouse Gas Emissions from the Government of Nova Scotia (Feb 2018) [3].

The carbon intensity of electricity is based on data from Nova Scotia Power [5].

Table 3-5: Carbon Intensity of Fuel

	Carbon Intensity
Electric Utilities [5]	0.656 kg/kWh
Fuel oil	*2.7 kg/l*
Propane	*1.51 kg/l*
Wood Fuel / Wood Waste @0% moisture content	*1.81 kg/kg*
LR100 (Vegetable Oil)	*NA*

The requirement in Nova Scotia is that emissions are reported as total emissions less the portion from biomass [6]. For this reason, the contribution from a biomass plant to the project could be considered essentially carbon neutral.

3.5 Technology

The technology specific assumptions are shown in Table 3-6. The efficiencies are stated for the heat pump and chiller as expected annual averages. These will vary depending on temperatures in the DH&C systems and the heat/cooling source.

System efficiencies are extremely important as they directly impact fuel costs for the various scenarios and as such have a significant impact on project economics.

The efficiency of the seawater chiller will likely be a little higher, as the seawater temperature is expected to be slightly lower than the air. However, the initial cost will likely be higher for a seawater-based system due to the higher costs associated with marine works.

The cost estimates are based on our experience and reference material for various technology options [1] and our internal cost database developed from previous projects. The investment costs shown are for each technology. Additional investment costs are expected, with our estimates shown in Table 3-7. Land purchase costs for an energy centre are not included in this estimate as it is assumed at this stage that an arrangement could be made to house equipment in one of the renovated buildings or new developments.

Table 3-6: Technology catalogue

	Fuel	Total efficiency		
Unit		*%-h*	*%-c*	*%-e*
Heat pump	*Electricity*	*300 %*	*200 %*	
Electric chiller (dry cooler)	*Electricity*	---	*400 %*	
Electric chiller (sea-water)	*Electricity*	---	*500 %*	
Oil boiler	*Oil*	*80 %*	---	
Biomass boiler	*Wood chips*	*85 %*	---	
Absorption Chiller	---	---	*90%*	
ORC	*Thermal energy from biomass boiler*	*80%*		*18%*

Table 3-7: Additional investment costs

	Investment
Heat pump	*0.8 million$/MW-h*
Electric chiller	*0.33 m$/MW-c*
Electric chiller (seawater)	*0.28 m$/MW-c*
Absorption Chiller	*0.3m$/MW-c*
Oil boiler	*0.10 m$/MW-h*
Biomass boiler	*1.00 m$/MW-h*
ORC	*3.6 m$/MW-e*
Energy center building	*2000 $/m^2*
Sewage water heat exchanger treated	*0.25$/MW-h*
Sewage water heat exchanger untreated	*1.25m$/MW-h*
Seawater intake	*1.0 m$/MW-c*
Treated Sewage water connection	*1.5$/km*
Cooling Towers	*0.30 m$/MW-c*
Pumps, pipes, electric connections, etc.	*0.25$/MW*

*The value for the seawater intake is taken from a previous project. The cost of marine work varies greatly from one project to another.

Investment costs for different technologies vary considerably from project to project. Some environments such as marine works are particularly variable.

3.6 Biomass

A requirement for the use of biomass is that there is a local biomass source available. We assume in our study that this biomass source is available based on conversations we have had with forestry experts and an initial desktop study. A detailed assessment of the forestry supply chain and suppliers has not been undertaken at this time. It is recommended that if biomass is taken forward to the next stage of development, there should be a detailed study undertaken to assess biomass supply chain and overall sustainability of available biomass in Cape Breton.

There is an existing biomass supply chain in Cape Breton to support the Point Tupper Power Plant. The power plant has attracted a significant amount of negative commentary in local media and is a point of controversy in Cape Breton. This may impact the perception of a biomass-based district energy system in Sydney. Outreach to local community groups would be needed during the development of such a project to establish the support or lack thereof for such a facility in downtown Sydney.

It has come to the attention of the project team that CBRM may have a potential biomass waste stream that could be utilized as a fuel source. The assumptions made in this report are that primary fuel for the biomass boiler would be locally sourced wood chips and the moisture content of the fuel would be approximately 55%. The project as described here would require 7100 tons biomass per annum.

3.7 Sewage water

The sewage water outlet can be used as a heat source for a heat pump. In Appendix 2 we outline the analysis of the available sewage heat in closer detail. Based on available data we estimate that the heat capacity is around 9 MW. This is more than enough to cover the full heat demand for the system with a heat pump and to allow for potential future expansion.

This report assesses both a scenario whereby treated water is distributed to the energy centre from the wastewater treatment plant. Heat recovery from raw sewage is also assessed. Heat rejection to the sewer can also be accommodated under this scenario.

A temperature and flow study of the sewer system is recommended to confirm assumptions should this option be considered in further detail.

3.8 Seawater

Available temperature information for Sydney Harbour was not sufficiently detailed to allow a full assessment to be undertaken and the results in this report are based on Ramboll's experience from other projects. It is expected that there is more than enough capacity for the project's requirements.

In our simulations, we assume that the capacity of the electric chiller limits how much cooling can be produced. In Appendix 1, a more detailed analysis of technical challenges surrounding seawater cooling is presented.

4. TECHNICAL ANALYSIS

This section outlines the DH&C network dimensions, and for each scenario; scaled production units, estimated investment costs and production distributions. In addition, outputs from our hourly simulation model is included.

The scenarios are structured based on the technologies introduced in the technology catalogue. Fuel Oil boilers are included in all scenarios as back-up/peak heat production, as well as thermal storage for both heating and cooling.

The scenarios assessed are the following:

- Scenario 1: Biomass boiler + electric chiller with dry coolers
- Scenario 2: Biomass boiler + electric chiller with seawater
- Scenario 3: Combined heating and cooling/sewer heat pump + electric chiller with dry coolers
  - (a) Based on treated wastewater
  - (b) based on heat recovered from raw sewage
- Scenario 4: Combined heating and cooling/sewer heat pump + electric chiller with seawater
  - (a) Based on treated wastewater
  - (b) based on heat recovered from raw sewage
- Scenario 5: An organic rankine cycle option based on a biomass supply
  - (a) electric chillers only
  - (b) Absorption chiller and electric chiller

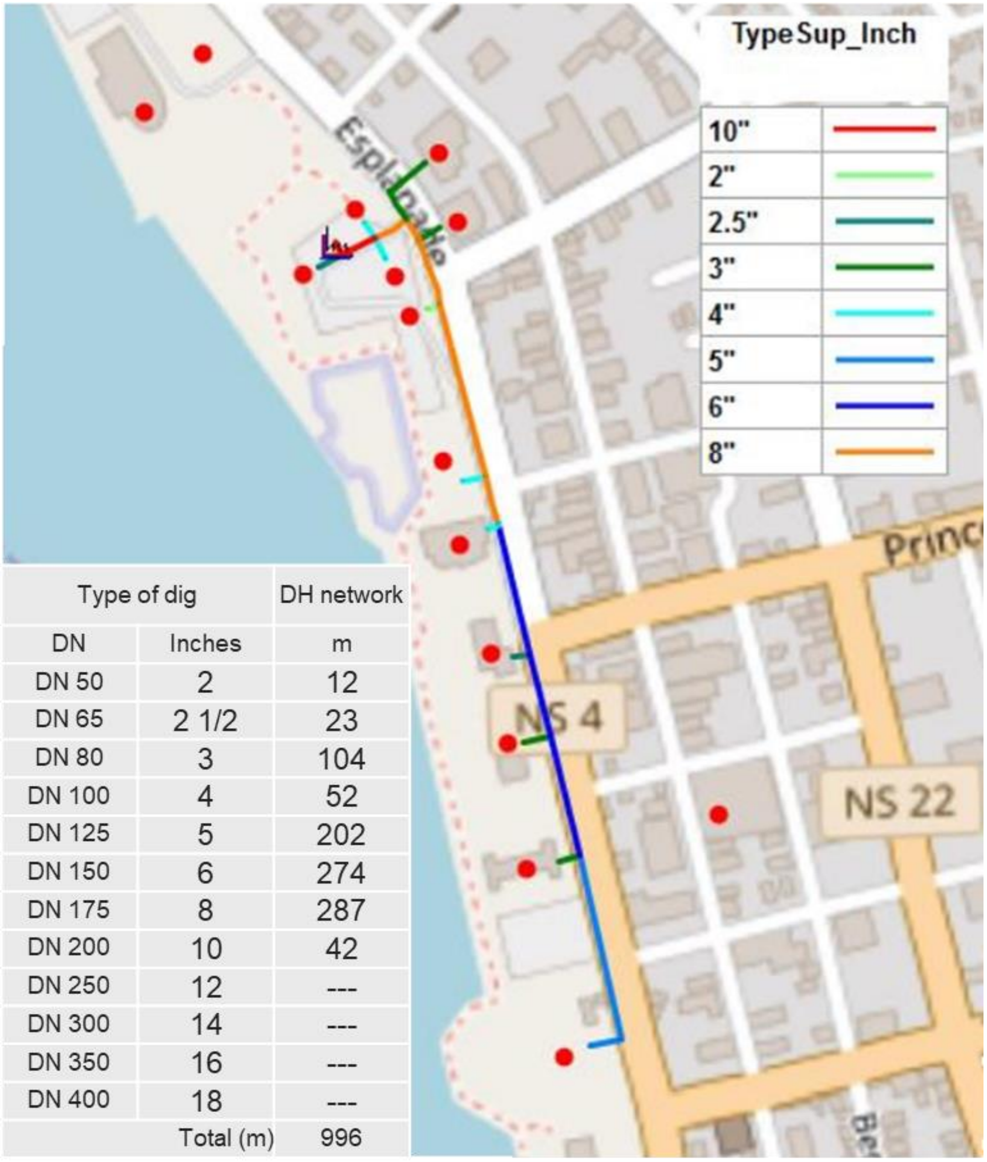
4.1 District heating and cooling networks

The DH&C networks are the same for all scenarios considered. These are shown shown in Figure 4 1 and Figure 4 2.

Pipe sizes were calculated based on the peak energy demand estimated for each building and the assumed temperatures outlined in we have undertaken hydraulic analysis. The results from this analysis are shown in Table 3-1, together with estimated total investment costs in pipes assuming it is a hard dig (tarmac, sidewalks).

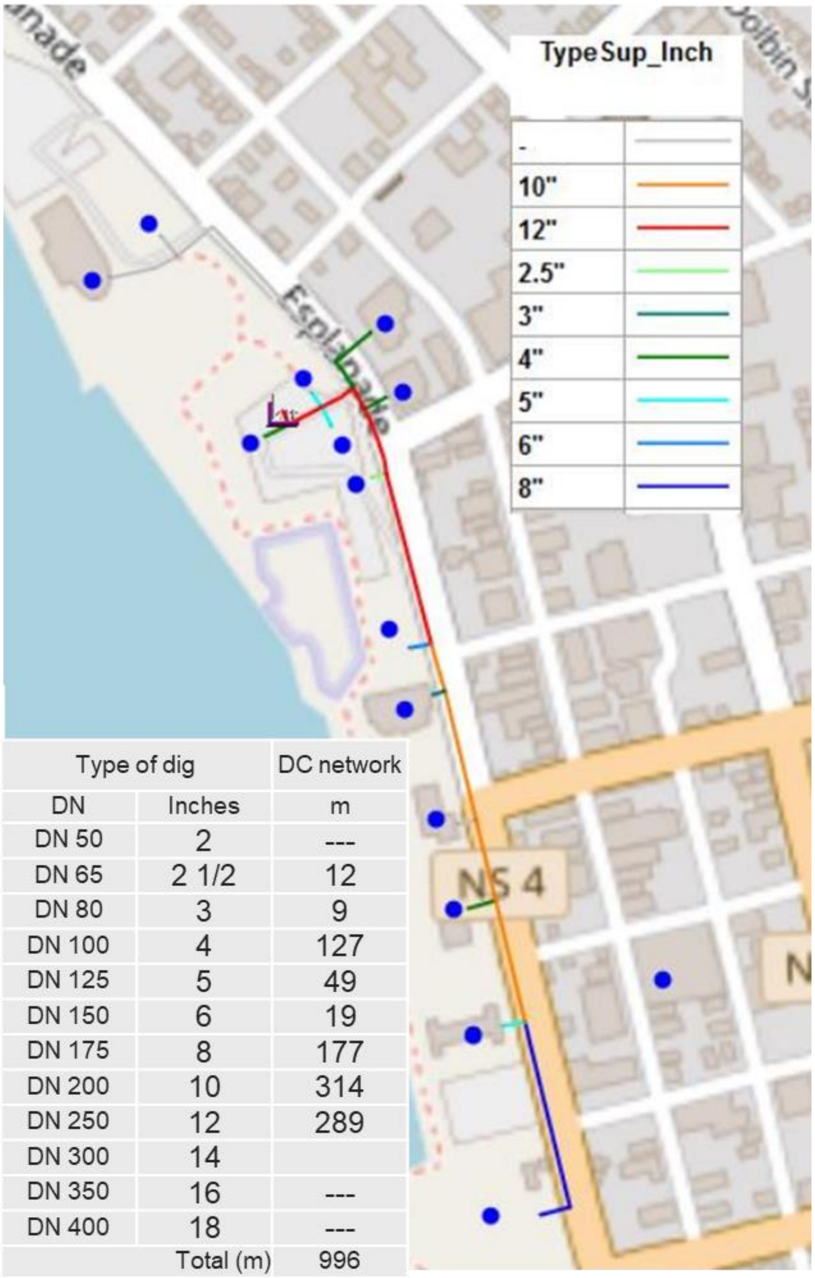
Table 4-1: District heating and cooling networks

Type of dig		DH network	DC network
DN	Inches	m	m
DN 50	2	12	---
DN 65	2 1/2	23.1	---
DN 80	3	203.6	21
DN 100	4	99	28.1
DN 125	5	172	43
DN 150	6	197	253
DN 175	8	242	150.2
DN 200	10	---	197
DN 250	12	---	50
DN 300	14	---	192
DN 350	16	---	---
DN 400	18	---	---
	Total (m)	*934*	*934*
	Total (million$)	*1.0*	*1.40*



Type of dig		DH network
DN	Inches	m
DN 50	2	12
DN 65	2 1/2	23
DN 80	3	104
DN 100	4	52
DN 125	5	202
DN 150	6	274
DN 175	8	287
DN 200	10	42
DN 250	12	---
DN 300	14	---
DN 350	16	---
DN 400	18	---
	Total (m)	996

Table 4-2: District heating network



Type of dig		DC network
DN	Inches	m
DN 50	2	---
DN 65	2 1/2	12
DN 80	3	9
DN 100	4	127
DN 125	5	49
DN 150	6	19
DN 175	8	177
DN 200	10	314
DN 250	12	289
DN 300	14	
DN 350	16	---
DN 400	18	---
	Total (m)	996

Table 4-3: District cooling network

4.2 Energy system simulation

For each scenario we have performed an energy system simulation on an hourly level to find the annual production distribution. Electricity prices in this simulation are assumed fixed, as such the production costs of heat pumps are also fixed. A variable electricity price will result in a more flexible operating profile for renewable energy systems in relation to any renewable energy production and make use of the thermal storages even more profitable.

The temperature of the heat source and district heating network influences the efficiency (COP) of a heat pump. Thus, the marginal cost of a heat pump will change according to the temperature of the heat source. Although, this again will not have any influence on the results, as only one base unit is considered for heating and cooling production in each scenario respectively.

Table 4-4: District heating and cooling production capacity per scenario

	Unit	Scenario 1	Scenario 2	Scenario 3 a&b	Scenario 4a&b	Scenario 5a	Scenario 5b
Biomass boiler	*MW-h*	*3*	*3*	*0*	*0*	*4*	*4*
Organic Rankine Cycle	*MW-h*	*0*	*0*	*0*	*0*	*3*	*3*
Oil boiler	*MW-h*	*5*	*5*	*5*	*5*	*5*	*5*
Heat pump	*MW-h / MW-c*	*0/0*	*0/0*	*3/2*	*3/2*	*0*	*0*
Electric chiller (dry coolers)	*MW-c*	*7*	*0*	*5*	*0*	*7*	*4.3*
Electric chiller (seawater)	*MW-c*	*0*	*7*	*0*	*5*	*0*	*0*
Absorption Chiller	*MW-c*	*0*	*0*	*0*	*0*	*0*	*2.7*

In Table 4-4 the heat production capacities for each unit in each scenario are shown. We have previously seen that enough energy is available in the sewage water for a heat pump. In fact, the sewage heat pump capacity is well below the estimated heat capacity in the sewage water allowing for potential future expansion of the system in the future. Similarly, there is more than enough cooling source capacity in the seawater and air.

The results from the simulations are shown in Table 4-5 as annual production distributions. For the first two scenarios, the production of heating and cooling is not combined. We have selected the capacities of the biomass boiler and heat pump, so these units can supply the entire heat demand as a combined full back up and peaking arrangement. Similarly, the chillers can supply the entire cooling demand, irrespective of whether the cooling source is air or seawater. In the last two scenarios, we combine the heating and cooling production, by a heat pump that produces combined heating and cooling. When the heat pump is not producing cooling, we assume that the sewage can be used as a heat source. Still, much of the heat is produced with sewage heat, and cooling is mainly supplied from the chillers.

Table 4-5: District heating and cooling production per scenario

Plant Energy Production (metric)	Unit	Scenario 1	Scenario 2	Scenario 3a	Scenario 3b	Scenario 4a	Scenario 4b	Scenario 5a (1)	Scenario 5b(1)
Biomass Boiler	*MWh-h*	*11,179*	*11,179*	*0*	*0*	*0*	*0*	15,281	21,570
Oil boiler	*MWh-h*	3649	3649	*1972*	*1972*	*1972*	*1972*	*1690*	*1690*
ORC	*MWh-h*	*0*	*0*	*0*	*0*	*0*	*0*	11,461	16,178
Heat pump (combined heating and cooling)	*MWh-h/*	*0*	*0*	*2,992*	*2,992*	*2,992*	*2,992*	*0*	*0*
	MWh-c	*0*	*0*	*1,995*	*1,995*	*1,995*	*1,995*	*0*	*0*
Heat pump (sewage)	*MWh-h*	*0*	*0*	*8,187*	*8,187*	*8,187*	*8,187*	*0*	*0*
Electric chiller (dry coolers)	*MWh-c*	*8,135*	*0*	*6,140*	*6,140*	*0*	*0*	8,135	3,890
Absorption Chillers	*MWh-c*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*4245*
Electric chiller (seawater)	*MWh-c*	*0*	*8,135*	*0*	*0*	*6,140*	*6,140*	*0*	*0*

(1) Note that the biomass output is used as the ORC input to produce heat and electricity

Table 4-6: Plant Energy Consumption

Energy Consumed		Scenario 1	Scenario 2	Scenario 3a	Scenario 3b	Scenario 4a	Scenario 4b	Scenario 5a	Scenario 5b (1)
Electricity	MWh	*1,799*	*1,799*	*5,349*	*5,349*	*5,349*	*5,349*	*1,049*	*-176*
Natural Gas	m3	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Fuel Oil	l	*463,908*	*463,908*	*250,735*	*250,735*	*250,735*	*250,735*	*214,885*	*214,885*
LR100	l	-	-	-	-	-	-	-	-
Propane	l	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Wood Chips	tonnes	*7,117*	*7,117*	*0*	*0*	*0*	*0*	*10,702*	*16,784*

(1) Scenario 5a and 5b both include for electricity production, as such their electricity consumed values are lower than total electricity consumed and where negative this indicates a positive balance of generation versus consumption.

4.3 Investment cost estimates

For each scenario we have estimated the investment costs per technology in Table 3-7. The investment cost assessment is considered appropriate at this stage for subsequent economic analysis to assess initial feasibility and to select between scenarios.

	Total investment							
Unit	Scenario 1	Sce-nario 2	Sce-nario 3a	Sce-nario 3b	Sce-nario 4a	Sce-nario 4b	Sce-nario 5a	Sce-nario 5b
Building Alterations	$4.08	$4.08	$4.08	$4.08	$4.08	$4.08	$4.08	$4.08
Building Connections	$1.21	$1.21	$1.21	$1.21	$1.21	$1.21	$1.21	$1.21
Heat pump	0.00	0.00	2.40	2.40	2.40	2.40	0.00	0.00
Electric chiller (dry cooler)	2.31	0.00	1.65	1.65	0.00	0.00	2.31	1.42
Electric chiller (sea-water)	0.00	1.96	0.00	0.00	1.40	1.40	0.00	0.00
Absorption Chiller	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84
Oil boiler	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Biomass boiler	3.00	3.00	0.00	0.00	0.00	0.00	4.17	4.17
ORC	0.00	0.00	0.00	0.00	0.00	0.00	2.70	2.70
Energy center build-ing	1.2	1.2	0.8	0.8	0.8	0.8	1.5	1.5
Sewage water heat exchanger	0.00	0.00	0.75	0.00	0.75	0.00	0.00	0.00
Sewage water heat exchanger untreated	0	0	0	3.75	0	3.75	0	0
Seawater intake	0	7	0	0	5	5	0	0
Treated Sewage wa-ter connection	0	0	1.5	0	1.5	0	0	0
Dry coolers	2.1	0	1.5	1.5	0	0	2.1	1.29
Pumps, pipes, elec-tric connections, etc.	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.59
DH network	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
DC network	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38
Heat storage	0	0	0	0	0	0	0	0
Cold storage	0	0	0	0	0	0	0	0
Subtotal	**19.4**	**23.9**	**19.4**	**20.9**	**22.6**	**24.1**	**23.5**	**22.7**
Engineering/De-sign/Permitting 10%	1.9	2.4	1.9	2.1	2.3	2.4	2.4	2.3
Contractor overhead and profit 15%	2.9	3.6	2.9	3.1	3.4	3.6	3.5	3.4
Contingency 15%	2.9	3.6	2.9	3.1	3.4	3.6	3.5	3.4
Total	**27.1**	**33.5**	**27.1**	**29.2**	**31.7**	**33.8**	**33.0**	**31.8**

4.4 Estimated Carbon Impact of Scenarios

For each scenario we have estimated the carbon impact as shown in Table 4-7. These are based on the carbon intensity values set out in Table 3-5. Biomass is considered the lowest carbon fuel, based on the calculation methodologies set out in [3]. As has been noted above more thorough analysis of the biomass market in Cape Breton would be required prior to this project commencing.

Table 4-7: GHG Emissions

Energy Consumed	Units	Scenario 1	Scenario 2	Scenario 3a	Scenario 3b	Scenario 4a	Scenario 4b	Scenario 5a	Scenario 5b
Electricity	tonnes	*1468*	*1468*	*3797*	*3797*	*3797*	*3797*	*976*	*146*
Natural Gas	tonnes	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Fuel Oil	Tonnes	*1277*	*1277*	*690*	*690*	*690*	*690*	*592*	*427*
LR100	Tonnes	-	-	-	-	-	-	-	-
Propane	Tonnes	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Wood Chips	tonnes	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Total		**2745**	**2745**	**4487**	**4487**	**4487**	**4487**	**1567**	**572**

4.5 Operation and Maintenance Costs

Annual fuel costs are shown in Table 4-8 below based on estimated annual fuel and electricity consumption and costs outlined in Table 3-3 and Table 3-4.

Table 4-8: Annual Fuel Costs

Energy Cost	Units	Scenario 1	Scenario 2	Scenario 3a&b	Scenario 4a&b	Scenario 5a	Scenario 5b
Electricity	$	*272,262*	*272,262*	*704,338*	*704,338*	*180,987*	*27,082*
Natural Gas	$	*0*	*0*	*0*	*0*	*0*	*0*
Fuel Oil	$	*487,103*	*487,103*	*263,272*	*263,272*	*225,629*	*162,670*
LR100	$	-	-	-	-	-	-
Propane	$	*0*	*0*	*0*	*0*	*0*	*0*
Wood Chips	$	*604,945*	*604,945*	*0*	*0*	*826,940*	*1,296,955*
Total	$	***1,364,310***	***1,364,310***	***967,610***	***967,610***	***1,233,556***	***1,486,707***

Where electricity costs are negative this represents the balance of electricity consumed and produced per scenario.

Marginal operation and maintenance costs are outlined below for plant based on annual operating hours. Nominal costs have been included for the oil boiler plant.

Table 4-9: Marginal Operation and Maintenance Costs per Annum

Technology	Value	Units	Scenario 1	Scenario 2	Scenario 3a	Scenario 3b	Scenario 4a	Scenario 4b	Scenario 5a	Scenario 5b
Biomass boiler	10	$/MWh-h	111,790	111,790	0	0	0	0	152,813	215,702
Oil boiler	2	$/MWh-h	7,298	7,298	3,945	3,945	3,945	3,945	3,381	2,437
ORC	3	$/MWh	0	0	0	0	0	0	34,383	48,533
Heat pump (combined heating and cooling)	5	$/MWh-c	0	0	14,960	14,960	14,960	14,960	14,960	14,960
Heat pump (sewage)	5	$/MWh-h	0	0	40,935	40935	40935	40,935	0	0
Electric chiller (dry coolers)	5	$/MWh-c	40,676	0	30,701	30,701	0	0	40,676	19,451
Electric chiller (seawater)	5	$/MWh-c	0	40,676	0	0	30,701	30700.54	0	0
Absorption Chiller	5	$/MWh-c	0	0	0	0	0	0	0	21,225
Heating Network	0.75%	of capital investment	7,492	7,492	7,492	7,492	7,492	7,492	7,492	7,492
Cooling Network	0.75%	of capital investment	10,365	10,365	10365	10,365	10,365	10,365	10,365	10,365
Total ($/year)			**177,621**	**177,621**	**108,398**	**108,398**	**108,398**	**108,398**	**264,070**	**340,165**

5. ECONOMIC ASSESSMENT

All estimates of internal rate of return are preliminary, based on information available at this time, and subject to significant variation as the design progresses.

5.1 Assumptions

The economic assessment undertaken as part of this project is based on the following assumptions:

- EBIDTA (Earnings before interest, depreciation, taxation and amortisation).
- Capital costs presented here are considered to be accurate to +/- 30% based on available information and level of technical assessment
- Inflation is included at 2% per annum
- Energy price escalations are included as follows:
  - Electricity: 4% per annum
  - Fuel Oil: 2% per annum
  - Wood Chips: 1% per annum
  - Inflation is assumed included in energy price escalation
- NPV values presented here are considered real, pre-tax values.
- Unmanned district heating plant with local contractors responsible for maintenance
- The impact of the cap and trade system in Nova Scotia is reflected in the fuel prices for the plants based on published energy price impacts to 2022. These increases are maintained year on year beyond 2022 in the absence of more accurate information.
- The base case for all scenarios is the provision of both heating and cooling.
- The project lifetime is assumed to be 30 years.
- Grid decarbonisation is not included in the base case, the impact is presented as a sensitivity.
- Customer business as usual fuel costs and carbon tax impacts are assumed to remain constant, customer savings of 20% are applied to annual fixed and standing charges based on an assessment of customer savings.
- Reinvestment costs for the district energy system are assumed to be zero over the project 30-year lifetime. Ongoing operation and maintenance costs are included.
- Staffing costs are assumed to be $200,000 per annum.

5.2 Business as Usual

Each building has been assessed to determine the avoided fuel, operation and maintenance and capital costs for each customer.

As limited information is available for the harbour development and the New College, assumptions have been made regarding their alternative heating and cooling systems.

For new buildings central boilers based on fuel oil are assumed to provide the majority of heating and domestic hot water, rooftop chiller units are assumed as the central cooling plant.

- Plant efficiency of 80% for fuel oil boilers
- COP of 2.8 for chiller plant.
- A reinvestment cycle of 20 years
- Energy price escalations and carbon tax are included as per the district heating scenarios.

Table 5-1: Avoided Cost Assessment

Building	Fuel Costs Heating	Fuel Costs Cooling	O&M Costs Heating	O&M Costs Cooling	Capital Cost Heating	Capital Cost Cooling	Capital Cost AHUs	Total Capital	Comments
	$/annum	$/an-num	$/an-num	$/an-num	$	$	$	$	Basis
Sydney Justice Centre	31,202	27,226	18,688	20,174	69,600	167,700	303,542	540,842	*130ton chiller, baseboard heating, 3 No. AHUs (costed based on cfm)*
Commerce Tower	28,802	22,688	14,375	19,728	42,000		199,600	241,600	*baseboard heating, 3 No. AHUs (costed based on cfm)*
Holiday Inn	166,761	9,945	23,638	18,477	112,320	90,675	59,880	262,875	*PTAC and electric heat backup costs not in-cluded, replace 4x800MBH boilers, 1x155cooling tower and 12000cfm HRV unit*
Vista Heights	50,752	-	8,557	17,500	17,550	-		17,550	*Electric Baseboard heating replacement costs not included/replacement of easily accessible load only*
CBRM Civic Centre	29,808	21,132	14,877	19,575	18,500	167,700	305,762	491,962	*Replace 130 ton of chiller capacity and elec-tric baseboard heating, replacement costs for AHUs included, cost for electric perimeter heating unclear*
Cambridge Suites	134,590	57,288	22,693	23,126	257,072	245,100	117,265	619,437	*Replacement of boiler and chiller costs & AHU replacement costs included*
Casino & Hotel Tower	197,040	56,793	37,433	44,749	300,131	637,611	-	937,742	*Based on peak loads in an n+1 configuration*
Residential Apart-ment Tower	149,262	43,022	32,600	38,141	227,356	483,004	-	710,360	*Based on peak loads in an n+1 configuration*
Marine Interpretive Recreation Centre	31,387	9,047	20,675	21,840	47,809	101,566	-	149,375	*Based on peak loads in an n+1 configuration*
Regional Library	66,026	19,031	24,179	26,631	100,571	213,656	-	314,227	*Based on peak loads in an n+1 configuration*
Commercial Office Space	130,604	37,644	30,712	35,561	198,937	422,629	-	621,565	*Based on peak loads in an n+1 configuration*
New College	411,517	118,612	59,130	74,409	626,823	1,331,64 8	-	1,958,470	*Based on peak loads in an n+1 configuration*

The CBRM building is due to undergo upgrades to the existing HVAC system in the near future due to the existing systems reaching the end of their useful life. The report produced for CBRM estimates that the HVAC upgrades would cost $510,000 for an all electric replacement ranging up to $2,300,000 for water source heat pumps with fan coil units. However, it is noted in the report that the cheaper option will result in no improvements to thermal comfort and system efficiency in the building. A mid-range option of installing boilers and chillers in the building which could improve thermal comfort and system efficiency was estimated to cost $1,100,000.

The estimated cost for conversion of the CBRM building to connect to the district energy system are $1,770,000.

The ongoing fuel costs for the CBRM building under the cheapest conversion option are $53,900, under the district energy scenario this would be reduced to approximately $51,000.

5.3 Summary of Results

In all cases outlined below building conversion costs are assumed to be paid for by external grant funding as the burden of covering these costs greatly reduces economic benefits of the project. The discount rate utilized to assess the project NPV was 9%[1].

Table 5-2: Summary of Results

Project Outcomes	Units	Scenario 1	Scenario 2	Scenario 3a	Scenario 3b	Scenario 4a	Scenario 4b	Scenario 5a	Scenario 5b
IRR[2]	%	7.0%	4.5%	9.0%	8.5%	6.9%	6.5%	5.9%	3.5%
NPV	000 $	-$4,081	-$12,029	$42	-$1,093	-$5,634	-$6,770	-$7,858	-$12,399
Emissions reductions	t/annum	3,296	3,296	1,553	1,553	1,553	1,553	4,473	5,486

Economically the scenario which has the highest value is Scenario 3a based on sewer heat recovery from the treated water at the Battery Point Wastewater Treatment Plant.

This project achieves an unlevered IRR of 9%, which is generally consistent with rate regulated utility returns; however, given the nature and risk profile of a new development project without guaranteed revenue base, significantly greater returns would be required to make this project feasible.
A 1km connection from Battery Point to the district energy plant located at the waterfront development is included in the economic analysis.

For Scenario 3a the energy centre footprint would be approximately 400m^2 at the indicative library location. Additional space would be required at the wastewater treatment plant for heat exchangers and pumping equipment.

The equipment to be housed in the energy centre includes:

- 1400-ton chillers (3 chillers total)
- 10,240MBH [3MW$_{th}$]heat recovery chiller
- 17,060 MBH fuel oil boilers (3 boilers total)
- Network distribution pumps
- Pressurisation unit

[1] This rate was selected based on an IRR which would be considered consistent with the target for a rate regulated utility.

- Water Treatment equipment
- Buffer tank
- Dirt and Air Separator
- Network heat exchangers.

It is assumed that there is available space for a heat exchanger installation at Battery Point.

The following loads are excluded from Connection:

- Joan Harris Cruise Pavilion - low load and distance from the central plant
- Sydney GOCB – low load and distance from the central plant
- YMCA – low load and distance from the network
- Centre 200 – lack of load

The new College has been included in this analysis based on the very high-level information available.

Based on the above assumptions Scenario 3a achieves lifetime CO2 emissions reductions of 46,604 tonnes, or 1,553 tonnes per annum. When grid decarbonisation is included, the project economics remain stable, total lifetime CO2 emissions further reduce to 69,995 tonnes over 30 years and 1,629 tonnes per annum.

The following factors have the largest impact on project IRR:

(1) Energy price escalation: A reduction in electricity price escalation from 4% to 2% reduces the project IRR to 8.5%.
(2) Increasing initial capital costs by 20% will reduce the project IRR to 8%.
(3) Inclusion of building conversion costs will reduce the IRR to 7.4%.
(4) Network costs have a minimal impact on the overall economic assessment.
(5) A cooling only project would have a reduced IRR of 9.5% but with a greatly reduced capital outlay of $12.3 million compared to $21.4million for a combined system.

Scenario 1, a biomass boiler option is the second best performing independent option for the energy network with an IRR of 7%. In order to achieve the same IRR as Scenario 3a (sewer heat recovery), a biomass cost of $38/ton biomass would be required.

If the biomass option is selected for further investigation a plant footprint of 600m_2 could be expected.

The analysis outlined above is based on the project being built out in a single year in order to assess the best-case scenario for the project. Once the preferred scenario was identified an additional assessment was carried out based on a phased build out of the project.

5.4 Scenario 3a Economic Assessment Based on Phased Build Out

To assess a realistic timeframe for the preferred scenario the following assumptions were made:

Table 5-3: Connection Year for Scenario 3a Buildings

Building	Year Connected	
Justice Centre	*2,022*	*Phase 2*
Commerce Tower	*2,022*	*Phase 2*
Holiday Inn Sydney Waterfront	*2,023*	*Phase 3*
Vista Heights	*2,023*	*Phase 3*
CBRM Civic centre	*2,023*	*Phase 3*
Cambridge Suites	*2,023*	*Phase 3*
Casino & Hotel Tower	*2,027*	*Phase 6*
Residential Apartment Tower	*2,021*	*Phase 1*
Marine Interpretive Recreation Centre	*2,025*	*Phase 5*
Regional Library	*2,021*	*Phase 1*
Commercial Office Space	*2,023*	*Phase 3*
New College	*2,024*	*Phase 4*

Capital Costs were incurred on a staggered basis with investment for major plant and equipment accounted for in the year previous to commissioning.

Capital costs which are phased over time include for inflation. The initial investment in the plant is for oil boilers and chillers sized for Phase 1.

This initial plant is assumed to be installed in the new Regional library. The initial space required would be 150 – 200 m^2 to accommodate the boilers, chillers, pumping equipment.

By sizing the initial plant for connections in the first two years this allows the first phase of the network to be developed without the large capital outlay required for the primary plant (sewer heat recovery and infrastructure). This reduces the risk profile of the initial capital investment and allows time for critical conversion work to be completed.

Table 5-4: Phased Capital Cost

Scenario 3a	Unit	2020	2021	2022	2023	2024	2025	2026
Building Alterations	$	$0	$0	$0	$0	$0	$0	$0
Building Connections	$	$206,984	$192,888	$462,308	$146,300	$77,480	$0	$121,968
Heat pump	$	0	0	$2,400,000	$0	$0	$0	$0
Electric chiller (dry cooler)	$	$694,347	0	0	$414,882			$991,085
Oil boiler	$	$176,853			$122,861			$122,030
Energy center building	$			$800,000				
Sewage water heat exchanger	$	0		$1,050,000				
Treated Sewage water connection	$	0		$1,500,000				
Dry coolers	$	$631,224			$377,166			$900,986
Pumps, pipes, electric connections, etc.	$	$968,153			$621,457			$1,055,896
DH network	$	$40,738	$111,762	$740,430	$214,524	$6,582	$0	$11,674
DC network	$	$47,952	$138,255	$868,486	$263,408	$7,413	$0	$15,899
Subtotal		**$2,766,251**	**$451,763**	**$7,526,003**	**$2,292,844**	**$321,022**	**$0**	**$4,056,328**
Engineering/Design/Permitting	*10%*	$276,625	$45,176	$752,600	$229,284	$32,102	$0	$405,632
Contractor overhead and profit	*13%*	$345,781	$56,470	$940,750	$286,605	$40,127	$0	$507,040
Contingency	*15%*	$414,937	$67,764	$1,128,900	$343,926	$48,153	$0	$608,449
Total Capital Cost		**$3,803,595**	**$621,174**	**$10,348,254**	**$3,152,661**	**$441,405**	**$0**	**$5,577,450**

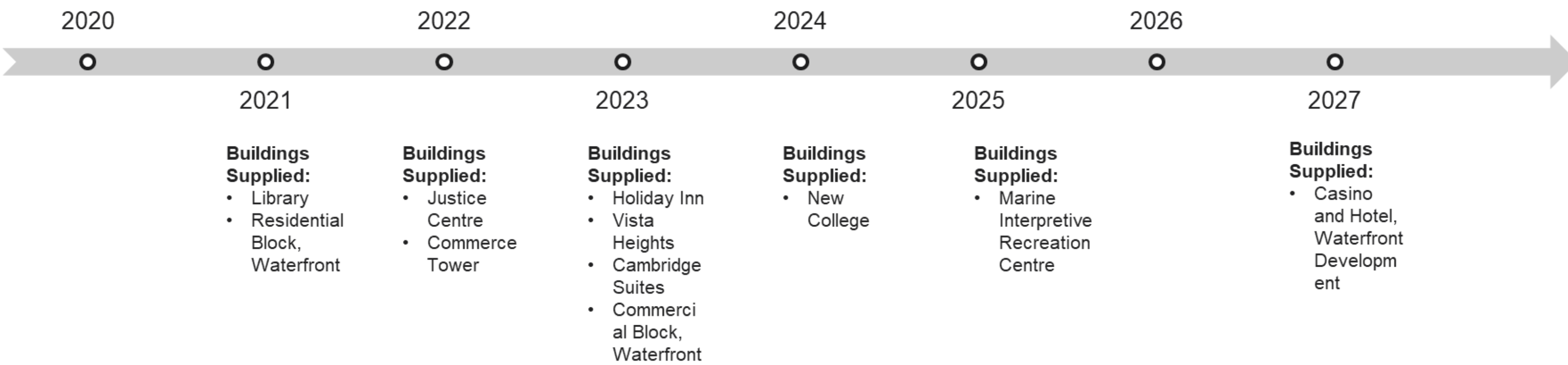


Figure 5-1: Phased Connections

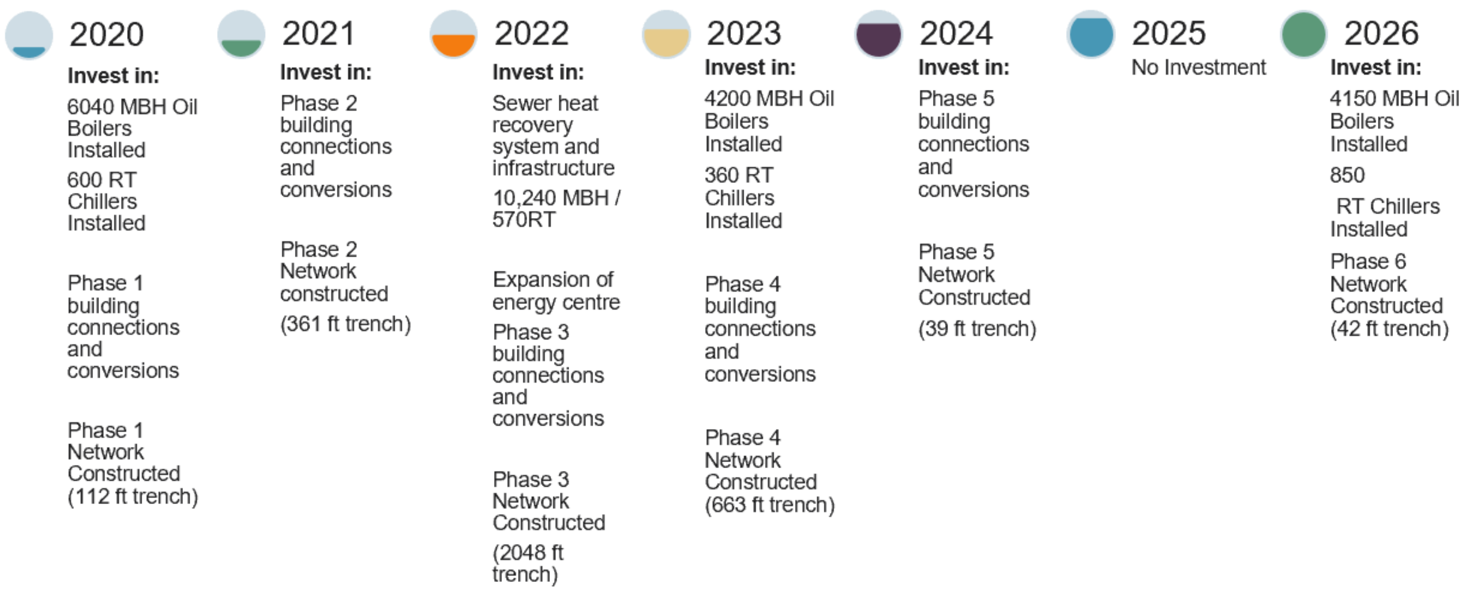


Figure 5-2: Phased Investment

The impact on the project outcomes would be as follows:

Table 5-5: Impact on Project Results

Metric	Scenario 3a	Scenario 3a (Phased)
Pre-Tax IRR, %	9.0%	7.3%
NPV $	$42,000	-$2,660,000
Emissions Reductions, tCO_2e/year	1,553	1,324 (average)
Emissions Reduction, %	26%	24%

As can be seen phasing the implementation of the project reduces the IRR to 7.3% and reduces the average annual carbon emissions savings.

6. CONCLUSIONS

Based on the initial economic assessment there appears to be an opportunity for district energy in Sydney if incentive funding for reducing GHG emissions and energy use can be secured to support the project. There are a number of sensitivities and optimisations that could further improve the economic outlook for Sydney.

The following assumptions need to be true in order to achieve the project outcomes for Scenario 3a.

Buildings outlined in

- Table 2-3 connect to the district system as noted.
- Energy Centre integrated with a new building.
- Funding secured for building conversion costs.

Heating and cooling demand as per

- Table 2-3.
- Assumptions regarding avoided costs for customers as outlined in Table 5-1 agreed with customers.
- 15% savings on fixed costs to customers
- WWTP Temperatures and Flows as per assumptions outlined in Appendix 2.
- 4% electricity escalation rate
- Project development costs at 38%

For the project to be viable, it is likely that funding in the range of approximately $4 million to $5.4 million would be required in addition to the $4.1million needed for building conversion costs.

Sewer heat recovery is an attractive option for this project and makes sense in the context of this project. A sewer heat recovery project utilising waste heat from the local wastewater treatment plant could be incorporated into the planned developments in Sydney in a more straightforward fashion than a biomass boiler plant where plant location, permissions and acceptance in the downtown location may prove more difficult in this case.

For Scenario 3a the energy centre footprint would be approximately 400m^2 at the indicative library location. Additional space would be required at the wastewater treatment plant for heat exchangers and pumping equipment.

The equipment to be housed in the energy centre includes:

- 1400-ton chillers (3 chillers total)
- 10,240MBH [3MW$_{th}$]heat recovery chiller
- 17,060 MBH fuel oil boilers (3 boilers total)
- Network distribution pumps
- Pressurisation unit
- Water Treatment equipment
- Buffer tank
- Dirt and Air Separator
- Network heat exchangers.

If the biomass option is selected for further investigation a plant footprint of 600m_2 could be expected.

Next steps for the project would be for locally based project champions to work to de-risk the project commercially and technically.

The commercial steps should be addressed first.

Commercial

- Sign up buildings to a letter of intent, this would be a non-binding agreement which would demonstrate to potential network developers that there is appetite for the project and a willingness to participate on behalf of the building owners.
- Agree on value proposition with building owners – this process will begin with approaching building owners and developers to continue previous discussions.
- Agree on development schedule for new building developments
- Building owners should be presented with the assumed avoided costs outlined in Table 5-1 to begin discussions. This portion of the work may take some time as it will be important to work with building owners to uncover the true cost of owning, operating and maintaining their HVAC systems in order to build an attractive business case per building.
- Secure grants and/or incentive funding from such sources as the Green Municipal Fund, Green Infrastructure Fund, the Nova Scotia Green Fund, Atlantic Canada Opportunities Agency, or others.

Technical due diligence should be undertaken once there is more certainty regarding the commercial proposition.

Technical

- Confirm energy centre location with CBRM stakeholders and local developers; this has been assumed as the regional library but would be subject to the timeline for developments and the appetite of building owners to incorporate a district energy centre with their building.
- Conduct a detailed engineering study on integrating heat exchangers at Battery Point Wastewater Treatment Plant to confirm the technical feasibility (including space availability) and indicative costs of the proposals.
- Monitor flow and temperature of treated water to confirm calculated capacities
- Meter building heating and cooling use to confirm demand projections and operating temperatures
- Schematic Design of overall project
- Reassessment of costs based on schematic and detailed design
- Confirmation of project economic viability

The level of detail for the cost breakdown for each scenario is high level, these are based on available information and costs will change as the design progresses. We believe that the values used in this report are appropriate for the stage of analysis of the project.

7. REFERENCES

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[5] https://www.nspower.ca/en/home/about-us/environmental-commitment/air-emissions-reporting/total-system-emissions-all-plants.aspx

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https://novascotia.ca/just/regulations/regs/envqrv.htm

Appendix 1 – Seawater cooling

Using seawater as a cooling source is a possibility, when the energy center is located in Sydney Harbour. The upside is less noise, when compared to dry coolers, where air is used as the cooling source. We went through the *Review of the physical oceanography of Sydney Harbour* [4] but found that the data on temperature profiles in the seawater were not detailed or specific enough to draw specific conclusions. If this option is selected for bringing forward to more detailed assessment measurements and monitoring will be required in the harbour to establish design conditions.

Of practical problems related to the utilization of seawater in a pumping system, we can mention; microbiological growth in pipes – including algal growth, mussel growth (some can be the size of a fist) and barnacles' growth. The following is a list of solutions that can be considered individually or in combination.

- Differential pressure measurement can be established and monitored in the SCADA system, so actions can be taken before the filter is clogged.
- Redundancy on filters, so the capacity is not reduced during filter cleaning.
- There are filter systems available that automatically back washes, when the differential pressure becomes too high. This in turn reduces the need for service on the filters.
- Dive pumps can be fitted with cutter wheels at the water inlets.
- Plastic pipes with low roughness can be used at the water inlets to minimize mussel growth (bio-growth in general).
- High flow rates in the pipes can be used to minimize mussel growth in the pipes.
- A back-wash solution could be established to protect against mussel growth in pipes and exchangers. A possibility could be a Bernoulli filter.
- A CIP (cleaning in place) solution could minimize possible problems with deposits. This is applicable to pipes and exchangers in direct contact with these.

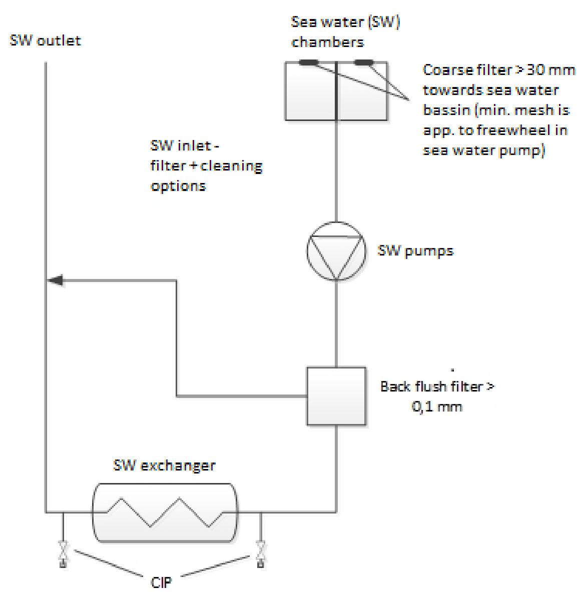


Figure A-1: Coarse filter in seawater basin

A simple seawater intake filtering system is sketched on Figure A-1. The filtering process ensures that fish, mussels, etc. can not pass into the seawater exchanger. Also, a constant monitoring of the exchanger is ensured using the CIP plant. However, a plant specifically designed for Sydney Harbour is of course necessary. One more thing that we must take into consideration is the risk of ice formation. This influences where the water intake can be located in terms of depth.

Appendix 2 – Sewage water heating

Sewage heat is a useful heat source for a heat pump, with data shown in Table 5-1. A comprehensive study of available sewage water collection points in and around Sydney Harbour can be found in the attached Power Point presentation.

It will be an advantage to have the sewage water heat recovery infrastructure located in segment 3 or 4 close to the energy center. Because the temperature of the sewage water is varying over the year, the heat capacity will also vary. The same will likely be true for a district heating system, where the inlet temperature can be reduced during the summer period. Thus, the COP of the heat pump will be higher during the summer than winter period.

We are assuming for Scenario 3a that we can use treated sewage water from the outlet of the sewage water treatment plant, as visualized on Figure 5-2, it may still contain micro organisms that can block a heat exchanger. Therefore, a filtering plant is necessary, just like that presented for the seawater intake. On Figure 5-2 it is also shown how a heat pump can use both the district cooling system and sewage water as heat source.

For Scenario 3b it is assumed that heat will be extracted from raw sewage in the town centre using a packaged energy recovery solution.

Table A-1: Sewage heat source

	Value
Flow	*22.56 m^3/min*
Temperature (winter and summer)	*10-20 ^oC*

The amount of heat that can be extracted from the sewage can be calculated based on the flow and a temperature drop. We assume that the temperature of the heat source is always reduced to 4 ^oC. The reason being, that by reducing the temperature any lower, there will be a risk of ice formation. This may destroy the shell/tube heat exchanger, which is the usual type of heat exchanger in an evaporator. Alternatively, another heat exchanger can be selected.

$$1000\frac{kg}{m^3}\cdot 4.18\frac{kJ}{kg\cdot K}\cdot\left(22.56\frac{m^3}{min}\Big/60\right)\cdot(10-4)\,K\cdot 10^{-3}\approx 9.4\,MW$$

We then use an average heat pump COP of 3 to calculate the heat capacity.

$$\frac{9.4\,MW}{3-1}\cdot 3\approx 14\,MW$$

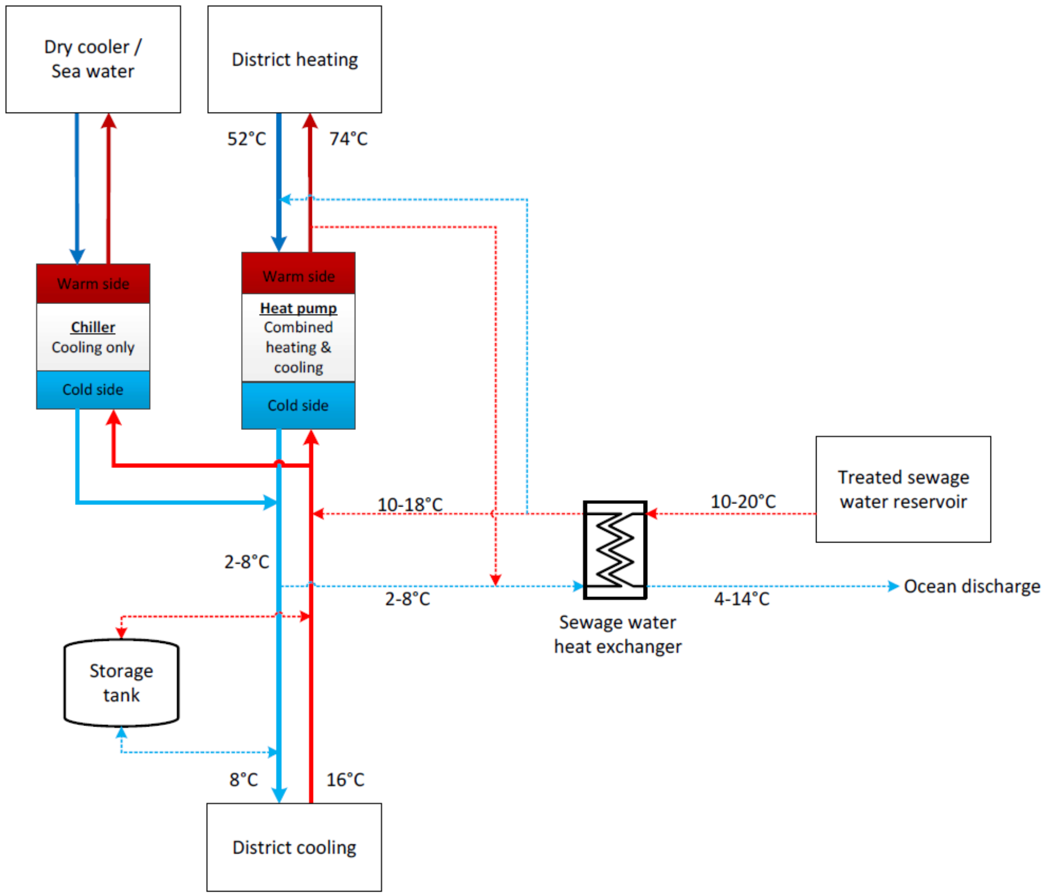


Figure A-2: Sewage water and district cooling concept

Appendix 3 – Building Reports

F.C. O'Neill, Scriven
& Assoc's Limited
Consulting Engineers

CBRM District Energy System
Phase 1 Screening Assessment
Former DFO Building

Building and Systems Description

This building was constructed in the late 1970's as a Federal Government Department of Fisheries Administration and Laboratory building. The building is three storeys with building areas as follows:

1. Basement: 5,400sqft
2. Main Floor: 5,400 sqft
3. Second Floor: 5,400 sqft

Currently the building is undergoing renovations to accommodate its use as a multi-tenant office building. To provide for upgrades in an economical manner the existing ventilation systems on the Main and Second Floors have been completely demolished brand new ventilation distribution connected to packaged rooftop heat pumps will be installed. This system has not yet been sized nor new RTU's selected. The ventilation system in the Basement, which is limited, will remain although it is currently not operating.

The heating plant for the original building design consisted of:

1. Two oil fired boilers each with a connected load of approximately 2,830 MBH. This is a higher load than would typically be expected for a building of this size. However in its original configuration a load of 1,750 MBH was provided for laboratory ventilation systems.
2. The oil fired boilers are currently operational and connected to a distribution system that provides heating water to perimeter radiation and duct mounted hot water coils. Since all of the ventilation system on the Main and Second Floor is being demolished and the limited ventilation system on the Basement Floor is all that will remain, the heating plant load associated with the heating coils is no longer relevant.

Scope of Upgrades Necessary for Integration into the District Energy System

Given the status of the building the opportunity to integrate this buildings HVAC system into a district energy system is very good. However at this juncture renovations planned for the Main and Second Floor, it may be that the only reasonable future upgrades are to tie the existing heating distribution into the district energy system. What is unclear is what form this tie-in should take. If for example the Owner wants to abandon the existing boilers in lieu of using roof mounted heat pumps, then potential for district energy integration could be limited. If on the other hand the Owner is interested in maximizing the potential benefits of district energy integration, the possibilities are many.

Integration Probable Conversion Cost Considerations

At this juncture the further discussion is required on varying approaches to the options for district energy system integration.

CBRM District Energy System
Phase 1 & 2 Screening Assessment
Sydney Justice Centre – 136 Charlotte Street

Building and Systems Description

This building was constructed in the late 1980's as a six storey office building. In 1999 the building was fully renovated into the new Sydney Justice Centre, including courtrooms, solicitor offices, judge's chambers, holding cells, and support space. Each floor is nominally 11,600 square feet.

The building is served by:

1. Ventilation System #1, which serves the north and east portion of the top five floors consists of a supply fan, cooling coil, electric heating coil and return fan, all ducted together to create the system. This system has nominal capacities as follows:
    a. Nominal Airflow: 27,215 cfm complete with one 20HP supply fan and one 15HP return fan.
    b. Nominal Heating Capacity: 100kW via an electric heating coil in the AHU.
    c. Nominal Cooling Capacity: 65 tons representing 1/2 of the total building capacity.
2. Ventilation System #2, which serves the south and west portion of the top five floors consists of a supply fan, cooling coil, electric heating coil and return fan, all ducted together to create the system. This system has nominal capacities as follows:
    a. Nominal Airflow: 27,215 cfm complete with one 20HP supply fan and one 15HP return fan.
    b. Nominal Heating Capacity: 85kW via an electric heating coil in the AHU.
    c. Nominal Cooling Capacity: 65 tons representing 1/2 of the total building cooling capacity.
3. AHU-3, which is a built-up air handler serves the Lower Level. This unit was added in the 1999 renovations and consists of the following:
    a. Nominal Airflow: 6,400 cfm with complete with one 10hp supply fan and one 3hp return fan.
    b. Nominal Heating Capacity: 20kW via an electric heating coil in the AHU.
    c. Cooling capacity fed from the existing chiller via a new chilled water piping loop.
4. A 130 ton rooftop air cooled chiller completed with chilled water distribution system for air handler coils. This distribution loop is fed by (2) 7.5Hp pumps with a capacity of 345gpm.
5. In the heating season the outside air dampers on each of Ventilation System #1 & #2 and AHU-3 are modulated to minimum position, and the outside air is mixed with return air that is tempered to 55^{0}F by the electric heaters for delivery to the building. In cooling season the mixing valve on the chilled water coil is modulated to maintain a 55^{0}F supply air temperature, and free cooling is achieved through modulation of the outside and exhaust air dampers depending upon outside air temperature conditions.
6. Throughout all floors there is perimeter electric baseboard heat. The ducted distribution system is complete with VAV boxes for zone control. Where a VAV zone serves an area with perimeter baseboard heat, the heaters are interlocked with the VAV boxes. For the interior zones there are also duct mounted reheat coils with each VAV box.

Building Energy Consumption Information

We were not able to obtain specific energy consumption information for this building. However we can make the following observations:

1. This building was constructed at the same time as Commerce Tower by the same developer;
2. Building occupancy loads are similar, although slightly different, since there are court facilities in the building. These spaces do not operate during the conventional 9am to 5pm business day, however most other supporting spaces do operate during typical business hours;
3. Nominal system capacities seem to be in the 20% to 30% larger range; and
4. This building uses a chiller for cooling, which is typically more economical than packaged DX cooling systems, which are present at Commerce Tower.

Based on this we have assumed that the loads for this building are:

1. 30% higher during the heating season; and
2. 20% higher during the cooling season.

Therefore a rough approximation of heating and cooling loads are:

1. 979,430 Btu/hr during the heating season; and
2. 524,294 Btu/hr during the cooling season

Scope of Upgrades Necessary for Integration into the District Energy System
The existing HVAC system is centralised in nature with primary heating and cooling coming from the air system. As a result, an easy way to integrate the existing building into the district energy system is through the addition of heating and cooling coils in each AHU thereby eliminating the need for the large electric heaters and chiller. This scope of work would include:

1. Removal of the existing electric heaters in each of the three ventilation systems;
2. Supply and installation of a new 1,000,000 Btu/hr heating only heat exchanger for connection to the district energy system;
3. Supply and installation of new source and load side circulators;
4. Supply and installation of new hot water and chilled water distribution piping from the new heat exchangers to the HVAC system in the penthouse on the top floor; and
5. Supply and installation of a new control system for this upgraded HVAC plant.

In this arrangement the existing baseboard heat and duct mounted zone re-heat coils would remain for back-up during the coldest part of the winter and for local zone control. The existing control system which is pneumatic, would not be changed, except that the parts that control the existing supply, return, cooling and heating for the ventilation system would be replaced by the new control system.

The new heating coils could be designed around 140^0F EWT and the cooling coils around 45^0F EWT.

Integration Probable Conversion Cost Considerations
With respect to these integration upgrades, a high level (±30%) opinion of probable construction costs is $440,000. It should be noted that this cost will reflect the value to offset the 100% of the total cooling load and 80% of the total heating load. The remaining 20% of the heating load will be assumed to be for electric baseboard heat and zone reheat coils during the coldest part of the winter.

CBRM District Energy System
Phase 1 & 2 Screening Assessment
Commerce Tower – 15 Dorchester

Building and Systems Description

This building was constructed in the late 1980's as a six storey office building. Since the original construction the building has experienced numerous interior renovations to accommodate new tenant requirements. However, these renovations have not changed the base building systems, which consist of the following:

1. A packaged roof-top air conditioning unit (AHU-1) that serves the north and east portion of the top five floors with the following capacity:
    a. Nominal Airflow: 20,000 cfm complete with one 25HP supply fan and one 15HP return fan.
    b. Nominal Heating Capacity: there is no electric heater in the AHU.
    c. Nominal Cooling Capacity: 55 ton DX cooling capacity built into the roof-top unit.
2. A separate packaged roof-top air conditioner (AHU-2) serves the south and west portion of the top five floors with the following capacity:
    a. Nominal Airflow: 20,000 cfm complete with one 25HP supply fan and one 15HP return fan.
    b. Nominal Heating Capacity: there is no electric heating coil in the AHU.
    c. Nominal Cooling Capacity: 55 ton DX cooling capacity built into the roof-top unit.
3. In the heating season the outside air dampers on each AHU are modulated as required maintain a supply air temperature from each AHU of 70^0F. In DX cooling system ensures delivery of air to the building at 55^0F.
4. Throughout all floors there is perimeter electric baseboard heat. The ducted distribution system is complete with VAV boxes for zone control. Where a VAV zone serves an area with perimeter baseboard heat, the heaters are interlocked with the VAV boxes.

This building contains banking and government tenants with general operating hours from 8:30am until 5pm Monday through Friday. Certain times of the year there is shift work associated with some of the government offices, but this is limited.

Building Energy Consumption Information

We have obtained annual electrical bills from the Owner for this building, with a summary of the consumption noted in the table below.

Summary of Annual Energy Consumption for 2015/2016

Month	Electrical Consumption (kWhr)[1]
January 2016	149,200
February 2016	144,400
March 2015	151,200
April 2015	125,600
May 2015	99,200
June 2015	120,000
July 2015	123,600
August 2015	129,200
September 2015	124,400
October 2015	126,400
November 2015	112,800
December 2015	154,400
Annual Total	1,560,400

Notes:

1. Electrical consumption show is total consumption and includes, plug, light, equipment, and heating load.

We completed a very high level energy model of this building based on a more sophisticated model we had previously completed for two floors for the same building. Using this data we have estimated that 45% of the total annual electrical consumption can reasonably be attributed to heating the building. Therefore the annual heating load for this building is ~702,180 kWhr.

The number of hours in a typical year when the average temperature is less than 65^{0}F is 7950 hours based on BIN temperature data for Sydney. If we average heating the heating requirement of 2,395,937,504 (702,180 * 3412) Btu/7950 hrs, we get an average heating demand of 301,363 Btu/hr. Using the same model we have estimated that the peak load in this building would result in a multiplier of approximately 2.5 for a peak capacity of ~753,408 Btu/hr.

We have developed a very rough approximation, at a high level, of the total energy consumption required for cooling the building, which is 10% of the annual energy consumption. This translates to 156,040 kWhr. This represents the energy consumed by the cooling equipment during the cooling season. To determine the average cooling demand we have:

1. Cooling equipment SEER = 9.6, therefore cooling COP = 2.8;
2. 156,040 kWhr * 2.8 = 436,912 Btu/hr for an average cooling load

Scope of Upgrades Necessary for Integration into the District Energy System

Since the existing system is not water based it is not easily integratable into district energy system. As a result there are several options for tying the existing system into the district energy system as follows:

<u>Option 1</u>

1. Removal of the existing electric baseboard heating system, and supply and installation of a new hot water baseboard radiation system;
2. Supply and install a new 750,000 Btu/hr heating only heat exchanger for connection to the district energy system;

3. Supply and install new source and load side circulators;
4. Supply and installation of a new hot water distribution system to connect the new perimeter radiation to the district energy circulator;
5. Supply and installation of new zoning for the perimeter heating system; and
6. New heating system circulator and heat exchanger control

The above option would replace 100% of the existing electric heating with new district energy based heating, but leave the cooling unchanged.

Option 2

This will include the addition of a new cooling system will be installed in order to deliver chilled water to the existing roof mounted air conditioners allowing those units to turn off the existing DX cooling systems. This renovation would include the supply and installation of:

1. New chilled water system heat exchanger;
2. New source and load side circulators;
3. Chilled water distribution piping up to the Mechanical Penthouse;
4. Two new chilled water coils with one in each of the S/A ducts for the two existing roof-top air conditioners. This would include considerable reworking of the ducting in the existing penthouse to permit for installation of the coils; and
5. New cooling system circulator and heat exchanger controls.

Option 3

This option will be the same as Option 1 except that it will include the supply and installation of a new heating system and coils in the S/A ductwork for each of the two existing roof-top units. With this option the existing electric baseboard heat would remain in place and only be used for back-up during the coldest period of the winter.

Integration Probable Conversion Cost Considerations
With respect to the integration upgrades possible, some high level (±30%) opinion of probable construction costs are as follows:

1. Option 1: $580,000
2. Option 2: $256,000
3. Option 3: $210,000

In summary:

1. Option 1 would allow for the conversion of the entire heating load of 2,395,937,504 Btu to be generated by a the district system for a cost of $580,000;
2. Option 2 would allow for the conversion of the entire cooling load of 1,482,380 Btu to be generated by the district energy system for a cost of $256,000; and
3. Option 3, in comparison with Option 1, would allow for conversion of 80% of the 2,395,937,504 Btu heating load for a lower cost of $210,000, but at a loss of 20% of the capacity since the electric heat would remain in place and still be used for back-up during the peak heating season. The opinion of probable construction cost noted assumes that this work is complete in conjunction with Option 2 for some cost efficiencies.

CBRM District Energy System
Phase 1 & 2 Screening Assessment
Holiday Inn

Building and Systems Description

The building was constructed in the mid 1980's and consists of a Lower Floor with Pool and Conference Rooms, Main Floor with hotel reception, meeting rooms and food service areas, and floors 2 through 8 for Guest Rooms. Each of the Lower and Main Floors have a nominal area of 13,500 sqft. The Guest Room floors are each 7,000 sqft.

The building is served by:

1. Heating and cooling is provided to the Lower and Main Floors via numerous water-to-air heat pumps located in the ceiling space on both floors. These heat pumps are two pipe units connected to a supply and return distribution loop. In the winter the water is heated by two 800 MBH propane boilers that feed a large thermal storage tank. Hot water from the storage tank is then fed into a heat exchanger, so that a glycol/water mixture can be fed to the heat pumps. In the summer the glycol/water loop is cooled by a ~155 ton roof mounted cooling tower.
2. There are also two 800MBH propane boilers that are used for domestic hot water heating.
3. A rooftop heat recovery ventilator (HRV) providing Guest Room washroom exhaust and general building ventilation has a capacity as follows:
    a. Nominal Airflow: 12,000cfm
    b. Nominal Heating Capacity: 900 MBH
4. All guest suites are served by electric powered PTAC units with back-up electric heaters.

Building Energy Consumption Information

We have obtained annual energy bills from the Owner for this building, with a summary of the consumption noted in the table on the next page.

We know that the propane consumption is for heating of domestic hot water and heating water for the heat pumps. We also know that the heating water for heat pumps will not be required during July and August. However, with there does not appear to be a significant drop in consumption during July and August compared with the balance of the year. Therefore it is not obvious what portion of this load can be attributed to the domestic water heating, and what portion to space heating on the Main and Lower Levels.

With respect to the electricity consumption we know that this data relates to the lights, plug loads HVAC pumps and fans, heat pumps and the cooling tower. However, there is no obvious consumption trend during different periods during the year given the general consistency of the values noted.
The only exception is the months of December, January, and March. A reasonable conclusion is that this increase in consumption may be related to the use of electric heaters in the PTAC units. However the notable comparative decrease in February provides some uncertainty in this assumption.

Summary of Annual Energy Consumption for 2017

Month	Propane Consumed (L)	Equivalent Energy Consumed (Btu)[1]	Electrical Consumption (kWhr)[2]
January	15,267	331,510,963	192,600
February	16,469	357,611,453	157,200
March	17,869	388,011,358	182,400
April	12,970	281,633,405	136,200
May	17,467	379,282,242	129,600
June	12,385	185,070,278	141,600
July	18,232	395,893,619	138,000
August	13,208	286,801,388	141,600
September	13,143	285,389,964	147,600
October	16,183	351,401,186	121,800
November	14,763	320,566,997	137,400
December	17,334	376,394,251	180,000
Annual Total	185,290	3,939,597,104	934,200

Notes:

1. Conversion from Litres consumed to energy generated for building consumption is based on 91,330 Btu/usgal and an assumed boiler efficiency of 90%.
2. Electrical consumption show is total consumption and includes, plug, light, equipment, and heating load. Consumption noted is based on a two month billing cycle.

Based on the above the most reasonable conclusion that we can draw the following:

1. Heating: a district energy system would have to be capable of providing 3,939,597,104 Btu over the course of the entire year or an average of 3,939,597,104/8760 = 449,725 Btu/hr, with a peak load of ~1.3millon Btu/hr assuming a peaking factor of 3. Note that this energy consumption is related to space heating on the Main and Lower Floors and domestic hot water heating. With the information presented to date it is not possible to predict the consumption in the building related to the PTAC operation; and
2. Cooling: based on modelling of other buildings we may reasonably assume that 10% - 15% of the total annual energy consumption can be attributed to cooling system operation. However in this building there is a cooling tower with a nominal EER of 14 responsible for cooling the Main and Lower Floors, and PTAC's with a nominal EER of 9.5 for the Guest Rooms.

   For example if we assume that total cooling is 10% of the annual consumption, then we have:

   .1 Cooling Tower: EER of 14 and a related COP = 4.1 with an average energy consumption of ~ 934,200*0.1*0.5*4.1 =191,511 Btu/hr with a peak of ~ 600 MBH; and

   .2 PTAC: EER of 9.5 and a related COP of 2.8 with an average energy consumption of ~ 934,200*0.1*0.5*2.8 = 130,788 Btu/hr with a peak of ~ 400 MBH.

   Combined these suggest an average cooling demand in the 1 million Btu/hr range.

Scope of Upgrades Necessary for Integration into the District Energy System

Given that the heat pumps serving the Main and Lower Floors are fed from a glycol water based heating loop, this system can be easily integrated into the district energy system. The existing Boiler Room is very congested, with little spare space for equipment additions. However, there are four (4) boilers present in this room. As a result we can reasonable remove three of the four to make room for the necessary upgrades. This upgrade would include:

1. Removal of three of the existing propane fired hot water boilers to make room for the supply and installation of a new heat exchanger. With this change a significant re-piping of the boiler room would be necessary to arrange the system so that the heat exchanger would be installed in series with the boiler to act as the primary heating source with the remaining boiler being used to "top-up" the heating supply water temperature as required;
2. Supply and installation of a new heat exchanger with a nominal capacity of 1,500,000 Btu/hr;
3. Supply and installation of two circulators to take water off of the district energy heating loop for delivery through the heat exchanger, including new power supplies
4. General boiler room piping upgrades to accommodate the changes noted above; and
5. Supply and installation of upgrade controls and logic for the heating plant upgrade.

The integration of the existing system for cooling is also relatively straight forward since the heat exchanger would simply need to replace the cooling tower and be connected into the existing distribution system. Based on this the upgrades would include:

1. Removal of the roof mounted cooling tower and abandonment of the chilled water piping from the Boiler Room up to the roof;
2. A new heat exchanger to generate a chilled water source for the building;
3. Two pumps to circulate chilled water from the district energy system through the heat exchanger, including new power supplies;
4. Re-working of the existing chilled water piping in the Boiler Room to allow for integration of this new heat exchanger into the existing chilled water loop;
5. A new chilled water piping system; and
6. Control system upgrades.

The above renovations would enable the district energy system to replace heating and cooling loads on the Main and Lower Levels, as well as domestic hot water heating loads. It would not however be able to replace the heating and cooling loads associated with the existing PTAC's. To complete this conversion the supply and installation of the following upgrades would be necessary:

1. New heating distribution throughout the Main Floor ceiling;
2. New heating risers to each Guest Room in approximately twenty four (24) different locations in the building;
3. New drainage piping throughout the Main Floor ceiling floor to connect the condensate drainage for the new heat pumps in the Guest Rooms;

4. Thermostatic control and power supplies for each heat pump. This will include supply and installation of a new heat pump distribution panel power circuits in risers in the same pipe chases up to each stacked heat pump

Integration Probable Conversion Cost Considerations
With respect to the integration upgrades possible, some high level (±30%) opinion of probable construction costs are as follows:

1. Heating System Upgrades: $120,0000
2. Cooling System Upgrades: $462,900
3. Guest Room Upgrades: $2million. This is the cost necessary to remove the PTAC's to allow for the Guest Rooms to be heated and cooled off of the district energy system.

CBRM District Energy System
Phase 1 & 2 Screening Assessment
Vista Heights

Building and Systems Description

This building was constructed in 1975 as a twelve storey seniors apartment building. Very little changes have been made to the mechanical systems since the original installation, with the exception that new boilers have been installed. The total building area is approximately 94,900 sqft. The building systems generally consist of:

1. Three oil fired hot water boilers that are used to provide hot water for:
   a. Two indirect fired domestic hot water heaters for domestic hot water; and
   b. A hydronic heating coil in the corridor make-up air ventilation system.
2. The heat throughout the rest of the building is provided by electric baseboard heat.

Building Energy Consumption Information

We have obtained the total annual electrical and fuel oil consumption for the building, with a summary of this consumption noted in the table below.

Summary of Annual Energy Consumption for 2017/2018

Annual	Fuel Oil Consumed (L)	Equivalent Energy Consumed (Btu)[1]	Electrical Consumption (kWhr)[2]
January - February	48,335	1,426,019,126	1,341,600

Notes:

1. Conversion from Litres consumed to energy generated for building consumption is based on 139,600 Btu/usgal and an assumed boiler efficiency of 80%.
2. Electrical consumption show is total consumption and includes, plug, light, equipment, and heating load.

The fuel oil consumption is based on heating domestic hot water and the central ventilation systems, and is therefore 100% of this capacity can be integrated into the district energy system.

We were not provided with a monthly breakdown of the electricity consumption for the building. However, based on high level energy model information we anticipate that 50% to 55% of the total annual electrical consumption is related to heating. This translates into 670,800 kWhr or 2,288,769,600 Btu over the entire heating season. This can be converted to a rough approximation of an hourly rate as follows:

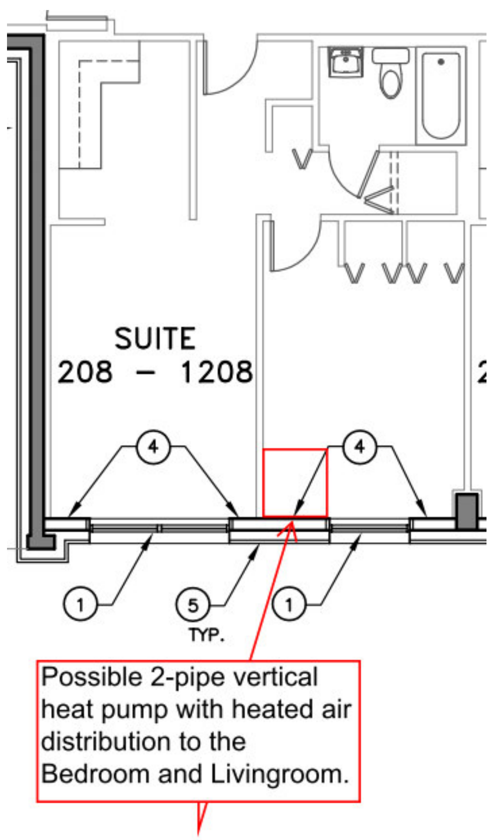
1. There are 7950 hrs in Cape Breton where the temperature is less than 65^0F based on historical BIN data for the area.
2. Therefore the average heating load is 287,895 Btu/hr (2,288,769,600 Btu/7950 hr); and
3. A peak load of approximately 863,686 Btu/hr based on a peaking factor of 3.

Scope of Upgrades Necessary for Integration into the District Energy System

The full capacity of the fuel oil based energy consumption can be integrated into the district energy system, since it is hot water based. The sizing of the heat exchanger is not straight forward since the consumption is based on domestic hot water demand and ventilation air heating requirements. For purposes of the costing exercise, we will assume a heat exchanger capacity of 500,000 Btu/hr. The renovations would include:

1. Supply and installation of a new heat exchanger with a nominal capacity of 500,000 Btu/hr;
2. Supply and installation of two circulators to take water off of the district energy heating loop for delivery through the heat exchanger, including new circulator power supplies;
3. General boiler room piping upgrades to accommodate the changes noted above;
4. Supply and installation of standalone controls to manage the heating plant upgrade.

The conversion of the building heating will be more difficult since the building is currently heated with electric baseboard heaters. This will require substantial renovations. On Floors 2 through 12 there are 12 single bedroom apartments on each floor, and these apartment units are stacked. On the lowest floor only 2/3rd of the floor has apartment units, but these are stacked below the upper floor units. The balance of the lowest floor provides general amenity space for the occupants. A typical apartment conversion could be as noted below:



Given the stacked nature of the building the supply and installation of the vertical heat pumps could be completed done in phases with installation of Suites 208 – 1208 initially. This would limit the construction to a series of stacked apartments. Once the conversion of this series of stacked units was complete then the next series of stacked units could be completed. This would help to minimize the impact on the building. With this scenario the existing electric baseboard heating would be retained for pick-up during the coldest period of the winter. The benefit of this system to the occupants of the building is that it would also provide cooling during the summer.

The scope of the renovations would include the supply and installation of:

1. A new heat exchanger with a nominal capacity of 500,000 Btu/hr, this reduced capacity makes some allowance for the COP of the heat pump;
2. Two circulators to take water off of the district energy heating loop for delivery through the heat exchanger, including new circulator power supplies;
3. Two new load side circulators to deliver heating water to the new heat pumps in each apartment;
4. New heating distribution throughout the lower floor;
5. New heating risers to each apartment in twelve (12) different locations in the building;
6. New drainage piping throughout the lower floor to connect the condensate drainage for the heat pumps. On the Lowest Floor the drainage would be piped through the exterior wall;
7. New heat exchanger with a nominal cooling capacity of 500,000 Btu/hr;
8. Two circulators to take chilled water off of the district energy system. Since the heat pumps proposed are two-pipe there would be a changeover required in the spring and fall, but a single two pipe distribution system would be installed. General boiler room piping upgrades to accommodate the changes noted above;
9. A new standalone vertical heat pumps in each apartment for a total of 142, including two heat pumps for the general amenity space on the lowest floor;
10. Thermostatic control and power supplies for each heat pump. This will include supply and installation of a new heat pump distribution panel power circuits in risers in the same pipe chases up to each stacked heat pump.

An alternate approach is to only integrate the existing hydronic system into the district energy system. This renovation would include:

1. A new heat exchanger with a nominal capacity of 500,000 Btu/hr. This capacity would have to be verified through additional analysis to confirm the amount of hydronic energy required for domestic water heating vs ventilation air heating;
2. Two circulators to take water off of the district energy heating loop for delivery through the heat exchanger, including new circulator power supplies;
3. Upgrades to the piping in the boiler room to allow the return water from the building to be run through the new heat exchanger prior to returning to the boilers;

Integration Probable Conversion Cost Considerations

With respect to the integration upgrade a high level (±30%) opinion of probable construction costs is $1.5 million. If the intent is to only replace the existing hydronic heating through the district energy system, then the opinion of probable construction costs reduces to $80,000.

CBRM District Energy System
Phase 1 and 2 Screening Assessment
CBRM Civic Centre

Building and Systems Description

In the 1960's the Sydney Police Station consisting of a single storey was constructed at this site. In the mid 1970's the CBRM Civic Centre was constructed with the former police station forming the Basement Level of the new five storey Civic Centre Building. In the early 1990's a Community Room and rentable store fronts located at Basement Level on the water side of the building were constructed. The building areas are:

1. Main Administration Area: ~9,200 sqft/floor
2. Council Chambers: ~3,500 sqft
3. Community Room: ~3,400sqft
4. Store Fronts: ~2,400sqft

There have been numerous renovations to the original HVAC system over the intervening years. The current configuration of the HVAC system is as follows:

1. AHU-1 – Serving the Main through Fourth Floors of the main administration office portion building. This unit is a roof mounted air handler with a nominal capacity of 31,260 cfm complete with a chilled water cooling coil fed from the rooftop air cooled chiller. There is no heating coil in this AHU;
2. AHU-2 – Serving the Main through Fourth Floors of the main administration office portion building. This is a roof mounted air handler with a nominal capacity of 26,015 cfm complete with a chilled water cooling coil fed from the rooftop air cooled chiller. There is no heating coil in this AHU;
3. Each of the above AHU's is complete with both supply and return fans, which are both powered through VFD's;
4. The 110 ton rooftop air cooled chiller is connected to a chilled water distribution system in the ceiling of the top floor. This system circulates chilled water to AHU-1 & AHU-2;
5. AHU-4 – Serving the Basement Level is an interior air handler with a nominal capacity of 4,000 cfm that is located in a Mechanical Room at Basement Level. This AHU has an associated return fan with the system providing mixed and heated air to the Basement Level. There is no air conditioning provided to this unit;
6. A ducted distribution has been provided throughout the building with numerous VAV boxes for zone control on the Main through Fourth Floors. There are numerous electric reheat coils associated with these VAV boxes. There is also perimeter electric baseboard heat on the Main through Fourth Floors;
7. A similar arrangement exists on the Basement Level, except that VAV boxes are not installed.
8. The Community Room is now supplied with a new 10 ton distributed heat pump complete with three ceiling mounted indoor evaporators and a single outdoor air cooled condenser package. There is perimeter electric back-up heat in the space;
9. The Store Fronts are served by two conventional split system heat pumps with each system serving two (2) store fronts. The capacity of each system is 4 tons; and

10. A new roof mounted air conditioner was installed to serve the Council Chambers in 2009. This system has a 20 ton capacity, with no heating section. For heating and zone control in the space there are 6.5kW, 5kW and 40kW heaters installed in the ductwork.

Building Energy Consumption Information

We have obtained annual electrical bills from the Owner for this building, with a summary of the consumption noted in the table below.

Summary of Annual Energy Consumption for 2017/2018

Month	Electrical Consumption (kWhr)(1)
January 2018	200,856
February 2018	162,000
March 2018	150,816
April 2018	122,784
May 2018	95,976
June 2017	89,664(2)
July 2017	83,352
August 2017	85,200
September 2017	78,216
October 2017	86,184
November 2017	123,600
December 2017	174,744
Annual Total	1,453,392

Notes:
1. Electrical consumption show is total consumption and includes, plug, light, equipment, and heating load.
2. Electrical consumption data for this month was missing from the information submitted. For purposes of this assessment the value noted was assumed based on the average of the May 2018 and July 2017 values.

Based on the distribution of energy consumption shown in the table we can draw the following conclusions:

1. The basic load in the summer for lights, plugs and air conditioning is approximately 84,000 to 85,000 kWhr.
2. The increase in electrical consumption starting in November and lasting through to May would be expected to be due to electric heating requirements. This translates into roughly 430,000kWhr of increased consumption over the heating season.
3. This does not represent the complete heating demand, since some of the demand in the cooling season is required to operate air conditioning systems. Therefore the 430k kWhr would reasonably be expected to be larger, but it is not possible to determine the contribution of air conditioning with the consumption values presented.

We completed a high level energy model with the building, and used the total consumption values listed in the table as a way to test the accuracy of the model. The results of this model suggested the following breakdown for heating and cooling:

1. Heating consumption: 50% of total annual consumption; and
2. Cooling consumption: 10% of total annual consumption

Converting these consumption valves to average energy needs we have:

1. Heating: (1,453,392 kWhr * 50% * 3412 Btu/kWhr)/7,950 hrs in the year below 65^{0}F = 311,885Btu/hr. This is an average value with a peak value of roughly 935,655 Btu/hr; and
2. Cooling: Cooling equipment SEER = 9.6. Therefore cooling equipment COP = 2.8. Based on this the average cooling needs are 1,453,392 kWhr * 10% * 2.8 = 406,950 Btu/hr. To accommodate for peak conditions a factor of 3 would be reasonable.

Scope of Upgrades Necessary for Integration into the District Energy System

Since the existing system is not water based it is not easily integratable into district energy system. As a result there are several options for tying the existing system into the district energy system as follows:

<u>Option 1</u>

1. Removal of the existing electric baseboard heating system, and supply and installation of a new hot water baseboard radiation system;
2. Supply and install a new 1,000,000 Btu/hr heating only heat exchanger for connection to the district energy system;
3. Supply and install new source and load side circulators;
4. Supply and installation of a new hot water distribution system to connect the new perimeter radiation to the district energy circulator;
5. Supply and installation of new zoning for the perimeter heating system; and
6. New heating system circulator and heat exchanger control

The above option would replace 100% of the existing perimeter base board electric heat load, which based on the current design with no heating section in the main AHU's, offsets most of the heat loss from the spaces served.

<u>Option 2</u>

This will include the addition of a new cooling system to deliver chilled water to the existing roof mounted air conditioners allowing the existing DX cooling systems to be disengaged. This renovation would include the supply and installation of:

1. Removal of the existing roof mounted air cooled chiller;
2. New chilled water system heat exchanger with a nominal capacity of 1,500,000 Btu/hr;
3. New source side circulators;
4. Chilled water distribution piping up to the ceiling of the top floor for connection to the existing distribution system;

5. New chilled water coils in each of four (4) air handlers serving the main building, and council chambers. The system serving the store fronts would remain as is and unchanged. and
6. New cooling system circulator and heat exchanger controls.

Option 3

This option will be used to add heating coils to the main AHU's and replace the duct mounted electric coils with duct mounted hot water heating coils. The scope of work would supply and installation of:

1. A new heating heat exchanger with capacity specifically for the AHU and duct coils. This would be in addition to the heat exchanger for the perimeter heating, or be a larger heat exchanger for all heating;
2. New source and load side circulators;
3. Heating distribution piping throughout the building to supply new hot water based duct mounted coils to replace existing duct mounted electric coils;
4. New hot water based duct mounted heating coils and new hot water based heating coils in air handling equipment;
5. Upgraded control system.

Integration Probable Conversion Cost Considerations

With respect to the integration upgrades possible, some high level (±30%) opinion of probable construction costs are as follows:

1. Option 1: $790,000;
2. Option 2: $980,000; and
3. Option 3: $490,000.

Since the neither of the existing AHU-1 nor AHU-2 have heating coils, it is reasonable to assume that the areas served by these units rely on heating from the perimeter baseboard heaters. If AHU-1 and AHU-2 were provided with heating coils and the control strategy changed, it seems reasonable that the existing electric heat could be used as supplemental heat during the coldest periods of the winter. In this case it might be possible to pick up approximately 70% of the total electrical heating load without having to replace the existing radiation. That is, the work associated with Option 1 may not be necessary.

These estimates assume that each option is considered as a separate scope of work. If one or more a considered as a single project, cost savings may be possible. However, it is worth noting that the CBRM Civic Centre is a fully occupied and busy building, and that any upgrade of this nature will have to be completed in phases. As a result cost savings from combining options may not be realized on account of the cost implications of phasing the work.

CBRM District Energy System
Phase 1 & 2 Screening Assessment
Cambridge Suites

Building and Systems Description

This building was constructed in 1989 as an eight storey building. Very few changes have been made to the mechanical systems since the original installation. The total building area is approximately 86,000 sqft. The building systems generally consist of:

1. There are two oil-fired hot water heating boilers serving:
    a. Two indirect fired 200 gallon domestic hot water heaters, each heating using a heating bundle fed from the boiler;
    b. Hot water baseboard radiation for the 8th Floor;
    c. Hydronic heating coils for the various ventilation systems in the building; and
    d. Fan coil units that provide heating and cooling to each suite.

    Each boiler has a nominal gross output of 3,662 MBH.
2. Two split system chillers with indoor evaporator and outdoor air cooled condenser. The capacity of each chiller is 95 tons. These chillers provide chilled water to AHU coils in the building, and fan coils located in the suites.
3. There are five (5) air handlers in the building with capacities fed from the boiler and chiller plants as follows:
    a. SF1: airflow capacity of 7,500 cfm with a heating coil capacity of approximately 500MBH, and cooling coil capacity of 20 tons;
    b. SF2: airflow capacity of 3,200 cfm with a heating coil capacity of approximately 70 MBH, and a cooling coil capacity of 7.5 tons;
    c. SF3: airflow capacity of 3,550 cfm with a heating coil capacity of approximately 220MBH, and a cooling coil capacity of 8.5 tons;
    d. SF4: airflow capacity of 3,000 cfm with a heating coil capacity of approximately 260MBH. There is no cooling coil in this unit;
    e. SF5: airflow capacity of 5,000 cfm with a heating coil capacity of approximately 140MBH, and a cooling coil capacity of 15 tons; and
    f. SF6: airflow capacity of 1,250 cfm with a heating coil capacity of approximately 75MBH, and a cooling coil capacity of 3.5 tons
4. There are five (5) different types of fancoil units that are used for the suites in the building, which range from 2 ton units down to ½ ton units.
5. The heating water for the fan coils, ventilation system heating coils and domestic heating bundlers were designed for 180^{0}F EWT and 160^{0}F LWT.
6. The chilled water coils in the fan coils, and ventilation system cooling coils were designed for an EWT of 45^{0}F and LWT of between 55^{0}F and 60^{0}F.

Building Energy Consumption Information

We have obtained annual energy bills from the Owner for this building, with a summary of the consumption noted in the table below.

Summary of Annual Energy Consumption for 2017

Month	Fuel Oil Consumed (L)	Equivalent Energy Consumed (Btu)(1)	Electrical Consumption (kWhr)(2)
January	17,167	910,529,881	88,590
February	14,472	752,203,699	80,364
March	13,190	719,852,744	89,664
April	15,205	813,420,590	92,343
May	7,776	435,554,655	154,224
June	3,873	230,489,358	128,745
July	6,024	356,823,043	148,767
August	5,805	326,081,835	146,166
September	2,015	107,803,329	134,061
October	11,471	581,530,585	141,918
November	12,195	555,412,839	109,884
December	18,958	831,897,841	88,707
Annual Total	128,181	6,621,600,399	1,403,433

Notes:

1. Fuel oil consumption noted is for the 2017 calendar year. Conversion from Litres consumed to energy generated for building consumption is based on 139,600 Btu/usgal and an assumed boiler efficiency of 80%.
2. Electrical consumption shown is total consumption that includes, plug, light, equipment, air conditioning and heating load. Consumption noted is from June 2017 through to the end of May 2018.

Based on the above consumption summary and the description of the systems we can conclude the following with regards to the fuel oil consumption:

1. 100% of the fuel oil consumed could be provided by the district energy system for the heating of domestic hot water, fan coils, and ventilation system heating coils;
2. We can reasonably assume that there is no need for heating during July and August, which also reflects peak occupancy periods for the facility. The total energy consumed for each of these months averaged out at 341,452,439 Btu, which over a 30 day period results in an average hourly demand for hot water heating of ~475 MBH. This demand is assumed to be attributed to domestic hot water heating; and
3. Removing the domestic hot water demand of approximately 341,452,439 Btu/month from the total demand results in a remaining demand of 2,524,495,131 Btu over the entire heating season. It must be pointed out that this value is low since the domestic hot water heating demand varies from month-to-month and is less during the off-peak periods. Nevertheless a low end estimate of average heating demand over the 7,950 hrs during which the outside air temperature is below 65^{0}F in Sydney is 318MBH (2,524,495,131/7,950), with a peaking factor of 3x for a capacity of approximately 900 MBH.

For the electricity consumption we can draw the following conclusions:

1. There are no cooling requirements from January through March. During this time the average electrical consumption was 86,206 kWhr.

2. July and August have fairly constant consumption rates averaging at 147,482 kWhr. Of this we can reasonably assume that 61,275 kWhr/month (147,482 – 86,206) is related to cooling needs of the building.
3. Looking at the overall energy consumption trend it seems apparent that there is also a cooling demand in May, June, September, October, and possibly November. If we prorate against the average for July and August of 61,275 kWhr over these other months based on the energy consumption over 86,206 kWhr, we have a total electrical consumption related to cooling of approximately 394,000 kWhr over the entire cooling season
4. Assuming a SEER of 9.6 for the cooling equipment and therefore a COP of 2.8, we have an average cooling demand of 1,103,200 Btu/hr.

Scope of Upgrades Necessary for Integration into the District Energy System

There is a substantial existing hot water based heating load in the building that can be easily integrated into a district energy system. This could be done with the following renovations:

1. Removal of one of the existing oil fired hot water boilers to make room for the supply and installation of a new heating system heat exchanger. With this arrangement the heat exchanger would be installed in series with the boiler and act as the primary heating source. The boiler would then be used to "top-up" the heating supply water temperature as required.
2. Supply and installation of a new heat exchanger with a nominal capacity of 1, 500,000 Btu/hr based on:
    a. Average demand during high season of 341 MBH; and
    b. Approximate peak demand during heating season of 900 MBH.
3. Supply and installation of two circulators to take water off of the district energy heating loop for delivery through the heat exchanger, including new power supplies;
4. Supply and installation of heating water risers from the district energy system up through the building to the mechanical penthouse;
5. General boiler room piping upgrades to accommodate the changes noted above; and
6. Supply and installation of upgrade controls and logic for the heating plant upgrade.

For the cooling system the entire chilled water plant could be removed and replaced with the district energy system using the existing infrastructure for delivery of chilled water to the building. The scope of these renovations would include:

1. Removal of the existing chilled water equipment including both inside and outside components;
2. Supply and installation of a 1,500,000 Btu/hr heat exchanger for connection to the district energy system;
3. Supply and installation of two circulators to connect the new heat exchanger to the district energy system;
4. Supply and installation of chilled water risers from the district energy system up through the building to the mechanical penthouse;
5. General piping upgrades in the penthouse; and
6. Upgraded controls for the new cooling system.

Integration Probable Conversion Cost Considerations

With respect to the integration upgrades possible, some high level (±30%) opinion of probable construction costs is $375,000

CBRM District Energy System
Phase 1 & 2 Screening Assessment
Cape Breton Family YMCA

Building and Systems Description

The original building was constructed in the 1960's with a pool addition constructed in the 1980's. The new pool space was constructed as a two story addition. The balance of the building contained a small gymnasium and administration space. In 2007 the building underwent a significant renovation with the demolition of the 1960's building, refurbishment of the pool portion built in the 1980's and construction of two building additions. With the completion of this alteration and renovation the building areas are:

1. Pool: 5,600 sqft space that is two storey's in height;
2. Main Floor: 25,000 sqft
3. Second Floor: 25,000 sqft

The existing systems are varied and consist of:

1. Two oil fired boilers each with a heating output of 2,770 MBH. This boiler provides heating for:
    a. Cardio Area AHU heating coils with a total connected capacity of 865 MBH
    b. Pool Water Heating with a total connected capacity of 562MBH
    c. Pool Air Heating with a total connected capacity of 400 MBH
    d. Admin/Service Area AHU duct mounted reheat coils with connected capacity of 935 MBH
    e. Perimeter heating in the Admin/Service Area with connected capacity of 250 MBH
    f. Domestic water heating connected load of 840 MBH.
2. There are numerous roof mounted air handlers that serve various portions of the building. In some cases the heating for these units is through hot water heating coils from the boiler as noted in #1 above. The balance of the air handling equipment consists of packaged roof mounted heat pumps complete with back-up electric heaters. In this case the total connected load for these back-up electric heaters is 126 kW. It should be pointed out that there is a BAS in the building that controls these air handlers so that the electric heaters are only used if the heat pump and duct mounted hot water reheat coils fail to maintain acceptable space temperatures.
3. Cooling for the building is provided through DX cooling coils in each of the roof top air handlers. The total connected cooling load for all units is 130 tons.
4. There is also a DX system in the pool dehumidification system that is used to dehumidify the outside air introduced through the pool system.

The building has extended operating hours as follows:

1. Monday through Thursday: 5am until 10pm
2. Friday: 5am through 9pm
3. Saturday: 7am through 6pm
4. Sunday: 8am through 5pm

Building Energy Consumption Information

We have obtained annual energy bills from the Owner for this building, with a summary of the consumption noted in the table below.

Summary of Annual Energy Consumption for 2017

Month	Fuel Oil Consumed (L)	Equivalent Energy Consumed (Btu)(1)	Electrical Consumption (kWhr)(2)
January	10,430	307,714,482	
February	10,691	315,141,720	155,520
March	7,410	218,615,945	
April	7,819	230,682,602	142,920
May	5,617	165,717,377	
June	5,898	174,007,672	164,160
July	2,356	65,512,376	
August	3,407	100,516,130	165,600
September	3,212	94,763,079	
October	4,814	142,026,607	150,120
November	6,839	201,769,831	
December	8,217	242,424,727	155,880
Annual Total	76,710	2,263,165,549	934,200

Notes:

1. Conversion from Litres consumed to energy generated for building consumption is based on 139,600 Btu/usgal and an assumed boiler efficiency of 80%.
2. Electrical consumption show is total consumption and includes, plug, light, equipment, and heating load. Consumption noted is based on a two month billing cycle.

Based on the system descriptions we know that the fuel oil consumption is for the provision of hot water for domestic water, space and air heating. Therefore 100% of this load is replaceable with the same load provided through a district energy system. However, it is more difficult to establish the electrical consumption that is specifically related to the heating and cooling in the building. Nevertheless, based on the consumption values noted we can draw the following general conclusions:

1. Given the primary use of fuel oil for all heating needs we can reasonably assume that the load consumption in April may be connected to equipment, plug loads and lights, since heating requirements are minimal and cooling can be handled through economizer operation.
2. Based on #1 above, then it may also be reasonable to assume that 12,600 kWhr (155,520 kWhr – 142,920 kWhr) may be associated with back-up electric resistance heating in the roof top heat pumps during the coldest period of the winter. It may also be reasonably assumed that this same approximate load is related to back-up electric resistance heating during November and December. Therefore in addition to the energy consumed using fuel oil as a source, we have an addition 37,800 kWhr for space heating.
3. For the period from May through to the end of August, which is the typical cooling season in Cape Breton, the electrical consumption is ~42,480 kWhr ((164,160-142,920) + (165,600-142,920)). The heat pumps installed are Trane Model WCD180 with an SEER of 9.6, which translates into a cooling COP of 2.8.

4. We therefore can convert the 42,480 kWhr consumed to cooling load generated as follows:
    a. 2.8 x 42,480 kWhr = 118,104 kWhr = 402,970 MBtu

Scope of Upgrades Necessary for Integration into the District Energy System

There is a substantial existing hot water based heating load in the building that can be easily integrated into a district energy system. This could be done with the following renovations:

1. Removal of one of the existing oil fired hot water boilers to make room for the supply and installation of a new heat exchanger. The existing heating plant uses a primary/secondary piping system. With this arrangement the heat exchanger would be installed in series with the boiler and act as the primary heating source. The boiler would then be used to "top-up" the heating supply water temperature as required.
2. Supply and installation of a new heat exchanger with a nominal capacity of 500,000 Btu/hr based on:
    a. 2,263,165,549 Btu (oil equivalent);
    b. 7950 hrs in Cape Breton where the temperature is less than 65^0F; and
    c. 284,675 Btu/hr – to provide an approximate of the average load; and
    d. 854,025 Btu/hr as an approximation of the peak load.
3. Supply and installation of two circulators to take water off of the district energy heating loop for delivery through the heat exchanger, including new power supplies;
4. General boiler room piping upgrades to accommodate the changes noted above; and
5. Supply and installation of upgrade controls and logic for the heating plant upgrade.

The integration of the existing system into the district energy system for cooling is more complicated since the existing cooling system is not water based. Nevertheless the upgrades could include supply and installation of:

1. A new heat exchanger to generate a chilled water source for the building;
2. Two pumps to circulate chilled water from the district energy system through the heat exchanger, including new power supplies;
3. Two pumps to circulate chilled water throughout the building, including new power supplies;
4. A new chilled water piping system;
5. New duct mounted chilled water coils in the upstream of the existing duct mounted hot water heating coils. Additionally duct mounted heating coils will be installed in the S/A ductwork for each of AHU-1 and AHU-2. The existing DX cooling systems in these units would not be modified, but remain in place as back-up;
6. Control system upgrades; and
7. Miscellaneous ceiling removals and reinstatements for new chilled water piping distribution.

The new cooling system equipment could be located in the mezzanine above the Boiler Room.

Integration Probable Conversion Cost Considerations
With respect to the integration upgrades possible, some high level (±20%) opinion of probable construction costs are as follows:

1. Heating System Upgrades: $86,300
2. Cooling System Upgrades: $462,900

CBRM District Energy System
Phase 1 & 2 Screening Assessment
Joan Harriss Cruise Pavilion

Building and Systems Description
In 2004 an existing warehouse on the main Sydney wharf was converted into the Joan Harriss Cruise Pavilion. This renovation was undertaken to create infrastructure to support the increasing cruise ship traffic to Sydney. As part of this project a new two storey structure was added to the existing warehouse. Existing building areas are:

1. Vendor floor space and Theatre area: 13,200 sqft
2. Main Floor Concourse: 11,700 sqft
3. Second Floor Museum: 6,600 sqft
4. Second Floor Restaurant: 5,600 sqft
5. Waterfront Vendor Stalls: 2,200 sqft

The building is served by:

1. Two oil fired boilers each with a nominal gross heating capacity of 1,445 MBH that provide a heating water supply temperature of 180F during the coldest parts of the winter.
2. Distribution of heating water is through a primary/secondary circulation system, with a separate glycol water supply loop for the air handing system coils. There is a combination of perimeter radiation, convectors and cabinet heaters for base building heating. All radiation elements and heating coils are designed based on delivery of 180F supply water from the heating system.
3. AHU-1 serves the Vendor floor space and Theatre area with the following capacity:
    a. Nominal Airflow: 15,000 cfm
    b. Nominal Heating Capacity: 1,330 MBH
    c. Nominal Cooling Capacity: 920 MBH
4. AHU-2 serves the Second Floor Museum space with the following capacity:
    a. Nominal Airflow: 5,300 cfm
    b. Nominal Heating Capacity: 205MBH
    c. Nominal Cooling Capacity: 417 MBH
5. AHU-3 serves the balance of the building including the Main Floor Concourse, Second Floor Restaurant, and Vendor Stalls with the following capacity:
    a. Nominal Airflow: 16,000 cfm
    b. Nominal Heating Capacity: 422 MBH
    c. Nominal Cooling Capacity: 607 MBH
6. A 110 ton rooftop air cooled chiller completed with chilled water distribution system for air handler coils is provide for cooling capacity.
7. A ducted distribution has been provided throughout the building. Only the distribution system for AHU-3 has been provided with VAV boxes and hot water reheat coils for zone control throughout the spaces served. There is also perimeter baseboard radiation along the perimeter in portions of the Main Floor Concourse, and Second Floor Restaurant. The total connected load for the building heating loop is nominally 650 MBH.

Building Energy Consumption Information

We have obtained annual electrical bills and fuel oil consumption bills from the Owner for this building, with a summary of the consumption noted in the table below.

Summary of Annual Energy Consumption for 2017/2018

Month	Fuel Oil Consumed (L)	Equivalent Energy Consumed (Btu)(1)	Electrical Consumption (kWhr)(2)
January	8,071	238,139,166	77,760
February	3,884	114,588,976	64,800
March	7,665	226,139,166	60,000
April	6,326	186,634,881	44,160
May	3,013	88,892,017	50,400
June	3,383	99,808,063	54,720
July	0	0	59,520
August	0	0	68,640
September	0	0	73,440
October	0	0	58,560
November	8,777	258,946,310	54,720
December	11,831	349,047,942	61,920
Annual Total	52,950	1,700,336,408	934,200

Notes:

1. Conversion from Litres consumed to energy generated for building consumption is based on 139,600 Btu/usgal and an assumed boiler efficiency of 80%.
2. Electrical consumption show is total consumption and includes, plug, light, equipment, and heating load. Consumption noted is based on a monthly billing cycle.

Based on the system descriptions we know that the fuel oil consumption is for the provision of hot water for space and air heating. Therefore 100% of this load is replaceable with the same load provided through a district energy system. However it is more difficult to establish the electrical consumption that is specifically related to the cooling in the building. This is because an apparent and consistent constant level is not present in the winter months as might be expected for a building that is heated with an oil fired hot water system. There are several reasons for this as follows:

1. The building is used for a wide range of events that are varied throughout the year with varying degrees of electrical consumption; and
2. There is a commercial kitchen in the facility that is associated with both catering for events and a restaurant.

For this reason it is difficult to estimate the cooling load for the building. However, based on energy models that we have completed for other dissimilar buildings, as well as high level energy models for other buildings in this assessment, we estimate that a reasonable order of magnitude valve is that 10% of the total annual energy consumption can be attributable to cooling.

This translates into 93,420 kWhr. If we assume a cooling system SEER of 10 then the related cooling COP will be 2.9. For related average consumption we then have:

.1 93,420 kWhr consumed = 318,749 Btu/hr
.2 Assuming a SEER of 10 for the cooling equipment, the cooling load at COP = 318,842 x 2.9 = 924,372 Btu/hr cooling energy provided to the building.

Scope of Upgrades Necessary for Integration into the District Energy System
Given that heating and chilled water was used as the primary energy transfer method this building should be readily integrated into a district energy system. The scope of these changes would include:

1. Removal of one of the existing oil fired hot water boilers to make room for the supply and installation of new heat exchangers. The existing heating plant uses a primary/secondary piping system. With this arrangement the heat exchanger would be installed in series with the boiler and act as the primary heating source. The boiler would then be used to "top-up" the heating supply water temperature as required.
2. Supply and installation of a new heat exchanger with a nominal capacity of 750,000 Btu/hr based on:
    a. 1,700,336,408 Btu (oil equivalent);
    b. 7950 hrs in Cape Breton where the temperature is less than 65^0F. This 7,950 hrs is based on historical BIN data for the area.
    c. 213,878 Btu/hr – to provide an approximate indication of average load; and
    d. A peaking factor of 3.
3. Supply and installation of two circulators to take water off of the district energy heating loop for delivery through the heat exchanger, including new circulator power supplies;
4. General boiler room piping upgrades to accommodate the changes noted above;
5. Supply and installation of upgrade controls and logic for the heating plant upgrade.
6. Removal of the existing roof mounted chiller;
7. Supply and installation of new cooling system heat exchanger with a nominal capacity of 1,000,000 Btu/hr;
8. Supply and installation of two new circulators to take chilled water off of the district energy system;
9. Modifications to the existing chilled water system piping;
10. Modifications to the existing chilled water system controls.

Given that the existing building has heating elements that are based on 180^0F EWT, the any integration into the tie-in to the district energy system will need to produce 180^0F EWT for this building. With the renovation arrangement noted, a district energy system supplying 140^0F could be used for 100% of the heating needs for a large portion of the year with the existing remaining boiler used to increase the 140^0F EWT to higher temperatures in colder weather.

The existing chilled water design is based on 45^0F EWT and so all cooling from the district energy system would have to be designed to match.

Integration Probable Conversion Cost Considerations
With respect to the integration upgrade a high level (±30%) opinion of probable construction costs is $250,000.

CBRM District Energy System
Phase 1 Screening Assessment
Sydney GOCB

Building and Systems Description

The original building was fully renovated in the late 1980's and converted into what is currently referred to as the Sydney GOCB (Government of Canada Building). This building contains offices supporting a Citizenship and Immigration processing centre and CRA processing offices. The building is three (3) floors with approximately 25,000 sqft/floor.

The lowest floor is below grade except that there are window wells on the south-east and south-west corners that allow light from outside into that level from the Main Floor. This floor is the main mail sorting area with very low occupancy. The Main and Second Floor are both fully occupied.

The HVAC systems consist of:

1. Four (4) pipe fan coils that serve the Lowest Level c/w a 100% outside air system that delivers outdoor air to each fan coil. Heating for the fan coils is provided via an oil-fired hot water heating system. Chilled water is from an air cooled roof mounted chiller. About 20 years ago a fluid cooler was added to this chilled water loop to take advantage of "free cooling" during the winter.
2. There are two types of fan coils serving the Lowest Floor with a total combined capacity of:
    a. Heating: 253,600 Btu/hr for the Type A units and 480,000 Btu/hr for the Type B units.
    b. Cooling: 192,000 Btu/hr for the Type A units and 315,000 Btu/hr for the Type B units
3. The outdoor air unit that serves the Lowest Level is mounted on the roof and has the following capacity:
    a. Airflow capacity: 3,000 cfm
    b. Heating capacity: 68kW electric duct heater
    c. Cooling capacity: none.
4. The chiller that serves the fan coils has a rated 30 ton cooling capacity. Chilled water from this chiller is piped to the fan coil units located on the Lowest Floor.
5. A small portion of the Lowest Floor that is used for storage is ventilated with a mixed air system with the following capacities:
    a. Airflow capacity: 3,400 cfm
    b. Heating capacity: 110 MBH
    c. Cooling capacity: none
6. The Main and Second Floors are served by two large packaged RTU's with electric heating and air cooled DX cooling. AHU-1 serves the North and East sections of the Main and Second floors, and AHU-2 serves the South and West portions of the Main and Second Floors. The capacities of these systems are:
    a. AHU-1:
        i. Airflow capacity: 33,650 cfm
        ii. Heating capacity: 160 kW electric heater
        iii. Cooling capacity: unknown at this time.
    b. AHU-2
        i. Airflow capacity: 26,400 cfm
        ii. Heating capacity: 125 kW electric heater
        iii. Cooling capacity: unknown at this time.

7. Hot water baseboard radiation is provided along the perimeter of both the Main and Second Floors with some unit heaters on the Lowest Floor and cabinet heaters at entrances on both the Lowest and Main Floors. The connected capacity of these heating elements is:
    a. Lowest Floor: 110 MBH for two unit heaters and one cabinet heater;
    b. Main Floor: 540 MBH through mainly perimeter radiation and cabinet heaters at the entrances; and
    c. Second Floor: 410 MBH through perimeter radiation.
8. The heating capacity for the radiation and Lowest Floor ventilation system is provided by two oil-fired hot water boilers. The capacity of the boilers is currently unknown.
9. The heating coils in the existing system and the radiation elements are based on 180^{0}F EWT.

Building Energy Consumption Information

To be completed once fuel oil and electrical consumption data is available.

Scope of Upgrades Necessary for Integration into the District Energy System

There is a substantial existing hot water based heating load in the building that can be easily integrated into a district energy system. This could be done with the following renovations:

1. Although there is a significant amount of space in the existing Boiler Room for additional equipment, connection to a district energy system would make the need for both boilers redundant. Therefore this scope allows for the removal of one of the existing oil fired hot water boilers. The existing heating plant uses a primary/secondary piping system. With this arrangement the heat exchanger would be installed in series with the boiler and act as the primary heating source. The boiler would then be used to "top-up" the heating supply water temperature as required.
2. Supply and installation of a new heat exchanger for connection to the district energy system.
3. Supply and installation of two circulators to take water off of the district energy heating loop for delivery through the heat exchanger, including new power supplies;
4. General boiler room piping upgrades to accommodate the changes noted above; and
5. Supply and installation of upgrade controls and logic for the heating plant upgrade.

With respect to cooling the existing air cooled chiller that serves the Lowest Floor could be fully replaced by the district energy system. This renovation would include:

1. Removal of the existing roof mounted chiller;
2. Abandonment of the chilled water risers from the roof to the Lowest Floor Boiler Room;
3. Supply and installation of a new cooling heat exchanger, including source side circulators and power supplies;
4. Re-working of the chilled water piping in the boiler room to allow the existing distribution system to obtain chilled water from the new heat exchanger; and
5. Supply and installation of upgraded controls for the new cooling plant.

At this juncture cooling requirements and configuration for AHU-1 and AHU-2 is unknown. Once this information is available, a system upgrade recommendations will be provided.

Integration Probable Conversion Cost Considerations

With respect to the integration upgrades possible, some high level (±30%) opinion of probable construction costs are as follows:

1. Heating System Upgrades: $105,000
2. Cooling System Upgrades – Lowest Floor: $110,000
3. Cooling System Upgrades – AHU-1 & AHU-2: N/A