TOWN OF ANTIGONISH

PATHWAY TO ZERO EMISSIONS FEASIBILITY STUDY

FEASIBILITY STUDY

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TOWN OF ANTIGONISH

FEASIBILITY STUDY

PROJECT NO.: CA0016522.4178
DATE: MARCH 27, 2025

WSP

WSP.COM

March 27, 2025

Town of Antigonish
274 Main Street
Antigonish, Nova Scotia B2G 2C4

Attention: Lise Roy, Strategic Initiatives Coordinator

Dear Lise:

Subject: Community District Energy System Feasibility Study

Please find attached the final Community District Energy System Feasibility Study.

Yours sincerely,

Matt Rodgers

Matthew Rodgers

Director Buildings - M&E

WSP ref.: CA0016522.4178

WSP Canada Inc.
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REVISION HISTORY

FIRST ISSUE

	PATHWAY TO ZERO EMISSIONS FEASIBILITY STUDY			
Prepared by	Reviewed by	Approved By		
Brian Warren	Gardiner MacNeill	Matthew Rodgers		

SECOND ISSUE

	PATHWAY TO ZERO EMISSIONS FEASIBILITY STUDY			
Prepared by	Reviewed by	Approved By		
Brian Warren	Adrian Spaziani	Matthew Rodgers		

THIRD ISSUE

	PATHWAY TO ZERO EMISSIONS FEASIBILITY STUDY			
Prepared by	Reviewed by	Approved By		
Brian Warren	Adrian Spaziani	Matthew Rodgers		

SIGNATURES

PREPARED BY

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Matthew Rodgers, P.Eng.
Project Manager, Mechanical Date 27 March 2025

Brian Warren

Brian Warren, P.Eng. Date 27 March 2025
Team Lead, M&E

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THE TOWN OF ANTIGONISH

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Sustainable Communities Challenge Fund

This project is supported by the Sustainable Communities Challenge Fund, delivered by the Nova Scotia Federation of Municipalities on behalf of the Province of Nova Scotia.

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TABLES

FIGURES

APPENDICES

1 EXECUTIVE SUMMARY

The Town of Antigonish (TOA), situated in Northeastern Nova Scotia, serves as an economic hub and service centre for the surrounding rural communities. TOA operates its own municipal electricity utility (MEU), giving it a distinctive advantage in tackling the climate emergency. By investing in green infrastructure, the TOA can support growing energy demands while maintaining affordable energy rates and mitigating risks associated with carbon pricing. The town has committed to becoming the first zero-carbon community in Canada by focusing on large scale electrification and renewable energy initiatives.

The town, in partnership with St. Francis Xavier University (St. FX), has proposed a community district energy system (CDES). This would allow St. FX to decommission its aging fuel oil-burning steam central heating system, which represents the single largest source of greenhouse gas (GHG) emissions in Antigonish. A new electrified district heating system will need to be identified to replace the aging system and provide affordable, green thermal energy to the university and the surrounding community.

WSP was engaged to perform a Community District Energy Feasibility Study for the TOA. The overall mandate is to identify and recommend a community district energy system to supply long-term, cost-effective, low carbon thermal energy to the community supported by St. FX, and to assist the TOA with development of a business case to make their decarbonization goals a reality.

To perform this study, WSP gathered available data on existing building heating system loads and capacities and used energy analysis tools to estimate building heating system loads to develop district-level heating system load duration profiles. Our team studied and evaluated available and emerging energy production, distribution, storage and recovery technologies, developed, analyzed and costed concept-level CDES designs and layouts. We engaged trusted district energy operations and maintenance experts to perform an operation & maintenance (O&M) costing study based on our concept designs and performed both capital expenditure and net-present value (NPV) cost analysis to provide the TOA with a complete financial vision for the recommended technical CDES solutions. We also provided an emissions study for existing St FX and TOA buildings, and a roadmap for a 40% reduction of GHG emissions within a 3-year timeframe as requested by the TOA.

The option with both the highest up-front and annual operating costs was a central plant solution consisting of deep bore geothermal (DBG) exchange, water-source heat pumps (WSHP) with resistive electric boiler backup, and direct-buried, factory insulated distribution piping. Incidentally, the energy performance of this option provided the most favourable energy costs and net present value (NPV) over a 25 year period, effectively offsetting the up-front costs when compared to the other options (a plant with electric boilers only, and a plant with electric steam boilers).

Based on our study, the recommended solution which best balances first-cost, NPV, and O&M costs while guiding the TOA and their stakeholders towards their modernization and decarbonization goals is a new CDES at the St FX campus housing water-source heat pumps (WSHP) with electric boiler backup, thermal energy storage tanks and a deep-bore geothermal (DBG) geoexchange system leveraging stable subsoil temperatures to provide low-carbon heating and the flexibility of energy storage to the St FX Campus and surrounding Town of Antigonish buildings. New direct-buried low-temperature hot water (LTHW) piping distribution throughout the St FX campus and along key thoroughfares in the TOA can deliver heating water to buildings on campus and in the Town, and future heating energy sources utilizing wastewater and year-round cooling demands at the St. Martha’s Regional Hospital can be utilized after the initial CDES is built and commissioned.

Both the WSHP/DBG and electric boiler solutions have been broken down and presented in three phases as detailed in both the feasibility study report and drawings (Appendix D) and the accompanying capital expenditure and O&M cost reports (appendices E and F respectively). Phasing the construction of the CDES will be necessary given the effort and cost required to convert St. FX and TOA buildings to LTHW heating, and to allow the University and Town to minimize disruption to their operations during a multi-year project.

2 APPROACH

As a first step in undertaking our study, WSP performed an exhaustive review of all available information on the loads and performance of the existing St. FX Central Heating Plant (CHP), the connected St. FX buildings, and key stakeholder buildings within the surrounding Town of Antigonish. Site visits were conducted to review as-built conditions in the St. FX buildings, and information from St. FX operations staff was reviewed and downloaded. St. FX provided three years' worth of steam meter readings at 15-minute intervals for most of their campus buildings, along with BAS screenshots and general walkthroughs of each building and its mechanical systems. The Town buildings were reviewed along with energy consumption data provided by the TOA.

WSP's approach for a Community District Energy System Feasibility Study consisted of the following phases, which are further detailed in subsequent sections:

1. Building Screening at St FX: WSP visited the St FX campus, met with operating staff, reviewed available drawings and steam metering data, reviewed the existing plant and associated building-level heating equipment and systems, and analyzed available data in order to develop load profiles for the University buildings;
2. Building Screening of identified TOA stakeholder facilities: WSP visited the buildings identified as potential Community DES stakeholders, reviewed their existing heating systems and their compatibility with available district energy technologies. Available utility metering data (provided by TOA) was reviewed;
3. Information and Gap Analysis: Steam meter data from St FX was utilized to develop load profile curves for individual campus buildings, as well as an overall plant heating load duration curve. Gaps in information were identified through development of a Master Building Information List (MBIL) tabulating known heating load data, utility metering data, installed building heating system descriptions and capacities, among other known building information (basic construction details and usage information, floor areas, and pertinent observations from our site reviews);
4. Informed by the gap analysis, our team then used available building information (drawings and equipment schedules) to develop energy load profiles for buildings using IESVE simulation software.
5. Once a DES loading profile was developed, a technology review was conducted and available DES technologies were evaluated and ranked based on several characteristics as they applied to the TOA and St FX's specific needs and challenges.
6. Based on the results of the technology review and evaluation matrix, preliminary equipment layouts and system schematics were developed.
7. To further validate proposed technologies, emissions and net-present-value (NPV) analyses were completed for both the existing oil-fired steam DES system the top-ranking electric DES solutions from the technology study;
8. Informed by the emissions analysis, a strategy to reduce overall campus emissions by 40% within 3 years was developed;
9. Capital Cost analysis was performed for the top-ranking technologies, and a third party was consulted to provide an O&M costing exercise to inform TOA and St FX of their total capital expenditures, anticipated energy costs, and operating expenses for the proposed DES solutions.

3 ST. FX EXISTING INFRASTRUCTURE

3.1 EXISTING CENTRAL PLANT

The central plant at St. FX is equipped with two 7.8 MW oil-fired high pressure steam boilers and one 4.0 MW oil-fired high pressure steam boiler serving a common steam header.

The equipment outputs discussed in this report were reviewed in comparison to the hourly steam meter data provided by St. FX for most buildings for the years 2018-2020. For some buildings, 2018-2020 data was not available and data from 2023 was utilized.

The district energy central plant on the St. FX campus was installed over 100 years ago and in general, its operation has remained the same with maintenance and expansion completed as needed. Utilizing an underground high-pressure steam and condensate distribution system and energy transfer stations located within the connected buildings, this central plant supplies heating to the entire campus. The existing plant provides steam via oil-fired boilers and has reached the end of its useful service life.

The Peak heating load of the operational buildings supported by the central plant were determined through interval steam metering data provided by St. FX, for the 2018-2020 calendar years. This data represents the maximum heating requirements. Below is a summary of the peak system heating loads for 2018-2020. The loads are assumed to have remained constant in the years since the data was recorded.

2018 Peak Heating Load	**8 MW**
2019 Peak Heating Load	7.5 MW
2020 Peak Heating Load	7 MW

3.2 ENERGY TRANSFER STATIONS

Generally, each building on the St. FX campus is equipped with its own Energy Transfer Station (ETS). These stations use steam-to-water heat exchangers to transfer thermal energy from the district energy system to the building’s own hydronic heating and domestic water heating systems. The current district energy distribution system from the central plant supplies high pressure steam at 100 psi.

On the building side of the ETS, different buildings were designed with various heating water supply and return temperatures, but most are in the range of 150-180°F supply.

3.3 GEOTHERMAL BOREFIELDS

Five existing buildings on the St FX campus are provided with heating and cooling energy from three geothermal borefields coupled with water-source heat pumps. These buildings also have connections to the existing high-pressure steam and condensate distribution system from the central plant as backup to their heat pump systems. The manufacturers, capacities and deployment strategies of the heat pumps within the buildings vary, but it is our understanding that with the exception of the borefield serving O’Regan and Riley Halls (which appears undersized based on steam consumption data), the geothermal systems are functioning as intended and have effectively decoupled these newer buildings from their reliance on fossil-fuel fired boilers.

4 ST. FRANCIS XAVIER UNIVERSITY CAMPUS (ST. FX) – BUILDING SYSTEM SUMMARIES

“St. FX is located in Mi’kma’ki, the unceded ancestral territory of the Mi'kmaw people. The Mi'kmaw name for Antigonish is Nalikitquniejk, meaning ‘place where branches are torn off.’”

St. FX campus has a central steam plant which feeds high pressure steam to the campus steam network. Each building on this network uses a pressure reducing valve (PRV) station to lower steam pressure prior to energy exchange between steam and low temperature hot water.

There are two (2) buildings on campus that are not on the campus steam plant and have dedicated boiler units.

1. J Bruce Brown
2. MacDonald Hall

Five (5) buildings on the campus use heat pumps, served by geothermal wells as their primary source of heat, supplemented by steam.

1. Schwartz
2. Nicholson Tower
3. Mulroney Hall
4. O'Regan Hall
5. Riley Hall

The following is a summary of each building use, their systems, and how they currently are operating.

4.1 XAVIER HALL

4.1.1 MECHANICAL SUMMARY

Xavier Hall is a heritage building. Construction of the east wing began in 1888. The west wing and main section with the tower were built in 1895. The building was renovated in c. 1895 to include the kitchen, infirmary, and client comforts. This building was again renovated in 1897 and 1899 to include additional dormitory space and laboratories. It was again renovated in 1996 to replace the windows, and roof. Exhaust fans for the washrooms were installed at this time. New steam and condensate pipes were installed to serve the existing cast iron radiators. There are electric baseboard heaters in selected areas of the building.

4.1.2 ELECTRICAL SUMMARY

The building presently has a 200A, 600V, 3 Phase, 3Wire main disconnect switch. The service is fed from a 150A, 600V, 3 Phase fused disconnect switch with an energy meter located in Coady Institute (East) building. There is a 75kVA, 600V to 208/120V stepdown transformer to service the building loads. The existing building service will accommodate the mechanical approach to this building.

There a 625kVA, 600V standby generator power for this facility.

4.2 SCHWARTZ SCHOOL OF BUSINESS

4.2.1 MECHANICAL SUMMARY

The Schwartz School of Business was built c. 1950’s and renovated in 2010. The building is heated and cooled by several water-to-air heat pump units which are fed by water-to-water heat pumps connected to the geothermal wells. The building is connected to the campus steam network as a backup heat source, which is almost never used.

Electric water heaters supply domestic hot water. Dual flush and low flow fixtures contribute to low water usage.

The campus' main server room is in this building. The server room is cooled by two (2) water to water heat pumps and one (1) water to air heat pump in addition to a DX rack unit.

Figure 1: Central water to water HP units & steam PRV – Schwartz

4.2.2 ELECTRIC SUMMARY

The building presently has an 800A, 600V, 3 Phase, 3 Wire main service consisting of a Cutler-Hammer PRL3000 main switchboard with a 500AT/600AF main breaker. The existing main switchboard is in good shape and contains a wireway, main breaker section, and a 347/600V distribution section. The peak demand for the building is 275 kW. The existing building service will accommodate the mechanical approach to this building.

This service is fed from a three phase 600A, 600V, 3 Phase 600A fused disconnect switch that is located in Coady Institute (East) building.

There is no standby generator power for this facility, but the building receives emergency power from the 800A splitter in the Boiler house basement through a 200A fused disconnect that travels to a 100A, fused disconnect and feeds Panel EPA.

4.3 ST. NINIANS CATHEDRAL & PLACE

4.3.1 MECHANICAL SUMMARY

This heritage building was constructed 1867 through to 1874. It is constructed of stone and limestone. An addition was later added to the rear of the building (St. Ninians Place). The mechanical system is served by the university’s main steam plant network. Steam is fed to cast iron radiators throughout the building. This building is not maintained by the university, mechanical information is limited.

4.3.2 ELECTRICAL SUMMARY

The building is presently fed from an overhead three-phase pole mounted transformer bank, independent of the campus underground system. This building is not maintained by the university, electrical information is limited.

There is no standby generator power for this facility.

4.4 ANGUS L. MACDONALD LIBRARY

4.4.1 MECHANICAL SUMMARY

The original A. L. MacDonald Library was built in 1965. The second wing of the current library (Richard Chater Hall) was built in 1985. The main heating source is steam and includes two (2) steam to hot water heat exchanger to provide hot water to AHU’s pre-heat coils and radiant panels. Building cooling is provided by chillers which were recently removed and replaced by VRF units. Domestic hot water supplied by electric water heaters.

Figure 2: Main steam entrance & steam heat exchanger (HX) – MacDonald Library

4.4.2 ELECTRICAL SUMMARY

The building presently has a 1200A, 600/347V, 3 Phase, 4 Wire Siemens switchboard built in November 1985.

The service is fed from a 750/1000kVA three phase 12.47kV-600/347V transformer located in the main electrical room and fed from MH#14’s underground feeds.

The existing main service switchboard is in fair shape. The peak demand for the building is 218 kW. The existing building service will accommodate the mechanical approach to this building.

The building has a 400A, 600V Automatic Transfer Switch (ATS) that feeds a 3 x 100kVA transformer bank from 600V to 208/120V. This transformer feeds a 1200A enclosure with a 400A 3 Pole breaker connected to a 400A, 208/120V 3 Phase, 4 Wire splitter. The ATS receives its emergency feed from a 400A, 600V, 3 Phase, 3W splitter in the Central Heating Plant. This splitter shares the output of a 625kVA, 600V standby generator power located at the Central Heating Plant.

4.5 MOUNT SAINT BENARD (MSB)

4.5.1 MECHANICAL SUMMARY

Mount Saint Benard is a cluster of four (4) student residence buildings: Camden, Immaculate, Marguerite, Gilmora and a chapel.

The main steam entrance is in the Immaculate Hall for the MSB and contains two (2) steam to hot water heat exchangers.

Figure 3: Main steam entrance & steam HX – MSB

CAMDEN HALL

Camden Hall is a student residence. Level 1 is served by an air handling unit (AHU-1) with glycol heating coil and VAV reheat coil. Level 2 heating is provided by hot water baseboards. Level 3,4,5 student residence is served by baseboard radiators. A fresh air makeup unit (AHU 4-7) and glycol heating coils provide ventilation and cooling needs.

Figure 4: Hot water baseboard – Camden Hall

IMMACULATE HALL

This building was built in 1883 and renovated in the 1920's. It houses the main steam entrance with two (2) steam heat exchangers. Heat is provided by cast iron radiators. There are four (4) heat recovery ventilators (HRV) with hot water heating coils and a 6-ton heat pump provides additional cooling and heating was installed couple of years ago.

A steam driven instantaneous domestic hot water system is located in this building. It feeds domestic hot water to each of the buildings.

MARGUERITE HALL

Marguerite Hall and simulation lab (SIM) are equipped with air handling unit (AHU-3 and AHU-2) respectively. Heating is provided by glycol heat coil served by dedicated hot water to glycol heat exchangers and cold water is supplied by two (2) 27-ton air-to-water chiller modules.

Figure 5: Chillers - Marguerite Hall

GILMORA HALL

Gilmora Hall is the music hub of the campus. Built c. 1940's, the heat is provided by cast iron radiators. It has a mixed air AHU system with a hot water heat coil.

4.5.2 ELECTRICAL SUMMARY

Mount Saint Benard is a cluster of four (4) student residence buildings: Camden Hall, Immaculate Hall, Marguerite Hall, Gilmora Hall and a chapel.

The service is fed from a 450kVA, 4.16kV -600/347V three phase transformer protected with a 600A switch fused at 100A. The building presently has 400A, 600/347V, 3 Phase, 4 Wire panel. The peak demand for the building is 190 kW. There is no standby generator power for this facility.

4.6 MACDONALD HALL

4.6.1 MECHANICAL SUMMARY

MacDonald Hall is heated by a single oil boiler (B-2) and is not connected to the central steam plant. Boiler serves the air handling unit (AHU-1) and radiators. Domestic hot water (DHW) is provided by electric hot water heaters.

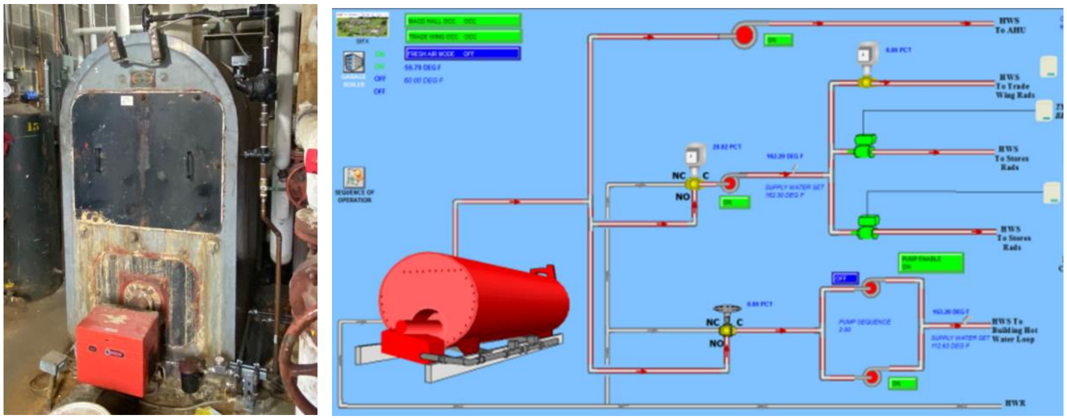

Figure 6: Oil Boiler & piping schematic – MacDonald Hall

4.6.2 ELECTRICAL SUMMARY

4.6.2.1 DISTRIBUTION OVERVIEW

The building presently has one (1) 208/120V sub feed from MacNeil Hall.

The load is fed from MacNeil Hall from a 225A, 600V splitter through a 60A, 600V fused disconnect switch to a 12.47kV line through a 45kVA, 600V to 208/120V, 3 Phase transformer. This feeds through a 200A, 208/120V, 3 Phase fused disconnect to a Panel E within MacDonald Hall

There is no generator for this facility

The peak demand for the building is 43 kW.

4.7 NICHOLSON TOWER

4.7.1 MECHANICAL SUMMARY

Nicholson Tower was built c. 1960's and was completely renovated in 2018. Building utilizes two (2) modular 20-ton heat pump units supplying hot & cold water to AHU's and fan coil units across the building. Heat pumps are served by a geothermal well (shared with Mulroney Hall) and has steam as backup (usage not being monitored). Domestic hot water is supplied by multiple electric water heaters.

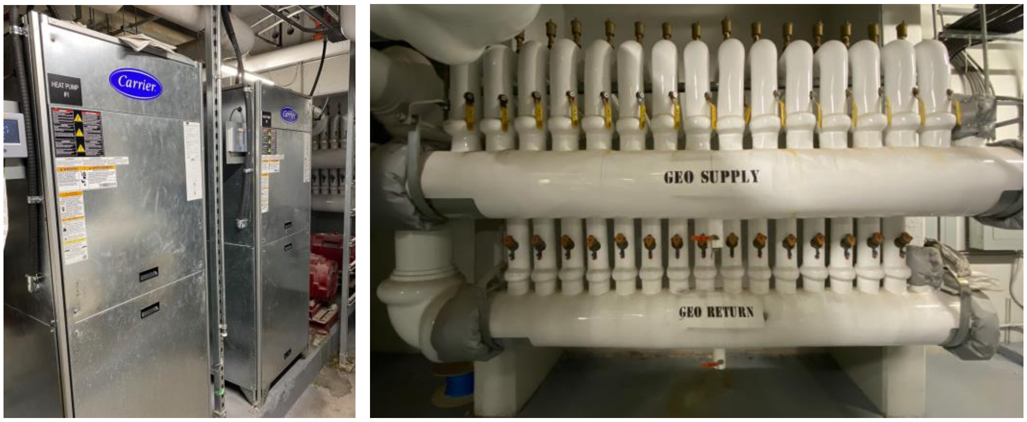

Figure 7: Central water to water HP units - Nicholson Tower

4.7.2 ELECTRICAL SUMMARY

The building presently has two (2) medium voltage feeds coming into the building from Manhole #12. The two (2) incoming lines are connected to a common bus prior to the connection of the two (2) loads and service the loads with a NO and NC switch configuration.

The first load is a 12.47kV line through a 600A switch fused at 125A to a 1500kVA, 12.47kV to 600/347V, 3 Phase transformer. This feeds through a 2000A, 600/347V, 3 Phase, 4 Wire main switchboard.

The second feed is a 12.47kV line through a 600A switch fused at 125A to the Annex building.

The peak demand for the building is 434 kW.

There is a 250kW/312.5kVA, 600/347V generator for this facility that powers a 400A, 600/347V, 3 Phase, 4 Wire Panel EP1A and in turn supplies power to a 225A, 600/347V ATS and a 100A, 600/347V ATS.

4.8 ANNEX

4.8.1 MECHANICAL SUMMARY

Existing building is to be demolished and replaced with a new building in next two (2) years. For this report analysis, we have assumed same load profile to continue. Existing building is connected to central steam plant.

4.8.2 ELECTRICAL SUMMARY

The Annex is presently fed from the medium voltage feed coming into the Nicholson Hall from Manhole #12. The two (2) incoming lines are connected to a common bus prior to the connection of the two (2) loads and service the loads with a NO and NC switch configuration.

The first load is a 12.47kV line through a 600A switch fused at 125A to a 1500kVA, 12.47kV to 600V, 3 Phase transformer. This feeds through a 2000A, 600/347V, 3 Phase, 4 Wire main switchboard.

The second feed is a 12.47kV line through a 600A switch fused at 125A to the Annex building.

4.9 J BRUCE BROWN

4.9.1 MECHANICAL SUMMARY

The J Bruce Brown building is the centre for animal and plant research. It houses an aquatic room as well as a greenhouse on the roof. The building was constructed c. 1970's. Four (4) propane boilers were installed in 2020 which serves the AHU's and perimeter hydronic radiators. Domestic hot water is served by electric hot water heaters. The building also houses a 150-ton water cooled chiller. This building has no steam connection.

Figure 8: Propane Boilers & Chiller - JBB

4.9.2 ELECTRICAL SUMMARY

The building presently has two (2) medium voltage feeds coming into the building from Manhole #9. The two (2) incoming lines are connected to a common bus prior to the connection of the single load.

The load is a 12.47kV line through a 600A switch fused at 125A to a 1500kVA, 12.47kV to 600/347V, 3 Phase transformer. This feeds through a 1200A, 600/347V, 3 Phase, 4 Wire main switchboard with a 1600AT/1600AF main breaker. The 200AT/400AF branch Breaker feeds the 225A, 600/347V, 3 Phase, 4Wire ATS that powers a 225A, 600/347V, 3 Phase, 4 Wire Panel EPA

There is a 125kW/156kVA, 600/347V, 3 Phase, 4 Wire generator with a 150A main breaker for this facility.

4.10BLOOMFIELD CENTRE

4.10.1 MECHANICAL SUMMARY

The Bloomfield centre was built in 1972. This is the Student Union building, along with convenience store and café. There are two (2) steam to hot water heat exchangers in the building serving radiators and a steam to glycol heat exchanger serving AHU-1. A hot water to glycol exchanger serving AHU-2. Multiple Mitsubishi variable refrigerant flow (VRF) units serve areas across the building. Two (2) 80-gal hybrid heat pump domestic hot water tanks were installed in 2023.

Figure 9: Main steam entrance, DHW & VRF units - Bloomfield Centre

4.10.2 ELECTRICAL SUMMARY

The building presently has two (2) medium voltage feeds coming into the building from Manhole #10. The two (2) incoming lines are connected to a common bus prior to the connection of the single load.

The load is a 12.47kV line through a 600A switch fused at 50A to a 450kVA, 12.47kV to 208/120V, 3 Phase transformer. This feeds through a 1600A, 208/120V, 3 Phase, 4 Wire main switchboard with a 1600AT/1600AF main breaker. The 600AT/800AF branch Breaker feeds the 400A, 208/120V, 3 Phase, 4 Wire ATS that powers a 600A, 208/120V, 3 Phase, 4 Wire emergency panel.

There is a 175kW/219kVA, 208/120V, 3 Phase, 4 Wire generator for this facility

The peak demand for the building is 222 kW.

4.11MACISAAC HALL

4.11.1 MECHANICAL SUMMARY

MacIsaac Hall was built in 1967. This dormitory was renovated in 2015. There are two (2) steam to hot water heat exchangers providing hot water to the building heating system. A steam to glycol heat exchanger serves the air handling unit (AHU-1). Domestic hot water is served by an instantaneous steam to hot water heat exchanger.

Figure 10: Main steam entrance & steam HX - MacIsaac Hall

4.11.2 ELECTRICAL SUMMARY

The building presently has two (2) medium voltage feeds coming into the building from Manhole #6. The two incoming lines are connected to a common bus prior to the connection of the single load.

The load is a 12.47kV line through a 600A switch fused at 40A to a 450kVA, 12.47kV to 208/120V, 3 Phase transformer. This feeds through a 1600A, 208/120V, 3 Phase, 4 Wire main switchboard with a 1600AT/2000AF main breaker.

There is no generator for this facility

The peak demand for the building is 87 kW.

4.12FX HALL

FX Hall is a student residence and was built c. 1966. There are two (2) steam to hot water heat exchangers serving to building heat (perimeter radiators) and domestic hot water respectively.

Figure 11: Steam HX - FX Hall

4.12.1 ELECTRICAL SUMMARY

No information was obtained for this site

4.13CHARLES V. KEATING CENTRE (KMC)

4.13.1 MECHANICAL SUMMARY

The Charles V. Keating Centre was built in 2001. This building houses two (2) indoor ice rinks. There are four (4) steam heat exchangers serving the building located in the adjacent building (Saputo Centre). Two (2) steam to glycol heat exchanger serves snow melting system and AHU’s, and the remaining two (2) steam to hot water heat exchangers serves in-floor heat and radiators. There are two (2) 120-gal glycol to domestic hot water tanks. Cooling is provided by direct expansion (DX) coil.

Figure 12: Steam HX – Keating Centre

4.13.2 ELECTRICAL SUMMARY

The building presently has two (2) medium voltage feeds coming into the building from Manhole #2. The two (2) incoming lines are connected to a common bus prior to the connection of the load.

The load is a 12.47kV line through a 600A switch fused at 100A to a 1500kVA, 12.47kV to 600/347V, 3 Phase transformer. This feeds through a 2500A, 600/347V, 3 Phase, 4 Wire main switchboard with a 2000AT/2000AF main breaker. The 200AT/800AF branch breaker feeds the 200A, 600/347V, 3 Phase, 4Wire ATS that powers a 250A, 600/347V, 3 Phase, 4 Wire Panel EPA.

There is a 125kW/156kVA, 600/347V, 3 Phase, 4 Wire generator with a 150A main breaker for this facility.

The peak demand for the building is 459 kW.

4.14SAPUTO CENTRE (FORMERLY OLAND CENTRE) + POOL

4.14.1 MECHANICAL SUMMARY

Amella Saputo Centre is the primary recreation program facility in the campus and is currently under renovation. The existing Airmec system is being replaced with eight (8) new 15-ton variant refrigerant flow (VRF) Samsung units as indicated by the maintenance staff. New indoor fan coil units will be added to the building. Building also used steam for heating and many of the existing AHU’s will continue to stay on steam after renovations. The building also has a pool which is heated by steam.

Figure 13: Main steam entrance - Saputo Centre

4.14.2 ELECTRICAL SUMMARY

The building presently has two (2) medium voltage feeds coming into the building from Manhole #4. The two (2) incoming lines are connected to a common bus prior to the connection of the load.

The load is a 12.47kV line through a 600A switch fused at 25A to a 450kVA, 12.47kV to 208/120V, 3 Phase transformer. This feeds through a 1200A, 208/120V, 3 Phase, 4 Wire main switchboard with a 1200AT/2000AF main breaker. The 200AT/800AF branch breaker feeds the 200A, 600/347V, 3 Phase, 4Wire ATS that powers a 250A, 600/347V, 3 Phase, 4 Wire Panel EPA.

There is no standby generator power for this facility, but the building receives emergency power from the 600A, 600V, 3 Phase, 3Wire splitter in the Boiler house basement through a 200A fused disconnect the travels to a 200A, fused disconnect that feeds a 200A, 600V emergency splitter that feeds a 75kVA 600V to 208/120V transformer. This transformer is protected with a 100A fuse and feeds Panel EDP in the facility. The emergency splitter also feeds MacNeil Hall.

The peak demand for the building is 229 kW.

4.15GOVERNORS HALL

4.15.1 MECHANICAL SUMMARY

Governors Hall was built in 2005. There are two (2) steam to glycol heat exchangers that supply hot water to the baseboard heaters and a steam to instantaneous domestic hot water (DHW) at 63-gpm. Each unit in the building has an indoor fan coil unit served by the heat exchanger for heating and a136-ton chiller for cooling. Fresh air is provided by multiple HRV units.

Figure 14: Main steam entrance & Chiller - Governors Hall

4.15.2 ELECTRICAL SUMMARY

The building presently has two (2) medium voltage feeds coming into the building from Manhole #19. The two (2) incoming lines are connected to a common bus prior to the connection of the load and service the load with a NO and NC switch configuration.

The load is a 12.47kV line through a 600A switch fused at 40A to a 500kVA, 12.47kV to 208/120V, 3 Phase transformer. This feeds through a 2000A, 208/120V, 3 Phase, 4 Wire main switchboard.

The peak demand for the building is 276kW.

There is a 60kW/75kVA, 208/120V generator for this facility that powers an ATS that feeds a 400A, 208/120V, 3 Phase, 4 Wire Panel EDP.

4.16POWER & SOMERS HALL

4.16.1 MECHANICAL SUMMARY

Power and Somers Hall were built c. 1999. Power Hall houses the main steam entrance for both buildings. Power Hall is comprised of thirty-two (32) residential units. Somers is comprised of 40 residential units. There are two (2) steam to hot water heat exchangers to serve each building. Each residential unit has a heat recovery ventilator (HRV). Power Hall has eighteen (18) 80-gal electric domestic hot water tanks. Somers Hall has twenty-two (22) 80-gal electric domestic hot water tanks.

Figure 15: Main steam entrance & steam HX - Power & Somers Hall

4.16.2 ELECTRICAL SUMMARY

The Power Hall building presently has two (2) medium voltage feeds coming into the building from Manhole #17. The two (2) incoming lines are connected to a common bus prior to the connection of the load and service the load with a NO and NC switch configuration.

The load is a 12.47kV line through a 600A switch fused at 35A to a 450kVA, 12.47kV to 208/120V, 3 Phase transformer. This feeds through a 1600A, 208/120V, 3 Phase, 4 Wire main switchboard with a 1600AT/1600AF main breaker.

A 600A branch breaker from the Power Hall main service feeds Somers Hall through a 600A, 208/120V, 3 Phase, 4Wire Panel PBB.

There is no standby generator power for this facility, but the building receives emergency power from the 600A, 600V, 3 Phase, 3Wire splitter in the Boiler house basement through a 60A fused disconnect the travels to a 60A, fused disconnect that feeds a 45kVA 600V to 208/120V transformer. This transformer is protected with a 60A fuse and feeds a 225A, 208/120V 3 Phase, 4 Wire ATS which in turn feeds a 225A, 208/120V 3 Phase, 4 Wire Panel EDP in the facility. Panel EDP feeds a 225A, 208/120V 3 Phase, 4 Wire Panel EAB which has a 100A branch breaker that feds a 100A, 208/120V 3 Phase, 4 Wire ATS.

The peak demand for the building is 218kW.

4.17BISHOPS HALL

4.17.1 MECHANICAL SUMMARY

Bishops Hall opened in 1963. It was renovated in 2007. There are two (2) steam to hot water convertors serving ceiling radiant panels and a steam to glycol heat exchanger serving AHU’s make-up air units.

Figure 16: Main steam entrance & steam HX - Bishops Hall

4.17.2 ELECTRICAL SUMMARY

The University Chapel Vault presently has one (1) medium voltage feeds coming into the building from Manhole #13 via the Central Heating Plant.

The load is a 12.47kV line through a 600A switch fused at 15A to a second 600A switch fused at 20A in the vault that feeds a 300kVA, 12.47kV to 600/347V, 3 Phase transformer. This feeds through a 1200A, 600/347V, 3 Phase, 4 Wire main Cutler-Hammer switchgear located in the University Chapel Vault is in good condition and was built in 2007.

A 400A branch breaker from the switchboard in the University Chapel Vault feeds Bishops Hall through a 400A fused disconnect switch to a Panel PPA, which is a Cutler-Hammer #PRL4 distribution panel that was built in 2007 and is in good condition.

The second feed from the 1200A, 600/347V, 3 Phase, 4 Wire main switchboard in the University Chapel Vault is a 150A branch breaker that feeds a 112.5kVA, 600 to 208/120V, 3 Phase transformer. This feeds through a 400A, 208/120V, 3 Phase, 4 Wire main Panel DPA in the University Chapel Vault.

The peak demand for the building is 57kW.

There is no standby generator power for this building.

4.18ST. FX UNIVERSITY CHAPEL

4.18.1 MECHANICAL SUMMARY

St. FX University Chapel was built in 1948. Building uses cast iron steam radiators for heating and in 2013 a steam to hot water heat exchanger was added to serve the air handling unit heat coils.

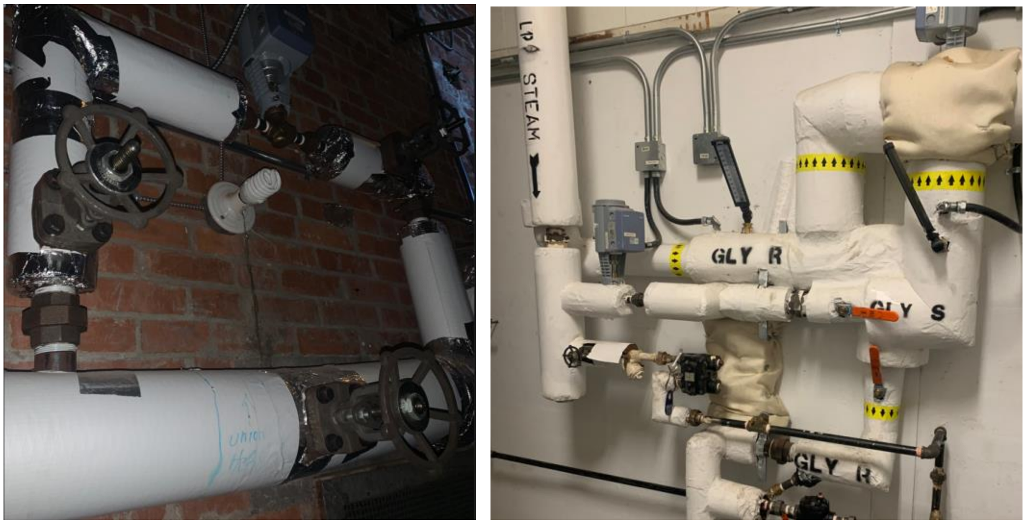

Figure 17: Main steam entrance & steam HX - Chapel

4.18.2 ELECTRICAL SUMMARY

The University Chapel Vault presently has one (1) medium voltage feed coming into the building from Manhole #13 via the Central Heating Plant.

The load is a 12.47kV line through a 600A switch fused at 15A to a second 600A switch fused at 20A in the vault that feeds a 300kVA, 12.47kV to 600/347V, 3 Phase transformer. This feeds through a 1200A, 600/347V, 3 Phase, 4 Wire main Cutler-Hammer switchgear located in the University Chapel Vault is in good condition and was built in 2007.

A 400A branch breaker from the switchboard in the University Chapel Vault feeds Bishops Hall through a 400A fused disconnect switch to a Panel PPA, which is a Cutler-Hammer #PRL4 distribution panel that was built in 2007 and is in good condition.

The second feed from the 1200A, 600/347V, 3 Phase, 4 Wire main switchboard in the University Chapel Vault is a 150A branch breaker that feeds a 112.5kVA, 600 to 208/120V, 3 Phase transformer. This feeds through a 400A, 208/120V, 3 Phase, 4 Wire main Panel DPA in the University Chapel Vault.

The peak demand for the building is 57kW.

There is no standby generator power for this building.

4.19BAUER THEATRE

4.19.1 MECHANICAL SUMMARY

The Bauer Theatre was built in 1974 and renovated in 1997. Building has cast iron steam radiators for building heat and electric 75-gal hot water tank. The air handling uses a 2-stage electric heat and DX coil for cooling.

Figure 18: Main steam entrance & cast-iron steam radiator - Bauer theatre

4.19.2 ELECTRICAL SUMMARY

The Bauer Theatre has two (2) feeds that originate in the Central Heating Plant.

One (1) feed is 60A fused disconnect switch feed from an 800A, 600V, 3 Phase, 3Wire splitter in the Central Heating Plant that feeds a 30kVA, 600 to 208/120V, 3 Phase transformer within the Bauer Theatre.

The second feed is a 200A breaker from a 600A, 600V, 3 Phase, 3Wire panel board in the Central Heating Plant that feeds the Bauer Theatre Panel PBT within the Bauer Theatre.

The peak demand for the building is 58kW.

There is no standby generator power for this building.

There is no standby generator power for this facility, but the building receives emergency power from the 600A, 600V, 3 Phase, 3Wire ATS in the Boiler house basement that is connected to a shared 625kVA, 600/347V, 3 Phase, 4 Wire standby generator power located in the Central Heating Plant.

4.20PHYSICAL SCIENCES CENTRE (PSC)

4.20.1 MECHANICAL SUMMARY

The Physical Science Centre was built in 2004. It houses two (2) steam to hot water heat exchangers serving perimeter and reheat coils. There are two (2) steam to glycol heat exchangers serving air handling units AHU 1-4. There are two (2) domestic hot water tanks served by a steam to hot water heat exchanger. Cooling is provided by rooftop chiller serving the AHU’s.

Figure 19: Steam PRV units & Chiller – PSC

4.20.2 ELECTRICAL SUMMARY

The building presently has two (2) medium voltage feeds coming into the building from Manhole #16. The two (2) incoming lines are connected to a common bus prior to the connection of the load.

The load is a 12.47kV line through a 600A switch fused at 90A to a 1500kVA, 12.47kV to 600/347V, 3 Phase transformer. This feeds through a 2000A, 600/347V, 3 Phase, 4 Wire Siemens main switchboard which contains a wireway, 1000AT/2000AF main breaker, Utility CT/PT and meter section and a 600V distribution section. There is a 400A branch breaker that feeds the 400A, 600/347V, 3 Phase, 4Wire ATS that powers a 400A, 600/347V, 3 Phase, 4 Wire Panel EPP1.

There is a 360kW/450kVA, 600/347V, 3 Phase, 4 Wire generator with a 400A main breaker for this facility.

The peak demand for the building is 455 kW.

4.21MORISSON HALL

4.21.1 MECHANICAL SUMMARY

Morrisson Hall is the main dining space for student residents. The building has multiple heating systems. The top two (2) floors are heated by perimeter steam radiators. The building also has two (2) steam to hot water heat exchangers which serve the AHU's and perimeter hydronic baseboard across the building. The main dining area and Starbucks spaces also has VRF units to provide heating and cooling. Domestic hot water (DHW) is provided by two (2) steam to DHW converter tanks. Make-up air for the kitchen is served by three (3) air handling units (AHU 1, 2, and 5). Rooftop heat recovery ventilators units (AHU-3 and AHU-4) serve the remainder of the building.

Figure 20: Main steam entrance & VRF units - Morisson Hall

4.21.2 ELECTRICAL SUMMARY

The building presently is fed from an 800A breaker from the 1200A, 600/347V, 3 Phase, 4 Wire CDP Panel in the MacDonald Library. This feeds through an 800A, 600/347V, 3 Phase, 4 Wire Siemens main switchboard with an 800A main breaker. The switchboard that is in good condition.

A branch breaker from the Morrison Hall panel feeds the normal connection for an ATS that services the Fire Pump.

A second branch breaker from the Morrison Hall panel feeds a second 250A, 600V ATS that services a 400A, 600V, 3 Phase, 3 Wire splitter. The splitter feed the emergency connection for an ATS that service the Fire Pump and a 225kVA 600 to 208/120V transformer the services Panel 3E1. The second ATS receives its emergency feed from a 400A, 600V, 3 Phase, 3W splitter in the Central Heating Plant routed through a connection in the Angus MacDonald Library. This splitter shares the output of a 625kVA, 600V standby generator power located at the Central Heating Plant.

The peak demand for the building is 243kW.

4.22MACKINNON HALL

4.22.1 MECHANICAL SUMMARY

MacKinnon Hall was built c. 1950's. It is an architectural twin to Cameron Hall. This student residence is composed of the Chisholm, Gillis, and MacNeil Houses. Direct steam serves all three (3) zones steam radiators, controlled by pressure relief valves. Domestic hot water (DHW) is served by a single steam to DHW tank.

Figure 21: Main steam entrance & DHW tank - MacKinnon Hall

4.22.2 ELECTRICAL SUMMARY

The building presently is fed from the 800A, 600V, 3 Phase, 3 Wire splitter in the Central Heating Plant. This feeds through a 400A, 600V, 3 Phase, 3 Wire splitter in MacKinnon Hall.

A fusible disconnect switch, fused at 200A feeds the Cody Institute (East) Building.

A second fusible disconnect switch fused at 60A feeds a 225A, 600V, 3Phase, 3 Wire splitter in MacKinnon Hall. This splitter services the elevator and a 75kVA 600 to 208/120V transformer the services Panel PPA.

The 800A, 600V, 3 Phase, 3 Wire splitter in the Central Heating Plant shares the output of a 625kVA, 600V standby generator power located at the Central Heating Plant.

The peak demand for the building is 50kW.

4.23CAMERON HALL

4.23.1 MECHANICAL SUMMARY

Cameron Hall was built in c. 1945. This student residence is composed of the Thompson/Thompkins, MacPherson and MacDonald houses. Direct steam serves all three (3) zones steam radiators, controlled by pressure relief valves. Domestic hot water (DHW) is served by two (2) steam to DHW tanks and one (1) electric DHW tank.

Figure 22: Main steam entrance & DHW tank - Cameron Hall

4.23.2 ELECTRICAL SUMMARY

The building presently has two (2) 200A, 208/120V, 3 Phase, 4 Wire feeders coming from the Coady International Institute (East) building.

The first feeder is from a 200A-3P breaker in a 208/120V, 800A, 3 Phase, 4 Wire panel located in the Coady International Institute (East), which feeds Panel NB in Cameron Hall.

The second feeder is from a 200A-3P breaker in the same 208/120V, 800A, 3 Phase, 4 Wire panel located in the Coady International Institute (East), which feeds Panel NA in Cameron Hall.

The peak demand for the building is 57 kW.

This building originally power by the 800A, 600V, 3 Phase, 3 Wire splitter in the Central Heating Plant that shares the output of a 625kVA, 600V standby generator power located at the Central Heating Plant.

4.24MOCKLER HALL

4.24.1 MECHANICAL SUMMARY

Mockler Hall was built in 1915. It houses one (1) steam to hot water heat exchanger and two (2) electric 75-gal domestic hot water tanks. Heating is provided by hot water radiators.

4.24.2 ELECTRICAL SUMMARY

More electrical information is required.

The peak demand for the building is 27 kW.

4.25COADY INTERNATIONAL INSTITUTE (EAST)

4.25.1 MECHANICAL SUMMARY

The Coady International Institute (East) building was built c. 1800's and was renovated in 2007. There are two (2) steam to glycol heat exchangers serving three (3) constant air volume air handling units (AHU). Electric baseboard heating is used in select locations. A 66-ton air-cooled chiller located outside with a heated slab (snow melting) serves the AHU's coil. Domestic hot water (DHW) is provided by five (5) electric DHW heaters.

Figure 23: Glycol exchanger & Chiller - Coady (East)

4.25.2 ELECTRICAL SUMMARY

The building presently has one (1) 200A, 600/347V, 3 Phase, 4 Wire feeder coming from the MacKinnon Hall main 400A, 600V, 3 Phase, 3 Wire splitter. It is protected with a 200A fused disconnect switch.

The feeder supplies a 400A, 600V, 3Phase, 3 Wire splitter located in the Coady International Institute (East), which feeds a splitter in Xavier Hall with a 150A fused disconnect switch and a 225kVA 600 to 208/120V transformer that services an 800A, 208/120V, 3 Phase, 4Wire Panel located in the Coady International Institute (East).

This building has a connection to the 1600A, 600V, 3 Phase, 3 Wire Panel PPA in the Central Heating Plant that shares the output of a 625kVA, 600V standby generator power located at the Central Heating Plant. Internally it has Panel PPA and Panel PPB. Panel PPB feeds Coady Institute (West).

4.26 COADY INTERNATIONAL INSTITUTE (WEST)

4.26.1 MECHANICAL SUMMARY

The Coady International Institute (West) building was built c. 1800's and was renovated in 2007. There are two (2) steam to glycol heat exchangers serving three (3) packaged roof top units heating coil with DX cooling. Building also used glycol and electric unit heaters in select locations.

Figure 24: Glycol exchangers - Coady (West)

4.26.2 ELECTRICAL SUMMARY

The building presently has one (1) 300A, 600/347V, 3 Phase, 4 Wire feeder coming from the Coady International Institute (East) Panel PPB.

Panel PPB is a 400A, 600V, 3 Phase, 3 Wire panel that feeds a 400A, 600V, 3Phase, 3 Wire Panel PPC located in Coady International Institute (West). It is protected with a 300A fused disconnect switch

This building has a connection to the 1600A, 600V, 3 Phase, 3 Wire Panel PPA in the Central Heating Plant that shares the output of a 625kVA, 600V standby generator power located at the Central Heating Plant.

4.27 O'REGAN HALL & RILEY HALL

4.27.1 MECHANICAL SUMMARY

O'Regan and Riley Hall were built in 2013. These student residences are similar in architecture and mechanical/ electrical systems. Both buildings have in floor heating and cooling provided by geothermal wells and heat pump configuration. Each building has four (4) heat pump modules and a shared geothermal well. Ventilation is provided by two (2) AHUs with heat pump cooling and heat provided by steam to glycol exchanger. It was reported by the maintenance staff that geothermal wells were not enough to meet the in-floor heating and AHUs heating load together and hence they switched AHUs to 100% steam heat (usage not being monitored). Domestic hot water is supplied by steam to DHW exchanger in each building.

Figure 25: Steam to Glycol exchanger & HP modules - O'Regan & Riley Hall

4.27.2 ELECTRICAL SUMMARY – O’REGAN HALL

The building presently has two (2) medium voltage feeds coming into the building from MacIsaac Hall. The two (2) incoming lines are connected to a common bus prior to the connection of the single load.

The load is a 12.47kV line through a 600A switch fused at 30A to a 500kVA, 12.47kV to 600/347V, 3 Phase transformer. This feeds through a 600A, 600/347V, 3 Phase, 4 Wire main switchboard. The 250AT/400AF branch Breaker feeds the 400A, 600/347V, 3 Phase, 4 Wire Panel PPB in Riley Hall.

The second branch breaker is a 60A breaker is for a 100A, 600V, 3 Phase, 4 Wire ATS that supplies a 250A, 600/347V, 3 Phase, 4 Wire Panel EPA. The Panel EPA also has a 50A branch breaker that supplies the 250A, 600/347V, 3 Phase, 4 Wire Panel EPA in Riley Hall.

There is a 40kW/50kVA, 600/347V, 3 Phase, 4 Wire generator with a 50A main breaker for this facility.

The peak demand for the building is 237 kW.

4.28 MULRONEY HALL

4.28.1 MECHANICAL SUMMARY

Mulroney Hall is a LEED Gold, educational and media facility opened in 2019. There is a shared geothermal field (60 wells, drilled 600 feet into the ground) on the south side of the building shared with Nicholson Tower, which combined with a series of heat pumps, keeps the building comfortable year-round. There are four (4) heat pump modules with three (3) dedicated for heating and remaining one (1) dedicated for cooling. Building uses steam as backup (usage not being monitored).

Dual flush and low flow fixtures contribute to maintain low water usage.

Mulroney Hall has two (2) solar panel arrays on its rooftops that produce a portion of the building’s electricity needs. Domestic hot water is supplied by electric water heaters.

Figure 26: HP modules, DHW & rooftop solar - Mulroney Hall

4.28.2 ELECTRICAL SUMMARY

More electrical information is required.

5 BUILDINGS WITHIN TOA

5.1 DR. JOHN HUGH GILLIS REGIONAL HIGH SCHOOL

5.1.1 MECHANICAL SUMMARY

Dr. John Hugh Gillis High School was built c. 1970. It is a two-storey high school designed for 1100 student capacity, currently running at ~750 occupancy year-round.

Three (3) VITOROND 200 oil-fired boilers were installed in 2010 & 2011. Heat distributed throughout the building using hot water radiant heaters and ten (10) AHUs.

The AHUs and domestic hot water tank are served by hot water to glycol heat exchangers.

DX Cooling is provided between 8:00am – 3:00pm to classrooms, staff room, and server room.

Figure 27: Boilers & Outdoor condensing units - Dr. John Hugh Gillis Regional High School

5.1.2 ELECTRICAL SUMMARY

Based on the mechanical summary the current electrical service is adequate to support tie-in to the district energy system.

5.2 ANTIGONISH EDUCATION CENTRE

5.2.1 MECHANICAL SUMMARY

The Antigonish Education Centre (AEC) was built in 2000. It is a two-storey building with a student capacity of 540. The heating is provided by two (2) oil-fired boilers that feed hot water to the in-floor heating grid, radiant heater units serving the gymnasium and glycol heat exchanger serving AHUs heating coil. There is no cooling in this building.

Domestic hot water is served by two (2) indirect domestic hot water tanks.

Figure 28: Boilers & Outdoor condensing units - Dr. John Hugh Gillis Regional High School

5.2.2 ELECTRICAL SUMMARY

Based on the mechanical summary the current electrical service is adequate to support tie-in to the district energy system.

5.3 ST. ANDREW JUNIOR HIGH

5.3.1 MECHANICAL SUMMARY

St. Andrew Junior High was built in 1996. It is a two-storey building. Heating is provided by two (2) oil-fired boilers. There is no cooling in this building. Heat distributed throughout the building using hot water radiant heaters. Hot water to glycol heat exchanger serves AHUs and HRV units. The AHUs have humidifiers which, according to maintenance staff, is never used. There is one indirect domestic hot water tank and an electric 120-gal unit.

Figure 29: Boilers & a DHW unit - St. Andrew Junior High

5.3.2 ELECTRICAL SUMMARY

Based on the mechanical summary the current electrical service is adequate to support tie-in to the district energy system.

5.4 ST. MARTHA REGIONAL HOSPITAL

5.4.1 MECHANICAL SUMMARY

St. Martha Regional Hospital was originally built in 1989. It is four-storeys high with a rooftop mechanical penthouse.

A Wellness Centre was built adjoining the hospital in 1967 also known as Martha Centre consists of admin/office spaces. It is five-storeys high with a rooftop mechanical penthouse.

A steam main plant, located in the hospital building serves both buildings. The plant consists of three (3) oil-fired boilers and serves steam to medical device reprocessing, kitchen, laundry, domestic hot water storage tanks and a steam to hot water heat exchanger. The steam to hot water heat exchangers serve heat to AHU heating coils, VAV reheat coils and perimeter radiant heat units, serving the majority of the building heating loads with a low-temperature hot water system.

There are two (2) chillers serving St. Martha Hospital, an 80-ton air cooled chiller and a 417-ton heat recovery chiller unit. It was reported by the maintenance team that during high humid season, both chillers are required to serve the load, otherwise only one is used to meet the load. St. Martha's operations staff also mentioned that the heat recovery feature of the chiller is never used and has been decommissioned for some time.

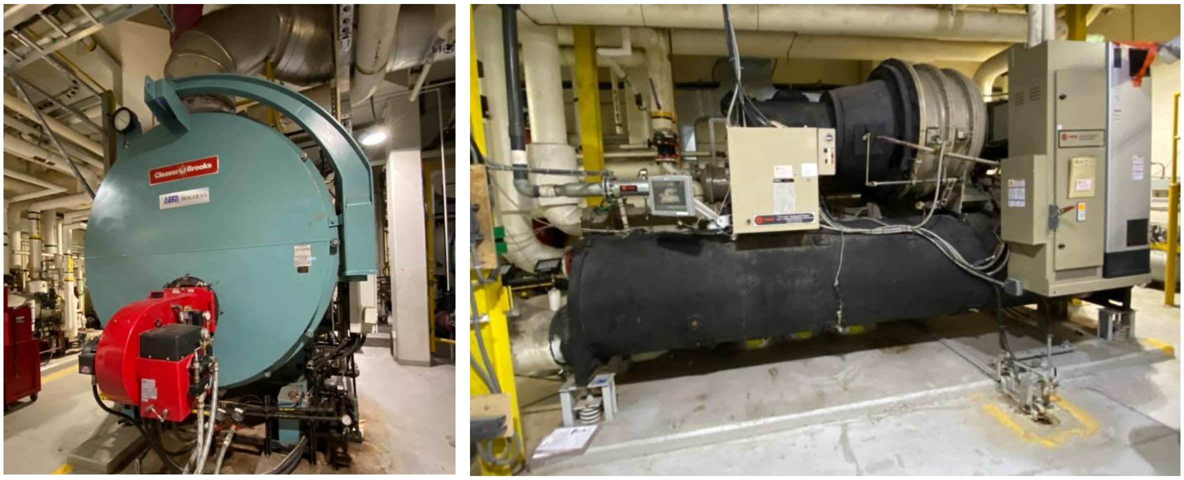

Figure 30: Boiler & Heat Recovery Chiller - St. Martha Regional Hospital

5.4.2 ELECTRICAL SUMMARY

The service is fed with two (2) 1500kVA, 25kV/600 transformer that go into a main distribution switchboard. The main distribution switchboard is split into a left and right side, each side contain a main 1600A frame ACB set at 1600A.

Based on the mechanical summary the current electrical service is adequate to support tie-in to the district energy system.

5.5 RK MACDONALD NURSING HOME

5.5.1 MECHANICAL SUMMARY

The RK MacDonald Nursing Home has 136 residences plus staff. The building includes suites, dining, commercial kitchen, and laundry facilities. The building is served by two (2) hot water boilers and two (2) low pressure steam boilers. There is a steam to glycol heat exchanger serving the air handling unit (AHU-2), kitchen, and domestic hot water.

An addition was built to serve as the resident wing. It is 25 years old and is heated by hot water radiators.

There are ten (10) air handling units. serving the nursing home, select being 100% outdoor air systems. Cooling is provided by multiple split unit systems in the resident wing.

A new RK MacDonald nursing home is under design. For this report analysis we have assuming the existing building will continue to operate as is.

Figure 31: Boiler & Hot water tank - RK MacDonald Home

5.5.2 ELECTRICAL SUMMARY

Based on the mechanical summary the current electrical service is adequate to support tie-in to the district energy system.

5.6 EAST COAST CREDIT UNION

The East Coast Credit Union’s HVAC system currently includes electric heat pumps. This building is hence not included in the study because it is already electrified and connecting it to district heating system will cost more than it will provide energy savings.

5.7 CANADIAN TIRE

Canadian Tire is the anchor tenant in the Antigonish mall. The building is served by electrical heating/cooling source without any use of fossil fuel. This building was also not included in the study.

5.8 MICROTEL INN & SUITES

Microtel Inn & Suites has three (3) propane fired hot water heaters for domestic hot water, one propane clothes dryer and propane dehumidifier for the pool.

Building heat is provided by heat pump units and ventilation by a rooftop air handling unit.

This building is also not considered in this study due to its distance from the remainder of the buildings.

6 PEAK HEATING LOAD, GAP ANALYSIS AND ENERGY MODELLING RESULTS

6.1 PEAK HEATING LOAD

To determine the proposed system size, an estimate of the peak loads required for each building also needed to be determined. The buildings are majorly divided into two subcategories: ST. Francis Xavier University (St. FX) campus and Town of Antigonish (TOA). These are discussed below:

6.1.1 ST. FX UNIVERSITY

The maintenance team provided the steam meter data for most of the buildings on campus. The data shared was from 2018-2020 and 2023 data for few buildings for which 2018-2020 data was not available (MSB, Morrison, FX hall & Bauer). There are few buildings on the campus for which steam meter data was not available and energy models were created for those buildings to identify peak loads. These buildings were either not on the steam plant and had dedicated oil boilers or they used geothermal heat pumps as the primary source of heat with steam as a backup.

The steam meter data shared was recorded at 15-minute interval per building. The data was interpolated to include time record inconsistencies (time tags were off by a minute in some instances), negative numbers, missing data due to functional/maintenance issues).

The data then was converted to 1-hour data by averaging 15-minute interval data per hour to obtain hourly peak values for individual buildings. Steam meter data was in lbs of steam, and it was converted to kW at 1,189 BTU/lb. pressure.

For the few buildings for which 2019-2020 steam data was missing, 2018 data was used. The graph shown below is the combined steam plant load of all the buildings. It follows a typical annual heat load profile. Individual building load profile graphs can be found in Appendix A.

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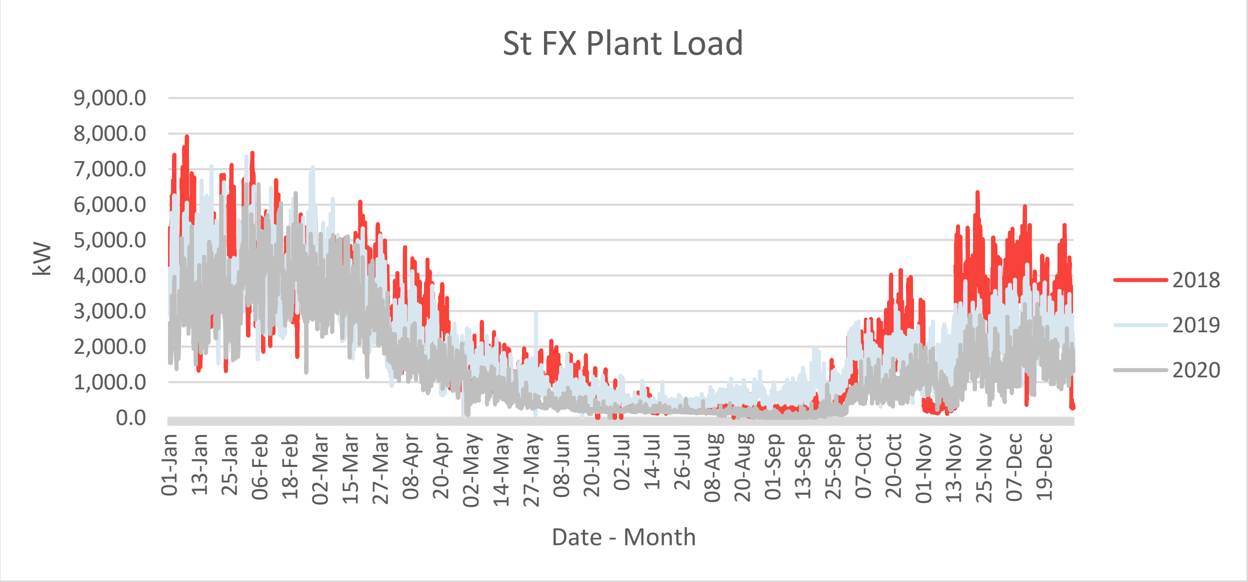


6.1.2 TOWN OF ANTIGONISH

As noted in the Buildings Within TOA section, East coast credit union, Canadian Tire and Microtel Inn & Suites are not included in this study because of being already electrified or being too far away from the district loop. For the remaining five (5) buildings, we received either annual oil bills or daily oil readings recorded by the maintenance staff. This data was helpful in estimating annual energy consumption and to estimate peak load we used different methods, which are discussed in the section below.

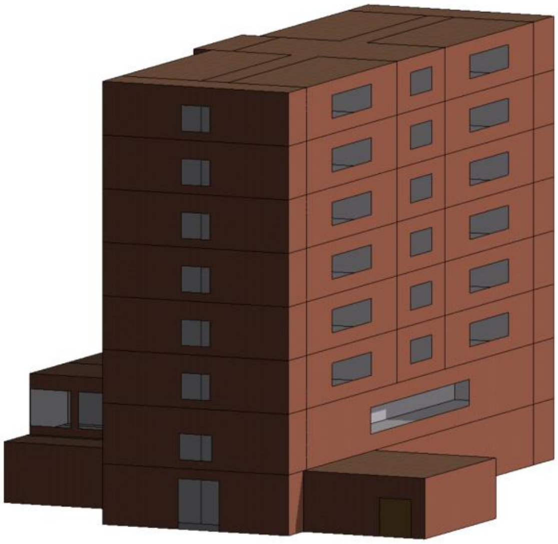
6.2 GAP ANALYSIS

Part of our initial review of the existing heating loads for the St. FX and TOA buildings was identifying information gaps and taking steps to inform ourselves of missing load data. As an example, the steam metering data for St. FX was skewed by faulty equipment and in some cases, complete lack of data due to failed or removed steam meters. For these datasets, some curve fitting was done to fill in missing info. For the purposes of a feasibility study however, only measured peak loads were considered in our preliminary equipment selections and layouts.

The St. FX buildings that were upgraded with geothermal heat pumps no longer have steam meters despite relying on steam for backup heat in the event of heat pump failure. Since these buildings have potential to benefit from and contribute a campus-wide LTHW DES, WSP used energy modelling analysis to estimate their annual peak heating loads. The modelling methodologies and results for these buildings are described within this section.

This section also shows approach taken for TOA building for which limited data was available.

6.2.1 NICHOLSON TOWER



Nicholson tower and Mulroney Hall uses water-to-water heat pump connected to a shared geothermal well system. These buildings loads were not being monitored and required energy modelling to estimate annual peak heating load and annual heating energy required to maintain comfort conditions in the building. The model was created in IESVE simulation software. Inputs are based on the architectural and mechanical drawings provided, and on ASHRAE 90.1-2016 defaults for lighting loads and internal gains according to space type.

Annual energy consumption is calculated using the CWEC 2020 weather file for the nearby Tracadie, NS weather station.

6.2.1.1 SUMMARY OF INPUTS AND ASSUMPTIONS

Nicholson Tower was rehabilitated in 2018. The building has a brick masonry wall which was partially insulated with 1-1/2” of spray foam. The insulation does not appear to continue around the vertical ventilation shafts between the windows, and the insulation plane does not line up with the plane of the windows, leading to significant thermal bridging at the window-wall interface. Insulated portions of the wall are estimated to have an overall thermal resistance of R-17 (including the pre-existing masonry wall, the insulation, and the internal stud wall) and uninsulated portions are estimated to be R-5. The uninsulated area is estimated to be 1/3 of the total opaque wall area. Including thermal bridging at the wall-window interface[1], the resulting average R-value is estimated to be R-7.9. The roof is estimated to be R-15.8, including the impact of thermal bridging at the uninsulated parapet. Below grade walls and the ground floor slab are modelled as uninsulated.

ENVELOPE	R-VALUE (FT^2·°F·HR/BTU)	U-VALUE (BTU/HR/FT^2·°F)
Exterior Walls	7.9	0.127
Windows	2.2	0.450
Roof	15.8	0.063
Window-to-wall ratio	13%	

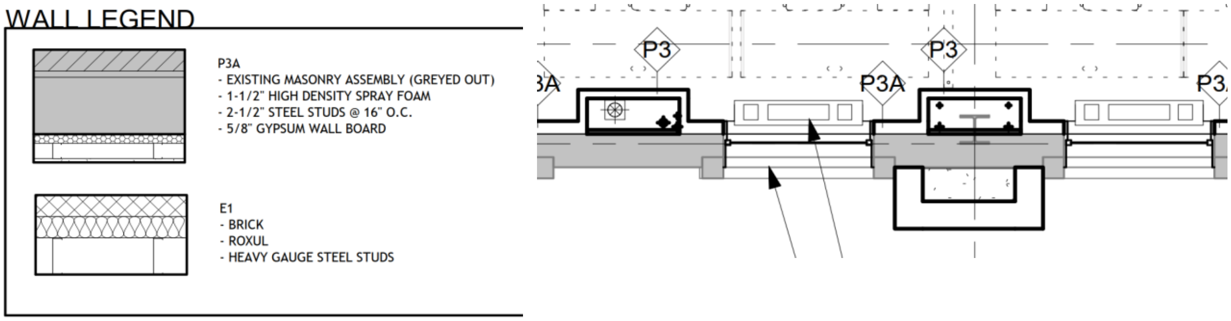


Figure 32: Wall details from architectural drawings

Equipment and lighting loads and occupant loads are based on ASHRAE defaults by space-type. The predominant space types in the Nicholson Tower are office and meeting spaces. The building-wide averages are given below.

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[1] Thermal bridging estimated following the procedures of V1.6 of the BC Hydro Thermal Bridging Guide, details 7.3.7 and 7.5.3.

INTERNAL LOADS	KW	W/FT^2
Lighting	31.5	0.81
Equipment	24.5	0.63

OCCUPANCY	NUMBER	FT^2/PERSON
Building peak occupancy	257	152

Ventilation rates are based on ASHRAE 62 default rates by space types. The building wide ventilation rate is given below.

VENTILATION	CFM	CFM/FT^2	CFM/PERSON
Minimum outdoor air	4,304	0.11	16.8

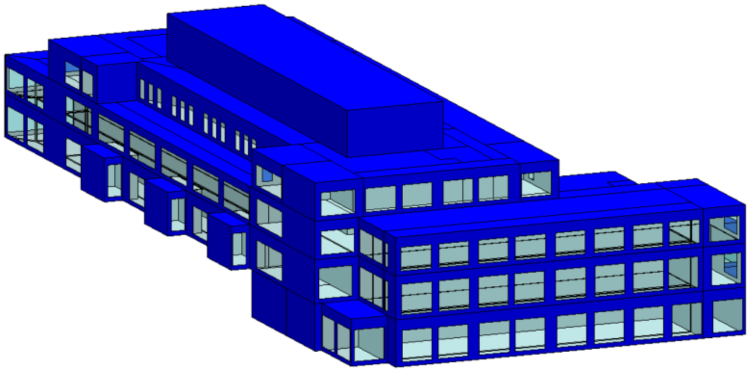
6.2.1.2 RESULTS

Peak heating loads and annual heating energy delivered to the building are given below.

HEATING PEAK DEMAND		HEATING PEAK DEMAND INTENSITY
kW	kBtu/hr	Btu/hr/ft^2
179	612	15.7

ANNUAL ENERGY DEMAND	MWH	KWH/M^2	MBTU	KBTU/FT^2
Heating	240	66	820	21.0

6.2.2 MULRONEY HALL



An energy model of Mulroney Hall on the campus of St. Francis Xavier University was created to estimate peak heating load and to estimate the annual heating energy required to maintain comfort conditions in the building. The model was created in IESVE simulation software. Inputs are based on the architectural and mechanical drawings provided, and on ASHRAE 90.1-2016 defaults for lighting loads and internal gains according to space type.

Annual energy consumption is calculated using the CWEC 2020 weather file for the nearby Tracadie, NS weather station.

6.2.2.1 SUMMARY OF INPUTS AND ASSUMPTIONS

Mulroney Hall is a new building opened in 2019. The building has a steel-framed wall with brick and stone veneer and metal wall panels. The walls are well insulated with 6 inches of semi-rigid insulation. Brick ties and thermal spacers provide a connection between the underlying structure and the brick or metal panels with minimal thermal bridging. The brick veneer appears to return around the sides of the windows, leading to significant thermal bridging at the window-wall interface. Spandrel panels are used in the multi-storey curtain walls to obscure the floor slabs. The spandrel panel R-value of 3.6 is based on Detail 2.1.1 of the BC Hydrothermal Bridging guide. Including the spandrel panels, the opaque exterior walls are estimated to have an average overall thermal resistance of R-10.7. The roof is estimated to be R-40 with 10 inches of insulation shown on the drawings. Insulation continues in the same plane down the wall into the foundation to the top of the footing. the foundation to the top of the footing. Windows are assumed to be relatively high performance in keeping with what is known about the envelope as a whole.

ENVELOPE	R-VALUE (FT^2·°F·HR/BTU)	U-VALUE (BTU/HR/FT^2·°F)
Exterior Walls	10.7	0.127
Windows	3.1	0.320
Roof	41.9	0.024
Window-to-wall ratio	27%	

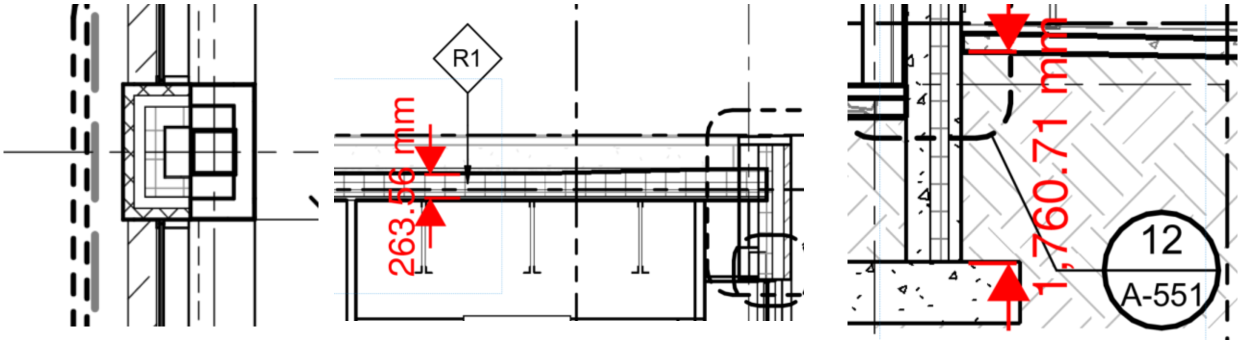


Figure 33: Wall and roof details from architectural drawings

Equipment and lighting loads and occupant loads are based on ASHRAE defaults by space-type. The predominant space types in the Mulroney Hall are classroom and lectures spaces, exhibit halls, and offices. The building-wide averages are given below. Note that ASHRAE default occupancy densities for auditorium and classrooms spaces lead to much higher occupancy that what is shown on the drawings for the auditorium and classroom spaces. The occupancy shown on the drawings (e.g. by counting seats in the auditorium) is used for these spaces.

INTERNAL LOADS	KW	W/FT^2
Lighting	79.1	0.80
Equipment	57.6	0.58

OCCUPANCY	NUMBER	FT^2/PERSON
Building peak occupancy	1,707	58

Ventilation rates are based on ASHRAE 62 default rates by space types. The building wide ventilation rate is given below.

VENTILATION	CFM	CFM/FT^2	CFM/PERSON
Minimum outdoor air	20,534	0.21	12.0

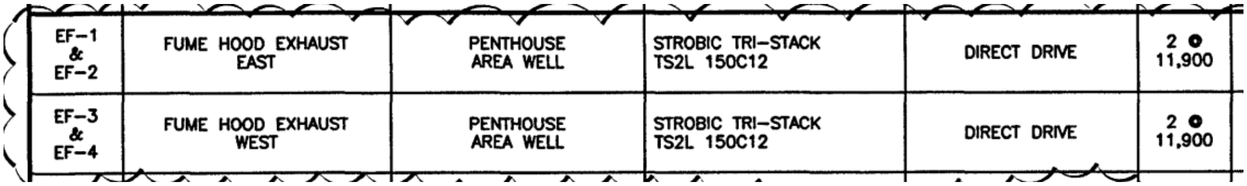
6.2.2.2 RESULTS

Peak heating load and annual heating energy delivered to the building are given below.

Table 1: Peak heating load

HEATING PEAK DEMAND		HEATING PEAK DEMAND INTENSITY
kW	kBtu/hr	Btu/hr/ft^2
332	1,131	11.5

The mechanical schedules for Mulroney Hall show significant exhaust flow rates of up to 47,600 cfm for fume hood exhaust.



EF-1 & EF-2	FUME HOOD EXHAUST EAST	PENTHOUSE AREA WELL	STROBIC TRI-STACK TS2L 150C12	DIRECT DRIVE	2 @ 11,900
EF-3 & EF-4	FUME HOOD EXHAUST WEST	PENTHOUSE AREA WELL	STROBIC TRI-STACK TS2L 150C12	DIRECT DRIVE	2 @ 11,900

Figure 34: Fume hood exhaust from mechanical schedule

If these exhaust fans are running at their full flow rate, they could add significantly to the peak heating loads. The resulting peak heating load for the building, including fume hood exhaust, are given below.

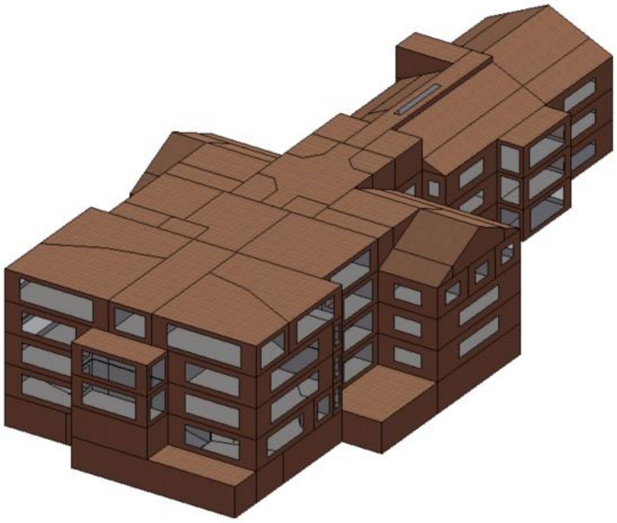
Table 2: Peak heating load including fume hood exhaust

HEATING PEAK DEMAND		HEATING PEAK DEMAND INTENSITY
kW	kBtu/hr	Btu/hr/ft^2
717	2,445	24.8

Table 3: Annual heating energy demand (not including fume hood exhaust)

ANNUAL ENERGY DEMAND	MWH	KWH/M^2	MBTU	KBTU/FT^2
Heating	403	44	1,375	14.0

6.2.3 SCHWARTZ BUILDING LOAD CALCULATIONS



As the geothermal plant is not sub-metered, the heating energy for the Schwartz building is not known. An energy model of the Gerald Schwartz Building on the campus of St. Francis Xavier University was created to estimate peak heating load, and to estimate the annual heating energy required to maintain comfort conditions in the building. The model was created in IESVE simulation software. Inputs are based on the architectural and mechanical drawings provided, and on ASHRAE 90.1-2016 defaults for lighting loads and internal gains according to space type.

Annual energy consumption is calculated using the CWEC 2020 weather file for the nearby Tracadie, NS weather station.

6.2.3.1 SUMMARY OF INPUTS AND ASSUMPTIONS

The Gerald Schwarz Building was renovated in 2010 and includes a new addition. The building has a brick wall. It is assumed that insulation was added to the walls during the renovation, and exterior walls are estimated to have an average overall thermal resistance of R-7. The roof is estimated to be R-20. Below-grade walls in the new construction are assumed to have vertical wall insulation with a thermal resistance of R-7. Due to the large number of mullions in the windows, leading to a high framing fraction, windows are assumed to have a U-value of 0.45.

ENVELOPE	R-VALUE ($FT^2{\cdot}°F{\cdot}HR/BTU$)	U-VALUE ($BTU/HR/FT^2{\cdot}°F$)
Exterior Walls	7.0	0.143
Windows	2.20	0.450
Roof	20.5	0.049
Window-to-wall ratio	29%	

Equipment and lighting loads and occupant loads are based on ASHRAE defaults by space-type. The predominant space types in the Schwartz Building are classroom and lectures spaces, and offices. The building-wide averages are given below. Note that ASHRAE default occupancy densities for auditorium and classrooms spaces lead to much higher occupancy that what is shown on the drawings for the auditorium and classroom spaces. The occupancy shown on the drawings (e.g. by counting seats in the auditorium) is used for these spaces. The basement includes a server room. The equipment power consumption is estimated to be 5.0 kW for this space.

INTERNAL LOADS	KW	W/FT^2
Lighting	61.4	0.76
Equipment	76.0	0.94

OCCUPANCY	NUMBER	FT^2/PERSON
Building peak occupancy	1,385	58

Ventilation rates are based on ASHRAE 62 default rates by space types. The building wide ventilation rate is given below.

VENTILATION	CFM	CFM/FT^2	CFM/PERSON
Minimum outdoor air	17,809	0.22	12.9

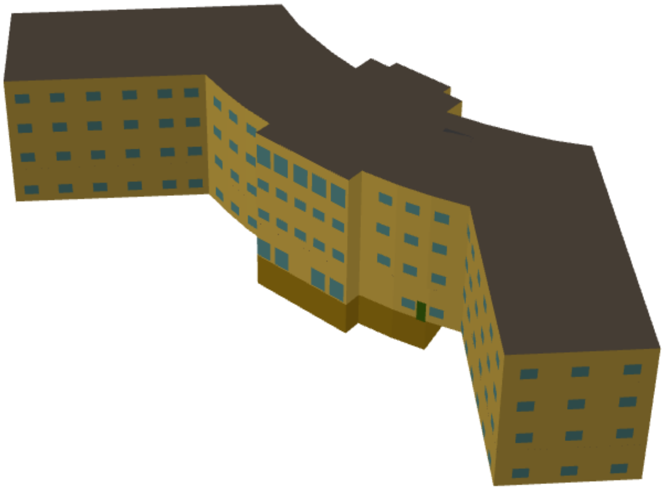
RESULTS

Peak heating and annual heating energy delivered to the building are given below.

HEATING PEAK DEMAND		HEATING PEAK DEMAND INTENSITY
kW	kBtu/hr	Btu/hr/ft^2
590	2,014	25.0

ANNUAL ENERGY DEMAND	MWH	KWH/M^2	MBTU	KBTU/FT^2
Heating	545	73	1,859	23.1

6.2.4 O'REGAN HALL & RILEY HALL



O’Regan and Riley Hall are student residences which are similar in architecture and mechanical systems. These buildings have in-floor heating provided by water-to-water heat pumps connected to a shared geothermal well. Both buildings also have 100% outdoor air handling units which are served by the campus steam plant as indicated by the maintenance team.

As the geothermal plant is not sub-metered, the heating energy for the O‘Regan Hall and Riley Hall is not known. An energy model was created to estimate the peak heating loads, and to estimate the annual heating energy heating degree day (HDD) method was used. The model was created in Carrier HAP v6 Software. Architectural floor plans were available for this building, but the building envelope details were not. Inputs are based architectural floor plans, mechanical drawings, and ASHRAE 90.1-2016 defaults for lighting loads and internal gains according to space type.

6.2.4.1 SUMMARY OF INPUTS AND ASSUMPTIONS

O’Regan and Riley Hall are student residences which are similar in architecture and mechanical systems. The exterior of the buildings is brick. The overall R-value of the exterior wall assembly is estimated to have an average overall thermal resistance of R-7.8. The roof is estimated to be R-20. Below-grade walls are assumed to be vertical wall insulation with a thermal resistance of R-7. Due to the large number of mullions in the windows, leading to a high framing fraction, windows are assumed to have a U-value of 0.45.

ENVELOPE	R-VALUE (FT^2·°F·HR/BTU)	U-VALUE (BTU/HR/FT^2·°F)
Exterior Walls	7.8	0.128
Windows	2.20	0.450
Roof	20.5	0.049
Window-to-wall ratio	16%	

Equipment and lighting loads and occupant loads are based on ASHRAE defaults by space-type. The predominant space types in these buildings are dormitory.

Ventilation rates are based on ASHRAE 62 default rates by space types

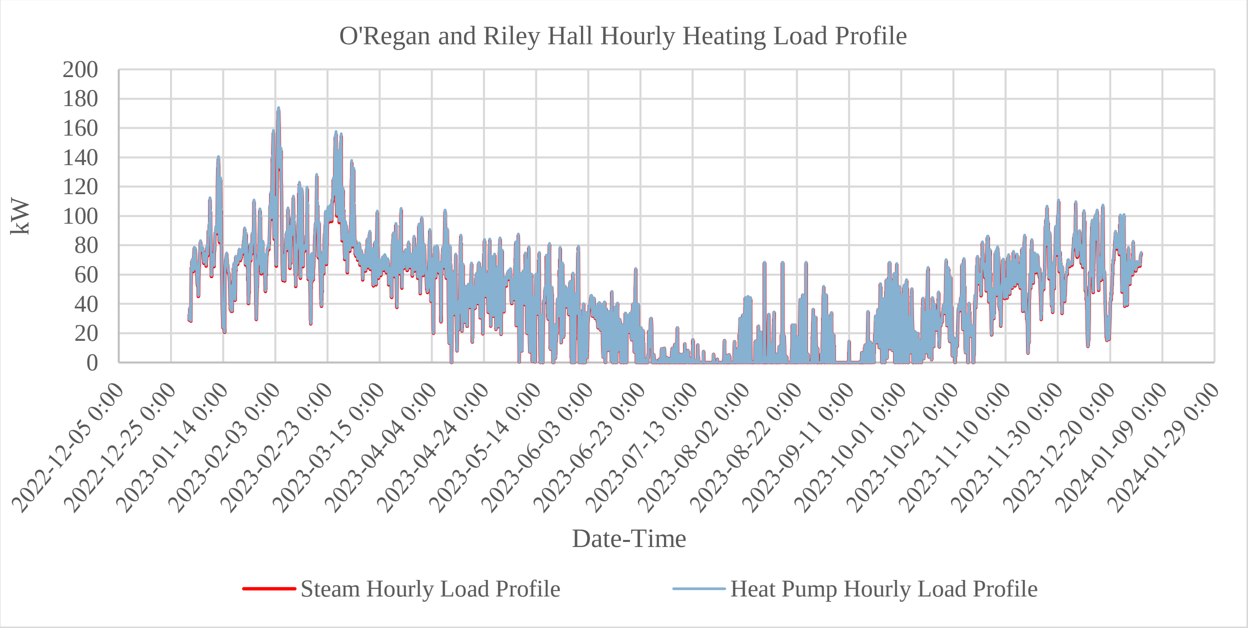
RESULTS

The peak heating load for the building is shown below.

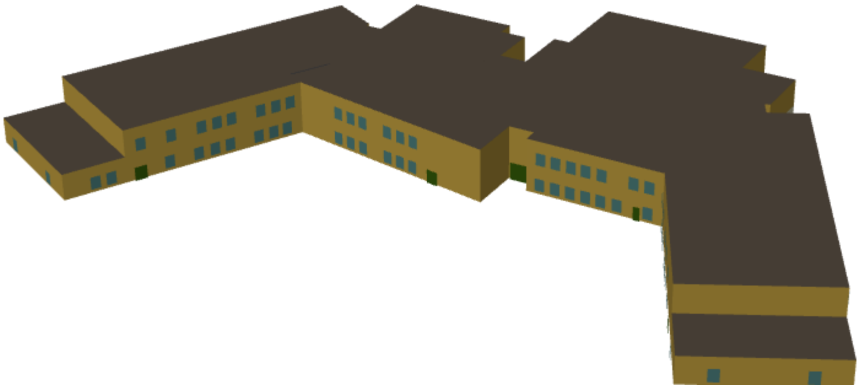
HEATING PEAK DEMAND		HEATING PEAK DEMAND INTENSITY
kW	kBtu/hr	Btu/hr/ft^2
345	1,177	20.3

Note: Mechanical drawing indicates that the heating coil capacity for the AHU is 172kW. As indicated by the facility, the AHU is served by steam, therefore it is assumed that the remaining load of 173kW is served by the heat pumps.

To estimate annual heating energy consumption associated with heat pump and steam, heating degree day (HDD) method was used. Below graph shows the peak hourly load over the year using HDD method.



6.2.5 ANTIGONISH EDUCATION CENTRE



The Antigonish Education Centre has two (2) boilers providing heating year-around. The oil bill data for the school was available and was helpful to estimate annual heating energy consumption.

To calculate peak load energy modelling was done. Carrier HAP v6 software was used. Architectural drawing for the school were used to model the school. Building envelope details were noted from the drawing. Mechanical drawings for the school were not available and a general hydronic heating system was modelled to calculate the peak load. ASHRAE 90.1-2016 defaults for lighting loads and internal gains according to space type were used.

6.2.5.1 RESULTS

The peak heating load for the building came to 729kW or 2,478 kBtu/hr and peak heating intensity of 29.4 Btu/hr/ft^2.

There are two (2) boilers at the school of 833kW capacity each. Considering 100% redundancy configuration our analysis result came less than the boiler capacity at site. For this reason, we have used the boiler size on site for proposed system sizing.

6.2.6 ST. ANDREW JUNIOR HIGH

Oil filling data for this building was available and was used to calculate annual heating energy consumption.

To estimate peak heating load, the peak heating intensity calculated for Antigonish Education Centre was used.

6.2.6.1 RESULTS

The peak heating load for the building came to 746kW or 2,546 kBtu/hr.

There are two (2) boilers at school of 981kW capacity each. Considering n+1 configuration our analysis result came less than the boiler capacity at site. For this reason, we have used the boiler size on site for proposed system sizing.

6.2.7 DR. JOHN HUGH GILLIS REGIONAL HIGH SCHOOL

Oil filling data for this building was not available but we were able to collect the daily oil level reading noted by the facility. This data was not complete and required adjustments. On days of oil tank refill, the meter reading went higher than the day before. Those readings were ignored and for days missing oil reading, monthly daily average oil consumption was calculated. Average was calculated using only the number of days for which data was available.

To estimate peak heating load, the peak heating intensity calculated for Antigonish Education Centre was used.

6.2.7.1 RESULTS

The peak heating load for the building came to 746kW or 2,546 kBtu/hr.

There are three (3) boilers at school of 1093kW capacity each. Considering n+1 configuration our analysis result came less than the boiler capacity at site. For this reason, we have used the boiler size on site for proposed system sizing.

6.2.8 ST. MARTHA REGIONAL HOSPITAL

Oil filling data for this building was available for year 2023 and was used to calculate annual heating energy consumption.

Existing boiler capacity of 300 boiler horsepower was used for proposed system sizing.

6.2.9 RK MACDONALD NURSING HOME

Oil filling data for this building was not available but we were able to collect the daily oil level reading noted by the facility for year 2022 & 2023. This data was not complete and required adjustments like as mentioned for Dr. John Hugh Gillis Regional High School.

Existing boiler capacity of 520kW and 796kW was used for proposed system sizing.

7 EMISSIONS ASSESSMENT

Emission factors represent the relationship between a specific activity or resource utilization and the corresponding amount of carbon dioxide equivalent (CO_2eq) released. This section of the report assesses the CO_2eq emissions of the St. FX and the town buildings that were being considered to be connected to the proposed district energy system. A total of twenty-nine (29) university buildings and five (5) town buildings were included in the assessment. The buildings assessed currently use various heating technologies, including geothermal heat recovery with a water source heat pump and steam backup, a VRF system with steam backup, propane boilers, and oil boilers.

7.1 DATA GATHERING AND ANALYSIS

Various data sources and methods were used when determining the current emission level of the town and university building:

- Annual steam consumption for each building was determined using steam metering data from the years 2018, 2019, and 2020, provided by St. FX. For each building, the year with the most data points was selected as the source for the total steam consumption. An efficiency of 67% was assumed for the existing campus steam distribution system and accounted for when calculating building emissions.
- Electricity metering data was not available for buildings utilizing heat pumps. Therefore, energy modelling and the heating degree day method were conducted for these buildings to determine the total heating and corresponding annual electricity consumption. The modelling and method used are discussed in the gap analysis and can be found in Section 6.2 of the report. Nova Scotia 2024 power grid's emission intensity was then accounted for when calculating the building emissions. It is worth noting that in 2024 the grid emission intensity is 560.1 gCO_2eq/kWh. The emission intensity of the province is expected to continue to drop and reach 52.8 gCO_2eq/kWh by 2034. Therefore, the emission from electricity sources is projected to be further lower in the coming years.
- Emission calculations for buildings with available consumption data for propane and #2 fuel oil were conducted using the emission intensities of these fuels. For buildings with insufficient data, an alternative approach was employed to determine its annual emissions. For instance, a gap analysis of the oil usage at Dr. John Hugh Gillis Regional High School was conducted and can be found in Section 6.2 of this report.

A comprehensive list of the buildings assessed, along with their heating sources, energy consumption, greenhouse gas emissions, and related assumptions, is provided in Appendix B.

7.2 ANNUAL EMISSION BY ENERGY SOURCE

Emission factors represent the relationship between a specific activity or resource utilization and the corresponding amount of carbon dioxide equivalent (CO_2eq) released. This section of the report assesses the CO_2eq emissions of the town and St. FX buildings that were being considered to be connected to the proposed district energy system. A total of twenty-nine (29) university buildings and five (5) town buildings were included in the assessment. The assessed buildings currently use a variety of heating sources, including geothermal heat recovery with a water-source heat pump and steam backup, a VRF system with steam backup, propane boilers, and oil boilers.

The annual consumption of each energy source used for heating the buildings was collected and summarized. Using the emission factor for each energy source, their respective annual emissions were calculated and are presented in the following table:

Table 4: Annual Emissions of St. Francis Xavier University and the Town of Antigonish

Thermal Energy Source	Annual Electricity Use [kWh]	Annual No. 2 Fuel Oil Use Equivalent [kWh]	Annual No. 2 Fuel Oil Use [L]	Annual Propane Use [L]	Annual Emission [tonnesCO$_2$eq]
St. FX Heat Pump and Geothermal - Electricity	653,533				366
St. FX Steam Plant - No. 2 Fuel Oil		30,078,400			7,520
St. FX Oil Fired Boilers - No. 2 Fuel Oil			35,462		95
St. FX Propane Boilers - Propane				86,475	134
Antigonish Town Buildings - No. 2 Fuel Oil			1,466,911		3,945

The buildings assessed release a total of 13,177 metric ton of GHG annually through heat generation. The St. FX steam plant has the highest annual GHG emissions, as it supplies thermal energy to most St. FX buildings by burning carbon-intensive No. 2 fuel oil. Similarly, Antigonish town buildings, which operate oil-fired boilers using No. 2 fuel oil, have the second-highest annual GHG emissions.

The emission factor used for calculating the annual emissions are listed below:

- Electricity Grid Emission Intensity (year 2024): 560.1 gCO$_2$eq/kWh
- No. 2 Fuel Oil Emission Intensity: 250 gCO$_2$eq/kWh
- No. 2 Fuel Oil Emission Intensity: 2689 gCO$_2$eq/L
- Propane Emission Intensity: 1544 gCO$_2$eq/L

7.3 EMISSION REDUCTION STRATEGY

With the goal of achieving a 40% reduction in GHG emissions at the St. FX within three years. Six (6) university buildings with the highest annual GHG emissions have been identified and are shown in the table below. These buildings account for 42.06% of the total heating-related GHG emissions for all the university’s buildings investigated in this report.

Table 5: Buildings with the Highest Annual GHG Emissions at St. Francis Xavier University

Building Names	Annual Emissions [tonnesCO2eq]	Percentage of the Total Emissions
Saputo Pool (Aquatic Centre)	769.2	9.48%
PSC - Physical Science Centre	717.7	8.85%
Morrison Hall	525.9	6.48%
Xavier Hall	477.7	5.89%
Saputo Centre	467.1	5.76%
Governors	455.5	5.61%

7.3.1 EMISSION REDUCTION STRATEGY, ELECTRIFYING BUILDING THERMAL SOURCES

Saputo Pool at the Aquatic Centre has the highest heating-related GHG emissions among all the St. FX buildings studied, followed by five (5) other university buildings. Together, these six (6) buildings contributed 42.06% of the total GHG emissions of the university buildings examined. The remaining twenty-three (23) university buildings each account for 0.55% to 5.46% of the total emissions. To achieve a 40% reduction in GHG emission over the next three (3) years, the university should prioritize converting the existing fossil fuel-based steam heating systems of the buildings listed in the table above to an electrified low-temperature hot water system as soon as possible. In particular, the following improvements are recommended:

Saputo Centre: We understand that a variable refrigerant flow (VRF) heat pump system is being installed to serve many of the building HVAC loads, but AHU heating coils and the pool heating system are fed direct steam from the existing oil-fired DES. Steam coils should be replaced with LTHW coils and a temporary electric LTHW boiler should be installed to serve both the AHUs and a new LTHW-heated pool heating system until the new LTHW CDES is complete.

Physical Sciences Centre: The existing secondary systems are LTHW and glycol and the DHW system is heated by steam. Replacing the DHW system with an electric tank-style system, and installation of a temporary electric LTHW boiler would decarbonize the building heating.

Morrison Hall: AHUs in Morrison Hall have LTHW coils and the DHW system is heated by steam – replacing the DHW system with an electric tank-style, installing a temporary electric boiler for the AHU coil circuit and replacing the upper-floor steam radiators with modern electric or LTHW radiators would decarbonize the building’s heating system.

Xavier Hall: This building is heated by steam and electric radiators. Steam rads could be replaced over the warmer months with LTHW radiators and a temporary electric boiler could be used until the decarbonized DES is up and running.

Governor’s Hall: The existing DHW system is heated by steam which also heats a glycol loop for hydronic heating. The DHW system can be replaced with an electric tank-style system and a small electric boiler can supply LHTW and heat the glycol with it.

The next step toward reducing emissions is to transition the district energy plant from an oil-fired steam system to an electrically powered low-temperature hot water (LTHW) system, different technology and central plant configurations are discussed in later sections. This will require modifications to the aforementioned buildings as a priority, and the construction of a new LTHW district energy plant. A phased approach could be adopted for the implementation of the new district energy plant. Priority should be given to the top size (6) large thermal-consuming buildings, with heating equipment installed first to meet their loads. Once district production, distribution and energy transfer station (ETS) equipment are in place for priority buildings, the university can begin converting the remaining ETS within each building from steam heating to the LTHW system, gradually transitioning the entire university to heating powered by electrified thermal sources. This approach would allow the university to quickly transition away from fossil fuel-based steam heating system, helping to achieve their emission reduction goals.

7.3.2 BUILDING IMPROVEMENTS AND OTHER CONSIDERATIONS

In addition to electrifying the heating and cooling sources of the university buildings, several of the high emission buildings were also identified for improvement in the previous report, “Net Zero Building Envelope Evaluation” by WSP, which was included as an appendix in Siemens’s “St. FX Electrification Preliminary Assessment” Report[2]. The most impactful measures recommended include air-sealing and weather-stripping all openings, as well as replacing older windows with high-performance alternatives. Additionally, some buildings are due for new roofs, and many are currently uninsulated. Wall insulation projects would require the removal of interior finishes and would only be practical during major planned renovations. In general, improving building insulation would reduce losses in thermal energy, reducing emissions associated with heating and cooling energy consumption. A few examples of recommendations for specific buildings are outlined below:

- **The Saputo Pool building (Aquatic Centre)**: Does the building have heat recovery on dehumidification? I s it using a modern pool HVAC system? A review of mechanical systems for energy savings opportunities is recommended.
- **PSC - Physical Science Centre**: Are there fume hoods installed in the building, and have they been upgraded to modern variable-flow hoods? A review of mechanical systems for energy savings opportunities is recommended.
- **Morrison Hall**: The roof is due for replacement and is poorly insulated. Openings (doors and windows) require weather-stripping, and many would benefit from high-performance window replacements. The walls are uninsulated and could be upgraded during a major renovation.
- **Xavier Hall**: Existing windows have poor thermal performance and should be replaced. Insulation is needed for the walls and the below-grade foundation wall at the perimeter.

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[2] St. FX Electrification Preliminary Assessment, Simens Report – 2021, Appendix 7 – Building Envelope, St. Francis Xavier University Net Zero Building Envelope Evaluations

- **Saputo Centre**: The roof should be upgraded to R40. Many windows have poor thermal performance and should be replaced, and wall insulation is recommended.
- Bishops Hall: Foundation wall insulation is recommended along with window upgrades. The walls are uninsulated and could be improved during a major renovation.

7.3.3 EMISSION REDUCTION STRATEGY FOR TOWN BUILDINGS

In addition to the university buildings evaluated, several other buildings in the Town of Antigonish also produce significant heating-related GHG emissions, namely the St. Martha Regional Hospital and the Dr. John Hugh Gillis Regional High School. Together, these two (2) town buildings account for 78.78% of the total GHG emission from the five (5) evaluated town buildings. The following two sections will review the current thermal energy production of both buildings and propose strategies for decarbonization.

7.3.3.1 ST. MARTHA REGIONAL HOSPITAL

St. Martha Regional Hospital currently relies on an oil-burning steam plant to meet its heating needs, consuming up to 40,000 liters of fuel oil per week during the winter months and up to 40,000 liters per month during the summer months. Its cooling demand is met by two (2) chillers, which have a high coefficient of performance. Its cooling plant consists of one (1) 80-ton air-cooled chiller and one (1) 417-ton water-cooled heat recovery chiller connected to a rooftop open-loop cooling tower. However, the heat recovery chiller is currently used only to supply cooling to the building, as its heat recovery mode has not been operational for years.

A clear solution is to make use of the Hospital's coincident heating and cooling loads, implement the existing chillers' heat recovery mode and operate it in simultaneous heating and cooling mode. The heating generated by the high-efficiency chillers would help reduce the demand on the steam plant, thereby lowering overall fuel usage for energy production. Another important step is to convert the steam heating system serving building heating and domestic water heating loads to a low-temperature hot water system, incorporating electric thermal equipment such as heat pumps and electric boilers in the hospital's plant room. Additionally, the hospital could be connected to the larger electrically powered district energy system proposed in previous sections.

7.3.3.2 DR. JOHN HUGH GILLIS REGIONAL HIGH SCHOOL

Dr. John Hugh Gillis Regional High School currently relies on two (2) oil burning boilers to meeting its heating needs, consuming up to 200,000 liters of fuel oil each year. This represents a significant source of greenhouse gas emissions. The first step would be to electrify the school's heating system, converting the oil burning boilers to the more efficient and sustainable electric boilers and heat pumps. Additionally, the school could be connected to the larger electrically powered district energy system proposed in previous sections.

8 TECHNOLOGY REVIEW

The objective of the Technology Review is to identify suitable technologies and solutions for developing a new energy system that will supply the energy needs of the St. FX and surrounding communities.

To recommend the most effective, affordable, and low carbon district energy system to provide heating to the Town of Antigonish (TOA), as well as to the community support by anchor client, St. Francis Xavier university (St. FX), a review of commercially available technologies was carried out. The section below provides a summary of these technologies.

8.1 CENTRAL PLANT TECHNOLOGIES

8.1.1 ELECTRIC RESISTANCE BOILERS

An electrical resistance boiler operates by utilizing heating elements that generate heat through electrical resistance when supplied with electricity. The generated heat then produces steam or hot water, as required. The heated fluid is circulated through a network of pipes that run throughout the district, delivering heat energy to buildings and infrastructure. Automated control systems are employed for precise control of the boiler temperature and pressure.

Electrical resistance boilers offer high efficiency (97% - 99%), precise control, and reduced greenhouse gas emission in comparison to gas fired boilers. With fewer moving parts, they require less maintenance and can utilize a smaller footprint to install. Furthermore, these boilers can achieve a better turndown ratio than conventional boilers, meaning a wider operational range between maximum and minimum output.

The electrical resistance boiler’s ability to supply hot water or steam at any temperature or pressure make it an excellent decarbonization solution for facilities that would require significant investment to utilize low temperature hot water.

However, the electrical resistance boilers also come with several disadvantages, including elevated electricity cost and reliance on a stable power grid. Moreover, the environmental impact of the electrical resistance boilers depends on the carbon intensity of the electricity source, in areas with a high percentage of fossil-fueled power generation, the carbon footprint may be significant. The Town of Antigonish currently receives most of its electricity from coal burning plants. To achieve true decarbonization, the electrical power fuel source should be considered.

The high operating cost associated with electric boilers are tied to electricity pricing but can be managed and partially mitigated through strategies such as peak shaving and demand management.

Electrical resistance boilers have been a proven technology to supply thermal energy for decades. However, these boilers do require a carefully monitored water treatment protocol, more stringent than a traditional natural gas boiler. If this is not managed, it can result in significant corrosion and ultimately boiler failure. This risk can be mitigated through dedicated water treatment systems and knowledgeable operational staff.

8.1.2 ELECTRODE BOILERS (ELECTRIC STEAM BOILERS)

Electrode boilers, also known as electric steam boilers, utilize the electrical conductivity and resistance of water to generate steam. Inside the electrode boiler, a pump sprays water from the neutrally charged nozzle stock to an energized electrode, with water acting as the conductor for current flow. This current generates heat within the water due to its resistance, resulting in steam production. Precise control of steam output is achieved by regulating the water impacting the electrodes, steam temperature is controlled by adjusting the voltage over the electrode. Excess water flows to the bottom of the vertical tank and is recirculated via a pump. Boiler operation initiates and stops with the control of the pump, and even when is pump is off, the electrode can remain energized, as no current flows without the pump running. During inactivity, a standby heater can help maintain a high-water temperature and a near-minimum operating pressure, ensuring fast start-up of the electrode boiler. Like fossil-fuel fired steam boilers, Electrode boilers work in conjunction with deaerators and condensate return systems. Water conductivity is monitored by an automatic conductivity controller, which activates a chemical feed pump when conductivity is low, and feeds in fresh makeup water when the conductivity is high. An automated control system is used for precise control of the boiler temperature and pressure.

Electrode boilers offer high efficiency (99% - 100%), precise control, and reduced greenhouse gas emission compared to gas fired boilers. In addition, these boilers allow rapid steam production adjustment, able to quickly generate steam upon water discharge and electrification, and quick shutdown when waterflow is cut-off, since water acts as a resistive conductor and generates heat directly.

However, electrode boilers also come with several disadvantages, including elevated electricity cost, reliance on a stable power grid and the carbon intensity of the electricity source, as well as routine maintenance to prevent electrode scale buildup. Additionally, for heating applications where steam is not suitable, the requirement for a steam-to-hot-water heat exchanger results in significantly higher maintenance requirements over a traditional hot water system. Steam systems also require condensate return and management systems (traps, flash tanks, valves, pumps, tanks and piping) which add considerable operation and maintenance effort and cost.

St. FX currently operates an aging steam and condensate distribution system, with energy production and distribution equipment at or near its anticipated end of service life. If electing to continue using a steam system for district energy distribution in Antigonish, with proper restoration of distribution infrastructure, electrode boilers could be a feasible choice.

Electrode boilers are typically more suited to large capacities and are only used to develop steam. Conversion to hot water would require heat exchanger.

8.1.3 BIOMASS BOILERS

Biomass boilers operate in the same principle as a conventional gas boiler. Instead of using natural gas as its fuel, the boiler uses organic material, such as wood, agricultural residues, forestry waste, and dedicated energy crops. Biomass boilers offer an efficiency around 80 – 90%, similar to natural gas boilers. The biomass fuel is fed into a combustion chamber, the energy released through combustion is used to heat water inside the boiler. The heated fluid is distributed through a network of pipes that run throughout the district, delivering heat energy to buildings and infrastructure. Automated control systems are used to deliver biomass fuel into the boiler at a controlled rate, maintaining the pressure and temperature of the boiler.

Biomass boilers can be an economical solution considering the lower cost of the biomass fuel in dollar per kWh compared to other fossil fuel such as gas and oil. This is because biomass fuel is typically derived from wood and agricultural residue with low commercial value. In addition, biomass fuel may be considered a low carbon fuel source, however the Federal Government currently does not consider biomass carbon neutral. If biomass is considered for the Town of Antigonish or St. FX plant, consideration should be taken for carbon capture to ensure carbon neutrality.

Biomass boilers also come with a few disadvantages, such as, varying fuel quality and consistency, large fuel storage space requirements due to low energy density, high maintenance costs, large space requirements for material handling and post combustion treatment and capture auxiliaries, and higher risk of carbon monoxide poisoning. In addition, it produces more air pollution than conventional heating fuels, even with the use of advanced combustion technology.

To give a sense of fueling logistics, a table has been provided below to summarize key metrics when considering biomass boilers:

Table 6: Biomass Boilers

Biomass Boiler Plant Maximum Design Capacity	15 Megawatts
Tonnes of fuel consumed per Megawatt	0.2 tonnes
Tonnes of fuel consumed during design conditions	3 tonnes per hour
Recommended fuel reserve capacity	72 hours or 216 tonnes
Typical truck shipment size	72 tonnes or 106m^3
Shipment frequency during design conditions	One (1) per day
Expected reserve storage volume	318m^3
Expected storage area footprint	130m^2 (assumes max height of 3m plus accessibility)

In addition to the required footprint for the storage area, a biomass system will require significantly more space than a traditional boiler system.

From an operations standpoint, a biomass system can demand a higher level of operation and maintenance in comparison to a traditional boiler. Ash fusion is a common issue in biomass combustion that occurs when high combustion temperature causes ash material to melt while still in the combustion chamber. The melted ash then travels through to the ash removal system where it cools and forms large solid deposits known as clinkers. These clinkers can cause the ash removal system to clog, requiring temporary shutdowns to remove them.

8.1.4 AIR SOURCE HEAT PUMPS (ASHPS)

An Air Source Heat Pump (ASHP) is an application of mature vapor-compression refrigeration technology, and resembles an outdoor condensing as is common in residential and light commercial air conditioning systems. Its design stems from the vapour compression refrigeration cycle. A refrigerant in gas form is compressed, causing its temperature to rise. It is then passed through a heat exchanger with a colder medium on the opposing side, cooling the compressed hot gas. That gas is then allowed to expand, which drops its temperature, after which it is passed through another heat exchanger with a hotter medium on the opposing side. The cycle operates continuously to transfer heat from one medium to another. Via this cycle, the ASHP can either reject heat from a connected hydronic loop to the outside air or extract heat from the outside air and inject it to the connected hydronic loop. As such, they can often achieve greater levels of performance than a conventional electric boiler. Where an electric boiler has a coefficient of performance (COP) of 1, or one unit of heat per unit of electricity, ASHPs in heating can achieve a COP of 1.8. making them initially appealing when compared at face value with electric boilers. In cooling applications, their COP can sit closer to 3.

ASHPs do come with drawbacks. Most commercial ASHPs do not work at outdoor air temperatures between -15°C and -25°C due to limitations of conventional refrigerants, and thus require supplementary heating in colder weather. Under these conditions, they rely on electric or fossil fuel heating for backup which reduces their COP during peak load conditions. It is possible to use different refrigerants to compensate for this, but equipment models offering that level of specialization typically come with higher cost. Additionally, maximum capacity, COP, and leaving water temperature drop severely as outdoor temperatures reduce, requiring more units and subsequently space to achieve design loads. They suffer the same drawbacks for cooling in terms of space and equipment quantities. ASHPs often hit an applicability barrier in mid or high-rise buildings due to their space requirements as a result of typical capacity per unit.

8.1.5 WATER SOURCE HEAT PUMPS (WSHPS)

Water-source heat pumps (WSHPs) are similar to air-source heat pumps (ASHPs) in that they both employ the vapour-compression refrigeration cycle. However, instead of transferring heat from a hydronic loop to the ambient air, heat is transferred between two separate water loops. As an advantage, WSHPs generally perform better than ASHPs in terms of coefficient of Performance (COP), as the energy source typically stays at more stable temperatures, especially in colder climates. ASHPs’ efficiency drops significantly during harsh winter month, making WSHPs the preferable option. Furthermore, WSHPs require less space per unit capacity as compared to ASHPs, and typically are more reliable due to their stable operating conditions.

Modern WSHP technology has made substantial advances in lift and supply water temperature capabilities, enhancing its compatibility with modern low-temperature hot water district energy systems. WSHPs can now achieve condenser fluid temperatures of up to 80°C for heating and evaporator fluid temperatures as low as 4.5°C for cooling. This flexibility allows WSHPs to meet a wider range of heating and cooling demands with minimal system modifications.

However, WSHPs are not able to function as a source of heating or cooling on their own, they can only transfer heat from one fluid medium to another. While ASHPs use the ambient air as a thermal reservoir, WSHPs need to be paired with other systems that connect to a thermal source. Examples include cooling towers, geothermal exchange loops, or deep lake thermal exchange systems. WSHPs often perform a similar role to a heat exchanger in scenarios where heat needs to be extracted from a colder medium and injected into a hotter medium.

Additionally, most commercial-grade WSHPs above a 500 ton capacity do not come equipped with a reversing valve and require a manual switchover between heating and cooling operational modes.

8.1.6 GEOTHERMAL EXCHANGE

Geothermal exchange is the process of using the consistent temperature of the earth for the purposes of heating or cooling. While ambient air temperatures can vary, ground temperatures stay relatively constant year-round. Geothermal exchange uses an underground piping network designed to transfer heat to or from the earth and can come in two typical arrangements: closed loop vertical boreholes and open loop water wells.

A closed loop vertical borehole arrangement involves drilling a series of boreholes deep underground. Depths can vary depending on systems needs. A desktop study for the proposed geothermal borefield to support a 20 MW heat pump based DES was completed by WSP and can be found in Appendix C. This arrangement is often more efficient due to temperatures being quite consistent at lower depths. Horizontal arrangements also exist but are limited due to low conductivity and large space requirements.

The open loop water well option requires the presence of a major groundwater aquifer beneath the property and a system of supply and injection wells. Groundwater is pumped from the supply wells, through heat exchangers in the central plant and back to the aquifer via the injection wells. Environmental impact and permitting must be considered when considering any open loop application.

Both arrangements are connected to a WSHP which transfers heat either in or out of the ground loop depending on building demand. In terms of operating efficiency, geothermal exchanges use the earth as a thermal reservoir requiring relatively little extra work to access when paired with WSHPs and are able to provide heating or cooling effectively.

Geothermal loops are typically limited by soil quality, space constraints, and seasonal load differences. Test boreholes need to be drilled before a geothermal exchange can be considered as certain types of soil and hydrogeological systems act as poor thermal reservoirs. Additionally, geothermal bore-fields require a significant physical footprint per unit of energy output. Finally, a geothermal exchange works best if loads are balanced; the amount of heating extracted in winter is equal to the amount of cooling used in summer. This will extend the span over which the geothermal exchange delivers consistent performance. In an unbalanced system, the geothermal exchange will have a comparatively limited lifespan after which, if not replenished or given time to regenerate, it will cease to meet demand. This can be mitigated by increasing the space between boreholes, but at the cost of needing additional space.

St. FX’s existing geothermal systems and associated heat pumps could be integrated into a new district energy system. Further expansion of the existing borefields is also possible to increase overall system capacity.

8.1.7 WASTEWATER HEAT RECOVERY

Wastewater heat recovery allows for the transfer of thermal energy to or from city sewers to provide energy for buildings. It makes use of low-grade heat that would otherwise go unutilized. Typically, this energy would otherwise be wasted to the ground surrounding the sewers or the environment once the wastewater reaches the treatment plant. Determining the available thermal energy in the sewer system is a critical first step when considering it as a thermal source, as there is a limit to how much energy can be extracted from the sewer system.

From a technological standpoint, a wastewater heat recovery system is relatively simple system. Two connections to the existing sewer are required; a source connection which is where the source flow will be drawn from, and a downstream return connection where the sewage is returned to the sewer. While the source and return cannot be at the same location, they do not need to be too far apart. From this point, all of the current products on the market generally all work in the same manner. The sewage is drawn from the city main then run through either a macerating pump or a separator, which will separate the large solids and thick sludge from the liquids. The liquid is then pumped to a purpose-built heat exchanger, where the thermal energy is transferred to one side of the heat pump loop. To render this recovered thermal energy suitable for heating purpose, a reverse refrigeration cycle, facilitated by a heat pump is used. Recovered energy can serve as a supplementary source to offset the energy cost for other heating equipment in a district energy plant or can independently provide heat to buildings. Heat exchangers used for wastewater heat recovery are designed to reduce potential fouling through a number of strategies, including flow reversing valves, screw conveyors to remove settled solids, and other automated cleaning systems. Once effluent slurry flow has passed through the heat exchanger, it returns to the location of the macerating pump, where the removed solids are re-introduced into the liquid flow. This flow is then discharged back into the sewer system and conveyed to the treatment plant. The entire sewage side of the process is completely sealed and separate from the heat pumps and building systems.

Based on the Wastewater Energy Map, there is an available 2 MW of available heating capacity in Antigonish. This flow has an average winter temperature of 6.88 Celsius. This temperature lends itself very well to the efficient use of water source heat pumps.

The advantages of utilizing a wastewater heat recovery system are that the source temperatures are generally steady and predictable within the ideal operating window of heat pump technology which would provide COPs in the range of 3-4 in heating, there are no operating temperature limitations that ASHPs may suffer from, reduced greenhouse gas emissions, and the because the thermal energy is transferred rather than generated from a utility source, much less energy intensive than other heating systems. Some of the downsides include the need to add infrastructure to connect to the sewer system, the potential for additional maintenance requirements, and this is still a developing implementation of existing technologies within North America. This technology, while not yet widely adopted, permits the use of heat pump systems operating at near to their optimal efficiency, while utilizing an energy source that would otherwise be wasted.

8.1.8 THERMAL ENERGY STORAGE WITH WATER TANK

Thermal energy storage leverages off-peak hours to balance and potentially reduce heating and cooling costs. This is achieved by using a large thermal mass, such as a buried or partially buried insulated water storage tank, as an energy reservoir. The heating system, including heat pumps and boilers, operates during off-peak hours when demand and energy costs are lower. The stored thermal energy is then released to the building during peak demand and high-cost periods. For example, building heating demand is typically highest in the early morning and evening during winter, coinciding with peak electricity demand. During off-peak hours, the tank water is heated to a high temperature, storing thermal energy until needed. As the buildings' heating demand increases, the system draws heat from the storage tank instead of the primary heating system. Once the water temperature in the tank drops to a level where it is no longer effective for heating, the buildings switch back to the primary heating system. The same principle applied when using this technology to store chilled water for cooling load.

As the town of Antigonish gains abundant renewable power from its connection to the Ellershouse Wind Farm, heat pumps and electrical boilers can be used to produce hot water, which is then stored in tanks for future use when wind energy is abundant, and heating needs are minimal.

Thermal energy storage with buried water tank can be applied with great success provided certain considerations have been accounted for:

- Sufficient space is needed for a thermal mass large enough to justify operating and installation costs.
- There will be losses in the thermal energy storage due to thermal conduction. These would need to be considered against more operating hours and utility costs.

8.1.9 BOREHOLE THERMAL ENERGY STORAGE (BTES)

Borehole thermal energy storage (BTES) operates on a similar principle to the geothermal exchange system discussed previously. BTES is an energy storage system that stores thermal energy underground using boreholes, allowing excess electricity to be converted to heat and stored during the hot month and later retrieved during the cold month. BTES is particularly suited for seasonal energy storage and is often integrated with renewable energy sources such as wind and solar power systems. It helps capture the surplus energy obtained through the renewable energy sources and store it underground for use during colder periods.

BTES relies on a network of boreholes drilled deep into the ground. A heat transfer fluid, such as water, circulates through U-shaped pipes within these boreholes. During the summer months, electricity obtained from renewable sources or purchased at off-peak hours at lower prices can be converted into thermal energy using heat pumps and electric boilers. The heated water is then pumped into the boreholes, where the heat is transferred to the surrounding earth. By the end of summer, the temperature of the earth around the boreholes can become significantly elevated. For example, the BTES system at Drake Landing Solar Community in Alberta uses a solar thermal system to transfer heat into the ground, raising the temperature in the borehole field to up to 80°C. In the colder months, this process is reversed: the stored heat is extracted for space and domestic hot water heating. To prevent significant heat loss throughout the year, the entire borehole field is insulated with materials such as sand, high-density R-40 insulation, waterproof membranes, clay, and other landscaping materials.

Integrating BTES into district heating and cooling system can significantly improve efficiency. For instance, the Town of Antigonish could store excess wind power or cheap off-peak electricity as thermal energy in the BTES boreholes, leading to both financial saving and contributing to decarbonization goals.

8.1.10 THERMAL ENERGY STORAGE USING PHASE CHANGE MATERIAL

Thermal energy storage using Phase Change Material (PCM) is an innovative technology that stores and releases heat during a material’s phase change, typically from solid to liquid. It is increasingly being applied in district energy systems and building HVAC systems to enhance energy efficiency.

PCMs store energy through latent heat, the energy absorbed or released during a phase change. When a PCM melts, it absorbs heat without a significant temperature rise, and when it solidifies, it releases the stored heat. This makes PCM ideal for efficient thermal energy storage. A typical PCM-based energy storage system uses heat exchangers where a heat source, such as an electric boiler or heat pump, heats the PCM to a liquid state. This material can store up to four times more energy than water due to its latent heat properties. Once the PCM reaches its melting point, it transitions to a liquid state, storing thermal energy. When there is a demand for heat, the PCM solidifies and releases the store energy. This makes PCM-based system ideal for applications that required energy on demand, allowing the user to charge the thermal storage using excess renewable energy or off-peak electricity, and discharge during when thermal demand is high, reducing overall energy costs. The scalability of PCM system also makes it suitable for district energy applications.

8.1.11 SOLAR THERMAL ENERGY

Solar thermal is the process of harvesting the energy from the sun for the purpose of heating or producing hot water. To do so, a solar collector must be used. In Canada and other northern climates, the most popular is an evacuated tube solar collector. The reason for its popularity is its performance in cold weather compared to other solar collectors. The evacuated tube is a coated glass tube which is sealed at vacuum pressures. When the sun hits the evacuated tube, the coating causes friction generating additional thermal energy. Inside the evacuated tube is a suspended copper tube which is filled with a working fluid. As the sun’s energy enters the evacuated tube, the working fluid begins to vaporize and causes it to rise. Once it reaches the top of the tube, the heat is transferred to the heating supply water and the refrigerant is condensed. The condensed working fluid will then fall back down the tube to complete the cycle.

Besides providing thermal energy directly to buildings, solar thermal energy at St. FX can also be used to maintain the thermal balance of the geothermal field. Due to the local climate, if the energy extracted from the ground in winter is not balanced against the energy injected in summer, the lifespan of the geothermal field will be significantly impacted. Solar energy absorbed by the collector can be used to rebalance the geothermal field by replenishing heat to the ground. Similarly, dry cooler can be used to provide cooling to the ground if cooling is required for balancing.

Solar thermal offers zero emission and requires less maintenance compared to other energy production technologies. However, due to its reliance on solar power and weather condition, the energy production can be inconsistent, and it requires a significant physical footprint for each unit of energy output.

8.2 RENEWABLE ELECTRICITY GENERATION AND STORAGE TECHNOLOGIES

8.2.1 SOLAR PHOTOVOLTAIC (PV)

Marked increase in the popularity of solar panels has allowed for increased product development, allowing for the technology to become more efficient while more cost effective. By integrating a solar PV array to either the CEC or multiple buildings, the system will be able to displace baseload electrical demand at the connected facilities. Solar PV is a viable way to lower utility costs while reducing the overall campus carbon footprint and can be installed in several mounting configurations including building roof-mount, ground-mount, and carport installations.

Solar panels are typically constructed using silicon as their most significant component. Two (2) types of silicon semi-conductors are used in the production of a solar panel, an N-type, and a P-type. The N-type semiconductor is a version of silicon which is phosphorus-doped, providing extra electrons, while the P-type semiconductor is a version of silicon which is boron-doped, resulting in missing electrons. These missing electrons are known as holes. The construction of a solar panel consists of the N-type semiconductor closest to the sun and the P-type semiconductor located below it. The changes to the silicon result in the N-type semiconductor being negatively charged and the P-type semiconductor being positively charge, thus creating an electric field at the interface of the two (2) materials. The energy from the sun is transferred in the form of photons. When the photons hit the solar panel, the extra electrons in the P-type semiconductor are knocked free. The electric field then pushes the free electrons out of the silicon material where they are collected and can be used as useful energy.

Electricity generated from solar panels is direct current. In order to make the electricity compatible with existing infrastructure, an inverter is used to change from direct to alternating current.

Silicon solar panels are typically split into two (2) categories, monocrystalline and polycrystalline. The difference between the two (2) options is the purity of the silicon and the efficiencies achieved. Monocrystalline silicon panels use higher purity silicon, thus are more expensive but can reach efficiencies up to 22% for a commercially available product while the polycrystalline option has a maximum efficiency of 18% in a commercially available product. Thus, the monocrystalline option will produce more electricity per unit area than the polycrystalline option.

Solar Photovoltaic technology is a viable option for generating low-carbon electricity in Antigonish. However, since it is not a thermal generating technology, it will not be included in the evaluation matrix for the district energy central plant design.

8.2.2 BATTERY ENERGY STORAGE SYSTEM (BESS)

A Battery Energy Storage System is a type of energy storage system that uses batteries to store and distribute energy in the form of electricity. These systems are commonly used in electricity grids and in other applications such as electric vehicles, solar power installations, and smart homes. At its most basic level, a BESS consists of one (1) or more batteries that store electrical energy for later use. This stored energy can then be drawn upon when needed to meet various demands for power across different applications. BESS can also provide advantages over other energy storage systems, including greater efficiency and flexibility, faster response times when powering equipment or devices, and lower costs overall.

BESS relies on one (1) or more batteries to store energy, which can then be used at a later time. These batteries may be charged using excess electricity generated by wind or solar farms, for example, or by grid connection during periods of low demand. Once the battery is full, it stores the electricity until it is needed.

Battery Energy Storage Systems offers more than just a standard battery. It is fully packed with technologies allowing its system to capture charge and execute discharge. The following are the typical technologies it includes:

- **Inverters:** inverters are devices that transform direct current (DC) to alternating current (AC). AC is the type of electricity used in homes and businesses.
- **Control Components:** the control components of a BESS manage the charging and discharging of the batteries and regulate the flow of electricity to and from the grid.
- **Integrated sensors:** integrated sensors monitor the BESS's performance and conditions, providing valuable data to help optimize its operation.
- **Multiply Battery Modules:** multiple battery modules are composed of multiple batteries that work together to store and release energy.

Battery Energy Storage Systems are used in a variety of applications, some of which are listed below:

- **Peak Shaving:** peak shaving reduces the peak electricity demand by using stored energy to meet part of the demand. This can help reduce the overall cost of electricity during peak hours.
- **Uninterruptible Power Supply (UPS):** a UPS is an electrical device that supplies continuous power to critical loads during power outages. A BESS is often used in conjunction with a UPS to help ensure that critical equipment continues to function without interruption during power outages.

There are various types of BESS available, some common types include Lithium-Ion batteries, Lead Acid batteries, Flow batteries and Flywheels. Each type has its advantages and disadvantages in performance, lifespan and cost.

Marked increase in the popularity of solar panels has allowed for increased product development, allowing for the technology to become more efficient while more cost effective. By integrating a solar PV array to either the CEC or multiple buildings, the system will be able to displace baseload electrical demand at the connected facilities.

Battery energy storage is seen as a gateway technology that allows technologies such as electric boilers to become competitive financially to more traditional natural gas heating solutions. However, battery energy storage does present significant operational and ultimately financial risks. Given battery energy storage is an expensive technology, storage within these solutions is usually limited to 1 to 4 hours of their rated output. If the battery energy storage system is discharged to early and the peak is missed, the financial impact is significant. To mitigate this risk, peak prediction software can be utilized as well as various other risk transfer strategies.

Battery Energy Storage System is a viable technology to help Antigonish to reduce overall electricity cost. However, since it is not a thermal generating technology, it will not be included in the evaluation matrix for the district energy central plant design.

8.2.3 SMALL MODULAR REACTORS (SMRS)

Small modular reactors (SMRs) are a new class of nuclear reactors that are considerably smaller in both sizes and power output compared to traditional reactors, along with enhanced safety features. Operating on the principle of nuclear fission, the reactors generate substantial heat energy, which is then transferred to a coolant, such as water or molten salt, circulating through the reactor core. The heated coolant then moves through a heat exchanger, transmitting thermal energy to a secondary loop. Water in the secondary loop heats into high-pressure, high-temperature steam, driving a steam turbine connected to a generator, ultimately producing electricity.

Unlike conventional nuclear power plants, which are large-scale with electrical outputs ranging from 600 to 1400 MWe, SMRs are notably smaller, both physically and in power output. Ranging from the size of a three-story building to a large city block, SMRs can generate electrical power from 20 to 300 MWe, aligning more closely with the electricity needs of smaller communities or cities.

As of the current writing, there are no commercially operational Small Modular Reactors (SMRs) in Canada. However, there is a growing industry interest, with several proposed SMR facilities undergoing licensing review by the Canadian Nuclear Safety Commission (CNSC) at various stages:

- Global First power: proposing to construct a micro modular reactor project in Chalk River, Ontario. Designed to provide 45 MW (thermal) of process heat to an adjacent plant via molten salt, which will generate electrical power and/or heat for an operating lifespan of 40 years.
- New Brunswick Power: proposing to construct an ARC-100 SMR at the Point Lepreau Nuclear Generating Sation, which would provide 100 MW of electricity.
- Ontario Power Generation: proposing to deploy a BWRX-300 SMR reactor at the Darlington Nuclear Generating Station, able to provide 300 MW of electricity to the grid, with a project operational span exceeding 60 years.
- Saskatchewan Power: is also considering the deployment of a BWRX-300 SMR reactor, intended to provide 300 MW of electricity to the grid, with a project operational span exceeding 60 years.

Currently, up to 60% of Antigonish's electricity demand is met by coal-fired power plants. Beyond electrifying building heating and cooling systems, consideration should be given to the fuel source for electricity to transition the town into a Net Zero community. Hence, it is advantageous for the town to consider adopting the SMRs technology, as it produces a substantial amount of electricity without generating greenhouse gases. Other benefits include the modular design enabling future capacity expansion without extensive infrastructure overhauls, adding additional module to increase system capacity. Moreover, SMRs incorporate enhanced safety features, further fortifying the reliability of established nuclear power technology.

If implemented correctly, Small Modular Reactors (SMRs) could offer significant benefits to the town and its community. However, due to the nature of SMRs and the need for strict operating safety standards, several challenges and concerns must be addressed. These include regulatory and licensing processes, site selection for construction, training for operators and staff, logistics for maintenance, ensuring fuel supply, and managing the grid during periods of excess electricity production.

Additional challenges such as financial incentives, waste management, and public perception should also be considered. Although requiring less capital investment than traditional nuclear power reactors due to their smaller size, their ability to compete financially with other low-carbon, low-cost electricity generation forms in Nova Scotia requires further investigation. Waste management and decommissioning processes require careful consideration for environmental responsibility. Additionally, public perception and acceptance of nuclear energy could pose hurdles to widespread adoption.

Small Modular Reactors Technology is a viable option for generating low-carbon electricity in Antigonish. However, since it is not a thermal generating technology, it will not be included in the evaluation matrix for the district energy central plant design.

8.3 DISTRIBUTION TECHNOLOGIES

Transfer of energy to various locations is a fundamental aspect of district energy system design. Whether heating or cooling, the method by which energy is distributed can impact both how the system functions as well as future readiness and operability. Methods of energy distribution explored in this study are introduced below.

8.3.1 HOT AND CHILLED WATER LOOP

Hot water and chilled water loops are an efficient and traditional distribution method for district heating and cooling systems. Hot and chilled water are typically supplied at a wide range of temperatures from a central plant to various buildings within the district via a distributed network of piping where the water is used to heat or cool the building. The district hot water and chilled water systems interface with the connected buildings through the use of a heat exchanger or a direct connection with a pipe bridge. From the buildings, water is then returned to the central plant where it can be heated or cooled using many central plant technologies.

Hot water and chilled water loops are effective in that they use readily available equipment and system components while relying on established design practices. These systems have been used in various forms for many decades and their operation has become standardized over the years making them reliable. They can also be designed to meet future capacity requirements by sizing main loops with future expansion in mind. This is particularly beneficial when considering the capital costs associated with having to replace existing piping with a larger size as the network expands. It should be noted that changing the primary system supply and return temperatures may also allow the network to deliver more energy to the user buildings but may require replacement of equipment within the system such as heat exchangers, and secondary side equipment within user buildings. To ensure the effective operation of both DES and secondary systems it is important to set primary and secondary system parameters for all connected and future buildings to follow and adhere to after interconnection.

On the hot water side, the operating temperatures of the district hot water loop can cause limitations to the technologies that can be utilized within the central plant. Low carbon technologies such as heat pumps operate most efficiently at lower hot water output temperatures. It is common to see modern district energy systems designed for hot water supply temperatures below 60℃.

The existing St. FX district energy system utilizes a steam central heating system distributed by a 100+ year old boiler plant. Within most buildings steam is converted to hot water and distributed through hydronic systems. The overall system efficiency was determined to be 67%[3] with many aging equipment subject to failure. In addition, the boiler plant burns bunker-C fuel oil, which releases over 7,520 tCO2e/year, representing the largest source of GHG emission in the town. By converting the existing steam system to a Low Temperature Hot Water (LTHW) system, St. FX and TOA will see significant benefits in both increased efficiency and reduced GHG emissions.

Several challenges need to be addressed when considering integrating the existing St. FX geothermal heating system into a district hot water loop. Thermal energy rejected by water-source heat pumps from building cooling loads could be incompatible with a hot water loop due to low temperature. Hot water loop systems will often supply heating water around 80℃, while most water-source heat pumps can supply hot water to a maximum of 76.6°C. Heat rejected by water-source heat pumps would require additional temperature boosting from electric boilers or additional heat pumps to mitigate degradation of a warmer district heating loop. This concern could be mitigated by adopting the ambient loop system detailed in the subsequent section of the report. Moreover, it is essential to ensure a balance in energy extraction and injection into the geothermal field.

To delivery the hot and chilled water to buildings from a central plant, the distribution piping will incorporate a carrier pipe (typically steel), an insulation layer, and insulation jacket. There are several options currently available:

- EN Standard factory-insulated pipes.
- ASME (American Society of Mechanical Engineers) Standard North American factory-insulated pipes.

8.3.1.1 EUROPEAN STANDARD FACTORY INSULATED PIPING SYSTEMS

European (EN) Standard piping systems are a well-established system for buried district heating and cooling piping networks, offering a variety of pre-insulated pipe options, and is recognized for prioritizing energy efficiency, durability, and ease of installation. Products following the EN Standards have been widely adopted in the Canadian market as well. EN piping manufacturers offers substantial support for engineering projects, providing technical assistance throughout the design stages. In addition, the EN standard is an all-encompassing standard covering fabrication through design to installation and commissioning. Applicable EN Standards for the various aspects of the system are as follows:

EN 253 – District heating pipes - Bonded single pipe systems for directly buried hot water networks - Factory made pipe assembly of steel service pipe, polyurethane thermal insulation and a casing of polyethylene

EN 448 – District heating pipes - Bonded single pipe systems for directly buried hot water networks - Factory made fitting assemblies of steel service pipes, polyurethane thermal insulation and a casing of polyethylene

EN 488 – District heating pipes - Bonded single pipe systems for directly buried hot water networks - Factory made steel valve assembly for steel service pipes, polyurethane thermal insulation and a casing of polyethylene

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[3] St. FX Electrification Preliminary Assessment, Siemens Report - 2021

EN 489 – District heating pipes - Bonded single and twin pipe systems for buried hot water networks - Part 1: Joint casing assemblies and thermal insulation for hot water networks in accordance with EN 13941-1

EN 13941-1 – District heating pipes - Design and installation of thermal insulated bonded single and twin pipe systems for directly buried hot water networks – Part 1: Design

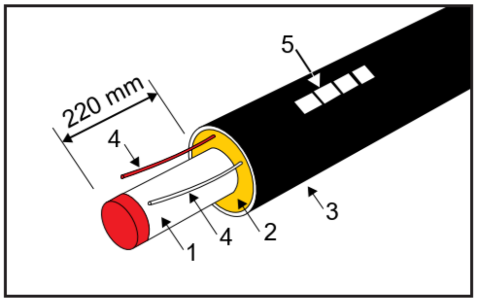
EN 13941-2 – District heating pipes - Design and installation of thermal insulated bonded single and twin pipe systems for directly buried hot water networks - Part 2: Installation

There are several manufacturers of EN Standard piping, however they vary in the product and service offering. Logstor, a leading manufacturer, provides full-service support to engineers, contractors and operators to ensure satisfactory results throughout the lifespan of the product. Logstor also provides a comprehensive range of documentation, including Design Manual, Handling & Installation, Weld Joint Manual, Surveillance Manual, Foam Pack Folders, and FlexPipe Handbook, aiding in informed decision making during the design process. They also offer on site training and certification to ensure installers and designers are accredited in all aspects of the installation.

In comparison to alternatives within the Logstor products, the Bonded Single Pipe emerges as a viable solution for constructing a hot water loop at the Town of Antigonish and St. FX. This is a factory fabricated, pre-insulated piping system for hot water transmission and distribution in district heating and chilled water networks. The product is offered with four different levels, series 0 (uninsulated), to series 3, of insulation depending on the network heat loss requirements. The piping system is suitable for operation within the following maximum design conditions:

- Maximum operating temperature: 120 °C
- Maximum operating pressure: 25 bar
- Service Life: 30 years

The system component include:



1. Service pipe: steel.
2. Insulation: polyurethane foam.
3. Outer casing: polyethylene, HDPE.
4. Leak Detection: two 1.5 mm2 copper wires for surveillance. One wire is tinned.
5. Pipe Label.

8.3.1.1.1 ADVANTAGES

A significant advantage of the Logstor products, when compared to other piping systems such as the North American Standard piping systems, lies in Logstor's capacity to provide comprehensive design documentation, technical support and training, accompanied by a complete set of tools and installation parts. Additionally, the Logstor Bonded Single Pipe offers superior quality in moisture and leak protection. The following outlines the specific advantages of the Logstor Bonded Single Pipe:

Documentation and Support:

- Well-documented design manual and comprehensive supporting documentation is available.
- Offers technical support throughout design stages.

Tooling and Training:

- Logstor provides a complete set of parts and tools and for system installation (including for initial install and leak detection testing), accompanied by a complete personnel training and instructions.

Leak Detection and Protection:

- Logstor provides a much more robust leak detection system compared to other suppliers. The system can locate the leakage section and leakage rates automatically (fast leak and slow leak indicating from pipe or from ground).

Insulation, Jacket welding, and Integrity:

- The system offers a pre-packed and pre-weighted insulation mixture package, streamlining the field insulation process, while ensuring the joint insulation quality.
- Logstor features an electro-fusion closure at the joints, preventing leaks and moisture penetration.

Installation Flexibility:

- Ability to be installed at shallow depth.

Remote Monitoring and Safety Check:

- Each Logstor pipe section can have a barcode for remote monitoring of status and location via the Logstor server, adding an extra layer of safety check. (Note: This point can be an advantage or disadvantage based on client preference.)

8.3.1.1.2 DISADVANTAGES

The primary drawback of the EN piping system is the manufacturing location and adherence to the EN standard. Being designed and manufactured in Europe only, EN Standard systems could lead to a longer lead time. Additionally, the EN standard design poses a challenge in sourcing compatible parts in north America. However, Logstor addresses this challenge by providing a comprehensive parts and tool sets. It is, however, worth noting that the EN standard will pose no negative impact on the design and installation complexity. With its more stringent European standard, pipes would exhibit better quality than its North American counterparts. The following outlines the specific disadvantages of the Logstor EN Standard Piping system:

Manufacturing and Design:

- Design and production in Denmark may lead to longer lead times.
- Sourcing compatible parts in North America can be challenging due to the EN standard design, although this challenge is mitigated by the comprehensive parts and toolset Logstor provides.

Installation Challenges:

- EN standard design results in larger fitting geometry, potentially complicating navigation through tight spaces and sudden changes in direction. Careful design planning and layout is needed to compensate this.
- The Logstor pipe utilizes a thinner steel pipe wall construction (6.3 mm), making welding more difficult when compared to its North American counterparts.
- Compared to a concrete encased system, the Logstor Bonded Single Pipe has a smaller loading capacity and is more susceptible to damage if not installed and transported with care, thorough training on material handling may be required.

Client Preference:

- While each Logstor pipe section can have a barcode for remote monitoring, client preferences may vary regarding this feature's advantage or disadvantage.

8.3.1.2 NORTH AMERICAN FACTORY INSULATED PIPING SYSTEMS

Several North American piping suppliers provide a factory insulated piping solution. Unlike the EN Standard piping, the North American offerings are not all constructed to the same manufacturing standard and therefore are difficult to compare directly. Some examples are:

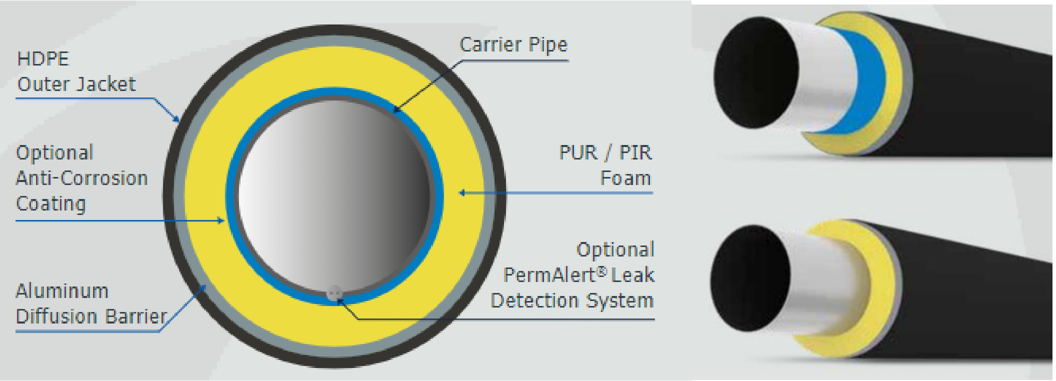
- Perma-Pipe
- Thermacor
- Urecon

North American piping systems are available with many options for carrier pipe material, insulation density, and insulation cover material, and offer optional single wire leak detection, and diffusion barrier to prevent insulation degradation. The largest difference between the EN piping system and the North American systems are in the application of field insulation on the welded straight joints, and fitting (elbows) welded joints. The North American system joints do not undergo the same rigor and testing during installation to ensure that the joints are 100% watertight.

In comparison to the EN Standard piping, the North American piping system can operate under the same maximum design temperature and pressure conditions, but will see a slightly shorter life expectancy when compared to the EN system due to the difference in joint quality:

- Maximum operating temperature: 120°C
- Maximum operating pressure: 25 bar
- Service Life: 25 – 30 years

The system components include:



8.3.1.2.1 ADVANTAGES

A notable advantage of the North American products, in comparison to the EN systems, is attributed to their manufacturing location, and adherence to ASME (American Society of Mechanical Engineers) standards. This results in a shorter lead time, easier sourcing of compatible parts, and enhanced maneuverability in tight spaces. The following outlines the specific advantages of the North American Systems:

Manufacturing and Design:

- Designed and produced in the US/Canada, shorter lead time compared to EN option.
- Follows ASME (American Society of Mechanical Engineers) standard, making it easier to source compatible parts in North America compared to EN option.

Installation:

- ASME standard design allows smaller fitting geometry, making it easier to navigation through tight spaces and sudden directional changes.
- Standard (0.375" thick) wall thickness compared to EN piping (0.25" thick), allowing non-specialized welding techniques and details.

Tooling and Training:

- Manufacturers offer complete set of parts accompanied by personnel training and instruction. It is important to note, however, that based on WSP's previous experience, Logstor has also demonstrated a comprehensive level of support and training in this regard.

8.3.1.2.2 DISADVANTAGES

While North American Manufacturers provide a level of component design documents, supporting manuals, and personnel training and support, EN system, and specifically Logstor, offers an extensive range of modeling tools and support throughout the design and installation stages when compared. Additionally, North American product leak detection system, leak protection and insulation ability is less advanced compared to what EN systems provide provides. As a result, the North American systems will not perform to the same level as the EN systems. Finally, the field insulation mixture is not pre-weighted for correct ratios, potentially resulting in inconsistencies in joint insulation and subsequently decreasing the overall insulation quality of the system. The following outlines the specific disadvantages of the North American factory insulated piping system:

Documentation and Support:

- Provides less well-documented design manual and supporting documentation.
- Offers less technical support throughout the design stages.

Leak Detection and Protection:

- Offers leak detection using a single copper leak detection wire.
- Able to detect leakage location.
- Unable to determine leakage rate.

Insulation:

- High density foam insulation, however, the mixture packages are not pre-packed or pre-weighted for correct ratio, manual weighing and mixing will be done on site by the contractor with instructions from the manufacturer.
- Less options for increased insulation thickness.

8.3.2 AMBIENT LOOP

Ambient water loops combine the district network for heating and cooling into one set of supply and return piping. Temperatures in hot water and chilled water systems will often sit around 80°C and 5°C respectively, whereas in an ambient water loop the temperatures will typically range from 15°C to 30°C. The loop essentially acts as a conduit by which energy is moved between various nodes. For cooling, heat from the buildings is rejected to the ambient loop (typically via chiller condenser or heat pump) where it is then circulated back to the central plant. Heat from the ambient loop is either repurposed or rejected to the outdoors through a dry cooler or condenser. The same heat transfer mechanism occurs in heating but with building heat pumps extracting thermal energy from the ambient loop. Under these conditions, colder water will return to a central plant where heat is added as necessary by boilers or heat pumps.

An ambient loop offers several benefits. For initial installation, it only requires one set of supply and return pipes as opposed to two sets for a typical heating and chilled water loop which reduces initial capital costs. Operating at moderate temperatures also means reduced energy loss over long pipe runs. It is also possible to do energy recovery between buildings with varying load profiles (ex. one building requires heating, one requires cooling). However, an ambient loop will generally still need the same quantity and size of equipment with a total capacity for heating and cooling (ie. boilers and chillers) as a hot and chilled water loop. Additionally, heat pumps will be required at each building instead of the heat exchangers used with steam, hot or chilled water loops. This requires significantly more mechanical space within the connected building than a four-pipe district energy solution. Beyond the space required within the connected buildings for heat pumps, a central plant is required to add or reject thermal energy from the ambient loop to maintain a consistent operating temperature. Central plant equipment sizing for an ambient loop network can be significantly reduced if a network's heating and cooling load profiles are complementary, however this is highly dependent on network layout and climate.

From an operation and maintenance perspective, the ambient loop solution requires additional resources over a traditional four (4) pipe solution, this is due to the distributed heat pumps across the network.

The heating and chilled water temperature generated by heat pumps from geothermal source are sufficient for ambient loop technology, which mitigates dependence on boilers for central heating. Using heat pumps to generate heat instead of boilers contributes to a more efficient system with a lower carbon footprint due to the coefficient of performance (COP) of refrigeration-based technologies such as heat pumps and heat recovery chillers.

Currently the Town of Antigonish does not have an existing distribution system, if the town and St. FX opt for different distribution methods, one (1) for hot and chilled system and another for an ambient loop system, integration between two (2) system could be feasible but limited. This can be done through the use of heat exchangers. However, since the systems will operate as two (2) hydraulically independent loops, there will be limited resiliency or redundancy benefit.

8.4 EVALUATION MATRIX

Each of the innovative technologies discussed was evaluated based on technical, financial, and environmental criteria to rank technologies for inclusion in the thermal energy solution development. The following criteria were considered:

- Technical Viability
- Required Footprint
- Capital Cost
- Operation and Maintenance Cost
- Maintainability
- Reliability and Resiliency

- Carbon Impact

Each of the technologies was assigned a score between 1 and 5 for each criterion, with 1 being the lowest score and 5 being the highest. If an option was to have an extremely attractive cost relative to its value added, it would receive a 5 for its score in that criterion. The scores of the individual technologies are then summed to produce a total score, and the technologies with the highest total score would be the most attractive option for adoption.

Technical viability refers to the overall compatibility and feasibility of the technology with the current vision for the Town of Antigonish and St. FX, as well as the general market viability of the technology.

Required footprint is defined as the area required to install the technology in relation to the energy or benefit that the system provides. The most efficient use of space was given a score of 5 and the least efficient use of space was given a score of 1.

The technologies were also evaluated for their capital cost and operation/maintenance cost, respectively. The technology requiring the least capital for setup received a score of 5, while the most expensive one received a score of 1. Similarly, the technology with the lowest maintenance cost received a score of 5, while the one with the highest maintenance cost received a score of 1.

Maintainability was considered as the ease with which maintenance activities can be performed by maintenance personnel and ensuring ease of access for components requiring servicing. Technology requiring large clearances relative to their size and output would score lower as an example. The technology with the highest maintenance accessibility received a score of 5, while the one with the lowest accessibility received a score of 1.

Reliability and resiliency measures flexibility when faced with variable operating conditions, likelihood of a system failure, as well as ability function normally without the need for maintenance. The technology requiring the least maintenance received a score of 5, while the one needing the most maintenance received a score of 1.

Carbon impact was viewed as the overall benefit the technology provided in reducing carbon emissions. For some technologies, GHG emissions are relatively neutral and dependent on the main plant (ex. the distribution network is relatively neutral for emissions on its own). GHG emissions were mainly considered in relation to the energy consumption and output of these technologies, with options having the most efficient use of energy and least GHG output receiving a score of 5 and least efficient use of energy and most GHG output receiving a score of 1.

Technology	Technical Viability	Required Footprint	Capital Cost	Operation and Maintenance Cost	Maintainability	Reliability and Resilience	Carbon Impact	Total Score
Electrical Resistance Boilers	5	5	4	5	3	4	4	30
Electrode Boilers (Electric Steam Boilers)	2	3.5	3	3	2	4	4	21.5

Biomass Boilers	1.5	1	2	2	1	2	2.5	12
Air Source Heat Pumps	1	2	2	2	3	2	4	16
Water Source Heat Pumps	5	4	3	3	4	4	4	27
Geothermal Exchange	5	2	3	5	2	4	5	26
Wastewater Heat Recovery	5	4	2	3	4	3	5	26
Thermal Energy Storage with Water Tank	5	3	4	4	4	4	5	29
Borehole Thermal Energy Storage	3	2	3	4	2	4	5	22
Thermal Energy Storage Using Phase Change Material	2	3	3	3	4	3	5	23
Solar Thermal	2	1	1	3	3	3	5	18
Solar Photovoltaic (PV)	2	1	2	4	3	3	5	20
Battery Energy Storage System (BESS)	4	3	2	3	4	4	3	23
Small Modular Reactors (SMS)	1	5	1	2	3	5	5	22
Heating and Chilled Water Loops	5	3	3	3	4	5	5	28
Ambient Loop	2	3	3	3	3	4	5	23

For ease of reference, a list of the viable technologies that scored highest have been highlighted in blue text as well as being listed below:

- Electrical resistance boilers
- Electrode boilers (Electric steam boilers)
- Water source heat pumps
- Geothermal exchange
- Wastewater heat recovery
- Thermal Energy Storage with water tank
- Heating and chilled water loops

9 SOLUTION DEVELOPMENT

After developing the campus load duration curve from the steam meter data and using several methodologies and energy modelling techniques to estimate building heating loads for the Town facilities, WSP was able to undergo high-level design exercises for redevelopment and expansion of the campus CHP to serve the Town at large. At St. FX's request, one of the solutions we reviewed was replacement of the existing oil-fired steam boilers with electric steam boilers to demonstrate the lowest-cost option.

WSP has developed three (3) possible solutions using different arrangements of the technologies discussed in the Technology Review. The performance and financial details of these solutions are provided in the subsequent sections, along with the high-level flow schematics and proposed plant layouts for each configuration.

It should be noted that the direct-buried piping technology described in the Technology Review has been utilized as the assumed distribution method for all configurations due to technical viability.

Equipment shown in each developed solution reflects a high-level planning based on peak loading and estimated available spaces for the potential plant; it is not comprehensive in nature. Additionally, the developed solutions include an N+1 redundancy of production equipment. This means that if the largest heating or cooling equipment were to fail, the remaining equipment is designed to handle the peak heating load, ensuring system reliability.

9.1 CONFIGURATION #1: WATER-SOURCE HEAT PUMPS AND ELECTRIC BOILERS

Based upon the results of the Feasibility Matrix in the Technology Review, our recommended approach for decarbonization and modernization of the St. FX and TOA CDES is a hybrid of water-source heat pump technology, geothermal energy, and electric resistance boilers with thermal energy storage (TES) in the form of low temperature hot water storage tanks.

St. FX has identified an area south of the existing campus which provides an adequate footprint for a new energy centre and an accompanying geothermal well field and storage tank. Viability of the site for implementation of district-level geothermal exchange is discussed in Appendix C. When coupled with an adequately sized electrical substation, a new DES using geothermal-source heat pump technology and electric resistance boiler technology can be used to generate low temperature hot water to meet the current and future demands of the University, the Town and its identified stakeholders. A proposed plant layout is shown in Appendix D.

Water from a new geothermal well field which maintains a year-round temperature of approximately 9˚C can be used as a thermal energy source for water-source heat pumps, generating low temperature heating water at approximately 76˚C. While this temperature is lower than what many of the St. FX buildings currently utilize for hydronic heating, a gradual modernization of building heating systems as they come online with the new system will allow the plant and building operators to reduce the supply water setpoint, reducing energy consumption at the central plant.

The most significant advantage to utilizing heat pump technology for Antigonish is a property of refrigeration machines called the Coefficient of Performance (COP). The proposed heat pumps (York/JCI CYK heat recovery chillers) have a worst-case COP of approximately 2.7, meaning that for every unit of electrical energy supplied to the unit, 2.7 units of heat are produced. With the COP working in their favour, Antigonish can utilize heat pump technology to overcome the portion of their electricity which is sourced from non-renewable sources.

A key aspect of the proposed DES plant arrangement for Antigonish is the Thermal Energy Storage (TES) tank, which can hold enough low temperature hot water to supply the peak network heating load for a duration of 12 hours. While the heating plant is operating, it fills a large storage tank with hot water which is dispatched as required to serve the DES heating loads. Inclusion of a TES tank in the plant design provides resiliency as the campus loads can be served for several hours without a need to run heat pumps or boilers, and can allow operators to run heating equipment in off-peak hours to lower electricity costs.

The Town of Antigonish, in partnership with Alternative Resource Energy Authority (AREA) has recently come to an agreement to purchase additional renewable energy from an expanded Ellershouse Wind Farm in Ellershouse, NS. The quantity of electricity available from this wind farm could potentially put the Town into a renewable energy surplus, which further strengthens the case for TES in the proposed Antigonish/St. FX DES design.

A preliminary flow schematic of the preferred DES solution can be found in Appendix D. Electric boilers would be provided and piped in series with the heat pumps, topping up their supply water temperature to meet the demands of the buildings and also providing backup heat in the event of chiller maintenance or sustained energy imbalance in the geothermal well field leading to evaporator entering water temperature degradation. Heat from the electric boilers could also be used to directly recharge the well field in the event of degraded performance, which has not yet been observed in the existing geothermal heat pump systems serving 5 buildings on campus. Another option for geothermal borefield energy balancing would be to utilize stored heating water from the TES tanks.

To meet the peak heating demands of the existing St. FX campus and Town, WSP has proposed the following equipment configuration. Note that the proposed layout includes N+1 redundancy for the heat pumps. Design capacity for the plant was developed after a review of the existing St. FX campus heating loads (measured directly from steam meters at most buildings), and a review of existing building systems and building elements (consisting of site visit, utility billing review, information gap analysis, and high-level energy modeling).

	Equipment Plan	**Design Capacity**
Heating	3 × 10,000 kW water-source heat pump 1 × 5,000 kW electric boilers	20 MW
Thermal Energy Storage	2 x 7,500,000 L hot water storage tanks	12 hours of peak heating load

This DES option would require the construction of a new dedicated electrical distribution line from the TOA utility to the identified area south of the existing campus earmarked for the new energy centre. While the energy centre building systems and larger auxiliary equipment would operate at 600/347V with 208/120V available for lighting and plug loads, the district energy system equipment would operate at a combination of 4,160V and 600V.

9.1.1 FUTURE EXPANSION AND PHASING CONSIDERATIONS

In reviewing the overall layout of the TOA and its CDES stakeholder facilities, two potential future expansion opportunities and associated construction phasing were identified and are described below for TOA's consideration. Both additional phases are included in Appendix E (Capital Cost Estimate) and were included in our hydraulic analysis for the proposed LTHW network piping distribution.

- Phase 1: Redevelopment of existing St. FX DES plant implementing the LTHW technologies described in the Solution Development section;
- Phase 2: St. Martha's Regional Hospital Central Plant Redevelopment and DES Tie-in

  As described in section 5.4, the St. Martha's Regional Hospital is heated by an oil-fired high-pressure steam boiler system and cooled by an electric chiller plant. Hospitals have considerable year-round coincident heating and cooling loads, and as such are suitable applications for WSHP systems which are capable of simultaneous heating and cooling with high efficiencies (COPs exceeding 4 are published by York for the CYK-series heat recovery chillers being considered for the TOA/St. FX CDES system). If the CDES heating water distribution network was expanded across the bridge to connect to an electrified heating and cooling system at St. Martha's, heat from the hospital's cooling system could be rejected and utilized by other buildings on the CDES network. In addition, connection to a DES would provide the hospital with redundancy on its heating system, allowing them to decarbonize their heating system.
- Phase 3: Wastewater Heat Recovery Installation at the Antigonish Sewage Treatment Plant

As part of our initial information review, flow and temperature data for the existing wastewater infrastructure in Antigonish was found to show potential for an application of wastewater heat recovery technology. While this option was not reviewed in detail as part of the study mandate, we are presenting it as worthy of exploration should the Town choose to redevelop their sewage treatment facility in the future. Review of recorded flow and temperature data shows promise for up to 2 MW of heat recovery, using the wastewater heat recovery technology and water source heat pump technology described in the Technology Review.

9.1.2 CHP ELECTRICAL DISTRIBUTION OVERVIEW

The Central Heating Plant in configuration #1 will be new and will house:

Three (3)	10,000 kW	Water-source Heat Pumps
One (1)	5,000 kW	Electric Boiler

The establishing of a new 25kV Antigonish Electric dedicated feeder would be required to feed the new CHP. The site transformation required would be two (2) 15/20MVA transformers to provide the required the redundancy to the 20MW for the Central Heating Plant equipment operating at 4,160V or 600V and 1 MW of building load to support the facility HVAC and building systems operating at 600/347V and 208/120V.

The new site will require the following infrastructure:

- power distribution, protection and SCADA equipment necessary to meet utility design standards of an intertie substation including:
    - an embedded ground grid system,
    - perimeter security fence enclosure,
    - concrete pads
    - steel support structures,
    - area LED lighting,
    - 25kV gang-operated disconnect switch(es),
    - station class surge arresters,
    - distribution class surge arresters,

All substation and distribution apparatus, such as two (2) power transformers, voltage regulators, distribution reclosers, load break switches, insulators, lighting arresters, metering tanks, will be specified to NSPI standards to allow for easy access to spares and replacement parts.

The transformers shall be sealed, naturally cooled, oil filled (ONAN/ONAF) units. Each unit to be rated for 15/20MVA. Transformers shall have taps at nominal voltage ratio and +/- 2.5% and +/- 5% by off-load tap switch connected to the primary winding.

Low and high voltage power cables to electrical equipment are to be XLPE multi-core armoured cables. Cable construction shall be 600/1000V and 25kV class respectively, plain annealed stranded copper conductor, cross linked polyethylene (XLPE) insulated PVC extruded bedded, single galvanized steel wire armoured and an overall black PVC sheath.

Switchgear and transformers shall be protected against surges by metal oxide varistors (MOV) surge arresters.

9.2 CONFIGURATION #2: ELECTRIC LTHW BOILERS

As an alternative to heat pump technology, a new LTHW DES at St. FX could be equipped with electric immersion boilers, such as those manufactured by Gaumer or Chomalox.

Electric boilers are capable of providing water at 76˚C or higher, with nearly 100% turndown with no impact to overall energy efficiency which is approximately 99%. Since Antigonish's electricity source is not 100% renewable (currently 64%), electric boilers alone would not be capable of fully decarbonizing the St. FX DES and are thus not being recommended as the #1 DES solution. The town owns and operates its own municipal electricity utility, with about 64 per cent of its energy coming from renewable sources. If the new DES consisted of electric boilers alone, a larger fraction of the Town's electricity supply would have to be supplemented by renewable energy (wind and solar) for the Town to reach its goal of fully decarbonizing by 2035. We understand that an upcoming agreement between TOA/AREA and the Ellershouse Wind Farm will significantly improve the carbon footprint of Antigonish's electricity source and could put the Town into a renewable energy surplus – while further information on renewable energy production and load duration curves could further validate the carbon footprint of an electric boiler plant without heat pumps, our recommendation for this option would be to pair it with TES in a similar fashion to option #1 to allow the peak energy production of the wind farm to generate heat, while also providing the DES operations team with flexibility for both maintenance shutdowns and electricity savings via off-peak generation of DES heating energy.

9.3 CONFIGURATION #3: ELECTRIC STEAM BOILERS

At St. FX's request, we have included an option to heat the St. FX campus and surrounding town with steam as a lowest capital cost option.

Electric steam boilers, as described in the Technology Review (Section 10) are capable of generating high-pressure steam with a thermal efficiency of approximately 99%, similarly to electric LTHW boilers. The town owns and operates its own municipal electricity utility, with about 64 per cent of its energy coming from renewable sources. Given that St. FX's campus is currently heated by steam, the lowest cost and lowest complexity solution for modernization and expansion of the existing St. FX DES would be to continue using steam as a heating medium, thereby allowing the system to operate with some existing infrastructure and existing ETSs in the buildings. The existing buried steam and condensate infrastructure would require some upgrading, the extent of which cannot be known without a detailed review which would take place during a detailed design exercise.

Despite their near-perfect thermal efficiency however, steam boilers would still not be capable of decarbonizing the town on their own, and utilization of this technology would necessitate a much larger fraction of the town's electricity to be generated by renewable resources such as wind and solar power.

10 BUILDING DES CONNECTIONS

10.1BUILDING CONVERSION AND ETS

All buildings connection to the District Energy System will require an energy transfer station (ETS) to transfer heat between the primary DES distribution side, and secondary system, being the individual building system. These ETS's are designed and sized specifically to meet the loads and requirements of each individual building. As represented on Drawings M300 through M303 in Appendix D the quantity of heat exchangers and DHW heat exchangers can be included in the ETS installation.

Where new heat exchanger installation is required, a parallel installation is typically preferred from a constructability standpoint. Parallel ETS arrangements involve the construction of a new heat exchanger and associated piping and control components completely before a parallel tie-in (via shutdown or hot tapping) and commissioning process is completed, followed by decommissioning of existing ETS equipment. This allows for the new piping system to be installed while the existing ETS still operates. Once the new system is ready, the building can be transitioned to the new ETS and the old ETS can be removed. If parallel installation can not be accommodated due to space constraints, installation in situ can be done but more significant building shutdowns are to be expected in order to connect the building to the new system while the existing system is removed.

Drawing M300 represents a single heat exchanger installation intended for small buildings only, for redundancy two or more heat exchangers are typically preferred but for small loads, in order to appropriately size the heat exchangers, single heat exchangers are recommended. Additionally, on Drawing M300, an optional existing heat pump tie-in is shown. Our review of the St. FX campus identified five buildings with geothermal fields and heat pumps. When tied into the primary side piping, these heat pumps can provide energy to the rest of the DES when capacity allows it. This will allow the entire campus to benefit from the high efficiency, low GHG energy generated by these heat pumps. The individual building can still be isolated from the DES system and operate independently through its own ETS when required. This type of arrangement will require the installation of pumps in those specific ETS that can achieve the DES distribution pressure and more advanced controls.

For the optional DHW connection, this can be configured in many ways. The heat exchanger can operate as an instantaneous water heater or can serve as a source of heat for DHW storage tanks. The preferred approach can be determined on a building per building basis as the heat exchanger can be sized accordingly. The secondary side controls remain unchanged for both configurations.

11 HYDRAULIC MODELING RESULTS

The LTHW district energy solutions discussed in configurations #1 and #2 of the Solution Development section were modeled using FluidIt Heat software to estimate pipe sizes and pumping energy. Proposed buried pipe routing was analyzed and optimized on the premises of flow velocity and pressure loss in three proposed phases of DES development:

Phase 1: St. FX Campus Central Plant Redevelopment

Phase 2: St. FX Campus Central Plant Redevelopment + St. Martha's Regional Hospital Nodal Plant

Phase 3: St. FX Campus Central Plant Redevelopment + St. Martha's Regional Hospital Nodal Plant + Schools

In the Phase 1 scenario, peak heating load information from the St FX steam meter data were assigned to campus buildings and proposed main distribution piping was routed with proximity to existing roads and infrastructure as a priority for constructability purposes.

In the phase 2 scenario, a redevelopment of the St Martha's Regional Hospital central energy plant was considered in addition to the St FX central heating plant redevelopment, with proposed heating water supply and return piping along Main Street connecting the proposed main and nodal plants.

Phase 3 of the proposed community DES network in Antigonish consists of the St FX campus DES redevelopment and hospital central plant upgrades proposed in phase 2, with an extension from James Street to Fairview Street and Highland Drive and Braemore Avenue to serve the town's three schools (Dr. JH Gillis Regional High School, Saint Andrew Junior School, and the Antigonish Education Centre).

Buried piping sizing for the proposed final connected DES was optimized using FluidIt Heat and was found to range from DN65 to DN500 as indicated below in figures 35 and 37.

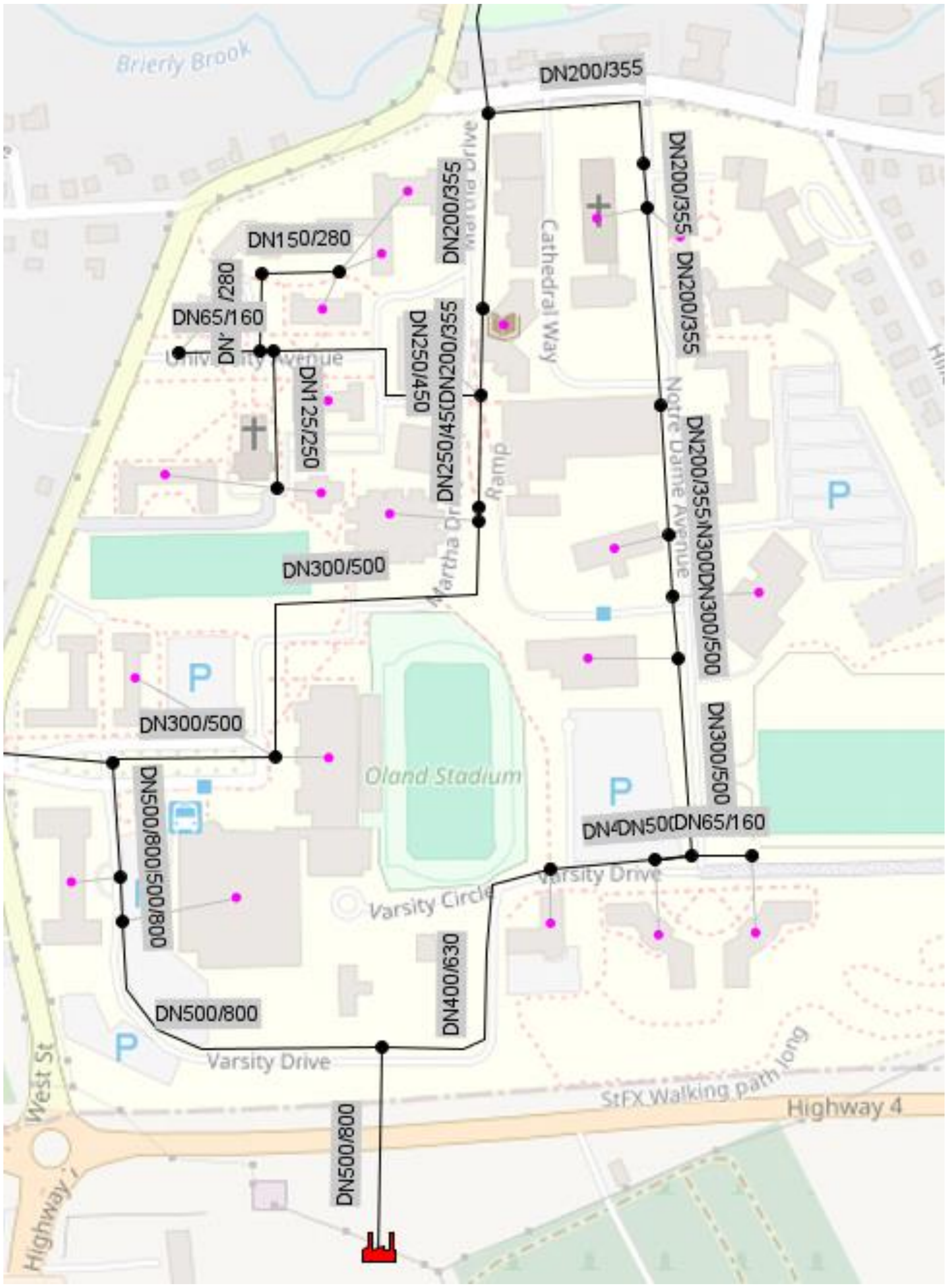


Figure 35: FluidIt Heat Pipe Sizing Results – St FX DES Redevelopment, Phase 1

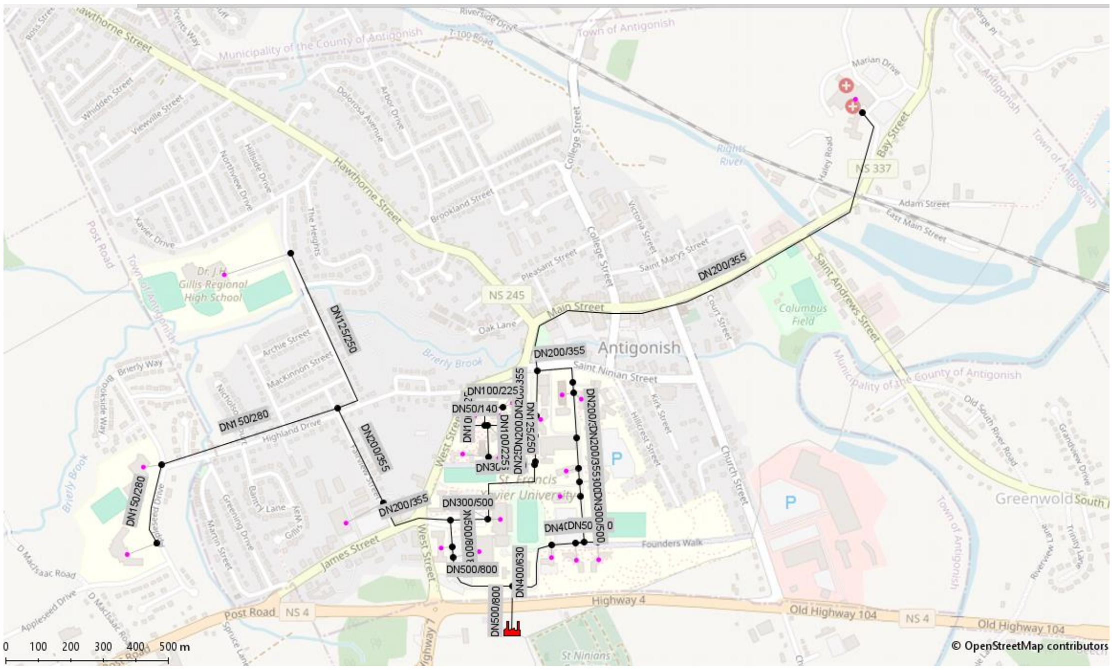


Figure 36: Preliminary DES Pipe Sizing, Phase 3

Velocity analysis results for the total proposed connected community DES network are indicated in figure 37 below. At the current stage of design development, pipe sizes and flow velocities inform a conservative capital expenditure estimate. A detailed design process would result in smaller piping and higher velocities, but a more complex layout including provisions for thermal expansion. The proposed heating supply and return main piping to the hospital and schools are sized with capacity for future expansion of the DES.

Figure 37: Flow Velocity Visualization from FluidIt Heat analysis – total connected DES network

Overall, the hydraulic modeling results indicated that the geographic layout of the Town of Antigonish is favourable for a LTHW DES, with resulting pumping and pipe sizing parameters falling within expected ranges for a network of the proposed heating capacity (20 MW). An overall pressure drop with central pumps located in the St FX plant and an index run to the St Martha’s Regional Hospital resulted in a pressure drop of approximately 4 bar which would allow a DES network to be designed with an 16 bar design pressure, based on a desktop review of publicly available elevation data. As indicated in Figure 37, all velocities at peak loading were kept below 3 m/s.

12 CAPITAL COST ESTIMATE

Preliminary capital cost estimates have been prepared for the three central plant configurations discussed above and are detailed in Appendix E.

The scope of work of the three options is summarized below:

Option 1: Water-source heat pump with electric boilers:

- New central plant building.
- New heat pumps and electric boilers within new central plant building, including all associated piping, equipment and controls.
- New energy transfer stations to 42nr buildings.
- New district LTHW heating piping network.
- Geo-thermal system, including 876nr 1,500ft deep boreholes.
- Wastewater heat recovery system (equipment supply & installation only).
- Associated electrical distribution.
- New 4,850 m^3 Thermal Storage Tanks.

Option 2: Electric LTHW boilers:

- New central plant building.
- New electric boilers within new central plant building, including all associated piping, equipment and controls.
- New energy transfer stations to 42nr buildings.
- New district LTHW heating piping network.
- Associated electrical distribution.
- New 4,850 m^3 Thermal Storage Tanks.

Option 3: Electric steam boilers:

- New central plant building.
- New steam boilers within new central plant building, including all associated piping, equipment and controls.
- Associated electrical distribution.

A breakdown of this cost is summarized in the table below. All costs are based on present day Canadian dollars and escalation has been excluded.

Table 7: Capital Cost Estimate Summary

	TOTAL C$
OPTION 1: Water-source Heat Pumps and Electrical Boilers	
Phase 1	109,125,420
Phase 2	61,421,258
Phase 3	35,497,685
Grand Total Option 1	**206,044,363**
OPTION 2: Electric LTHW Boilers	
Phase 1	65,981,175
Phase 2	19,152,072
Phase 3	10,945,146
Grand Total Option 2	**96,078,393**
OPTION 3: Electric Steam Boilers (Single Phase)	
Grand Total Option 3	**28,109,527**

13 ENERGY COST ASSESSMENT

WSP conducted an energy cost assessment to evaluate the cost implications of various central plant configurations for heat production. Using data provided by the town and university, the heating demand from the central plant throughout the year is estimated. Energy consumption and costs are then calculated for different plant configurations. The objective of this analysis is to identify the configuration with the lowest energy cost over a 25-year period. The total energy cost is presented as a net present value (NPV) in 2025 Canadian dollars (C$). Costs of the central plant configurations are not included in this assessment and can be found in the previous section. The operations and maintenance costs are not included in this assessment. The total energy cost of the existing system, based on the provided historical energy consumption data, has also been estimated and is used for comparison with the central plant options. Carbon tax is also considered for the existing system's propane and fuel oil usage. Summaries of the energy cost/NPV and associated sensitivity analyses can be found in Appendix G.

13.1 INPUT AND ASSUMPTIONS

For this assessment, the following are the key common assumptions for all three central plant options:

Power costs:

- Town of Antigonish "Large General Service" rate class considered:
    - Demand Rate: $13.845 per month per kVA of maximum demand of the current month or the maximum actual demand of the previous December, January, or February, occurring in the previous eleven months.
    - Energy Rate: $0.09850 per kilowatt hour (plus FAM).
    - Transformation Charges: 1.75% times Energy charges only (including FAM).
    - DSM Rate: $0.00568 per kilowatt hour for all consumption.
    - Transmission Loss Factor: 2.14%.

Heating oil costs:

- 1.75 $/Liter.
    - Source: 2023 Halifax Weekly Average Retail Price for Furnace Oil considered.

Propane costs:

- 0.8 $/Liter.
    - Source: CBCL report "Pathway to Net Zero Emissions Feasibility Study Town of Antigonish".

Project assumptions:

- The net present value of the total utility cost of the next 25 years is considered, assuming that the central plant is to be installed and going into operation in 2025.
- Total annual energy consumption from the central plant remains the same for the next 25 years.

Financial assumptions:

- Inflation factor for all other non-power cost: 2%.
- 2024 – 2025 electricity cost escalation: 2.4%.
- Annual electricity cost escalation after 2025: 2% (tracking inflation).

- Annual propane and oil price escalation: 4.5%.
- Carbon tax:
    - 2024 – 2030: price increase by 15 \$/tonnes CO_2 per year.
    - 2030 and beyond: 2% annual escalation following inflation factor.

District energy system assumptions:

- Central plant hot water supplied at 85 °C, hot water returned at 70 °C.
- Water-source heat pump delta T: 6.67 °C (temperature boost from 70 °C to 76.67 °C).
- Boiler to boost heat pump supply water temperature from 76.67 °C to 85 °C.

For this assessment, the following key data inputs were used to determine the thermal demand of the town and university:

- Building steam consumption data provided by St. FX.
- Building propane and oil consumption data provided by St. FX.
- Building oil consumption data provide by the town.
- Building energy modeling conducted during the gap analysis.
- Building peak heating demand calculated using the Energy Use Intensity (EUI) from a similar building with sufficient data.

For the three plant configurations in addition to the existing system, some of the key inputs are shown in the table below:

Table 8: Energy Cost Assessment Input Summary

		EXISTING SYSTEM	CONFIGURATION 1: HEAT PUMPS & ELECTRIC BOILERS	CONFIGURATION 2: ELECTRIC LTHW BOILERS	CONFIGURATION 3: ELECTRIC STEAM BOILERS
Power					
Annual Power Consumption	MWh	654	29,291	40,439	40,033
First Year Power Costs (2025$)	$million	0.10	4.63	6.41	6.34
Heating Oil (Existing System)					
Annual Heating Oil Consumption	L	4,525,328			
Annual Heating Oil Costs (2025$)	$million	7.92			
Propane (Existing System)					
Annual Propane Consumption	L	86,475			
Annual Propane Costs (2025$)	$million	0.07			
Total First Year Energy Cost (2025$)	$million	8.09	4.63	6.41	6.34

13.2MODELING RESULTS

Based on the above inputs and assumptions, the energy cost assessment results are summarized as Net Present Value (NPV) as shown below:

Table 9: Energy Cost Assessment Result

PLANT CONFIGURATION	ENERGY COST NPV C$ MILLIONS	CARBON TAX COST NPV C$ MILLIONS	NPV C$ MILLIONS
Town of Antigonish and St. FX Existing Heating System	280.38	21.14	301.52
Configuration #1: Water-Source Heat Pump and Electrical Boilers	116.30	-	116.30
Configuration #2: Electric LTHW Boilers	160.79	-	160.79
Configuration #3: Electric Steam Boilers	159.17	-	159.17

It is clear that all three central plant configurations offer significantly lower energy cost compared to the town and university's existing system. This is primarily due to the lower electricity price and slower price escalation compared to propane and fuel oil. Additionally, these central plant configurations offer fully electric system, which helps avoid carbon tax payment. Among all options, Configuration #1 offers the lowest energy costs, primarily because it incorporates water-source heat pumps with considerably higher efficiency. These pumps can generate up to three times the thermal energy relative to the electrical energy input, which is significantly more efficient than the electric hot water boilers and electric steam boilers chosen for the other two plant configurations.

It is also important to note that the assumptions made regarding the district energy heating system temperature and the operating temperature of the water-source heat pumps represent a worst-case scenario. In reality, with a more optimized system operating parameters, the central plant using water-source heat pumps could achieve even greater efficiency, further reducing the overall energy cost.

13.3SENSITIVITY ANALYSIS

The Net Present Value (NPV) of the energy cost assessment provides a high-level analysis intended for relative comparison. Several parameters used in the analysis involves a degree of uncertainty and require further investigation. These parameters of uncertainty include:

- Energy Cost: Nova Scotia power grid electricity annual cost escalation.
- Energy Cost: Propane and oil annual price escalation.
- Wind Energy: Percentage of electricity received from AREA's wind farm.

It would be difficult to project the future inflation within Canada, as it will depend on variables beyond the scope of this study. For the purpose of this analysis, the overall inflation factor for all other non-power cost will remain at 2%.

A sensitivity analysis is then conducted for each parameter, while holding the other two constant. As with the energy cost NPV assessment discussed in the previous section, the outcomes of these sensitivity analyses are intended to support relative comparisons. A carbon tax is included in all sensitivity analysis results.

13.3.1 SENSITIVITY #1 ENERGY COST: NOVA SCOTIA POWER GRID ANNUAL ELECTRICITY COST ESCALATION

The base case assumes an annual escalation of 2% for grid electricity costs starting in 2025 and continuing over the project's lifespan. The following sensitivity results are based on escalation rate of 2%, 3%, 7%, and 10%.

Assumptions:

- 100% of the electricity is assumed to be supplied by the Nova Scotia Power Grid and follows the “Large General Service” rate class.

Table 10: Sensitivity #1 Energy Cost: Nova Scotia Power Grid Electricity Cost Escalation

PLANT CONFIGURATION	NPV C$ MILLIONS WITH 2% GRID ELECTRICITY COST ESCALATION	NPV C$ MILLIONS WITH 3% GRID ELECTRICITY COST ESCALATION	NPV C$ MILLIONS WITH 7% GRID ELECTRICITY COST ESCALATION	NPV C$ MILLIONS WITH 10% GRID ELECTRICITY COST ESCALATION
Town of Antigonish and St. FX Existing Heating System	301.52	301.85	303.82	306.34
Configuration #1: Water-Source Heat Pump and Electrical Boilers	116.30	131.07	219.05	332.40
Configuration #2: Electric LTHW Boilers	160.79	181.20	302.84	459.54
Configuration #3: Electric Steam Boilers	159.17	179.38	299.80	454.93

13.3.2 SENSITIVITY #2 ENERGY COST: PROPANE AND OIL ANNUAL PRICE ESCALATION

The base case assumes an annual escalation of 4.5% for propane and oil price, lasting over the project’s lifespan. The following sensitivity results are based on an escalation rate of 1.5%, 4.5%, 7.5%, and 10%.

Assumptions:

- 100% of the electricity is assumed to be supplied by the Nova Scotia Power Grid and follows the “Large General Service” rate class.

Table 11: Sensitivity #2 Energy Cost: Propane and Oil Price Escalation

PLANT CONFIGURATION	NPV C$ MILLIONS WITH 1.5% PROPANE/OIL COST ESCALATION	NPV C$ MILLIONS WITH 4.5% PROPANE/OIL COST ESCALATION	NPV C$ MILLIONS WITH 7.5% PROPANE/OIL COST ESCALATION	NPV C$ MILLIONS WITH 10% PROPANE/OIL COST ESCALATION
Town of Antigonish and St. FX Existing Heating System	211.20	301.52	447.98	639.30
Configuration #1: Water-Source Heat Pump and Electrical Boilers	116.30	116.30	116.30	116.30
Configuration #2: Electric LTHW Boilers	160.79	160.79	160.79	160.79
Configuration #3: Electric Steam Boilers	159.17	159.17	159.17	159.17

13.3.3 SENSITIVITY #3 WIND ENERGY: PERCENTAGE OF ELECTRICITY RECEIVED FROM AREA WIND FARM

The base case assumes that all electricity used in generating heating and cooling is supplied by the Nova Scotia Power Grid.

With the potential for the Town of Antigonish to receive renewable wind power from the Ellershouse Wind Farm located in Ellershouse, NS. This energy supply has the potential to eventually place the town into a renewable energy surplus. To assess the impact of utilizing electricity generated by wind energy for heating and cooling, the following sensitivity analysis is conducted, evaluating various scenarios with electricity sourced from the wind farm at 0%, 25%, 50%, 75%, and 100%.

Assumptions:

- Wind farm electricity rate structure: $0.10/kWh (year 1).
- Annual wind farm electricity cost escalation: 2% (tracking inflation).
- Transmission Loss Factor: 2.14% applied to electricity from the wind farm.
- Monthly Peak Demand: Assumed constant (in kVA) for electricity supplied from the Nova Scotia Power Grid.

Table 12: Sensitivity #3 Wind Farm Electricity

PLANT CONFIGURATION	NPV C$ MILLIONS WITH 0% POWER FROM WIND FARM	NPV C$ MILLIONS WITH 25% POWER FROM WIND FARM	NPV C$ MILLIONS WITH 50% POWER FROM WIND FARM	NPV C$ MILLIONS WITH 75% POWER FROM WIND FARM	NPV C$ MILLIONS WITH 100% POWER FROM WIND FARM
Town of Antigonish and St. FX Existing Heating System	301.52	302.22	301.47	301.45	300.56
Configuration #1: Water-Source Heat Pump and Electrical Boilers	116.30	115.14	113.99	112.83	73.23
Configuration #2: Electric LTHW Boilers	160.79	159.19	157.59	155.99	101.10
Configuration #3: Electric Steam Boilers	159.17	157.59	156.01	154.43	100.08

The results shows that the overall energy cost does not decrease significantly until 100% of the electricity is sourced from the wind farm. This outcome is primarily due to the high Demand Rate charge under the “Large General Service” rate class:

- Demand Rate: $13.845 per month per kVA of maximum demand of the current month or the maximum actual demand of the previous December, January, or February, occurring in the previous eleven months.

Due to the unavailability of historical demand data, it was assumed that monthly peak demand (kVA) from the Nova Scotia Power Grid remains unchanged for the 0%, 25%, 50%, and 75% wind power cases but drops to 0 kVA in the 100% wind power case. Since the Demand Rate charge constitutes a significant portion of the electricity bill, the cost benefits of wind power are not fully realized until wind power accounts for 100% of electricity consumption.

One potential solution is to prioritize the use of wind power during periods of peak electricity consumption to reduce the monthly peak demand charges imposed under “Large General Service” rate class. In conclusion, integrating wind power would ultimately enable the Town to achieve further reduction in energy costs.

14 NEXT STEPS

In this report, a comprehensive overview of the solutions to provide heating to the Town of Antigonish has been presented. The options considered included a deep-bore geothermal (DBG) and water-source heat pump (WSHP) solution, and an electric boiler solution, each coupled with tank-style thermal energy storage (TES) solutions. Each of these options was carefully assessed for its feasibility, efficiency, and overall benefit to the project.

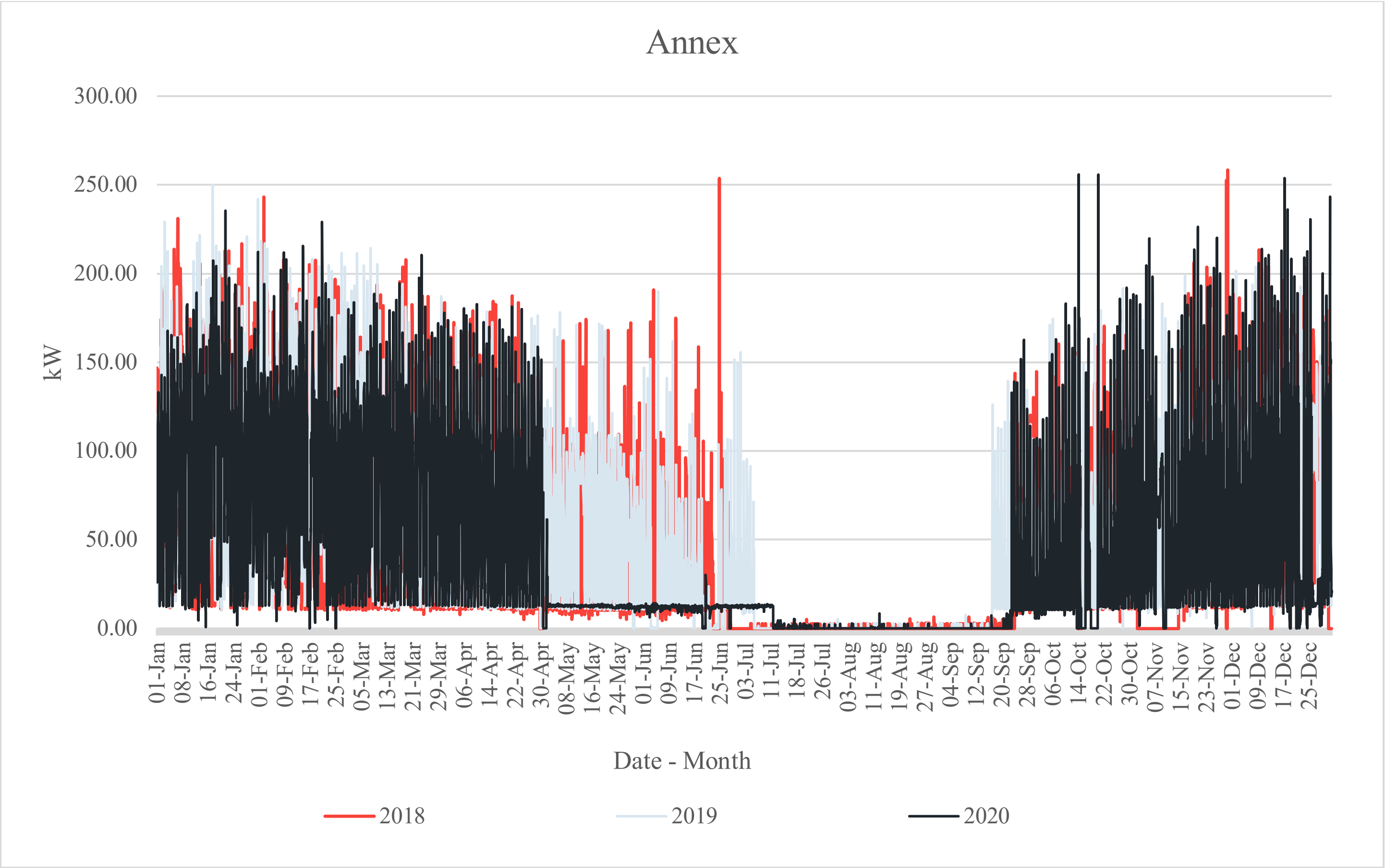
After a thorough review, it was determined that the geothermal/WSHP/electric boiler solution offered the most significant advantages for the project. This conclusion was based on various factors, including the potential for energy savings, environmental impact, and alignment with the project's sustainability goals. Consequently, it was recommended that the deep bore geothermal (DBG) solution be analyzed further to fully understand its benefits and implementation requirements.

To support this recommendation, a detailed financial analysis was conducted over the lifecycle of the project. This analysis utilized varying financial parameters to evaluate the long-term costs and benefits associated with each solution. The financial assessment aimed to provide a clear understanding of the economic viability of the DBG/WSHP/EB solution compared to the other options, ensuring that the most cost-effective and sustainable choice is made for the heating and cooling needs of the TOA and St. FX.

To move forward, we recommend the following:

- Validation and Refinement: Continue to validate assumptions made during the feasibility study. Engage with stakeholders, including local subject matter experts, to refine the approach. Ensure that the proposed systems aligns with both the project goals and the broader organizational objectives.
- Obtain Approval: Seek formal approval at defined points from relevant decision-makers before proceeding further. These gates ensures that the project is well-vetted and supported.
- Funding Opportunities:
  - Further explore government grants, subsidies, and incentives specifically aimed at renewable energy projects.
  - Explore partnerships with private investors interested in wastewater energy transfer and sustainable projects.
- Schematic Design: Refine the proposed DBG/WSHP/TES solution and strategy and develop the schematic design documents.
- Strategize user building conversions. Existing buildings fed from steam will require conversion before the commissioning of a new CDES and connection to a LTHW distribution network.

A BUILDING LOAD INFORMATION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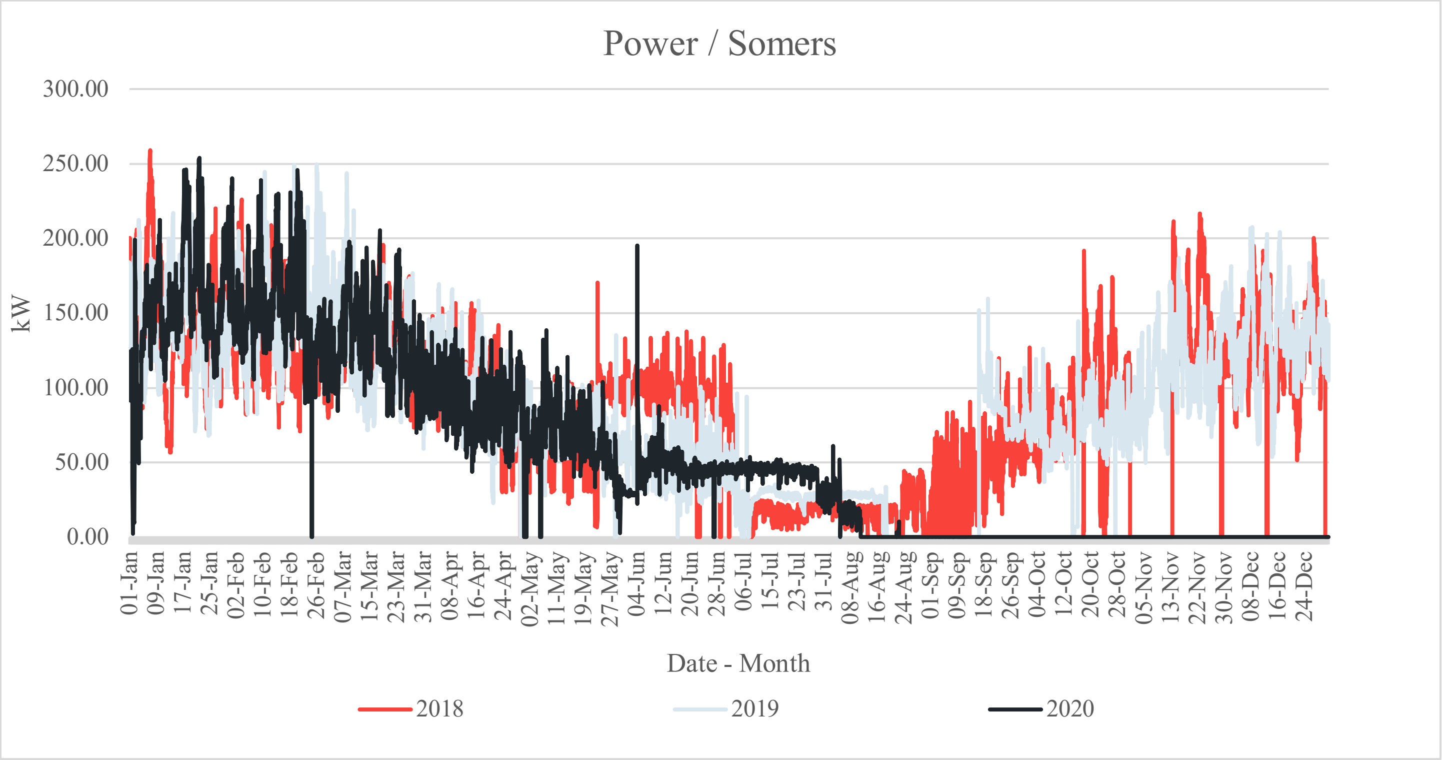
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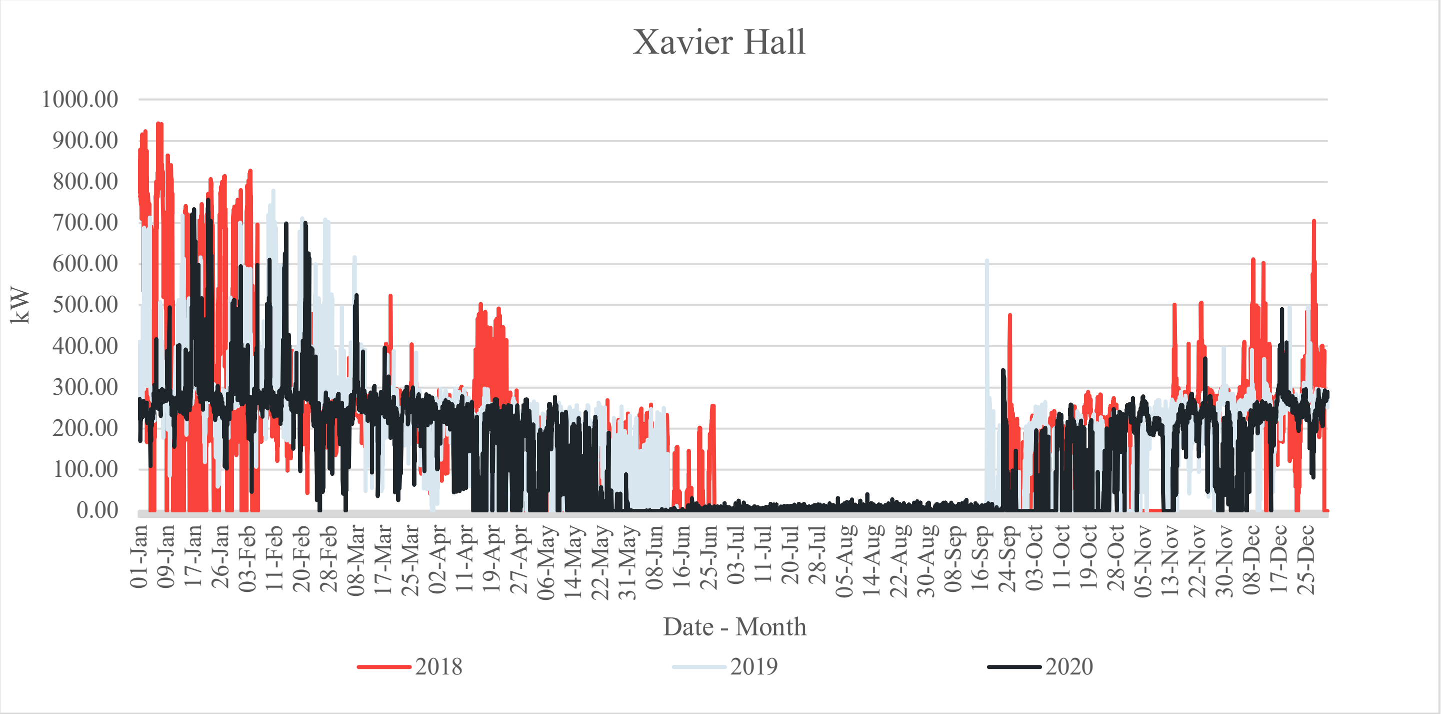
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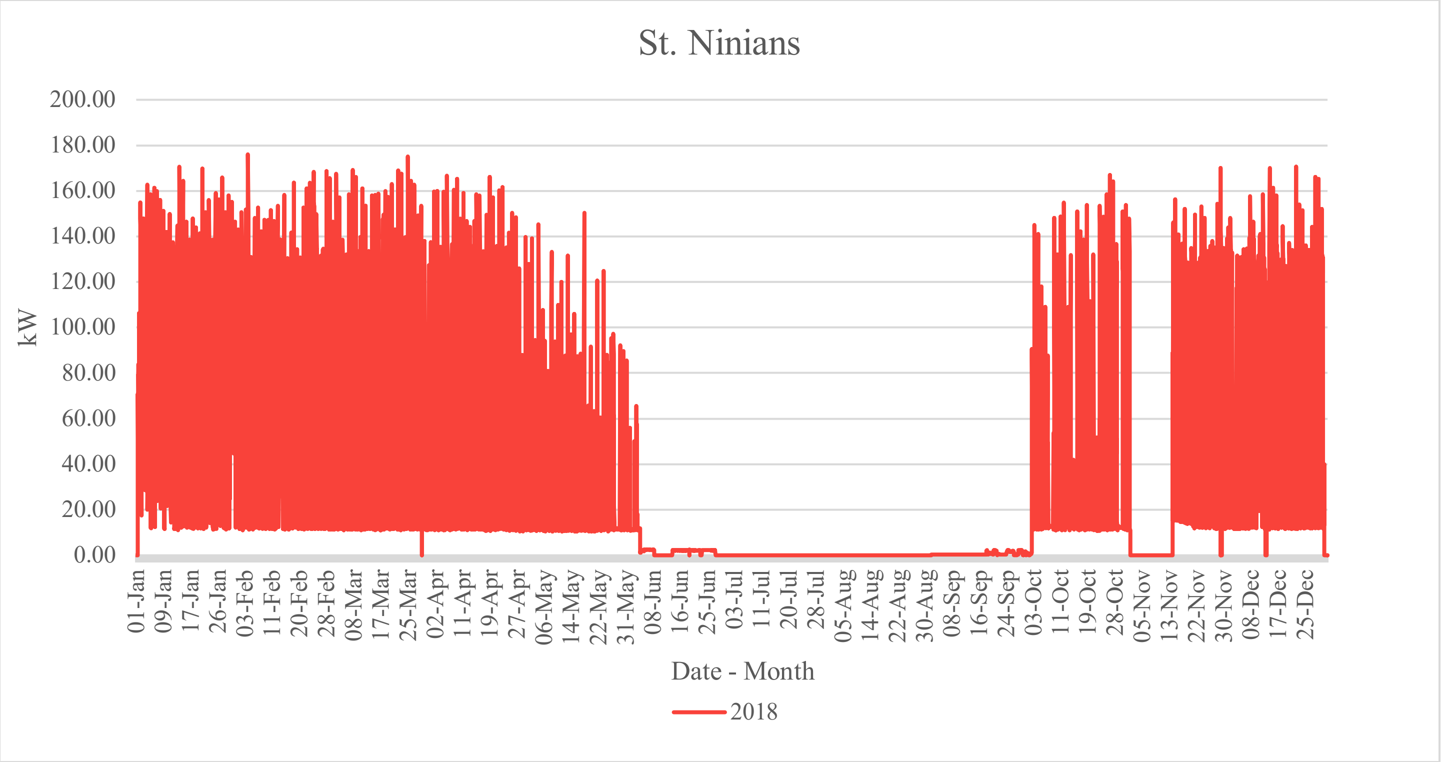
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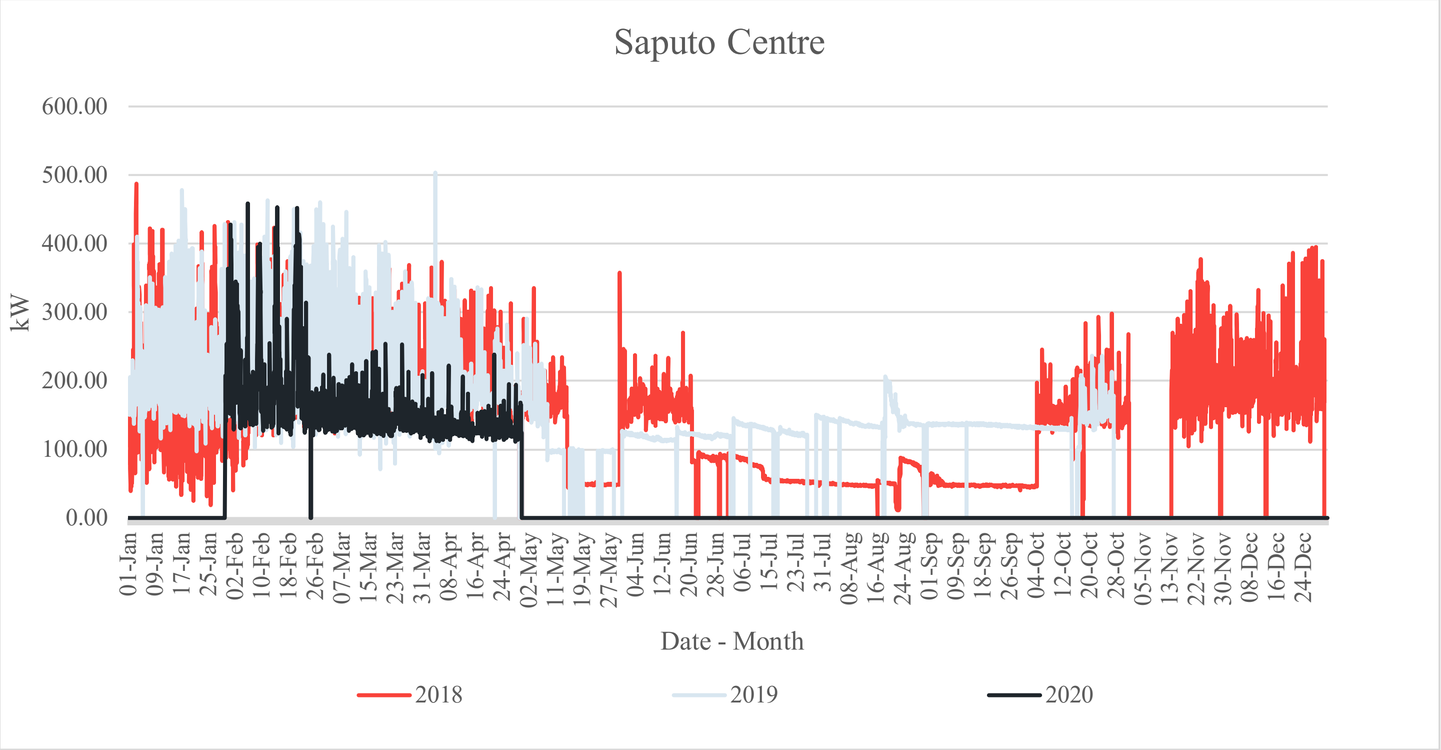
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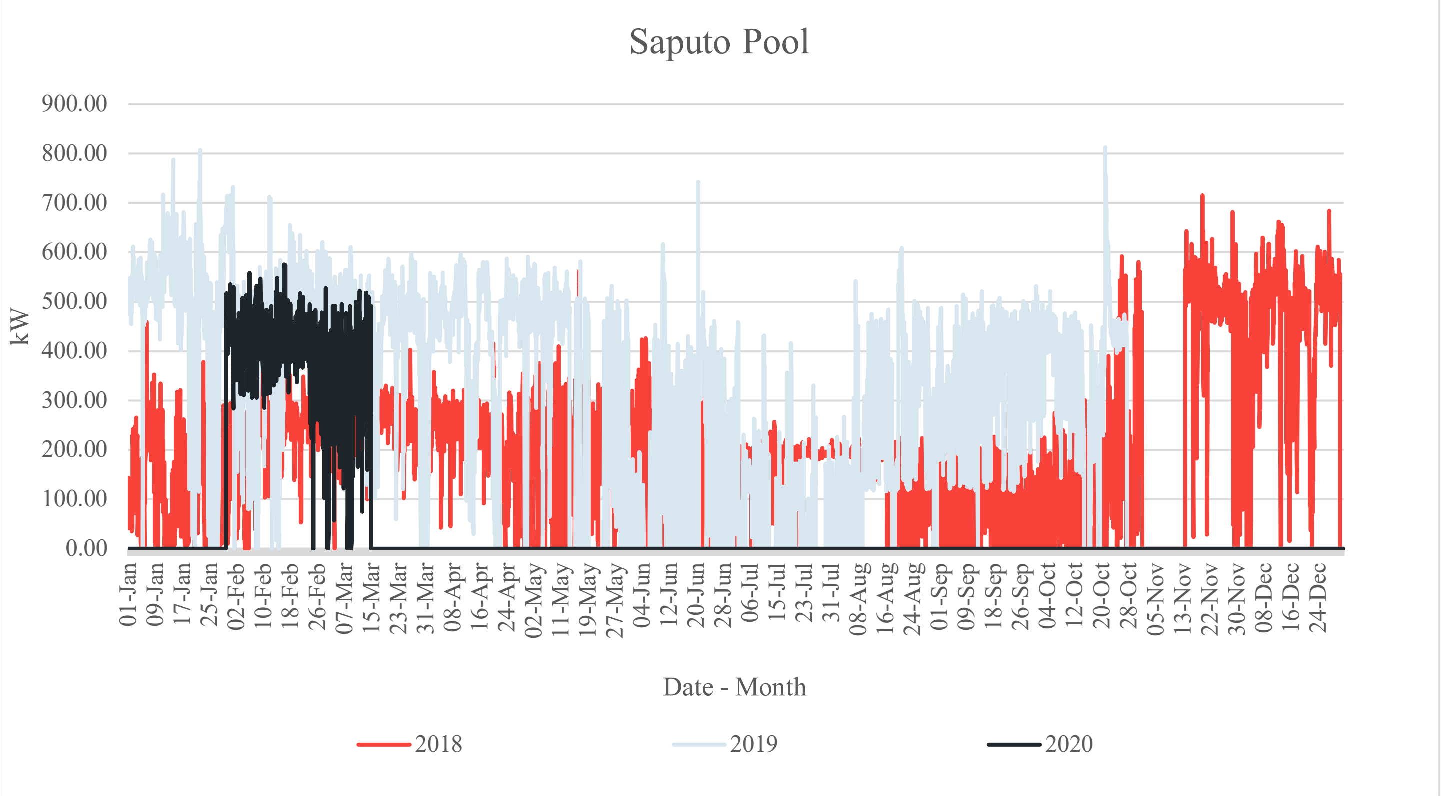
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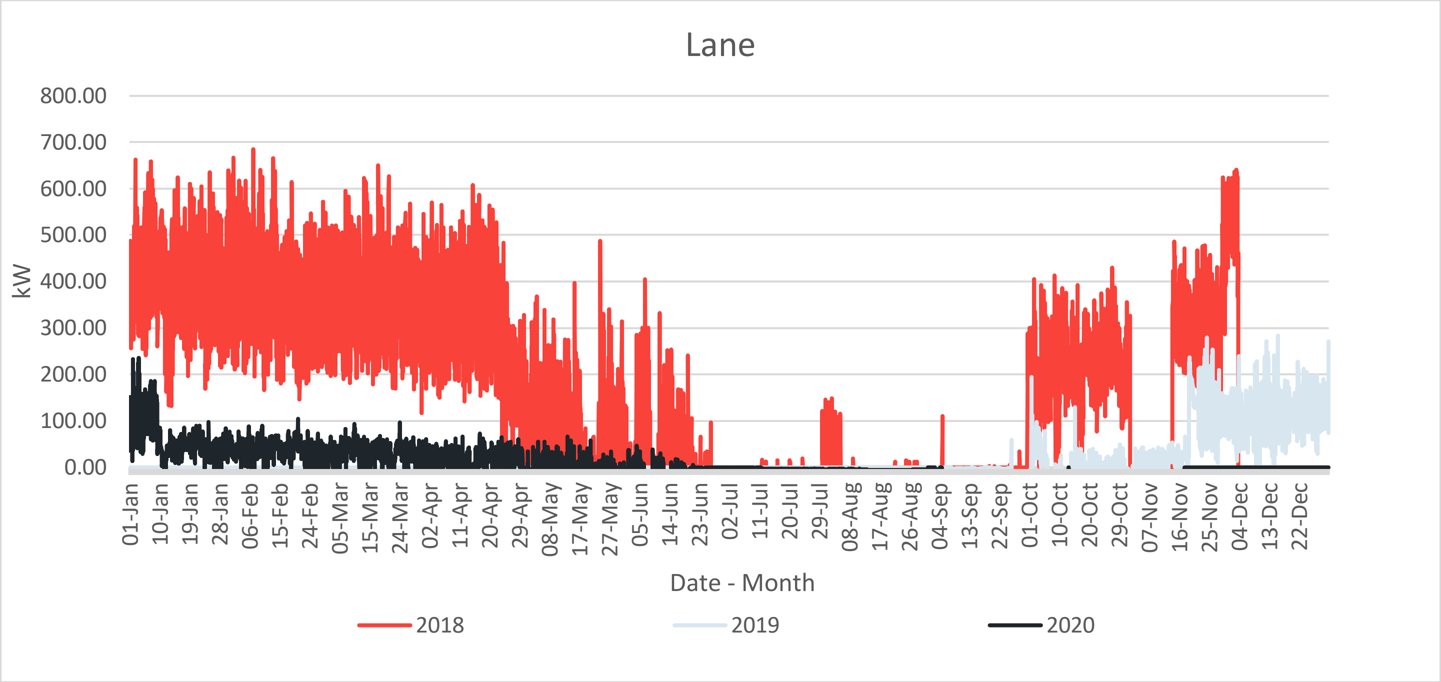
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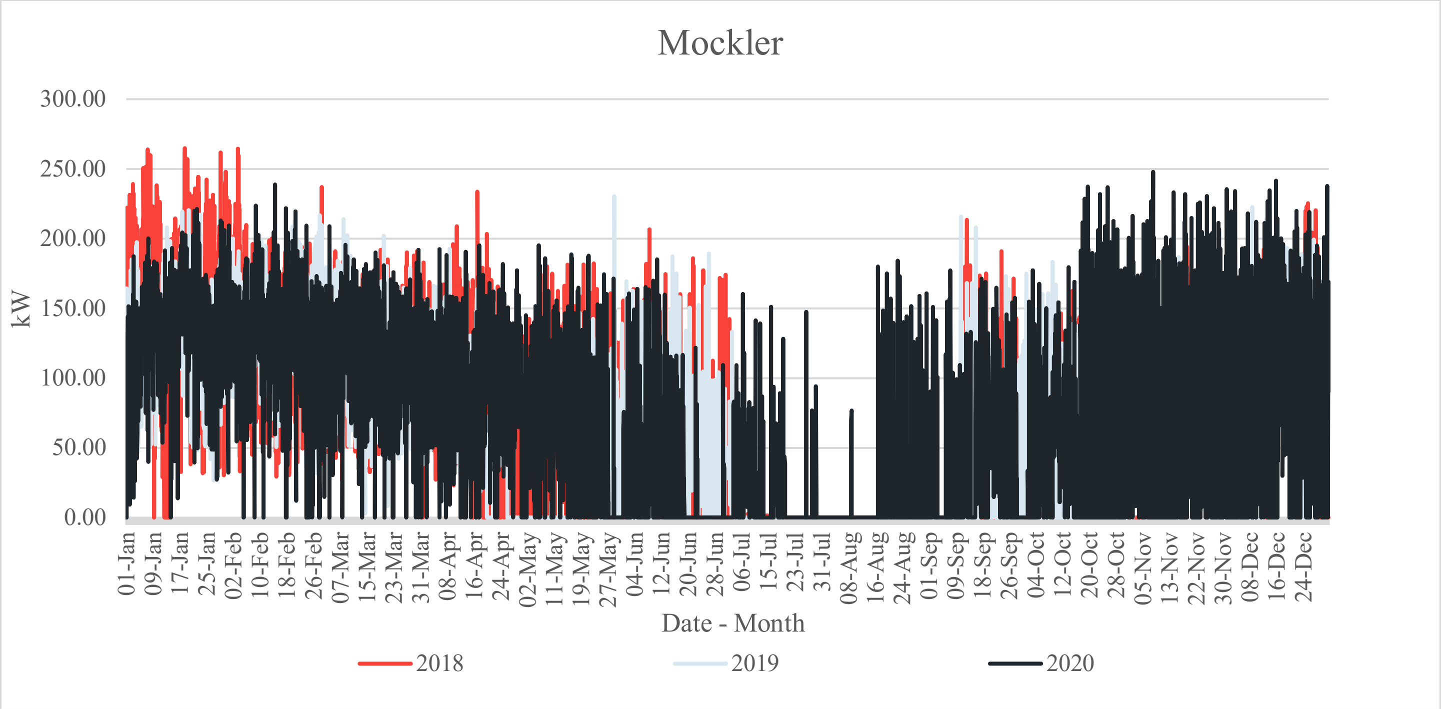
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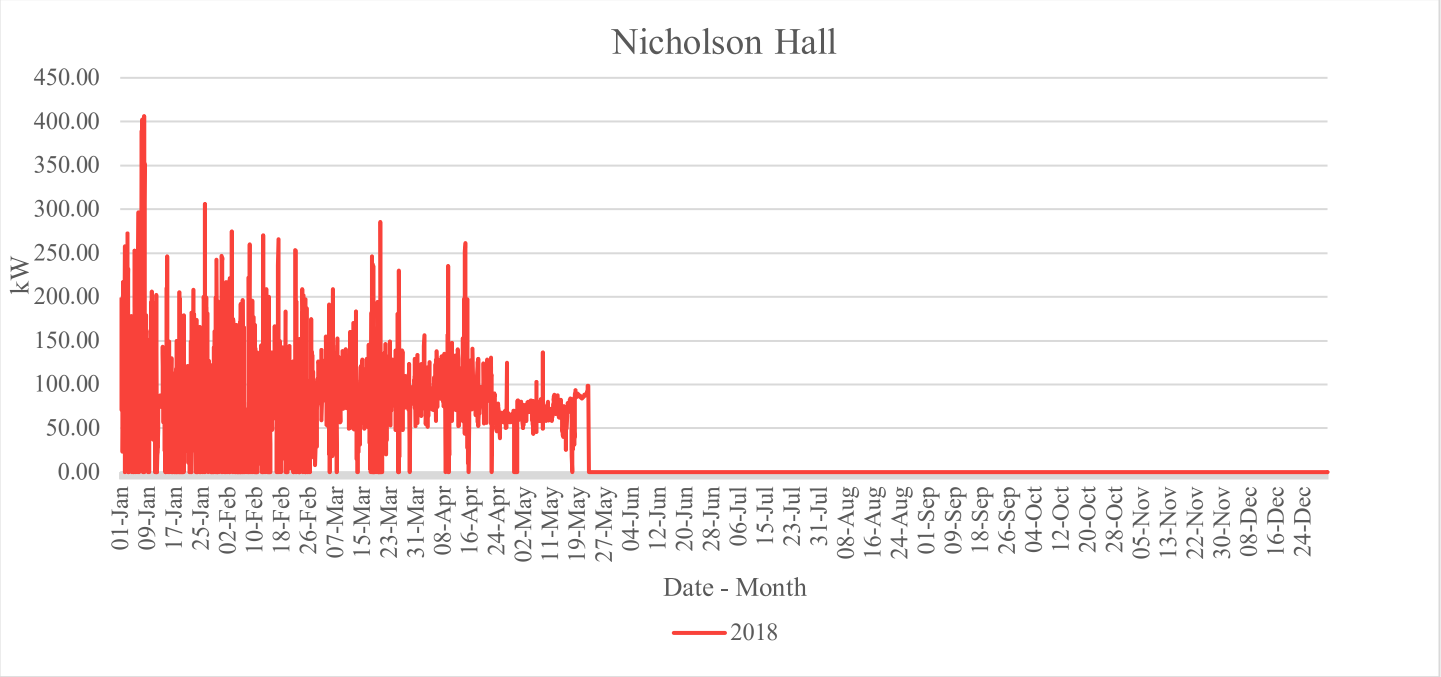
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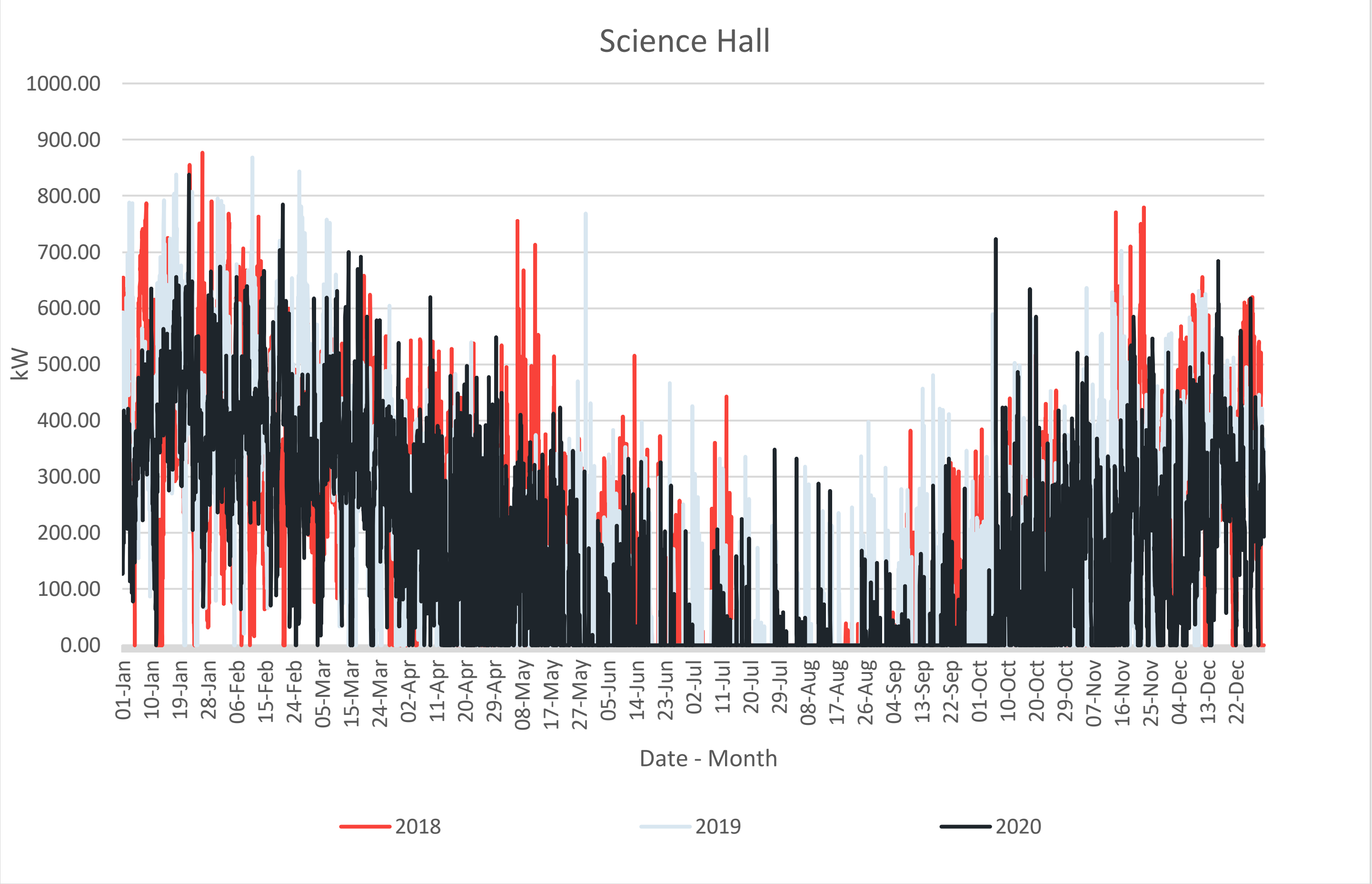
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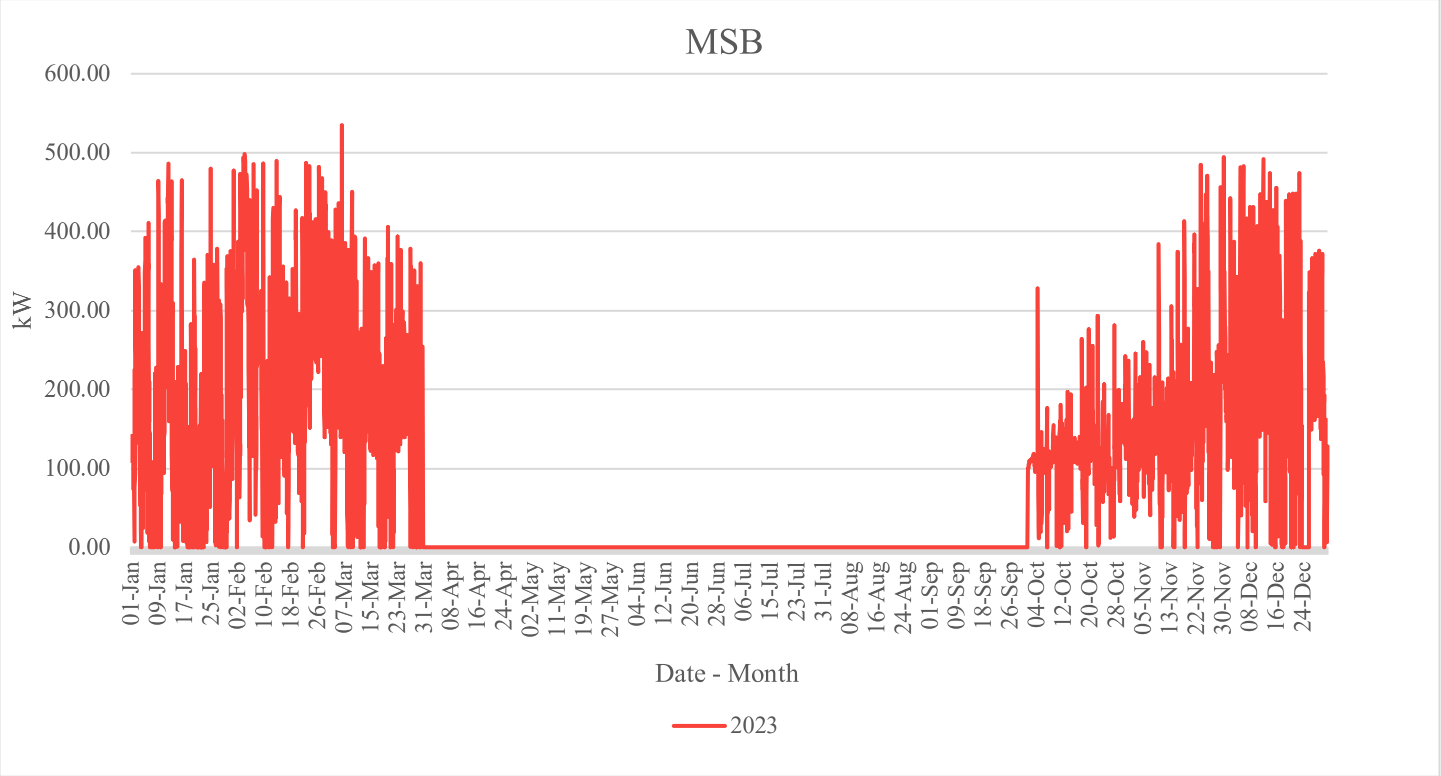
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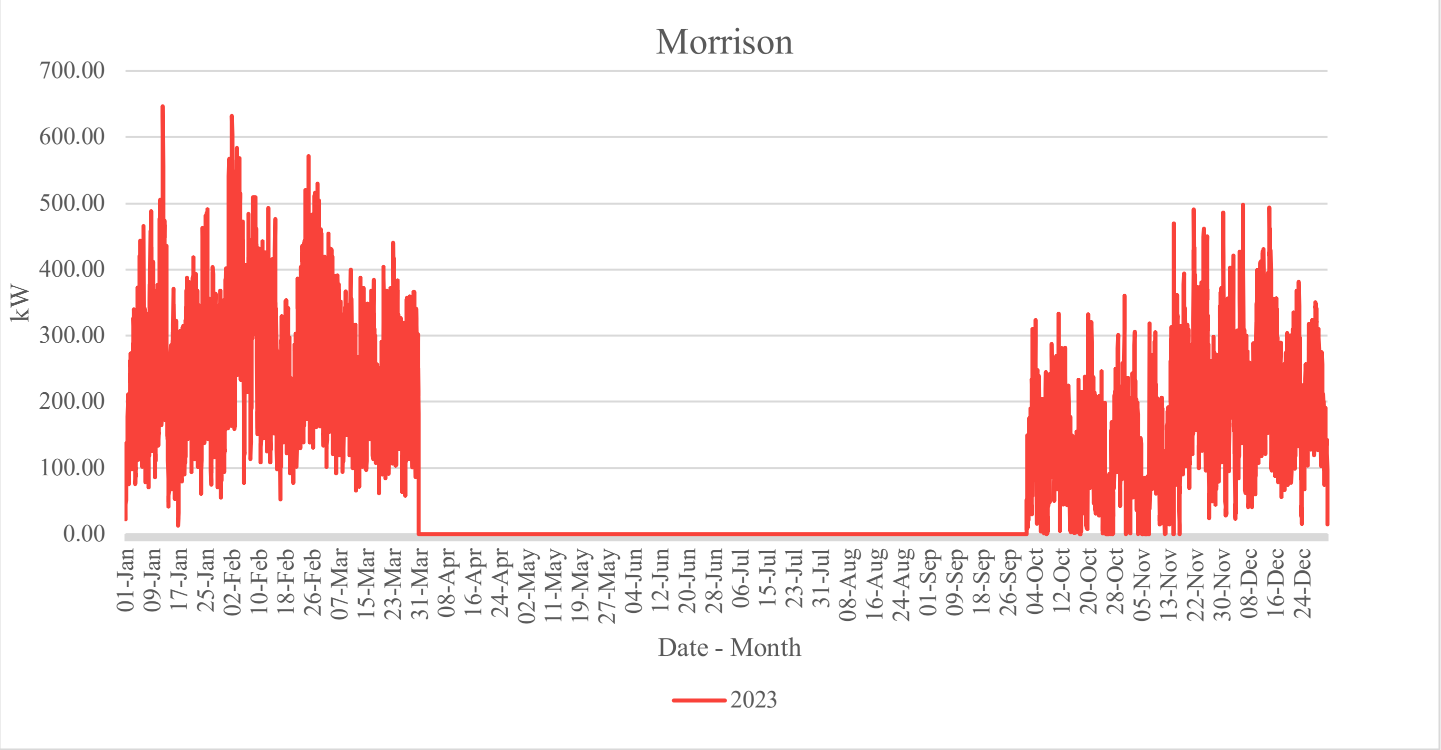
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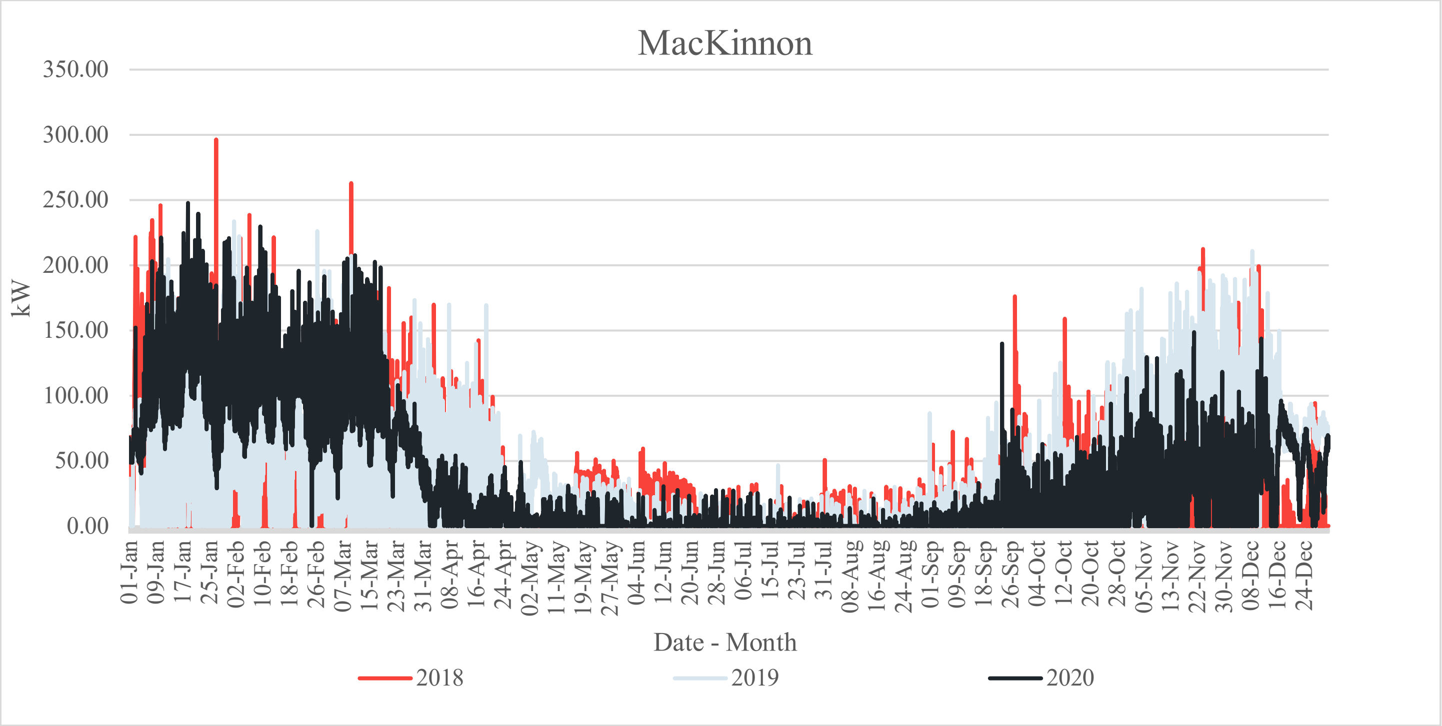
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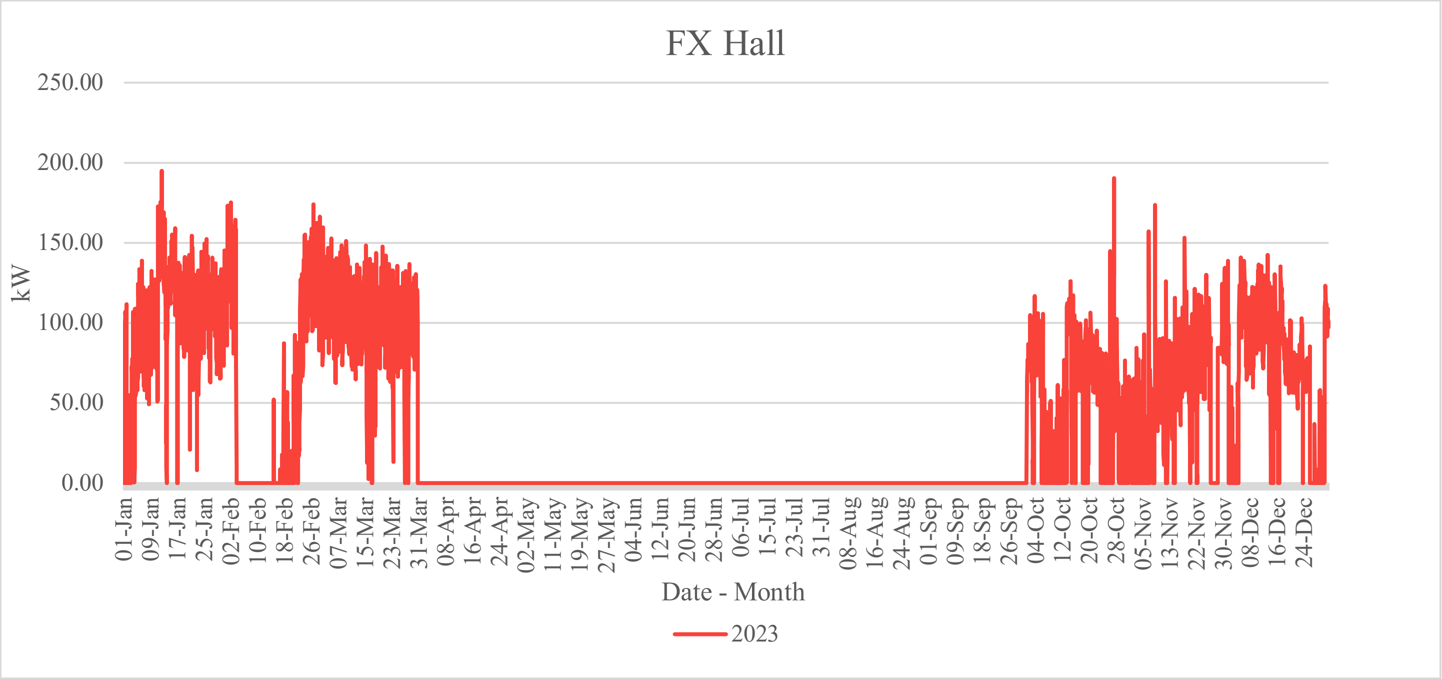
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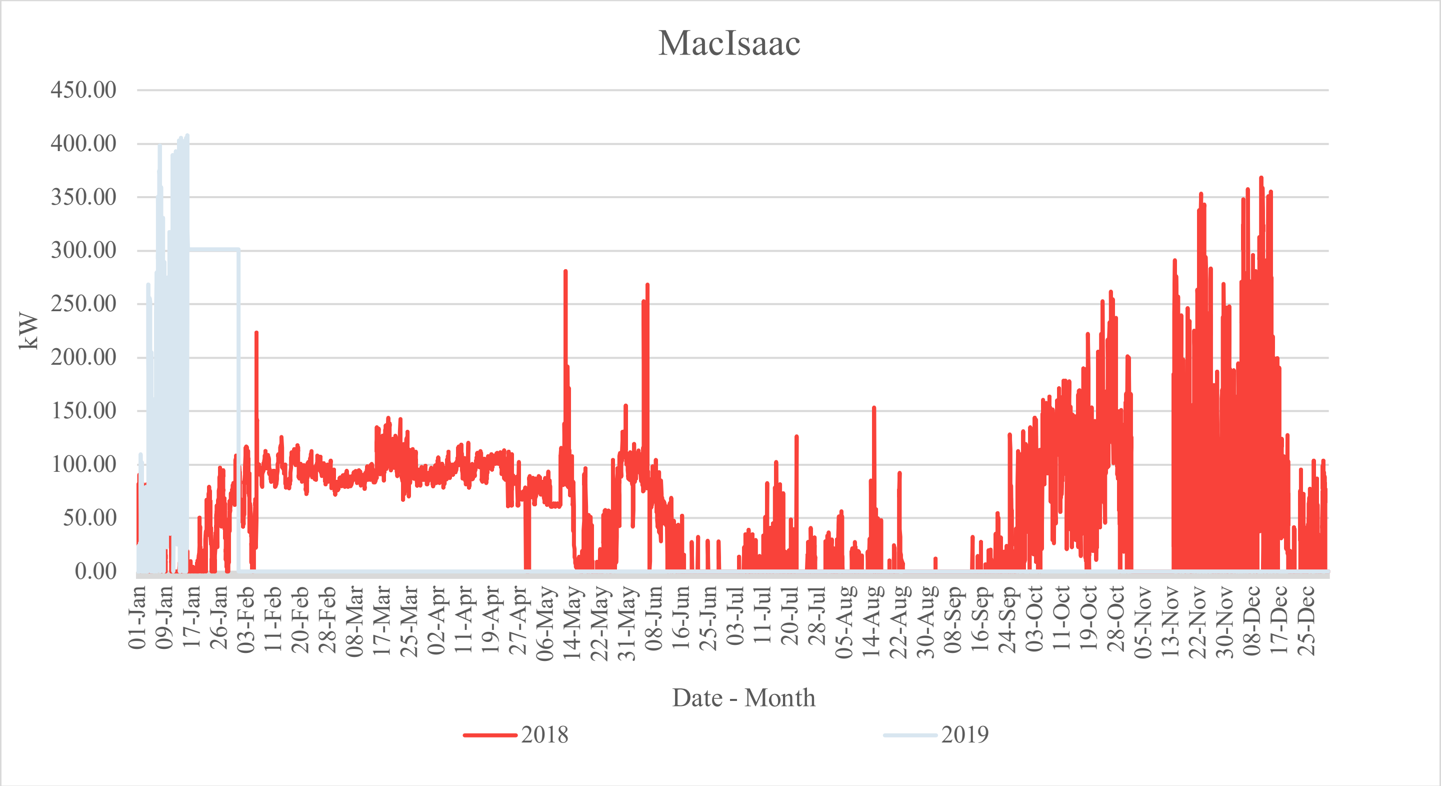
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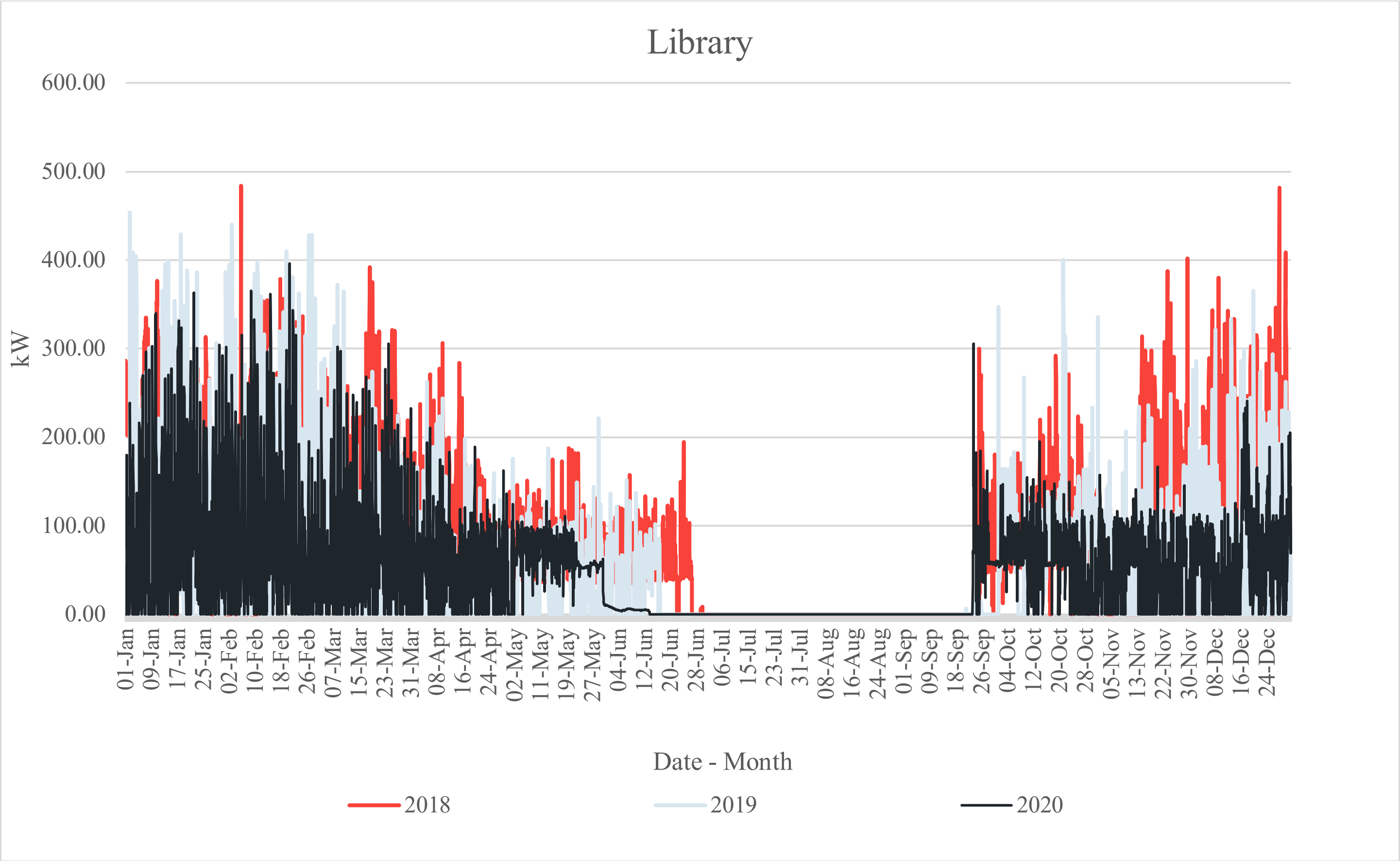
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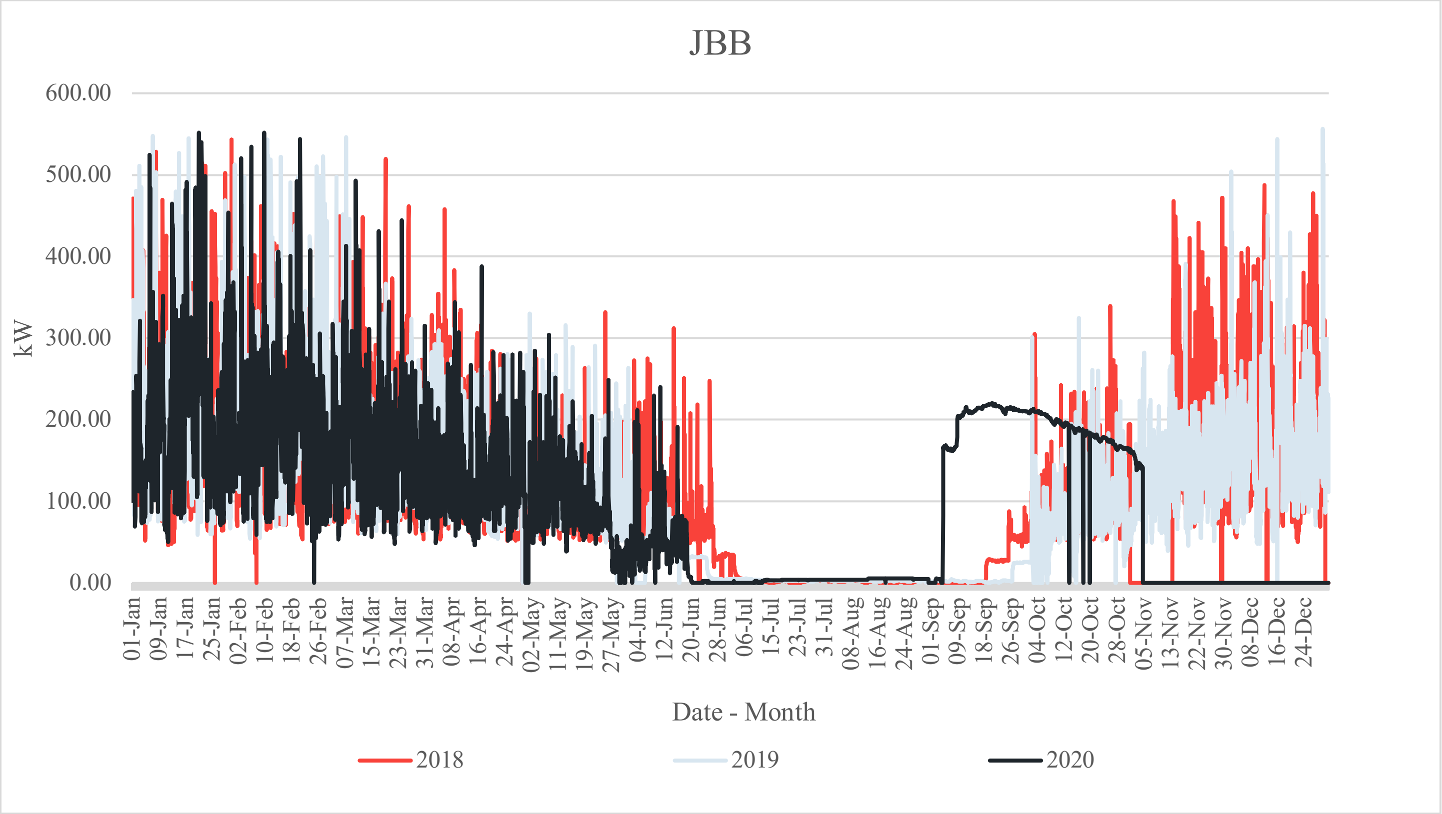
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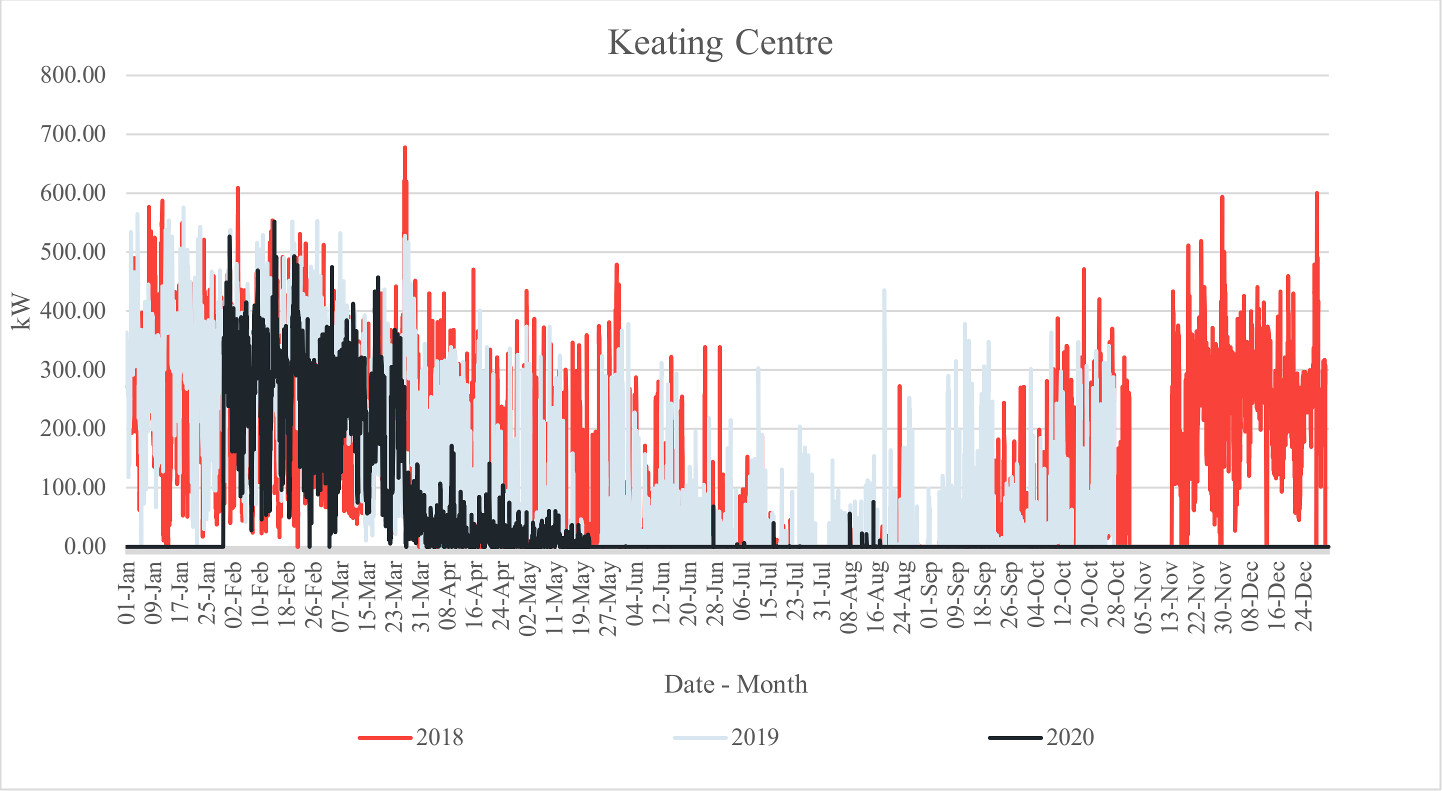
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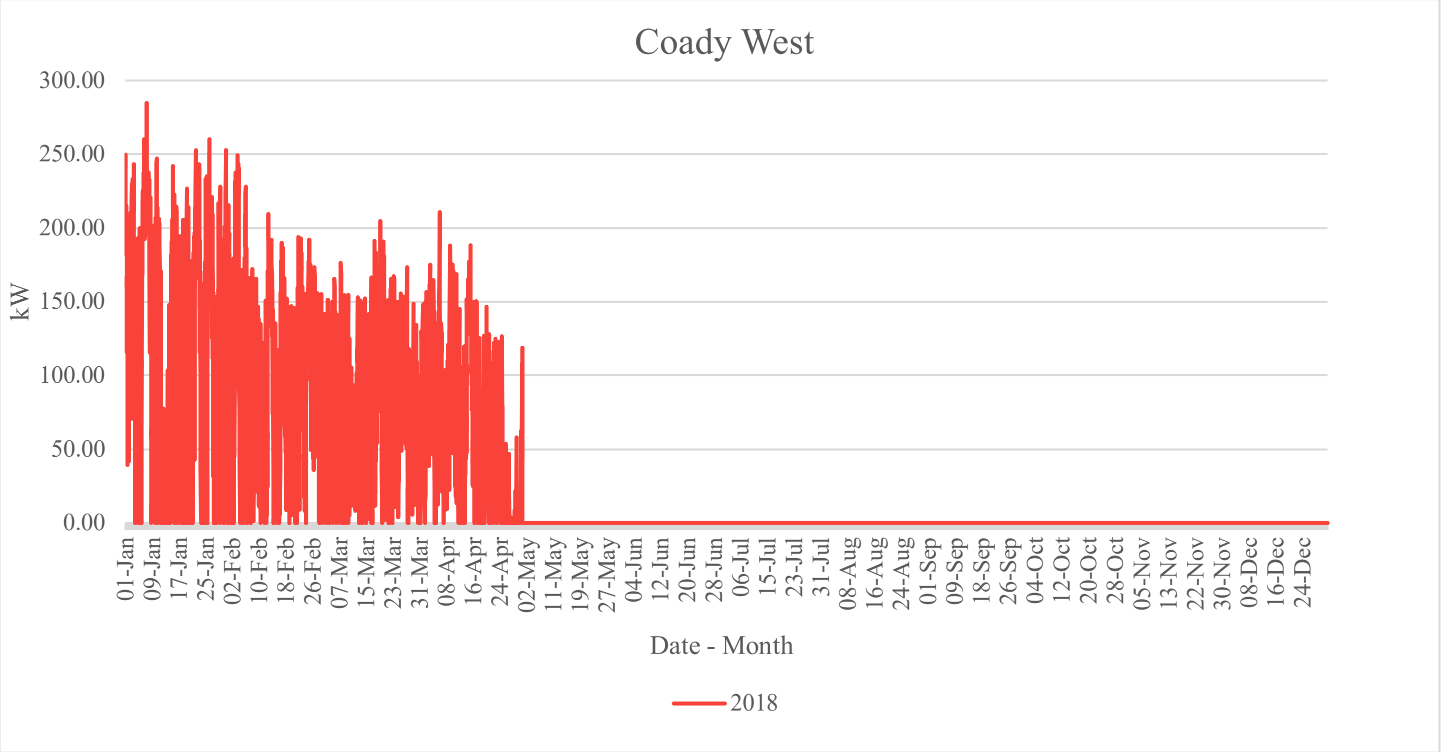
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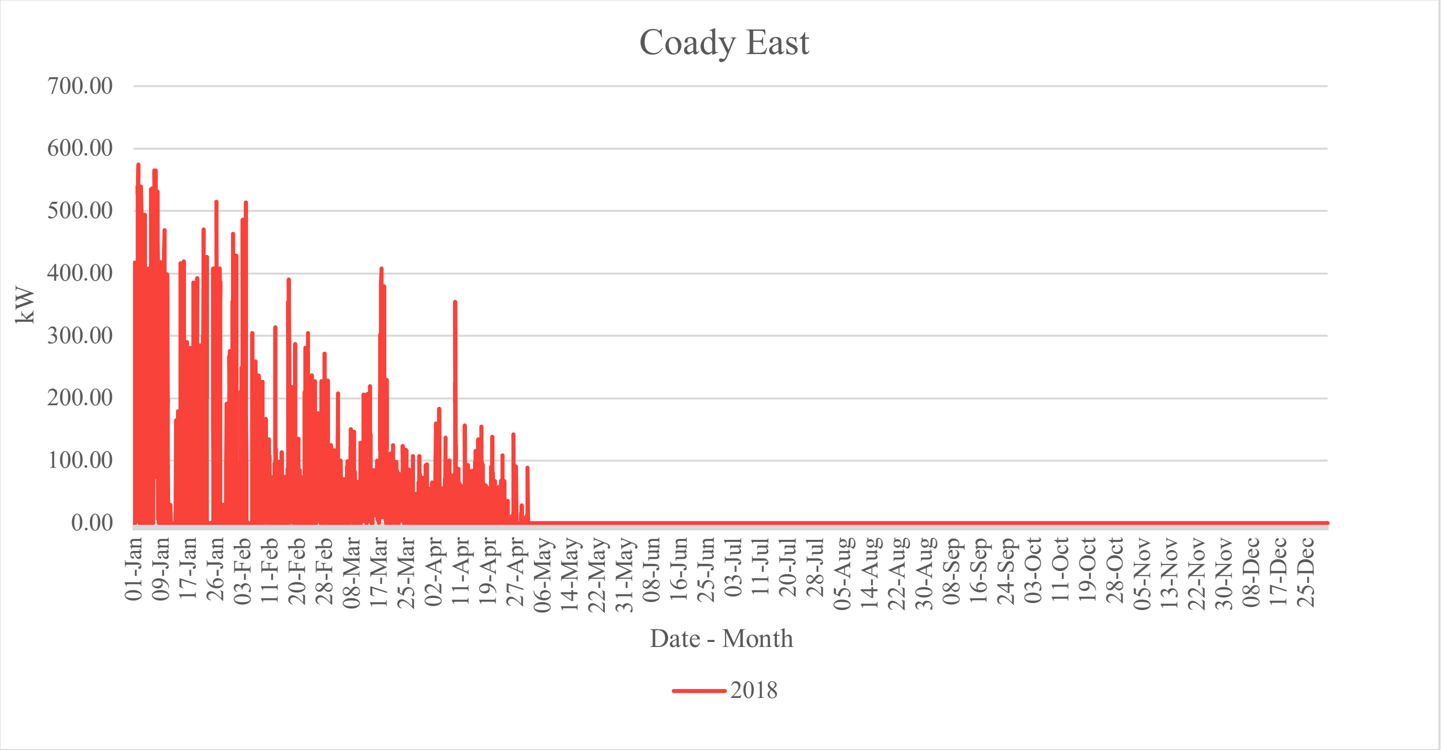
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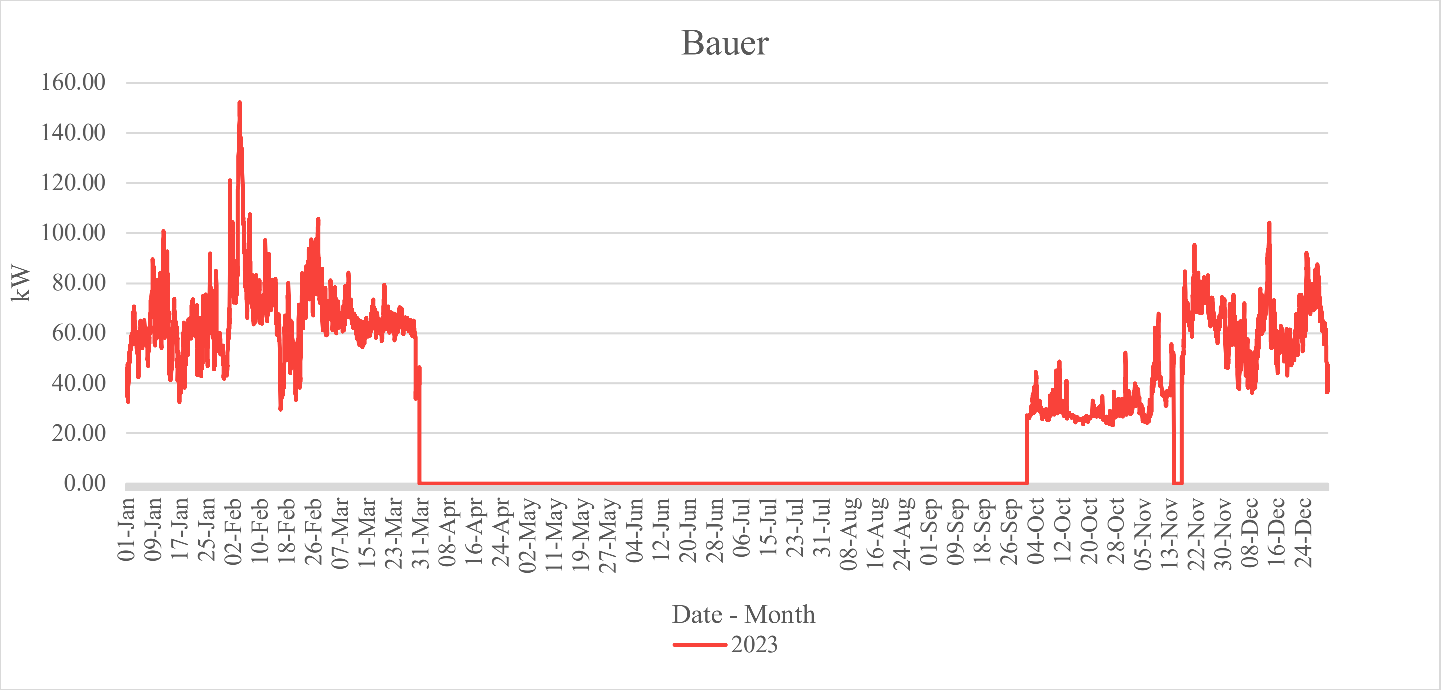
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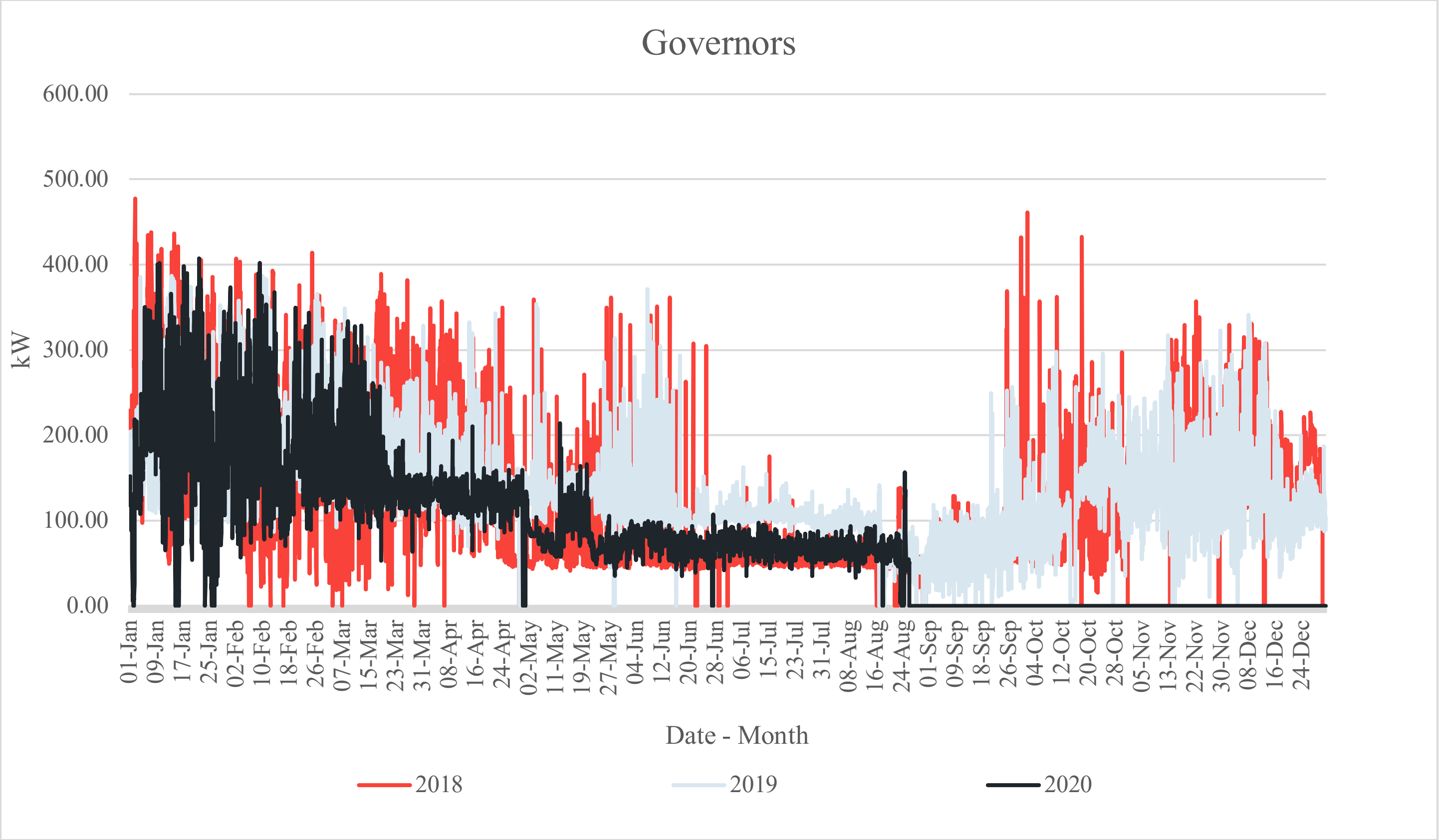
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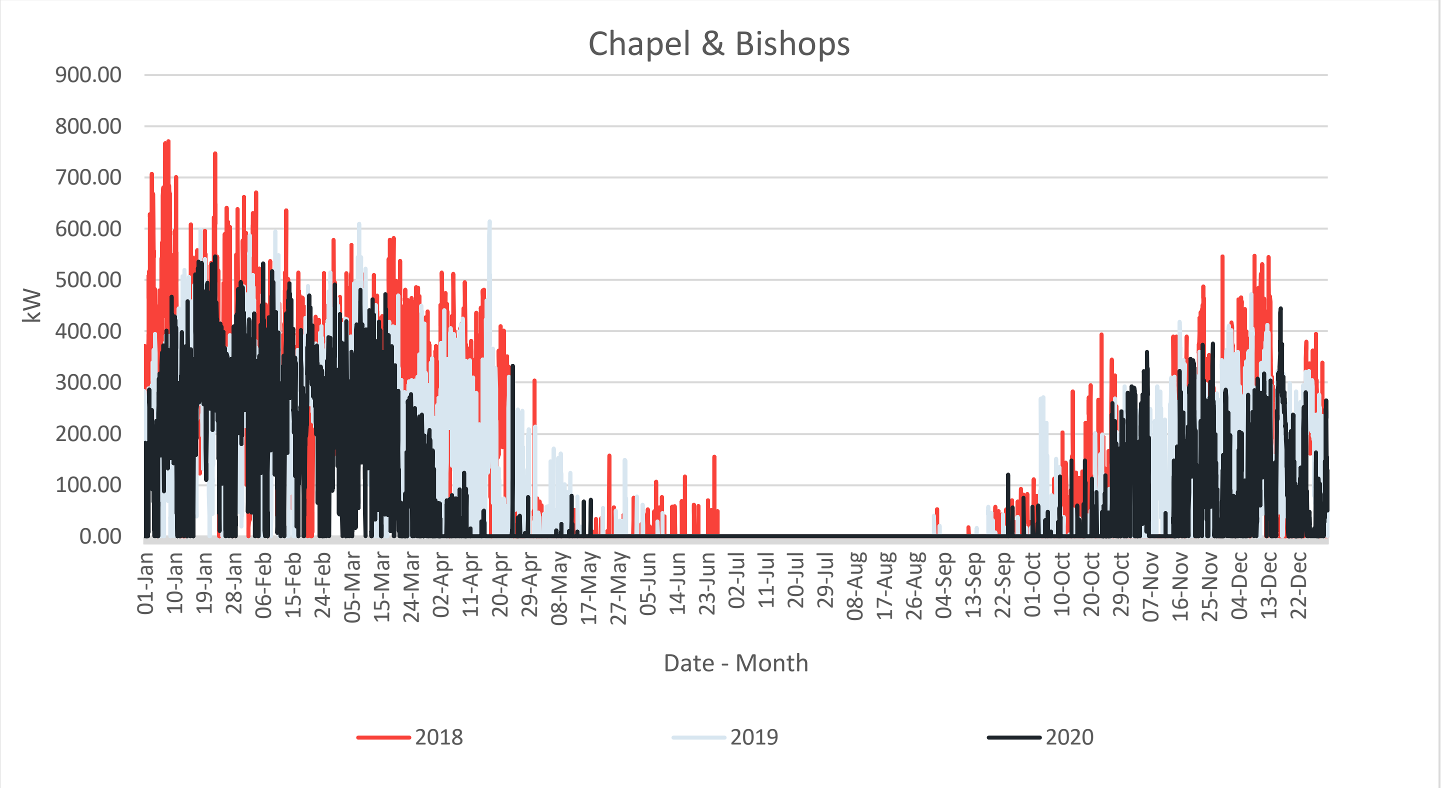
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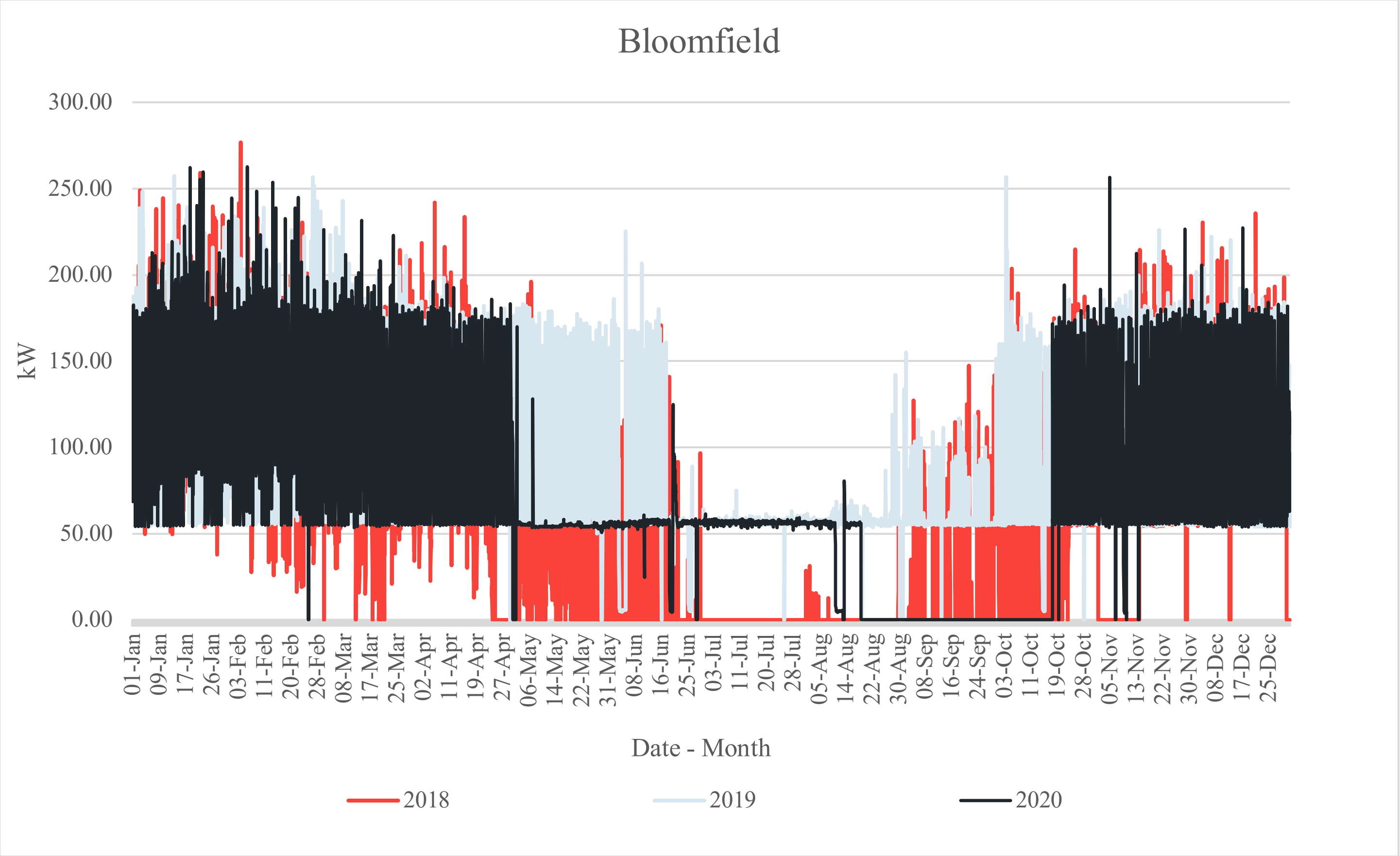
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B BUILDING ENERGY CONSUMPTION & GHG EMISSION BREAKDOWN

Building Energy Consumption and GHG Emission Breakdown

Building Name	Comments & Assumptions	Peak Heating Demand (kW)	Heating Source	Annual Steam Supply (kWh)	#2 Oil Consumption - Accounting 67% Plant Efficiency (kWh)	Annual Heat Pump Thermal Supply (kWh)	Heat Pump Electricity Consumption (kWh)	Annual Propane Supply (kWh)	Propane consumption (L)	Annual Oil Supply (kWh)	Oil consumption (L)	Annual Building Thermal Demand (kWh) - Space Heating Only	Annual GHG Emission (ton CO2 eq)
Schwartz	-Steam backup never used	590.22	Primary Heating Source: Geothermal with Heat Pump Backup Heating Source: Steam	-	-	544,876	181,625	-	-	-	-	544,876	101.7
Nicholson Tower	-Steam backup never used	197.43	Primary Heating Source: Geothermal with Heat Pump Backup Heating Source: Steam	-	-	240,380	80,127	-	-	-	-	240,380	44.9
O'Regan Hall	-Energy modeling and available drawing indicates at peak heating demand: -172KW received from steam -174KW received from heat pump	346.00	During peak heating demand: -172KW received from steam -174KW received from heat pump	381,683	569,676	386,121	128,707	-	-	-	-	767,803	214.5
Riley Hall	-Riley Hall is identical to O'Regan Hall -Energy modeling and available drawing indicates at peak heating demand: -172KW received from steam -174KW received from heat pump	346.00	During peak heating demand: -172KW received from steam -174KW received from heat pump	381,683	569,676	386,121	128,707	-	-	-	-	767,803	214.5
Mulroney Hall	-Steam backup never used -Not including fume hood exhaust	332.00	Primary Heating Source: Geothermal with Heat Pump Backup Heating Source: Steam	-	-	403,100	134,367	-	-	-	-	403,100	75.3
J Bruce Brown (Biology Building)	-In 2020, Steam heating replaced with propane boiler heating -Peak heating demand load obtained from the steam data available, assuming building thermal demand remained the same after switching to propane boilers -Annual thermal demand obtained from steam data -Yearly propane consumption data obtained from St FX - Buildings Energy.xlsx	542.89	Primary Heating Source: Propane Boilers	-	-	-	-	619,254	86,475	-	-	495,403	133.5
MacDonald Hall	- Peak heating demand obtained from EUI: 20.7 BTU/HR SQFT -Yearly fuel oil consumption data obtained from St FX - Buildings Energy.xlsx	132.00	Primary Heating Source: #2 Fuel Oil Boiler	-	-	-	-	-	-	360,879	35,462	292,919	95.4
Annex	-Steam data adjusted for missing dates -Assuming all steam generated by #2 Fuel Oil -Assuming mid June - mid Sept heating is off	255.00	Steam	359,376	536,382	-	-	-	-	-	-	359,376	134.1
Xavier Hall	-Steam data adjusted for missing dates -Assuming all steam generated by #2 Fuel Oil -Assuming mid June - mid Sept heating is off	942.00	Steam	1,280,177	1,910,712	-	-	-	-	-	-	1,280,177	477.7
Bauer	-Steam data adjusted for missing dates -Assuming all steam generated by #2 Fuel Oil -Assuming mid June - mid Sept heating is off	152.00	Steam	370,332	552,734	-	-	-	-	-	-	370,332	138.2
Coady Institute (East)	-Steam data adjusted for missing dates -Assuming all steam generated by #2 Fuel Oil -Assuming mid June - mid Sept heating is off	575.00	Steam	503,037	750,802	-	-	-	-	-	-	503,037	187.7
Coady Institute (West)	-Steam data adjusted for missing dates -Assuming all steam generated by #2 Fuel Oil -Assuming mid June - mid Sept heating is off	260.00	Steam	673,239	1,004,834	-	-	-	-	-	-	673,239	251.2
Morrison Hall	-Steam data adjusted for missing dates -Assuming all steam generated by #2 Fuel Oil -Assuming mid June - mid Sept heating is off	600.00	Steam	1,409,296	2,103,427	-	-	-	-	-	-	1,409,296	525.9
PSC - Physical Science Centre	-Steam data adjusted for missing dates -Assuming all steam generated by #2 Fuel Oil -Assuming mid June - mid Sept Heating is off	877.02	Steam	1,923,562	2,870,988	-	-	-	-	-	-	1,923,562	717.7
MacDonald Library	-Steam data adjusted for missing dates -Assuming all steam generated by #2 Fuel Oil -Assuming mid June - mid Sept heating is off	409.00	Steam	723,685	1,080,127	-	-	-	-	-	-	723,685	270.0
St Ninians Cathedral/Place	-Steam data adjusted for missing dates -Assuming all steam generated by #2 Fuel Oil	176.00	Steam	356,273	531,750	-	-	-	-	-	-	356,273	132.9
Mockler Hall	-Steam data adjusted for missing dates -Assuming all steam generated by #2 Fuel Oil -Assuming mid June - mid Sept heating is off	266.00	Steam	679,849	1,014,699	-	-	-	-	-	-	679,849	253.7
Cameron Hall	-Steam data adjusted for missing dates -Assuming all steam generated by #2 Fuel Oil	297.00	Steam	299,128	446,460	-	-	-	-	-	-	299,128	111.6
MacKinnon Hall	-Steam data adjusted for missing dates -Assuming all steam generated by #2 Fuel Oil -Assuming mid June - mid Sept heating is off	297.00	Steam	299,128	446,460	-	-	-	-	-	-	299,128	111.6
Bishops & University Chapel	-Steam data adjusted for missing dates -Assuming all steam generated by #2 Fuel Oil	770.30	Steam	872,504	1,302,245	-	-	-	-	-	-	872,504	325.6
Power & Somers	-Steam data adjusted for missing dates -Assuming all steam generated by #2 Fuel Oil	259.00	Steam	796,820	1,189,284	-	-	-	-	-	-	796,820	297.3
Governors	-Steam data adjusted for missing dates -Assuming all steam generated by #2 Fuel Oil	477.00	Steam	1,220,667	1,821,891	-	-	-	-	-	-	1,220,667	455.5
FX Hall	-Steam data adjusted for missing dates -Assuming all steam generated by #2 Fuel Oil -Assuming mid June - mid Sept heating is off	174.00	Steam	561,172	837,570	-	-	-	-	-	-	561,172	209.4
MacIsaac Hall	-Steam data adjusted for missing dates -Assuming all steam generated by #2 Fuel Oil -Assuming mid June - mid Sept heating is off	405.00	Steam	574,407	857,324	-	-	-	-	-	-	574,407	214.3
MSB (Mount Saint Bernard)	-Steam data adjusted for missing dates -Assuming all steam generated by #2 Fuel Oil -Assuming mid June - mid Sept heating is off	498.00	Steam	1,181,510	1,763,448	-	-	-	-	-	-	1,181,510	440.9
Keating Centre	-Steam data adjusted for missing dates -Assuming all steam generated by #2 Fuel Oil -Assuming mid June - mid Sept heating is off	622.00	Steam	1,186,877	1,771,459	-	-	-	-	-	-	1,186,877	442.9
Bloomfield	-Steam data adjusted for missing dates -Assuming all steam generated by #2 Fuel Oil	245.00	Steam	804,748	1,201,116	-	-	-	-	-	-	804,748	300.3
Saputo Centre	-Building equipped with a 120TON VRF system, VRF usage for heating unknow, assuming all heating provided by steam for conservative estimate	443.00	Steam + VRF (assume all steam)	1,251,853	1,868,438	-	-	-	-	-	-	1,251,853	467.1
Saputo Pool (Aquatic Centre)	-Steam data adjusted for missing dates -Assuming all steam generated by #2 Fuel Oil	800.00	Steam	2,061,521	3,076,898	-	-	-	-	-	-	2,061,521	769.2
Dr. John Hugh Gillis Regional High School	-2023 #2 Fuel Oil consumption quantity used for building thermal and GHG estimates -Assuming 80% furnace efficiency	2186.00	Oil Fired Boiler	-	-	-	-	-	-	2,210,526	204,831	1,768,421	550.8
Antigonish Education Centre (AEC)	-2021 #2 Fuel Oil consumption quantity used for building thermal and GHG estimates -Assuming 80% furnace efficiency	833.00	Oil Fired Boiler	-	-	-	-	-	-	1,453,341	134,669	1,162,673	362.1
St. Andrew Junior High	-2023 #2 Fuel Oil consumption quantity used for building thermal and GHG estimates -Assuming 80% furnace efficiency	981.00	Oil Fired Boiler	-	-	-	-	-	-	1,192,515	110,500	954,012	297.1
St. Martha Regional Hospital	-2023 #2 Fuel Oil consumption quantity used for building thermal and GHG estimates -Assuming 80% furnace efficiency	300.00	Oil Fired Boiler	-	-	-	-	-	-	10,261,105	950,811	8,208,884	2,556.7
RK MacDonald Nursing Home	-Oil consumption bills were not shared with WSP; we used daily oil meter readings to estimate annual oil consumption. -2023 #2 Fuel Oil consumption quantity used for building thermal and GHG estimates: February and March 2022 data were used to fill in the missing data. -Oil consumption was undeterminable on days with oil refills. We estimated oil usage for the missing days based on the general trend. -Assuming 80% furnace efficiency	796.00	Oil Fired Boiler	-	-	-	-	-	-	713,348	66,100	570,678	177.7

C GEOTHERMAL DESKTOP STUDY

MEMO

Date: October 29, 2024

From: John Peterson

To: Brian Warren

cc: Aaron Dahlstrom

Subject: Town of Antigonish/St FX University Geothermal System Desktop Study

DESKTOP STUDY OBJECTIVE

Based on the currently available information, are we confident that the proposed location for a geoexchange well field will be capable of supporting the proposed District Energy System (DES)?

BACKGROUND DATA

The system being proposed will be a 20 MW low temperature hot water district heating system using geothermal exchange as a thermal energy source and heat pumps (basis of design is York CYK) as the primary means of producing low temperature hot water. Temperatures and flowrates have been approximated based on a review of the existing loads. The system will have electric boilers (Gaumer or equivalent) as backup to the heat pumps. Resiliency of the system will be determined during detailed design. Assuming N+1 on all production equipment and full electric backup.

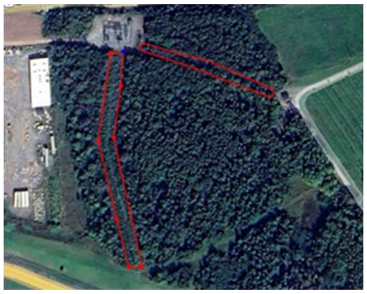
Location for the proposed geoexchange well field.

The proposed geoexchange well field is approximately 400,000 ft^2. This area may be less due to the presence of power lines from the substation and be approximately 370,000 ft^2. These values represent the maximum available area for the geoexchange wells. The amount of geoexchange wells will be determined by the well spacing and area required for horizontal piping and connections.

Measure the distance or area of a geometric shape on the ground

Perimeter: 2,573.08 Feet

Area: 392,475.84 Square Feet



WSP USA
2 Monument Square, Suite 200
Portland, ME 04101
USA

T+ 1 207-775-5401

wsp.com

Data points assumed for the proposed geoexchange well field based on the Formation Thermal Conductivity Test (FTCT) & Data Analysis (GRTI, August 2016), tested to a depth of 400 ft.

- Formation Thermal Conductivity = 0.97 Btu/hr-ft-0F (1.69W/m-K)
- Formation Thermal Diffusivity ≈ 0.68ft^2/day ((0.0073 cm^2/s)
- Undisturbed Formation Temperature ≈ 48.8-52.4^{0}F (9.3-11.3^{0}C)
- Formation Description
    - Sand/till/gravel 0'-159' (0-48.5m)
    - Mudstone 159'-400' (48.5-121.9m)

Per the geologic map of the Antigonish Basin (Map ME 1982-002), the proposed geoexchange well field is in an area mapped as the Windsor Group (ECHI) Hood Island Formation: red siltstone and sandstone with intercalated marine limestone and dolostone and minor gypsum; rhythmic alteration of these rock units in characteristic.

OBSERVATIONS

Based on the general geologic mapping in the area, the proposed geoexchange well field is assumed to have similar geologic and thermal characteristics summarized in the August 2016 FTCT.

The assumed geoexchange well system is vertical closed loop. WSP has experience with a couple of types of vertical closed loop systems. One system being a traditional HDPE Ubend and the other system being a coaxial Deep Bore Geothermal (DBG) from Rygan https://rygancorp.com/.

Closed loop system thermal characteristics: While we cannot change the bedrock and overburden thermal characteristics, we can look to optimize the ground connection with the use of more efficient wells to reduce the borehole resistivity. In WSP's experience, the DBG system has a lower borehole resistivity and more efficient hydraulics than a traditional HDPE Ubend. This results in a higher geoexchange capacity per foot of boring/well. Traditional HDPE Ubend geoechange wells can be installed to approximately 500 to 600 feet below ground surface (bgs) and the DBG system can be installed up to 1,500 feet bgs.

Based on the two vertical loop well systems noted above and their characteristics, we have provided the following conceptual approaches for the proposed geoexchange well field.

WELL SPACING

- 20 by 20 node = 400 ft^2
- 25 by 25 node = 625 ft^2
- 30 by 30 node = 900 ft^2

While well spacing can be potentially less than 20 feet (e.g., 15 feet), there is a higher risk of borehole deviation and wells intersecting and lower long-term performance. Well spacing typically is evaluated on multiple factors such as space, layout/geoexchange circuits, performance, and borehole deviation risk.

WELL PERFORMANCE

- HDPE Ubend 250 ft per ton
- DBG 125 ft per ton

The well performance noted above are empirical assumptions for the purpose of this conceptual desktop evaluation. These well performance numbers also do not consider the load side aspects (e.g., seasonality, imbalances, et...). There are various factors that can impact well performance and would require more detailed analysis and modeling. For this evaluation, the primary aspect regarding well performance is the relative geoexchange performance difference.

WELL DENSITY

Based on the background data noted previously, the proposed geoexchange well field is approximately 400,000 ft^2 and with the presence of apparent power lines across the area, more likely 370,000 ft^2. As noted previously the area required for horizontal piping and connections may further reduce the area. Therefore 350,000 ft^2 was used as an approximate area for this evaluation.

Based on an approximate 350,000 ft^2 of potential available area, the following number of geoexchange wells might be feasible based on the well spacing chosen.

Area	Geoexchange Wells	Spacing
350,000 ft^2	875	20 foot well nodes (400 ft^2)
350,000 ft^2	560	25 foot well nodes (625 ft^2)
350,000 ft^2	389	30 foot well nodes (900 ft^2)

Based on the type of geoexchange system used (HDPE Ubend or DBG), the depth of wells, the available area, the spacing of wells, the capacity of the proposed geoexchange well field could range from approximately 2,000 Tons and 5,000 Tons (7 MW to 18 MW). The lowest capacity being the HDPE Ubend system and the highest capacity being the DBG system.

EVALUATION VARIABLES AND UNCERTAINTIES

The evaluation uses assumptions for cooling capacity and converts to potential heating capacity using a units conversion. This adds uncertainty.

The evaluation uses assumptions for cooling capacity which presumes a rough annual balance of cooling versus heating load. Applying it to a heating-only application adds uncertainty.

The evaluation uses assumptions for peak capacity which presumes load fall-off and resting for the borefield. While data has been provided for pattern of use for StFX load, no pattern of use has been established for the remainder, which adds uncertainty.

The application of cooling-dominant / cooling-constrained figures to a heating-dominant application use case introduces uncertainty.

The possible range of the output from the proposed geoexchange well field area is wide without further testing and analysis.

Optimizing output is possible and the ability to dispatch portions of the wellfield under low-load conditions could allow other portions to “rest”.

Generating peak output continually is not assumed possible from the proposed well field, hence the contribution of the well field will be higher if there are other sources of heat on the thermal network that allow the well field to rest as needed.

RECOMMENDATIONS

Prepare a parametric analysis using GLHEPro software showing the anticipated thermal response of proposed well field arrangement and size:

- Parameters that can be varied include portion of peak load available, monthly distribution of load, and "base load-to-peak load" ratio on peak day and through the year. This could be performed with current data or improved with basic information about the non-University loads.
- Parameters that WSP may vary include grout approach, well design and spacing, assumptions about equipment performance and hydronic loop characteristics

Consultation with internal / external resources re: sub-grade conditions in the region, to identify any known limitations on deeper drilling (eg a confining layer than cannot be penetrated, AHJ regulations that limit bore depth, a known change in sub-surface conditions at a given depth, etc)
Install a deeper test bore on site, to capture formation data for proposed deeper bores.

D FLOW SCHEMATICS, PLANT LAYOUTS, ETS P&IDS & BURIED PIPING LAYOUT

LINES AND PIPING

- NEW PIPING
- EXISTING PIPING
- FUTURE PIPING
- VENDOR PACKAGE
- CONCENTRIC REDUCER
- ECCENTRIC REDUCER
- END CAP
- FLANGED JOINT AND BLANKED END
- SERVICE / DRAWING NUMBER — CONTINUATION OF SERVICE AND FLOW DIRECTION
- FLOW DIRECTION

GENERAL

- 01 — REVISION
- A1 — HOLD
- * — SUPPLIED & SHIPPED LOOSE BY VENDOR

GENERAL NOTES

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. ELEVATIONS ARE IN MILLIMETERS ABOVE SEA LEVEL, UNLESS STATED OTHERWISE.

PROCESS - VALVES AND EQUIPMENT

- GATE VALVE - NORMALLY OPENED / CLOSED
- BALL VALVE - NORMALLY OPENED / CLOSED
- GLOBE VALVE - NORMALLY OPENED / CLOSED
- NO NC — BUTTERFLY VALVE - NORMALLY OPENED / CLOSED
- PLUG VALVE - NORMALLY OPENED / CLOSED
- NEEDLE VALVE - NORMALLY OPENED / CLOSED
- CHECK VALVE
- BACKFLOW PREVENTER
- 3-WAY VALVE
- Y-PATTERN GLOBE REGULATING VALVE
- RELIEF VALVE (INLINE PATTERN)
- RELIEF VALVE (ANGLE PATTERN)
- PRESSURE REDUCING VALVE
- BACK PRESSURE REGULATING VALVE
- SELF ACTING DIFFERENTIAL PRESSURE CONTROL VALVE (DPCV)
- SELF ACTING TEMPERATURE CONTROL VALVE
- CONTROL VALVE
- ELECTRICALLY ACTUATED CONTROL VALVE
- PNUEMATICALLY ACTUATED CONTROL VALVE (DIAPHRAGM TYPE)
- COMBINATION TYPE PRESSURE INDEPENDANT CONTROL VALVE (PICV)
- THERMOWELL
- THERMOSTAT (COMMUNICATING)
- PRESSURE TRANSMITTER I
- PRESSURE GAUGE W/ SHUTOFF VALVE
- 'Y' TYPE STRAINER
- TRIPLE DUTY VALVE
- MEASURING POINT (TEST POINT)

LO	LOCKED OPEN
LC	LOCKED CLOSED
NO	NORMALLY OPENED
NC	NORMALLY CLOSED
FO	FAIL OPEN
FC	FAIL CLOSED
FL	FAIL TO LAST POSITION
WBV	WELDED BALL VALVE
PP	PETES PLUG

- BASKET STRAINER
- DUPLEX STRAINER
- SUCTION GUIDE
- TANK
- PUMP (DUTY)
- PUMP (STANDBY)
- M — MOTOR
- FREQUENCY INVERTER
- HEAT EXCHANGER

INSTRUMENTATION

FLOW MEASURING DEVICES

- FT — IN LINE FLOW TRANSMITTER
- ULTRASONIC FLOW METER
- M — THERMAL ENERGY FLOW METER

DRAWING LIST

DRAWING NO.	DESCRIPTION
M000	LEGENDS & DRAWING LIST
M100	OPTION 1 - HEAT PUMPS AND ELECTRIC LTHW BOILERS P&IDs
M101	OPTION 2 - ELECTRIC LTHW BOILERS P&IDs
M102	OPTION 3 - STEAM ELECTRIC BOILERS P&IDs
M200	OPTION 1 - HEAT PUMPS AND ELECTRIC LTHW BOILERS FLOOR PLAN
M201	OPTION 2 - ELECTRIC LTHW BOILERS FLOOR PLAN
M202	OPTION 3 - STEAM ELECTRIC BOILERS FLOOR PLAN
M300	HEATING WATER SCHEMATICS (1 HEX, 100% BUILDING LOAD) - TYPICAL ENERGY TRANSFER STATION
M301	HEATING WATER SCHEMATIC (2 HEX, 50%/50% BUILDING LOAD) - TYPICAL ENERGY TRANSFER STATION
M302	HEATING WATER SCHEMATIC (3HEX, 50%/50%/50% BUILDING LOAD) - TYPICAL ENERGY TRANSFER STATION
M303	DOMESTIC HOT WATER ENERGY TRANSFER STATION
M400	TOWN INFORMATION MAP - BUILDING IDENTIFICATION AND DISTRIBUTION PIPE SIZING

REVISION:

REV	DATE	DESCRIPTION	BY
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PROJECT NUMBER: CA0016522.4178

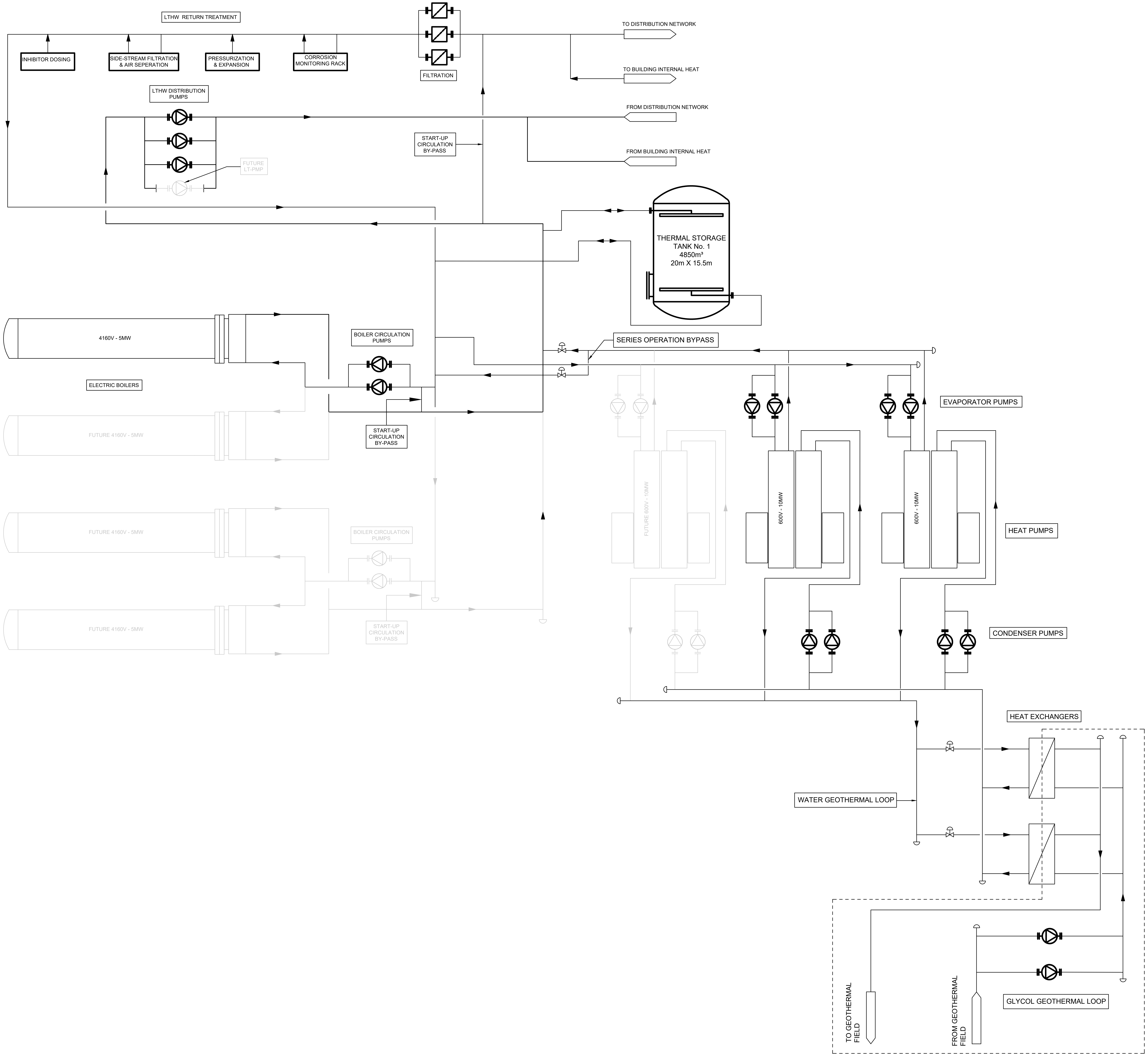
CLIENT:
TOWN OF ANTIGONISH

CLIENT REF. #: --

PROJECT:
COMMUNITY DISTRICT
ENERGY SYSTEM
FEASIBILITY STUDY

TITLE:
LEGENDS AND DRAWING LIST

DRAWING NUMBER: M000
REV. 0



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TITLE:

OPTION 1

HEAT PUMPS AND
ELECTRIC LTHW BOILERS
P&IDs

DRAWING NUMBER: M100
REV. 0

CTB: ----
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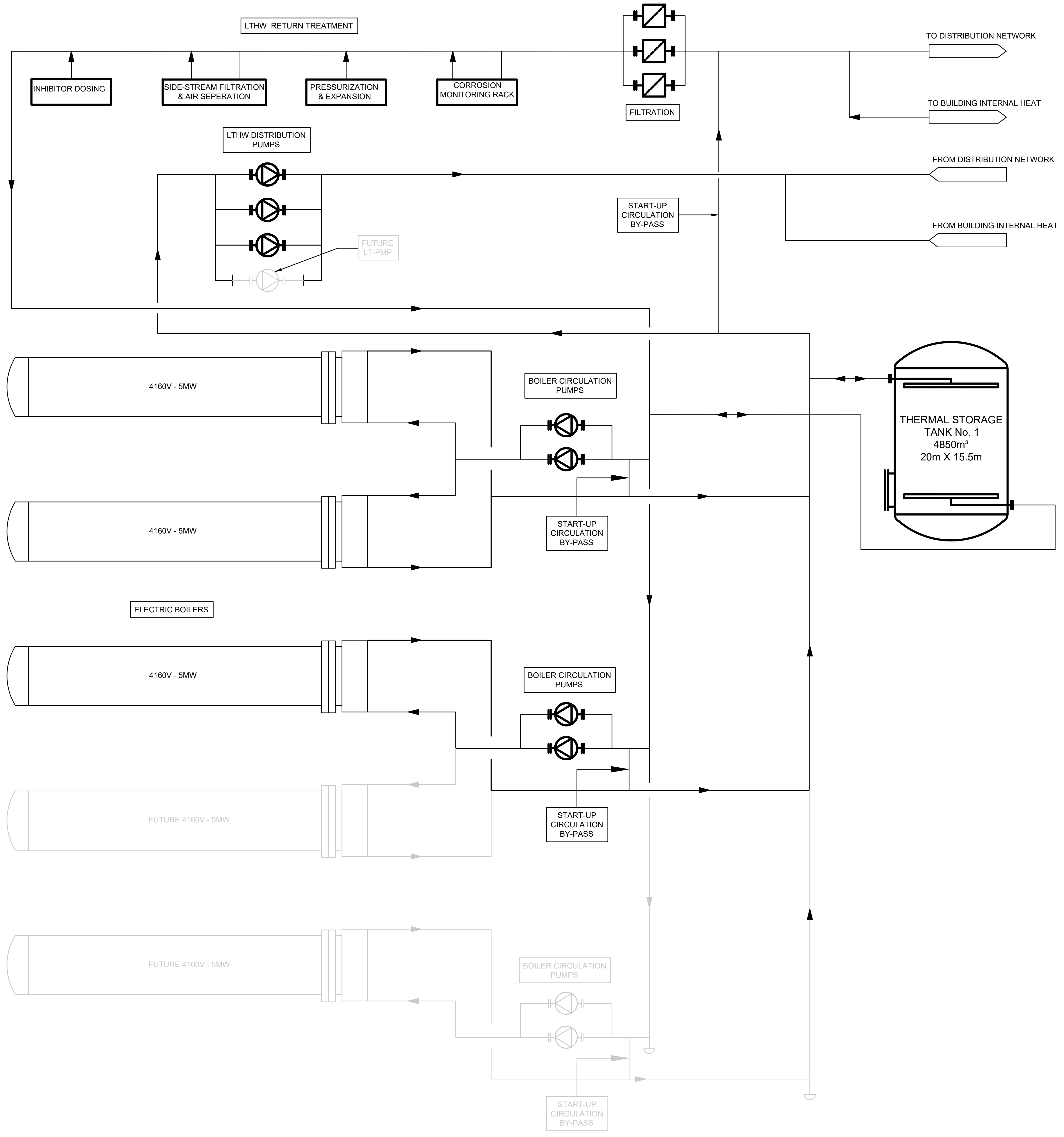

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PROJECT:

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ENERGY SYSTEM
FEASIBILITY STUDY

TITLE:

OPTION 2

ELECTRIC LTHW BOILERS
P&IDs

DRAWING NUMBER: M101

REV. 0

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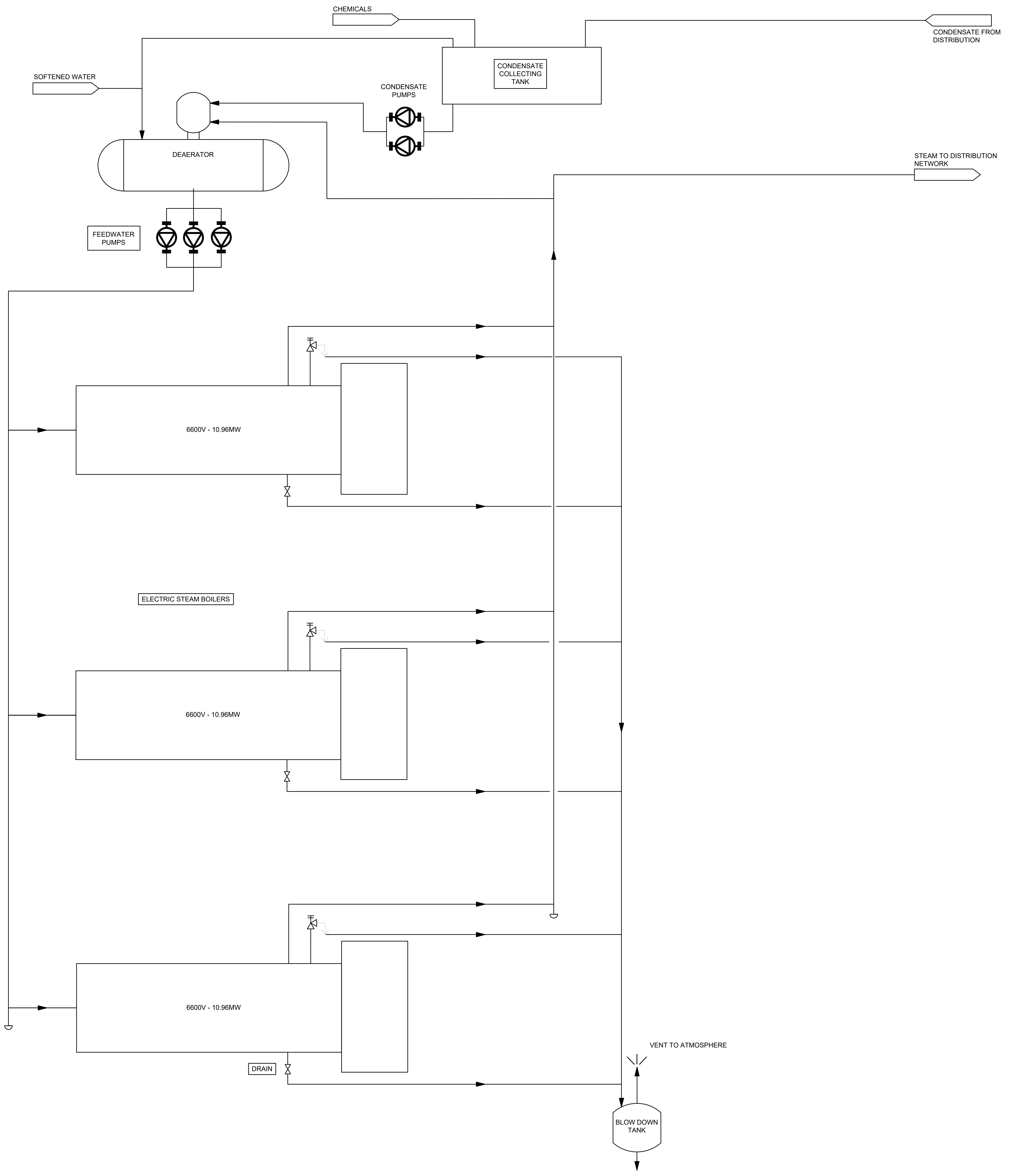

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CLIENT REF. #: --

PROJECT:
COMMUNITY DISTRICT
ENERGY SYSTEM
FEASIBILITY STUDY

TITLE:
OPTION 3

STEAM ELECTRIC BOILERS
P&IDs

DRAWING NUMBER: M102
REV. 0A

CTB: ----
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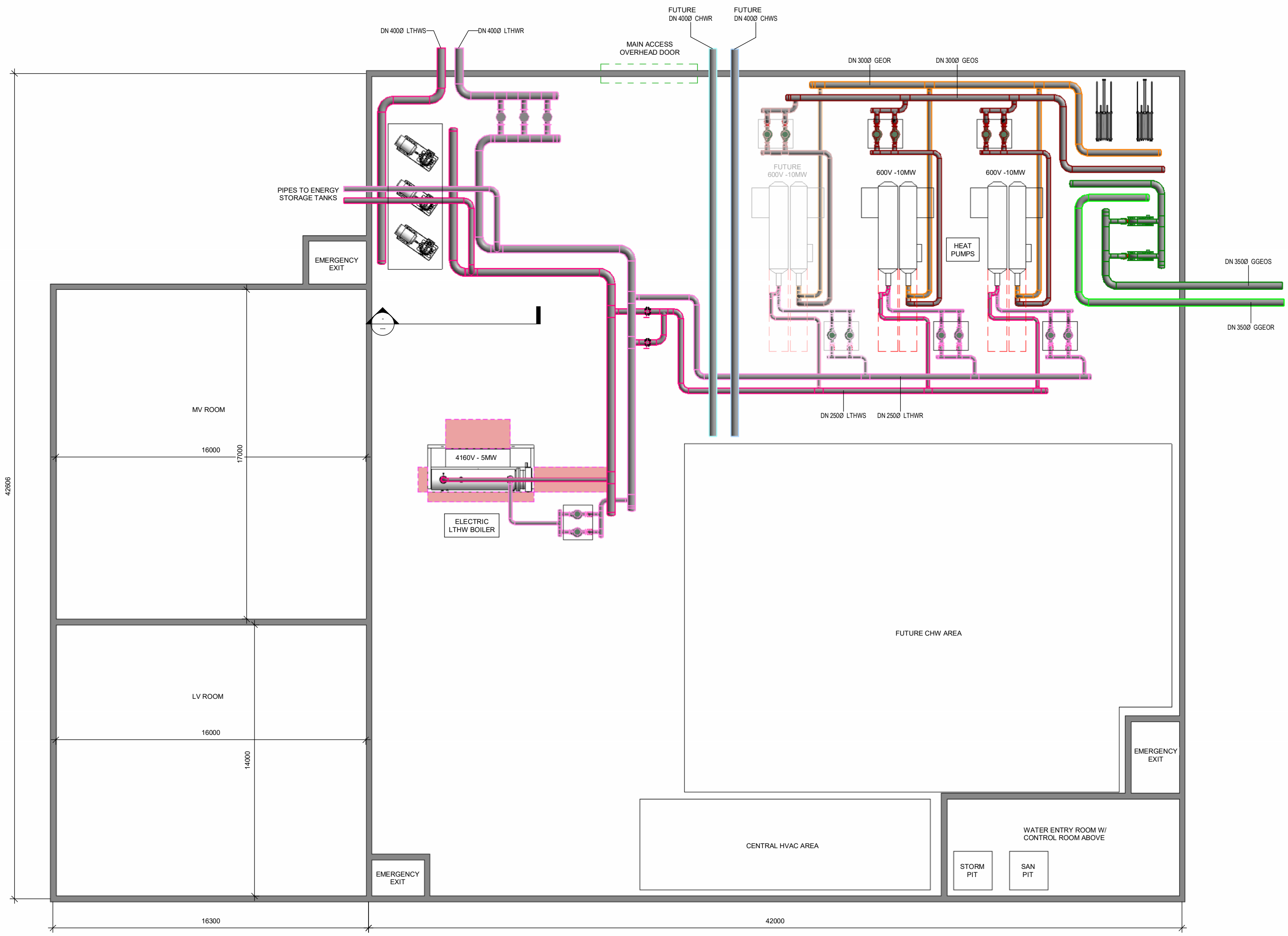

① Option 1 - Heat Pumps+EB
1 : 100

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DISCIPLINE/PROJECT DEFINED (eg LEGEND / KEY PLAN / LOGOS)

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DATE:
2024-11-19

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Approver
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Checker
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Author
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CLIENT REF. #:

PROJECT:

COMMUNITY DISTRICT ENERGY SYSTEM FEASIBILITY STUDY

TITLE:

OPTION 1 - HEAT PUMPS AND ELECTRIC LTHW BOILERS FLOOR PLAN

DRAWING NUMBER:
M200

REV.
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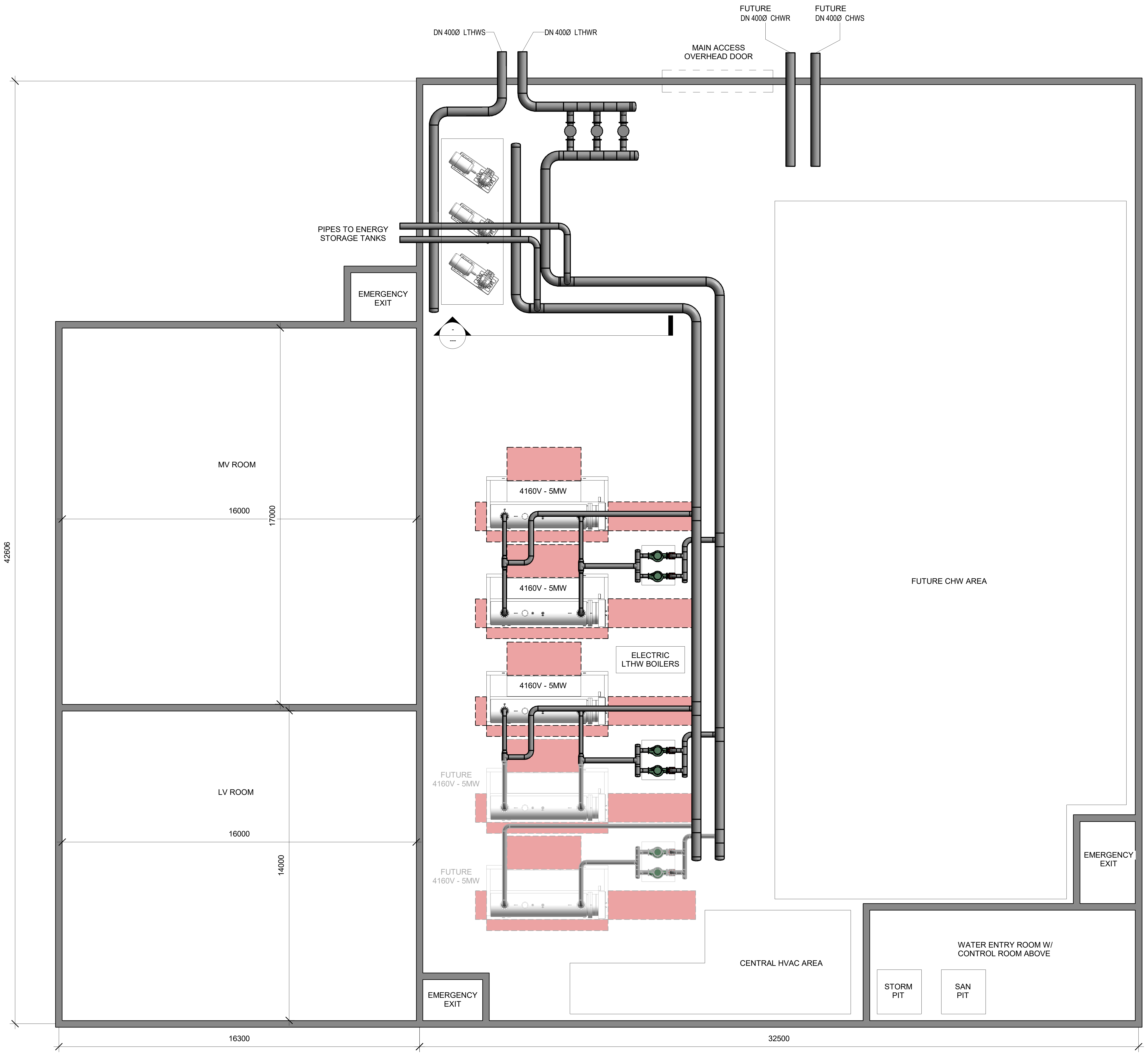

1 Option 2 - EB LTHW only

1 : 100

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CLIENT:

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CLIENT REF. #:

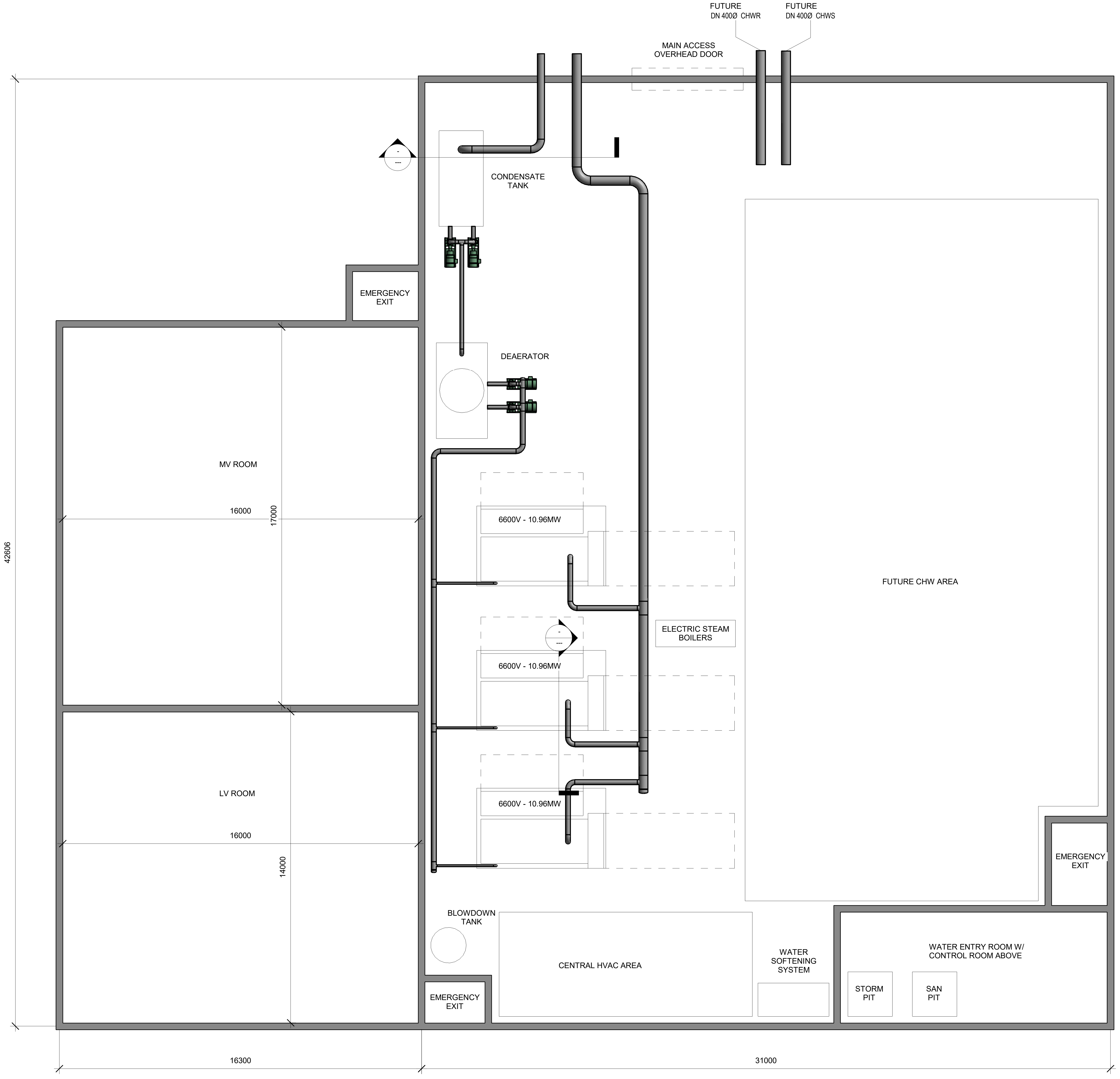
PROJECT:

COMMUNITY DISTRICT ENERGY
SYSTEM FEASIBILITY STUDY

TITLE:

OPTION 2 - ELECTRIC LTHW
BOILERS
FLOOR PLAN

DRAWING NUMBER: M201
REV. 0



1 Option 3 - Steam EB

1 : 100

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CLIENT:

TOWN OF ANTIGONISH

CLIENT REF. #:

PROJECT:

COMMUNITY DISTRICT ENERGY SYSTEM FEASIBILITY STUDY

TITLE:

OPTION 3 - ELECTRIC STEAM BOILERS FLOOR PLAN

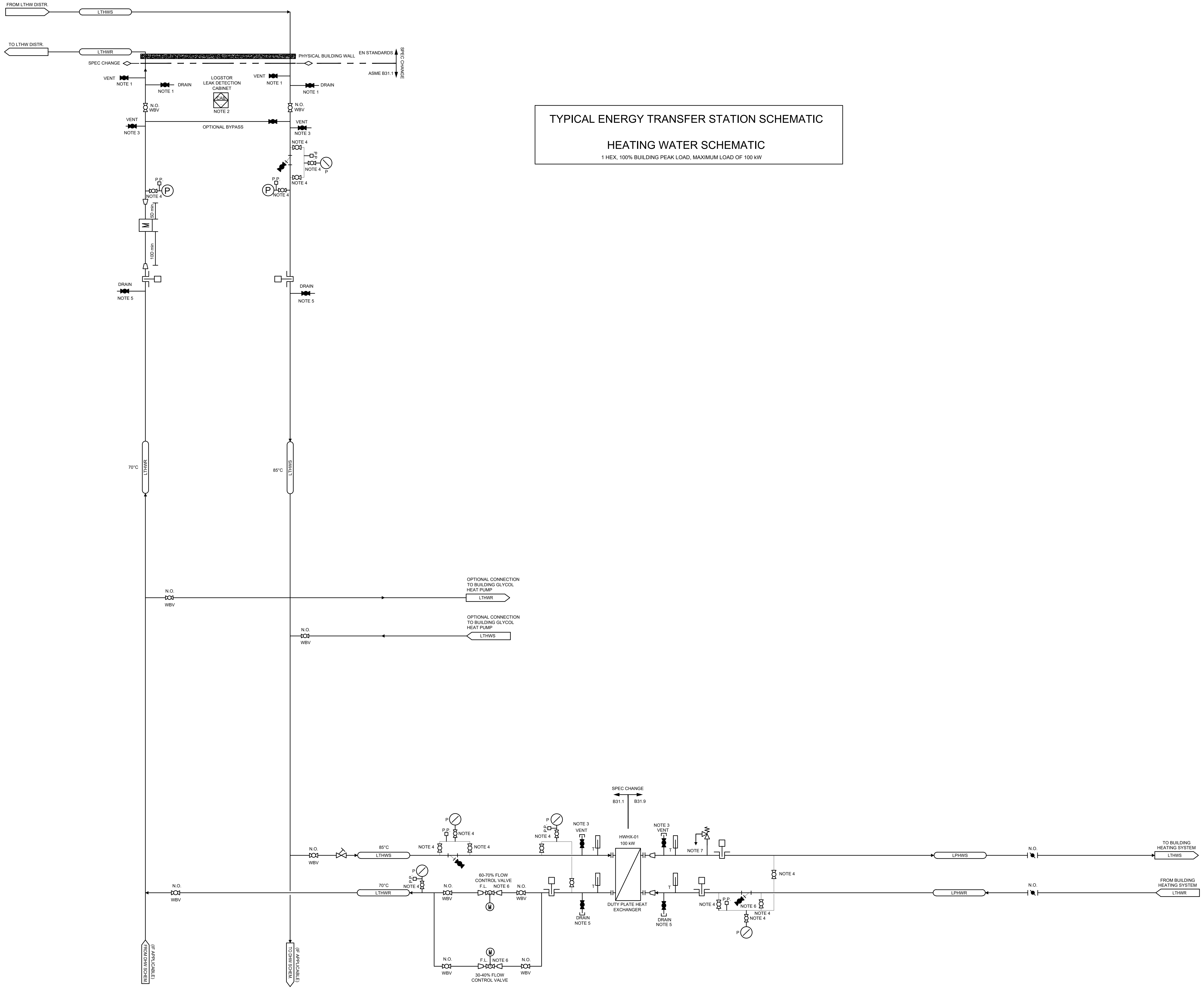
DRAWING NUMBER: M202

REV. 0

TYPICAL ENERGY TRANSFER STATION SCHEMATIC

HEATING WATER SCHEMATIC

1 HEX, 100% BUILDING PEAK LOAD, MAXIMUM LOAD OF 100 kW



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PLOTTED: 2024-11-15 - 12:08 PM
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A1-V VERSION 1.1

REVISION:

REV	DATE	DESCRIPTION	BY
0	2024-10-25	ISSUED FOR REPORT	--

SEAL:

ORIGINAL SCALE:
DATE:
APPROVED BY:
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DISCIPLINE:

WSP Canada Inc.
2611 Queensview, Ottawa, Ontario
T 613-829-2800 | www.wsp.com

PROJECT NUMBER: CA0016522.4178

CLIENT:

TOWN OF ANTIGONISH

CLIENT REF. #: --

PROJECT:

COMMUNITY DISTRICT
ENERGY SYSTEM
FEASIBILITY STUDY

TITLE:

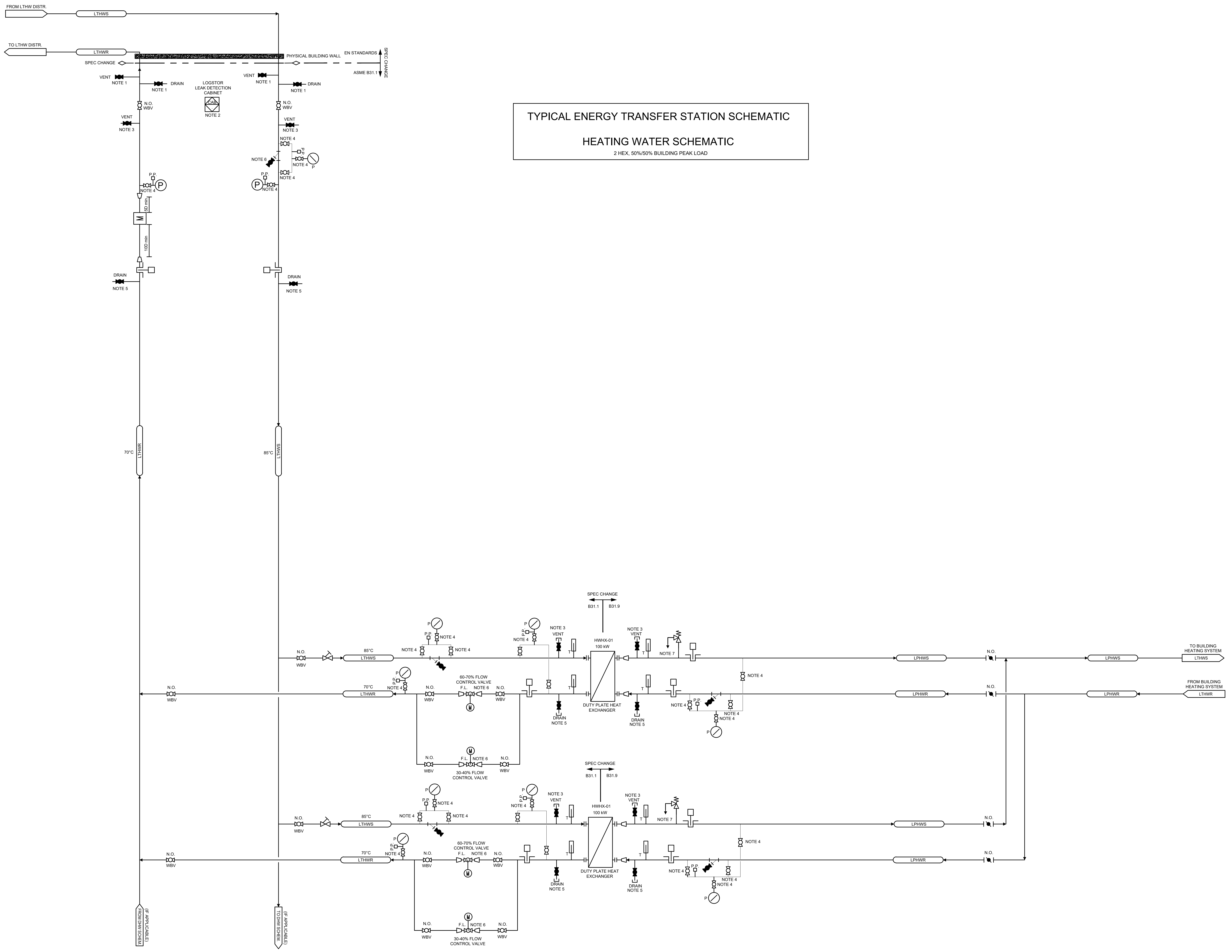
HEATING WATER SCHEMATIC
(1 HEX, 100% BUILDING LOAD)
TYPICAL ENERGY TRANSFER
STATION

DRAWING NUMBER: M300
REV.: 0

TYPICAL ENERGY TRANSFER STATION SCHEMATIC

HEATING WATER SCHEMATIC

2 HEX, 50%/50% BUILDING PEAK LOAD



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REV	DATE	DESCRIPTION	BY
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CLIENT REF. #: --

PROJECT:

COMMUNITY DISTRICT
ENERGY SYSTEM
FEASIBILITY STUDY

TITLE:

HEATING WATER SCHEMATIC
(2 HEX, 50%/50% BUILDING LOAD)
TYPICAL ENERGY TRANSFER
STATION

DRAWING NUMBER: M301
REV. 0

CTB: monochrome.ctb
PLOTTED: 2024-11-15 - 12:08 PM
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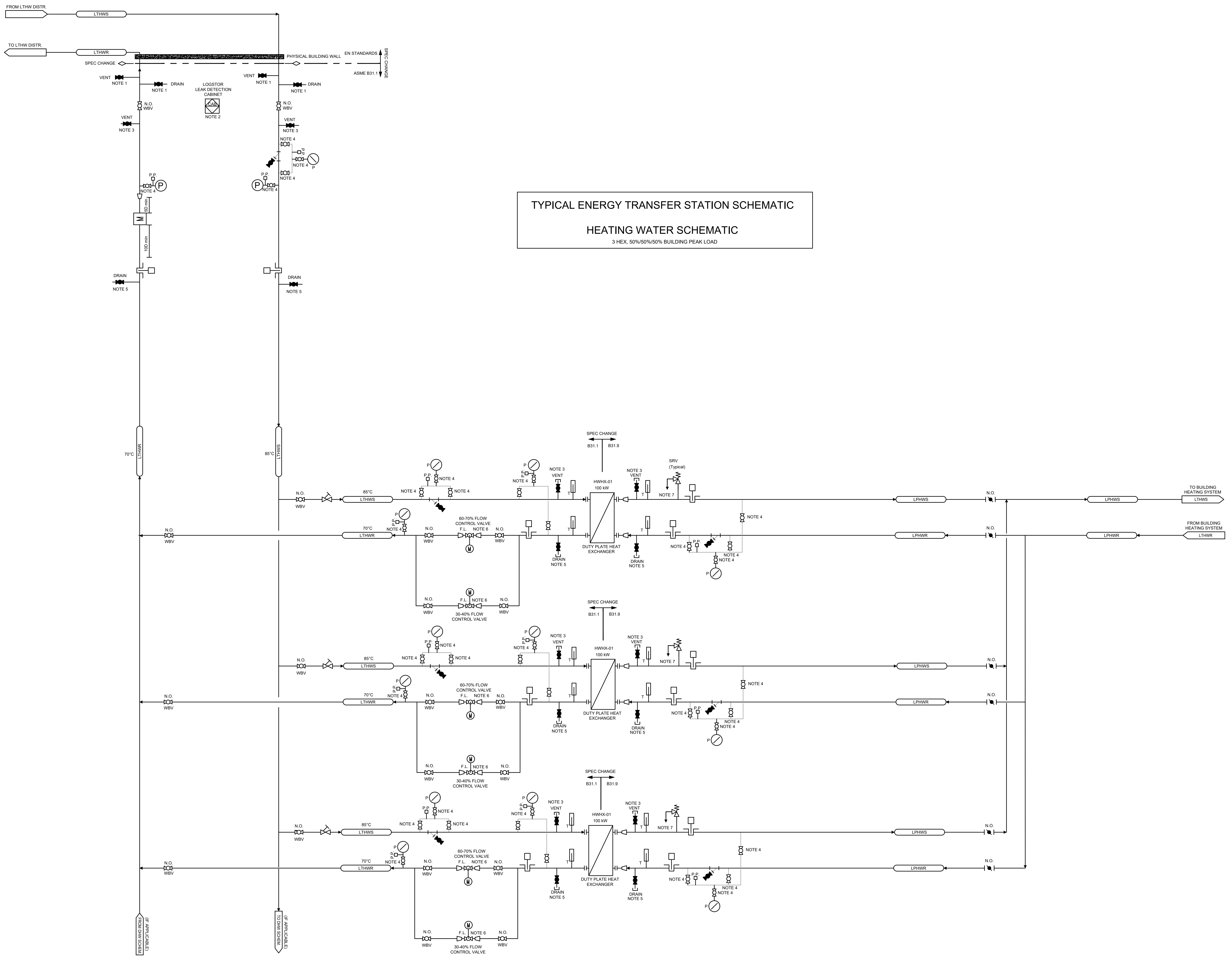
TYPICAL ENERGY TRANSFER STATION SCHEMATIC

HEATING WATER SCHEMATIC

3 HEX, 50%/50%/50% BUILDING PEAK LOAD



REVISION:

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PROJECT NUMBER: CA0016522.4178

CLIENT:

TOWN OF ANTIGONISH

CLIENT REF. #: --

PROJECT:

COMMUNITY DISTRICT
ENERGY SYSTEM
FEASIBILITY STUDY

TITLE:

HEATING WATER SCHEMATIC
(3 HEX, 50%/50%/50% BUILDING LOAD)
TYPICAL ENERGY TRANSFER
STATION

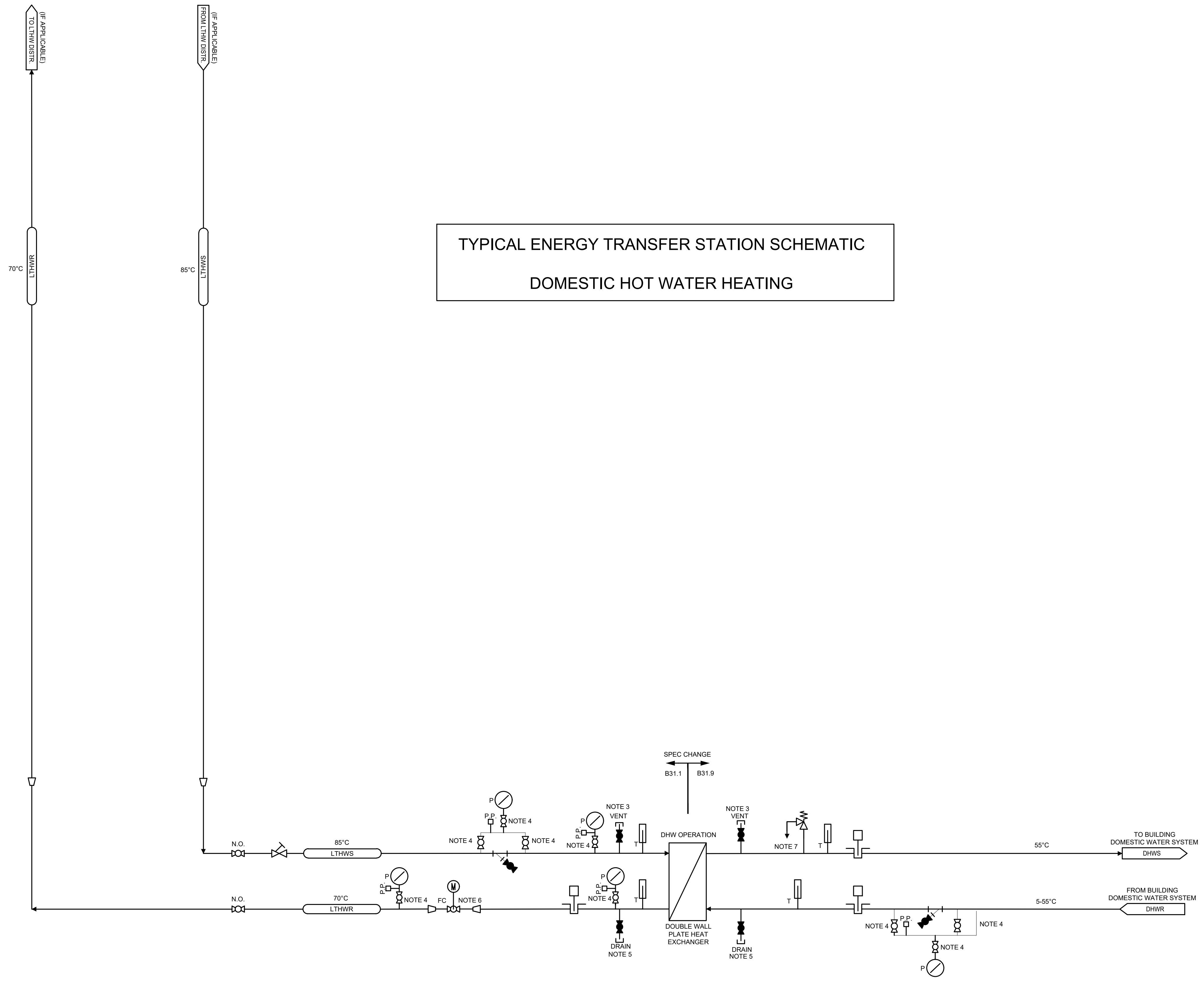
DRAWING NUMBER: M302

REV. 0

CTB: monochrome.ctb
PLOTTED: 2024-11-15 - 12:08 PM
FILE: c:\users\cafj063304\documents\antigonish\antigonish ets p&ids.dwg
A1-V VERSION 1.1

TYPICAL ENERGY TRANSFER STATION SCHEMATIC

DOMESTIC HOT WATER HEATING



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DRAWN BY (OPTIONAL):

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PROJECT NUMBER: CA0016522.4178

CLIENT:

TOWN OF ANTIGONISH

CLIENT REF. #: --

PROJECT:

COMMUNITY DISTRICT
ENERGY SYSTEM
FEASIBILITY STUDY

TITLE:

DOMESTIC HOT WATER
ENERGY TRANSFER STATION

DRAWING NUMBER: M303
REV. 0

CTB: monochrome.ctb
PLOTTED: 2024-11-15 - 12:08 PM
FILE: c:\users\cafj063304\documents\antigonish\antigonish ets p&ids.dwg
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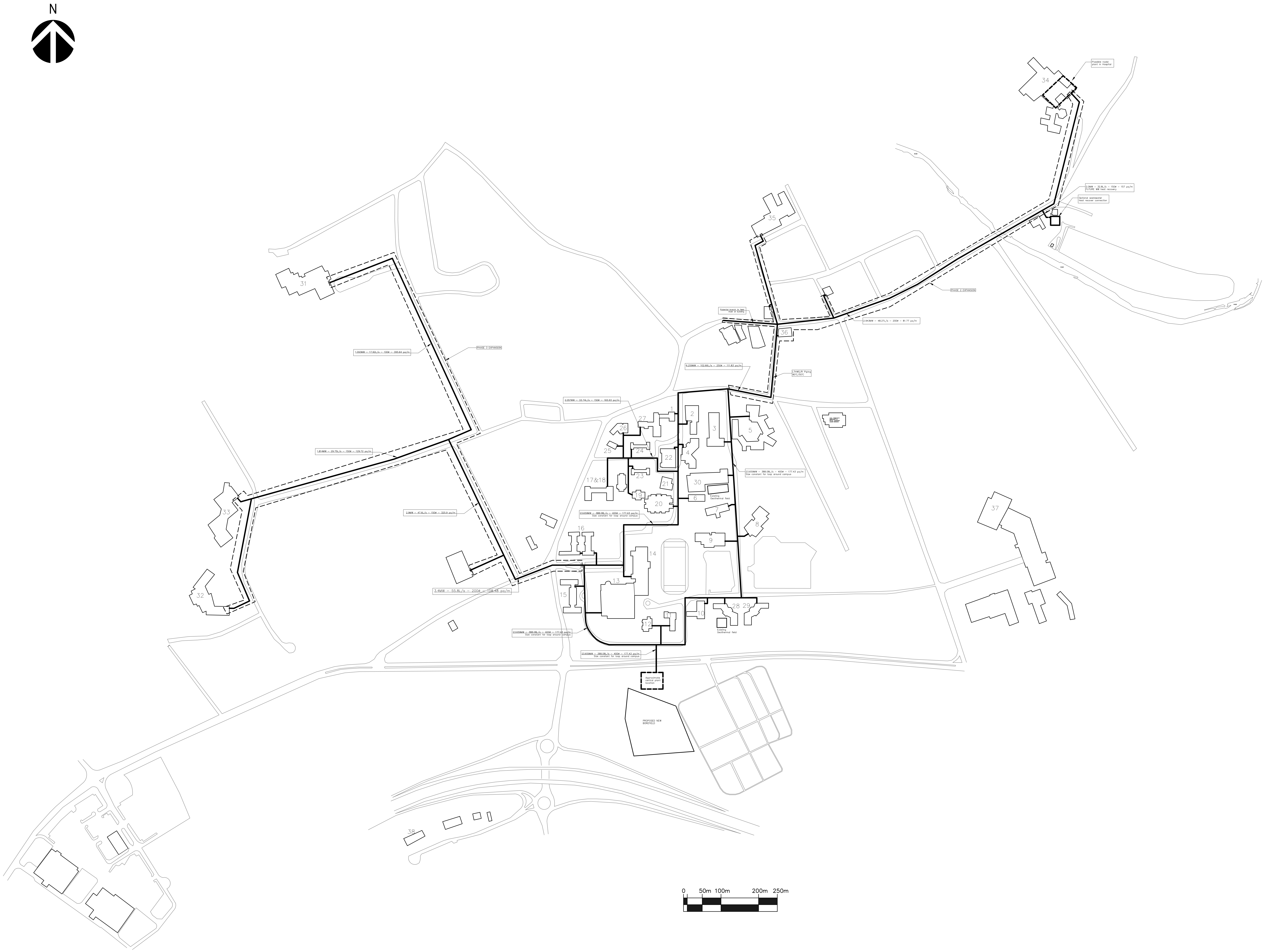

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PROJECT NUMBER: CA0016522.4178

CLIENT:

TOWN OF ANTIGONISH

CLIENT REF. #: --

PROJECT:

COMMUNITY DISTRICT ENERGY SYSTEM FEASIBILITY STUDY

TITLE:

TOWN INFORMATION MAP

BUILDING IDENTIFICATION AND DISTRIBUTION PIPE SIZING

DRAWING NUMBER: M400

REV. 0

CTB: _wsp_standard.ctb
PLOTTED: 2024-11-18 - 3:58 PM
FILE: c:\users\cafj063304\documents\antigonish\antigonish map cad_new.dwg
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E

CAPITAL COST ESTIMATE

THE TOWN OF ANTIGONISH

THE TOWN OF ANTIGONISH – COMMUNITY DISTRICT ENERGY SYSTEM

CLASS 4 COST ESTIMATE (FEASIBILITY STUDY)

THE TOWN OF ANTIGONISH – COMMUNITY DISTRICT ENERGY SYSTEM

CLASS 4 COST ESTIMATE (FEASIBILITY STUDY)

THE TOWN OF ANTIGONISH

REVISION 1

PROJECT NO.: CA0016522.4178
CLIENT REF: THE TOWN OF ANTIGONISH
DATE: NOVEMBER 27, 2024

WSP

WSP.COM

November 27, 2024

The Town of Antigonish
Via Email

Attention: The Town of Antigonish

Dear Sir / Madam,

RE.: THE TOWN OF ANTIGONISH – COMMUNITY DISTRICT ENERGY SYSTEM - CLASS 4 COST ESTIMATE (FEASIBILITY STUDY)

Please find enclosed WSP's Class 4 Cost Estimate and Basis of Estimate for the Town of Antigonish's Community District Energy System Project.

We have estimated three separate options, and the estimated total construction cost of each option is summarized below:

- Option 1: Geothermal with Heat Pumps & Electric Boiler Backup = **CAD $206,044,363**
- Option 2: Electric Boilers LTHW Only = **CAD $96,078,393**
- Option 3: Steam Electric Boilers = **CAD $28,109,527**

Should there be any questions, please do not hesitate to contact me.

Yours sincerely,

Richard Tyms, MSc, PQS
Senior Cost Consultant, WSP Canada

Encl.
cc:
WSP ref.: CA0016522.4178

REVISION HISTORY

FIRST ISSUE

October 30, 2024	Class 4 Cost Estimate			
Prepared by	**Reviewed by**	**Approved By**		
WSP Estimating Dept.	WSP	WSP		
REVISION 1				
November 27, 2024	Class 4 Cost Estimate			
Prepared by	**Reviewed by**	**Approved By**		
WSP Estimating Dept.	WSP	WSP		
Prepared by	**Reviewed by**	**Approved By**		

SIGNATURES

PREPARED BY

Richard Tyms, MSc, PQS

November 27, 2024

Date

APPROVED[1] BY

Paul Jardine, MRICS, PQS, MCIOB

November 27, 2024

Date

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CONTRIBUTORS

CLIENT

The Town of Antigonish

WSP

WSP Canada, Buildings, Project Management Department

SUBCONSULTANTS

None

TABLE OF CONTENTS

TABLES

N/A

FIGURES

N/A

APPENDICES

1 PROJECT OVERVIEW

1.1 SCOPE OF WORK

The Scope of Work for the three options is summarized below:

Option 1: Geothermal with Heat Pumps & Electric Boiler Backup

- New central plant building.
- New heat pumps and electric boiler within new central plant building, including all associated piping, equipment and controls.
- New energy transfer stations to 42nr buildings.
- New district LTHW heating piping network.
- Geo-thermal system, including 876nr 1,500ft deep boreholes.
- Wastewater heat recovery system (equipment supply & installation only).
- Associated electrical distribution.
- New 4,850m3 Thermal Storage Tank.

The scope of work for Option 1 is split into three phases and the estimated breakdown associated with each phase is as follows:

- Option 1 Phase 1 = $109,125,420
- Option 1 Phase 2 = $61,421,258
- Option 1 Phase 3 = $35,497,685
- **Grand Total Option 1 = $206,044,363**

Option 2: Electric Boilers LTHW Only

- New central plant building.
- New electric boilers within new central plant building, including all associated piping, equipment and controls.
- New energy transfer stations to 42nr buildings.
- New district LTHW heating piping network.
- Associated electrical distribution.
- New 4,850m3 Thermal Storage Tank.

The scope of work for Option 2 is split into three phases and the estimated breakdown associated with each phase is as follows:

- Option 2 Phase 1 = $65,981,175

- Option 2 Phase 2 = $19,152,072
- Option 2 Phase 3 = $10,945,146
- **Grand Total Option 2 = $96,078,393**

Option 3: Steam Electric Boilers

- New central plant building.
- New steam boilers within new central plant building, including all associated piping, equipment and controls.
- Associated electrical distribution.

The scope of work for Option 3 forms one phase only and the estimated breakdown associated with this option is as follows:

- **Grand Total Option 3 = $28,109,527**

This project is located in Antigonish, Nova Scotia, Canada.

1.1.1 KEY TIMELINES

The base date for the estimate is August 2024.

All costs are based on present day costs and escalation has been excluded.

1.2 CONSTRUCTION SEQUENCING & STAGING

To be decided by awarded contractor.

2 BASIS OF ESTIMATE

2.1 DOCUMENTS

This Class 4, Feasibility Cost Estimate is based on the following documents:

- WSP Antigonish Pipe Layout Map R2 received November 19, 2024 (1 page).
- WSP Antigonish Plant Layout drawings R2 received November 26, 2024 (3 pages).
- Emails / discussions with WSP Engineering department.

2.2 CONTINGENCIES & ALLOWANCES

The Class 4 Estimate includes the following contingencies:

- Design & Pricing Contingency: 20%
- Escalation Allowance: Excluded.

2.3 INDIRECT COSTS

The Class 4 Estimate includes for the following indirect costs:

- Contractor General Conditions/General Requirements: 10%
- Contractor Overhead and Fee: 5%
- Bonds & Insurance: 1.75%

2.4 EXCLUSIONS, ASSUMPTIONS & NOTES

2.4.1 EXCLUSIONS

The following items are excluded from the estimate:

1. Water / sewer utility upgrades.
2. Electrical substations.
3. Cooling Systems such as piping, chillers, cooling towers, pumps etc.
4. Natural Gas installations.
5. Backup generators.
6. Escalation from present day costs.
7. Option 3 – new district heating steam piping.
8. Option 3 – new ETS’s to buildings.
9. Option 3 – cleaning / maintenance to existing steam distribution piping.

10. Site Lighting / Street Lighting.
11. Roadways / Car Parking / Landscaping to new Central Plant and Wastewater Heat Recover Buildings.
12. Permanent Cranes / Equipment Lifting equipment.
13. New heating distribution systems to buildings (ETS only allowed to each building).
14. Demolition and removal of existing steam network, equipment or buildings.
15. Demolition / site clearing for new central plant / wastewater heat recovery buildings.
16. Financing/interest costs.
17. Property Acquisition costs.
18. Premium cost for sole-sourcing materials and equipment.
19. Fast-tracking costs.
20. Impact costs to residents and businesses.
21. FF&E other than those specifically identified within the estimate.
22. Any permanent fall / edge protection.
23. Any hazardous materials abatement that maybe required to buildings or the site.
24. Project / risk contingency.
25. Professional services (Design, Project Management, Legal, Surveys, etc).
26. Construction permits.
27. Owners & Builder’s Risk Insurances.
28. Construction contingency (Change Orders).
29. Works outside normal working hours.
30. Temporary works such as boilers, generators etc.
31. HST / GST.
32. Construction phasing.
33. Hospital nodal plant.
34. Piping and ETS’s to commercial sector buildings.
35. Construction and/or fit out of Wastewater Heat Recovery Plant Building.

2.4.2 ASSUMPTIONS

1. Work to be performed by skilled Union Labour.
2. Bids will be received from a minimum of three (3) General Contractors and a minimum of three (3) Subcontractors for each trade.
3. A General Contractor will employ mechanical, electrical, geo-thermal & specialist tank trade contractors to carry out the mechanical, electrical, geo-thermal & tank elements of the project.
4. Assumes sufficient water, sewer and electrical utility capacities & connections will be available adjacent to the new central plant and wastewater heat recovery buildings.

2.4.3 NOTES

1. Detailed unit pricing is based on current Canadian dollars.
2. Current market and commodities volatility could negatively impact the number of bidders and bid prices.
3. This is an AACE Class 4 Estimate and is considered to have an expected accuracy range of -30% to +50%.
4. The estimate contained in Appendix A has been spit into 3 Phases. However, all 3 phases are based on present day costs.

APPENDIX

A

CLASS 4 COST ESTIMATE

	TOTAL $
OPTION 1: Geothermal with Heat Pumps & Electric Boiler Backup	
Option 1 - Geothermal with Heat Pumps & Electric Boiler Backup - Phase 1	43,940,645
Sitework - Opt 1 - Geothermal with Heat Pumps & EB Backup - Phase 1	65,184,776
Grand Total Option 1 Phase 1	**109,125,420**
Option 1 - Geothermal with Heat Pumps & Electric Boiler Backup - Phase 2	13,940,203
Sitework - Opt 1 - Geothermal with Heat Pumps & EB Backup - Phase 2	47,481,055
Grand Total Option 1 Phase 2	**61,421,258**
Option 1 - Geothermal with Heat Pumps & Electric Boiler Backup - Phase 3	1,411,799
Sitework - Opt 1 - Geothermal with Heat Pumps & EB Backup - Phase 3	34,085,886
Grand Total Option 1 Phase 3	**35,497,685**
Grand Total Recommended Budget Option 1	**206,044,363**
OPTION 2: Electric Boilers LTHW Only	
Option 2 - Electric Boilers LTHW Only - Phase 1	25,348,939
Sitework - Opt 2 - EB LTHW Only - Phase 1	40,632,236
Grand Total Option 2 Phase 1	**65,981,175**
Option 2 - Electric Boilers LTHW Only - Phase 2	7,611,366
Sitework - Opt 2 - EB LTHW Only - Phase 2	11,540,706
Grand Total Option 2 Phase 2	**19,152,072**
Option 2 - Electric Boilers LTHW Only - Phase 3	1,411,799
Sitework - Opt 2 - EB LTHW Only - Phase 3	9,533,346
Grand Total Option 2 Phase 3	**10,945,146**
Grand Total Recommended Budget Option 2	**96,078,393**

	TOTAL $
OPTION 3: Steam Electric Boilers	
Option 3 - Steam Electric Boilers - Phase 1	22,696,968
Sitework - Opt 3 - Steam Electric Boilers - Phase 1	5,412,559
Grand Total Option 3 Phase 1	**28,109,527**
Option 3 - Steam Electric Boilers - Phase 2	0
Sitework - Opt 3 - Steam Electric Boilers - Phase 2	0
Grand Total Option 3 Phase 2	**0**
Option 3 - Steam Electric Boilers - Phase 3	0
Sitework - Opt 3 - Steam Electric Boilers - Phase 3	0
Grand Total Option 3 Phase 3	**0**
Grand Total Recommended Budget Option 3	**28,109,527**

Class 4 Estimate (Feasibility Study) R1 Option 1 - Geo, Heat Pumps & Boilers Summary

Ref.	Description		%	TOTAL $
A10	Foundations		1%	351,150
A	Substructure		1%	351,150
B10	Superstructure		2%	936,400
B20	Exterior Enclosure		2%	1,051,109
B30	Roofing		1%	309,012
B	Shell		4%	2,296,521
C10	Interior Construction		1%	550,135
C30	Interior Finishes		1%	427,740
C	Interiors		2%	977,875
D20	Plumbing Systems		0%	234,100
D30	Heating, Ventilation & Air Conditioning		60%	35,464,333
D40	Fire Protection		0%	140,460
D50	Electrical Lighting, Power & Communications		4%	2,579,480
D	Services		65%	38,418,373
BUILDING ELEMENTAL COST BEFORE CONTINGENCIES			71%	42,043,919
Z10	General Conditions	10.00%	7%	4,204,392
Z12	Contractor OH & Fee	5.00%	4%	2,312,416
Z13	Design Contingency	20.00%	16%	9,712,145
BUILDING ELEMENTAL COST INCLUDING CONTINGENCIES			98%	58,272,872
Z22	Bonds & Insurance	1.75%	2%	1,019,775
BUILDING CONSTRUCTION COST BEFORE ESCALATION			100%	59,292,647
Z30	Escalation	0.00%	0%	Excluded
RECOMMENDED CONSTRUCTION BUDGET - November, 2024			100%	59,292,647

Item Description	Quantity	Unit	Rate	Total
A10 Foundations				
A1010 Standard Foundations				140,460
PHASE 1				
Allowance for foundations - Central Plant Building	2,341	m2	60.00	140,460
PHASE 2				
Allowance for foundations - Wastewater Heat Recovery Building		m2		*Excluded*
A1030 Slab On Grade				210,690
PHASE 1				
Allowance for slab on grade - Central Plant Building	2,341	m2	90.00	210,690
PHASE 2				
Allowance for slab on grade - Wastewater Heat Recovery Building		m2		*Excluded*
				351,150
B10 Superstructure				
B1010 Floor Construction				280,920
PHASE 1				
Allowance for floor construction - Central Plant Building	2,341	m2	120.00	280,920
PHASE 2				
Allowance for floor construction - Wastewater Heat Recovery Building		m2	120.00	*Excluded*
B1020 Roof Construction				655,480
PHASE 1				
Allowance for roof construction - Central Plant Building	2,341	m2	280.00	655,480
PHASE 2				
Allowance for roof construction - Wastewater Heat Recovery Building		m2		*Excluded*
				936,400
B20 Exterior Enclosure				
B2010 Exterior Walls				924,695
PHASE 1				

Item Description	Quantity	Unit	Rate	Total
Allowance for exterior walls - Central Plant Building	2,341	m2	395.00	924,695
PHASE 2				
Allowance for exterior walls - Wastewater Heat Recovery Building		m2		*Excluded*
B2020 Exterior Windows				49,161
PHASE 1				
Allowance for exterior windows - Central Plant Building	2,341	m2	21.00	49,161
PHASE 2				
Allowance for exterior windows - Wastewater Heat Recovery Building		m2		*Excluded*
B2030 Exterior Doors				77,253
PHASE 1				
Allowance for exterior doors - Central Plant Building	2,341	m2	33.00	77,253
PHASE 2				
Allowance for exterior doors - Wastewater Heat Recovery Building		m2		*Excluded*
				1,051,109
B30 Roofing				
B3010 Roof Coverings				280,920
PHASE 1				
Allowance for roof coverings - Central Plant Building	2,341	m2	120.00	280,920
PHASE 2				
Allowance for roof coverings - Wastewater Heat Recovery Building		m2		*Excluded*
B3020 Roof Openings				28,092
PHASE 1				
Allowance for roof openings - Central Plant Building	2,341	m2	12.00	28,092
PHASE 2				
Allowance for roof openings - Wastewater Heat Recovery Building		m2		*Excluded*
				309,012

Item Description	Quantity	Unit	Rate	Total
C10 Interior Construction				
C1010 Partitions				210,690
PHASE 1				
Allowance for internal walls - Central Plant Building	2,341	m2	90.00	210,690
PHASE 2				
Allowance for internal walls - Wastewater Heat Recovery Building		m2		*Excluded*
C1020 Interior Doors				35,115
PHASE 1				
Allowance for interior doors - Central Plant Building	2,341	m2	15.00	35,115
PHASE 2				
Allowance for interior doors - Wastewater Heat Recovery Building		m2		*Excluded*
C1030 Fittings				304,330
PHASE 1				
Miscellaneous metal, braces, lintels, pipe supports, and signages - Central Plant Building	2,341	m2	130.00	304,330
PHASE 2				
Miscellaneous metal, braces, lintels, pipe supports, and signages - Wastewater Heat Recovery Building		m2		*Excluded*
				550,135
C30 Interior Finishes				
C3010 Wall Finishes				117,050
PHASE 1				
Allowance for wall finishes (painting to concrete, block walls, and repairs - Central Plant Building	2,341	m2	50.00	117,050
PHASE 2				
Allowance for wall finishes (painting to concrete, block walls, and repairs - Wastewater Heat Recovery Building		m2		*Excluded*
C3020 Floor Finishes				240,460
PHASE 1				
Allowance for floor finishes (concrete hardener & sealer to floors, patch, and repairs - Central Plant Building	2,341	m2	60.00	140,460
Allowance for concrete plant bases - Central Plant Building	1	ls	100,000.00	100,000
PHASE 2				
Allowance for floor finishes (concrete hardener & sealer to floors, patch, and repairs - Wastewater Heat Recovery Building		m2		*Excluded*
Allowance for concrete plant bases - Wastewater Heat Recovery Building		ls		*Excluded*

Item Description	Quantity	Unit	Rate	Total
C3030 Ceiling Finishes				70,230
PHASE 1				
Allowance for ceiling finishes (patching / repair only) - Central Plant Building	2,341	m2	30.00	70,230
PHASE 2				
Allowance for ceiling finishes (patching / repair only) - Wastewater Heat Recovery Building		m2		*Excluded*
				427,740
D20 Plumbing Systems				
D2020 Domestic Water Distribution				234,100
PHASE 1				
Allowance for Plumbing fit-out to central plant building, including domestic water, sanitary, and rainwater installations	2,341	m2	100.00	234,100
PHASE 2				
Allowance for Plumbing fit-out to wastewater heat recovery building, including domestic water, sanitary, and rainwater installations		m2		*Excluded*
				234,100
D30 Heating, Ventilation & Air Conditioning				
D3020 Heat Generating Systems				25,455,548
PHASE 1				
Heat Pump - 10,000kw capacity	2	ea	7,000,000.00	14,000,000
Electric Boilers - 5,000kW capacity	1	ea	1,370,000.00	1,370,000
Boiler Circulation / Evaporator / Condenser Pumps	10	ea	60,000.00	600,000
LTHW Distribution Pumps	3	ea	110,000.00	330,000
Hot water supply and return primary and secondary piping, assume 400mm diameter, black steel pipe, assume length	255	m	2,400.00	611,280
Hot water supply and return primary and secondary piping, assume 250mm diameter, black steel pipe, assume length	101	m	1,300.00	131,820
Hot water supply and return primary and secondary piping, assume 200mm diameter, black steel pipe, assume length	156	m	1,000.00	156,000
Allowance or fittings	1	ls	350,000.00	350,000
Allowance for valves and miscellaneous equipment	1	ls	440,000.00	440,000
Insulation	512	m	270.00	138,267
PHASE 2				
Heat Pump - 10,000kw capacity	1	ea	7,000,000.00	7,000,000
Boiler Circulation / Evaporator / Condenser Pumps	4	ea	60,000.00	240,000
Hot water supply and return primary and secondary piping, assume 200mm diameter, black steel pipe, assume length	40	m	1,000.00	40,300
Allowance or fittings	1	ls	16,000.00	16,000

Item Description	Quantity	Unit	Rate	Total
Allowance for valves and miscellaneous equipment	1	ls	21,000.00	21,000
Insulation	40	m	270.00	10,881
D3040 Distribution Systems				8,408,785
PHASE 1				
HVAC fit-out to central plant building, including controls.	2,341	m2	350.00	819,350
PHASE 2				
HVAC fit-out to wastewater heat recovery building, including controls.		m2		*Excluded*
PHASE 1				
Allowance for new Energy Transfer Stations to the following buildings. Including heating piping from the building line district energy network connection, heat exchangers, valves, insulation, ancillary equipment, associated controls and testing / commissioning				
Building 1 - 3,428m2 / Peak Demand 942kw	3,428	m²	70.00	239,960
Building 2 - 8,330m2 / Peak Demand 281kw	8,330	m²	20.00	166,600
Building 3 - 1,513m2 / Peak Demand 176kw	1,513	m²	40.00	60,520
Building 4 - 3,700m2 / Peak Demand 484kw	3,700	m²	40.00	148,000
Building 5 - 17,408m2 / Peak Demand 535kw	17,408	m²	20.00	348,160
Building 6 - 3,296m2 / Peak Demand 128kw	3,296	m²	20.00	65,920
Building 7 - 2,792m2 / Peak Demand 972kw	2,792	m²	90.00	251,280
Building 8 - 6,145m2 / Peak Demand 543kw	6,145	m²	20.00	122,900
Building 9 - 7,379m2 / Peak Demand 277kw	7,379	m²	20.00	147,580
Building 10 - 4,572m2 / Peak Demand 368kw	4,572	m²	30.00	137,160
Building 11 - 2,009m2	2,009	m²	50.00	100,450
Building 12 - 1,692m2 / Peak Demand 195kw	1,692	m²	30.00	50,760
Building 13 - 7,654m2 / Peak Demand 678kw	7,654	m²	30.00	229,620
Building 14 - 9,257m2 / Peak Demand 1,203kw	9,257	m²	40.00	370,280
Building 15 - 7,558m2 / Peak Demand 477kw	7,558	m²	20.00	151,160
Building 16 - 7,598m2 / Peak Demand 259kw	7,598	m²	20.00	151,960
Building 17 - 4,243m2 / Peak Demand 770kw (inc Bldg 18)	4,243	m²	40.00	169,720
Building 18 - 1,711m2	1,711	m²		*Inc*
Building 19 - 1,383m2 / Peak Demand 152kw	1,383	m²	30.00	41,490
Building 20 - 8,041m2 / Peak Demand 877kw	8,041	m²	30.00	241,230
Building 22 - 7,111m2 / Peak Demand 647kw	7,111	m²	30.00	213,330
Building 23 - 2,655m2 / Peak Demand 297kw	2,655	m²	30.00	79,650
Building 24 - 2,655m2 / Peak Demand 297kw	2,655	m²	30.00	79,650
Building 25 - 1,944m2 / Peak Demand 266kw	1,944	m²	40.00	77,760
Building 26 - 1,242m2 / Peak Demand 285kw	1,242	m²	60.00	74,520
Building 27 - 3,839m2 / Peak Demand 575kw	3,839	m²	40.00	153,560
Building 28 - 5,395m2 / Peak Demand 509kw	5,395	m²	30.00	161,850
Building 29 - 5,395m2 / Peak Demand 509kw	5,395	m²	30.00	161,850
Building 30 - 10,524m2 / Peak Demand 1,018kw	10,524	m²	30.00	315,720
PHASE 2				

Item Description	Quantity	Unit	Rate	Total
Allowance for new Energy Transfer Stations to the following buildings. Including heating piping from the building line district energy network connection, heat exchangers, valves, insulation, ancillary equipment, associated controls and testing / commissioning				
Building 34 - 25,190m2 / Peak Demand 2,943kw	25,190	m²	30.00	755,700
Building 35 - Peak Demand 1,316kw - no area	1	ls	350,000.00	350,000
Building 36 - East Cost Credit Union - no area / peak load	1	ls	120,000.00	120,000
Building 37 - Canadian Tire - no area / peak load	1	ls	140,000.00	140,000
Building 38 - Microtel Inn & Suites - no area / peak load	1	ls	250,000.00	250,000
Building ## - Antigonish Town Hall - no area / peak load	1	ls	130,000.00	130,000
Building ## - Antigonish Town & County Library - no area / peak load	1	ls	130,000.00	130,000
Building ## - Antigonish Fire Hall - no area / peak load	1	ls	80,000.00	80,000
Building ## - BMO / Canada Post / Shoppers Drug Mart - no area / peak load	1	ls	120,000.00	120,000
PHASE 3				
Allowance for new Energy Transfer Stations to the following buildings. Including heating piping from the building line district energy network connection, heat exchangers, valves, insulation, ancillary equipment, associated controls and testing / commissioning				
Building 31 - 12,953m2 / Peak Demand 1,093kw	12,953	m²	25.00	323,825
Building 32 - 7,860m2 / Peak Demand 833kw	7,860	m²	30.00	235,800
Building 33 - 8,049m2 / Peak Demand 981kw	8,049	m²	30.00	241,470
Antigonish Arena - 500kw assumed - no area	1	ls	200,000.00	200,000
D3060 Controls and Instrumentation				1,400,000
PHASE 1				
Allowance for district heating system controls and instrumentation	1	ls	1,000,000.00	1,000,000
PHASE 2				
Allowance for district heating system controls and instrumentation	1	ls	400,000.00	400,000
D3070 Systems Testing & Balancing				200,000
PHASE 1				
Allowance for testing and commissioning	1	ls	160,000.00	160,000
PHASE 2				
Allowance for testing and commissioning	1	ls	40,000.00	40,000
				35,464,333

D40 Fire Protection

Item Description	Quantity	Unit	Rate	Total
D4010 Sprinklers				140,460
PHASE 1				
Sprinkler fit-out to central plant building, including distribution pipe and sprinklers only	2,341	m²	60.00	140,460
PHASE 2				
Sprinkler fit-out to wastewater heat recovery building, including distribution pipe and sprinklers only		m²		*Excluded*
				140,460
D50 Electrical Lighting, Power & Communications				
D5010 Electrical Service & Distribution				1,407,800
PHASE 1				
Central Plant Building				
4.16kV, 3PH, 4W Switchgear (Assume 8-cells)	1	ea	631,000.00	631,000
4.16kV-600V 1000kVA Transformer	1	ea	140,000.00	140,000
600V-120/208V 300kVA Transformer	1	ea	63,000.00	63,000
1000A, 600V, 3PH, 4W Switchboard	1	ea	125,000.00	125,000
600V, 3PH, 4W Panel	4	ea	9,000.00	36,000
120/208V, 3PH, 4W Panel	4	ea	4,000.00	16,000
Feeders from 4.16KV Switchgear to 4.16KV-600V Transformer	1	ea	3,200.00	3,200
Feeders from 4.16KV Switchgear to mechanical panels	7	ea	6,000.00	42,000
4.16KV-600V transformer secondary feeder	1	ea	38,000.00	38,000
600V-208V/120V transformer primary feeder	1	ea	10,000.00	10,000
600V-208V/120V transformer secondary feeder	1	ea	45,000.00	45,000
Feeders from 600V Switchboard to distribution Panels	4	ea	6,400.00	25,600
Miscellaneous Feeders	1	ls	16,000.00	16,000
Grounding System	1	ls	23,000.00	23,000
Cable trays c/w connectors, fittings, hardware's etc.	1	ls	24,000.00	24,000
PHASE 1				
Power to District Energy Mechanical Equipment				
Heat Pumps	2	ea	15,000.00	30,000
Electric Boiler	1	ea	17,000.00	17,000
Pumps	13	ea	4,000.00	52,000
Miscellaneous electrical connections	1	ls	30,000.00	30,000
PHASE 2				
Power to District Energy Mechanical Equipment				
Heat Pumps	1	ea	15,000.00	15,000
Pumps	4	ea	4,000.00	16,000
Miscellaneous electrical connections	1	ls	10,000.00	10,000

Item Description	Quantity	Unit	Rate	Total
PHASE 2				
Wastewater Heating Recovery Building				
Incoming service, allowance		ls		*Excluded*
Transformer, allow		ls		*Excluded*
600V Switchboard, panels		ls		*Excluded*
600V-208V/120V, Distribution Transformers		ls		*Excluded*
Feeders, Conduit, Busway and Controls		ls		*Excluded*
D5020 Lighting & Branch Wiring				491,610
PHASE 1				
Central Plant Building				
Lighting System	2,341	m²	175.00	409,675
Devices	2,341	m²	35.00	81,935
PHASE 2				
Wastewater Heating Recovery Building				
Lighting System		m²		*Excluded*
Devices		m²		*Excluded*
D5030 Communications & Security				222,395
PHASE 1				
Central Plant Building				
Fire alarm system	2,341	m²	35.00	81,935
Communication system	2,341	m²	30.00	70,230
Security System	2,341	m²	30.00	70,230
PHASE 2				
Wastewater Heating Recovery Building				
Fire alarm system		m²		*Excluded*
Communication system		m²		*Excluded*
Security System		m²		*Excluded*
D5090 Other Electrical Systems				457,675
PHASE 1				
Central Plant Building				
SCADA System	2,341	m²	110.00	257,510
Grounding System	2,341	m²	35.00	81,935
Lightning Protection	2,341	m²	30.00	70,230
Testing and Commissioning	1	ls	34,000.00	34,000
Co-ordination	1	ls	14,000.00	14,000
PHASE 2				
Wastewater Heating Recovery Building				
SCADA System		m²		*Excluded*
Grounding System		m²		*Excluded*

Item Description	Quantity	Unit	Rate	Total
Lightning Protection		m²		*Excluded*
Testing and Commissioning		ls		*Excluded*
Co-ordination		ls		*Excluded*
				2,579,480

Class 4 Estimate (Feasibility Study) R1 Sitework - Opt 1 - Geo, Heat Pumps & Boilers Summary

Ref.	Description		%	TOTAL $
G10	Site Preparation		4%	5,443,240
G20	Site Improvements		4%	5,713,500
G30	Site Mechanical Utilities		61%	90,015,672
G40	Site Electrical Utilities		2%	2,888,000
G	Building Sitework		71%	104,060,412
SITE ELEMENTAL COST BEFORE CONTINGENCIES			71%	104,060,412
Z10	General Conditions	10.00%	7%	10,406,041
Z12	Contractor OH & Fee	5.00%	4%	5,723,323
Z13	Design Contingency	20.00%	16%	24,037,955
SITE ELEMENTAL COST INCLUDING CONTINGENCIES			98%	144,227,731
Z22	Bonds & Insurance	1.75%	2%	2,523,985
SITE CONSTRUCTION COST BEFORE ESCALATION			100%	146,751,716
Z30	Escalation	0.00%	0%	Excluded
RECOMMENDED CONSTRUCTION BUDGET - November, 2024			100%	146,751,716

Item Description	Quantity	Unit	Rate	Total
G10 Site Preparation				
G1010 Site Clearing				289,000
PHASE 1				
General Site				
Temporary hoarding and signage to staging and laydown areas	1	ls	25,000.00	25,000
Traffic Management including plan - allow	1	ls	25,000.00	25,000
Temporary access provisions to entrances and roadways - allow	1	ls	15,000.00	15,000
Reinstatement of hard and soft landscaping after work is complete - allow	1	ls	50,000.00	50,000
- Noise and vibration monitoring allow	1	ls	30,000.00	30,000
PHASE 2				
General Site				
Temporary hoarding and signage to staging and laydown areas	1	ls	12,000.00	12,000
Traffic Management including plan - allow	1	ls	12,000.00	12,000
Temporary access provisions to entrances and roadways - allow	1	ls	8,000.00	8,000
Reinstatement of hard and soft landscaping after work is complete - allow	1	ls	25,000.00	25,000
- Noise and vibration monitoring allow	1	ls	15,000.00	15,000
PHASE 3				
General Site				
Temporary hoarding and signage to staging and laydown areas	1	ls	12,000.00	12,000
Traffic Management including plan - allow	1	ls	12,000.00	12,000
Temporary access provisions to entrances and roadways - allow	1	ls	8,000.00	8,000
Reinstatement of hard and soft landscaping after work is complete - allow	1	ls	25,000.00	25,000
- Noise and vibration monitoring allow	1	ls	15,000.00	15,000
G1020 Site Demolition and Relocations				500,000
PHASE 1				
Allowance to isolate and abandon in place existing steam and condensate distribution	1	ls	$ 250,000.00	250,000
PHASE 2				
Allowance to isolate and abandon in place existing steam and condensate distribution	1	ls	$ 125,000.00	125,000
PHASE 3				
Allowance to isolate and abandon in place existing steam and condensate distribution	1	ls	$ 125,000.00	125,000
G1030 Site Earthwork				4,654,240
PHASE 1				
General Site				
- Trench Excavation	18,818	m³	40.00	752,720
- 4.0 MPa pipe bedding	2,167	m³	210.00	455,070
- Backfill Trench	12,000	m³	80.00	960,000
- Allowance for temporary shoring of excavations	1	ls	50,000.00	50,000
- Allowance for dewatering of excavations	1	ls	50,000.00	50,000

Item Description	Quantity	Unit	Rate	Total
- Allowance to protect existing utilities	1	ls	25,000.00	25,000
PHASE 2				
General Site				
- Trench Excavation	9,440	m³	40.00	377,600
- 4.0 MPa pipe bedding for roadway and grass	1,049	m³	210.00	220,290
- Backfill Trench	6,000	m³	80.00	480,000
- Allowance for temporary shoring of excavations	1	ls	25,000.00	25,000
- Allowance for dewatering of excavations	1	ls	25,000.00	25,000
- Allowance to protect existing utilities	1	ls	15,000.00	15,000
PHASE 3				
General Site				
- Trench Excavation	9,833	m³	40.00	393,320
- 4.0 MPa pipe bedding for roadway and grass	1,144	m³	210.00	240,240
- Backfill Trench	6,500	m³	80.00	520,000
- Allowance for temporary shoring of excavations	1	ls	25,000.00	25,000
- Allowance for dewatering of excavations	1	ls	25,000.00	25,000
- Allowance to protect existing utilities	1	ls	15,000.00	15,000
G1040 Hazardous Waste Remediation				
Assume not required				
				5,443,240
G20 Site Improvements				
G2010 Roadways				5,713,500
PHASE 1				
Allowance for reinstatement of pavements, including sub-base, base and surfacing	9,409	m2	300.00	2,822,700
PHASE 2				
Allowance for reinstatement of pavements, including sub-base, base and surfacing	4,720	m2	300.00	1,416,000
PHASE 3				
Allowance for reinstatement of pavements, including sub-base, base and surfacing	4,916	m2	300.00	1,474,800
				5,713,500
G30 Site Mechanical Utilities				
G3010 Water Supply				75,000
Phase 1				
Allowance for new water supply to Central Plant Building	1	ls	50,000.00	50,000
Phase 2				

Item Description	Quantity	Unit	Rate	Total
Allowance for new water supply to Wastewater Heat Recovery Building	1	ls	25,000.00	25,000
G3020 Sanitary Sewer				75,000
Phase 1				
Allowance for new sanitary sewer to Central Plant Building	1	ls	50,000.00	50,000
Phase 2				
Allowance for new sanitary sewer to Wastewater Heat Recovery Building	1	ls	25,000.00	25,000
G3030 Storm Sewer				75,000
Phase 1				
Allowance for new storm sewer to Central Plant Building	1	ls	50,000.00	50,000
Phase 2				
Allowance for new storm sewer to Wastewater Heat Recovery Building	1	ls	25,000.00	25,000
G3040 Heating Distribution				29,560,672
PHASE 1				
Logstor bonded single pipe, insulation series 2 (assumed)				
400mm dia pipe	5,328	m	$ 1,640.00	8,737,920
150mm dia pipe	770	m	$ 480.00	369,792
100mm dia pipe	2,237	m	$ 320.00	715,776
Allowance for fittings, joint kits, accessories and valves	1	ls	$ 4,100,000.00	4,100,000
Allowance for district heating pipeline non-destructive testing	1	ls	$ 200,000.00	200,000
Allowance for leak detection system	1	ls	$ 300,000.00	300,000
Allowance for testing and commissioning	1	ls	$ 140,000.00	140,000
Thermal Storage Tanks				
Thermal Storage Tank - 4850m3 20mx15.5m AWWA D110 Type III prestressed concrete tank, including standard safety/access appurtenances, internal tank diffusers piping system, external insulation finishing system and foundation allowance	1	ea	$ 5,700,000.00	5,700,000
PHASE 2				
Logstor bonded single pipe, insulation series 2 (assumed)				
250mm dia pipe	1,462	m	$ 950.00	1,388,520
200mm dia pipe	2,342	m	$ 850.00	1,991,040
100mm dia pipe	962	m	$ 320.00	307,968
Allowance for fittings, joint kits, accessories and valves	1	ls	$ 1,500,000.00	1,500,000
Allowance for district heating pipeline non-destructive testing	1	ls	$ 70,000.00	70,000
Allowance for leak detection system	1	ls	$ 120,000.00	120,000
Allowance for testing and commissioning	1	ls	$ 50,000.00	50,000
PHASE 3				
Logstor bonded single pipe, insulation series 2 (assumed)				
200mm dia pipe	626	m	$ 850.00	532,440
150mm dia pipe	2,141	m	$ 510.00	1,091,808
100mm dia pipe	2,954	m	$ 320.00	945,408

Item Description	Quantity	Unit	Rate	Total
Allowance for fittings, joint kits, accessories and valves	1	ls	$ 1,100,000.00	1,100,000
Allowance for district heating pipeline non-destructive testing	1	ls	$ 60,000.00	60,000
Allowance for leak detection system	1	ls	$ 100,000.00	100,000
Allowance for testing and commissioning	1	ls	$ 40,000.00	40,000
G3090 Other Site Mechanical Utilities				60,230,000
PHASE 1				
Geo-Thermal System. Including 292nr 1500ft deep boreholes, piping, valves, pumps, heat exchangers up to but not including heat pumps.	1	ls	$ 15,000,000.00	15,000,000
Allowance for 350mm Geothermal S/R Header Piping	1,000	m	$ 1,400.00	1,400,000
Allowance for fittings, joint kits, accessories and valves	1	ls	$ 600,000.00	600,000
Allowance for Geo-Thermal pipeline non-destructive testing	1	ls	$ 40,000.00	40,000
Allowance for leak detection system	1	ls	$ 50,000.00	50,000
Allowance for header piping excavation and backfill	1	ls	$ 320,000.00	320,000
PHASE 2				
Geo-Thermal System. Including 292nr 1500ft deep boreholes, piping, valves, pumps, heat exchangers up to but not including heat pumps.	1	ls	$ 15,000,000.00	15,000,000
Allowance for 350mm Geothermal S/R Header Piping	1,000	m	$ 1,400.00	1,400,000
Allowance for fittings, joint kits, accessories and valves	1	ls	$ 600,000.00	600,000
Allowance for Geo-Thermal pipeline non-destructive testing	1	ls	$ 40,000.00	40,000
Allowance for leak detection system	1	ls	$ 50,000.00	50,000
Allowance for header piping excavation and backfill	1	ls	$ 320,000.00	320,000
PHASE 3				
Geo-Thermal System. Including 292nr 1500ft deep boreholes, piping, valves, pumps, heat exchangers up to but not including heat pumps.	1	ls	$ 15,000,000.00	15,000,000
Allowance for 350mm Geothermal S/R Header Piping	1,000	m	$ 1,400.00	1,400,000
Allowance for fittings, joint kits, accessories and valves	1	ls	$ 600,000.00	600,000
Allowance for Geo-Thermal pipeline non-destructive testing	1	ls	$ 40,000.00	40,000
Allowance for leak detection system	1	ls	$ 50,000.00	50,000
Allowance for header piping excavation and backfill	1	ls	$ 320,000.00	320,000
PHASE 2				
High-level allowance for Wastewater Heat Recovery System. Including equipment, piping, shaft, connection to sewer and controls	1	ls	8,000,000.00	8,000,000
				90,015,672
G40 Site Electrical Utilities				
G4010 Electrical Distribution				2,888,000
PHASE 1				
15/12 MVA, 27.6kV - 4.16kV Transformers	2	ea	1,050,000.00	2,100,000
Pad mounted concrete	2	ea	7,000.00	14,000
Grounding, allow	2	ea	7,000.00	14,000
Bollards, allow	16	ea	1,500.00	24,000
Fencing, allow	1	ls	50,000.00	50,000

Item Description	Quantity	Unit	Rate	Total
Feeder				
25KV incoming feeder to 27.6kV - 4.16kV Transformers	2	ea	103,000.00	206,000
15/12 MVA, 27.6kV - 4.16kV Transformers secondary feeders				
Duct Bank	2	ea	240,000.00	480,000
Cables - allow	60	m		*Included above*
Conduit, 8x103mm PVC, allow	60	m		*Included above*
Forming, reinforcing and concrete	17	m3		*Included above*
Allowance for excavation and backfill	122	m3		*Included above*
				2,888,000

Class 4 Estimate (Feasibility Study) R1 Option 2 - Electric Boilers LTHW Only Summary

Ref.	Description		%	TOTAL $
A10	Foundations		1%	290,100
A	Substructure		1%	290,100
B10	Superstructure		2%	773,600
B20	Exterior Enclosure		3%	868,366
B30	Roofing		1%	255,288
B	Shell		6%	1,897,254
C10	Interior Construction		1%	454,490
C30	Interior Finishes		1%	340,760
C	Interiors		2%	795,250
D20	Plumbing Systems		1%	193,400
D30	Heating, Ventilation & Air Conditioning		54%	18,717,807
D40	Fire Protection		0%	116,040
D50	Electrical Lighting, Power & Communications		7%	2,363,120
D	Services		62%	21,390,367
BUILDING ELEMENTAL COST BEFORE CONTINGENCIES			71%	24,372,971
Z10	General Conditions	10.00%	7%	2,437,297
Z12	Contractor OH & Fee	5.00%	4%	1,340,513
Z13	Design Contingency	20.00%	16%	5,630,156
BUILDING ELEMENTAL COST INCLUDING CONTINGENCIES			98%	33,780,938
Z22	Bonds & Insurance	1.75%	2%	591,166
BUILDING CONSTRUCTION COST BEFORE ESCALATION			100%	34,372,104
Z30	Escalation	0.00%	0%	Excluded
RECOMMENDED CONSTRUCTION BUDGET - November, 2024			100%	34,372,104

Item Description	Quantity	Unit	Rate	Total
A10 Foundations				
A1010 Standard Foundations				116,040
PHASE 1				
Allowance for foundations - Central Plant Building	1,934	m2	60.00	116,040
A1030 Slab On Grade				174,060
PHASE 1				
Allowance for slab on grade - Central Plant Building	1,934	m2	90.00	174,060
				290,100
B10 Superstructure				
B1010 Floor Construction				232,080
PHASE 1				
Allowance for floor construction - Central Plant Building	1,934	m2	120.00	232,080
B1020 Roof Construction				541,520
PHASE 1				
Allowance for roof construction - Central Plant Building	1,934	m2	280.00	541,520
				773,600
B20 Exterior Enclosure				
B2010 Exterior Walls				763,930
PHASE 1				
Allowance for exterior walls - Central Plant Building	1,934	m2	395.00	763,930
B2020 Exterior Windows				40,614
PHASE 1				
Allowance for exterior windows - Central Plant Building	1,934	m2	21.00	40,614
B2030 Exterior Doors				63,822
PHASE 1				
Allowance for exterior doors - Central Plant Building	1,934	m2	33.00	63,822
				868,366
B30 Roofing				
B3010 Roof Coverings				232,080
PHASE 1				
Allowance for roof coverings - Central Plant Building	1,934	m2	120.00	232,080

Item Description	Quantity	Unit	Rate	Total
B3020 Roof Openings				23,208
PHASE 1				
Allowance for roof openings - Central Plant Building	1,934	m2	12.00	23,208
				255,288
C10 Interior Construction				
C1010 Partitions				174,060
PHASE 1				
Allowance for internal walls - Central Plant Building	1,934	m2	90.00	174,060
C1020 Interior Doors				29,010
PHASE 1				
Allowance for interior doors - Central Plant Building	1,934	m2	15.00	29,010
C1030 Fittings				251,420
PHASE 1				
Miscellaneous metal, braces, lintels, pipe supports, and signages - Central Plant Building	1,934	m2	130.00	251,420
				454,490
C30 Interior Finishes				
C3010 Wall Finishes				96,700
PHASE 1				
Allowance for wall finishes (painting to concrete, block walls, and repairs - Central Plant Building	1,934	m2	50.00	96,700
C3020 Floor Finishes				186,040
PHASE 1				
Allowance for floor finishes (concrete hardener & sealer to floors, patch, and repairs - Central Plant Building	1,934	m2	60.00	116,040
Allowance for concrete plant bases - Central Plant Building	1	ls	70,000.00	70,000
C3030 Ceiling Finishes				58,020
PHASE 1				
Allowance for ceiling finishes (patching / repair only) - Central Plant Building	1,934	m2	30.00	58,020
				340,760
D20 Plumbing Systems				
D2020 Domestic Water Distribution				193,400
PHASE 1				

Item Description	Quantity	Unit	Rate	Total
Allowance for Plumbing fit-out to central plant building, including domestic water, sanitary, and rainwater installations	1,934	m2	100.00	193,400
				193,400
D30 Heating, Ventilation & Air Conditioning				
D3020 Heat Generating Systems				9,651,472
PHASE 1				
Electric Boilers - 5,000kW capacity	3	ea	1,370,000.00	4,110,000
Boiler Circulation Pumps	4	ea	60,000.00	240,000
LTHW Distribution Pumps	3	ea	110,000.00	330,000
Hot water supply and return primary and secondary piping, assume 400mm diameter, black steel pipe, assume length	300	m	2,400.00	720,480
Hot water supply and return primary and secondary piping, assume 200mm diameter, black steel pipe, assume length	237	m	1,000.00	236,600
Allowance or fittings	1	ls	380,000.00	380,000
Allowance for valves and miscellaneous equipment	1	ls	470,000.00	470,000
Insulation	537	m	270.00	144,936
PHASE 2				
Electric Boilers - 5,000kW capacity	2	ea	1,370,000.00	2,740,000
Boiler Circulation Pumps	2	ea	60,000.00	120,000
Hot water supply and return primary and secondary piping, assume 200mm diameter, black steel pipe, assume length	73	m	1,000.00	72,800
Allowance or fittings	1	ls	30,000.00	30,000
Allowance for valves and miscellaneous equipment	1	ls	37,000.00	37,000
Insulation	73	m	270.00	19,656
D3040 Distribution Systems				8,266,335
PHASE 1				
HVAC fit-out to central plant building, including controls.	1,934	m2	350.00	676,900
PHASE 1				
Allowance for new Energy Transfer Stations to the following buildings. Including heating piping from the building line district energy network connection, heat exchangers, valves, insulation, ancillary equipment, associated controls and testing / commissioning				
Building 1 - 3,428m2 / Peak Demand 942kw	3,428	m²	70.00	239,960
Building 2 - 8,330m2 / Peak Demand 281kw	8,330	m²	20.00	166,600
Building 3 - 1,513m2 / Peak Demand 176kw	1,513	m²	40.00	60,520
Building 4 - 3,700m2 / Peak Demand 484kw	3,700	m²	40.00	148,000
Building 5 - 17,408m2 / Peak Demand 535kw	17,408	m²	20.00	348,160
Building 6 - 3,296m2 / Peak Demand 128kw	3,296	m²	20.00	65,920
Building 7 - 2,792m2 / Peak Demand 972kw	2,792	m²	90.00	251,280
Building 8 - 6,145m2 / Peak Demand 543kw	6,145	m²	20.00	122,900

Item Description	Quantity	Unit	Rate	Total
Building 9 - 7,379m2 / Peak Demand 277kw	7,379	m^2	20.00	147,580
Building 10 - 4,572m2 / Peak Demand 368kw	4,572	m^2	30.00	137,160
Building 11 - 2,009m2	2,009	m^2	50.00	100,450
Building 12 - 1,692m2 / Peak Demand 195kw	1,692	m^2	30.00	50,760
Building 13 - 7,654m2 / Peak Demand 678kw	7,654	m^2	30.00	229,620
Building 14 - 9,257m2 / Peak Demand 1,203kw	9,257	m^2	40.00	370,280
Building 15 - 7,558m2 / Peak Demand 477kw	7,558	m^2	20.00	151,160
Building 16 - 7,598m2 / Peak Demand 259kw	7,598	m^2	20.00	151,960
Building 17 - 4,243m2 / Peak Demand 770kw (inc Bldg 18)	4,243	m^2	40.00	169,720
Building 18 - 1,711m2	1,711	m^2		*Inc*
Building 19 - 1,383m2 / Peak Demand 152kw	1,383	m^2	30.00	41,490
Building 20 - 8,041m2 / Peak Demand 877kw	8,041	m^2	30.00	241,230
Building 22 - 7,111m2 / Peak Demand 647kw	7,111	m^2	30.00	213,330
Building 23 - 2,655m2 / Peak Demand 297kw	2,655	m^2	30.00	79,650
Building 24 - 2,655m2 / Peak Demand 297kw	2,655	m^2	30.00	79,650
Building 25 - 1,944m2 / Peak Demand 266kw	1,944	m^2	40.00	77,760
Building 26 - 1,242m2 / Peak Demand 285kw	1,242	m^2	60.00	74,520
Building 27 - 3,839m2 / Peak Demand 575kw	3,839	m^2	40.00	153,560
Building 28 - 5,395m2 / Peak Demand 509kw	5,395	m^2	30.00	161,850
Building 29 - 5,395m2 / Peak Demand 509kw	5,395	m^2	30.00	161,850
Building 30 - 10,524m2 / Peak Demand 1,018kw	10,524	m^2	30.00	315,720
PHASE 2				
Allowance for new Energy Transfer Stations to the following buildings. Including heating piping from the building line district energy network connection, heat exchangers, valves, insulation, ancillary equipment, associated controls and testing / commissioning				
Building 34 - 25,190m2 / Peak Demand 2,943kw	25,190	m^2	30.00	755,700
Building 35 - Peak Demand 1,316kw - no area	1	ls	350,000.00	350,000
Building 36 - East Cost Credit Union - no area / peak load	1	ls	120,000.00	120,000
Building 37 - Canadian Tire - no area / peak load	1	ls	140,000.00	140,000
Building 38 - Microtel Inn & Suites - no area / peak load	1	ls	250,000.00	250,000
Building ## - Antigonish Town Hall - no area / peak load	1	ls	130,000.00	130,000
Building ## - Antigonish Town & County Library - no area / peak load	1	ls	130,000.00	130,000
Building ## - Antigonish Fire Hall - no area / peak load	1	ls	80,000.00	80,000
Building ## - BMO / Canada Post / Shoppers Drug Mart - no area / peak load	1	ls	120,000.00	120,000
PHASE 3				
Allowance for new Energy Transfer Stations to the following buildings. Including heating piping from the building line district energy network connection, heat exchangers, valves, insulation, ancillary equipment, associated controls and testing / commissioning				
Building 31 - 12,953m2 / Peak Demand 1,093kw	12,953	m^2	25.00	323,825
Building 32 - 7,860m2 / Peak Demand 833kw	7,860	m^2	30.00	235,800
Building 33 - 8,049m2 / Peak Demand 981kw	8,049	m^2	30.00	241,470

Item Description	Quantity	Unit	Rate	Total
Antigonish Arena - 500kw assumed - no area	1	ls	200,000.00	200,000
D3060 Controls and Instrumentation				600,000
PHASE 1				
Allowance for district heating system controls and instrumentation	1	ls	400,000.00	400,000
PHASE 2				
Allowance for district heating system controls and instrumentation	1	ls	200,000.00	200,000
D3070 Systems Testing & Balancing				200,000
PHASE 1				
Allowance for testing and commissioning	1	ls	150,000.00	150,000
PHASE 2				
Allowance for testing and commissioning	1	ls	50,000.00	50,000
				18,717,807
D40 Fire Protection				
D4010 Sprinklers				116,040
PHASE 1				
Sprinkler fit-out to central plant building, including distribution pipe and sprinklers only	1,934	m²	60.00	116,040
				116,040
D50 Electrical Lighting, Power & Communications				
D5010 Electrical Service & Distribution				1,386,800
PHASE 1				
Central Plant Building				
4.16kV, 3PH, 4W Switchgear (Assume 8-cells)	1	ea	631,000.00	631,000
4.16kV-600V 1000kVA Transformer	1	ea	140,000.00	140,000
600V-120/208V 300kVA Transformer	1	ea	63,000.00	63,000
1000A, 600V, 3PH, 4W Switchboard	1	ea	125,000.00	125,000
600V, 3PH, 4W Panel	4	ea	9,000.00	36,000
120/208V, 3PH, 4W Panel	4	ea	4,000.00	16,000
Feeders from 4.16KV Switchgear to 4.16KV-600V Transformer	1	ea	3,200.00	3,200
Feeders from 4.16KV Switchgear to mechanical panels	5	ea	6,000.00	30,000
4.16KV-600V transformer secondary feeder	1	ea	38,000.00	38,000
600V-208V/120V transformer primary feeder	1	ea	10,000.00	10,000
600V-208V/120V transformer secondary feeder	1	ea	45,000.00	45,000
Feeders from 600V Switchboard to distribution Panels	4	ea	6,400.00	25,600
Miscellaneous Feeders	1	ls	16,000.00	16,000

Item Description	Quantity	Unit	Rate	Total
Grounding System	1	ls	23,000.00	23,000
Cable trays c/w connectors, fittings, hardware's etc.	1	ls	24,000.00	24,000
PHASE 1				
<u>Power to District Energy Mechanical Equipment</u>				
Electric Boiler	3	ea	17,000.00	51,000
Pumps	7	ea	4,000.00	28,000
Miscellaneous electrical connections	1	ls	30,000.00	30,000
PHASE 2				
<u>Power to District Energy Mechanical Equipment</u>				
Electric Boiler	2	ea	17,000.00	34,000
Pumps	2	ea	4,000.00	8,000
Miscellaneous electrical connections	1	ls	10,000.00	10,000
D5020 Lighting & Branch Wiring				406,140
PHASE 1				
<u>Central Plant Building</u>				
Lighting System	1,934	m²	175.00	338,450
Devices	1,934	m²	35.00	67,690
D5030 Communications & Security				183,730
PHASE 1				
<u>Central Plant Building</u>				
Fire alarm system	1,934	m²	35.00	67,690
Communication system	1,934	m²	30.00	58,020
Security System	1,934	m²	30.00	58,020
D5090 Other Electrical Systems				386,450
PHASE 1				
<u>Central Plant Building</u>				
SCADA System	1,934	m²	110.00	212,740
Grounding System	1,934	m²	35.00	67,690
Lightning Protection	1,934	m²	30.00	58,020
Testing and Commissioning	1	ls	34,000.00	34,000
Co-ordination	1	ls	14,000.00	14,000
				2,363,120

Class 4 Estimate (Feasibility Study) R1 Sitework - Opt 2 - Electric Boilers LTHW Only Summary

Ref.	Description		%	TOTAL $
G10	Site Preparation		9%	5,443,240
G20	Site Improvements		9%	5,713,500
G30	Site Mechanical Utilities		48%	29,710,672
G40	Site Electrical Utilities		5%	2,888,000
G	Building Sitework		71%	43,755,412
SITE ELEMENTAL COST BEFORE CONTINGENCIES			71%	43,755,412
Z10	General Conditions	10.00%	7%	4,375,541
Z12	Contractor OH & Fee	5.00%	4%	2,406,548
Z13	Design Contingency	20.00%	16%	10,107,500
SITE ELEMENTAL COST INCLUDING CONTINGENCIES			98%	60,645,001
Z22	Bonds & Insurance	1.75%	2%	1,061,288
SITE CONSTRUCTION COST BEFORE ESCALATION			100%	61,706,289
Z30	Escalation	0.00%	0%	Excluded
RECOMMENDED CONSTRUCTION BUDGET - November, 2024			100%	61,706,289

Item Description	Quantity	Unit	Rate	Total
G10 Site Preparation				
G1010 Site Clearing				289,000
PHASE 1				
General Site				
Temporary hoarding and signage to staging and laydown areas	1	ls	25,000.00	25,000
Traffic Management including plan - allow	1	ls	25,000.00	25,000
Temporary access provisions to entrances and roadways - allow	1	ls	15,000.00	15,000
Reinstatement of hard and soft landscaping after work is complete - allow	1	ls	50,000.00	50,000
- Noise and vibration monitoring allow	1	ls	30,000.00	30,000
PHASE 2				
General Site				
Temporary hoarding and signage to staging and laydown areas	1	ls	12,000.00	12,000
Traffic Management including plan - allow	1	ls	12,000.00	12,000
Temporary access provisions to entrances and roadways - allow	1	ls	8,000.00	8,000
Reinstatement of hard and soft landscaping after work is complete - allow	1	ls	25,000.00	25,000
- Noise and vibration monitoring allow	1	ls	15,000.00	15,000
PHASE 3				
General Site				
Temporary hoarding and signage to staging and laydown areas	1	ls	12,000.00	12,000
Traffic Management including plan - allow	1	ls	12,000.00	12,000
Temporary access provisions to entrances and roadways - allow	1	ls	8,000.00	8,000
Reinstatement of hard and soft landscaping after work is complete - allow	1	ls	25,000.00	25,000
- Noise and vibration monitoring allow	1	ls	15,000.00	15,000
G1020 Site Demolition and Relocations				500,000
PHASE 1				
Allowance to isolate and abandon in place existing steam and condensate distribution	1	ls	$ 250,000.00	250,000
PHASE 2				
Allowance to isolate and abandon in place existing steam and condensate distribution	1	ls	$ 125,000.00	125,000
PHASE 3				
Allowance to isolate and abandon in place existing steam and condensate distribution	1	ls	$ 125,000.00	125,000
G1030 Site Earthwork				4,654,240
PHASE 1				
General Site				
- Trench Excavation	18,818	m³	40.00	752,720
- 4.0 MPa pipe bedding	2,167	m³	210.00	455,070
- Backfill Trench	12,000	m³	80.00	960,000
- Allowance for temporary shoring of excavations	1	ls	50,000.00	50,000
- Allowance for dewatering of excavations	1	ls	50,000.00	50,000

Item Description	Quantity	Unit	Rate	Total
- Allowance to protect existing utilities	1	ls	25,000.00	25,000
PHASE 2				
General Site				
- Trench Excavation	9,440	m³	40.00	377,600
- 4.0 MPa pipe bedding for roadway and grass	1,049	m³	210.00	220,290
- Backfill Trench	6,000	m³	80.00	480,000
- Allowance for temporary shoring of excavations	1	ls	25,000.00	25,000
- Allowance for dewatering of excavations	1	ls	25,000.00	25,000
- Allowance to protect existing utilities	1	ls	15,000.00	15,000
PHASE 3				
General Site				
- Trench Excavation	9,833	m³	40.00	393,320
- 4.0 MPa pipe bedding for roadway and grass	1,144	m³	210.00	240,240
- Backfill Trench	6,500	m³	80.00	520,000
- Allowance for temporary shoring of excavations	1	ls	25,000.00	25,000
- Allowance for dewatering of excavations	1	ls	25,000.00	25,000
- Allowance to protect existing utilities	1	ls	15,000.00	15,000
G1040 Hazardous Waste Remediation				
Assume not required				*Nil*
				5,443,240
G20 Site Improvements				
G2010 Roadways				5,713,500
PHASE 1				
Allowance for reinstatement of pavements, including sub-base, base and surfacing	9,409	m2	300.00	2,822,700
PHASE 2				
Allowance for reinstatement of pavements, including sub-base, base and surfacing	4,720	m2	300.00	1,416,000
PHASE 3				
Allowance for reinstatement of pavements, including sub-base, base and surfacing	4,916	m2	300.00	1,474,800
				5,713,500
G30 Site Mechanical Utilities				
G3010 Water Supply				50,000
Phase 1				
Allowance for new water supply to Central Plant Building	1	ls	50,000.00	50,000
G3020 Sanitary Sewer				50,000
Phase 1				

Item Description	Quantity	Unit	Rate	Total
Allowance for new sanitary sewer to Central Plant Building	1	ls	50,000.00	50,000
G3030 Storm Sewer				50,000
Phase 1				
Allowance for new storm sewer to Central Plant Building	1	ls	50,000.00	50,000
G3040 Heating Distribution				29,560,672
PHASE 1				
Logstor bonded single pipe, insulation series 2 (assumed)				
400mm dia pipe	5,328	m	$ 1,640.00	8,737,920
150mm dia pipe	770	m	$ 480.00	369,792
100mm dia pipe	2,237	m	$ 320.00	715,776
Allowance for fittings, joint kits, accessories and valves	1	ls	$ 4,100,000.00	4,100,000
Allowance for district heating pipeline non-destructive testing	1	ls	$ 200,000.00	200,000
Allowance for leak detection system	1	ls	$ 300,000.00	300,000
Allowance for testing and commissioning	1	ls	$ 140,000.00	140,000
Thermal Storage Tanks				
Thermal Storage Tank - 4850m3 20mx15.5m AWWA D110 Type III prestressed concrete tank, including standard safety/access appurtenances, internal tank diffusers piping system, external insulation finishing system and foundation allowance	1	ea	$ 5,700,000.00	5,700,000
PHASE 2				
Logstor bonded single pipe, insulation series 2 (assumed)				
250mm dia pipe	1,462	m	$ 950.00	1,388,520
200mm dia pipe	2,342	m	$ 850.00	1,991,040
100mm dia pipe	962	m	$ 320.00	307,968
Allowance for fittings, joint kits, accessories and valves	1	ls	$ 1,500,000.00	1,500,000
Allowance for district heating pipeline non-destructive testing	1	ls	$ 70,000.00	70,000
Allowance for leak detection system	1	ls	$ 120,000.00	120,000
Allowance for testing and commissioning	1	ls	$ 50,000.00	50,000
PHASE 3				
Logstor bonded single pipe, insulation series 2 (assumed)				
200mm dia pipe	626	m	$ 850.00	532,440
150mm dia pipe	2,141	m	$ 510.00	1,091,808
100mm dia pipe	2,954	m	$ 320.00	945,408
Allowance for fittings, joint kits, accessories and valves	1	ls	$ 1,100,000.00	1,100,000
Allowance for district heating pipeline non-destructive testing	1	ls	$ 60,000.00	60,000
Allowance for leak detection system	1	ls	$ 100,000.00	100,000
Allowance for testing and commissioning	1	ls	$ 40,000.00	40,000
				29,710,672
G40 Site Electrical Utilities				
G4010 Electrical Distribution				2,888,000
PHASE 1				

Item Description	Quantity	Unit	Rate	Total
15/12 MVA, 27.6kV - 4.16kV Transformers	2	ea	1,050,000.00	2,100,000
Pad mounted concrete	2	ea	7,000.00	14,000
Grounding, allow	2	ea	7,000.00	14,000
Bollards, allow	16	ea	1,500.00	24,000
Fencing, allow	1	ls	50,000.00	50,000
Feeder				
25KV incoming feeder to 27.6kV - 4.16kV Transformers	2	ea	103,000.00	206,000
15/12 MVA, 27.6kV - 4.16kV Transformers secondary feeders				
Duct Bank	2	ea	240,000.00	480,000
Cables - allow	60	m		*Included above*
Conduit, 8x103mm PVC, allow	60	m		*Included above*
Forming, reinforcing and concrete	17	m3		*Included above*
Allowance for excavation and backfill	122	m3		*Included above*
				2,888,000

Class 4 Estimate (Feasibility Study) R1 — Option 3 - Steam Electric Boilers Summary

Ref.	Description		%	TOTAL $
A10	Foundations		1%	280,200
A	Substructure		1%	280,200
B10	Superstructure		3%	747,200
B20	Exterior Enclosure		4%	838,732
B30	Roofing		1%	246,576
B	Shell		8%	1,832,508
C10	Interior Construction		2%	438,980
C30	Interior Finishes		1%	331,520
C	Interiors		3%	770,500
D20	Plumbing Systems		1%	186,800
D30	Heating, Ventilation & Air Conditioning		47%	10,642,702
D40	Fire Protection		0%	112,080
D50	Electrical Lighting, Power & Communications		10%	2,269,440
D	Services		58%	13,211,022
BUILDING ELEMENTAL COST BEFORE CONTINGENCIES			71%	16,094,230
Z10	General Conditions	10.00%	7%	1,609,423
Z12	Contractor OH & Fee	5.00%	4%	885,183
Z13	Design Contingency	20.00%	16%	3,717,767
BUILDING ELEMENTAL COST INCLUDING CONTINGENCIES			98%	22,306,603
Z22	Bonds & Insurance	1.75%	2%	390,366
BUILDING CONSTRUCTION COST BEFORE ESCALATION			100%	22,696,968
Z30	Escalation	0.00%	0%	Excluded
RECOMMENDED CONSTRUCTION BUDGET - November, 2024			100%	22,696,968

Item Description		Unit	Rate	Total
A10 Foundations				
A1010 Standard Foundations				112,080
PHASE 1				
Allowance for foundations - Central Plant Building	1,868	m2	60.00	112,080
A1030 Slab On Grade				168,120
PHASE 1				
Allowance for slab on grade - Central Plant Building	1,868	m2	90.00	168,120
				280,200
B10 Superstructure				
B1010 Floor Construction				224,160
PHASE 1				
Allowance for floor construction - Central Plant Building	1,868	m2	120.00	224,160
B1020 Roof Construction				523,040
PHASE 1				
Allowance for roof construction - Central Plant Building	1,868	m2	280.00	523,040
				747,200
B20 Exterior Enclosure				
B2010 Exterior Walls				737,860
PHASE 1				
Allowance for exterior walls - Central Plant Building	1,868	m2	395.00	737,860
B2020 Exterior Windows				39,228
PHASE 1				
Allowance for exterior windows - Central Plant Building	1,868	m2	21.00	39,228
B2030 Exterior Doors				61,644
PHASE 1				
Allowance for exterior doors - Central Plant Building	1,868	m2	33.00	61,644
				838,732
B30 Roofing				
B3010 Roof Coverings				224,160
PHASE 1				

Item Description		Unit	Rate	Total
Allowance for roof coverings - Central Plant Building	1,868	m2	120.00	224,160
B3020 Roof Openings				22,416
PHASE 1				
Allowance for roof openings - Central Plant Building	1,868	m2	12.00	22,416
				246,576
C10 Interior Construction				
C1010 Partitions				168,120
PHASE 1				
Allowance for internal walls - Central Plant Building	1,868	m2	90.00	168,120
C1020 Interior Doors				28,020
PHASE 1				
Allowance for interior doors - Central Plant Building	1,868	m2	15.00	28,020
C1030 Fittings				242,840
PHASE 1				
Miscellaneous metal, braces, lintels, pipe supports, and signages - Central Plant Building	1,868	m2	130.00	242,840
				438,980
C30 Interior Finishes				
C3010 Wall Finishes				93,400
PHASE 1				
Allowance for wall finishes (painting to concrete, block walls, and repairs - Central Plant Building	1,868	m2	50.00	93,400
C3020 Floor Finishes				182,080
PHASE 1				
Allowance for floor finishes (concrete hardener & sealer to floors, patch, and repairs - Central Plant Building	1,868	m2	60.00	112,080
Allowance for concrete plant bases - Central Plant Building	1	ls	70,000.00	70,000
C3030 Ceiling Finishes				56,040
PHASE 1				
Allowance for ceiling finishes (patching / repair only) - Central Plant Building	1,868	m2	30.00	56,040
				331,520
D20 Plumbing Systems				

Item Description		Unit	Rate	Total
D2020 Domestic Water Distribution				186,800
PHASE 1				
Allowance for Plumbing fit-out to central plant building, including domestic water, sanitary, and rainwater installations	1,868	m2	100.00	186,800
				186,800
D30 Heating, Ventilation & Air Conditioning				
D3020 Heat Generating Systems				9,388,902
PHASE 1				
Electric Steam Boilers - 10.96MW capacity	3	ea	2,660,000.00	7,980,000
Feedwater / Condensate Pumps, allowance	5	ea	60,000.00	300,000
Condensate Collecting Tank, allowance	1	ea	100,000.00	100,000
Deaerator, allowance	1	ea	140,000.00	140,000
Blowdown Tank, allowance	1	ea	40,000.00	40,000
Chemicals, allowance	1	ea	50,000.00	50,000
Softened Water, allowance	1	ea	50,000.00	50,000
Central plantroom steam / condensate piping, assume 450mm diameter, carbon steel pipe, assume length	72	m	2,700.00	193,050
Central plantroom steam / condensate piping, assume 300mm diameter, carbon steel pipe, assume length	16	m	1,600.00	24,960
Central plantroom steam / condensate piping, assume 250mm diameter, carbon steel pipe, assume length	35	m	1,300.00	45,630
Central plantroom steam / condensate piping, assume 200mm diameter, carbon steel pipe, assume length	88	m	1,000.00	88,400
Allowance or fittings	1	ls	140,000.00	140,000
Allowance for valves and miscellaneous equipment	1	ls	180,000.00	180,000
Insulation	211	m	270.00	56,862
D3040 Distribution Systems				653,800
PHASE 1				
HVAC fit-out to central plant building, including controls.	1,868	m2	350.00	653,800
D3060 Controls and Instrumentation				500,000
PHASE 1				
Allowance for district heating system controls and instrumentation	1	ls	500,000.00	500,000
D3070 Systems Testing & Balancing				100,000
PHASE 1				
Allowance for testing and commissioning	1	ls	100,000.00	100,000
				10,642,702
D40 Fire Protection				

Item Description		Unit	Rate	Total
D4010 Sprinklers				112,080
PHASE 1				
Sprinkler fit-out to central plant building, including distribution pipe and sprinklers only	1,868	m²	60.00	112,080
				112,080
D50 Electrical Lighting, Power & Communications				
D5010 Electrical Service & Distribution				1,324,800
PHASE 1				
Central Plant Building				
4.16kV, 3PH, 4W Switchgear (Assume 8-cells)	1	ea	631,000.00	631,000
4.16kV-600V 1000kVA Transformer	1	ea	140,000.00	140,000
600V-120/208V 300kVA Transformer	1	ea	63,000.00	63,000
1000A, 600V, 3PH, 4W Switchboard	1	ea	125,000.00	125,000
600V, 3PH, 4W Panel	4	ea	9,000.00	36,000
120/208V, 3PH, 4W Panel	4	ea	4,000.00	16,000
Feeders from 4.16KV Switchgear to 4.16KV-600V Transformer	1	ea	3,200.00	3,200
Feeders from 4.16KV Switchgear to mechanical panels	3	ea	6,000.00	18,000
4.16KV-600V transformer secondary feeder	1	ea	38,000.00	38,000
600V-208V/120V transformer primary feeder	1	ea	10,000.00	10,000
600V-208V/120V transformer secondary feeder	1	ea	45,000.00	45,000
Feeders from 600V Switchboard to distribution Panels	4	ea	6,400.00	25,600
Miscellaneous Feeders	1	ls	16,000.00	16,000
Grounding System	1	ls	23,000.00	23,000
Cable trays c/w connectors, fittings, hardware's etc.	1	ls	24,000.00	24,000
Power to District Energy Mechanical Equipment				
Electric Steam Boiler	3	ea	17,000.00	51,000
Pumps	5	ea	4,000.00	20,000
Miscellaneous electrical connections	1	ls	40,000.00	40,000
D5020 Lighting & Branch Wiring				392,280
PHASE 1				
Central Plant Building				
Lighting System	1,868	m²	175.00	326,900
Devices	1,868	m²	35.00	65,380
D5030 Communications & Security				177,460
PHASE 1				
Central Plant Building				
Fire alarm system	1,868	m²	35.00	65,380

Item Description		Unit	Rate	Total
Communication system	1,868	m²	30.00	56,040
Security System	1,868	m²	30.00	56,040
D5090 Other Electrical Systems				374,900
PHASE 1				
Central Plant Building				
SCADA System	1,868	m²	110.00	205,480
Grounding System	1,868	m²	35.00	65,380
Lightning Protection	1,868	m²	30.00	56,040
Testing and Commissioning	1	ls	34,000.00	34,000
Co-ordination	1	ls	14,000.00	14,000
				2,269,440

Ref.	Description		%	TOTAL $
G30	Site Mechanical Utilities		18%	950,000
G40	Site Electrical Utilities		53%	2,888,000
G	Building Sitework		71%	3,838,000
SITE ELEMENTAL COST BEFORE CONTINGENCIES			71%	3,838,000
Z10	General Conditions	10.00%	7%	383,800
Z12	Contractor OH & Fee	5.00%	4%	211,090
Z13	Design Contingency	20.00%	16%	886,578
SITE ELEMENTAL COST INCLUDING CONTINGENCIES			98%	5,319,468
Z22	Bonds & Insurance	1.75%	2%	93,091
SITE CONSTRUCTION COST BEFORE ESCALATION			100%	5,412,559
Z30	Escalation	0.00%	0%	Excluded
RECOMMENDED CONSTRUCTION BUDGET - November, 2024			100%	5,412,559

Item Description	Quantity	Unit	Rate	Total
G30 Site Mechanical Utilities				
G3010 Water Supply				50,000
Phase 1				
Allowance for new water supply to Central Plant Building	1	ls	50,000.00	50,000
G3020 Sanitary Sewer				50,000
Phase 1				
Allowance for new sanitary sewer to Central Plant Building	1	ls	50,000.00	50,000
G3030 Storm Sewer				50,000
Phase 1				
Allowance for new storm sewer to Central Plant Building	1	ls	50,000.00	50,000
G3040 Heating Distribution				800,000
Phase 1				
Allowance to connect central plant building steam distribution piping to existing steam site distribution, including associated civil works	1	ls	800,000.00	800,000
				950,000
G40 Site Electrical Utilities				
G4010 Electrical Distribution				2,888,000
PHASE 1				
15/12 MVA, 27.6kV - 4.16kV Transformers	2	ea	1,050,000.00	2,100,000
Pad mounted concrete	2	ea	7,000.00	14,000
Grounding, allow	2	ea	7,000.00	14,000
Bollards, allow	16	ea	1,500.00	24,000
Fencing, allow	1	ls	50,000.00	50,000
Feeder				
25KV incoming feeder to 27.6kV - 4.16kV Transformers	2	ea	103,000.00	206,000
15/12 MVA, 27.6kV - 4.16kV Transformers secondary feeders				
Duct Bank	2	ea	240,000.00	480,000
Cables - allow	60	m		*Included above*
Conduit, 8x103mm PVC, allow	60	m		*Included above*
Forming, reinforcing and concrete	17	m3		*Included above*
Allowance for excavation and backfill	122	m3		*Included above*
				2,888,000

F

OPERATION COST REPORT

Town of Antigonish Community District Energy
O&M Costing Mandate
V1

WSP

Project Number : ET.PED0.060.00.03

December 2024
ISO 9001:2015

EQUANS

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IMPORTANT

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1 Context

The Town of Antigonish (TOA), situated in northeastern Nova Scotia, serves as an economic hub and service centre for the surrounding rural communities. TOA operates its own municipal electricity utility (MEU), giving it a distinctive advantage in tackling the climate emergency. By investing in green infrastructure, TOA can support growing energy demands while maintaining affordable energy rates and mitigating risks associated with carbon pricing. The town has committed to becoming the first zero-carbon community in Canada by focusing on large scale electrification initiatives.

The town, in partnership with St. Francis Xavier University (St. FX), has proposed a Community District Energy System (CDES). This would allow St. FX to decommission its existing fuel oil-burning steam central heating system, which represents the single largest source of greenhouse gas (GHG) emissions in Antigonish. WSP was mandated to present a number of options for the design of the CDES.

WSP mandated Equans Services Inc (Equans) to analyze the Operations and Maintenance (O&M) costs of each option. With Equans' extensive District Energy, Central Utility Plant and Facility management experience, some information used for the analysis stems from documentation, while other information is based on industry experience and best practices. The results of said mandate are contained in this report.

The analyses are based on the following documents :

- Antigonish CP Sharc Selection REV1
- Antigonish Full Package R2
- Series of emails between Equans and WSP

Disclaimer

There are several methods of operating District Energy Systems, based on the operator's comfort level, autonomy, technical and operational experience, service level, vision, and output goals. The following report is based on scenarios where if Equans was operating the system. Therefore, costs are high level estimates and should be adjusted based on the actual operator's reality.

2 Life Cycle Costing and Phases

As the system shall be deployed in phases, a number of expansions shall take place over time. However, Equans does not have visibility on the timeline of said expansions. Therefore, all life cycle costing is based on a 20-year horizon. The reader can then extrapolate the cost of each phase, based on the most realistic expansion schedule. The choice of a 20-year timeline stems from the fact that most of the equipment proposed by WSP will have a life cycle of at least 20 years. Some of the equipment can have even more, such as 25 or 30 years, but using a 20-year comparison basis captures all of the proposed scenarios. The complete life cycle analysis is presented in Appendix A.

Disclaimer

The costing of life cycle elements is based on industry best practices, manufacturer recommendations and return on experience. Life cycle planning depends on how each equipment is maintained and operated. The assumption in this report is that all equipment is maintained and operated according to manufacturer recommendations. However, some, more complex assets, may show different results, such as compressors and controls infrastructure. The presented costs represent average case scenarios.

3 Option 1

3.1 Equipment

The Option 1 outlined in WSP's study proposes two (2) 10 MW heat pumps, with a future spot for an identical third. If York CYK chillers are installed, then they will utilize R513A refrigerant which is classified as A1. As the units will each have 10 MW of power on the condenser side, the prime mover, driving the compressor, will have a power of more than 1000 kW. According to the Nova Scotia Power Engineers Regulations (N.S. Reg. 12/2011) or the "Regulations", article 11, the plant will hold the rating of First Class. This means that a First Class Power Engineer must be identified as the Chief Power Engineer. However, the Power Engineers Chief Inspector may authorize periodic supervision, following articles 16 and 18, if the plant meets all requirements of a guarded plant, and if the plant and if all buildings serviced by the plant are unoccupied.

The Option 1 also proposes one (1) 5 MW electric Hot Water Boiler. As these will operate under the limit of 121°C, they are unregulated, per article 3 of the Regulations.

Phase 2 includes the addition of a third 10 MW heat pump, a district energy piping expansion, as well as a fourth LTHW circulating pump.

Phase 3 only includes a district energy piping expansion.

As O&M pricing is a high-level estimate, the actual cost between phases 1, 2 and 3 are negligeable. Therefore, only one (1) O&M costing scenario is presented. This is due to the fact that the main part component of the cost is the operations team and associated expenses, which is identical in all three (3) phases.

<u>Assumptions :</u>

- 40-60 Energy Transfer Stations;
- Approximately 2.5 kms of buried district energy LTHW piping in Phase 1;
- Approximately 5 kms of buried district energy LTHW piping in Phase 2;
- Approximately 7 kms of buried district energy LTHW piping in Phase 3;
- Extended warranty of five (5) years, purchased upon order on :
  - Boilers;
  - Heat Pumps;
- Standard warranty or other equipment;
- For comparison reasons, architectural and structural cost items are not included;
- For comparison reasons, housekeeping and pest control cost items are not included;
- For comparison reasons, fire life safety and security cost items are not included;
- All costs are presented in 2024 Canadian Dollars.

3.2 Staffing

In this scenario, the heat pumps obligate a continuous supervision under the Regulations. As it is assumed that the buildings serviced by the plant shall always be occupied, the Regulations will not allow for periodic supervision, per article 18.2.c. Therefore, Equans proposes that the plant be staffed 24/7, by a licensed Second Plant Power Engineer, under continuous supervision. The following operations team is proposed :

- Plant Chief Power Engineer, First Class Power Engineer, works as plant manager, Monday to Friday, on days;
- Four (4) Second Class Power Engineers, work as operators, on 12-hour shifts, on rotation (days, nights, weekdays and week-ends);
- One (1) Third Class Power Engineer, usually performs preventative maintenance and repairs, Monday to Friday, on days, also relieves on shifts, during absences of the operators (sick days, vacation, or authorizes leave);
- Partial resource for administrative support (20%)

<u>Direct Labour Costs :</u>

The direct cost associated to labour, include uniforms, benefits, premiums, IT equipment, PPEs and personal tools. The following cost is calculated under the scenario that a private third-party company would perform the O&M of the plant.

<u>In-house tasks</u>

Basic operator tasks should include the following :

- Plant monitoring and BMS operations;
- Bi-weekly chemical testing on closed loop systems;
- Equipment operations (Heat pumps, pumps, boilers, HVAC, etc…);
- Service calls;
- Light repairs and maintenance (Less than one (1) hour);
- Daily generator inspection (if equipped);
- Weekly generator testing (if equipped);
- Monthly generator testing (if equipped);
- Fuel management (for generator);
- Emergency response.

The Third Class Power Engineer should be focused on maintenance and repairs when not relieving operator absences. This should represent approximately half of his time. When on maintenance, his tasks should include :

- Pump preventative and predictive maintenance (lubrication and vibration analysis);
- Pump repairs;
- Belt replacements;

- Pulley replacement;
- General HVAC Maintenance;
- Light plumbing work;
- Light piping insulation;
- Lighting replacement;
- Painting;
- Cleaning;
- Instrumentation component replacement;
- Safety valve replacement;
- Pressure reducing valve repairs and replacement.

3.3 Subcontractors

Because of the small sized onsite team, there isn't sufficient manpower to conduct large maintenances. Also, some expertise is complex and is best given to experts, in Equans' experience, such as :

- Heat pumps (quarterly or monthly running inspection, annual maintenance, periodic condenser and evaporator tube brushing, Eddy current testing, refrigerant leak testing, repairs, emergency calls;
- Pump rebuilds;
- Motor rewinds;
- Periodic boiler inspection and cleaning;
- Other pressure vessel inspections;
- Hoisting and rigging preventative maintenance, inspection and repairs;
- Health and safety equipment inspection;
- Monthly chemical testing and consultation;
- Refrigerant monitor calibrations;
- Instrumentation and controls preventative maintenance and service calls;
- Generators (annual and semi-annual maintenances, service calls);
- Electrical (Infrared testing, preventative maintenance, service calls);
- Automatic Transfer Switches (ATS') (Preventative maintenance, services calls);
- UPS' and batteries (Preventative maintenance, services calls);
- Fuel delivery equipment inspections and preventative maintenance;
- Geothermal bores repairs;
- District Energy piping repairs;

3.4 Other Costs

The other costs include energy management, Computerized Maintenance Management system (CMMS), plant tooling, a service vehicle, a call center (for services calls), and office supplies.

3.5 O&M Costing Summary

Cost Item	Annual Cost
Direct Labour Costs	1,100,000 $
Preventative Maintenance, Repairs and Subcontractors	450,000 $
Other Costs	55,000 $
Total	1,605,000 $

4 Option 2

4.1 Equipment

The Option 2 proposes three (3) 5 MW electric Hot Water Boilers. As these will operate under the limit of 121°C, they are unregulated, per article 3 of the Regulations.

Phase 2 includes the addition of two (2) 5 MW electric Hot Water Boilers, a district energy piping expansion, as well as a fourth LTHW circulating pump.

Phase 3 only includes a district energy piping expansion.

Assumptions :

- 40-60 Energy Transfer Stations;
- Approximately 2.5 kms of buried district energy LTHW piping in Phase 1;
- Approximately 5 kms of buried district energy LTHW piping in Phase 2;
- Approximately 7 kms of buried district energy LTHW piping in Phase 3;
- Extended warranty of five (5) years, purchased upon order on :
    - Boilers;
- Standard warranty or other equipment;
- For comparison reasons, architectural and structural cost items are not included;
- For comparison reasons, housekeeping and pest control cost items are not included;
- For comparison reasons, fire life safety and security cost items are not included;
- All costs are presented in 2024 Canadian Dollars.

4.2 Staffing

In this scenario, there no legal obligation for staffing, under the Regulations. Therefore, several staffing configurations are possible, depending on the owner’s vision. Equans proposes the following team, per our experience managing plants of this size:

- Plant Chief Power Engineer, or Plant Manager, works Monday to Friday, on days;
- Two (2) operators, either on 12-hour shifts, on days only, on rotation (weekdays and week-ends), or on days, Monday to Friday;
- Partial resource for administrative support (20%)

However, as the plant shall be unattended, on nights and possibly weekends, the owner must have a remote monitoring system and have the capacity to respond to emergencies, outside of working hours.

Direct Labour Costs :

The direct cost associated to labour, include uniforms, benefits, premiums, IT equipment, PPEs and personal tools. The following cost is calculated under the scenario that a private third-party company would perform the O&M of the plant.

In-house tasks

Basic operator/maintenance tasks should include the following :

- Plant monitoring and BMS operations;
- Bi-weekly chemical testing on closed loop systems;
- Equipment operations (pumps, boilers, HVAC, etc…);
- Service calls;
- Light repairs and maintenance (Less than one (1) hour);
- Daily generator inspection (if equipped);
- Weekly generator testing (if equipped);
- Monthly generator testing (if equipped);
- Fuel management (for generator);
- Emergency response.
- Pump preventative and predictive maintenance (lubrication and vibration analysis);
- Pump repairs;
- Belt replacements;
- Pulley replacement;
- General HVAC Maintenance;
- Light plumbing work;
- Light piping insulation;
- Lighting replacement;
- Painting;
- Cleaning;
- Instrumentation component replacement;
- Safety valve replacement.

4.3 Subcontractors

Because of the small sized onsite team, there isn’t sufficient manpower to conduct large maintenances. Also, some expertise is complexe and is best given to experts, in Equans’ experience, such as :

- Pump rebuilds;
- Motor rewinds;
- Periodic boiler inspection and cleaning;
- Hoisting and rigging preventative maintenance, inspection and repairs;
- Health and safety equipment inspection;
- Monthly chemical testing and consultation;
- Refrigerant monitor calibrations;
- Instrumentation and controls preventative maintenance and service calls;
- Generators (annual and semi-annual maintenances, service calls);
- Electrical (Infrared testing, preventative maintenance, service calls);
- Automatic Transfer Switches (ATS’) (Preventative maintenance, services calls);
- UPS’ and batteries (Preventative maintenance, services calls);
- Fuel delivery equipment inspections and preventative maintenance;
- District Energy piping repairs.

4.4 Other Costs

The other costs include energy management, Computerized Maintenance Management system (CMMS), plant tooling, a service vehicle, a call center (for services calls), and office supplies.

4.5 O&M Costing Summary

Phase 1

Cost Item	Annual Cost
Direct Labour Costs	570,000 $
Preventative Maintenance, Repairs and Subcontractors	460,000 $
Other Costs	55,000 $
Total	1,085,000 $

Phase 1+2+3

Cost Item	Annual Cost
Direct Labour Costs	570,000 $
Preventative Maintenance, Repairs and Subcontractors	540,000 $
Other Costs	55,000 $
Total	1,165,000 $

5 Option 3

5.1 Equipment

The Option 3 outlined in WSP's study proposes three (3) 11 MW steam electric boilers. This scenario is proposed to showcase the closest option to "Status Quo". As the units will have a total power above 20 MW, according to the Regulations, article 11, the plant will hold the rating of First Class. This means that a First Class Power Engineer must be identified as the Chief Power Engineer.

Assumptions :

- 40 Steam Pressure Reducing Valves, one per building;
- Extended warranty of five (5) years, purchased upon order on :
  - Boilers;
- Standard warranty or other equipment;
- For comparison reasons, architectural and structural cost items are not included;
- For comparison reasons, housekeeping and pest control cost items are not included;
- For comparison reasons, fire life safety and security cost items are not included;
- All costs are presented in 2024 Canadian Dollars.

Pricing particularity for Option 3

This option consists of only boiler plant asset replacement, whereas Options 1 and 2 pricing include the entire LTHW distribution system, as well as the Energy Transfer Stations. In Option 3, the current operator must consider O&M and lifecycle costs associated with the existing steam and condensate piping network, as well as the existing Energy Transfer Stations (Pressure Reducing Valves). Equans has no visibility on the state of this infrastructure and cannot comment on lifespan nor life cycle costs.

5.2 Staffing

In this scenario, the Regulations obligate the plant to be under continuous supervision. Therefore, Equans proposes that the plant be staffed 24/7, by a licensed Second Plant Power Engineer, under continuous supervision. The following operations team is proposed :

- Plant Chief Power Engineer, First Class Power Engineer, works as plant manager, Monday to Friday, on days;
- Four (4) Second Class Power Engineers, work as operators, on 12-hour shifts, on rotation (days, nights, weekdays and week-ends);
- One (1) Third Class Power Engineer, usually performs preventative maintenance and repairs, Monday to Friday, on days, also relieves on shifts, during absences of the operators (sick days, vacation, or authorizes leave);
- Partial resource for administrative support (20%)

Direct Labour Costs :

The direct cost associated to labour, include uniforms, benefits, premiums, IT equipment, PPEs and personal tools. The following cost is calculated under the scenario that a private third-party company would perform the O&M of the plant.

In-house tasks

Basic operator tasks should include the following :

- Plant monitoring and BMS operations;
- Shift chemical testing on steam and condensate;
- Equipment operations (Heat pumps, pumps, boilers, HVAC, etc…);
- Service calls;
- Light repairs and maintenance (Less than one (1) hour);
- Daily generator inspection (if equipped);
- Weekly generator testing (if equipped);
- Monthly generator testing (if equipped);
- Fuel management;
- Emergency response.

The Third Class Power Engineer should be focused on maintenance and repairs when not relieving operator absences. This should represent approximately half of his time. When on maintenance, his tasks should include :

- Pump preventative and predictive maintenance (lubrication and vibration analysis);
- Pump repairs;
- Belt replacements;
- Pulley replacement;
- General HVAC Maintenance;
- Light plumbing work;
- Light piping insulation;
- Lighting replacement;
- Painting;
- Cleaning;
- Instrumentation component replacement;
- Safety valve replacement;
- Pressure reducing valve repairs and replacement.

5.3 Subcontractors

Because of the small sized onsite team, there isn't sufficient manpower to conduct large maintenances. Also, some expertise is complex and is best given to experts, in Equans' experience, such as :

- Boiler preventative maintenance;
- Pressure vessel periodic inspection (condensate tank, boilers, deaerator, etc…)
- Pump rebuilds;
- Motor rewinds;
- Periodic boiler inspection and cleaning;
- Hoisting and rigging preventative maintenance, inspection and repairs;
- Health and safety equipment inspection;
- Monthly chemical testing and consultation;
- Instrumentation and controls preventative maintenance and service calls;
- Generators (annual and semi-annual maintenances, service calls);
- Electrical (Infrared testing, preventative maintenance, service calls);
- Automatic Transfer Switches (ATS') (Preventative maintenance, services calls);
- UPS' and batteries (Preventative maintenance, services calls);
- Fuel delivery equipment inspections and preventative maintenance;
- District Energy piping repairs.

5.4 Other Costs

The other costs include energy management, Computerized Maintenance Management system (CMMS), plant tooling, a service vehicle, a call center (for services calls), and office supplies.

5.5 O&M Costing Summary

Cost Item	Annual Cost
Direct Labour Costs	1,100,000 $
Preventative Maintenance, Repairs and Subcontractors	650,000 $
Other Costs	55,000 $
Total	1,805,000 $

6 Waste Water Heat Recovery System

A 2MW wastewater heat recovery system is proposed, within the wastewater treatment plant, in Phase 2 of Options 1 and 2. The proposed setup is two (2) Sharc 880 units. These units essentially consist of a macerator, a plate-and-frame heat exchanger, as well as a controls system. The assumption is that this unit has a lifespan of at least 20 years, if operated and maintained properly.

Quarterly preventative maintenance is proposed which consists of sharpening the macerator blades, exchanger chemical cleaning in place, controls updates, general inspection and lubrication.

Maintenance and repairs for these units should not exceed 6,000 $ per year, per unit. The total operational cost of these units should be of approximately 12,000 $ per year, provided it is remotely operated by the plant operators.

There should be no significant life cycle costs associated with this equipment.

7 Computerized Maintenance Management System (CMMS)

The preventative maintenance, life cycle management and corrective maintenance should all be programmed in a CMMS. This should be a proven software and will require a considerable implementation cost, as well as recurring annual costs (licenses, modifications, upgrades, etc…). The CMMS should be properly programmed at this start and should offer predictive maintenance management, to properly manage equipment life cycle.

8 Consumables and Tooling

The CUP operator should plan for the following consumables, at a minimum :

- Chemicals for cooling towers;
- Chemicals for boilers and condensate;
- Chemicals for closed loop systems;
- Grease and other lubricants;
- Belts;
- Sensors, actuators, and other field controls components;
- Gauge glasses;
- Piping connections;
- Paint;
- Pipe Insulation;
- Chemical treatment and testing equipment;
- Combustible gas and refrigerant testing equipment;
- Pipe fitting tools;
- Instrumentation tools;
- Electrical diagnostic tools;
- Painting tools;
- Power Tools (handheld and stationary);
- Hand tools;
- Fasteners;
- Vibration analysis tool;
- Steam trap testing tool;
- Pump alignment tools;
- Health and safety equipment (fall prevention and arrest, confined space, working at heights, etc…);
- Hoisting and rigging equipment;
- Safety valves;
- Pressure reducing valves and components;
- Valving.

9 Documentation and Reporting

The management of a CUP requires a number of documents and reports that need to be drafted and kept updated, such as :

- Health and Safety Plan;
- Staffing Plan;
- Emergency Response Plan;
- Health and Safety Procedures (Between 5 and 20, depending on the complexity of the site);
- Corporate policies;
- Controls narratives;
- Operations Procedures;
- Preventative maintenance plans;
- Calibration reports;
- Inspections reports;
- Life Cycle management plans;
- Lock Out Tag Out Permitting database;
- Confined space permitting database;
- Etc…

10 Costing Summary

Phase 1

Option	Option 1	Option 2	Option 3
Annual O&M Cost	1,605,000 $	1,085,000 $	1,805,000 $
Life Cycle (20-year non-indexed)	3,300,000 $	3,300,000 $	2,700,000 $
Annual Life Cycle (non-indexed)	165,000 $	161,000 $	131,000 $
Wastewater HRS	0 $	0 $	0 $
Total Annual Cost	**1,770,000 $**	**1,246,000 $**	**1,936,000 $**

Phase 1+2

Option	Option 1	Option 2	Option 3
Annual O&M Cost	1,605,000 $	1,165,000 $	1,805,000 $
Life Cycle (20-year non-indexed)	4,200,000 $	4,400,000 $	2,700,000 $
Annual Life Cycle (non-indexed)	207,000 $	221,000 $	131,000 $
Wastewater HRS	12,000 $	12,000 $	0 $
Total Annual Cost	**1,824,000 $**	**1,398,000 $**	**1,936,000 $**

Phase 1+2+3

Option	Option 1	Option 2	Option 3
Annual O&M Cost	1,605,000 $	1,165,000 $	1,805,000 $
Life Cycle (20-year non-indexed)	4,600,000 $	4,900,000 $	2,700,000 $
Annual Life Cycle (non-indexed)	231,000 $	244,000 $	131,000 $
Wastewater HRS	12,000 $	12,000 $	0 $
Total Annual Cost	**1,848,000 $**	**1,421,000 $**	**1,936,000 $**

Prepared by :

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District Energy Director
Services Equans inc

Appendix A – Life Cycle Analysis

Appendix A
Life Cycle Analysis

Life Cycle Options Summary

		Phase 1		Phase 1+2		Phase 1+2+3	
		20-yr total	Annual Avg	20-yr total	Annual Avg	20-yr total	Annual Avg
OPT 1	Indexed	4,664,332 $	233,217 $	5,838,581 $	291,929 $	6,489,171 $	324,459 $
	Non-Indexed	3,300,000 $	165,000 $	4,142,000 $	207,100 $	4,612,000 $	230,600 $
OPT 2	Indexed	4,591,913 $	229,596 $	6,300,818 $	315,041 $	6,951,408 $	347,570 $
	Non-Indexed	3,224,000 $	161,200 $	4,415,000 $	220,750 $	4,885,000 $	244,250 $
OPT 3	Indexed	3,769,218 $	188,461 $	N/A			
	Non-Indexed	2,625,000 $	131,250 $				

Option 1 - Phase 1

(Indexed at 3% annual)

Item	Quantity	Unit	Frequency	Total LC work /unit	% Repair/ Replacement	Total LC work per instance	20-Year Total	Year 5	Year 6	Year 7
Plumbing - Pipe-fitting - Insulation	2.5	km	11	$ 200,000	100.00%	$ 500,000	$ 692,117	$ -	$ -	$ -
CYK Heatpump (10MW) - Overhaul	2	unit	11	$ 60,000	100.00%	$ 120,000	$ 166,108	$ -	$ -	$ -
CYK Heatpump (10MW) - Controls	2	unit	11	$ 50,000	100.00%	$ 100,000	$ 138,423	$ -	$ -	$ -
Energy Transfer Station	40	unit	11	$ 50,000	20.00%	$ 400,000	$ 553,694	$ -	$ -	$ -
BMS, instrumentation and controls (commercial grade)	1	unit	7	$ 300,000	100.00%	$ 300,000	$ 822,739	$ -	$ -	$ 368,962
Electrical	1	unit	8	$ 200,000	100.00%	$ 200,000	$ 574,295	$ -	$ -	$ -
VFDs	5	unit	8	$ 100,000	20.00%	$ 100,000	$ 287,148	$ -	$ -	$ -
Electric HW Boilers (5MW) - Element	180	unit	5	$ 2,500	5.00%	$ 22,500	$ 132,014	$ 26,084	$ -	$ -
Electric HW Boilers (5MW) - Controls	1	unit	14	$ 150,000	100.00%	$ 150,000	$ 226,888	$ -	$ -	$ -
Circulating Pump (100-125HP)	15	unit	5	$ 15,000	20.00%	$ 45,000	$ 264,027	$ 52,167	$ -	$ -
Filtration	1	unit	12	$ 20,000	100.00%	$ 20,000	$ 28,515	$ -	$ -	$ -
Chemical Treatment Equipment	1	unit	15	$ 40,000	100.00%	$ 40,000	$ 62,319	$ -	$ -	$ -
Pressurization & expansion tank system	1	unit	8	$ 50,000	100.00%	$ 50,000	$ 143,574	$ -	$ -	$ -
Lighting	1	unit	11	$ 50,000	100.00%	$ 50,000	$ 69,212	$ -	$ -	$ -
Control valves	20	unit	8	$ 50,000	10.00%	$ 100,000	$ 287,148	$ -	$ -	$ -
Manual valves	50	unit	6	$ 5,000	20.00%	$ 50,000	$ 216,112	$ -	$ 59,703	$ -
TOTAL				**$ 1,342,500**		**$ 2,247,500**	**$ 4,664,332**	**$ 78,251**	**$ 59,703**	**$ 368,962**

Year 8	Year 10	Year 11	Year 12	Year 14	Year 15	Year 16	Year 18	Year 20
$ -	$ -	$ 692,117	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ 166,108	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ 138,423	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ 553,694	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ 453,777	$ -	$ -	$ -	$ -
$ 253,354	$ -	$ -	$ -	$ -	$ -	$ 320,941	$ -	$ -
$ 126,677	$ -	$ -	$ -	$ -	$ -	$ 160,471	$ -	$ -
$ -	$ 30,238	$ -	$ -	$ -	$ 35,054	$ -	$ -	$ 40,638
$ -	$ -	$ -	$ -	$ 226,888	$ -	$ -	$ -	$ -
$ -	$ 60,476	$ -	$ -	$ -	$ 70,109	$ -	$ -	$ 81,275
$ -	$ -	$ -	$ 28,515	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ 62,319	$ -	$ -	$ -
$ 63,339	$ -	$ -	$ -	$ -	$ -	$ 80,235	$ -	$ -
$ -	$ -	$ 69,212	$ -	$ -	$ -	$ -	$ -	$ -
$ 126,677	$ -	$ -	$ -	$ -	$ -	$ 160,471	$ -	$ -
$ -	$ -	$ -	$ 71,288	$ -	$ -	$ -	$ 85,122	$ -
$ 570,047	**$ 90,714**	**$ 1,619,554**	**$ 99,803**	**$ 680,665**	**$ 167,481**	**$ 722,118**	**$ 85,122**	**$ 121,913**

Option 1 - Phase 1

Item	Quantity	Unit	Frequency	Total LC work /unit	% Repair/ Replacement	Total LC work per instance	20-Year Total	Year 5	Year 6	Year 7
Plumbing - Pipe-fitting - Insulation	2.5	km	11	$ 200,000	100.00%	$ 500,000	$ 500,000	$ -	$ -	$ -
CYK Heatpump (10MW) - Overhaul	2	unit	11	$ 60,000	100.00%	$ 120,000	$ 120,000	$ -	$ -	$ -
CYK Heatpump (10MW) - Controls	2	unit	11	$ 50,000	100.00%	$ 100,000	$ 100,000	$ -	$ -	$ -
Energy Transfer Station	40	unit	11	$ 50,000	20.00%	$ 400,000	$ 400,000	$ -	$ -	$ -
BMS, instrumentation and controls (commercial grade)	1	unit	7	$ 300,000	100.00%	$ 300,000	$ 600,000	$ -	$ -	$ 300,000
Electrical	1	unit	8	$ 200,000	100.00%	$ 200,000	$ 400,000	$ -	$ -	$ -
VFDs	5	unit	8	$ 100,000	20.00%	$ 100,000	$ 200,000	$ -	$ -	$ -
Electric HW Boilers (5MW) - Element	180	unit	5	$ 2,500	5.00%	$ 22,500	$ 90,000	$ 22,500	$ -	$ -
Electric HW Boilers (5MW) - Controls	1	unit	14	$ 150,000	100.00%	$ 150,000	$ 150,000	$ -	$ -	$ -
Circulating Pump (100-125HP)	15	unit	5	$ 15,000	20.00%	$ 45,000	$ 180,000	$ 45,000	$ -	$ -
Filtration	1	unit	12	$ 20,000	100.00%	$ 20,000	$ 20,000	$ -	$ -	$ -
Chemical Treatment Equipment	1	unit	15	$ 40,000	100.00%	$ 40,000	$ 40,000	$ -	$ -	$ -
Pressurization & expansion tank system	1	unit	8	$ 50,000	100.00%	$ 50,000	$ 100,000	$ -	$ -	$ -
Lighting	1	unit	11	$ 50,000	100.00%	$ 50,000	$ 50,000	$ -	$ -	$ -
Control valves	20	unit	8	$ 50,000	10.00%	$ 100,000	$ 200,000	$ -	$ -	$ -
Manual valves	50	unit	6	$ 5,000	20.00%	$ 50,000	$ 150,000	$ -	$ 50,000	$ -
TOTAL				**$ 1,342,500**		**$ 2,247,500**	**$ 3,300,000**	**$ 67,500**	**$ 50,000**	**$ 300,000**

Year 8	Year 10	Year 11	Year 12	Year 14	Year 15	Year 16	Year 18	Year 20
$ -	$ -	$ 500,000	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ 120,000	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ 100,000	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ 400,000	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ 300,000	$ -	$ -	$ -	$ -
$ 200,000	$ -	$ -	$ -	$ -	$ -	$ 200,000	$ -	$ -
$ 100,000	$ -	$ -	$ -	$ -	$ -	$ 100,000	$ -	$ -
$ -	$ 22,500	$ -	$ -	$ -	$ 22,500	$ -	$ -	$ 22,500
$ -	$ -	$ -	$ -	$ 150,000	$ -	$ -	$ -	$ -
$ -	$ 45,000	$ -	$ -	$ -	$ 45,000	$ -	$ -	$ 45,000
$ -	$ -	$ -	$ 20,000	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ 40,000	$ -	$ -	$ -
$ 50,000	$ -	$ -	$ -	$ -	$ -	$ 50,000	$ -	$ -
$ -	$ -	$ 50,000	$ -	$ -	$ -	$ -	$ -	$ -
$ 100,000	$ -	$ -	$ -	$ -	$ -	$ 100,000	$ -	$ -
$ -	$ -	$ -	$ 50,000	$ -	$ -	$ -	$ 50,000	$ -
$ 450,000	**$ 67,500**	**$ 1,170,000**	**$ 70,000**	**$ 450,000**	**$ 107,500**	**$ 450,000**	**$ 50,000**	**$ 67,500**

Option 1 - Phase 1 and 2

(Indexed at 3% annual)

Item	Quantity	Unit	Frequency	Total LC work /unit	% Repair/ Replacement	Total LC work per instance	20-Year Total	Year 5	Year 6
Plumbing - Pipe-fitting - Insulation	5	km	11	$ 200,000	100.00%	$ 1,000,000	$ 1,384,234	$ -	$ -
CYK Heatpump (10MW) - Overhaul	3	unit	11	$ 60,000	100.00%	$ 180,000	$ 249,162	$ -	$ -
CYK Heatpump (10MW) - Controls	3	unit	11	$ 50,000	100.00%	$ 150,000	$ 207,635	$ -	$ -
Energy Transfer Station	50	unit	11	$ 50,000	20.00%	$ 500,000	$ 692,117	$ -	$ -
BMS, instrumentation and controls (commercial grade)	1	unit	7	$ 300,000	100.00%	$ 300,000	$ 822,739	$ -	$ -
Electrical	1	unit	8	$ 200,000	100.00%	$ 200,000	$ 574,295	$ -	$ -
VFDs	6	unit	8	$ 100,000	20.00%	$ 120,000	$ 344,577	$ -	$ -
Electric HW Boilers (5MW) - Element	180	unit	5	$ 2,500	5.00%	$ 22,500	$ 132,014	$ 26,084	$ -
Electric HW Boilers (5MW) - Controls	1	unit	14	$ 150,000	100.00%	$ 150,000	$ 226,888	$ -	$ -
Circulating Pump (100-125HP)	20	unit	5	$ 15,000	20.00%	$ 60,000	$ 352,036	$ 69,556	$ -
Filtration	1	unit	12	$ 20,000	100.00%	$ 20,000	$ 28,515	$ -	$ -
Chemical Treatment Equipment	1	unit	15	$ 40,000	100.00%	$ 40,000	$ 62,319	$ -	$ -
Pressurization & expansion tank system	1	unit	8	$ 50,000	100.00%	$ 50,000	$ 143,574	$ -	$ -
Lighting	1	unit	11	$ 50,000	100.00%	$ 50,000	$ 69,212	$ -	$ -
Control valves	22	unit	8	$ 50,000	10.00%	$ 110,000	$ 315,862	$ -	$ -
Manual valves	54	unit	6	$ 5,000	20.00%	$ 54,000	$ 233,401	$ -	$ 64,479
TOTAL				**$ 1,342,500**		**$ 3,006,500**	**$ 5,838,581**	**$ 95,640**	**$ 64,479**

Year 7	Year 8	Year 10	Year 11	Year 12	Year 14	Year 15	Year 16	Year 18	Year 20
$ -	$ -	$ -	$ 1,384,234	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ 249,162	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ 207,635	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ 692,117	$ -	$ -	$ -	$ -	$ -	$ -
$ 368,962	$ -	$ -	$ -	$ -	$ 453,777	$ -	$ -	$ -	$ -
$ -	$ 253,354	$ -	$ -	$ -	$ -	$ -	$ 320,941	$ -	$ -
$ -	$ 152,012	$ -	$ -	$ -	$ -	$ -	$ 192,565	$ -	$ -
$ -	$ -	$ 30,238	$ -	$ -	$ -	$ 35,054	$ -	$ -	$ 40,638
$ -	$ -	$ -	$ -	$ -	$ 226,888	$ -	$ -	$ -	$ -
$ -	$ -	$ 80,635	$ -	$ -	$ -	$ 93,478	$ -	$ -	$ 108,367
$ -	$ -	$ -	$ -	$ 28,515	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ 62,319	$ -	$ -	$ -
$ -	$ 63,339	$ -	$ -	$ -	$ -	$ -	$ 80,235	$ -	$ -
$ -	$ -	$ -	$ 69,212	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ 139,345	$ -	$ -	$ -	$ -	$ -	$ 176,518	$ -	$ -
$ -	$ -	$ -	$ -	$ 76,991	$ -	$ -	$ -	$ 91,931	$ -
$ 368,962	**$ 608,050**	**$ 110,873**	**$ 2,602,360**	**$ 105,506**	**$ 680,665**	**$ 190,851**	**$ 770,259**	**$ 91,931**	**$ 149,004**

Option 1 - Phase 1 and 2

Item	Quantity	Unit	Frequency	Total LC work /unit	% Repair/ Replacement	Total LC work per instance	20-Year Total	Year 5	Year 6
Plumbing - Pipe-fitting - Insulation	5	km	11	$ 200,000	100.00%	$ 1,000,000	$ 1,000,000	$ -	$ -
CYK Heatpump (10MW) - Overhaul	3	unit	11	$ 60,000	100.00%	$ 180,000	$ 180,000	$ -	$ -
CYK Heatpump (10MW) - Controls	3	unit	11	$ 50,000	100.00%	$ 150,000	$ 150,000	$ -	$ -
Energy Transfer Station	50	unit	11	$ 50,000	20.00%	$ 500,000	$ 500,000	$ -	$ -
BMS, instrumentation and controls (commercial grade)	1	unit	7	$ 300,000	100.00%	$ 300,000	$ 600,000	$ -	$ -
Electrical	1	unit	8	$ 200,000	100.00%	$ 200,000	$ 400,000	$ -	$ -
VFDs	6	unit	8	$ 100,000	20.00%	$ 120,000	$ 240,000	$ -	$ -
Electric HW Boilers (5MW) - Element	180	unit	5	$ 2,500	5.00%	$ 22,500	$ 90,000	$ 22,500	$ -
Electric HW Boilers (5MW) - Controls	1	unit	14	$ 150,000	100.00%	$ 150,000	$ 150,000	$ -	$ -
Circulating Pump (100-125HP)	20	unit	5	$ 15,000	20.00%	$ 60,000	$ 240,000	$ 60,000	$ -
Filtration	1	unit	12	$ 20,000	100.00%	$ 20,000	$ 20,000	$ -	$ -
Chemical Treatment Equipment	1	unit	15	$ 40,000	100.00%	$ 40,000	$ 40,000	$ -	$ -
Pressurization & expansion tank system	1	unit	8	$ 50,000	100.00%	$ 50,000	$ 100,000	$ -	$ -
Lighting	1	unit	11	$ 50,000	100.00%	$ 50,000	$ 50,000	$ -	$ -
Control valves	22	unit	8	$ 50,000	10.00%	$ 110,000	$ 220,000	$ -	$ -
Manual valves	54	unit	6	$ 5,000	20.00%	$ 54,000	$ 162,000	$ -	$ 54,000
TOTAL				**$ 1,342,500**		**$ 3,006,500**	**$ 4,142,000**	**$ 82,500**	**$ 54,000**

Year 7	Year 8	Year 10	Year 11	Year 12	Year 14	Year 15	Year 16	Year 18	Year 20
$ -	$ -	$ -	$ 1,000,000	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ 180,000	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ 150,000	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ 500,000	$ -	$ -	$ -	$ -	$ -	$ -
$ 300,000	$ -	$ -	$ -	$ -	$ 300,000	$ -	$ -	$ -	$ -
$ -	$ 200,000	$ -	$ -	$ -	$ -	$ -	$ 200,000	$ -	$ -
$ -	$ 120,000	$ -	$ -	$ -	$ -	$ -	$ 120,000	$ -	$ -
$ -	$ -	$ 22,500	$ -	$ -	$ -	$ 22,500	$ -	$ -	$ 22,500
$ -	$ -	$ -	$ -	$ -	$ 150,000	$ -	$ -	$ -	$ -
$ -	$ -	$ 60,000	$ -	$ -	$ -	$ 60,000	$ -	$ -	$ 60,000
$ -	$ -	$ -	$ -	$ 20,000	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ 40,000	$ -	$ -	$ -
$ -	$ 50,000	$ -	$ -	$ -	$ -	$ -	$ 50,000	$ -	$ -
$ -	$ -	$ -	$ 50,000	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ 110,000	$ -	$ -	$ -	$ -	$ -	$ 110,000	$ -	$ -
$ -	$ -	$ -	$ -	$ 54,000	$ -	$ -	$ -	$ 54,000	$ -
$ 300,000	**$ 480,000**	**$ 82,500**	**$ 1,880,000**	**$ 74,000**	**$ 450,000**	**$ 122,500**	**$ 480,000**	**$ 54,000**	**$ 82,500**

Option 1 - Phase 1, 2 and 3

(Indexed at 3% annual)

Item	Quantity	Unit	Frequency	Total LC work /unit	% Repair/ Replacement	Total LC work per instance	20-Year Total	Year 5	Year 6
Plumbing - Pipe-fitting - Insulation	7	km	11	$ 200,000	100.00%	$ 1,400,000	$ 1,937,927	$ -	$ -
CYK Heatpump (10MW) - Overhaul	3	unit	11	$ 60,000	100.00%	$ 180,000	$ 249,162	$ -	$ -
CYK Heatpump (10MW) - Controls	3	unit	11	$ 50,000	100.00%	$ 150,000	$ 207,635	$ -	$ -
Energy Transfer Station	57	unit	11	$ 50,000	20.00%	$ 570,000	$ 789,013	$ -	$ -
BMS, instrumentation and controls (commercial grade)	1	unit	7	$ 300,000	100.00%	$ 300,000	$ 822,739	$ -	$ -
Electrical	1	unit	8	$ 200,000	100.00%	$ 200,000	$ 574,295	$ -	$ -
VFDs	6	unit	8	$ 100,000	20.00%	$ 120,000	$ 344,577	$ -	$ -
Electric HW Boilers (5MW) - Element	180	unit	5	$ 2,500	5.00%	$ 22,500	$ 132,014	$ 26,084	$ -
Electric HW Boilers (5MW) - Controls	1	unit	14	$ 150,000	100.00%	$ 150,000	$ 226,888	$ -	$ -
Circulating Pump (100-125HP)	20	unit	5	$ 15,000	20.00%	$ 60,000	$ 352,036	$ 69,556	$ -
Filtration	1	unit	12	$ 20,000	100.00%	$ 20,000	$ 28,515	$ -	$ -
Chemical Treatment Equipment	1	unit	15	$ 40,000	100.00%	$ 40,000	$ 62,319	$ -	$ -
Pressurization & expansion tank system	1	unit	8	$ 50,000	100.00%	$ 50,000	$ 143,574	$ -	$ -
Lighting	1	unit	11	$ 50,000	100.00%	$ 50,000	$ 69,212	$ -	$ -
Control valves	22	unit	8	$ 50,000	10.00%	$ 110,000	$ 315,862	$ -	$ -
Manual valves	54	unit	6	$ 5,000	20.00%	$ 54,000	$ 233,401	$ -	$ 64,479
TOTAL				**$ 1,342,500**		**$ 3,476,500**	**$ 6,489,171**	**$ 95,640**	**$ 64,479**

Year 7	Year 8	Year 10	Year 11	Year 12	Year 14	Year 15	Year 16	Year 18	Year 20
$ -	$ -	$ -	$ 1,937,927	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ 249,162	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ 207,635	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ 789,013	$ -	$ -	$ -	$ -	$ -	$ -
$ 368,962	$ -	$ -	$ -	$ -	$ 453,777	$ -	$ -	$ -	$ -
$ -	$ 253,354	$ -	$ -	$ -	$ -	$ -	$ 320,941	$ -	$ -
$ -	$ 152,012	$ -	$ -	$ -	$ -	$ -	$ 192,565	$ -	$ -
$ -	$ -	$ 30,238	$ -	$ -	$ -	$ 35,054	$ -	$ -	$ 40,638
$ -	$ -	$ -	$ -	$ -	$ 226,888	$ -	$ -	$ -	$ -
$ -	$ -	$ 80,635	$ -	$ -	$ -	$ 93,478	$ -	$ -	$ 108,367
$ -	$ -	$ -	$ -	$ 28,515	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ 62,319	$ -	$ -	$ -
$ -	$ 63,339	$ -	$ -	$ -	$ -	$ -	$ 80,235	$ -	$ -
$ -	$ -	$ -	$ 69,212	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ 139,345	$ -	$ -	$ -	$ -	$ -	$ 176,518	$ -	$ -
$ -	$ -	$ -	$ -	$ 76,991	$ -	$ -	$ -	$ 91,931	$ -
$ 368,962	**$ 608,050**	**$ 110,873**	**$ 3,252,950**	**$ 105,506**	**$ 680,665**	**$ 190,851**	**$ 770,259**	**$ 91,931**	**$ 149,004**

Option 1 - Phase 1, 2 and 3

Item	Quantity	Unit	Frequency	Total LC work /unit	% Repair/ Replacement	Total LC work per instance	20-Year Total	Year 5	Year 6
Plumbing - Pipe-fitting - Insulation	7	km	11	$ 200,000	100.00%	$ 1,400,000	$ 1,400,000	$ -	$ -
CYK Heatpump (10MW) - Overhaul	3	unit	11	$ 60,000	100.00%	$ 180,000	$ 180,000	$ -	$ -
CYK Heatpump (10MW) - Controls	3	unit	11	$ 50,000	100.00%	$ 150,000	$ 150,000	$ -	$ -
Energy Transfer Station	57	unit	11	$ 50,000	20.00%	$ 570,000	$ 570,000	$ -	$ -
BMS, instrumentation and controls (commercial grade)	1	unit	7	$ 300,000	100.00%	$ 300,000	$ 600,000	$ -	$ -
Electrical	1	unit	8	$ 200,000	100.00%	$ 200,000	$ 400,000	$ -	$ -
VFDs	6	unit	8	$ 100,000	20.00%	$ 120,000	$ 240,000	$ -	$ -
Electric HW Boilers (5MW) - Element	180	unit	5	$ 2,500	5.00%	$ 22,500	$ 90,000	$ 22,500	$ -
Electric HW Boilers (5MW) - Controls	1	unit	14	$ 150,000	100.00%	$ 150,000	$ 150,000	$ -	$ -
Circulating Pump (100-125HP)	20	unit	5	$ 15,000	20.00%	$ 60,000	$ 240,000	$ 60,000	$ -
Filtration	1	unit	12	$ 20,000	100.00%	$ 20,000	$ 20,000	$ -	$ -
Chemical Treatment Equipment	1	unit	15	$ 40,000	100.00%	$ 40,000	$ 40,000	$ -	$ -
Pressurization & expansion tank system	1	unit	8	$ 50,000	100.00%	$ 50,000	$ 100,000	$ -	$ -
Lighting	1	unit	11	$ 50,000	100.00%	$ 50,000	$ 50,000	$ -	$ -
Control valves	22	unit	8	$ 50,000	10.00%	$ 110,000	$ 220,000	$ -	$ -
Manual valves	54	unit	6	$ 5,000	20.00%	$ 54,000	$ 162,000	$ -	$ 54,000
TOTAL				**$ 1,342,500**		**$ 3,476,500**	**$ 4,612,000**	**$ 82,500**	**$ 54,000**

Appendix A
Life Cycle Analysis

Year 7	Year 8	Year 10	Year 11	Year 12	Year 14	Year 15	Year 16	Year 18	Year 20
$ -	$ -	$ -	$ 1,400,000	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ 180,000	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ 150,000	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ 570,000	$ -	$ -	$ -	$ -	$ -	$ -
$ 300,000	$ -	$ -	$ -	$ -	$ 300,000	$ -	$ -	$ -	$ -
$ -	$ 200,000	$ -	$ -	$ -	$ -	$ -	$ 200,000	$ -	$ -
$ -	$ 120,000	$ -	$ -	$ -	$ -	$ -	$ 120,000	$ -	$ -
$ -	$ -	$ 22,500	$ -	$ -	$ -	$ 22,500	$ -	$ -	$ 22,500
$ -	$ -	$ -	$ -	$ -	$ 150,000	$ -	$ -	$ -	$ -
$ -	$ -	$ 60,000	$ -	$ -	$ -	$ 60,000	$ -	$ -	$ 60,000
$ -	$ -	$ -	$ -	$ 20,000	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ 40,000	$ -	$ -	$ -
$ -	$ 50,000	$ -	$ -	$ -	$ -	$ -	$ 50,000	$ -	$ -
$ -	$ -	$ -	$ 50,000	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ 110,000	$ -	$ -	$ -	$ -	$ -	$ 110,000	$ -	$ -
$ -	$ -	$ -	$ -	$ 54,000	$ -	$ -	$ -	$ 54,000	$ -
$ 300,000	**$ 480,000**	**$ 82,500**	**$ 2,350,000**	**$ 74,000**	**$ 450,000**	**$ 122,500**	**$ 480,000**	**$ 54,000**	**$ 82,500**

Option 2 - Phase 1

(Indexed at 3% annual)

Item	Quantity	Unit	Frequency	Total LC work /unit	% Repair/ Replacement	Total LC work per instance	20-Year Total	Year 5	Year 6	Year 7
Plumbing - Pipe-fitting - Insulation	2.5	km	11	$ 200,000	100.00%	$ 500,000	$ 692,117	$ -	$ -	$ -
Energy Transfer Station	40	unit	11	$ 50,000	20.00%	$ 400,000	$ 553,694	$ -	$ -	$ -
BMS, instrumentation and controls (commercial grade)	1	unit	7	$ 300,000	100.00%	$ 300,000	$ 822,739	$ -	$ -	$ 368,962
Electrical	1	unit	8	$ 200,000	100.00%	$ 200,000	$ 574,295	$ -	$ -	$ -
VFDs	3	unit	8	$ 100,000	20.00%	$ 60,000	$ 172,289	$ -	$ -	$ -
Electric HW Boilers (5MW) - Element	540	unit	5	$ 2,500	5.00%	$ 67,500	$ 396,041	$ 78,251	$ -	$ -
Electric HW Boilers (5MW) - Controls	3	unit	14	$ 150,000	100.00%	$ 450,000	$ 680,665	$ -	$ -	$ -
Circulating Pump (100-125HP)	7	unit	5	$ 15,000	20.00%	$ 21,000	$ 123,213	$ 24,345	$ -	$ -
Filtration	1	unit	12	$ 20,000	100.00%	$ 20,000	$ 28,515	$ -	$ -	$ -
Chemical Treatment Equipment	1	unit	15	$ 40,000	100.00%	$ 40,000	$ 62,319	$ -	$ -	$ -
Pressurization & expansion tank system	1	unit	8	$ 50,000	100.00%	$ 50,000	$ 143,574	$ -	$ -	$ -
Lighting	1	unit	11	$ 50,000	100.00%	$ 50,000	$ 69,212	$ -	$ -	$ -
Control valves	10	unit	8	$ 50,000	10.00%	$ 50,000	$ 143,574	$ -	$ -	$ -
Manual valves	30	unit	6	$ 5,000	20.00%	$ 30,000	$ 129,667	$ -	$ 35,822	$ -
TOTAL				**$ 1,232,500**		**$ 2,238,500**	**$ 4,591,913**	**$ 102,596**	**$ 35,822**	**$ 368,962**

Year 8	Year 10	Year 11	Year 12	Year 14	Year 15	Year 16	Year 18	Year 20
$ -	$ -	$ 692,117	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ 553,694	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ 453,777	$ -	$ -	$ -	$ -
$ 253,354	$ -	$ -	$ -	$ -	$ -	$ 320,941	$ -	$ -
$ 76,006	$ -	$ -	$ -	$ -	$ -	$ 96,282	$ -	$ -
$ -	$ 90,714	$ -	$ -	$ -	$ 105,163	$ -	$ -	$ 121,913
$ -	$ -	$ -	$ -	$ 680,665	$ -	$ -	$ -	$ -
$ -	$ 28,222	$ -	$ -	$ -	$ 32,717	$ -	$ -	$ 37,928
$ -	$ -	$ -	$ 28,515	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ 62,319	$ -	$ -	$ -
$ 63,339	$ -	$ -	$ -	$ -	$ -	$ 80,235	$ -	$ -
$ -	$ -	$ 69,212	$ -	$ -	$ -	$ -	$ -	$ -
$ 63,339	$ -	$ -	$ -	$ -	$ -	$ 80,235	$ -	$ -
$ -	$ -	$ -	$ 42,773	$ -	$ -	$ -	$ 51,073	$ -
$ 456,037	**$ 118,937**	**$ 1,315,022**	**$ 71,288**	**$ 1,134,442**	**$ 200,199**	**$ 577,694**	**$ 51,073**	**$ 159,841**

Option 2 - Phase 1

Item	Quantity	Unit	Frequency	Total LC work /unit	% Repair/ Replacement	Total LC work per instance	20-Year Total	Year 5	Year 7	Year 8
Plumbing - Pipe-fitting - Insulation	2.5	km	11	$ 200,000	100.00%	$ 500,000	$ 500,000	$ -	$ -	$ -
Energy Transfer Station	40	unit	11	$ 50,000	20.00%	$ 400,000	$ 400,000	$ -	$ -	$ -
BMS, instrumentation and controls (commercial grade)	1	unit	7	$ 300,000	100.00%	$ 300,000	$ 600,000	$ -	$ 300,000	$ -
Electrical	1	unit	8	$ 200,000	100.00%	$ 200,000	$ 400,000	$ -	$ -	$ 200,000
VFDs	3	unit	8	$ 100,000	20.00%	$ 60,000	$ 120,000	$ -	$ -	$ 60,000
Electric HW Boilers (5MW) - Element	540	unit	5	$ 2,500	5.00%	$ 67,500	$ 270,000	$ 67,500	$ -	$ -
Electric HW Boilers (5MW) - Controls	3	unit	14	$ 150,000	100.00%	$ 450,000	$ 450,000	$ -	$ -	$ -
Circulating Pump (100-125HP)	7	unit	5	$ 15,000	20.00%	$ 21,000	$ 84,000	$ 21,000	$ -	$ -
Filtration	1	unit	12	$ 20,000	100.00%	$ 20,000	$ 20,000	$ -	$ -	$ -
Chemical Treatment Equipment	1	unit	15	$ 40,000	100.00%	$ 40,000	$ 40,000	$ -	$ -	$ -
Pressurization & expansion tank system	1	unit	8	$ 50,000	100.00%	$ 50,000	$ 100,000	$ -	$ -	$ 50,000
Lighting	1	unit	11	$ 50,000	100.00%	$ 50,000	$ 50,000	$ -	$ -	$ -
Control valves	10	unit	8	$ 50,000	10.00%	$ 50,000	$ 100,000	$ -	$ -	$ 50,000
Manual valves	30	unit	6	$ 5,000	20.00%	$ 30,000	$ 90,000	$ -	$ -	$ -
TOTAL				**$ 1,232,500**		**$ 2,238,500**	**$ 3,224,000**	**$ 88,500**	**$ 300,000**	**$ 360,000**

Year 10	Year 11	Year 12	Year 14	Year 15	Year 16	Year 18	Year 20
$ -	$ 500,000	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ 400,000	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ 300,000	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ 200,000	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ 60,000	$ -	$ -
$ 67,500	$ -	$ -	$ -	$ 67,500	$ -	$ -	$ 67,500
$ -	$ -	$ -	$ 450,000	$ -	$ -	$ -	$ -
$ 21,000	$ -	$ -	$ -	$ 21,000	$ -	$ -	$ 21,000
$ -	$ -	$ 20,000	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ 40,000	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ 50,000	$ -	$ -
$ -	$ 50,000	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ 50,000	$ -	$ -
$ -	$ -	$ 30,000	$ -	$ -	$ -	$ 30,000	$ -
$ 88,500	**$ 950,000**	**$ 50,000**	**$ 750,000**	**$ 128,500**	**$ 360,000**	**$ 30,000**	**$ 88,500**

Option 2 - Phase 1 and 2

(Indexed at 3% annual)

Item	Quantity	Unit	Frequency	Total LC work /unit	% Repair/ Replacement	Total LC work per instance	20-Year Total	Year 5	Year 6
Plumbing - Pipe-fitting - Insulation	5	km	11	$ 200,000	100.00%	$ 1,000,000	$ 1,384,234	$ -	$ -
Energy Transfer Station	50	unit	11	$ 50,000	20.00%	$ 500,000	$ 692,117	$ -	$ -
BMS, instrumentation and controls (commercial grade)	1	unit	7	$ 300,000	100.00%	$ 300,000	$ 822,739	$ -	$ -
Electrical	1	unit	8	$ 200,000	100.00%	$ 200,000	$ 574,295	$ -	$ -
VFDs	4	unit	8	$ 100,000	20.00%	$ 80,000	$ 229,718	$ -	$ -
Electric HW Boilers (5MW) - Element	900	unit	5	$ 2,500	5.00%	$ 112,500	$ 660,068	$ 130,418	$ -
Electric HW Boilers (5MW) - Controls	5	unit	14	$ 150,000	100.00%	$ 750,000	$ 1,134,442	$ -	$ -
Circulating Pump (100-125HP)	10	unit	5	$ 15,000	20.00%	$ 30,000	$ 176,018	$ 34,778	$ -
Filtration	1	unit	12	$ 20,000	100.00%	$ 20,000	$ 28,515	$ -	$ -
Chemical Treatment Equipment	1	unit	15	$ 40,000	100.00%	$ 40,000	$ 62,319	$ -	$ -
Pressurization & expansion tank system	1	unit	8	$ 50,000	100.00%	$ 50,000	$ 143,574	$ -	$ -
Lighting	1	unit	11	$ 50,000	100.00%	$ 50,000	$ 69,212	$ -	$ -
Control valves	12	unit	8	$ 50,000	10.00%	$ 60,000	$ 172,289	$ -	$ -
Manual valves	35	unit	6	$ 5,000	20.00%	$ 35,000	$ 151,279	$ -	$ 41,792
TOTAL				**$ 1,232,500**		**$ 3,227,500**	**$ 6,300,818**	**$ 165,197**	**$ 41,792**

Year 7	Year 8	Year 10	Year 11	Year 12	Year 14	Year 15	Year 16	Year 18	Year 20
$ -	$ -	$ -	$ 1,384,234	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ 692,117	$ -	$ -	$ -	$ -	$ -	$ -
$ 368,962	$ -	$ -	$ -	$ -	$ 453,777	$ -	$ -	$ -	$ -
$ -	$ 253,354	$ -	$ -	$ -	$ -	$ -	$ 320,941	$ -	$ -
$ -	$ 101,342	$ -	$ -	$ -	$ -	$ -	$ 128,377	$ -	$ -
$ -	$ -	$ 151,191	$ -	$ -	$ -	$ 175,271	$ -	$ -	$ 203,188
$ -	$ -	$ -	$ -	$ -	$ 1,134,442	$ -	$ -	$ -	$ -
$ -	$ -	$ 40,317	$ -	$ -	$ -	$ 46,739	$ -	$ -	$ 54,183
$ -	$ -	$ -	$ -	$ 28,515	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ 62,319	$ -	$ -	$ -
$ -	$ 63,339	$ -	$ -	$ -	$ -	$ -	$ 80,235	$ -	$ -
$ -	$ -	$ -	$ 69,212	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ 76,006	$ -	$ -	$ -	$ -	$ -	$ 96,282	$ -	$ -
$ -	$ -	$ -	$ -	$ 49,902	$ -	$ -	$ -	$ 59,585	$ -
$ 368,962	**$ 494,040**	**$ 191,508**	**$ 2,145,562**	**$ 78,417**	**$ 1,588,219**	**$ 284,329**	**$ 625,836**	**$ 59,585**	**$ 257,371**

Option 2 - Phase 1 and 2

Item	Quantity	Unit	Frequency	Total LC work /unit	% Repair/ Replacement	Total LC work per instance	20-Year Total	Year 5	Year 6	Year 7
Plumbing - Pipe-fitting - Insulation	5	km	11	$ 200,000	100.00%	$ 1,000,000	$ 1,000,000	$ -	$ -	$ -
Energy Transfer Station	50	unit	11	$ 50,000	20.00%	$ 500,000	$ 500,000	$ -	$ -	$ -
BMS, instrumentation and controls (commercial grade)	1	unit	7	$ 300,000	100.00%	$ 300,000	$ 600,000	$ -	$ -	$ 300,000
Electrical	1	unit	8	$ 200,000	100.00%	$ 200,000	$ 400,000	$ -	$ -	$ -
VFDs	4	unit	8	$ 100,000	20.00%	$ 80,000	$ 160,000	$ -	$ -	$ -
Electric HW Boilers (5MW) - Element	900	unit	5	$ 2,500	5.00%	$ 112,500	$ 450,000	$ 112,500	$ -	$ -
Electric HW Boilers (5MW) - Controls	5	unit	14	$ 150,000	100.00%	$ 750,000	$ 750,000	$ -	$ -	$ -
Circulating Pump (100-125HP)	10	unit	5	$ 15,000	20.00%	$ 30,000	$ 120,000	$ 30,000	$ -	$ -
Filtration	1	unit	12	$ 20,000	100.00%	$ 20,000	$ 20,000	$ -	$ -	$ -
Chemical Treatment Equipment	1	unit	15	$ 40,000	100.00%	$ 40,000	$ 40,000	$ -	$ -	$ -
Pressurization & expansion tank system	1	unit	8	$ 50,000	100.00%	$ 50,000	$ 100,000	$ -	$ -	$ -
Lighting	1	unit	11	$ 50,000	100.00%	$ 50,000	$ 50,000	$ -	$ -	$ -
Control valves	12	unit	8	$ 50,000	10.00%	$ 60,000	$ 120,000	$ -	$ -	$ -
Manual valves	35	unit	6	$ 5,000	20.00%	$ 35,000	$ 105,000	$ -	$ 35,000	$ -
TOTAL				**$ 1,232,500**		**$ 3,227,500**	**$ 4,415,000**	**$ 142,500**	**$ 35,000**	**$ 300,000**

Year 8	Year 10	Year 11	Year 12	Year 14	Year 15	Year 16	Year 18	Year 20
$ -	$ -	$ 1,000,000	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ 500,000	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ 300,000	$ -	$ -	$ -	$ -
$ 200,000	$ -	$ -	$ -	$ -	$ -	$ 200,000	$ -	$ -
$ 80,000	$ -	$ -	$ -	$ -	$ -	$ 80,000	$ -	$ -
$ -	$ 112,500	$ -	$ -	$ -	$ 112,500	$ -	$ -	$ 112,500
$ -	$ -	$ -	$ -	$ 750,000	$ -	$ -	$ -	$ -
$ -	$ 30,000	$ -	$ -	$ -	$ 30,000	$ -	$ -	$ 30,000
$ -	$ -	$ -	$ 20,000	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ 40,000	$ -	$ -	$ -
$ 50,000	$ -	$ -	$ -	$ -	$ -	$ 50,000	$ -	$ -
$ -	$ -	$ 50,000	$ -	$ -	$ -	$ -	$ -	$ -
$ 60,000	$ -	$ -	$ -	$ -	$ -	$ 60,000	$ -	$ -
$ -	$ -	$ -	$ 35,000	$ -	$ -	$ -	$ 35,000	$ -
$ 390,000	**$ 142,500**	**$ 1,550,000**	**$ 55,000**	**$ 1,050,000**	**$ 182,500**	**$ 390,000**	**$ 35,000**	**$ 142,500**

Option 2 - Phase 1, 2 and 3

(Indexed at 3% annual)

Item	Quantity	Unit	Frequency	Total LC work /unit	% Repair/ Replacement	Total LC work per instance	20-Year Total	Year 5	Year 6
Plumbing - Pipe-fitting - Insulation	7	km	11	$ 200,000	100.00%	$ 1,400,000	$ 1,937,927	$ -	$ -
Energy Transfer Station	57	unit	11	$ 50,000	20.00%	$ 570,000	$ 789,013	$ -	$ -
BMS, instrumentation and controls (commercial grade)	1	unit	7	$ 300,000	100.00%	$ 300,000	$ 822,739	$ -	$ -
Electrical	1	unit	8	$ 200,000	100.00%	$ 200,000	$ 574,295	$ -	$ -
VFDs	4	unit	8	$ 100,000	20.00%	$ 80,000	$ 229,718	$ -	$ -
Electric HW Boilers (5MW) - Element	900	unit	5	$ 2,500	5.00%	$ 112,500	$ 660,068	$ 130,418	$ -
Electric HW Boilers (5MW) - Controls	5	unit	14	$ 150,000	100.00%	$ 750,000	$ 1,134,442	$ -	$ -
Circulating Pump (100-125HP)	10	unit	5	$ 15,000	20.00%	$ 30,000	$ 176,018	$ 34,778	$ -
Filtration	1	unit	12	$ 20,000	100.00%	$ 20,000	$ 28,515	$ -	$ -
Chemical Treatment Equipment	1	unit	15	$ 40,000	100.00%	$ 40,000	$ 62,319	$ -	$ -
Pressurization & expansion tank system	1	unit	8	$ 50,000	100.00%	$ 50,000	$ 143,574	$ -	$ -
Lighting	1	unit	11	$ 50,000	100.00%	$ 50,000	$ 69,212	$ -	$ -
Control valves	12	unit	8	$ 50,000	10.00%	$ 60,000	$ 172,289	$ -	$ -
Manual valves	35	unit	6	$ 5,000	20.00%	$ 35,000	$ 151,279	$ -	$ 41,792
TOTAL				**$ 1,232,500**		**$ 3,697,500**	**$ 6,951,408**	**$ 165,197**	**$ 41,792**

Year 7	Year 8	Year 10	Year 11	Year 12	Year 14	Year 15	Year 16	Year 18	Year 20
$ -	$ -	$ -	$ 1,937,927	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ 789,013	$ -	$ -	$ -	$ -	$ -	$ -
$ 368,962	$ -	$ -	$ -	$ -	$ 453,777	$ -	$ -	$ -	$ -
$ -	$ 253,354	$ -	$ -	$ -	$ -	$ -	$ 320,941	$ -	$ -
$ -	$ 101,342	$ -	$ -	$ -	$ -	$ -	$ 128,377	$ -	$ -
$ -	$ -	$ 151,191	$ -	$ -	$ -	$ 175,271	$ -	$ -	$ 203,188
$ -	$ -	$ -	$ -	$ -	$ 1,134,442	$ -	$ -	$ -	$ -
$ -	$ -	$ 40,317	$ -	$ -	$ -	$ 46,739	$ -	$ -	$ 54,183
$ -	$ -	$ -	$ -	$ 28,515	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ 62,319	$ -	$ -	$ -
$ -	$ 63,339	$ -	$ -	$ -	$ -	$ -	$ 80,235	$ -	$ -
$ -	$ -	$ -	$ 69,212	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ 76,006	$ -	$ -	$ -	$ -	$ -	$ 96,282	$ -	$ -
$ -	$ -	$ -	$ -	$ 49,902	$ -	$ -	$ -	$ 59,585	$ -
$ 368,962	**$ 494,040**	**$ 191,508**	**$ 2,796,152**	**$ 78,417**	**$ 1,588,219**	**$ 284,329**	**$ 625,836**	**$ 59,585**	**$ 257,371**

Option 2 - Phase 1, 2 and 3

Item	Quantity	Unit	Frequency	Total LC work /unit	% Repair/ Replacement	Total LC work per instance	20-Year Total	Year 5	Year 6
Plumbing - Pipe-fitting - Insulation	7	km	11	$ 200,000	100.00%	$ 1,400,000	$ 1,400,000	$ -	$ -
Energy Transfer Station	57	unit	11	$ 50,000	20.00%	$ 570,000	$ 570,000	$ -	$ -
BMS, instrumentation and controls (commercial grade)	1	unit	7	$ 300,000	100.00%	$ 300,000	$ 600,000	$ -	$ -
Electrical	1	unit	8	$ 200,000	100.00%	$ 200,000	$ 400,000	$ -	$ -
VFDs	4	unit	8	$ 100,000	20.00%	$ 80,000	$ 160,000	$ -	$ -
Electric HW Boilers (5MW) - Element	900	unit	5	$ 2,500	5.00%	$ 112,500	$ 450,000	$ 112,500	$ -
Electric HW Boilers (5MW) - Controls	5	unit	14	$ 150,000	100.00%	$ 750,000	$ 750,000	$ -	$ -
Circulating Pump (100-125HP)	10	unit	5	$ 15,000	20.00%	$ 30,000	$ 120,000	$ 30,000	$ -
Filtration	1	unit	12	$ 20,000	100.00%	$ 20,000	$ 20,000	$ -	$ -
Chemical Treatment Equipment	1	unit	15	$ 40,000	100.00%	$ 40,000	$ 40,000	$ -	$ -
Pressurization & expansion tank system	1	unit	8	$ 50,000	100.00%	$ 50,000	$ 100,000	$ -	$ -
Lighting	1	unit	11	$ 50,000	100.00%	$ 50,000	$ 50,000	$ -	$ -
Control valves	12	unit	8	$ 50,000	10.00%	$ 60,000	$ 120,000	$ -	$ -
Manual valves	35	unit	6	$ 5,000	20.00%	$ 35,000	$ 105,000	$ -	$ 35,000
TOTAL				**$ 1,232,500**		**$ 3,697,500**	**$ 4,885,000**	**$ 142,500**	**$ 35,000**

Year 7	Year 8	Year 10	Year 11	Year 12	Year 14	Year 15	Year 16	Year 18	Year 20
$ -	$ -	$ -	$ 1,400,000	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ 570,000	$ -	$ -	$ -	$ -	$ -	$ -
$ 300,000	$ -	$ -	$ -	$ -	$ 300,000	$ -	$ -	$ -	$ -
$ -	$ 200,000	$ -	$ -	$ -	$ -	$ -	$ 200,000	$ -	$ -
$ -	$ 80,000	$ -	$ -	$ -	$ -	$ -	$ 80,000	$ -	$ -
$ -	$ -	$ 112,500	$ -	$ -	$ -	$ 112,500	$ -	$ -	$ 112,500
$ -	$ -	$ -	$ -	$ -	$ 750,000	$ -	$ -	$ -	$ -
$ -	$ -	$ 30,000	$ -	$ -	$ -	$ 30,000	$ -	$ -	$ 30,000
$ -	$ -	$ -	$ -	$ 20,000	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ 40,000	$ -	$ -	$ -
$ -	$ 50,000	$ -	$ -	$ -	$ -	$ -	$ 50,000	$ -	$ -
$ -	$ -	$ -	$ 50,000	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ 60,000	$ -	$ -	$ -	$ -	$ -	$ 60,000	$ -	$ -
$ -	$ -	$ -	$ -	$ 35,000	$ -	$ -	$ -	$ 35,000	$ -
$ 300,000	**$ 390,000**	**$ 142,500**	**$ 2,020,000**	**$ 55,000**	**$ 1,050,000**	**$ 182,500**	**$ 390,000**	**$ 35,000**	**$ 142,500**

Option 3

(Indexed at 3% annual)

Item	Quantity	Unit	Frequency	Total LC work /unit	% Repair/ Replacement	Total LC work per instance	20-Year Total	Year 4	Year 5	Year 6
Plumbing - Pipe-fitting - Insulation (WITHOUT DISTRIBUTION)	1	Unit	5	$ 20,000	100.00%	$ 20,000	$ 117,345	$ -	$ 23,185	$ -
BMS, instrumentation and controls (commercial grade)	1	unit	7	$ 300,000	100.00%	$ 300,000	$ 822,739	$ -	$ -	$ -
Electrical	1	unit	8	$ 200,000	100.00%	$ 200,000	$ 574,295	$ -	$ -	$ -
Electric Steam Boilers (11MW) - Element Bundle	3	unit	5	$ 250,000	5.00%	$ 37,500	$ 220,023	$ -	$ 43,473	$ -
Electric Steam Boilers (11MW) - Controls	1	Unit	9	$ 150,000	100.00%	$ 150,000	$ 451,081	$ -	$ -	$ -
Feedwater Pumps	3	unit	4	$ 25,000	100.00%	$ 75,000	$ 542,164	$ 84,413	$ -	$ -
Condensate Pumps	2	unit	5	$ 20,000	100.00%	$ 40,000	$ 234,691	$ -	$ 46,371	$ -
Filtration	1	unit	12	$ 20,000	100.00%	$ 20,000	$ 28,515	$ -	$ -	$ -
Chemical Treatment Equipment	1	unit	15	$ 40,000	100.00%	$ 40,000	$ 62,319	$ -	$ -	$ -
Pressurization & expansion tank system	1	unit	8	$ 50,000	100.00%	$ 50,000	$ 143,574	$ -	$ -	$ -
Lighting	1	unit	11	$ 50,000	100.00%	$ 50,000	$ 69,212	$ -	$ -	$ -
Control valves	10	unit	8	$ 50,000	20.00%	$ 100,000	$ 287,148	$ -	$ -	$ -
Manual valves	50	unit	6	$ 5,000	20.00%	$ 50,000	$ 216,112	$ -	$ -	$ 59,703
TOTAL				**$ 1,180,000**		**$ 1,132,500**	**$ 3,769,218**	**$ 84,413**	**$ 113,029**	**$ 59,703**

Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 14	Year 15	Year 16	Year 18	Year 20
$ -	$ -	$ -	$ 26,878	$ -	$ -	$ -	$ 31,159	$ -	$ -	$ 36,122
$ 368,962	$ -	$ -	$ -	$ -	$ -	$ 453,777	$ -	$ -	$ -	$ -
$ -	$ 253,354	$ -	$ -	$ -	$ -	$ -	$ -	$ 320,941	$ -	$ -
$ -	$ -	$ -	$ 50,397	$ -	$ -	$ -	$ 58,424	$ -	$ -	$ 67,729
$ -	$ -	$ 195,716	$ -	$ -	$ -	$ -	$ -	$ -	$ 255,365	$ -
$ -	$ 95,008	$ -	$ -	$ -	$ 106,932	$ -	$ -	$ 120,353	$ -	$ 135,458
$ -	$ -	$ -	$ 53,757	$ -	$ -	$ -	$ 62,319	$ -	$ -	$ 72,244
$ -	$ -	$ -	$ -	$ -	$ 28,515	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 62,319	$ -	$ -	$ -
$ -	$ 63,339	$ -	$ -	$ -	$ -	$ -	$ -	$ 80,235	$ -	$ -
$ -	$ -	$ -	$ -	$ 69,212	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ 126,677	$ -	$ -	$ -	$ -	$ -	$ -	$ 160,471	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ 71,288	$ -	$ -	$ -	$ 85,122	$ -
$ 368,962	**$ 538,377**	**$ 195,716**	**$ 131,032**	**$ 69,212**	**$ 206,735**	**$ 453,777**	**$ 214,221**	**$ 682,000**	**$ 340,487**	**$ 311,554**

Option 3

Item	Quantity	Unit	Frequency	Total LC work /unit	% Repair/ Replacement	Total LC work per instance	20-Year Total	Year 4	Year 5	Year 6
Plumbing - Pipe-fitting - Insulation (WITHOUT DISTRIBUTION)	1	Unit	5	$ 20,000	100.00%	$ 20,000	$ 80,000	$ -	$ 20,000	$ -
BMS, instrumentation and controls (commercial grade)	1	unit	7	$ 300,000	100.00%	$ 300,000	$ 600,000	$ -	$ -	$ -
Electrical	1	unit	8	$ 200,000	100.00%	$ 200,000	$ 400,000	$ -	$ -	$ -
Electric Steam Boilers (11MW) - Element Bundle	3	unit	5	$ 250,000	5.00%	$ 37,500	$ 150,000	$ -	$ 37,500	$ -
Electric Steam Boilers (11MW) - Controls	1	Unit	9	$ 150,000	100.00%	$ 150,000	$ 300,000	$ -	$ -	$ -
Feedwater Pumps	3	unit	4	$ 25,000	100.00%	$ 75,000	$ 375,000	$ 75,000	$ -	$ -
Condensate Pumps	2	unit	5	$ 20,000	100.00%	$ 40,000	$ 160,000	$ -	$ 40,000	$ -
Filtration	1	unit	12	$ 20,000	100.00%	$ 20,000	$ 20,000	$ -	$ -	$ -
Chemical Treatment Equipment	1	unit	15	$ 40,000	100.00%	$ 40,000	$ 40,000	$ -	$ -	$ -
Pressurization & expansion tank system	1	unit	8	$ 50,000	100.00%	$ 50,000	$ 100,000	$ -	$ -	$ -
Lighting	1	unit	11	$ 50,000	100.00%	$ 50,000	$ 50,000	$ -	$ -	$ -
Control valves	10	unit	8	$ 50,000	20.00%	$ 100,000	$ 200,000	$ -	$ -	$ -
Manual valves	50	unit	6	$ 5,000	20.00%	$ 50,000	$ 150,000	$ -	$ -	$ 50,000
TOTAL				**$ 1,180,000**		**$ 1,132,500**	**$ 2,625,000**	**$ 75,000**	**$ 97,500**	**$ 50,000**

Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 14	Year 15	Year 16	Year 18	Year 20
$ -	$ -	$ -	$ 20,000	$ -	$ -	$ -	$ 20,000	$ -	$ -	$ 20,000
$ 300,000	$ -	$ -	$ -	$ -	$ -	$ 300,000	$ -	$ -	$ -	$ -
$ -	$ 200,000	$ -	$ -	$ -	$ -	$ -	$ -	$ 200,000	$ -	$ -
$ -	$ -	$ -	$ 37,500	$ -	$ -	$ -	$ 37,500	$ -	$ -	$ 37,500
$ -	$ -	$ 150,000	$ -	$ -	$ -	$ -	$ -	$ -	$ 150,000	$ -
$ -	$ 75,000	$ -	$ -	$ -	$ 75,000	$ -	$ -	$ 75,000	$ -	$ 75,000
$ -	$ -	$ -	$ 40,000	$ -	$ -	$ -	$ 40,000	$ -	$ -	$ 40,000
$ -	$ -	$ -	$ -	$ -	$ 20,000	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 40,000	$ -	$ -	$ -
$ -	$ 50,000	$ -	$ -	$ -	$ -	$ -	$ -	$ 50,000	$ -	$ -
$ -	$ -	$ -	$ -	$ 50,000	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ 100,000	$ -	$ -	$ -	$ -	$ -	$ -	$ 100,000	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ 50,000	$ -	$ -	$ -	$ 50,000	$ -
$ 300,000	**$ 425,000**	**$ 150,000**	**$ 97,500**	**$ 50,000**	**$ 145,000**	**$ 300,000**	**$ 137,500**	**$ 425,000**	**$ 200,000**	**$ 172,500**