



City Centre District Energy Utility

Technical Requirements for Onsite Low-Carbon Energy Systems

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Figure 1: Three principal geoexchange subsystems (from GeoExchange BC, Professional Guidelines for Geoexchange Systems in British Columbia, 2014)	25
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Abbreviations

ASHP	Air-Source Heat Pump
BAS	Building Automation System
CCDEU	City Centre District Energy Utility
CEP	Central Energy Plant
DDC	Direct Digital Control
DES	District Energy System
DE	District Energy
Delta T; ΔT	Temperature Difference
DEU	District Energy Utility
DEP	District Energy Plant
DHW	Domestic Hot Water
DPS	Distribution Piping System
EMT	Electrometallic Tubing
ETS	Energy Transfer Station
FDC	Future DEU Connection
GFA	Gross Floor Area
GHG	Greenhouse Gas
GSHP	Ground-Source Heat Pump
HEX	Heat Exchanger
HMI	Human Machine Interface
HVAC	Heating, Ventilation & Air-Conditioning
LCES	Low-Carbon Energy System
LCEP	Low-Carbon Energy Plant
LIEC	Lulu Island Energy Company
MAU	Makeup Air Unit
MCC	Motor Control Centre
OAT	Outdoor Air Temperature
OI	Operator Interface
PCW	Primary Side Chilled Water
PHW	Primary Side Hot Water
PLC	Programmable Logic Controller
RTD	Resistive Temperature Detector
SC	Space Cooling
SH	Space Heating
SCW	Secondary Side Chilled Water
SEP	Standalone Energy Plant
SHW	Secondary Side Hot Water
SSHP	Sewage-Source Heat Pump
STES	Solar Thermal Energy System
UPS	Uninterrupted Power Supply
VFD	Variable-Frequency Drive

1 Document Purpose

The City of Richmond (City) is committed to sustainability and reduced environmental impact. To this end, the City is creating a new district energy service area in the City Centre neighbourhood. The new City Centre District Energy Utility (CCDEU) provides space heating, space cooling, and domestic hot water heating for buildings within the service area. The CCDEU be owned and operated by the City's wholly-owned subsidiary and district energy service provider Lulu Island Energy Company (LIEC).

Eventually, all buildings within the service area will be required to connect to the CCDEU to satisfy their thermal energy needs. To this end, the City requires that any new developments must be compatible with the CCDEU. Furthermore, as the CCDEU is being developed, an interim connection strategy is being implemented which involves use of a Low-Carbon Energy System (LCES) to satisfy all thermal energy demands for the development and allowance for a future connection to the CCDEU.

The purpose of this document is to outline the technical requirements and expectations regarding design and construction of a LCES. It is expected that the information presented in this document will be used by developers, building owners, engineers, and architects to tailor their designs for optimal compatibility with LIEC's requirements and the future CCDEU. This document shall be read in conjunction with the *City Centre District Energy Utility: A Guideline for On-Site Low-Carbon Energy Systems*, which gives a more general description of the overall Interim CCDEU strategy and responsibilities of all parties involved. LIEC will work closely with Developers and their design team throughout design and construction to ensure their design satisfies the intent of the Bylaw.

Note that this document is only intended as a guideline to clarify the minimum set of standards acceptable to LIEC. This guideline does not constitute a design, and the Developer's design team still carries sole responsibility for the design and construction of the LCES in accordance with all applicable laws, codes, standards, and industry best practice. In some cases, the Developer's proposed design may require more stringent requirements than what is outlined in this document, and it is the Developer's responsibility to ensure those requirements are satisfied.

In accordance with City of Richmond Bylaw 9895, it is essential that the Developers collaborate with LIEC on the LCES and Building (or Strata) mechanical systems as part of the Development Permit, Building Permit, and Construction processes.

2 Design Standards and References

2.1 Design Standards and References

Designs shall conform to all applicable regulations, codes, and design standards. For convenience, a number of applicable reference documents are listed below. The list should not be considered exhaustive. Compliance with codes, standards, and references not listed below, but required by law or best practice are still required. Unless noted otherwise, the most current edition of each reference shall be used.

2.1.1 General

1. British Columbia Building Code.
2. British Columbia Fire Code.
3. British Columbia Plumbing Code.
4. ASME Boiler and Pressure Vessel Code, Section VIII.
5. ASHRAE Handbooks: Refrigeration, Fundamentals, HVAC Systems and Equipment, HVAC Applications.
6. ASHRAE 62.1 Ventilation for Acceptable Indoor Air Quality.
7. ASHRAE 90.1 Energy Standard for Buildings Except Low-Rise Residential Buildings.
8. AWWA M14 Backflow Prevention and Cross-Contamination Control.
9. CSA A23.1 Concrete Materials and Methods of Concrete Construction.
10. CSA A23.2 Test Methods and Standard Practices for Concrete.
11. CSA A23.3 Design of Concrete Structures.
12. CSA B51 Boiler, Pressure Vessel, and Pressure Piping Code.
13. CSA B52 Mechanical Refrigeration Code.
14. CSA B149.1 Natural Gas and Propane Installation Code.
15. CEN – EN 1434-1 Heat Meters – Part 1: General Requirements.
16. CSA C900.1 Heat Meters – Part 1: General Requirements.
17. CSA G40.20 General Requirements for Rolled or Welded Structural Quality Steel.
18. CSA G40.21 Structural Quality Steel.
19. CSA O86 Engineering Design in Wood.
20. CSA S16 Design of Steel Structures.

21. CSA W47.1 Certification of Companies for Fusion Welding of Steel Structures.
22. CSA W48 Electrodes and Filler Metals Certification.
23. CSA W59-M Welded Steel Construction (Metal Arc Welding).
24. CSA W178.1 Welding Inspection Organizations Company Certifications.
25. CSA W178.2 Welding Inspector Certification.
26. NFPA 13 Standard for the Installation of Sprinkler Systems.
27. NFPA 214 Standard on Water-Cooling Towers.
28. NFPA 820 Standard for Fire Protection in Wastewater Treatment and Collection Facilities.
29. NSF 61 Drinking Water System Components.
30. NSF 372 Drinking Water Components – Lead Content.
31. SMACNA 006 HVAC Duct Construction Standards.
32. Workers Compensation Act; Occupational Health and Safety Regulation.
33. CSA CAN3-Z229 Quality Assurance Program.
34. CSA B149.2 Propane Storage and Handling Code.

2.1.2 Equipment

1. AHRI 370 Sound Performance Rating of Large Air-Cooled Outdoor Refrigerating and Air-Conditioning Equipment.
2. AHRI 550/590 Performance Rating of Water-Chilling and Heat Pump Water Heating Packages Using the Vapour Compression Cycle.
3. AHRI 575 Method of Measuring Machinery Sound Within Enclosure Space.
4. ASHRAE 15 Safety Standard for Refrigeration Systems.
5. ASHRAE 34 Designation and Classification of Refrigerants.
6. ASHRAE 147 Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment and Systems.
7. EPS 1/RA/2 Environmental Code of Practice for Elimination of Fluorocarbons Emissions from Refrigeration and Air Conditioning Systems.
8. HI - Hydraulic Institute Standards.
9. CSA B167 Overhead Cranes, Gantry Cranes, Monorails, Hoists, and Jib Cranes.

10. CSA B1967 CMAA Specification No. 70 Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Travelling Cranes.
11. CSA Z256-M87 Safety Code for Material Hoist.
12. GVRD Bylaw 1087 Boilers and Process Heaters Emission Regulation.
13. ANSI/NSF P453 Cooling Tower Water Systems – Treatment, Operation, and Maintenance to Prevent Legionella's.
14. CSA C448 Design and Installation of Earth Energy Systems.
15. Professional Guidelines for Geoeexchange Systems in British Columbia (Four Part Volume) – Geoeexchange BC.

2.1.3 Electrical

1. CSA C22.1 Canadian Electrical Code, Part 1, Safety Standard for Electrical Installations.
2. CSA C22.2 Canadian Electrical Code, Part 2, General Requirements.
3. CSA C22.2 No. 141 Emergency Lighting Equipment.
4. CSA C22.2 No. 236/ UL 1995 Heating and Cooling Equipment.
5. CAN3-C235-83 Preferred Voltage Levels for AC Systems, 0 to 50,000 V.
6. CSA Z462 Workplace Electrical Safety.
7. Electrical Contractor's Association of British Columbia: Seismic Restraint Manual, Guideline for Electrical Systems.

2.1.4 Piping & Fittings

1. ASME B31.1 Power Piping.
2. ASME B31.3 Process Piping.
3. ASME B31.5 Refrigeration Piping and Heat Transfer Components.
4. ASME B31.9 Building Services Piping.
5. ASME B1.20.1 Pipe Threads, General Purpose, Inch.
6. ASME B16.5 Standards for Pipes and Fittings.
7. ASME B16.9 Factory Made Wrought Butt-welding Fittings.
8. ASME B16.11 Forged Fittings, Socket-Welding and Threaded.
9. ASME B16.18 Cast Copper Alloy Solder Joints Pressure Fittings.
10. ASME B16.21 Non-metallic Flat Gaskets for Pipe Flanges.
11. ASME B16.22 Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.

12. ASME B16.26 Cast Copper Alloy Fittings for Flared Copper Tubes.
13. ASME B16.50 Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings.
14. ASME B32.1 Metal Products.
15. ASME B36.10 Welded and Seamless Wrought Steel Pipe.
16. CSA B242 Groove- and Shoulder-Type Mechanical Pipe Couplings.
17. EN 253 District Heating Pipes – Pre-insulated Bonded Pipe System for Directly Buried Hot Water Networks.
18. MSS SP-58 Pipe Hangers and Supports – Materials, Design, and Manufacture.
19. MSS SP-69 Pipe Hangers and Supports – Selection and Application.
20. MSS SP-77 Guidelines for Pipe Support Contractual Relationship.
21. MSS SP-89 Pipe Hangers and Supports – Fabrication and Installation Practices.
22. MSS SP-90 Guidelines on Terminology for Pipe Hangers and Supports.
23. MSS SP-127 Bracing for Piping Systems Seismic-Wind-Dynamic Design, Selection, and Application.
24. ASTM C547 Standard Specification for Mineral Fibre Pipe Insulation.

2.1.5 Valves

1. ASME B16.34 Valves Flanged, Threaded, and Welding End.
2. AWWA C508 Swing-Check Valves for Waterworks Service.
3. AWWA C511 Reduced Pressure Principle Backflow Prevention Assembly.
4. AWWA C515 Reduced-Wall, Resilient-Seated Gate Valves Water Supply Service.
5. AWWA C517 Resilient-Seated Cast-Iron Plug Valves.
6. AWWA C550 Protective Interior Coatings for Valves and Hydrants.
7. CSA B64 Backflow Preventers and Vacuum Breakers.
8. MSS SP-6 Standard Finishes for Contact Faces of Pipe Flanges of Valves and Fittings.
9. MSS SP-25 Standard Marking System for Valves, Fittings, Flanges and Unions.
10. MSS SP-42 Class 150 Corrosion Resistant Gate, Globe, Angle, and Check Valves with Flanged and Butt Weld Ends.

11. MSS SP-55 Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components.
12. MSS SP-61 Hydrostatic Testing of Steel Valves.
13. MSS SP-99 Instrument Valves.

3 General Requirements

3.1 Mechanical Room Requirements

1. Indoor spaces shall be climate controlled such that temperatures do not exceed 15 °C minimum or 35 °C maximum. Fresh air ventilation rates shall satisfy all regulatory and technical requirements. Refer to CSA B149.1, CSA B52, ASHRAE 62.1 and 90.1, and any other relevant standards. Outdoor spaces shall be provided with guardrails or equivalent such that fall arrest equipment is not required for routine operation and maintenance.
2. Spaces shall be illuminated in accordance with WorkSafeBC requirements, but not less than 150 lux. Provide adequate floor drains to facilitate typical operation and maintenance requirements. Sound levels at any location inside the plant shall not exceed 85 dBA during normal operation without prior written approval by LIEC. Provide adequate equipment isolation such that excessive noise and vibration is not transmitted to other portions of the building.
3. All spaces shall be included in the fire protection system for the base building including smoke/fire detection and fire suppression. The fire suppression system for the LCEP shall be a double interlock release type pre-action system. The base building fire alarm control panel shall communicate alarm status to the LCEP control panel. Refer to Section 5.5.1 for additional details.
4. Sound levels shall be attenuated to be in compliance with the City of Richmond Noise Regulation, Bylaw 8856.

3.2 Space Access Requirements

Adequate room for access to any piece of equipment for operation and maintenance, and the ability to remove an individual piece of equipment while maintaining operation of the plant (at a reduced capacity) is required. Access to space shall accommodate removal of largest component or piece of equipment that may have to be replaced through permanent access doors or hatches. Monorails may be required by LIEC depending on individual equipment accessibility.

4 Mechanical Equipment

4.1 General

This section identifies the minimum acceptable standards for major pieces of mechanical equipment.

4.1.1 Quality Assurance

1. All products shall be new, undamaged, and free from rust and defects.
2. All products of a similar nature shall be the product of a single manufacturer.
3. Rotating parts to be statically and dynamically balanced.
4. All equipment shall be CSA approved, or approved by other agency acceptable to Technical Safety BC (TSBC) including: CGA, ULC, ITS, ETL, cUL, cMET. The manufacturer shall have a representative for the equipment in the Greater Vancouver area, British Columbia.
5. The manufacturer shall have a minimum of ten (10) years' experience in fabrication of their supplied equipment with a quality assurance program approved by LIEC.
6. Equipment shall be hydrostatically tested, including submission of test report.
7. LIEC may require factory testing for select equipment.
8. ETL listed in accordance with UL Standard 1995, certified per CSA C22.2 No. 236 standard.
9. CSA C22.2 No. 0.4-17 Bonding of electrical equipment.

4.1.2 Warranty and Maintenance

1. All equipment shall be provided with a minimum one (1) year full parts and labour warranty starting from issuance of the Certificate of Acceptance. Extended parts only warranties are required for certain equipment as outlined in specific equipment sections below.
2. The equipment manufacturer must demonstrate that there is a local service organization qualified to service the equipment which shall:
 - i. have a well-equipped maintenance shop within the Greater Vancouver Area of British Columbia;
 - ii. be in existence long enough to have an established reputation with references for backup;
 - iii. have a number of qualified employees whose major commitment is to carry out service calls; and
 - iv. have commonly required spare parts in stock locally, or readily available.

4.1.3 Submittals

1. Manufacturer's specifications and technical data including partial performance data, materials of construction, methods of fabrication, and quality assurance program.
2. Wiring diagrams. Complete power and control schematics and wiring diagrams of the system.
3. Operation and Maintenance Manuals.
4. Testing, cleaning, and maintenance instructions.
5. Personnel operating instructions.
6. Maintenance materials list.
7. Parts list/Diagram.
8. Certified test reports indicating compliance with specified performance requirements.
9. Factory test procedures and test report.
10. Local Service Organization information, experience, and references.

4.1.4 Health & Safety

1. Safety power cut-off switch available at each equipment for maintenance lock-out.

4.2 Air-Source Heat Pumps and Chillers

This section outlines the requirements for air-source heat pumps and chillers.

4.2.1 Technical Requirements

1. Four-Pipe configuration designed for parallel flow of chilled and hot water piping with heat recovery capability.
2. Equipment and attachment to building designed to resist loads in accordance with the building code.
3. Minimum turndown of 15% without prior approval from LIEC.
4. Refrigerant type shall be in compliance with local regulatory requirements.
5. 316 stainless steel plate material, use a fouling factor in accordance to AHRI Guideline E.
6. Compressors shall include high discharge pressure and low suction pressure cut-outs.
7. The equipment shall be equipped with vibration isolators.
8. Capable of interfacing with plant automation system using BACnet communication protocols.

9. The equipment shall be provided with a sound dampened enclosure rated for outdoor service.
10. Engraved stainless-steel nameplate on each module.
11. Enclosure complete with access doors for access to all interior equipment, with adequate clearance in front of access doors to permit access. Adequate space for ladder access to fans and motors.
12. Heat pumps to meet local seismic and wind loading requirements.
13. Performance in accordance to AHRI 550/590 and ASHRAE 90.1 (Table 6.2.1B).
14. Min COP of 2.7 at heating only mode conditions (ambient of 10 °C and leaving condenser of 48.9 °C).
15. Min COP of 3.2 at cooling only mode conditions (ambient of 32 °C and leaving evaporator of 7.2 °C).
16. Min COP 7.5 [for heat recovery mode].
17. Typical schematic for an ASHP installation provided at end of document, refer to Figure 4.
18. A data sheet shall be provided which lists, as a minimum:
 - i. COP for heating only, cooling only, and heat recovery modes at different operation modes (including partial performance);
 - ii. Nominal, minimum, and maximum flows per unit with the corresponding pressure drops;
 - iii. Electrical power per motor;
 - iv. Sound levels, in 'dB', at 1.0 m away from the unit;
 - v. Equipment weight and dimensions;
 - vi. Minimum clearance requirements for operation and maintenance;
 - vii. Refrigerant type and weight; and
 - viii. Minimum turndown.
19. Units shall be supplied with certified test reports indicating compliance with specified performance for design operating conditions plus partial load performance at 25%, 50%, and 75% capacity with a constant condenser water temperature at design point.
20. Compressors shall include a minimum five (5) year parts only warranty.
21. The equipment shall have AHRI certification and have a CRN number registered with the local authority having jurisdiction.

4.2.2 Controls and Electrical

1. Heat pumps to include a standalone control panel that allows the optimization of individual modules/units to run in heating only mode, cooling only mode, and/or heat recovery mode.
2. Control panel shall allow remote connectivity to change set points and relay all available data and alarms generated by the heat pumps.
3. Inlet and outlet temperature sensors.
4. Differential pressure across inlet and outlet.
5. Refrigerant temperature.
6. High/low pressure alarms.
7. Integrated control panel system capable of staging modules to satisfy demands.

4.2.3 Standard of Acceptance

1. Trane (Multistack).
2. York (JCI).
3. Approved Equal.

4.3 Water-Source Heat Pumps and Chillers

This section outlines the requirements for water-source heat pumps and chillers.

4.3.1 Technical Requirements

1. Four-Pipe configuration designed for parallel flow of chilled and hot water piping with heat recovery capability.
2. Equipment and attachment to building designed to resist loads in accordance with the building code.
3. Minimum turndown of 15% without prior approval from LIEC.
4. Refrigerant type shall be in compliance with local regulatory requirements.
5. 316 stainless steel plate material, use a fouling factor in accordance to AHRI Guideline E.
6. Compressors shall include high discharge pressure and low suction pressure cut-outs.
7. The equipment shall be equipped with vibration isolators.
8. Capable of interfacing with plant automation system using BACnet communication protocols.
9. Engraved stainless-steel nameplate on each module.
10. Safety power cut-off switch available at each unit for maintenance lock-out.

11. Heat pumps to meet local seismic and wind loading requirements.
12. Performance in accordance to AHRI 550/590 and ASHRAE 90.1 (Table 6.2.1B).
13. Minimum COP of 4.5 at peak cooling conditions (ambient of 32 °C).
14. Minimum COP 7.5 for heat recovery mode.
15. Typical schematic for an ASHP installation provided at end of document, refer to Figure 4.
16. A data sheet shall be provided which lists, as a minimum:
 - i. COP for heating only, cooling only, and heat recovery modes;
 - ii. Nominal, minimum, and maximum flows per unit with the corresponding pressure drops;
 - iii. Electrical power per motor;
 - iv. Sound levels, in 'dB', at 1.0 m away from the unit;
 - v. Equipment weight and dimensions;
 - vi. Minimum clearance requirements for operation and maintenance;
 - vii. Refrigerant type and weight; and
 - viii. Minimum turndown.
17. Units shall be supplied with certified test reports indicating compliance with specified performance for design operating conditions plus partial load performance at 25%, 50%, and 75% capacity with a constant condenser water temperature at design point.
18. Compressors shall include a minimum five (5) year parts only warranty.
19. The equipment shall have AHRI certification and have a CRN number registered with the local authority having jurisdiction.

4.3.2 Controls and Electrical

1. Heat pumps to include a standalone control panel that allows the optimization of individual modules/units to run in heating only mode, cooling only mode, and/or heat recovery mode.
2. Control panel shall allow remote connectivity to change set points and relay all available data and alarms generated by the heat pumps.
3. Inlet and outlet temperature sensors.
4. Differential pressure across inlet and outlet.
5. Refrigerant temperature.

6. High/low pressure alarms.
7. Integrated control panel system capable of staging modules to satisfy demands.

4.3.3 Standard of Acceptance

1. Trane (Multistack).
2. Mitsubishi.
3. York.
4. Approved Equal.

4.4 Cooling Towers/Fluid Coolers

This section outlines the requirements for Cooling Towers/Fluid Coolers.

4.4.1 General

1. Cooling Towers/Fluid Coolers shall be designed, fabricated and tested in accordance to AHRI and CTI Standards.
2. Work shall be carried out only by qualified tradesmen.
3. Thermal performance of the fluid cooler shall confirm to CTI and minimum 8.46 m³/hr.kW efficiency per ASHRAE Standard 90.1.
4. Provide an induced-draft, cross flow or counter flow type, factory assembled, closed circuit, wet fluid cooler or cooling towers.
5. All products shall be new, undamaged and free from rust and defects.
6. Statically and dynamically balance rotating parts.
7. Structure to meet local BC seismic and wind loading conditions.
8. Construction shall permit complete servicing without breaking piping or motor connections.
9. Ladders and suitable access hatches shall be furnished to allow access to all components.
10. Maximum flame spread rating of 25.
11. Vibration isolation/vibration cut off switch.
12. Capable of interfacing with plant automation system using Modbus and BACnet communication protocol.
13. The equipment shall be provided with a sound dampened enclosure rated for outdoor service.
14. Engraved stainless-steel nameplate on each module.
15. Safety power cut-off switch available at each unit for maintenance lock-out.

16. A data sheet shall be provided listing, as a minimum, the following information:

- i. Efficiency at the design operating entering temperature;
- ii. Nominal, minimum, and maximum flows per unit with the corresponding pressure drops;
- iii. Electrical power information per motor;
- iv. Sound level, in 'dB', at 1.0 m away from the unit;
- v. Equipment weight and dimensions; and
- vi. Minimum clearance requirements for operation and maintenance.

17. Maximum sound levels to meet local jurisdictional requirements.

4.4.2 Coil

1. Fully welded box headers with serpentine tube circuits.
2. Hot dip galvanized as one unit after fabrication (copper may be approved with dielectric isolation).
3. Coil shall be designed to allow for free drainage of fluid.
4. Refer to Section 1.4 for design pressure and fluid characteristics.

4.4.3 Fan

1. Heavy duty, axial design.
2. Blades shall be aluminum alloy attached to a hot dip galvanized steel hub with U-bolts. Hubs shall be factory statically balanced.
3. Blades shall be individually adjustable.
4. Bearings shall be rated at L10A service life of 40,000 hours minimum.
5. Provide an air seal disc (cover) to prevent air circulation at the fan hub.

4.4.4 Fan Motor

1. NEMA Premium Efficiency TEFC.
2. Inverter Duty in accordance with NEMA MG-1 Part 31.
3. 1.15 service factor, variable torque, inverter duty and specially insulated for cooling, fluid cooler duty (Class F).
4. Speed and electrical characteristics shall be 1,800 rpm, single-winding, 3-phase, 60 hertz, 575 volts.
5. Motors shall operate in the shaft-vertical position and include a belt drive to fans. Nameplate power shall not be exceeded at design operation.

6. Motor shall be mounted out of the air stream.
7. The motor shall be controlled by a variable frequency drive where indicated.
8. Lubricate motor bearings with sight level oilers or grease fittings.
9. Provide stainless steel nameplate stating all ratings including bearing data.
10. Provide cable entry terminal box and ground lug on motor frame.
11. Class F insulation.

4.4.5 Belt Drive

- .1 The fan and fan drive assembly for each cell shall be supported by a rigid, galvanized steel structural support that resists misalignment.
- .2 The mechanical equipment assembly shall be warranted against any failure caused by defects in materials and workmanship for no less than five (5) years following the date of fluid cooler shipment. This warranty shall cover the fan(s), premium efficiency motor(s), drive shaft(s) and couplings, and the mechanical equipment support. Bearing assemblies and V-belts shall be warranted for 18 months.

4.4.6 Fan VFD

1. Provide a complete UL listed variable speed drive system in a NEMA 4 outdoor enclosure for fan control.
2. The VFD shall use PWM technology with IGBT switching. VFD out- put switching signal shall be programmed to not cause mechanical vibration issues with backlash in gearbox teeth or vibration issues associated with long drive shafts.
3. The VFD shall be programmed for variable torque applications and shall catch a fan spinning in the forward or reverse direction without tripping.
4. VFD panel construction shall include a main disconnect with short circuit and thermal overload protection with external operating handle, lockable in the off position for lock-out tag-out safety procedures.
5. A service switch directly ahead of the VFD shall be provided for voltage isolation during VFD maintenance.
6. An integrated full voltage non-reversing bypass starter shall be furnished allowing fan motor operation if VFD has failed.
7. The VFD system shall receive a speed reference signal from the building management system monitoring the fluid cooler cold-water temperature.
8. To prevent heating problems in the fan motor the VFD system shall de-energize the motor once 25% motor speed is reached (or as per manufacturer requirements) and cooling is no longer required.
9. The manufacturer shall supply VFD start-up assistance by a certified technician.

4.4.7 Vibration Limit Switch

1. Provide vibration limit switch for each cell.
2. Switch designed to shut down fan on excessive vibration.
3. Adjustable for sensitivity.
4. Remote manual reset; reset button to be located on fan deck, near the fan motor.
5. Double (DPDT) contact output.
6. NEMA 4 enclosure.

4.4.8 Fill

1. Film-type thermoformed of heavy-duty PVC.
2. Maximum air speed of 3.08 m/s.

4.4.9 Drift Eliminators

1. Design of drift eliminators shall limit drift loss to a maximum of 0.005% of the circulated water flow rate.
2. Cooling Tower design shall meet the drift eliminator manufacturer's requirements.
3. The maximum air velocity across the drift eliminators is limited to 3 m/s.
4. Eliminators to be fabricated from heavy duty PVC with a minimum of three (3) changes in air direction.
5. Flame spread rating of 25 or less.
6. Section is to be removable.

4.4.10 Inlet Louvers

1. Designed to minimize water splashing and eliminate direct sun light.
2. Coil air-inlet louvers shall be a minimum of 0'-5" air travel, triple-pass PVC to limit water splash out and prevent direct sunlight from entering the collection basin.
3. PVC louvers shall be easily removable for access to the coil(s).
4. Louvers with less than three changes in air direction are unacceptable.
5. Maximum air inlet speed of 4 m/s.

4.4.11 Pumps and Motor (water recirculation for fluid coolers only)

1. Select pumps to meet the final intended use meeting the specifications here in.
2. Provide lifting hooks on all equipment.
3. 600 V / 3-phase / 60 Hz.

4.4.12 Water Level Control

1. Provide a water level control system including a NEMA 4X control panel, water level probes and probe stilling chamber. The control system shall monitor the water level in the cold-water basin to determine level events used for cold-water make-up, high and low alarms and/or pump shut down. The control panel shall use electromechanical relays providing power for the make-up solenoid and electrical contacts for alarm and pump shutdown control circuits. Probes shall be contained in a vertical stilling chamber to stabilize the water in the cold-water basin. Probes shall have replaceable stainless-steel tips and level height shall be field-adjustable.

4.4.13 Nameplate

Each fluid cooler unit shall have a stainless-steel nameplate located in an easily visible location near floor level. The nameplate shall include at least the following data:

1. Manufacturer's name.
2. Year of manufacture.
3. Model number.
4. Serial number.
5. Rated capacity.
6. Nominal flows.

4.4.14 Controls and Electrical

1. Each cell of the Cooling Tower or the fluid cooler shall be equipped with a UL/CUL 508 listed control panel in a NEMA 4 outdoor enclosure designed specifically for this application.
2. The panel shall include a main thermal magnetic circuit breaker disconnect with an external operating handle, lockable in the off position for safety.
3. For spray pump operation use of a full voltage non-reversing magnetic starter with manual ON and OFF control via a door mounted selector switch shall be provided.
4. Dry status contacts wired to user terminal points indicating typical alarm and status events shall be provided.
5. Two safety circuits for the spray pump, low water cut off preventing a dry run pump and a pump shut down upon approaching freezing temperatures in the cold-water basin shall be provided.
6. Available Options to be included: Water level control with various combinations of make-up, high alarm, low alarm, high cut off and low cut-off events.
7. Power for damper actuator motor.

4.4.15 Freeze Protection

1. Basin heater controller with low water cut out: The system shall consist of one or more stainless-steel electric immersion heaters installed in threaded couplings provided in the side of the basin. A NEMA 4 enclosure shall house a magnetic contactor to energize heaters; a transformer to provide 24-volt control circuit power; and a solid-state circuit board for temperature and low water cut-off. Other freeze protection subject to LIEC approval.
2. A control probe shall be located in the basin to monitor water level and temperature. The system shall be capable of maintaining 4 °C water temperature at an ambient air temperature of -9 °C.
3. Spray pump heat trace circuit: Recirculating pump(s) shall be fitted with heat trace cable and insulated.

4.4.16 Preapproved Manufacturers

1. BAC.
2. SPX.
3. Approved Equal.

4.5 Boilers

This section outlines the requirements for Boilers.

4.5.1 General

1. Design, materials, and workmanship of the boiler, including the various accessories furnished herewith, shall fully comply with the requirements of the latest editions of all Federal, Provincial and Municipal laws, codes, and regulations.
2. The following listed standards and codes shall govern design and selection of equipment and material supplied:
 - American Boiler Manufacturer Association ABMA
 - American Institute for Steel Construction AISC
 - American Iron and Steel Institute AISI
 - American National Standards Institute ANSI
 - American Society for Testing and Materials ASTM
 - American Society of Heating, Refrigerating and Air Conditioning Engineers ASHRAE
 - American Society of Mechanical Engineers ASME
 - American Welding Society AWS
 - Technical Safety British Columbia TSBC
 - National Building Code of Canada NBC
 - Canadian Electrical Code CEC

- Canadian Standards Association:
 - Boiler, Pressure Vessel and Pressure Piping Code CSA B51-03
 - Natural Gas and Propane Installation Code CSA B149.1
 - Propane Storage and Handling Code CSA B149.2
 - Quality Assurance CSA Z299
 - Instrument Society of America ISA
 - National Electric Manufacturers Association NEMA
 - National Fire Protection Association NFPA
 - Occupational Health and Safety Authority OHSA
 - Steel Structure Painting Council SSPC
3. The boilers shall be natural gas fired, fully condensing, and be capable of at least a 10:1 turn-down ratio. The boiler shall have a Canadian Registration Number (CRN) valid for British Columbia and be compliant with both CSA B51 and ASME Section IV.
 4. Furnished with ASME boiler safety pressure relief valve, drain and vent valve, non-return valve, feed water control valve, condensate trap, and condensate neutralizer.
 5. A data sheet shall be provided listing, as a minimum, the following information:
 - i. Efficiency at the design operating entering temperature;
 - ii. Efficiency at 25%, 50%, 75% and 100% firing rate;
 - iii. Nominal, minimum, and maximum flows per unit with the corresponding pressure drops;
 - iv. Electrical power information per motor;
 - v. Sound level, in 'dB', at 1.0 meter away from the unit;
 - vi. Equipment weight and dimensions; and
 - vii. Minimum clearance requirements for operation and maintenance.
 6. The pressure vessel and heat exchanger shall carry a ten (10) year, prorated, limited warranty against any failure due to condensate corrosion, thermal stress, mechanical defects, or workmanship.

4.5.2 Burner

1. Exhaust gas emissions must comply with Metro Vancouver Boilers and Process Heaters Emission Regulation Bylaw No. 1087.
2. The burner shall be complete with all necessary accessories, including but not limited to the following:
 - i. Windbox.
 - ii. Igniter.

- iii. Pre-piped pilot fuel train.
- iv. Main fuel piping train pre-piped and skid mounted.

4.5.3 Burner Management System

1. The burner management and flame safeguard system shall comply with the latest regulations of IRI and shall be fully tested and operationally sound prior to shipment.
2. The system shall include automatic burner sequencing, flame supervision, status indication, first-out annunciation, and self-diagnosis.
3. The main flame scanner shall be an IR, auto-checking scanner. Provide a flame signal strength meter to measure the input signal to the scanner.
4. The system shall provide the following minimum functions:
 - i. Purge the Boiler volume a minimum of four times with controls at high fire.
 - ii. Prove all controls returned to low fire position for light-off.
 - iii. Provide dry contact output to Purchaser's control system for: purge position, minimum fire, and release to modulate.
5. Provide discrete dry contact outputs from Purchaser's control system to:
 - i. Initiate boiler start sequence.
 - ii. Initiate boiler shut-down.
 - iii. Shut down pilot flame after main flame ignition has been proved.
6. Shut off fuel to both pilot and main flame in the event of any of the following conditions:
 - i. Loss of flame.
 - ii. Low gas pressure.
 - iii. High gas pressure.
 - iv. Low combustion air flow.
 - v. Loss of flame scanner.
 - vi. Low water flow.
 - vii. High flue gas temperature.
7. Provide discrete dry contact outputs for all the above conditions, pre-wired to control panel terminal blocks for connection to Purchaser's control system.
8. The Contractor shall provide a low flow cut off differential pressure switch, wired into the burner control circuit, to prevent burner operation if flow rate falls below the designated safe level. It shall allow for automatic restart when the flow returns to normal.

9. The combustion control system shall include all components necessary to fully function.

4.5.4 Controls and Electrical

1. The condensing boiler shall be suitable for operation at all loads from start-up to design rating.
2. The boiler shall be furnished complete with automatic controls (solid state) for feedwater regulation (where applicable), combustion, burner and ignition and fuel safety. Boiler control shall be from a panel, fully instrumented, furnished by the Seller.
3. The following describes some of the details which shall be incorporated in the design. It is the Seller's responsibility to provide those features required for the control systems to ensure safe, reliable and efficient performance from both local and remote locations:
 - i. The burner and igniter control system shall include an automatically supervised sequence of all actions involved in light off and shutdown of burner equipment.
 - ii. Complete local boiler controls shall be provided with common trouble alarm for use in customer DCS. It shall also be capable of being remotely controlled from the customer DCS via instrument gateway (gateway by others) and hardwired signals from a supervisory PLC using BACnet communication protocol.
 - iii. The system components shall be approved by Underwriters Laboratories Canada (except the PLC).
4. Seller shall furnish explosion proof electrical equipment whenever required by applicable local, state or federal codes or by sound engineering practice.
5. Controls and necessary actuators shall be provided to maintain allowable emissions over firing range.

4.5.4.1 Preapproved Manufacturers

1. Lochnivar.
2. Viessman.
3. Clever Brooks.
4. Approved Equal.

4.6 Pumps

This section outlines the requirements for Pumps.

4.6.1 Quality Assurance and Reference Standards

1. Pumps shall be designed, fabricated and tested in accordance to Hydraulic Institute (HI) Standards.
2. Work shall be carried out only by qualified tradesmen.
3. Coupled pumps shall be aligned by a qualified millwright and alignment certified.

4. Ensure pumps operate at specified system fluid temperatures without vapour binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25% of midpoint of published maximum efficiency curve.
5. Each pump shall be tested in accordance with Hydraulic Institute (HI) standards for Rotodynamic Pumps for Hydraulic Performance Acceptance Tests for measurement of flow, head, power input to the pump, and Net Positive Suction Head Required. The substitution of a model pump for the test will not be acceptable. Pumps shall meet Hydraulic Institute performance tolerance B.

4.6.2 Submittals

1. Submit list of recommended spare parts with current prices for pumps and equipment.
2. Submit with shop drawings certified pump curves showing pump performance characteristics with pump and system operating point plotted for constant speed pumps. For variable speed pumps, provide curves at 25%, 50%, 75% and 100% of maximum speed.
3. Show the following points on the pump curves: minimum flow, operating point, best efficiency point, and maximum flow. For variable speed pumps show the curve for the following % speed (35, 50 75, 100).
4. Show pump operating weights, dimensions, clearance for operation and maintenance, motor and pump operating efficiencies and electrical power characteristics.
5. Where pumps are operated in conjunction with others such as parallel pumps, show all operating points on the pump curve.
6. Motor general arrangement drawing, terminal box for power wiring and terminal box for thermistor connection.

4.6.3 General

1. All products shall be new, undamaged and free from rust and defects.
2. All products of a similar nature shall be the product of a single manufacturer.
3. Statically and dynamically balance rotating parts.
4. Construction shall permit complete servicing without breaking piping or motor connections.
5. Provide lifting hooks on all equipment.
6. Mechanical seal, replaceable without removing the motor. Designed for closed system with positive suction pressure. Select for temperature, pressure and service as recommended by the manufacturer.
7. Where applicable, flexible spacer type coupling. Allow the removal from pump and motor shafts, leaving enough space between the shafts to replace the mechanical seal components without disturbing the pump or motor.

8. Select pump and motor for continuous operation at 40 °C.
9. Factory primed and painted with epoxy or enamel suitable to design temperature.
10. Designed for vertical-mounting applications.
11. Motors shall be of premium efficiency/Inverter duty.
12. Size the motor to be non-overloading for the entire pump curve. Operation within service factor (1.15) allowance is prohibited.
13. The pumps shall be controlled by a variable frequency drive where indicated.
14. Motor bearings shall be in accordance with NEMA M-1 Part 31.
15. Provide stainless-steel nameplate stating all ratings including bearing data.
16. Provide cable entry terminal box and ground lug on motor frame.
17. Pump selection shall allow for a 10% increase in flow by changing the impeller but not changing the motor.
18. The pump curve shall be drooping with the duty point between the mid curve and the best efficiency point.

4.6.4 Preapproved Manufacturers

1. Flowserve.
2. Taco.
3. Bell & Gossett.
4. Armstrong.
5. Grundfos.
6. Approved Equal.

4.7 Heat Exchangers (HEX)

This section outlines the requirements for Heat Exchangers.

4.7.1 General

1. Compliant with both CSA B51 and ASME Boiler and Pressure Vessel Code.
2. Canadian registration number (CRN).
3. AHRI rated.
4. Pressure tested to at least 1.25 times design pressure.
5. Sized to minimize approach temperature differential.
6. Engraved stainless-steel nameplate listing including the following information for both sides of the heat exchanger: design flow, design temperatures, pressure drop for design flow.

7. Self-supporting and anchored to resist expected loading (live loads, seismic, and others as relevant). Piping connected to HEX nozzles shall be designed such that loads applied to nozzles do not exceed allowable loads specified by the manufacturer.
8. Lifting lugs designed to lift the entire unit.
9. ANSI Class 150 or 300 flanged or stud nozzle connections preferred. (Threaded connections will be considered for nozzles 2" and below).
10. 316 stainless steel corrugated flow plates optimized for counter flow arrangement with minimum 0.35 mm thickness, 316 SS cover plates, copper brazing where applicable, EPDM gaskets, and stainless-steel bolts nuts and washers.
11. Plate and frame HEX shall allow for plate removal of any plate in the stack without removal of other plates and provide movable back plate with roller bearing for this purpose. Frame shall be factory baked epoxy enamel carbon steel, bolted construction (welding is prohibited).
12. HEX servicing DHW service shall be of double-wall construction to prevent cross contamination of fluid streams. Units shall be complete with individual channel leak detectors. Units shall be furnished with a drip tray and a moisture detector.
13. Plate and frame HEX frame shall allow for a 10% increase in capacity by adding more plates. Brazed HEX shall be oversized by 10%.
14. Ensure HEX is bypassed from system during flushing and hydrostatic testing.
15. HEX shall be factory or field insulated.

4.7.2 Preapproved Manufacturers

1. AIC.
2. Alfa Laval.
3. Tranter.
4. SWEP.
5. Bell and Gosset.
6. Mueller.
7. Xylem.
8. Approved Equal.

4.8 Ground Source Heat Exchange System

This section outlines the requirements for Ground-Source Heat Exchange Systems.

4.8.1 General Requirements

Geoexchange systems can take several forms, but always include three basic subsystems as illustrated below.



FIGURE 1: THREE PRINCIPAL GEOEXCHANGE SUBSYSTEMS (FROM GEOEXCHANGE BC, PROFESSIONAL GUIDELINES FOR GEOEXCHANGE SYSTEMS IN BRITISH COLUMBIA, 2014)

The subsystems also take several forms:

1. **Source Side Sub-system:** The source side, often referred to as the ground heat Exchanger (GHX) can take several forms including different types of closed-loop types and open loop types – each with different merits/drawbacks and operational characteristics.
2. **Heat Pump Sub-system:** Heat pump systems can take the form of central heat pump plant and distributed heat pump systems. In the category of central plants, there are different configurations including central plants internal to the building (with a building connection to the source side sub-system) and central plant systems external to the building, in which case the building is simply served by the load-side piping connections (with no connection to the source side). To provide both heating and cooling performance, the heat pumps can be configured with reversing valves or the heat pumps can be configured for uni-directional operation serving dedicated chilled and heated buffer tanks that are in turn configured within the load-side sub-system to accommodate both heating and cooling effect without the need for reversing the operation of the heat pumps.
3. **Load-Side Sub-system:** Low-temperature hydronic delivery systems are best suited for geoexchange applications. Hydronic delivery systems designed to meet peak heating requirements from heat pump plant supply temperatures no greater than 50 °C offer superior performance. Load-side hydronic systems can take the form of 2-pipe (changeover systems) or 4-pipe systems (that offer flexibility for concurrent heating and cooling for different zones within building).

4.8.2 Compatibility Strategies

While a future LIEC City Centre DES may develop district-style ground heat exchange (GHX) infrastructure (i.e., source side sub-systems), we understand any such future DES is unlikely to incorporate standalone district-scale heat pump energy plant capacity. Therefore, geoexchange

compatibility of developed buildings is contingent on incorporating building-specific heat pump plant and load-side distribution systems that are compatible with energy source supply from a GHX.

General geoexchange compatibility considerations:

1. **Adhere to Low Heating Delivery Temperature.** Designs based on load-side service delivery temperatures not exceeding 50 °C will offer superior energy performance and improved heat pump durability.
2. **Develop Stable System Control.** Careful and thoughtful design is required to ensure the geoexchange system can be controlled in a stable manner. While there are different ways to facilitate stable control, coupling of heat pumps to dedicated and adequately sized hot and chilled storage tanks is a common measure to enhance stable and reliable performance.
3. **Prevent Short-cycling of Heat Pumps.** Short-cycling of heat pumps is a common problem that leads to poor energy efficiency and premature heat pump failure. Thorough design and stable system control strategies will avoid short-cycling.
4. Incorporate ability to directly transfer heat within building without an intermediate transfer to GHX. Many types of buildings have extensive periods of concurrent heating and cooling loads. Energy efficiency and comfort-level can be significantly improved if the heat can be readily transferred within the building from point of excess to point of demand. This can be most readily facilitated with a 4-pipe load-side system and dedicated heated and chilled buffer tanks.
5. **Carefully Manage Pumping.** Careful management of pumping is crucial to energy performance and robust operation.
6. Plan for supply/return pipelines linking DES to the building heat pump plant to be geoexchange compatible. In many cases the supply from the GHX source side system may drop below freezing during the normal course of mid-winter operation. Careful design of this piping system is required, including careful specification of insulation to protect the structural elements from freezing and to reduce undesired heat loss.
7. **Keep it Simple.** Designs that strive for elegant simplicity will often strike an appropriate balance for improved constructability, enhanced controllability, improved energy performance, and rationalized cost.

4.9 Sewage Source Heat Exchange System

This section outlines the requirements for Sewage Source Heat Exchange Systems.

4.9.1 General

1. The sewage pumping system shall be in accordance with the City of Richmond.
2. Room explosive hazard classification shall be in accordance with NFPA 820 and the Canadian Electrical Code. Electrical equipment ratings shall be suitable for the room classifications.
3. Provide diaphragm seals for pressure transmitters and pressure gauges. Thermowells shall be used for temperature transmitters and temperature gauges.

4.9.2 Sewage Pumping System

1. The sewage pumping system shall be designed to minimize wet well entry requirements for routine maintenance. Valves shall be located in a separate vault or above-grade kiosk. Instrumentation installed inside the wet well shall be positioned such that it can be accessed without entering the wet well.
2. Components shall be municipal grade with coatings and materials to suit wastewater service.
3. Check Valves shall be:
 - i. fusion bonded epoxy ductile iron ball check valve; or
 - ii. fusion bonded epoxy ductile iron rubber flapper type check valve.
4. Isolation 75 mm and larger shall be:
 - i. resilient seated, fusion bonded epoxy ductile iron gate valve manufactured in accordance with AWWA C515; or
 - ii. lug-style epoxy coated ductile iron knife gate valve with guided stainless-steel gate providing bubble-tight bidirectional shutoff.
5. Isolation valves 64 mm and smaller shall be full-port, stainless steel ball valves.
6. Sewage Pumps shall be submersible sewage type or self-priming. Pumps shall be non-clogging and capable of passing 75 mm diameter (3 inch) solids.

4.9.3 Sewage Heat Transfer Unit

1. Unit shall be equipped with a screening system and automatic back flushing system such that cleaning frequency of the heat exchangers is limited to annual or semi-annual.

4.9.4 Preapproved Manufacturers

1. Sharc.
2. Approved Equal.

4.10 Solar Thermal Systems

This section outlines the requirements for Solar Thermal Systems.

4.10.1 General

1. **Evaluate Appropriate Loads.** The heat generation potential from solar thermal technologies is seasonally out-of-phase with the peak heat demand. Therefore, it is vitally important to carefully consider the loads that will be serviced by solar thermal technologies. Heating loads such as domestic hot water (DHW) heating, swimming pool heating, or other loads with year-round duration are best suited for solar thermal application.
2. **Avoid Over-production of Solar Heat.** Careful consideration is required to avoid over-producing solar thermal heat. In summer, when heat is most readily available, measures need to be considered for adequately accepting the produced heat. Inadequate summer heat loads can lead to a severe oversupply of solar produced heat during summer months and can lead to potentially dangerous circumstances of severe oversupply of very hot water.
3. **Incorporate Appropriate Heat Storage.** In some cases, heat storage can be incorporated into solar thermal systems to allow heat produced during peak generation periods to be stored for later use. In some cases, geoexchange ground heat exchangers (GHX) can be used for longer-term season-to-season storage (particularly in colder northern climates with one-way heating dominant building loads).
4. **Include Careful Freeze-protection Strategy.** The heat transfer fluid distributed to/from solar collectors will be inherently exposed to outdoor ambient temperatures. Careful freeze protection strategy (antifreeze or drain-down) is required.
5. Exercise good engineering judgment and adhere to applicable codes and standards.

5 Piping, Fittings, Valves, and Appurtenances

5.1 Piping and Fittings

This section outlines the requirements for Piping and Fittings.

5.1.1 General

1. All hydronic heating and cooling piping associated with the LCES shall be field-insulated carbon steel piping designed and installed in accordance with ASME B31.1.
2. The future CCDEU service connection piping will be pre-insulated carbon steel piping in accordance with EN 253, designed and installed in accordance with ASME B31.1.
3. At a minimum, it is expected that the Building (or Strata) side space heating and cooling piping will be field-insulated carbon steel installed in accordance with ASME B31.9.
4. At a minimum, it is expected that the Building (or Strata) side domestic hot water piping will be field-insulated stainless-steel or copper designed and installed in accordance with ASME B31.9 with materials and equipment conforming to NSF 61.
5. Natural gas piping shall be carbon steel, coated safety yellow, designed and installed in accordance with CSA B149.1.
6. For other services within the LCES not explicitly listed above, it is expected that materials and construction will be in accordance with industry best practice and relevant design codes.

5.1.2 Carbon Steel (50 mm diameter and smaller)

1. Pipe: dimensionally conforming to ASME B36.10, schedule 80 wall thickness, material conforming to ASTM A53 grade B or ASTM A105 grade A.
2. Joints: socket weld or threaded in accordance with ASME B1.20.1.
3. Fittings: socket welded or threaded in accordance with ASME B16.11, material conforming to ASTM A105.
4. Coating: At a minimum, indoor uninsulated installations in an air-conditioned space shall be coated with an alkyd primer to a minimum dry film thickness of 3 mils, and if installed outdoors (insulated or not) or in an unconditioned space an epoxy topcoat with a minimum dry film thickness of 3 mils is also required. All coatings shall be suitable for the service conditions and temperature.

5.1.3 Carbon Steel (larger than 50 mm diameter)

1. Pipe: dimensionally conforming to ASME B36.10, schedule 40 wall thickness, material conforming to ASTM A53 grade B or ASTM A105 grade A.
2. Joints: full penetration butt weld, flanged, or grooved in accordance with CSA B242.
3. Fittings: butt weld in accordance with ASME B16.9 with material conforming to ASTM A105 or grooved end couplings made from grade 65-45-12 ductile iron conforming to ASTM A536.
4. Flanges: Mild steel ASTM A105 grade B, raised face (except use flat face where connecting to flat faced equipment), slip-on or weld-neck to ASME B16.5.
5. Coating: At a minimum, indoor uninsulated installations in an air-conditioned space shall be coated with an alkyd primer to a minimum dry film thickness of 3 mils, and if installed outdoors (insulated or not) or in an unconditioned space an epoxy topcoat with a minimum dry film thickness of 3 mils is also required. All coatings shall be suitable for the service conditions and temperature.

5.1.4 Stainless Steel (50 mm diameter and smaller)

1. Pipe: dimensionally conforming to ASME B36.10, schedule 40S wall thickness, material conforming to ASTM A312, grade 304L or 316L.
2. Joints: socket weld or threaded in accordance with ASME B1.20.1.
3. Fittings: socket welded or threaded in accordance with ASME B16.11, material conforming to ASTM 403.
4. Coating: None required, pickle and passivate in accordance with ASTM A380 prior to delivery to site.

5.1.5 Stainless Steel (larger than 50 mm diameter)

1. Pipe: dimensionally conforming to ASME B36.10, schedule 10S wall thickness, material conforming to ASTM A312, grade 304L or 316L.
2. Joints: full penetration butt weld, flanged, or grooved in accordance with CSA B242. Groove sets shall be specially designed for use with thin-wall stainless steel piping.
3. Fittings: butt weld in accordance with ASME B16.9 with material conforming to ASTM A403 grade 304L or 316L. Grooved end fittings made from ASTM A403 grade 304L or 316L, OR grade 65-45-12 ductile iron conforming to ASTM A536 if coating is NSF 61 approved and rated for the service temperature.
4. Flanges: Stainless steel ASTM A182 Grade 304L or 316L, raised face (except use flat face where connecting to flat faced equipment), slip-on or weld-neck to ASME B16.5.
5. Coating: None required, pickle and passivate in accordance with ASTM A380 prior to delivery to site.

5.1.6 Copper

1. Pipe: ASTM B88 Type L annealed temper.
2. Joints: Soldered, brazed, flared, press-connect, or push-fit. ASTM B32 alloy Sn50 shall not be used.
3. Fittings: ASME B16.18, ASME B16.22, ASME B16.26, and ASME B16.50.
4. Flanges: shall be in accordance with ASME B16.24.
5. Coating: none required.

5.1.7 Joints

1. Other flange styles and dimensional standards may be required to mate with equipment connections.
2. Raised-face flanges shall not be used to mate with equipment using flat-faced flanges; flat-faced flanges should be used in this case.
3. Flange gaskets shall conform to ASME B16.21 constructed of materials suited for the proposed service.
4. Provide flange isolation type gaskets (or a dielectric union) at any connection between dissimilar metals.
5. Where flanges will regularly be exposed to damp conditions, 304 stainless steel bolts, nuts, and washers (where required) shall be used.
6. Welded joints shall be 100% visually inspected by a qualified welding inspector, and at least 20% of welded joints shall undergo radiographic examination in accordance with ASME B31.1 requirements. All NDT test results shall be fully documented with copies included in the owner's manual.

5.1.8 Alternates

1. The wall thicknesses and materials listed in this section are the minimum acceptable requirements. More stringent requirements may be required to suit the Proponent's design. The Proponent is responsible for confirming that materials and wall thicknesses satisfy design requirements.
2. Alternate piping systems, offering similar or superior performance, will be considered. Submit alternate systems for approval.

5.2 Valves

This section outlines the requirements for Valves.

5.2.1 General

1. All valves shall have a registered CRN number as required by the local safety Authority. All isolation valves shall have some means of lock-out.
2. Valves shall be in accordance with relevant MSS SP standards.
3. All valves installed 2.4 m above floor level shall have a chain operator.

5.2.2 Gate Valves

1. Cast carbon steel, metal seat, pressure-temperature ratings in accordance with ASME B16.34, flanged ends in accordance with ASME B16.5.

5.2.3 Globe Valves

1. Materials to suit application, pressure-temperature ratings in accordance with ASME B16.34, flanged ends in accordance with ASME B16.5, screwed ends in accordance with ASME B1.20.1.

5.2.4 Ball Valves (Main line)

1. Flanged or welded ends, valves shall be pressure-temperature rated in accordance with ASME B16.34 with flanged ends in accordance with ASME B16.5. Stainless steel ball, stainless steel blow-out proof stem, and EPDM elastomers.

5.2.5 Ball Valves (Drains, vents, and misc.)

1. Two-piece, full port, 1,000 psi WOG, threaded ends, carbon steel, bronze, or stainless steel.

5.2.6 Butterfly Valves

1. Class 150 lug or flanged style. The valve shall be a high-performance double-offset, metal seated design with stainless steel disk, stainless-steel blowout proof one-piece stem, and EPDM seat.

5.2.7 Check Valves

1. Pressure-temperature rated in accordance with ASME B16.34, flanged ends in accordance with ASME B16.5.

5.2.8 Needle Valves

1. Carbon steel body, stainless steel stem, Teflon packing with NPT ends. Rated for 69,000 kPa at 93 °C (10,000 psi at 200 °F). Body shall be stainless-steel for potable water and domestic hot water applications.

5.2.9 Pressure Relief Valve

1. Direct-operated, spring loaded, resilient seated pressure relief valve with brass/bronze base/body/bonnet, stainless steel warn ring/disk, and NPT ends. For potable water and domestic hot water use, all components shall be stainless steel, or use a brass/bronze valve certified to NSF 61 for potable water service. Valve selection shall comply with the requirements of ASME Section VIII, Div. 1 and ASME B31.1 where required.

5.2.10 Balancing Valve

1. Brass or ductile iron body and bonnet, stainless steel spring, EPDM elastomers, threaded or flanged ends. Valve shall incorporate the ability to balance, pre-set, measure, and shut-off.

5.2.11 Reduced Pressure Principle Backflow Device

1. Epoxy coated cast or ductile iron check valve bodies with stainless steel internals in accordance with AWWA C511, CSA B64.5, NSF 61, and NSF 372. Provide air gap assembly for relief valve drain connection.

5.2.12 Gas Pressure Regulator

1. Ductile iron or steel body in accordance with CSA 6.18, ANSI Z21.78/CSA 6.20, or ANSI Z21.80/CSA 6.22 as appropriate for intended service.

5.2.13 Triple Duty Valve

1. Ductile iron body, bronze disk, stainless steel stem and spring, nitrile elastomers, or other materials to suit application. Valve shall incorporate the abilities of a check valve, balancing valve, and isolation valve. Provide 6 mm tapping ports for gauge connections.

5.2.14 Suction Diffuser

1. Ductile iron body and guide vanes, stainless steel strainer and mesh, or other materials to suit application. Suction diffuser shall include a strainer and guide vanes to condition flow upstream of the pump. Refer to screening requirements in Clause 5.3.1. Provide 6 mm tapping ports for gauge connections.

5.2.15 Modulating Control Valves

1. Modulating control valves shall be globe style modulating type with equal flow characteristics with ANSI Class 150 or 300 raised face flanges and a minimum shut-off pressure of 150 psi. Valve shall include 316 SS trim, Teflon packing, and a physical valve position indicator.
2. Alternate valves for modulating control with similar performance will be considered.
3. Actuators shall be sized for 1.25 times maximum torque requirements of shut-off pressure rating and rated for at least 600 starts per hour. The power and controls terminals shall be segregated, and the actuator shall use 4-20 mA or 0-10 VDC position command input and position feedback output signals. The starter shall be solid state type where applicable, and the stroke speed shall be at least 3.8 mm/s. The actuator

shall be shipped from the factory including manual hand wheel, allowing for manual operation in the event of power or control failures, and limit switches.

5.2.16 On/Off Control Valves

1. On/Off control valves to suit application. Use ball valves, double- or triple-offset butterfly valves, gate valves, or globe valves as appropriate.
2. Actuators shall be sized for 1.25 times maximum torque requirements of shut-off pressure rating and rated for at least 120 starts per hour. The power and controls terminals shall be segregated, and the actuator shall use 4-20 mA or 0-10 VDC position command input and position feedback output signals. The starter shall be solid state type where applicable, and the stroke speed shall be at least 3.8 mm/s. The actuator shall be shipped from the factory including manual hand wheel, allowing for manual operation in the event of power or control failures, and limit switches.

5.2.17 Automatic Air Release Valve

1. Lever type valve sized to meet service requirements; valve discharge piping shall be routed to floor. Provide isolation valve between air release valve and service pipe.

5.3 Appurtenances

This section outlines the requirements for various miscellaneous Appurtenances.

5.3.1 Strainers

1. Strainers shall be provided upstream of ALL pumps, heat exchangers, and other equipment if required by the manufacturer.
2. Strainers should have flanged or welded connections and be coated carbon steel in a wye type configuration. For potable water applications the strainer certified for potable water use per NSF 61 or be of full stainless-steel construction.
3. At a minimum, the screen shall be a 3.5 mm (5/32 inch) stainless steel complete with #30 stainless steel mesh and an effective screen area at least 2.5 times the pipe size. Smaller mesh sizes may be required to protect downstream equipment as required by the equipment manufacturer.

5.3.2 Expansion Tanks

1. Expansion tanks shall be designed and constructed in accordance with ASME, Section VIII, Division 1 and have a Canadian Registration Number (CRN).
2. Carbon steel construction with epoxy coating and lining.
3. Engraved stainless-steel name plate with registration numbers, tank size, and pressure rating at a minimum.
4. Pre-charged bladder type expansion tanks preferred. Bladders shall be replaceable and be complete with membrane rupture detector, fill pressure indicator with isolation valve, and charging valve.

5. Tank shall be seismically restrained and be provided with a drain valve.

5.3.3 Insulation

1. Piping insulation shall be 50 mm (2 inch) thickness minimum.
2. Insulation for hot service (SH & DHW) shall be formed mineral fibre in accordance with ASTM C547. Insulation for chilled service (SC) shall be closed cell elastomeric in accordance with ASTM C547.
3. Interior insulated piping shall be covered with pre-formed PVC jacketing. Exterior insulated piping shall be covered with embossed aluminum cladding.
4. Provide removable insulation blankets for flanged or irregularly shaped equipment such as valves, strainers, flowmeters, heat exchangers, pumps, and others.
5. The Fire/Smoke spread rating for the insulation system shall not exceed 25/50 in accordance with CAN/ULC-S102-M.
6. The thermal conductivity of the insulation shall not exceed 0.035 W/m °C when tested at 24 °C in accordance with ASTM C335.
7. Ensure integrity of vapour barrier is maintained for cold service insulation.
8. Alternate insulation systems offering equivalent or superior performance will be considered.

5.3.4 Pressure Gauges

1. Pressure gauges shall be provided at all locations required to facilitate operation and maintenance of the facilities, and at any other location deemed necessary by LIEC.
2. Pressure gauges shall be of stainless-steel construction, liquid filled, dual scale (kPa and psi) with a 100 mm diameter gauge face and a needle valve for isolation from service.

5.3.5 Temperature Gauges

1. Temperature gauges shall be provided adjacent to all temperature sensors as a means of confirming sensor measurements, and at any other location where the LIEC deems it necessary for operation of the facility.
2. Gauges shall be of stainless-steel construction, dual scale (°T and °F) with an adjustable viewing angle and 125 mm diameter gauge face.
3. Temperature gauges shall be installed in ½" NPT stainless steel thermowells protruding 40% to 60% into the pipe cross-section with an extension length equal to the insulation thickness and filled with thermal gel.

5.3.6 Drains and Air Management

1. Piping shall be installed such that the system can be fully and completely drained, slope piping to low points and provide manual drains at all low points for this purpose.

2. At system high-points where air pockets can be expected to form, provide manual air release valves to facilitate purging of air from the system. In addition, an automatic air release valve shall be provided at the highest point in the system. The automatic air release valve shall be provided with a shut-off valve to isolate it from service and, if possible, piped back to the makeup water or glycol fill tank.
3. Provide an air separator upstream of all main circulator pumps. The air separator shall be constructed of coated carbon steel in accordance with ASME Section VIII, Division 1. Separator shall be complete with blow-down valve, stainless-steel strainer, automatic air vent, and bypass. Other air separation / venting subject to LIEC approval.

5.3.7 Building (or Strata) Side of ETS DHW Heat Exchanger

1. Piping, valves, and other equipment connected to the delivery side of the domestic hot water (DHW) heat exchanger shall be approved for use with potable water. Use ANSI/NSF 61 approved equipment.

5.4 Piping and Equipment Supports

1. Consider all load effects including but not limited to dead, live, wind, snow, thermal expansion, differential settlement (where relevant), and seismic events.
2. Supports, guides, and anchors shall not transmit unacceptable heat and vibration to the building.
3. All piping and equipment shall be designed to resist the effects of seismic forces and effects.
4. Piping and equipment supports shall be in accordance with relevant MSS-SP standards.
5. Provide housekeeping pads under all floor-mounted equipment, minimum 100 mm thick.
6. Oversize pipe hangers to be installed over insulation where a vapour barrier needs to be maintained, utilize inserts and saddles accordingly.
7. All concrete anchors shall be seismically rated, assume cracked concrete unless it can be proven otherwise.

5.5 Ancillary Systems

5.5.1 Fire Suppression System

1. The fire suppression system within LCEP space shall be an extension of the base building fire suppression system. All sprinkler heads servicing the LCEP space shall be serviced by a double interlock release type pre-action system. The pre-action system shall be triggered by the activation of fire alarm initiating device (manual pull station or heat detector) within the plant floor space and the activation of a sprinkler head on system piping.
2. The opening of the deluge valve shall not be dependent on the order of activation of the release devices, only that both devices must activate before the deluge valve will open.

The pre-action system shall be provided with all necessary appurtenances to complete the system and be in conformance with the current edition of NFPA 13: Standard for Installation of Sprinkler Systems.

5.5.2 Make-Up Water System

1. Hydronic water systems shall be provided with a make-up water connection to refill water lost from the system. Do not connect a make-up water system to a hydronic glycol system.
2. At a minimum, the make-up system shall be directly connected to the hydronic water system and be composed of:
 - i. a reduced pressure principal backflow prevention device;
 - ii. a pressure reducing valve to set system pressure;
 - iii. a mainline strainer upstream of the backflow prevention device and pressure reducing valve;
 - iv. a flowmeter with 4-20 mA signal output to indicate when the system is filling, and the volume added to the system;
 - v. pressure gauges upstream and downstream of the pressure reducing valve; and
 - vi. isolation valves to facilitate regular maintenance of the system.
3. Any piping or valves installed upstream of the backflow prevention device shall be appropriate for potable water use and ANSI/NSF 61 approved.

5.5.3 Make-Up Glycol System

1. Hydronic glycol systems shall be provided with a make-up glycol package to refill glycol solution lost from the system. Do not connect a make-up glycol system to a treated water system.
2. At a minimum, the make-up glycol system shall be directly connected to the hydronic glycol system and be composed of:
 - i. a storage and mixing tank;
 - ii. an accumulator tank with pressure diaphragm and manual diverter valve for purging air and agitating contents;
 - iii. a pump to pressurize accumulator tank complete with pressure switch, thermal cut-out switch and low-level pump cut-out;
 - iv. a pressure-reducing valve capable of setting set system pressure to between 35 and 380 kPa (5 to 55 psi) complete with pressure gauge, check valve, and system isolation valve; and
 - v. a low-level alarm with remote monitoring dry contacts and audible alarm.

5.5.4 Water Quality Control

1. Each closed loop hydronic piping system shall be equipped with a chemical addition pot feeder, corrosion coupon rack, and a side stream filter.
2. The chemical addition pot feeder shall accommodate system chemical addition. Size unit to suit system size and provide isolation valves.
3. The corrosion coupon rack shall be complete with one coupon sample for each material group comprising the system (carbon steel, copper, etc.). In addition, the rack shall be furnished with a flow indicator, globe valve or balancing valve, sample port, and isolation valves.
4. The side stream filter shall be of the replaceable cartridge type. The filter captured particle size and unit flow capacity shall be in accordance with industry best practice. The filter shall be complete with flow indicator, balancing valve, drain valve, and isolation valves. Alternate configurations for system filtering will be considered.
5. Open systems (such as cooling towers) shall have an automatic chemical dosing system with chemical storage for one (1) corrosion inhibitor and two (2) biocides.

5.5.5 Lifting Equipment

1. Where cranes are used for equipment removal, they shall be designed and installed in accordance with the following standards:
 - i. CAN/CSA B167 Overhead Cranes, Gantry Cranes, Monorails, Hoists, and Jib Cranes;
 - ii. CAN/CSA Z256-M87 Safety Code for Material Hoist;
 - iii. CAN/CSA B1967 CMAA Specification No. 70 Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Travelling Cranes; and
 - iv. CISC Crane Supporting Steel Structures: Design Guide.
2. Welding shall be completed by certified welders in accordance with applicable standards. All fabricated components shall be factory coated 'extra caution orange' with capacities clearly indicated on the hoist and crane. One litre of touch-up coating shall be supplied with the crane.

6 Electrical

6.1 General Requirements

6.1.1 Wiring Method

1. The wiring method shall be surface run conduit and wire, or armoured cable run in cable tray. Interior control panel wiring shall be bundled using 'TyRap' cable ties and be secured to rear mounting panel(s) or installed in 'Panduit' type wiring trough.

6.1.2 Ground Conductor

1. Provide separate ground conductor in all non-metallic conduit and duct, except for primary underground duct and telephone service duct.

6.1.3 Conduit

1. Provide galvanized steel Electrical Metallic Tubing (EMT) in all areas, except where direct buried or exposed to mechanical damage. EMT shall be installed with watertight fittings for outdoor applications.
2. Provide rigid PVC conduit (DB2) CSA 22.2 No. 211.1 (R2016) where direct buried or encased in concrete for conduit size 53 mm and larger. Use approved jointing cement.
3. Provide rigid hot dipped galvanized steel conduit in areas where exposed to mechanical damage.
4. Areas where conduit is exposed to mechanical damage are as follows:
 - i. Surface mounted outdoors, from 600 mm below ground to 1,600 mm above ground; and
 - ii. Stubbed up through floor to motors and control pilot devices.
5. Provide flexible conduit for last 500 mm of connection to motors, solenoid valves, pressure switches and similar devices.
6. Exposed conduit shall be parallel or perpendicular to building lines.
7. Support conduit to eliminate visible deflection.
8. Conduit entering an electrical enclosure or kiosk shall have locknut and washer on both sides of the enclosure or kiosk panel. Connection shall be to the standard of the enclosure.
9. Flexible conduit shall only be used where flexibility is required for future equipment changes or small equipment movement.

6.1.4 Flexible Conduit

1. Provide flexible water-tight conduit for connections to pump bases.
2. Flexible conduit shall be Hydrotite or Sealtight with extruded PVC jacket.

3. Non-metallic flexible conduit is acceptable.

6.1.5 Telephone Service Duct

1. Provide 53 mm orange PVC in accordance with telephone utility requirements.

6.1.6 Secondary Distribution Duct

1. Provide 103 mm PVC where direct buried or encased in concrete.
2. Adapt to rigid galvanized steel where exposed to mechanical damage.

6.1.7 Wire

1. Provide stranded copper conductor unless otherwise noted.
2. Provide solid copper conductor for lighting and receptacle circuits.
3. Provide extra flexible switchboard wire #16 AWG for all control panel wiring.
4. Provide minimum #12 AWG for lighting, heating and receptacle circuits.
5. Provide RW90 X LINK polyethylene insulated wire unless otherwise noted.
6. Wiring at 120/208 volts shall be 300 volt insulated.
7. Wiring at 600 volts shall be 1,000 volt insulated.
8. Any wiring sharing ducts or cable trays with 600 volt circuits shall be 1,000 volt insulated.

6.1.8 Teck Cable

1. Teck cable shall be aluminum armoured copper conductor with X link insulation complete with fire retardant PVC jacket overall. Voltage rating shall be minimum 600 volt for #10 AWG and smaller, 1,000 volt for #8 AWG and larger.
2. Provide appropriately sized PVC conduit sleeve in concrete for Teck cable entrances into buildings. Seal with duct seal.

6.1.9 Instrumentation and Communication Cable

1. Provide shielded twisted pairs with individual and overall shields.

6.1.10 Cable Tray

1. Provide cable tray for multiple runs of Teck cable in buildings.
2. Provide Burndy type A30 aluminum cable ladder with 300 mm-rung spacing, supported in accordance with manufacturer's recommendations. Size to ensure 1 cable diameter between all power cables.
3. Provide factory fabricated tee, elbow, angle, and special fittings as required.
4. Provide barrier between instrument cable and other cable.
5. Install tray after piping and/or ducting has been installed.

6. Suspend cable tray with minimum 3/8" ready rod. Attach to concrete ceiling with Hilti drop in anchors. Install as per manufacturer's recommendation.
7. Provide seismic restraint in accordance with the Electrical Contractor's Association of BC Seismic Restraint Manual.
8. Separate 600 V cables from 120 V cables. 24 V cable shall be separated by a barrier.
9. Ensure all tray is grounded and bonded in accordance with CEC requirements.

6.1.11 Connectors

1. Teck connectors shall be rain tight. Provide Thomas & Betts 'Spin-On Series II' connectors.
2. Connectors shall match the NEMA standard of the box, fitting or enclosure they enter.

6.1.12 Duct Seal

1. Provide Duct Sealant in all ducts.

6.1.13 Flame Stop Sealant

1. Provide flame safe firestop compound where conduits penetrate firewalls.

6.1.14 Junction Boxes

1. Provide hinged NEMA 4 enclosures with latching handle. Enclosures shall be steel, phosphatized and finished with a re-coatable powder inside and out of ANSI 61 smooth Gray. Enclosures shall be complete with back panel and terminal blocks as necessary to make all connections within.
2. Junction boxes with multiple voltages contained within shall be provided with partitions to maintain separation of control wiring, 120 V wiring and 600 V wiring.
3. Enclosures shall be sized to accommodate existing wiring connections with capacity for an additional 20%. Provide Hammond Eclipse Series or approved equal.

6.1.15 Rigid Steel Conduit to PVC Conduit Adapter

1. Provide PVC female adapter fitting. Rigid Steel conduit shall be threaded into female adapter at points of transition.

6.1.16 Waterstop Sealant Installation

1. Provide silicone rubber adhesive sealant.

6.1.17 Control Panel Wiring

1. Identify wiring at each end with tubular markers. Identification numbers shall match terminal numbers, and shall be as identified on the Proponent's drawings.
2. Provide wire numbers for all wires and terminals.

3. Colour code wiring 'Red' for 120 VAC;
'Blue' for 24 VDC; and
'Yellow' for 12 VDC.

6.1.18 Spare Conductors

1. Unused wiring in conduits or cable shall be clearly identified as spare with each conductor numbered individually.

6.1.19 Direct Buried Conduit and Teck Cable

1. Bury all wiring to minimum depths noted in Canadian Electrical Code unless otherwise noted.
2. Mark location with warning tape 'Danger Buried Cable' in trench 200 mm below grade.

6.1.20 Instrumentation Cable

1. Ground shield at one location, unless recommended otherwise by the equipment supplier.
2. Test continuity of shield prior to connecting instruments.
3. Fit clear plastic tubing over shield drain wires.
4. Where shield is not grounded, double back and fit heat shrink tubing to secure the shield to the respective pair and prevent connection to ground. Do not cut back to cable termination.
5. Fit insulated crimp on type ferrules on each end of each wire including shield (where grounded).
6. Provide adequate lightning and surge protection on all instrumentation cables entering a building or where noted herein and on the drawings.
7. Terminate armour in approved connector.

6.1.21 Equipment Mounting

1. Use 19 mm good one side (G1S), exterior grade plywood where required to mount electrical equipment.
2. Paint plywood with three coats minimum, one primer and two of the base colour. Base colour shall match the surrounding wall or be white if the wall is unpainted.

7 Electrical Equipment Requirements

This section identifies the minimum acceptable standard for major pieces of electrical equipment.

7.1 Programmable Logic Controller (PLC)

Provide Modicon Quantum PLC components including:

1. PLC Processor: 140 CPU 434 12U;
2. Power Supply: 140 CPS 434 12U;
3. Ethernet Adapter: 140 NOE 771 01;
4. Sixteen Slot Backplane: 140 XBP 016 00;
5. Ten Slot Backplane: 140 XBP 010 00;
6. Backplane Expander: 140 XBE 100 00;
7. Remote I/O Head Module: 140 CRP 931 00;
8. Remote I/O Module: 140 CRA 931 00;
9. Empty Slot Module: 140 XCP 500 00;
10. 120V 32 Discrete Input Module: 140 DAI 553 00;
11. Sixteen Discrete Output Relay Module: 140 DRA 840 00;
12. Eight 4-20mA Analog Input Module: 140 ACI 030 00; and
13. 4-20mA Analog Output Module: 140 ACO 130 00.

7.2 Variable-Frequency Drive (VFD)

1. Provide Danfoss VLT AQUA Drive VFDs.
2. The VFDs shall be sized and selected in accordance with the motor horsepower.
3. Minimum efficiency at full load: 96%.
4. Technology: IGBT with digital microprocessor.
5. Line/Load Conditioners: Include AC line and load reactors if required in accordance with manufacturer's recommendations for the specific application conditions.

7.3 Motor Starters

1. All starter components shall be co-ordinated for the full range of current values from normal running loads to maximum available fault current. Starters shall be combination type with circuit breakers with 22,000 amp RMS asymmetrical interrupting capacity, with magnetic only trip.
2. The external operating handle of the circuit breaker shall be interlocked with the door, so that the handle must be in the off position before the door can be opened. There shall be a facility for padlocking this handle in the open position with up to three padlocks. It shall not be possible to close the disconnect by any means, if the disconnect handle is locked open. When the disconnect is closed, it shall be possible, using a semi-secret defeater screw mechanism, to open the starter door, for testing purposes.
3. Starters shall have solid state overload relay:
 - i. with monitoring on three phases;
 - ii. which has a Form C alarm contact;
 - iii. which is ambient compensated; and
 - iv. which is manually reset.
4. Starters shall have 120 volt coils.
5. Starters in MCC shall be connected to the vertical bus by means of stab connectors plated with the same material as the bus.
6. Control power circuit shall be from individual control transformers in each starter complete with two primary and one secondary fuse sized for all components connected plus 100% capacity for future devices.

7.4 Uninterrupted Power Supply (UPS)

1. The Control Panel shall be powered by means of a Double Conversion On-Line UPS.
2. Provide a UPS with dry contact relay outputs connected to PLC inputs in the Control Panel.
3. The UPS relay outputs shall indicate 'UPS on Batteries' and 'UPS Fault'.
4. Provide a UPS capable of powering the Control Panel for minimum 2 hours.

7.5 Human-Machine Interface (HMI)

1. Provide 10" touchscreen HMI complete with ethernet communications.
2. HMI screens shall indicate the state of all monitored equipment including but not limited to all flows, pressures, temperatures, energy usages, valve positions, selector switch positions & power quality.

3. Multiple HMI screens shall be set up in a cascade sequence to show a system overview and multiple screens showing energy usage, flows, temperatures for all equipment.
4. The HMI shall be capable of displaying equipment operational status and process values, and accept manual input for set point changes.
5. The HMI shall have alarming, data logging, and trending capabilities.
6. Standard of acceptance is: Allen Bradley Panelview Plus7.

7.6 Motors

7.6.1 General

1. This specification covers the furnishing of motors, including all materials, supervision, labour, and services, to design, manufacture, shop test, deliver, install, commission, test, and guarantee the motors, in accordance with the information and data shown herein.
2. Motors shall be of a high efficiency design and conform to BC Hydro efficiency standards.
3. Three-phase motors shall be of a squirrel cage induction design.

7.6.2 Standards

1. Equipment shall be built to applicable EEMAC, NEMA and IEEE standards.
2. Equipment shall be CSA approved, and carry a CSA label.
3. Motors shall be dynamically balanced to NEMA standard MG1 2016 Part 12.6, standard balance limits.
4. Motors used with variable frequency drives (VFDs) shall be certified as Inverter Duty and meet the requirements for inverter duty motors, in accordance with NEMA MG1 Part 31.
5. Motors shall be designed to the NEMA type B torque characteristics.

7.6.3 Performance Requirements

1. Motors to be used in a VFD application shall be suitable for use with pulse width modulated variable frequency controllers with IGBT, BJT or GTO outputs and no output reactors.
2. Motors shall have adequate cooling, including cooling at all speeds when used in conjunction with a VFD.
3. Motors shall be 1.15 service factor at Class F temperature rise. Motors used in conjunction with a VFD shall not have the harmonic heating cause any reduction in the service factor.
4. Motors shall be capable of continuous reverse rotation to 125% speed.

7.6.4 Motor Features

1. Enclosures shall be open drip proof design with guarded openings for indoor use in dry environments. Motors for outdoor use above 250 hp shall be WP1. For outdoor or indoor use below 250 hp motors shall be TEFC.
2. Motors shall be T frame, up to 250 hp at 1,800 rpm standards. T frame motors shall have a cast iron frame.
3. One horsepower shall be the minimum motor size.
4. Shaft length shall be standard.
5. Bearings shall be anti-friction, ball or roller, grease lubricated, rated for 100,000 hours of continuous duty. Bearings to have alemite fittings and grease relief.
6. Main terminal boxes shall be diagonally split, and oversized i.e., adequately sized to allow the customer's termination, with consideration given to the customer typically needing to derate cables 50% from the Canadian Electrical Code Table II. Terminal boxes shall be suitable for rotation by 360 degrees in steps at 90 degrees. Terminal boxes shall be cast iron. Terminal boxes shall be gasketed.
7. Motors above T frame in size shall be provided with anti-condensation heaters, rated for 120 VAC nominal power.
8. Motors larger than 500 hp at 1,800 rpm shall be provided with 100 Ω platinum RTDs, three (3) in the windings, at the calculated hot spot, and two (2) for the bearings.
9. Motors shall be designed for use in the axial or horizontal mode, as determined by the installation requirements.
10. Motor shafts shall be of the hollow shaft design.
11. Stator insulation shall be Class F, non-hygroscopic. Insulation shall be such as to allow the use of the motor with a PWM VFD without output filters, located up to 1,000 feet from the drive. Motor insulation shall comply with standard NEMA MG1 – Part 31 when the motor will be used in conjunction with a VFD.
12. Motors used in conjunction with VFDs shall be fitted with suitable shaft grounding rings.
13. Stainless steel nameplates shall be provided.
14. Motors to be used in conjunction with a VFD shall show performance under VFD power and state suitability for use with VFD power.
15. Motors shall be painted with a zinc rich primer. Final paint colour shall be grey.
16. Motors above T frame sizes shall be provided with factory mounted Robert Shaw vibration switches.
17. Motors on belt drive or motors required to provide thrust to mechanical equipment shall be specifically designed to withstand the additional forces.

18. Motors shall be supplied with AC, spring set, electrically released, motor mounted disc brakes.
19. Motors above T frame sizes shall have copper rotor bars.
20. Motor stator windings shall be double dipped, vacuum pressure impregnated.
21. Bearings shall be SKF or NTN.
22. Separate terminal boxes shall be provided for space heaters and RTDs. Boxes shall be labelled.

7.6.5 Warranty

1. T frame motors shall have a three (3) year warranty.
2. Above T frame, motors shall have a one (1) year warranty.

7.7 Control Panel

1. The Control Panel shall be assembled in a CSA approved panel shop. Complete wiring and layout shop drawings showing dimensions are required for approval prior to manufacture.
2. Enclosure:
 - i. Provide double door, free standing NEMA 12 complete with:
 - 14 gauge steel;
 - External mounting feet; and
 - Continuously welded seams.
 - ii. Door and body stiffeners if required;
 - iii. Gasketed door;
 - iv. Lockable 3-point latching mechanism; and
 - v. High impact plastic drawing pocket mounted on inside of door.

7.8 Control Relays

1. Control relays shall have 120VAC coils with number of poles as required.
2. Control relays shall be complete with plug-in socket.

7.9 Timer Relays

1. Timer relays shall be Omron H3CR-AP 120 V, electronic timing relays with true on or off delay, not triggered circuits.
2. Timer Relays shall be complete with plug-in socket.

7.10 Pushbuttons, Selector Switches, and Indicator Lights

1. Provide Allen Bradley Bulletin 800T, heavy duty oil-tight devices with lamicoid nameplates as shown on the drawings. All indicating lights shall be “push-to-test” and shall have LED lamps.

7.11 Terminal Blocks

1. Provide Weidmuller SAK4, SAK6 and ASK1 (fused) terminal blocks as required.

7.12 Control Circuit Breakers

1. Control circuit breakers shall be DIN rail mountable, 120 VAC (min) rated.
2. Approved Control Circuit Breaker Manufacturers:
 - i. ETA.
 - ii. Weidmuller.
 - iii. Potter and Brumfield.

7.13 Power Supplies

1. Provide Weidmuller ‘Advanced’ power supplies Cat. No. CP-SNT-160W.

7.14 Ethernet Switch

1. Provide an Ethernet switch complete with the following:
 - i. 24VDC input power;
 - ii. DIN rail mountable;
 - iii. Metal case;
 - iv. Eight ports;
 - v. IP30 rating;
 - vi. Minimum 10/100 speed; and
 - vii. Provide N-Tron Part No. 108TX or approved equal.

7.15 Signal Isolators

1. Provide Moore loop powered Type ECT/4-20mA/4-20mA/12-42DC signal isolator or approved equal.

7.16 Control Panel Wiring

1. Provide Type TEW, 300 V insulation.

7.17 Motor Control Centre (MCC)

7.17.1 General Construction

1. The MCC shall have an EEMAC, Class 1A, general purpose enclosure with gaskets.
2. The MCC shall be front mounted and have floor mounting channel and lifting angles.
3. Buswork shall be tin plated aluminum.
4. Vertical bus shall be rated at 400 amps.
5. Horizontal bus shall be rated as suitable for the anticipated load.
6. The MCC shall have 200 Amp continuous ground bus.
7. Bus bracing shall withstand short circuit current as calculated by a Professional Engineer.
8. Vertical sections shall be:
 - i. 500 mm deep;
 - ii. 500 mm wide; and
 - iii. 2,325 mm high.
9. The MCC shall consist of one or more modular vertical sections bolted together to form a rigid, free standing, dead front assembly, and shall be designed to permit future additions or changes of individual units and extensions to the MCC by the user. MCCs shall be complete assemblies, with components, units and wiring as specified herein.
10. MCCs shall have units mounted in front of board only.
11. Wiring shall be EEMAC Class B.
12. All bus connections shall be front accessible for servicing.
13. Provide a 6 mm x 50 mm horizontal copper ground bus running the length of the MCC. Provide lugs for connecting cables/conductors.
14. All units, except those too heavy or bulky to manipulate, shall be plug in.
15. Each unit shall be automatically connected through a grounding finger to a vertical ground bus as it is inserted.
16. The MCC shall be painted ASA Grey 61.
17. Individual compartments shall be barriered so as to minimize the possibility of ionization occurring within a compartment spreading to other compartments.
18. There shall be provision for top and bottom entry of cables and conduit and there shall be entry plate for bottom of each section.

19. Control wiring shall be tagged at both ends with wire numbers in accordance with the Proponent's drawings.
20. Plastic tubular wire markers shall be used throughout.
21. Control wiring terminals shall be labelled.
22. Pushbuttons, pilot lights and selector switches, etc., shall be heavy duty oil tight. They shall be identified with lamicaid nameplates.

7.17.2 Detailed Description

The Motor Control Centre shall contain the following:

1. Utility - one incoming utility section, if required, complete with pull box, CT section, meter and main lugs suitable for copper conductor sized for the expected electrical load.
2. Motor starters.
3. Feeder breakers.
4. Main Breaker, which shall be:
 - i. Moulded case;
 - ii. 'Visible break', with windows over contacts;
 - iii. Solid state tripping element;
 - iv. Interrupting rating suitable for the anticipated available short circuit as calculated by a Professional Engineer;
 - v. Adjustable rating plug, capable of adjusting the trip setting from 70% to 100% of the plug nameplate rating; and
 - vi. Built in ground fault protection.

7.17.3 Metering and Instruments

1. Provide customer metering, including meters, selector switches, instrument transformers and fusing. Instruments shall be flush (semi flush) mounting, and similar types shall have matching faces.
2. Provide ammeter: 115 mm scale.
3. Provide voltmeter: 115 mm scale.
4. Provide selector switches switchboard type, three-phase.
5. Provide kilowatt hour meter: 3-phase, 4 wire, 3 element, with resettable 15 minute thermal demand indicator; semi drawout construction case.

6. Provide Power Quality Protection with the following features:

- i. Phase reversal protection, to open output relay when two phases are reversed for more than two cycles.
- ii. Phase loss protection, to open output relay when one phase drops below 70% of nominal voltage setting.
- iii. Phase imbalance protection, to open output relay when imbalance exceeds 4% average. Provide adjustable time delay for this feature.
- iv. Under voltage protection to open output relay when voltage drops below an adjustable pre-set value. Provide adjustable time delay up to 60 seconds. Output relay for d) shall be different than for a), b), and c).

7.17.4 Feeder Cubicles

1. The feeder cubicle components shall be co-ordinated for the full range of current values from normal running loads to maximum available fault current.
2. Feeder cubicles shall contain circuit breakers with minimum interrupting capacity higher than available as calculated by a Professional Engineer.
3. The external operating handle of the circuit breaker shall be interlocked with the door, so that the handle must be in the "off" position before the door can be opened. There shall be a facility for padlocking this handle in the open position for up to three padlocks. It shall not be possible to close the disconnect by any means if the disconnect handle is locked open. When the disconnect is closed, it shall be possible using a semi-secret defeater screw mechanism, to open the starter door for testing purposes.

7.18 Transformers

1. Transformers installed indoors in non-hazardous areas shall be Hammond Type F (single-phase) and Type K (three-phase) dry type air cooled of voltage and kVA ratings as shown on the Single Line Diagram.
2. Transformers shall have full capacity primary taps; 4 - 2.5% above 5 kVA for single-phase; 4 - 2.5% above 9 kVA for 3-phase.
3. Transformers shall be sized to carry 135% of the connected load.

7.19 Communication Protocol

1. All system components shall be based on the BACnet communication protocol.

7.20 Emergency Stop Button

Provide Emergency Stop push buttons with the following characteristics:

1. Red mushroom head actuator with 'Emergency Stop' lettering.
2. 1 N.O. and 1 N.C. contacts.

3. Maintained push-to-stop position; switch must be twisted and pulled to return to normal position
4. Switch shall be mounted in a yellow, NEMA4 rated, surface mount PVC box and be complete with a guarding mechanism to protect against accidental operation.
5. Switch shall also have a NEMA4 rating as required.

7.21 Pull and Junction Boxes

1. Provide pull and junction boxes appropriately sized where required.
2. Provide CSA approved, pressed steel construction, hot dip galvanized, except larger boxes may be enamelled, complete with grounding lugs, and screw on or hinged cover and sized per Canadian Electrical Code requirements, where conduit is concealed.
3. Provide cast FS type boxes of same material as conduit, where conduit is surface run.
4. Provide labelled terminals in all control junction boxes with more than four (4) junctions.
5. For control and instrumentation, provide labelled DIN rail mounted terminals in all control junction boxes with more than four (4) junctions. Junction box shall be NEMA4 or NEMA4X as required.

7.22 Receptacle and Switch Boxes

1. Size boxes to suit the number of conductors and connections required therein.
2. Use gang boxes as required for the number of switches.
3. Receptacle and switch boxes installed in concrete shall be of a type specifically designed and approved for this application. 87mm deep type MB boxes may be used in concrete and masonry.
4. Provide switch and receptacle boxes suitable for installation required.
5. In areas where conduit is surface run provide type F.S. boxes, constructed of same material as conduit.

7.23 Electronic Timers

1. Provide electronic timer complete with the following features:
 - i. Forty on/off events per week;
 - ii. Battery backup and;
 - iii. 1,500 Watt contact rating; and
 - iv. Provide Intermatic Cat. No. EI600WC or approved equal.

7.24 Wiring Connections

1. Use insulated twist on type for #10 AWG and smaller conductors.
2. Use bolted type for #8 and larger. Use Burndy Compression fittings for connecting spade type terminals to wiring.

8 Controls and Instrumentation

8.1 Control Panel

Each ETS shall be supplied with a control panel assembled in a CSA approved panel shop. The control panel shall include:

1. Terminal blocks (including 10% spare) complete with DIN mounting rail and all necessary accessories.
2. Wiring channel with removable covers (i.e., 'Panduit').
3. DIN rail mountable control circuit breakers and/or fused terminal blocks.
4. Copper grounding bus located at the bottom of the enclosure.
5. 24 VDC power supply with 25% over-capacity.
6. Four (4) port (minimum) Ethernet switch complete with one (1) fibre port (minimum).
7. All DC and instrument wiring shall be shielded.
8. Control relays with 120 VAC operating coils; contact ratings shall be sized accordingly.
9. Timer relays; preferably OMRON H3CR-AP.

8.2 Billing Energy Meter

1. The energy meter shall be utility-grade consisting of a flow meter, supply and return temperature sensors (paired), and a calculator unit to calculate and record energy use for billing purposes.
2. All energy calculator components shall comply with EN 1434, and all components shall be factory calibrated and supplied with corresponding calibration certificates.
3. Thermal energy meters must be approved, examined, and certified as meeting requirements of Measurements Canada Weights and Measures Act and Weights and Measures Regulations.
 - Meters must contain notice of approval;
 - Certification from EN 1434 and CSA 900-1; and
 - Undergo examination from a measurement Canada authorized service provider.
4. The energy meter shall be installed on the primary side supply or return piping for each ETS.
5. The flow meter shall be ultrasonic or magnetic tube type in accordance with Section 0.

6. The temperature sensors shall be paired Resistive Temperature Detector (RTD) probes in accordance with Section 8.7 except that they shall be 4-wire type with accuracy, repeatability, and linearity not to exceed $\pm 0.15\%$ of calibrated span and the transmitter shall be calibrated for 4 wire PT 500 ohm platinum RTD input.

8.3 Flowmeters

1. Flowmeters shall have a CRN.
2. ANSI Class 150 or 300 raised face flanges conforming to ANSI B16.1.
3. Include a local display (2-line minimum) and remote configuration feature.
4. Minimum accuracy shall be $\pm 0.5\%$ of reading for velocities from 0.3 to 10 m/s.
5. Electrical power shall be 120 VAC at 60 Hz and the output signal shall be 4-20 mA.
6. Install the meter with sufficient straight piping to satisfy minimum requirements dictated by the manufacturer.

8.4 Flow Switch

1. Thermal dispersion type flow switch with CRN.
2. 316 SS wetted parts and NEMA 4 enclosure.
3. Adjustable set point between 0.003 and 1.5 m/s and an adjustable response time from 1 to 10 seconds.

8.5 Differential Pressure Transmitters

1. Differential pressure transmitters shall include 316SS wetted parts and manifold with a NEMA 4 enclosure and diaphragm isolation with adjustable internal damping.
2. The unit shall include voltage surge protection and over pressure protection to 1.5 times the design pressure.
3. The unit shall be capable of operator zero and span adjustment (positively or negatively) and include remote configuration and a local display.
4. Accuracy shall be at least $\pm 0.5\%$ of calibrated span including the combined effect of repeatability and hysteresis, and the drift (over six months) and drift (due to temperature) shall be less than $\pm 0.3\%$ and $\pm 0.5\%$ of calibrated span respectively.
5. Supply voltage shall be 24 VDC (loop powered) with a 4-20 mA output signal.

8.6 Pressure Transmitters

1. Pressure transmitters shall include 316SS wetted parts with a ½" NPT connection in a NEMA 4 enclosure.
2. The unit shall include voltage surge protection and over pressure protection to 1.5 times the design pressure.
3. The unit shall be capable of operator zero and span adjustment (positively or negatively) and include remote configuration and a local display.
4. Accuracy shall be at least $\pm 0.5\%$ of calibrated span including the combined effect of repeatability and hysteresis, and the drift (over six months) and drift (due to temperature) shall be less than $\pm 0.3\%$ and $\pm 0.5\%$ of calibrated span respectively.
5. Supply voltage shall be 24 VDC (loop powered) with a 4-20 mA output signal.

8.7 Temperature Transmitters

1. General purpose temperature transmitters shall be spring-loaded 3-wire resistive temperature detector (RTD) probes with 316 SS sheath and NEMA 4 enclosure.
2. The accuracy, repeatability, and linearity shall be to $\pm 0.25\%$ of calibrated span and the transmitter shall be calibrated for 3-wire PT 100 ohm platinum RTD input.
3. Temperature transmitters shall be installed in ½" NPT stainless steel thermowells protruding 40 to 60 percent into the pipe cross-section with an extension length equal to the insulation thickness.
4. Supply voltage shall be 24 VDC (loop powered) with a 4-20 mA output signal.

8.8 Ambient (Indoor or Outdoor) Temperature Transmitter

1. Air temperature sensors shall be wall mounted with an operating range of at least $-30\text{ }^{\circ}\text{C}$ to $50\text{ }^{\circ}\text{C}$.
2. Sensors installed outdoors shall have housing specifically designed for outdoor use.
3. Accuracy shall be at least $\pm 0.5\text{ }^{\circ}\text{C}$ at $0\text{ }^{\circ}\text{C}$.
4. Electrical power shall be 120 VAC or 24VDC and the output signal shall be 4-20 MA.

8.9 Refrigerant Leak Detection

1. The refrigerant gas detector shall be an infrared type capable of detecting all refrigerants used in the plant.
2. The detector shall have a 1 ppm resolution with a measurement range of at least 0 to 1,000 ppm and a minimum accuracy of $\pm 10\%$ of measured value.

3. The detector shall be suitable for indoor ambient conditions from 0 to 40 °C and 5% to 90% RH (non-condensing) humidity.
4. The detection system shall be certified to CSA C22.2 No. 61010-1.

8.10 Gas (CH₄ & CO) Detection

1. Wall mounted dual-gas monitor with ability to detect CH₄ and CO and shall include at least two alarm relays plus 4-20 mA output signal.
2. CH₄ detection shall have a 0.5% LEL resolution with a range of 0 to 100% LEL.
3. CO detection shall have a 1 ppm resolution with a 0 to 250 ppm range.
4. The accuracy of both sensors shall be at least ±3.0% of full scale at 25 °C.
5. The detection system shall be certified to CSA C22.2 No. 61010-1.

8.11 Local Alarm Indication

1. Local alarm indication shall include a strobe light and audible alarm in excess of 85 dBA at 3 m.
2. The indication shall be installed in the LCEP and be triggered by detection of refrigerant, CH₄, CO, or fire/smoke.
3. Provide as many strobe lights and horns/buzzers as required such that an alarm can be seen and/or heard from any location in the plant with all equipment operating.
4. Alarm indication shall also be installed outside the main plant entrance door.

8.12 Intrusion Switch

1. Provide intrusion door switches on all exterior doors, wire into PLC for alarm monitoring.

8.13 Programming and Alarms

8.13.1 Programming

1. Provide all programming required for a completely automated control system. Programming shall be as directed by LIEC.
2. Programming shall include but not be limited to Variable Frequency Drives, Programmable logic controllers, remote terminal units & energy meters.

8.13.2 Alarms

1. Programming for alarms shall include but not be limited to equipment failures, values outside normal operating parameters, fire, intrusion and power fault & failure.

9 Equipment Identification and Tagging Standards

All equipment, instrumentation, and valves shall be given a unique identification number. The proponent shall submit their proposed identification numbers to LIEC for approval. In addition, all identification numbers shall be physically affixed (tagged) to the corresponding piece of equipment for identification in the field.

All identification numbers shall correspond with the process and instrumentation diagrams. It is preferred that identification numbers and process and instrumentation diagrams conform to ISA 5.1 standard. Where equipment is installed in more than one mechanical room, it is preferred that identification numbers are grouped by location. For example, numbers in the 100-199 range would correspond to equipment located in the LCEP, 200-299 series numbers would correspond to equipment installed in the FDC, and so on for any other mechanical rooms.

9.1 Equipment

Equipment shall be clearly labelled using lamicoid labels with minimum 10 mm high white letters on black background. Tape labels are not acceptable. An equipment schedule shall be provided.

9.2 Valves

Provide engraved stainless-steel identification tags for all valves with minimum 5 mm high lettering. Tags shall be affixed with stainless steel cable or ball chain. A valve schedule shall be provided.

9.3 Instrumentation

Provide engraved stainless-steel identification tags for all instrumentation with minimum 5 mm high lettering. Tags shall be affixed with stainless steel cable or ball chain. An instrumentation schedule shall be provided.

9.4 Piping

All piping shall be provided with identification labels indicating service and flow direction. Provide markers at 2 m nominal spacing, but at least one marker per pipe run. Service identification letters should correspond with the abbreviations used in the process and instrumentation diagrams. Use vinyl cloth markers (Brady B500, B946, or equivalent) with letter heights as follows:

1. 19 to 32 mm pipe diameter: 12 mm lettering height;
2. 38 to 50 mm pipe diameter: 19 mm lettering height;
3. 65 to 150 mm pipe diameter: 32 mm lettering height;
4. 200 to 250 mm pipe diameter: 65 mm lettering height; and
5. 250 to 450 mm pipe diameter: 75 mm lettering height.

9.5 Electrical Cable Tags

All cables and wires shall be affixed with a slip-on tag indicating voltage, source and destination. Tags shall be machine printed and permanently attached to the cable or wire. Two examples of cable tag identifiers are provided for reference:

1. 600V-MCC-DS101 (600 volt cable from the MCC to Disconnect Switch 101); and
2. 24V-CP-FS101 (24 volt from Control Panel to Flow Switch 101).

9.6 Signage

Provide warning and identification signs in accordance with regulatory requirements and industry best practice. Signs shall conform to CSA Z321, ANSI Z535.1, ANSI Z535.2, and ISO Standard 3864. Signage shall include, but not be limited to, exits, fire extinguisher, fire alarm pull station, emergency stop button, and others as required.

10 Commissioning and Start-up

10.1 Commissioning Agent

The Developer shall retain the services of a third-party commissioning agent acceptable to LIEC. The commissioning agent shall have a minimum of 10 years related experience and have their CCP, CBCP, or CPMP designations. Submit the commissioning agent's qualifications to LIEC for review. Qualifications shall include related experience and at least three (3) references from previous commissioning projects.

10.2 Pre-Commissioning Requirements

Prior to commissioning, all equipment shall be tested and found to be operating normally. The manufacturer's service representative shall be present for all equipment start-up, and the manufacturer's start-up sheets shall be completed and provided in the O&M manual. Non-standard start-up sheets are not acceptable. Submit start-up sheets to LIEC.

The hydronic system shall be flushed, pressure tested, and chemically cleaned and passivated prior to commissioning. The developer shall retain the services of a chemical treatment technician for this purpose. The hydrostatic pressure test shall be to a minimum of 1.5 times the maximum system design pressure or 1,551 kPa (225 psi), whichever is greater. Submit water quality test report and hydrostatic test results to LIEC.

10.3 Commissioning Requirements

Commissioning shall be conducted in accordance with industry best practice:

1. CSA Z320.
2. ASHRAE 202.
3. ASHRAE Guideline 0.
4. ASHRAE Guideline 1.1.
5. ASHRAE Guideline 1.5.
6. NFPA 3.
7. Building Commissioning Association: Building Commissioning Handbook.
8. Building Commissioning Association: New Construction Building Commissioning Best Practices.

10.4 Mechanical Systems to be Commissioned

1. Boilers.
2. Heat pumps and Chillers.

3. Cooling towers.
4. Pumps.
5. Geothermal systems.
6. Sewage heat recovery systems.
7. Solar thermal systems.
8. Hydronic systems.
9. Natural gas systems.
10. Chemical treatment and make-up systems.
11. Energy transfer stations.

10.5 Electrical Systems to be Commissioned

1. Secondary Service Electrical Systems.
2. Motor Control Centers.
3. Distribution and Branch Circuit Panel boards.
4. Lighting Fixtures and Controls.
5. Lightning Protection Equipment and Lightning Protection Systems.
6. Equipment Monitoring.
7. Fire Alarm Equipment/Fire Alarm Equipment Monitoring System.
8. AC Motors.
9. Grounding Equipment and Building Grounding System.
10. Security System.
11. Emergency Generators and Distribution System.
12. Uninterruptible Power Systems.
13. Control Devices.
14. Electrically Actuated Valves.
15. Control Programming.

10.6 Submittals

1. Contractor shall prepare Pre-functional Checklists and Functional Performance Test (FPT) procedures and execute and document results. All Pre-functional Checklists and tests must be documented using specific, procedural forms in Microsoft Word or Excel software developed for that purpose. Prior to testing, Contractor shall submit those forms to the Owner for review and approval.
2. Contractor shall provide Owner with documentation required for Commissioning work. At minimum, documentation shall include: Detailed Start-up procedures, Full sequences of operation, Operating and Maintenance data, Performance data, Functional Performance Test Procedures, Control Drawings, and details of Owner-Contracted tests.
3. Contractor shall submit to Owner installation and checkout materials actually shipped inside equipment and actual field checkout sheet forms used by factory or field technicians.
4. Contractor shall review and approve other relative documentation for impact on FPTs of the systems:
 - i. Shop Drawings and product submittal data related to systems or equipment to be commissioned. The Subcontractor responsible for the FPT shall review and incorporate comments from the Owner and A/E via the Contractor.
 - ii. Incorporate manufacturer's Start-up procedures with Pre-functional checklists.
 - iii. Factory Performance Test Reports: Review and compile all factory performance data to assure that the data is complete prior to executing the FPTs.
 - iv. Completed equipment Start-up certification forms along with the manufacturer's field or factory performance and Start-up test documentation; subcontractor performing the test will review the documentation prior to commencing with the scheduled FPTs.
 - v. Operating and Maintenance (O&M) information per requirements of the Technical Specifications and Division 01 requirements: to validate adequacy and completeness of the FPT, the Contractor shall ensure that the O&M manual content, marked-up record Drawings and Specifications, component submittal drawings, and other pertinent documents are available at the Project Site for review.

11 Owner's Manual

For any LCEP, LIEC shall be provided with an Owner's Manual detailing various aspects of the plants design, construction, operation, and maintenance. Provide three (3) bound hard copies plus one (1) electronic copy in PDF format. The Manual shall be complete with title page, table of contents, dividers, and divided into two major sections.

11.1 Operations and Maintenance Manual

1. Manufacturer maintenance instructions, operating manuals, and spare parts lists.
2. Balancing reports.
3. Shop drawings bearing engineer's stamp and comments.
4. Water quality test reports.
5. Hydrotest, flushing, and cleaning reports.
6. Material Testing Reports.
7. Commissioning Reports.
8. System descriptions.
9. Equipment Warranties and Start-up Reports.
10. WHMIS data sheets for equipment and material where required by WorkSafe BC.

11.2 Design and Construction Documents

1. Record Drawings.
2. Specifications.
3. Process Control Narrative.
4. Equipment, valves, and instrumentation lists with corresponding unique identification tag.
5. Alarm tables.
6. Welder qualifications, welding procedures, weld map, and NDT reports.
7. Engineering Field Review Reports.
8. Performance Validation Plan.
9. BC Building Code Letters of Assurance.
10. Sealed letter from the Developer's Engineer of Record confirming that the LCES and connected Building (or Strata) mechanical systems have been designed, constructed,

and installed in full compliance with the drawings and specifications approved and agreed to in the Development Permit and subsequent Building Permit review stages.

11.3 Spare Parts

At hand-over to the LIEC, the LCES shall be furnished with all manufacturers recommended spare parts and spare fuses for all equipment.

12 Typical Equipment Schematics and Forms

12.1 Typical Equipment Installation Schematics

The following typical equipment installation schematics can be found in Appendix A:

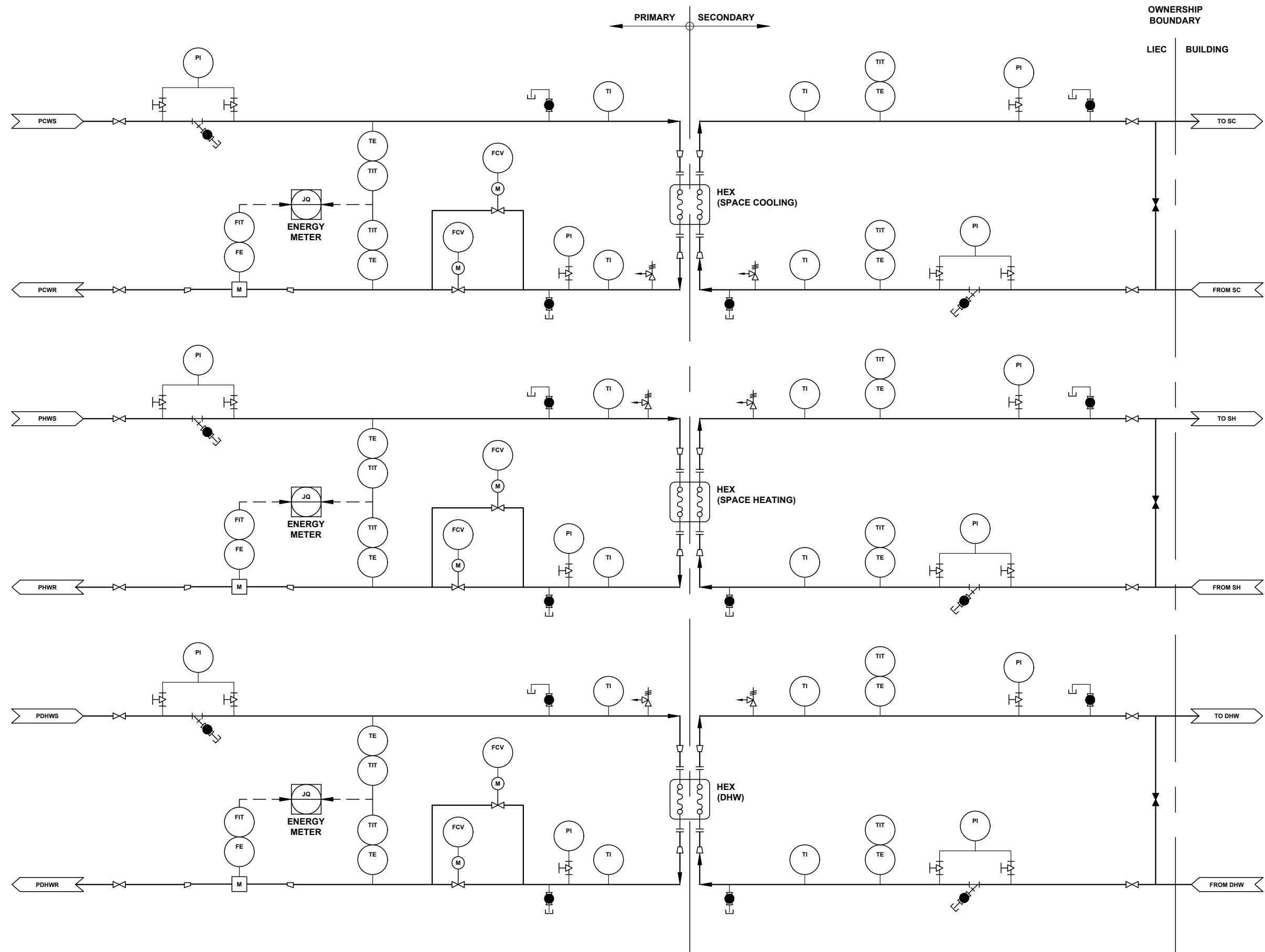
1. *Figure 1: Typical 6-Pipe ETS Schematic*
2. *Figure 2: Typical 4-Pipe ETS Schematic*
3. *Figure 3: Typical Future DEU Connection (FDC) Schematic*
4. *Figure 4: Typical Air-Source Heat Pump / Chiller Schematic*
5. *Figure 5: Typical Sanitary Heat Source Schematic*
6. *Figure 6: Typical Condensing Boiler Schematic*
7. *Figure 7: Typical Non-Condensing Boiler Schematic*

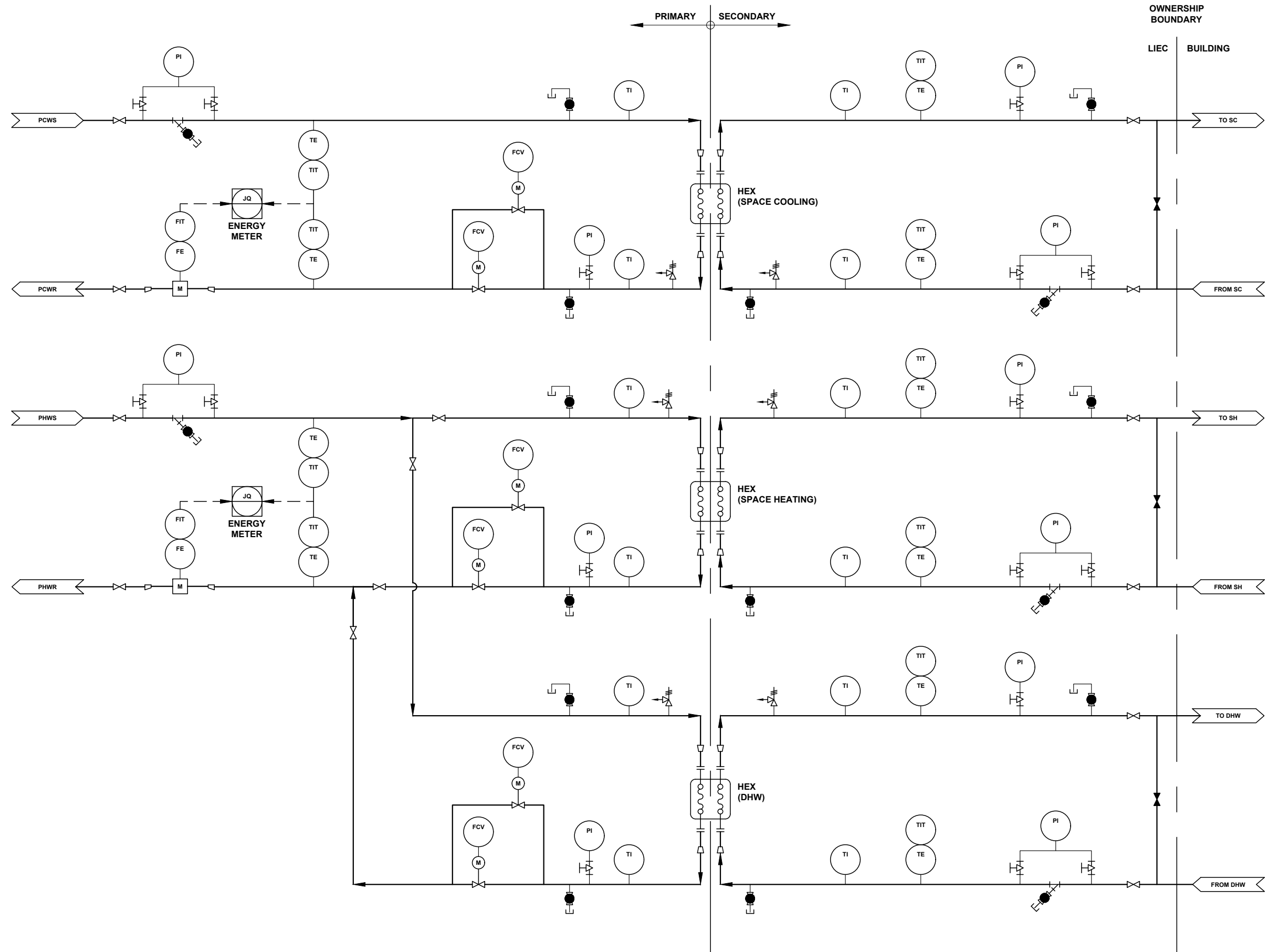
CCDEU Contact Information

For more information on the CCDEU and requirements of customer buildings, please contact:

Christopher David
Lulu Island Energy Company
Phone: 604-247-4902
Email: cdavid@luluislandenergy.ca

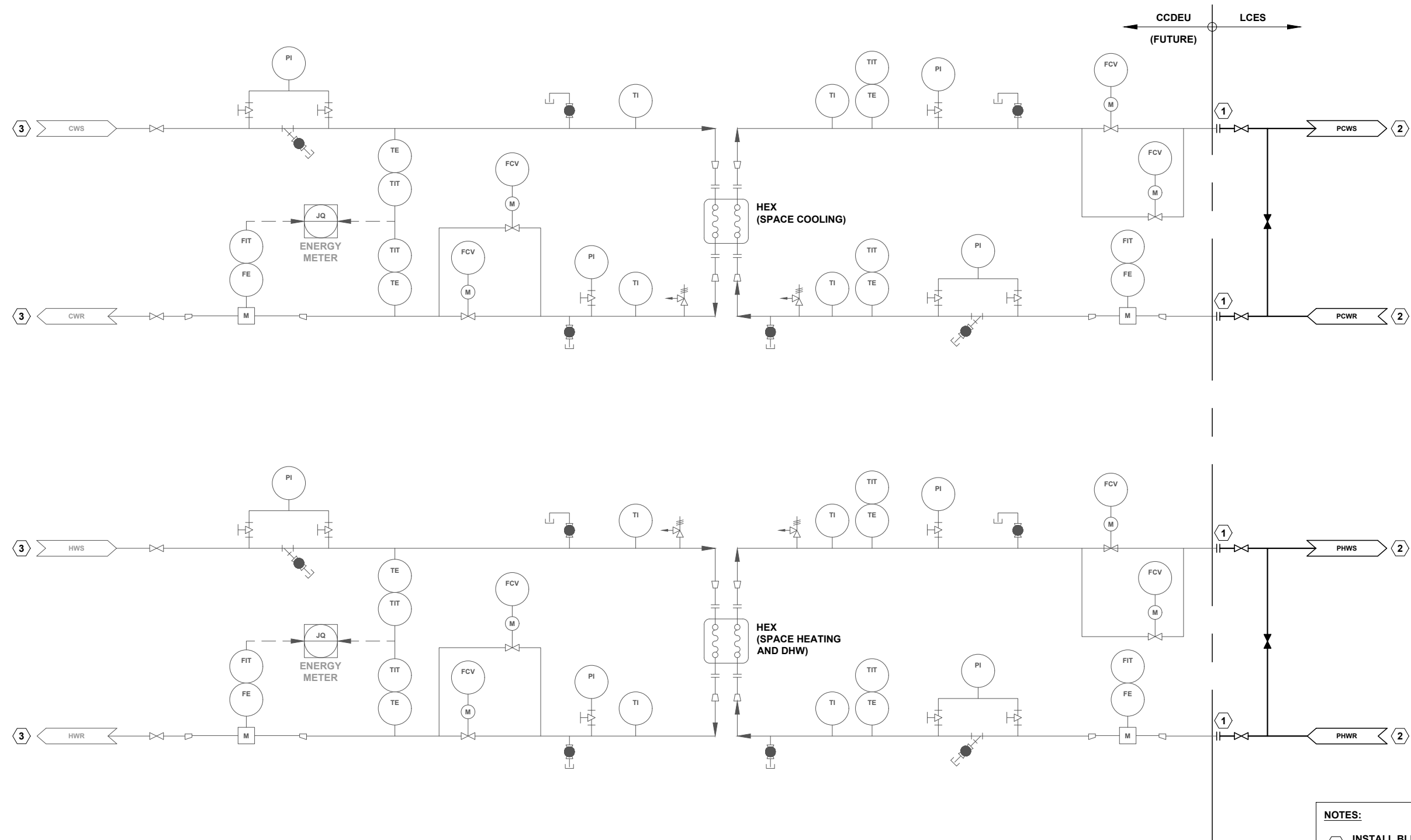
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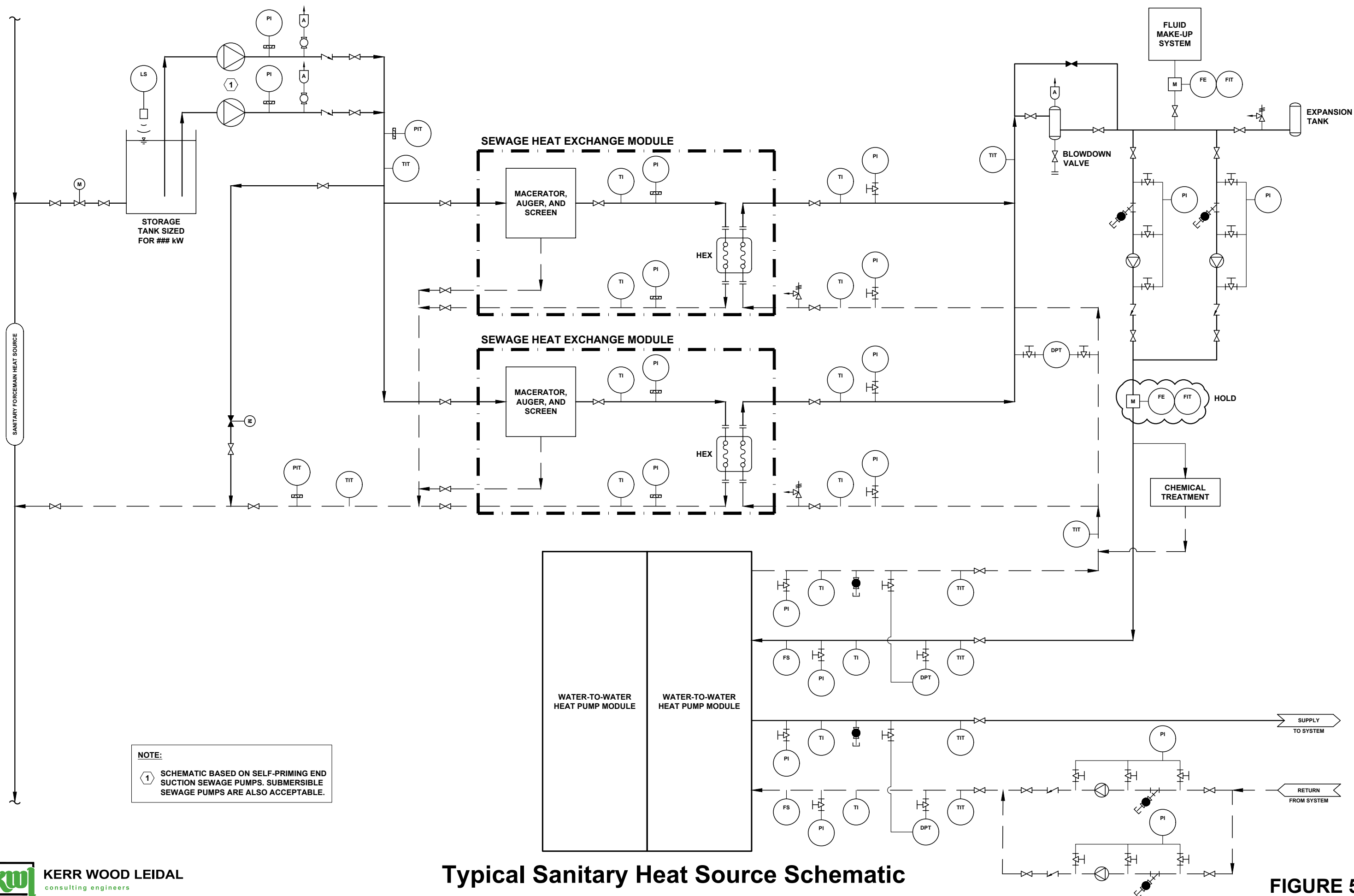


Typical 4-Pipe ETS Schematic

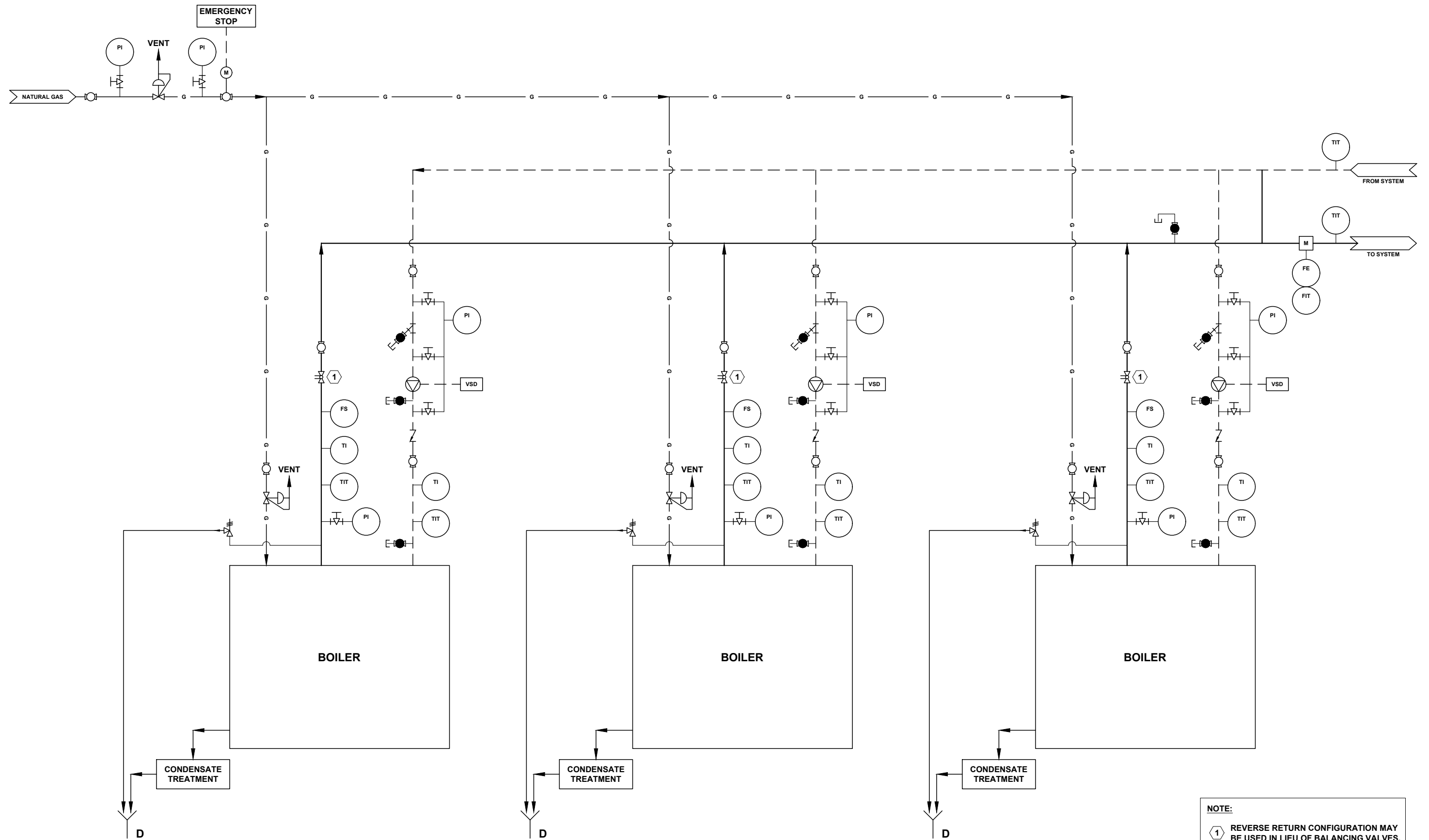
FIGURE 2



- NOTES:**
- 1 INSTALL BLIND FLANGES FOR FUTURE CONNECTION AND NITROGEN FILL.
 - 2 INSTALL FULL RUN OF PIPING TO ENERGY PLANT AND CAP JUST PRIOR TO SYSTEM TIE-IN. LINES SHALL BE NITROGEN FILLED FOLLOWING CONSTRUCTION.
 - 3 ENSURE THERE IS FEASIBLE FUTURE ROUTING FOR FUTURE CCDEU SERVICE CONNECTION. BLOCK-OUTS IN FOUNDATION WALLS AND SIMILAR MEASURES MAY BE REQUIRED.



NOTE:
1 SCHEMATIC BASED ON SELF-PRIMING END SUCTION SEWAGE PUMPS. SUBMERSIBLE SEWAGE PUMPS ARE ALSO ACCEPTABLE.



NOTE:
 1 REVERSE RETURN CONFIGURATION MAY
 BE USED IN LIEU OF BALANCING VALVES.

