corix® Utilities

Burnaby Mountain
District Energy Utility

Design Compatibility Guidelines for Connection to District Energy

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Definitions

BAS	Building Automation System
BCUC	British Columbia Utilities Commission
BMDEU	Burnaby Mountain District Energy Utility
CEP	Central Energy Plant
DE	District Energy
Delta T; ΔT	Temperature Difference
DHW	Domestic Hot Water
DHWR	Domestic Hot Water Return
DHWS	Domestic Hot Water Supply
DPS	Distribution Piping System
EC	Energy Centre
ETS	Energy Transfer Station
GHG	Greenhouse Gas
HVAC	Heating, Ventilation & Air-Conditioning
MAU	Makeup Air Unit
OAT	Outside Air Temperature
SFU	Simon Fraser University

1 Document Purpose

This document provides preliminary technical information to developers, building owners, engineers and architects to tailor their designs to integrate with a District Energy (DE) utility, thereby optimizing the benefits of the Burnaby Mountain District Energy Utility (BMDEU). Corix will work closely with developers of new buildings and their mechanical engineers to ensure good design integration between buildings and the BMDEU. The information in this document applies to all building types and uses, including residential and commercial.

2 Burnaby Mountain District Energy Utility

The BMDEU is a community based district energy system developed in cooperation between SFU Community Trust, SFU and Corix Utilities Inc. (Corix) which provides thermal energy to SFU and UniverCity for domestic hot water and space heating. The system is designed, built, owned and operated by Corix under the oversight and regulation of the BC Utilities Commission (BCUC). All customer rates are set using transparent cost of service principals and are approved by the BCUC.

The BMDEU consist of three main components:

1. **Central Energy Plant** (CEP) – the energy generation
2. **Distribution Piping System** (DPS) – the network
3. **Energy Transfer Stations** (ETS) – the interface between the building and DPS

Each of these components has its specific function and design requirements as described below.

The BMDEU provides its customers with thermal energy via hot water generated in the CEP and distributed underground through the DPS. The energy is then transferred indirectly to the buildings' space heating and domestic hot water (DHW) systems using an assembly of heat exchangers commonly referred to as an ETS. The BMDEU provides all the energy for space heating, DHW and make-up air requirements. No other heat sources are required or permitted.

2.1 Central Energy Plant

The CEP is a key component of the DE system where thermal energy is generated. The thermal energy can be produced by way of traditional energy sources (natural gas) using boilers, or by utilizing alternative energy sources, solar, such as biomass or waste heat recovery.

As with many other recent DE systems, the BMDEU is being implemented in phases. The initial load is being served by a temporary natural gas based CEP. An alternative energy source (wood-based biomass) has been approved by the BCUC and will be operational by 2019. The new permanent biomass CEP will be built to provide the full energy requirements of the UniverCity development. The alternative energy source will serve base load requirements of the system and deliver the majority of annual heating energy. Natural gas boilers will continue to provide peak heating and reliable backup capacity to ensure full and uninterrupted service to customers.

Production equipment and controls being implemented are state-of-the-art, based on the best of today's commercially proven technology. Wood-based biomass will be a primary source of energy, but other alternative energy sources will be continually evaluated in light of new advancements in technologies and evolving opportunities. The DE infrastructure is designed to accept additional renewable energy sources for thermal energy, such as solar thermal energy generated on-site at the UniverCity Childcare.

2.2 Distribution Piping System

Thermal energy is delivered to customers with a closed loop two-pipe (supply and return) hot water distribution network. The same water is heated in the CEP, distributed to the buildings, transferred at the ETS and returned back to the CEP to be reheated and distributed again. No water is drained or lost in the system, and no additional water is required during normal operation.

The DPS is composed of an all-welded, pre-insulated direct bury piping system in public streets and/or private corridors. The DPS is designed based on the size and location of customer buildings and CEPs. Distribution network modelling is completed to optimize system performance and efficiency, and to ensure that all customers will always receive sufficient thermal energy.

Variable speed pumps located at the CEP control flow through the DPS to maintain sufficient pressure and flow at every ETS. The DE supply temperature is automatically adjusted based on the outside air temperature (OAT), but is never less than 65ºC, such that it can always serve all domestic hot water (DHW) loads directly[1].

Achieving a large temperature difference (delta T; ∆T) between the BMDEU supply and return water is critical for efficient system operation. Low DE return water temperature is essential for high system efficiency and the optimal use of renewable and natural gas heat sources. DE return temperature is a function of the HVAC and DHW system performance in customer buildings; hence, it is essential for the utility to ensure that buildings connected to the system meet specific design and performance requirements.

2.3 Energy Transfer Stations

Each customer building houses an ETS that is owned and operated by the BMDEU. The key components of an ETS include:

- **DE supply and return piping**, connecting to the DPS through interior piping
- **Heat exchangers** to transfer heat to the building's hydronic heating and DHW systems
- **Control systems** to regulate and monitor the flow and temperatures required to meet the building's energy demand and regulate BMDEU return temperatures

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[1] i.e. without requiring other heat sources to supplement or elevate the temperature to meet the building's requirements.

- **Energy meters** to monitor the energy used by each customer for billing and system optimization purposes

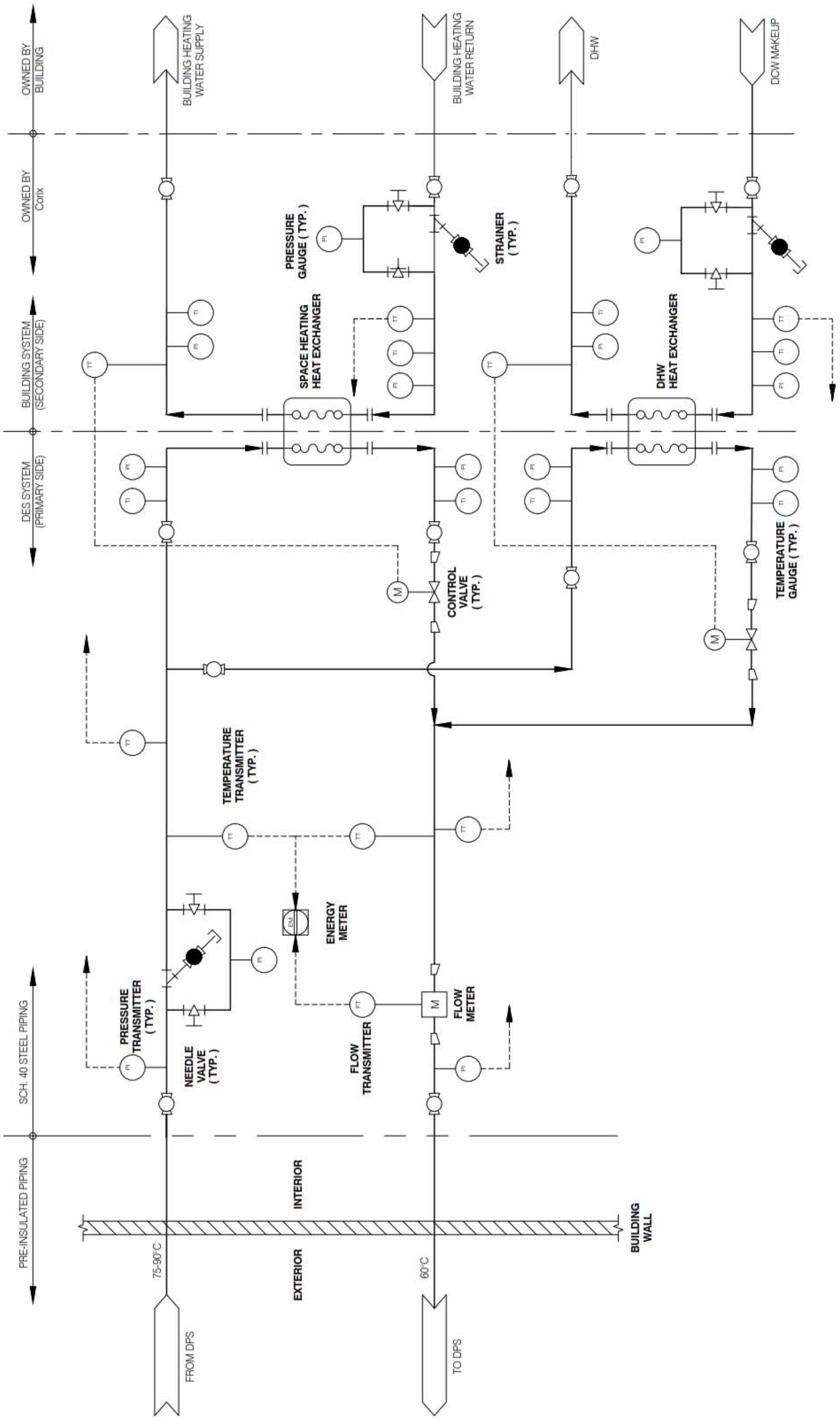
In most instances, the ETS will be prefabricated offsite, and delivered to site and installed by Corix.

As shown in Figure 1, flow through the primary (DE) side of the ETS is controlled to achieve the building's supply temperature set point.

ETS's generally have two heat exchangers: one for space heating, and a second for DHW. This is typical of most hot water DE systems around the world. There is a vast amount of experience and data regarding DE performance and reliability with this configuration, and it is also the most efficient for space and cost. Heat exchangers are very reliable (with no moving parts) and it is not necessary to have redundant units in an ETS since it is very unlikely to have a fault or complete failure with a heat exchanger.

Corix is able to repair or replace any damaged equipment quickly and on short notice if any issues arise. It is important to note that a leaking or faulty heat exchanger can often continue to supply heat, and the repair/replacement can be scheduled for a convenient, low demand period. Ultimately, Corix will be responsible for the cost, maintenance and reliable operation of the ETS, including the heat exchangers.

FIGURE 1: TYPICAL ETS FLOW SCHEMATIC



3 Responsibilities of the Developer and BMDEU

The following section outlines the responsibilities of the developer and Corix to ensure efficient and seamless integration of DE service.

3.1 Developer's Responsibility

3.1.1 HVAC System

The building developer is responsible for designing and installing the building HVAC systems. There are some differences and similarities with conventional systems, as explained below.

The following conventional building elements are <u>not required</u> for HVAC systems using DE:

- Boilers, furnaces, fireplaces, heat pumps, domestic hot water heaters, electric baseboards, or any other heat production equipment
- Auxiliaries to heating systems such as stacks and breeching
- Natural gas service[2]

The building will require internal thermal distribution systems, including:

- Internal distribution pumps and piping (i.e. a hydronic space heating distribution loop)
- Heating elements such as fan-coil units, air handling units, and/or perimeter (baseboard) or in-floor radiant heating systems

The following are some design conditions that are specific to DE:

- The BMDEU branch lines from the DPS enter the building, similar to other underground utilities, and connect to the ETS via interior piping. There are two DE pipes (supply and return) and a 2" communications conduit that will connect from the DPS to the ETS.
- The building owner and Corix shall agree on a suitable location for the ETS. The ETS invariably requires less space than comparable heat production equipment (e.g. boilers) that it replaces. To reduce the amount of BMDEU piping inside the building, the ETS should be located as close as possible to the BMDEU branch pipeline entering the building – generally on an exterior wall in the basement or ground floor of the building, nearest to the main street that houses the DPS main line.
- No housekeeping pad is required for the ETS
- The BMDEU operates most effectively and efficiently with the use of low temperatures in the building heating systems.
- The BMDEU will provide thermal energy for space heating and domestic hot water only.
- Section 4 on page 12 discusses specific requirements of the hydronic space heating and DHW systems for compatibility with hot water district energy system

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[2] *Natural gas service may still be required for range use in individual customer suites.*

- Corix reviews the HVAC and plumbing design of each building, but is not responsible for the design of the building system (which is executed by the developer). Corix may make suggestions as necessary to ensure appropriate integration with the BMDEU.

3.1.2 Installation and Operation Contract Boundary

The customer is responsible for all piping and other components necessary to connect the hydronic heating and DHW systems to the ETS at the agreed demarcation point for the service boundary on the secondary side of the heat exchangers. This demarcation point will be clearly marked on the BMDEU engineering drawings for the ETS. A typical example is shown in Figure 1 on page 5.

The customer is responsible for pressure testing, flushing and chemically cleaning all building piping connected to the ETS prior to opening the valves to the ETS at the service boundary. The customer typically installs normally closed bypasses just before the ETS connection to accommodate the flushing and cleaning.

3.1.3 Sub-Metering

Customers may install energy meters on individual units, suites or sub-systems within the heating and/or DHW systems in their building. These sub-meters are the sole responsibility of the customer, and will not affect the obligation of the customer to pay the BMDEU bill based on Corix's thermal energy meter (part of the ETS) for the whole building. If a customer decides to use sub-meters, it is recommended that they be used for allocation of total building thermal energy only.

3.1.4 Preparation of Building for DE Service

All customers will provide suitable space for the installation of the ETS, including space for service lines and interconnecting piping in a mechanical room in an agreed-upon location. The ETS should generally be located at an exterior wall facing the street, in the basement or ground level.

The following items must be provided by the customer for the installation of the ETS:

- The ETS room shall be ventilated and maintained at a temperature between 10ºC and 35ºC.

- The ETS room will require a double wide door to allow for installation of a prefabricated ETS (typical maximum dimensions are 4.11m L x 1.83m W x 2.13m H), and access to the room to accommodate these dimensions. **A housekeeping pad is not required**.

- A floor drain connected to the sanitary sewer system shall be provided in the ETS room within 1.0m of (not underneath) the ETS.

- One dedicated 25mm domestic water source with hose bib connection shall be made available inside the ETS room.

- A dedicated 15A, 120V 60 Hz single-phase electrical service, with a lockable breaker (lockable in the "on" position), is required to power the ETS control panel and shall be provided by the customer.

- A minimum 1.0m of clearance is required on the front and control panel side of the ETS and 300mm on the other two sides when it is placed in its final location.

- Outside air temperature (OAT) sensor: one dedicated 20mm (3/4") EMT conduit (c/w pull string and #18 AWG TP Stranded 600V cable) from mechanical room to a serviceable location (to be approved by Corix) on the north facing outside wall for the OAT sensor. Architect and/or Mechanical consultant to determine the appropriate routing of the conduit, and to include in drawings for building contractors. The conduit provided must be sufficient, by Code to overcome resistance by distance for wire pulls. Sensor will be supplied and installed by Corix, associated conduit and wiring to be done by building contractor. (See attached Electrical Field Wiring Scope of Work and Corix Outside Air Temperature Sensor - Installation Requirements). Building contractor to work with Corix to ensure the exterior detail is not compromised and meets Architectural detail requirements. A transition mounting box will be supplied and installed by Corix.

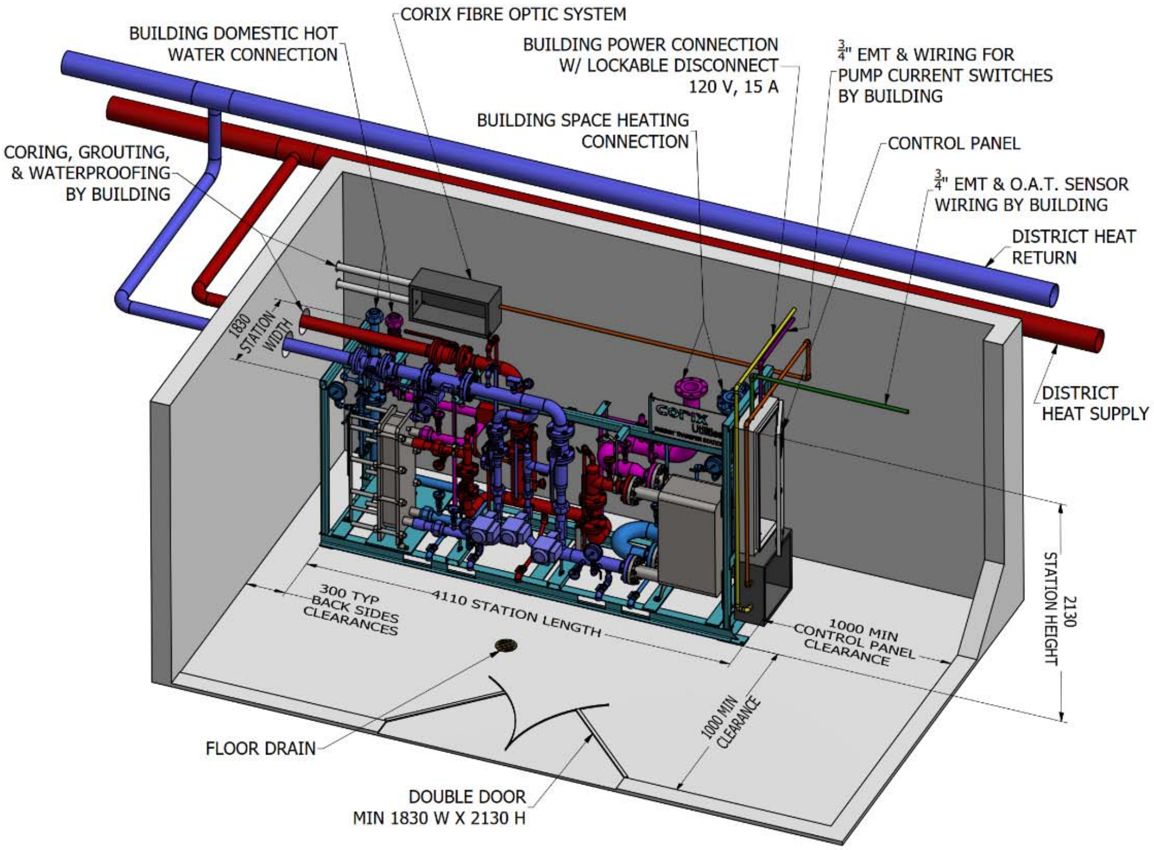
- Current transducers (CTs) to provide on/off pump status for each pump that delivers flow through the ETS for space heating and/or domestic hot water. Building contractor to provide all associated dedicated conduit, wiring and CTs between pump motors and the ETS control panel. See attached Electrical Field Wiring Scope of Work.

- Certification under seal from the building engineer in letter format confirming the building system has been designed, constructed and installed in full compliance with the specifications approved and agreed to in the Final Thermal Energy Deliver Parameters schedule. The flushing and cleaning reports must accompany the letter.

The footprint of an ETS depends on a number of factors, including customer load, number of heat exchangers, pipe size, configuration of the hydronic heating and DHW systems, and specific restrictions within the customer building. Generally, a typical ETS will not be larger than 4.11m L x 1.83m W x 2.13m H, and will have only one heat exchanger for space heating, one for DHW and a single energy meter for the entire ETS.

Prefabricated skids are typically designed to fit through double doors into the mechanical room. The exact size and location of the prefabricated ETS will be established by the customer and Corix during the design process. Figure 2 below shows a typical ETS located near the DPS underground piping in the street.

FIGURE 2: TYPICAL ETS INSTALLATION IN BUILDING BASEMENT



The customer is responsible for the DE service line building or foundation penetration, which meets Corix's requirements (size of opening, etc.), in a mutually agreeable location. Corix will mark the location for the penetration during construction, but relies on the building contractor to provide the core holes and complete all sealing and waterproofing around the piping once the piping is brought through the core holes. Corix is not responsible for maintaining such waterproofing. Penetrations may be core drilled (after foundation construction) or sleeved (during foundation construction). Since the alignment of the underground piping may need to change slightly during construction it is recommended to core holes instead of using knockouts or sleeves.

Corix will also install one or more (typically two,) 50mm plastic (PVC or HDPE) conduits into the customer building to facilitate communications with the ETS through a fiber-optic network. Communication allows for remote monitoring of the ETS, as well as remote reading of the energy meter. The customer is also responsible for providing and maintaining the penetration for communication conduit(s). A single conduit run will be required to follow any interior piping run to the ETS location form the building penetration location.

Corix will require uninterrupted access to the ETS and service line within a customer's building for installation, regular maintenance and repairs. This is defined by a BMDEU service agreement with Corix and Statutory Rights of Way document.

3.1.5 Hydronic Heating Water Quality & Expansion

Building owners are responsible for filling and managing their own building hot water heating system. The BMDEU requires that water treatment for the building system meet the minimum criteria set forth below:

Chloride:	< 30 ppm
Nitrate:	< 5%
Hardness:	< 2 ppm
pH Level:	9.5-10
Iron	< 1 ppm

The customer shall employ the services of a water treatment subcontractor to provide the necessary chemicals, materials and supervision for a complete cleaning and flushing of all piping to the ETS demarcation point. ETS start-up and commissioning will only occur after acceptable water quality analysis results have been obtained. Certification from the water treatment contractor verifying that the water quality is adequate is required before the customer can flow water through the ETS.

Building owners will manage the expansion of water in their respective hydronic hot water system(s).

3.1.6 Changes to the Building System

The Customer shall not materially change the design or substitute any pertinent equipment during installation without Corix's approval. After commissioning, any changes to the building's hydronic or DHW system that may impact the BMDEU performance shall be reported to Corix.

The ETS is owned and maintained by Corix. Under no circumstances is the customer or any of its contractors permitted to adjust, modify or otherwise tamper with any ETS equipment. This includes adjusting or changing the position of any valves, gauges or instruments and altering the controls and control panel.

3.2 BMDEU Responsibility

3.2.1 BMDEU Equipment within Customer Buildings

Corix designs, installs, operates and maintains the ETS at the agreed-upon location, as well as the primary (DE) distribution pipes to the ETS. Branch pre-insulated pipelines are generally direct buried from the mainline to the building penetration. From that point, DE piping runs inside the building to the ETS.

Corix provides strainers on the DE and building side at each heat exchanger in the ETS, which are routinely inspected. Corix services the energy metering equipment and verifies accuracy at regular intervals per manufacturer recommendations.

Corix provides temperature transmitters, pressure gauges, temperature gauges, thermowells, control valves, energy meters, and a control panel for the ETS. Temperature transmitters for the secondary side of the heat exchangers are also provided to facilitate monitoring and control of building side heating and DHW systems.

3.2.2 District Energy Side Water

The BMDEU provides all make-up water requirements for the DE system side. All necessary water treatment is accomplished at the CEP. Thermal expansion of water in the DE system is accommodated at the CEP.

3.2.3 ETS Commissioning

Corix, together with the developer or building operator, will start and commission the ETS. Commissioning includes verifying measurement points and testing the controls under various operating modes. The building operator is required for this process as the building internal hot water system must be ready to accept heat from the BMDEU. Corix is responsible for commissioning all components up to the DE service demarcation point.

4 Requirements for Building HVAC and DHW Systems

This section summarizes technical requirements for hydronic heating and domestic hot water systems for new developments at UniverCity. The information provided in this document should be regarded as a general guideline only, and the developer's Engineer shall be responsible for the final building-specific design. Corix will provide technical assistance to developers to improve integration of the customer building with the BMDEU. Heating system schematics, layouts, equipment schedules and sequence of operation or control strategies are required to assist in the BMDEU review process.

4.1 Design Strategies

The following table identifies the key elements or strategies that should be followed when designing the building heating system.

Strategy:	**Rationale:**
Centralized hydronic system	• Water has four times the specific heating capacity of air • Benefits from system load diversification • Reduces utility interconnect costs • Minimizes noise from mechanical systems
Low[3] supply temperatures	• Improves DE efficiency • Allows use of lower grade energy sources
Large temperature differentials	• Reduce piping capital cost • Reduce pumping capital & operating costs
Variable flow with variable frequency drives	• Reduces pumping operating costs • Improves system control
Two-way control valves	• Necessary to achieve variable flow and a large temperature differential
Seasonal reset of supply temperatures	• Improves energy efficiency • Improves system control

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[3] "Low" relative to traditional building HVAC design, which is typically 80°C or more on the building side of the ETS. The BMDEU is referred to as a "medium" temperature water system since it supplies water from 65°C up to 95°C and needs to be higher than the building side temperature.

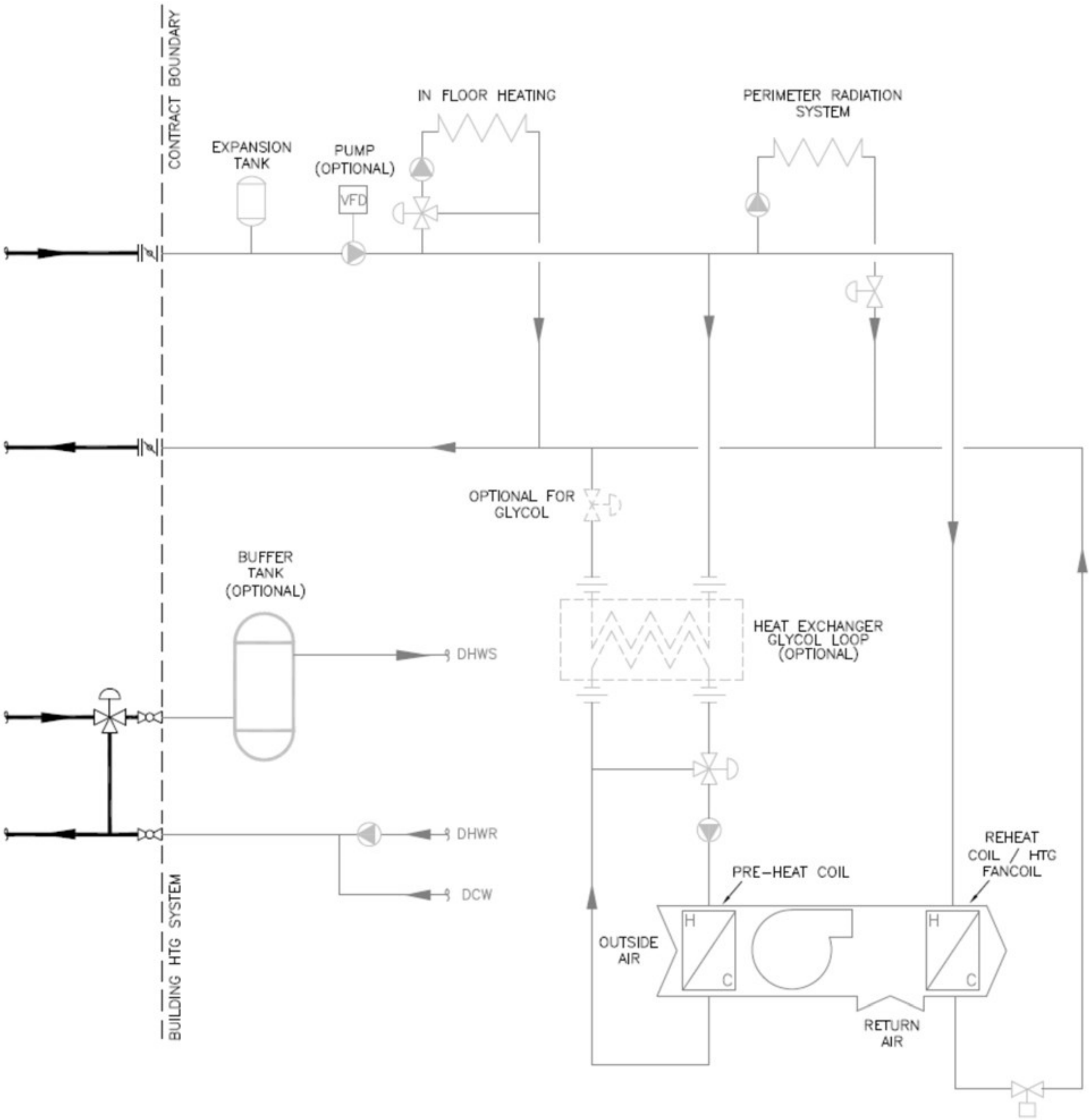
Return temperature limiting	• Improves energy efficiency
Direct Digital Control System	• Allows more accurate control and greater control flexibility • Potential opportunities for energy savings
Night setback settings & recovery times	• Minimize equipment sizes by allowing reasonable recovery times • Maximize recovery times from unoccupied to occupied mode

4.2 Pumping and Control Strategy

The building hydronic heating system shall be designed to maximize ∆T and minimize hot water return temperatures over all conditions.

The building heating system should be designed for variable hydronic flow (preferably with variable speed pumps to minimize pumping energy), using 2-way modulating (or on/off) control valves at terminal units (radiators, fan coil units, etc.). Alternatively, 3-way mixing valves at terminal units may be used. Bypass valves (e.g. 3-way bypass valves) are not permitted. See Figure 3 below for typical hydronic heating system configurations.

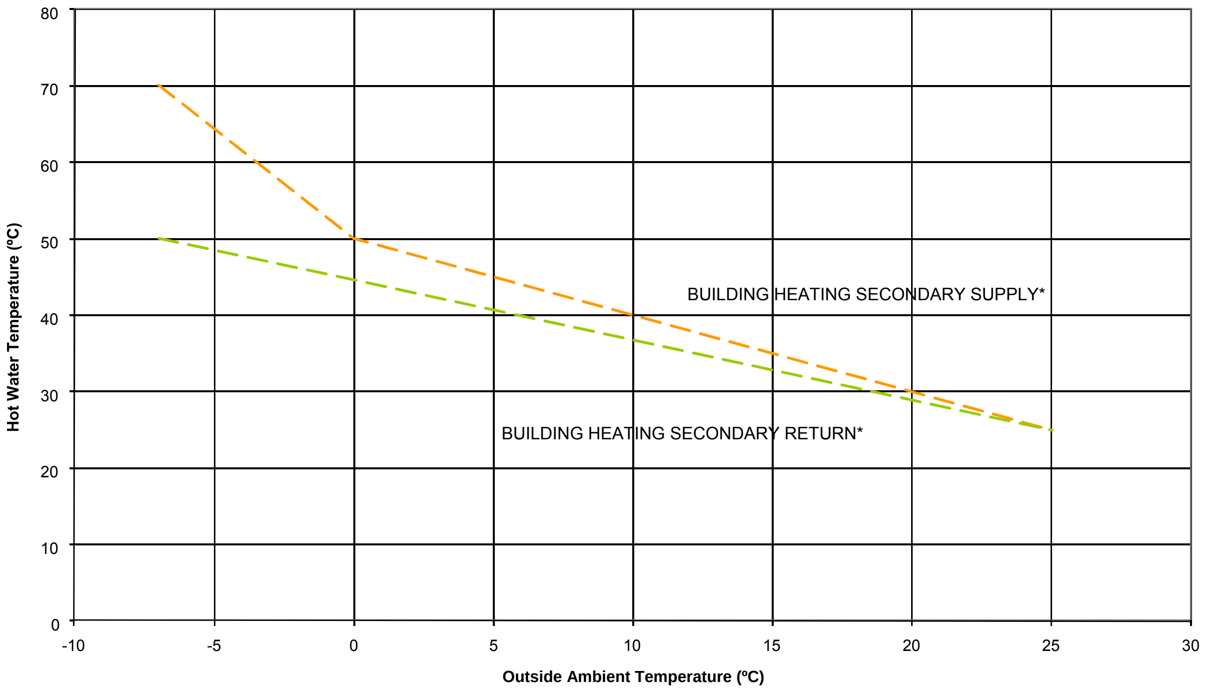
FIGURE 3: TYPICAL BUILDING HEATING SYSTEMS



4.3 Hydronic Heating and DHW System (Minimum) Requirements

Optimization of the hydronic heating system temperature difference or ΔT is critical to the successful operation of the BMDEU. The ETS controls the supply water temperature to the hydronic circuit (i.e. the temperature of the water leaving the space heating heat exchanger) based on an outside air temperature reset schedule. This is the maximum temperature available to the building hydronic circuit. A sample hydronic heating circuit supply and return temperature reset curve is shown in Figure 4 below.

FIGURE 4: TYPICAL TEMPERATURE RESET CURVE FOR VANCOUVER



* - Space heating only, direct primary DHW heating with Max. 60ºC DHWS

4.3.1 Hydronic Space Heating

The hydronic heating system shall be designed to provide **all** space heating and ventilation air heating requirements for the whole building, supplied from a central ETS. Gas-fired or electric resistance heating or ventilation equipment (roof top units, air handling units, electric coils, electric baseboards, etc.) are not permitted, unless approved by Corix when hydronic heating is not deemed feasible, or is prohibited by a building code.

Hot water generated by the ETS is distributed via a 2-pipe system to the various heating elements (terminal units) throughout the building. The building (secondary) heating system **must** be designed for temperatures no greater than those specified below.

Hydronic Space Heating System Temperatures (Building Side)

	Peak Winter	*Summer*
Supply Temperature, **Max.**	70°C (158ºF)	45°C (113ºF)
Return Temperature, **Max.**	50°C (122ºF)	40°C (104ºF)
Min. Difference (∆ T)	20°C (36ºF)	5°C (9ºF)
Design Pressure	≤1600 kPa	≤1600 kPa

Domestic Hot Water Heating System Temperatures (Building Side)

	Winter	*Summer*
Supply Temperature (with storage), **Max.**	60°C (140ºF)	60°C (140ºF)
Supply Temperature (no storage), **Max.**	55°C (131ºF)	55°C (131ºF)

The specified temperatures shall be regarded as maximum requirements; lower temperatures are desirable. The building return temperatures should be minimized to allow the BMDEU to take advantage of alternate energy technologies.

Specific types of heating systems (i.e. terminal units) can operate at lower temperatures. The terminal units must be selected based on temperatures as low as can be reasonably expected. The table below outlines **maximum** hot water supply (HWS) and hot water return (HWR) temperatures for which terminal units should be designed and selected.

Type of Terminal Unit	**Maximum HWS**	**Maximum HWR**
Radiant in-floor heating	50ºC (122ºF)	38ºC (100ºF)
Perimeter radiation system	70ºC (158ºF)	50ºC (122ºF)
Fan coil units & reheat coils[4]	70ºC (158ºF)	50ºC (122ºF)
Air handling pre-heat coils[5]	65ºC (149ºF)	45ºC (113ºF)

4.3.2 Domestic Hot Water

The Domestic Hot Water (DHW) system shall be designed to provide all DHW requirements for the building, supplied from a dedicated DHW heat exchanger from the ETS. It is understood that DHW systems require supply temperatures as high as 60ºC (140ºF); the BMDEU is able to supply this temperature to all buildings at all times.

DHW systems should be designed in a semi-instantaneous configuration. In a semi-instantaneous system, the storage capacity is small. In such a system, storage tanks act as "buffer tanks" only; there is no recirculation from DHW storage tanks directly back to the heat exchanger.

For smaller DHW loads, the instantaneous configuration without storage tanks can be discussed and agreed upon between the developers engineer and Corix. This configuration allows for lower

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[4] Unit heaters and forced flow heaters should follow the fan coil design criteria.

[5] Make-up Air Units (MAU) should follow the air handling pre-heat coil design criteria.

DHW supply temperature (≤ 55ºC / 130ºF) and would result in the greatest capital, maintenance cost and space allocation savings.

All domestic cold water (DCW) should enter the DHW system immediately before the ETS heat exchanger. Reducing storage capacity and recirculation requirements results in space and cost savings. Capital costs for the system are lower, maintenance requirements are reduced, and replacement costs when equipment reaches end of life are lower. With less storage capacity, the DHW has shorter residence time in the building, reducing the chance of bacteria growth such as Legionella.

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