corix® Utilities

Neighbourhood Utility Service at UniverCity

Design Guidelines for Connection to District Energy

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Definitions

BAS	Building Automation System
CEP	Central Energy Plant
DE	District Energy
Delta T; ΔT	Temperature Difference
NUS	Neighbourhood Utility Service
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	Outdoor Air Temperature

1 Document Purpose

This document provides preliminary technical information to developers, building owners, engineers and architects to tailor their designs to DE conditions, thereby optimizing the benefits of the Neighbourhood Utility Service (NUS). Corix will work closely with developers of new buildings and their Heating, Ventilation & Air-Conditioning (HVAC) engineers to ensure good design integration between buildings and the NUS. The information in this document applies to all building types and uses, including residential and commercial.

2 Neighbourhood Utility Service at UniverCity

The NUS at UniverCity is a community based thermal energy system developed in cooperation between SFU Community Trust and Corix Utilities Inc. (Corix). The system is designed, built, owned and operated by Corix under the oversight and regulation of the BC Utilities Commission (BCUC). The customer rates are set using a transparent cost of service model and are approved by the BCUC.

The utility provides its customers with thermal energy generated by the NUS and transferred to the building heating system via heat exchangers located in each building. The NUS provides all space heating, domestic hot water and make-up air requirements. A detailed description of all NUS components is provided in the following sections.

Thermal energy will be initially generated using natural gas to serve initial customers on the system, and will be ultimately switched to an alternative renewable energy source expected to be implemented in 2016-2017.

3 The NUS

NUS Description

Neighbourhood Utility Service at UniverCity, is a system that distributes thermal energy in the form of hot water from a central energy plant through a network of buried piping to individual customer buildings. The NUS interfaces indirectly via heat exchangers with the buildings' space heating and domestic hot water systems. No other heat sources are required.

The NUS consist of three main components:

- Central Energy Plant – the energy generation
- Distribution Piping System, – the network
- Energy Transfer Stations – the building interface

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

3.1 Central Energy Plant (CEP)

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, such as biomass or waste heat recovery.

As with many other recent DE systems, the UniverCity NUS is being implemented in phases. The initial load is being served by a temporary natural gas based CEP, an alternative energy source (woody biomass) is expected to be introduced when justified by system development and as approved by the BCUC. The new permanent biomass CEP will be built to provide 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. Woody biomass will be a primary source of energy , but other alternative energy conversion technologies will be continually evaluated in light of new opportunities and changing circumstances. The DE infrastructure is designed to facilitate the future use of new renewable energy sources for thermal energy at UniverCity.

Prior to final commissioning of any new connected building, the NUS will be capable of serving 100% of its thermal energy requirements from either temporary or permanent energy supply facilities.

The NUS will have a higher level of reliability than is generally found in standalone heating systems in individual homes or commercial and multi-use residential buildings.

3.2 Thermal Distribution Piping System (DPS)

Thermal energy is delivered to customers with a closed loop two-pipe hot water distribution network: the same water is heated in the CEP, distributed to the buildings, through the ETS, and returned back to the CEP to be reheated and redistributed. 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 CEP's. 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 outdoor 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 NUS supply and return water is crucial to system operation. Low DE return water temperature is essential to system efficiency and the optimal use of renewable and low-grade heat sources. DE return temperature is a function of the HVAC and DHW systems in customer buildings; hence, it is essential for the utility to ensure that buildings connected to the system meet performance requirements.

3.3 Energy Transfer Stations (ETS)

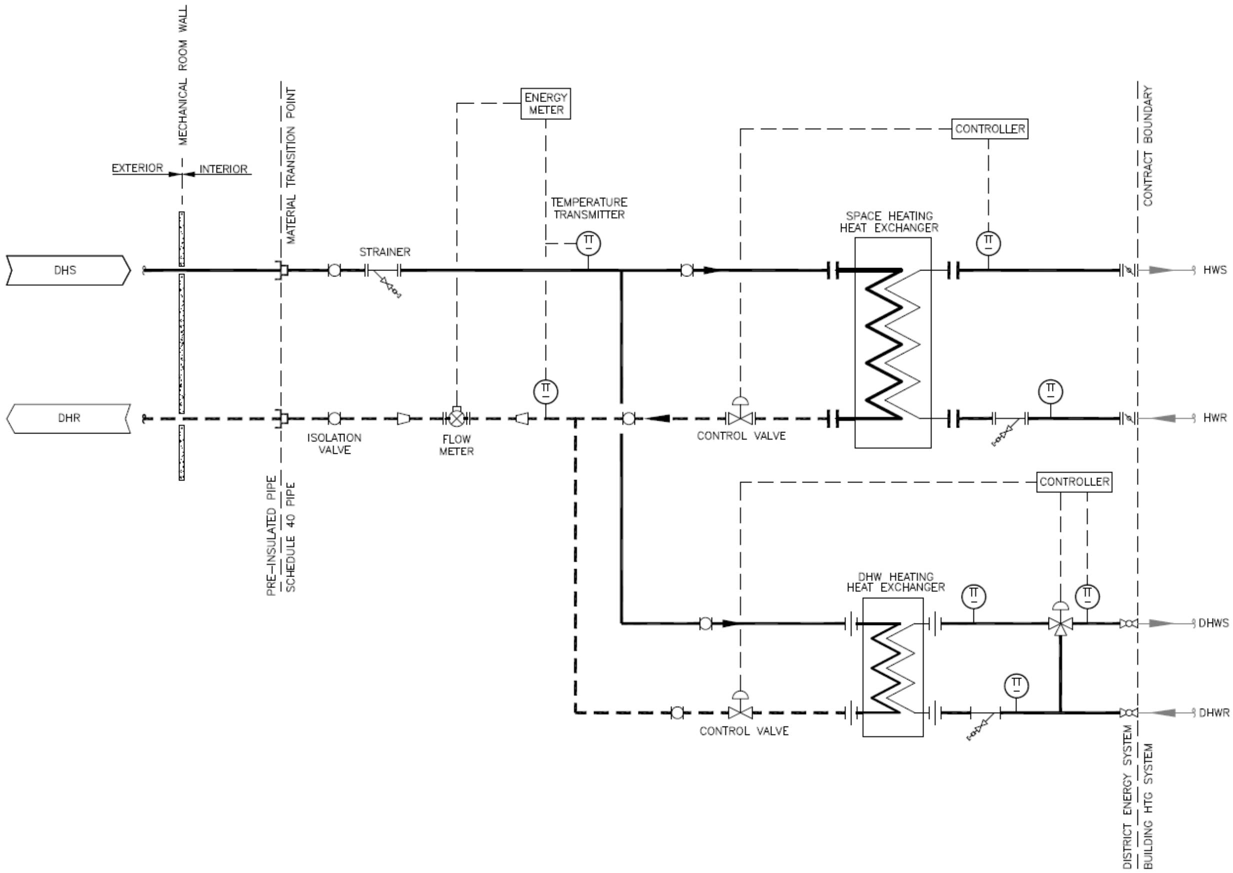
Each customer building houses an ETS that is owned by the NUS. The key components of an ETS include:

- DE supply and return pipes from the building penetration (interface with distribution system);
- Heat exchangers to transfer heat to the building's hydronic heating and DHW systems;
- Controls to regulate the flow required to meet the building's energy demand and maintain NUS return temperatures; and,
- Energy meters to monitor the energy used by each customer for billing and system optimization purposes.
- Whenever possible the ETS will be prefabricated by the NUS and delivered to site, to be installed by the NUS.

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

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

FIGURE 1: TYPICAL ETS FLOW SCHEMATIC



ETS's generally have two heat exchangers: one for space heating, and a second to directly serve DHW. This is typical of most hot water DE in North America and around the world. There is a vast amount of experience and data regarding DE performance and reliability with this configuration. Heat exchangers are very reliable (with no moving parts) and it is not necessary to have redundant units in an ETS. Though very unlikely, Corix will be able to repair or replace a faulty heat exchanger quickly and on short notice. 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.

An ETS with redundant heat exchangers is more costly and requires more space in the customer building. The customer will have to provide this additional space in the mechanical room. Ultimately, Corix will be responsible for the cost, maintenance and reliable operation of the ETS, including the heat exchangers.

4 Responsibilities of Customer and NUS

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

4.1 Developer's Responsibility

4.1.1 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 not required for HVAC systems in customer buildings:

- Boilers, furnaces, 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:

- Customer buildings host service connection lines from the DPS. The NUS branch lines enter the building, similar to other utilities, and transfer heat to the ETS.
- The building owner and Corix 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 NUS piping inside the building, the ETS should be located as close as possible to the NUS branch pipeline entering the building – generally on an exterior wall in the basement or ground floor of the building, nearest to the main street.
- The NUS operates most effectively and efficiently with the use of low temperatures in the building heating systems.

The NUS will provide thermal energy for heating and domestic hot water only.

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

Section 4 on page 12 discusses specific requirements of the hydronic space heating and DHW systems for compatibility with hot water district energy system.

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 NUS.

4.1.2 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 NUS engineering drawings for the ETS. A typical example is shown in Figure 1 on page 6.

4.1.3 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 NUS bill based on Corix's thermal energy meter (part of the ETS) for the whole building. Sub-meters are generally not utility grade and therefore less accurate. If a customer decides to use sub-meters, it is recommended that they be used for allocation of total building thermal energy only.

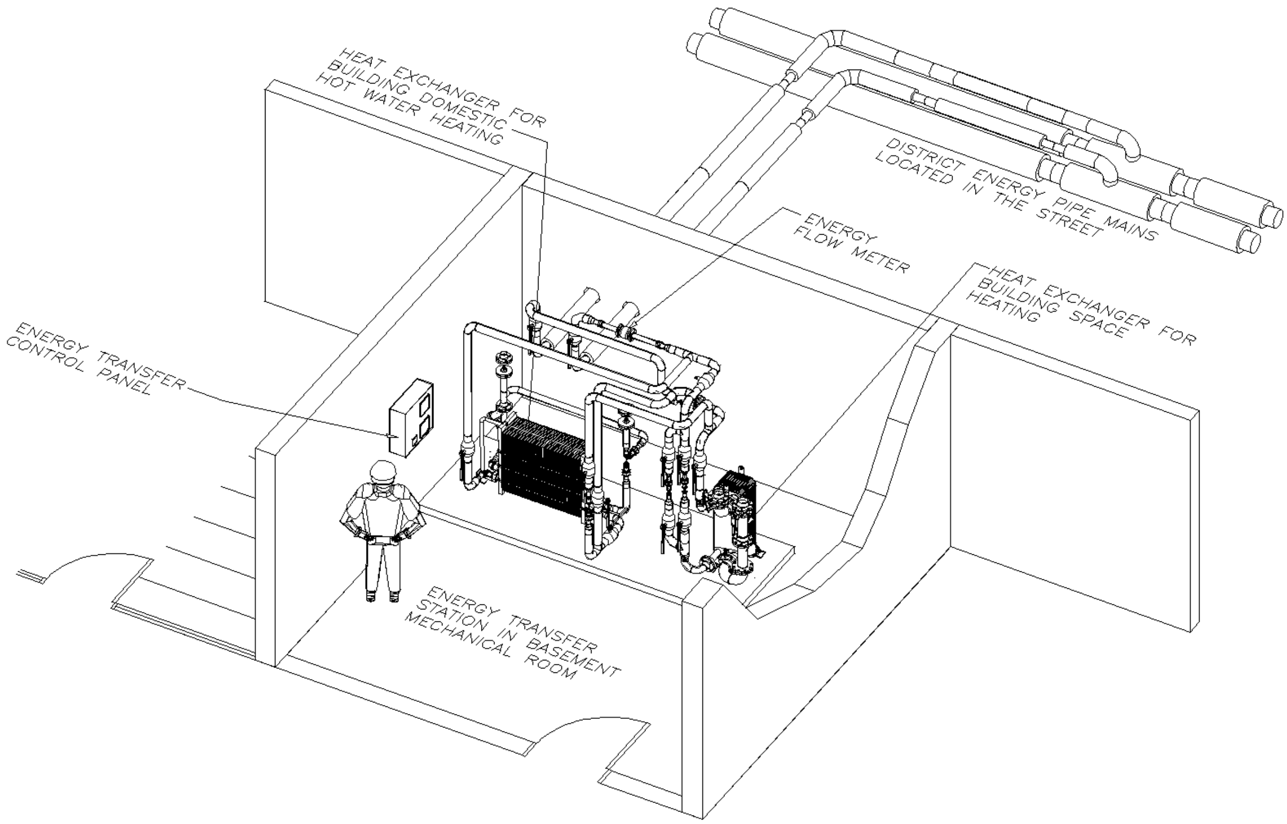
4.1.4 Preparation of Building for DE Service

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 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 the prefabricated NUS skid. A floor drain connected to the sanitary sewer system should be provided in the ETS room, as well as a domestic water source. A dedicated 15A 120V electrical service, with a lockable breaker, is required to power the ETS control panel. Allowance should be made in the Building Automation System (BAS), if one exists, to provide heating pump on/off status to the ETS control panel. If a BAS is not planned for the building, the NUS will directly monitor heating pump on/off status via a hardwire connection. As well, one 20mm electrical metallic tubing (EMT) conduit from the ETS room to a north facing exterior wall is required for the outdoor air temperature (OAT) sensor wiring.

The footprint of an ETS depends on a number of factors, including customer load, number of heat exchangers, configuration of the hydronic heating and DHW systems, and specific restrictions within the customer building. Generally, a typical ETS requires between 4 and 10 m^2 of floor space, with a minimum ceiling height of 2.7 m. The 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 mains 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 produce a penetration drawing during the detailed design stage. Penetrations may be core drilled (after foundation construction) or sleeved (during foundation construction). Corix will install the DE service line; however, as with other utilities, the customer is responsible for providing and maintaining the penetration.

Corix may also install one or more plastic (PVC or HDPE) conduits into the customer building to facilitate remote communication with the ETS. 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).

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 NUS service agreement with Corix and Statutory Rights of Way document.

4.1.5 Hydronic Heating Water Quality & Expansion

Building owners are responsible for filling and managing their own building hot water heating system. The NUS 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).

4.1.6 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 NUS 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.

4.2 NUS Responsibility

4.2.1 NUS 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 cleaned as necessary. 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 the building side heating and DHW systems.

4.2.2 District Energy Side Water

The NUS provides the 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.

4.2.3 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 NUS. Corix is responsible for commissioning all components up to the DE service demarcation point.

5 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 NUS. Heating system schematics, layouts, equipment schedules and sequence of operation or control strategies are required to assist in the NUS review process.

5.1 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.
Return temperature limiting	• Improves energy efficiency.

[3] "Low" relative to traditional building HVAC design, which is typically 80°C or more on the building side of the ETS. The NUS 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.

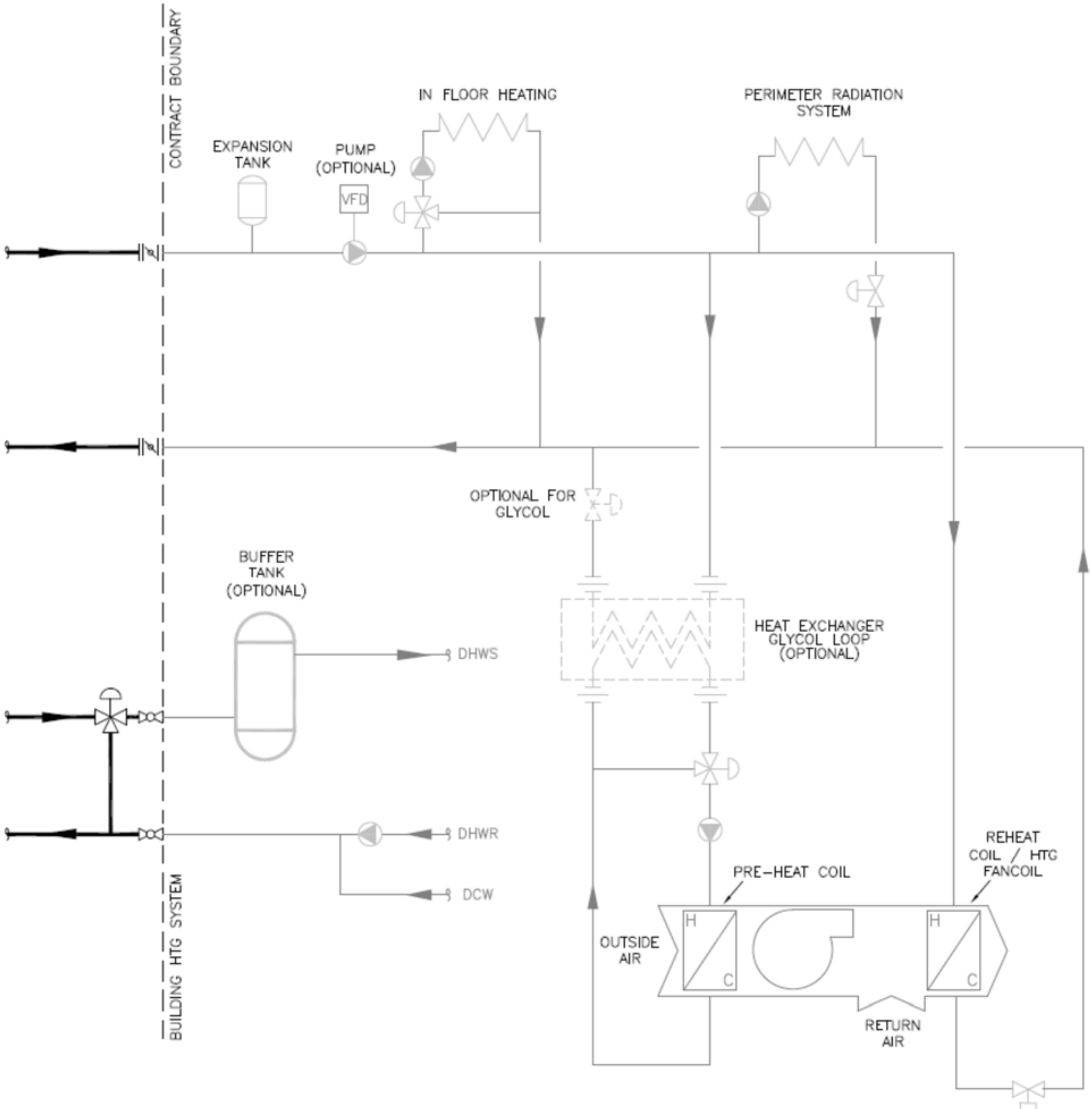
Direct Digital Control System	• Allows more accurate control and greater control flexibility. • Potential opportunities for energy savings.
Night setback settings & recovery times	• Minimize equipment sizes by allowing reasonable recovery times. • Maximize recovery times from unoccupied to occupied mode.

5.2 Pumping and Control Strategy

The building hydronic heating system shall be designed to maximize ΔT 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.

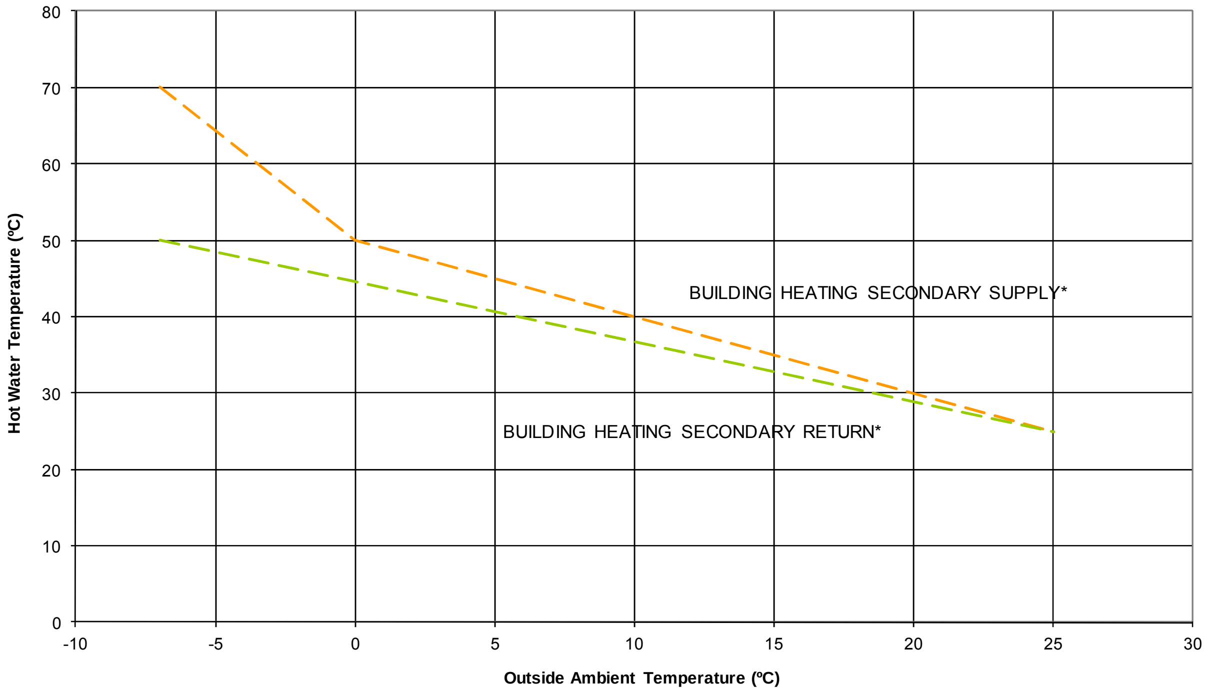
FIGURE 3: TYPICAL BUILDING HEATING SYSTEMS



5.3 Hydronic Heating and DHW System (Minimum) Requirements

Optimization of the hydronic heating system temperature difference or ∆T is critical to the successful operation of the NUS. 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.

5.3.1 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 NUS 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)

5.3.2 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 NUS 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.

[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.

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 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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