APPENDIX D

Low Carbon Resilience Design Recommendations

The recommendations below are expected to achieve a higher energy performance than what is mandated by BC Building Code or municipal bylaws. These recommendations are intended to build upon and complement health organization Technical or Owner Design Requirements.

Mechanical Design Guidance

The building mechanical system design and operation should comply with the following thermal energy optimization principles:

- Building recovered thermal energy should provide the first stage of heating (Figure 4).
- Compressor-based air-source and/or geo-source heat pumps should provide the second stage of heating.
- No fossil fuels should be used if heat is being rejected from the facility (by heat rejection equipment or as exhaust / relief air) that can viably be reclaimed with passive or active systems, to meet space heating, ventilation, or domestic hot water pre-heat loads. For example:
    - Exhaust/relief air systems over 945 L/s (2,000 cfm) should be equipped with capability of recovering heat such that the leaving air temperature can be reduced to at least 9°C at all outdoor air conditions.
    - Effort should be made to minimize the amount of smaller exhaust/relief air systems below 945 L/s (2,000 cfm), instead, smaller exhaust/relief systems should be grouped together in larger exhaust/relief air systems when allowed by code to improve performance of heat reclaim systems.
- To maximize total system efficiency:
    - Heating systems (closed loop) should use the lowest heating fluid temperature to satisfy a load and return the lowest fluid temperature.
    - Cooling systems should utilize the highest fluid temperature to satisfy a load and return the highest fluid temperature.
- Heat reclaim should take precedence over air-side and water-side economizing (i.e. “free cooling”). Economizer logic should be used only when the building cannot benefit from the heat reclaim.
- Heat reclaim should be holistically available for any building heating load.
- When possible, utilize direct heat transfer of thermal energy from reclaim source to load so long as the direct heat transfer system can reduce exhaust leaving air temperature to no higher than 9°C at all outdoor air conditions, otherwise a combination of direct and indirect heat recovery should be utilized.
- Demand based control logic should be implemented to automatically lower heating temperatures and raise cooling temperatures.
- Spaces listed in CAN/CSA-Z317.2, Special requirements for heating, ventilation, and air-conditioning (HVAC) systems in health-care facilities, Table 1: HVAC Design Criteria, require a

humidity range of 30% - 60%. Despite creating an energy penalty, recent research recommends a higher humidity range of 40% - 60%, for occupant health benefits[1]. Specialized areas such as Operating Rooms, may have more stringent criteria as outlined in each health organizations' technical requirements Consideration for efficient, low carbon means of humidification is recommended.

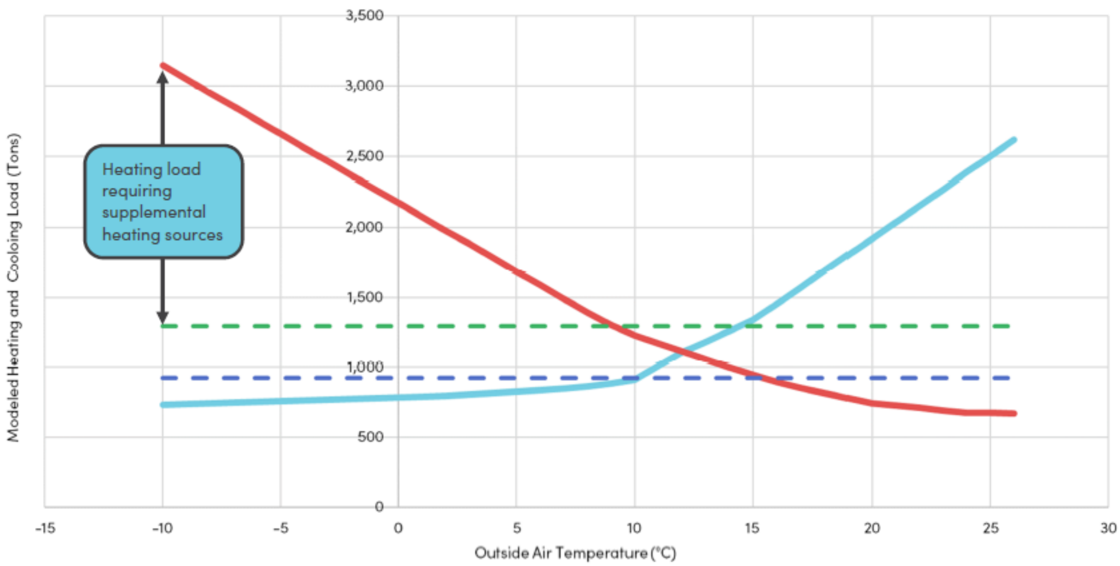

Figure 4 Model of thermal recovery. Heating (red) and cooling (light blue). Dashed lines indicate options for heat recovery load.

HVAC Design Recommendations

- All mechanical systems should be designed to 2050 climate projections and sized for optimal flexibility to 2080 climate projections.
- Displacement Ventilation should be considered as a means to simultaneously improve ventilation effectiveness and indoor environmental quality, and achieve energy and carbon savings.
- Where air handling units are designed to operate with mixed air during normal operation with the potential for 100% outside air, exhaust air heat reclaim systems should be sized to optimize efficiency at the higher outside air flow rates, where possible.
- Design, when possible, for exhaust air to come through a central plenum with heat recovery coils tied to a heat recovery chiller or heat pump.
- Explore design opportunities to connect lab/data centre heat rejection to central building heating, to maximize heat recovery.
- Integrate mechanical design into a central distribution, if building spaces incorporate individually zoned heating and cooling spaces for building occupants.

[1] https://www.nxtbook.com/nxtbooks/ashrae/ashraejournal_QVMNEO/index.php?startid=31#/p/30, Dr Stephanie Taylor, C. Michael Scofield, Patricia Graef, PE

- Use variable speed drives on terminal device pumps and fans to maintain system design pressure under variable flow conditions.

Mechanical Plant Recommendations

- Prioritize low carbon electric solutions for heating/cooling when feasible, including:
    - Heat recovery chiller
    - Air-to-water heat pump
    - Air-to-water heat pump water heater
    - Ground source heat pump
    - Air-to-air rooftop heat pump
    - Water-to-water heat pump
    - Exhaust air heat recovery heat pump
    - Sewage heat recovery heat pump
    - Electric boilers and batteries
- Compressor-based heating systems should be prioritized. Electric boilers and water heaters should be considered only when required to provide supplemental heating for compressor-based heating systems.
- Conduct a comparative analysis of Renewable Natural Gas (RNG) with various scenarios to optimize use, including peak loads and back up systems.
- Space and water heating equipment should be at least 100% efficient, in alignment with CleanBC. Additional plant capacity beyond peak loads during normal operation (i.e. sizing for catastrophic events) is exempt from this recommendation.
- Heating and cooling plants should be sized to reflect the seasonal nature of heating and cooling loads, to allow efficient operation under varying loads. Heating plants should be designed to modulate via a combination of equipment selection and controls.
- Consideration should be given to determine how frequently a facility might be running at 100% outdoor air and to sizing the heat recovery system accordingly to maximize heat recovery during typical operation.
- Heating and cooling equipment should be located in close proximity and ideally tied together to optimize heat recovery. Design should incorporate all simultaneous heating and cooling loads under the first stage of heating/cooling, with dedicated heating/cooling equipment providing the peak loads.
- Designs should consider thermal and/or electrical energy storage to increase the ability to use freely available thermal energy and/or to reduce peak electricity demand.
- Designs should integrate renewable energy sources, such as solar thermal, solar PV etc when financially feasible.

Building Envelope Recommendations

- ASHRAE 90.1 2019, Energy Standard for Buildings should be used as a guideline when developing the building envelope.
- The cost of approaching a Passive House Standard envelope performance should be assessed, by

taking into account capital savings that can be realized with a smaller central heating and cooling plant and distribution systems, and the co-benefits of thermal comfort and climate resilience.

- Passive House design strategies should be considered including:
    - Continuous insulation throughout the envelope without thermal bridging.
    - Airtight building envelope, preventing loss of conditioned air.
    - High-performance windows, doors and solar gain management to minimize overheating during cooling season and maximize solar gain during heating season (where appropriate).
    - Design of envelope to minimize demand on space conditioning systems.

Control System Recommendations

- ASHRAE Guideline 36, High-Performance Sequences of Operation for HVAC Systems should be used as a guideline when developing control sequences for the HVAC systems. Where conflicts or omissions exist between the ASHRAE Guideline 36 and CAN/CSA Z317.2, the CSA code should take precedence.
- Long-term trending of minimum 15-minute interval data should be captured by the control system for all inputs, outputs and all set points.
- Energy meters should be installed to monitor thermal energy from primary heating and cooling systems and major thermal heating systems such as, but not limited, to AHUs, heat recovery systems and DHW.

Equipment Selection Recommendations

Equipment selection within detailed design should:

- Consider electrical equipment when possible, if not consider energy usage and prioritize Energy Star labeled equipment
- Avoid once-through cooling (OTC) equipment (including processing equipment) that uses potable water in a single pass as a cooling medium.
- Explore alternative means of humidification without gas fired steam generation
- Explore alternatives to gas fired generation of steam for process steam loads
- Consider the life cycle cost when analyzing and selecting equipment.
- Consider heat recovery chillers that can also operate efficiently in cooling mode when heat recovery is not required.

Electrical Recommendations

- Power service to site should allow for full site electrification for typical peak heating loads (i.e. not including catastrophic events) to align with mechanical plant design recommendations unless mechanical design is already fully decarbonized.
- Power service should include allowance for electric vehicle infrastructure.
- Lighting controls should be non-addressable, unless in patient, doctor or nurse stations.
- Prioritize daylighting with sensors to control interior lighting when feasible.

- Light-emitting diode (LED) lighting should be used as the minimum standard for efficiency, avoid use of fluorescent technology.
- For interior/exterior lighting provide when feasible time clock, sensor or programmed switches.
- Provide motion sensor (or schedule) control for night lighting, exterior main doors and low use areas where economics are favourable.