Heat Pump RTU Switchover Temperature Guidance

Background

One of the most common types of heating, ventilation, and air conditioning (HVAC) systems that are used to condition commercial spaces in North America, are packaged Roof Top Units (RTUs). These HVAC systems are self-contained units, i.e., all the components of the air conditioning (AC) cycle, including the heat exchanger coils, compressor, expansion valve, and fans, are packaged into a single unit, that is typically placed on the roof of the building being conditioned. The conditioned air is then circulated into the building using ductwork. The AC functions by removing heat from the space using the evaporator coils, which causes the refrigerant to boil, after which it enters the compressor of the RTU. The compressor compresses the low-pressure, low-temperature refrigerant to a high-pressure, high-temperature gas, after which it enters the condenser, and is condensed into a liquid, giving off heat to the ambient. The liquid refrigerant then enters the expansion valve, where its pressure is reduced, and it enters the evaporator again.

The majority of RTUs provide heating to the building using natural gas or electric resistance heat. Heat pump RTUs function as a reversible AC – a reversing valve in the refrigeration system reverses the flow of refrigerant between the evaporator and condenser coils to switch between heating and cooling modes. HP RTUs are primarily of two types: (1) All-electric HP RTUs, and (2) Dual Fuel HP RTUs. All-electric HP RTUs primarily use mechanical heating (from the reversed refrigeration cycle) to provide heating and switch to auxiliary resistance heat as a backup for extremely cold temperatures. Dual Fuel HP RTUs pair the HP with a fuel-fired furnace and alternates between the two fuel sources for maximizing comfort, efficiency, or economics. The furnace and HP are packaged together. HP RTUs are extremely important in supporting decarbonization of commercial and industrial buildings. According to the U.S. Department of Energy, HP RTUs are estimated to reduce greenhouse gas emissions by up to 50% when compared with conventional RTUs that use natural gas for heating.

For HP RTUs, the ambient temperature at which the unit switches from primary (mechanical) heating to resistance heating (all-electric HP RTUs) or gas heating (dual fuel HP RTUs), is called the switchover temperature[1]. Setting the optimum switchover temperature depends on several factors, some of which are covered here.

Considerations

Generally, the value of the switchover temperature for an HP RTU is optimized either for a) lowest operating costs, or b) lowest greenhouse gas (GHG) emissions. Nevertheless, the feasibility and value of the optimum switchover temperature for facility operators depends upon a variety of factors:

- **HP RTU manufacturer** – Units from different manufacturers may have different adjustable switchover temperature ranges. Some products are user adjustable down to 0°F, whereas other products are in the range of 15-25°F.
- **Fossil fuel and electricity prices** – Depending on the relative price of electricity and the fossil fuel used, a building owner could see reduced utility bills and operating costs by having a lower switchover temperature if gas prices are significantly higher than electricity. Conversely, if electricity prices are higher than gas, then a higher switchover temperature would lead to more favorable operating costs.

[1] Note – some dual fuel HP RTUs may allow simultaneous operation of the HP and backup gas heating

- **HP RTU performance** – For dual fuel units that have better performance in cold climate conditions (i.e., higher coefficient of performance (COP) and/or heating capacity), it would be beneficial to have a lower switchover temperature. This strategy would have the maximum hours of mechanical (heat pump) heating for the RTU and switch to gas only at extremely low temperatures. Conversely, the switchover temperature should not be lowered to the extent that the COP of the HP drops below one or when the HP cannot meet the heating demand of the building.
- **Efficiency of the auxiliary heating system –** For an older dual fuel unit with low furnace efficiency, i.e., less than 80%, a lower switchover temperature is desirable
- **Location and local utility** – To avoid peak demand issues during winter cold snaps, some electric utilities, especially in rural areas, may request the building owner to have a higher switchover temperature so that the furnace operates for longer periods and reduces overall system demand.
- **GHG emissions mix for the local electricity supply** – for a location where the supplied electricity is predominantly coming from renewable energy resources, a lower switchover temperature is desirable to ensure that the HP RTU's carbon footprint is lower during operation

The image below shows the various outcomes of selecting a low or high switchover temperature for HP RTUs.

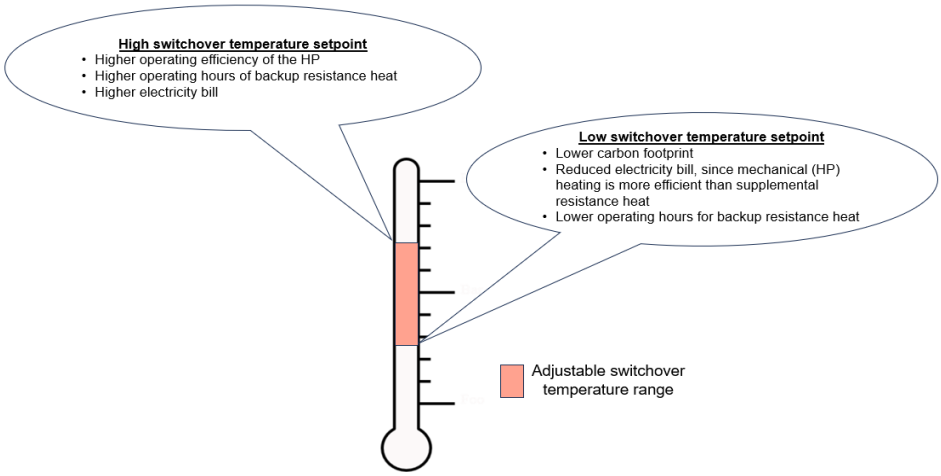

Figure 1. Pros and cons of having high or low switchover temperature for all-electric HP RTUs (Adapted from CEE report TBD)

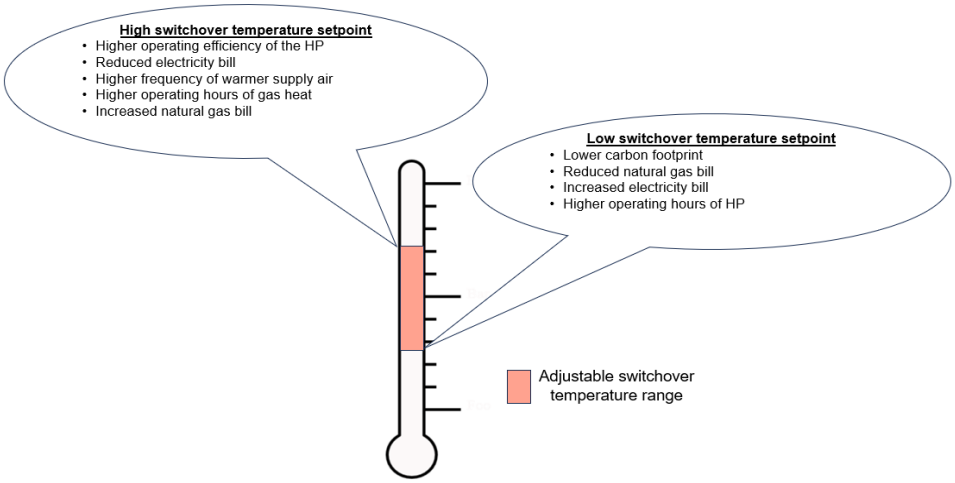

Figure 2. Pros and cons of having high or low switchover temperature for dual fuel HP RTUs (Adapted from CEE report TBD)