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The Role of Heat Pumps in Achieving Greenhouse Gas Emission Reductions in Canada's Existing Building Stock

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Extended Abstract

The impact of GHG emissions on climate is highlighting the urgent need to transition to non-carbon energy sources. Drought combined with extreme heat led to devastating forest fires across Canada in 2023 with some areas in Canada experiencing the worst air quality in the world. Nova Scotia experienced historic flash flooding in July 2023 and temperatures in Canada's far north reached record-breaking values.

The Canadian government has committed to reduce GHG emissions by 40-45% below 2005 levels by 2030 with a further goal of net-zero by 2050. Building energy use accounts for approximately 18% of Canada's emissions with space heating accounting for about 62% of those emissions. Retrofit of existing buildings will be required to achieve these goals. For regions with non-carbon-based electricity generation, heat pumps can provide an opportunity to reduce the GHG emissions associated with building space heating.

Ground source heat pumps (GSHP) are able to maintain a high coefficient of performance due to the relatively stable ground temperature. For a single homeowner GSHPs are, however, expensive to install and are often incompatible with older homes that use hot water radiators. Cold climate air source heat pumps have seen significant improvements and are able to maintain relatively high performance at cold outdoor air temperatures. Air source heat pumps are relatively easy to install in older homes with less expense than a GSHP. A key challenge of the broadscale implementation of heat pumps is the impact on electrical generation demand. Currently, Ontario experiences peak electricity demand in summer, however, demand forecasts indicate winter peaking in about 2035. These forecasts are based on minimal uptake of heat pumps in existing buildings in the residential sector. This is at odds with the urgent need to decarbonize space heating.

This presentation discusses a possible solution for electrical demand management through the incorporation of hybrid heating systems. A hybrid heating system integrates a heat pump with an existing high efficiency natural gas furnace. Based on the state of the electrical grid, a "smart controller" can be used to optimize the building heating source. This also reduces the need for new peaking power plants. As the electrical grid evolves to include more renewables, the use of the gas furnace can be ramped down to zero or it can be used to provide auxiliary heating during severe cold weather if the heat flux provided by the heat pump is insufficient. De-risking is achieved by using mature technologies. The goal of this presentation is to spark discussion amongst the engineering community on a path forward for achieving our GHG reduction targets within the existing building stock.