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Characterizing Canada's industrial heat needs for sustainable thermal energy

Summary

In Canada, the manufacturing subsector is responsible for 56.4% of total industrial energy use and 41.1% of GHG emissions. Renewable heating technologies including solar thermal, industrial heat pumps, and thermal energy storage are seeing accelerated uptake in industrial sectors worldwide. Using publicly available data, this study seeks to quantify and characterize the heat loads in the Canadian industrial sector that could be met using renewable and solar heat. Initial results find that 19% of process heat in the Canadian light industrial sector is below 100°C and 70% is between 100°C and 300°C, indicating significant potential for decarbonization using commercially available renewable heating technologies.

Keywords: solar heat for industrial processes, solar thermal, renewable heat, process heat, Sustainable and Solar Energy Transition

Field of application for the findings: Sustainable Heat for Industrial Process

Addressed audience: Researchers, Policymakers, Government, Industrial facility owners and operators

1. Introduction

In Canada, the manufacturing subsector is responsible for 56.4% of total industrial energy use and 41.1% of GHG emissions. The highly heterogenous nature of industrial loads make it a challenge to match low-carbon heating technologies like solar thermal, which are often dependent on the temperature and timing of loads, to applications. This study seeks to develop an initial estimate of the total heat use from light industrial users in Canada that would be at temperature levels suitable for renewable heat options.

There are a number of existing studies from the US and Europe which characterize and quantify industrial heat loads for those jurisdictions, separating the loads into temperature ranges. A potential study of solar thermal for industrial processes in Germany (Lauterbach et al. 2012) selected 11 sectors and analyzed their heating loads, considering loads under 300 °C appropriate for integration of solar thermal. (McMillan et al. 2016, 2021) used publicly available GHG reporting data to conduct a facility-level analysis of heat demand in 14 industrial subsectors and identify key opportunities for decarbonizing industrial loads with renewable and low-carbon technologies.

2. Approach

To characterize the temperature levels used in Canadian manufacturing, total energy use was estimated for facilities in the Canadian Greenhouse Gas Reporting Program database (GHGRP) by applying information from the National Renewable Energy Laboratory's datasets on Manufacturing Energy Use. Estimates of temperatures and fraction of total energy use by NAICS classification at the process level was then applied to develop a temperature profile of the industrial sector as a whole.

Canadian GHGRP database contains 1814 facilities that reported their greenhouse gas (GHG) emissions in 2022 to Environment and Climate Change Canada, totaling 293 Mt CO2, which represents 64% of Canada's industrial emissions. The National Renewable Energy Laboratory (NREL) has published datasets containing estimates of

thermal energy use by end use (e.g. process heating, space heating), temperature, location, etc., for all U.S. manufacturing industries with a 2014 reference year (McMillan 2019). The dataset was applied to the Canadian facility information to estimate total energy use related to process heat and temperature levels for each industrial subsector.

To estimate the opportunity for solar thermal to contribute to industrial decarbonization, the theoretical potential (all heat use below 300 °C) was reduced by two factors representing technical limitations to solar thermal systems. First, the availability of land or roof area is assumed to be 40%. Second, an average solar fractions of 30% is assumed (Lauterbach et al., 2012). This assumed solar fraction considers the variation of heat use over the year. Much higher solar fractions are achievable but may not be cost-effective, therefore this figure is a conservative estimate of technical potential.

3. Initial and Expected Results

The key results of this study are a breakdown of industrial heat loads by temperature level and industrial subsector in Canada. Figure 1 below illustrates thermal energy usage in the light industrial sector, that is, excluding "heavy" industries like iron and steel, glassmaking, and cement manufacturing. 19% of the light industrial sector's 464 PJ heat needs are at temperatures below 100 °C which could be suitable for conventional solar thermal technologies including flat plate and evacuated tube collectors, or commercially available industrial heat pumps. This represents the theoretical potential for solar and renewable heat, though factors including temporal profile and the availability of waste heat from higher temperature processes impact the technical potential. Additional expected results of the current work will include an analysis of the Canadian industrial subsectors with greatest potential for implementing low-carbon technologies to decarbonize existing processes, such as food and beverage.

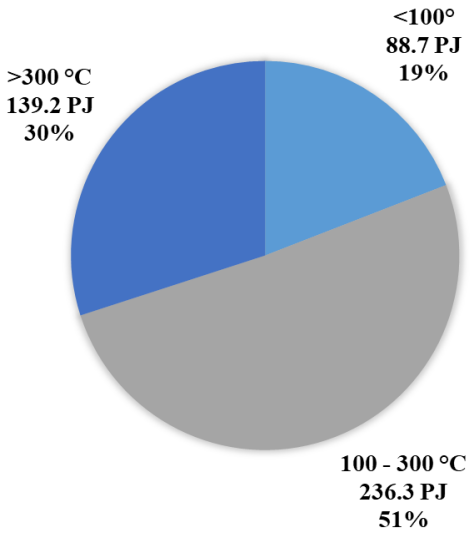

Fig. 1: 2019 Temperature breakdown of all light industrial loads, totaling 730 PJ (right). Light industrial in this case excludes cement, lime, glass, iron and steel, and includes food and beverage and chemical (e.g. Pharmaceuticals, industrial gas products, etc.).

The results of the solar thermal potential calculation determined that for temperatures under 100 °C, the national opportunity is 10.64 PJ or 2.3% of light manufacturing heat use. As a comparison, a higher range estimate is also calculated using a more ambitious solar fraction of 70%, increasing the national potential to 5% of light manufacturing heat use for <100 °C and 20% for <300 °C. One major subsector with high potential for renewable heat integration is Food and Beverage, for which 95% of heat needs are below 100 °C. Figure 2 shows the process heat needs of Food & Beverage facilities overlaid with average solar insolation across Canada, illustrating the good match between food production facilities and renewable resources.

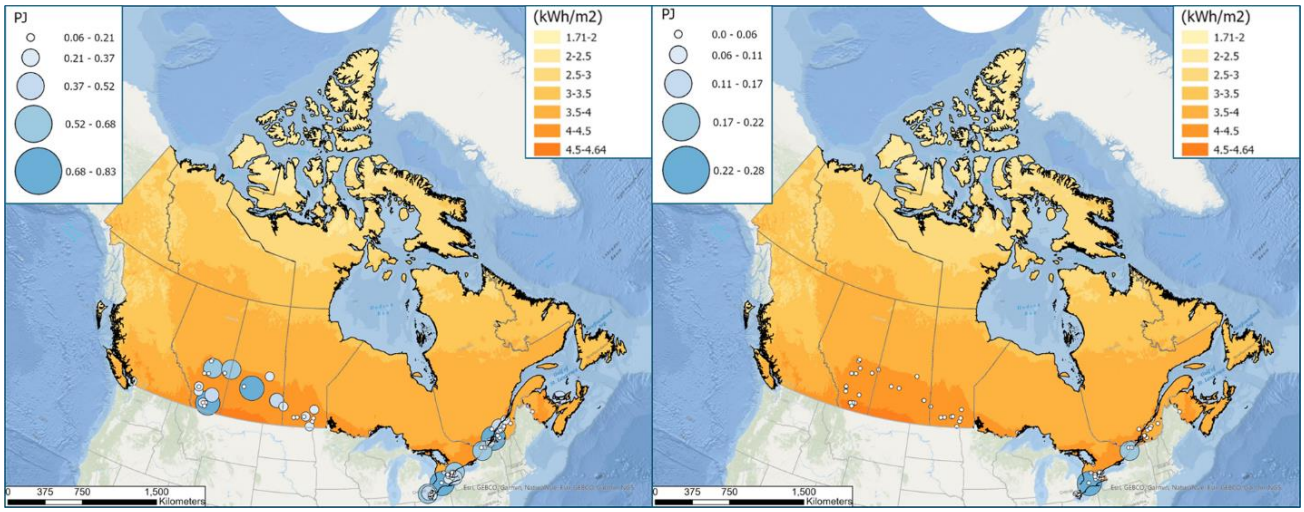

Fig. 2: 2019 Energy Use in Canadian Food Manufacturing sector <100 °C (left) 100-300°C(right) with daily average solar insolation on a fixed tilted surface of 0° relative to the horizontal plane

4. References

Greenhouse Gas Reporting Program (GHGRP) - Facility Greenhouse Gas (GHG) Data. Accessed January 15, 2025. https://open.canada.ca/data/en/dataset/a8ba14b7-7f23-462a-bdbb-83b0ef629823.

National Energy Use Database. Government of Canada, Natural Resources Canada. Accessed January 15, 2025. https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/data_e/databases.cfm.

Lauterbach, C., Schmitt, B., Jordan, U., and Vajen, K. 2012. The Potential of Solar Heat for Industrial Processes in Germany. Renewable and Sustainable Energy Reviews 16 (7): 5121–30. https://doi.org/10.1016/j.rser.2012.04.032.

McMillan, C. 2019. Manufacturing Thermal Energy Use in 2014. National Renewable Energy Laboratory - Data (NREL-DATA). https://doi.org/10.7799/1570008.

McMillan, C., Boardman, R., McKellar, M., Sabharwall, P., Ruth, M., and Bragg-Sitton, S. 2016. Generation and Use of Thermal Energy in the U.S. Industrial Sector and Opportunities to Reduce Its Carbon Emissions. Renewable Energy Lab. https://doi.org/10.2172/1334495.

McMillan, C., Schoeneberger, C., Zhang, J., Kurup, P., Masanet, E., Margolis, R., Meyers, S., Bannister, M., Rosenlieb, E., and Xi, W. 2021. Opportunities for Solar Industrial Process Heat in the United States. https://doi.org/10.2172/1762440