Energy Use Variation Among Tenants Occupying the Same Dwelling: A Study of 600+ Cases in Montreal and Quebec

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Abstract

Objective
This study investigates the variability in electricity consumption among tenants residing in the same dwelling in Montreal and Quebec City. The primary goals are to assess the extent to which occupant behavior and lifestyle influence electricity usage—particularly for heating—and to quantify the magnitude of variation in energy use between tenants.

Methodology
The analysis proceeded in three phases: data extraction and preparation, data processing and calculation of key indicators, and results analysis. Four data sources were utilized:

- A survey of residential electricity use
- A registry of tenants with move-in and move-out dates
- Monthly electricity consumption records
- Historical weather data

Key indicators calculated for each dwelling-tenant pair included monthly baseload, weather-adjusted heating energy use, and weather-adjusted total energy use. Outlier data were removed, resulting in a final sample of 652 dwellings. For each dwelling, statistical measures—mean, standard deviation, and coefficient of variation—were computed to evaluate the degree of energy use variation among tenants.

Results
The findings reveal substantial variability in energy consumption among tenants occupying the same dwelling. Average variations for total energy use, baseload, and heating were 22%, 33%, and 34%, respectively, with distributions that are both skewed and dispersed.

Context and Objectives

The purpose of this analysis is to examine the variation in energy consumption among tenants living in the same dwelling, with a particular focus on the impact of occupant behavior on heating and baseload electricity use (excluding heating and air conditioning). The study is limited to dwellings where electricity is the sole energy source.

Methodology

This document outlines the methodological framework applied in two principal phases:

1. Procurement of relevant data
2. Data preprocessing and computation of indicators

Data Procurement

Four primary data sources were used:

- An internal survey conducted in 2022, from which 695 dwellings were selected based on the following criteria:
  - Located in Montreal or Quebec City
  - At least three different tenants (including the respondent) since 2014
  - Electric heating as the primary system
  - Occupant responsible for heating costs
- The survey also provided move-in and move-out dates for respondents, some of whom relocated between their response in 2022 and the end of the analysis period in June 2024
- A comprehensive list of occupants for each dwelling from January 2014 to June 2024, including move-in and move-out dates
- Monthly electricity consumption histories for each dwelling over the same period
- Weather data for Montreal and Quebec City from January 2014 to June 2024

Data Preprocessing and Indicator Calculation

Data from the four sources were processed to remove outliers and calculate key indicators in four main steps:

- Calculation of monthly heating degree days (HDD) for Montreal and Quebec City, using a 12°C threshold:

$$HDD = \sum_{i=1}^{n} \max\left(12 - \bar{T}_i, 0\right) \quad (1)$$

  Where HDD is the number of heating degree days for the month, n is the number of days in the month, and $\bar{T}_i$ is the average temperature on day i.

- For each dwelling-tenant pair, the following indicators were calculated:
  - **Monthly baseload (kWh/month):** Median monthly consumption for months with fewer than 20 heating degree days, representing non-heating energy use
  - **Total heating consumption (kWh/year):** Sum of all consumption minus the product of monthly baseload and months of occupancy

- **Total heating degree days:** Sum of all heating degree days during occupancy
- **Weather-adjusted annual heating consumption (kWh/year):** Total heating consumption divided by heating degree days, multiplied by the average annual HDD for Montreal or Quebec City
- **Weather-adjusted total annual consumption (kWh/year):** Sum of weather-adjusted annual heating consumption and monthly baseload multiplied by 12

Weather-adjusted values enable comparisons between tenants who occupied the same dwelling at different times.

Data Cleaning

Outliers were removed based on the following criteria:

- Tenants must have resided in the dwelling for at least 250 days
- Dwellings must have had at least two different tenants or households
- Calculated heating consumption must be positive
- Monthly baseload must exceed 100 kWh/month

After cleaning, 652 dwellings remained, representing approximately 94% of the initial sample.

Statistical Analysis

For each dwelling, the following statistics were calculated:

- Means and standard deviations for monthly baseload, weather-adjusted annual heating consumption, and weather-adjusted total annual consumption
- Coefficients of variation (ratio of standard deviation to mean) for each indicator

Results and Discussion

Results are presented as distributions of the coefficients of variation for weather-adjusted total annual consumption, weather-adjusted annual heating consumption, and monthly baseload.

Key Findings

- **Weather-adjusted total annual consumption (Figure 1):**
  - Average variation between tenants is approximately 22%
  - Distribution is asymmetric and skewed right
  - Half of dwellings have coefficients of variation below 20% (median ≈ 20%)
  - About 10% of dwellings exceed 40% variation

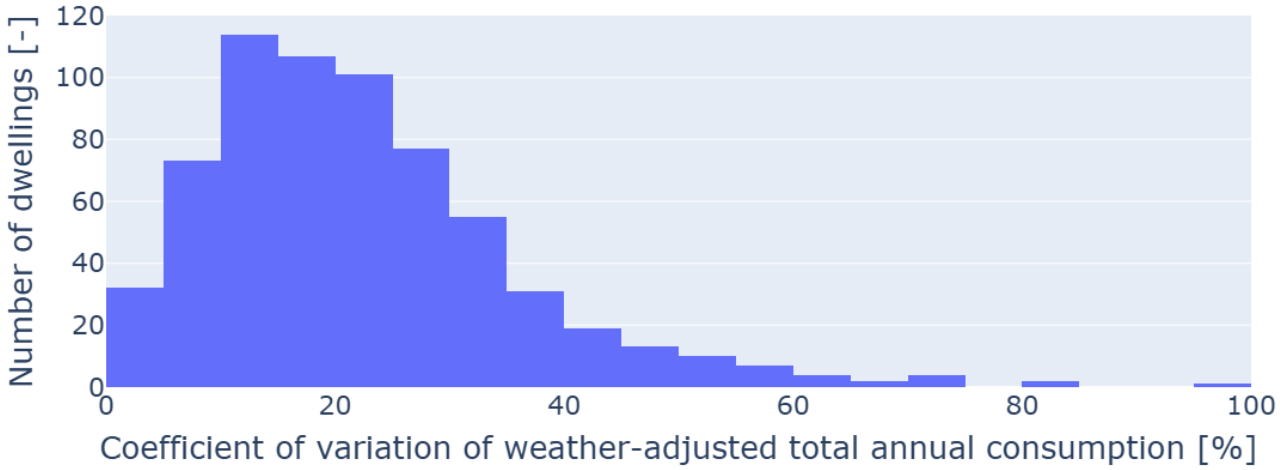

Figure 1. Distribution of coefficients of variation for weather-adjusted total annual consumption

- **Weather-adjusted annual heating consumption (Figure 2):**
  - Average variation is approximately 34%, higher than total consumption
  - Distribution is more skewed right
  - Only 30% of dwellings have coefficients of variation below 20%
  - About 10% exceed 65% variation

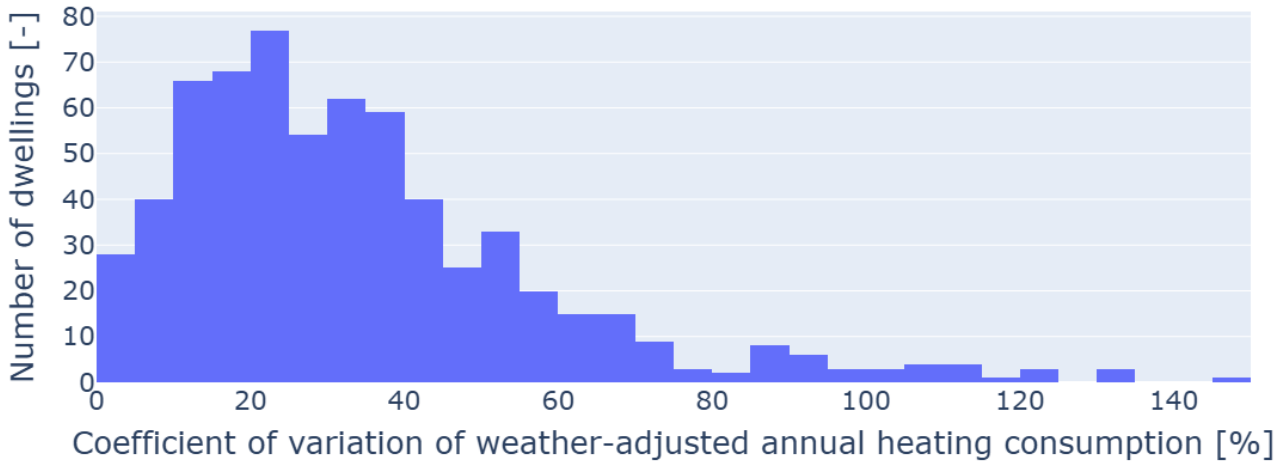

Figure 2. Distribution of coefficients of variation for weather-adjusted annual heating consumption

- **Monthly baseload (Figure 3):**
  - Average variation is approximately 33%, similar to heating consumption
  - Distribution is asymmetric and skewed right
  - About 25% of dwellings have coefficients below 20%
  - About 10% exceed 65% variation

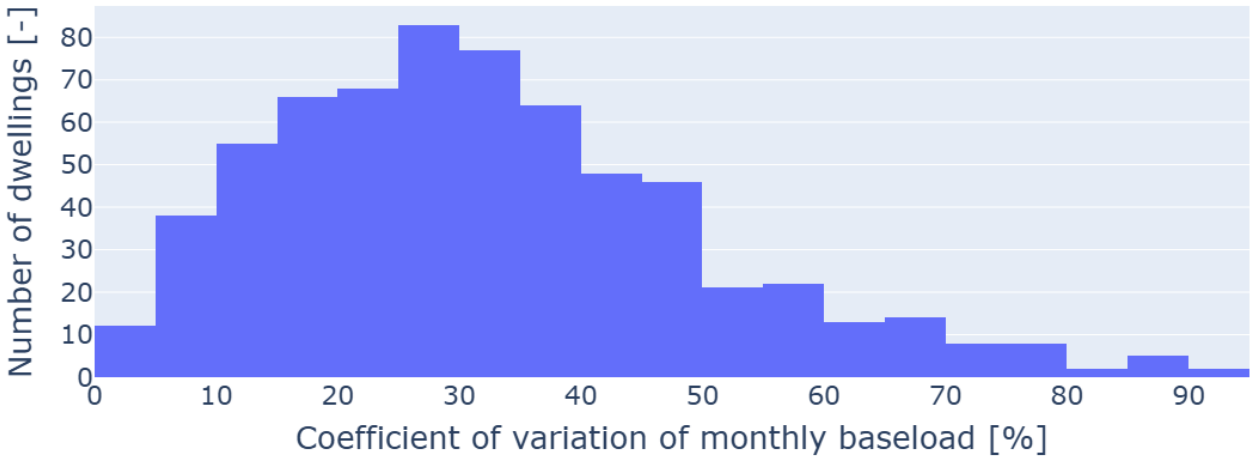

Figure 3. Distribution of coefficients of variation for monthly baseload

Conclusion

The observed variation in energy consumption among tenants of the same dwelling is both significant and undeniable. This variability is especially pronounced in heating and baseload consumption, while total consumption shows somewhat less—but still substantial—variation.