

TEMPORAL EVOLUTION OF HEATING DEGREE DAYS AND COMPARISON WITH ENERGY USE IN EU COUNTRIES

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1. Introduction

Heating Degree Days (HDD) are a widely used index of heating demand, calculated as deviations of outdoor temperature from a base level (commonly 18.3 °C) [1]. They reflect the impact of climate on building energy use and have declined significantly in Europe (~19% since 1979) due to warming trends [2-4]. However, residential energy use is shaped also, by occupant behavior and building characteristics [5], while urban design features like green roofs and façades can improve thermal comfort and modify heating needs [6]. Temperature variability indices also, such as TEVY, provide a refined assessment of climate impacts on energy demand [7–9], while social attitudes, measured via the NEP scale, inform adaptation strategies on environmental issues [10]. This study investigates HDD evolution in EU countries (2004–2024) to assess how thermal needs change over time and how these shifts relate to residential heating demand, energy policies, and strategies for climate adaptation.

2. Methodology

The analysis uses Eurostat databases to ensure comparability, covering both annual/seasonal HDD values and household energy use (64% for space heating). Countries are grouped into three climatic regions (Northern & Central Cold, Temperate Central, Southern Warm) to enable regional comparison. Statistical and graphical tools track fluctuations, long-term patterns, and the impact of extreme events on heating demand.

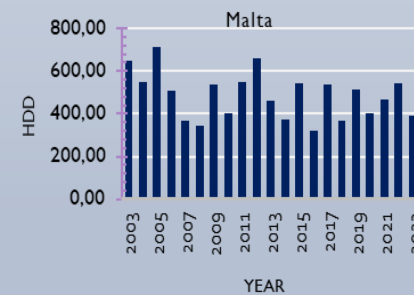
3. Results and Discussion

The results reveal a consistent downward trend in HDD over the past two decades, indicating the influence of global warming and a shortening of the cold season.

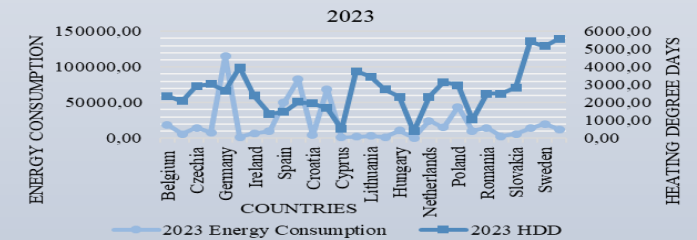
➤ In **Northern and Central Cold** countries such as Finland, Sweden, and Norway, heating demand remains high and relatively stable, with variability caused by severe winters in years such as 2010 and 2013.

➤ **Central European** countries, such as Poland, Austria, and Slovakia, are a transitional zone, with moderate but variable heating demands approximating continental and climate variability.

➤ **South nations** like Greece, Cyprus, and Malta generally have low heating demands, but theirs is less predictable, with dramatic increases reported for years with severe cold spells. Romania and Portugal, while geographically south, are particularly significant in that they have much higher HDD values due to the regional climatic factors.



In comparison with dwelling building energy consumption, the findings highlight that climate alone does not determine heating demand. In cold countries, high levels of insulation, sophisticated systems of heating, and long-term energy efficiency standards guarantee relatively constant consumption irrespective of extreme HDD. Conversely, in the southern countries, low HDD cannot guarantee low consumption due to factors such as poor thermal insulation, aging building stocks, and consumer behavior that can increase energy demand. These differences illustrate the significant role of technical, social, and policy-driven factors in shaping energy behavior.



4. Conclusions

Overall, the study confirms HDD to be a meaningful indicator of thermal requirement and climatic trends but not as a sole predictor for real energy demand. Full comprehension entails the correlation of climatic data with building characteristics, national policy, and user behavior. The results underscore adaptive heating measures and adaptive energy planning in a situation of climatic uncertainty. The findings also suggest the need for continued investment in energy-efficient building, renewable energy technologies, and certain national policies that address Europe's geographical and climatic diversity.

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