# *MIND THE PEAK: THE ROLE OF PEAK DEMAND CHARGES IN RESIDENTIAL FLEXIBILITY IN FLANDERS*

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## Overview

This study evaluates the impact of the introduction of peak demand charges in 2023 on (peak) residential electricity consumption in Flanders. Leveraging a natural experiment, we use a difference-in-difference approach to analyze high-frequency 15-minute smart meter data for over 49,000 households. Our findings reveal peak demand charges – on average – cause a monthly peak reduction between 38.02 W (0.7% of pre-treatment average) to 93.41 W (1.9%) among residential consumers.

Reductions strongly are heterogeneous and vary across households based on their adoption of technologies such as solar panels, heat pumps, and electric vehicles. Households equipped with both solar photovoltaic (PV) systems and electric vehicles (EVs) displayed the most substantial peak reductions, reflecting increased flexibility in shifting demand to off-peak hours, possibly explained by EV charging. Additionally, in the general sample, we observe evidence of response fatigue, with the impact of peak demand charges diminishing over time.

Three extensions complement these results. First, we analyse the grid charge component of electricity bills to study the redistributive impact of peak demand charges for different household types. Our analysis suggests a modest regressive effect, with households that initially had lower monthly peaks experiencing slight increases in their overall bills. Second, we simulate the low-voltage grid impact by aggregating individual load curves using bootstrap methods. These simulations indicate reductions in grid-level peak demand, although individual household effects diminish at higher levels of aggregation. Third, we explore the interaction between peak demand charges and real-time pricing incentives, analyzing the incentive compatibility of these tariff structures in shaping household responses.

In summary, this work provides the first large-scale empirical assessments of peak demand charges in a residential setting examining both individual and aggregate impacts, contributing to the empirical literature on electricity tariff design. Findings reaffirm heterogeneity in household price responsiveness and flexibility and clarifies limitations of peak demand tariffs at the aggregate level.

## Methods

The analysis relies on high-frequency electricity consumption data from a panel of over 49,000 residential customers in Flanders, spanning January 2022 to December 2023. This dataset includes detailed 15-minute smart meter readings. It captures monthly peak electricity demand (kW), grid withdrawals (kWh), and injections (kWh), as well as metadata on household characteristics such as solar photovoltaic (PV) capacity, battery storage, heat pump (HP) ownership, and electric vehicle (EV) adoption. To ensure robustness, we focus on households with at least one full year of pre-policy data.

To evaluate the impact of peak demand charges, we leverage a natural experiment using customers on the social tariff as a control group not exposed to these charges. A doubly robust differences-in-differences (DiD) approach (Sant'Anna & Zhao, 2020) is employed to enhance matching and ensure covariate balance between the treated and control groups. Our primary findings are further supported by a two-way fixed-effects (TWFE) model and a series of robustness checks. Additionally, we use an event-study methodology to analyze temporal dynamics and examine heterogeneity in responses based on the adoption of low-carbon technologies. For the extensions, we apply the following methods:

- Bill impact: The redistributive effects of peak demand charges are examined using a decomposition approach. We construct a counterfactual electricity bill, in which we decompose bill changes into those attributable to behavioral adjustments and those originating from changes in tariff design.

- Grid impact: Our detailed analysis of grid-level impacts uses a bootstrap aggregation method for groups of 25 and 100 households, the latter being the equivalent of the physical distribution cabin level in Flanders. We produce 1000 bootstrap simulations, analysed using a TWFE model.

- Interaction effects: The interaction effects and incentive compatibility with real-time pricing contracts is examined within the main differences-in-differences identification framework.

## Results

On average, treated households reduced their monthly peak demand by 94.14 W in response to peak demand charges, representing a 2.5% decrease from the pre-policy baseline. The response is heterogeneous, with households under a 1-second metering regime (with higher low-carbon technology adoption) showing the largest reductions, averaging 160.76 W (3.7%).

- Temporal dynamics: Event-study results reveal a gradual decline in the policy's effectiveness over the year, with the treatment effect becoming insignificant from October 2023, indicating possible response fatigue

- Heterogeneity:

    - The response to peak demand charges varies significantly depending on the adoption of low-carbon technologies. Households equipped with both solar photovoltaic (PV) systems and electric vehicles (EVs) displayed the most substantial reductions, with monthly peaks decreasing by 568.9 W on average. This reduction reflects enhanced flexibility in shifting demand to off-peak hours, possibly explained by EV charging. In contrast, heat pump (HP) owners exhibited limited responsiveness, with the only significant reductions observed only during specific time periods, such as early morning and evening hours in winter.

    - The response to peak demand charges correlates with pre-treatment average peaks. Households with larger pre-treatment peaks have a larger monetary incentive to reduce their peak consumption, and display the most pronounced response.

- Bill impact: overall grid charges increase for households with pre-treatment peaks smaller than 4000 W, whereas for larger households overall grid charges do not significantly change. The largest households, with pre-treatment peaks above 8000 W also observe increased grid charges. Most of the observed change is not due to behavioral changes, but rather to a change in tariff structure.

- Grid impact: At the aggregated grid level, reductions in peak demand were significant but attenuated compared to individual-level effects. For groups of 100 households (equivalent to a distribution cabin), the reduction was 1.53 kW (9.7% of individual reductions). This attenuation of grid-level effects is likely due to differences in peak-hour timing between households.

## Conclusions

This study is the first to examine peak demand charges using large-scale, high-frequency observational data, analyzing 15-minute smart meter readings from over 49,000 households. The results reveal a significant yet heterogeneous reduction in monthly peak demand. Our findings build on prior research into other electricity pricing schemes, such as real-time pricing (Fabra et al., 2021) and time-of-use pricing (Enrich et al., 2024). The pronounced heterogeneity observed in our results and in earlier studies highlights the need for targeted policies to enhance the flexibility of low-carbon technology adopters, increase consumer awareness, and mitigate response fatigue.

## References

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