Subsidizing Crises: Evidence from Norway's Electricity Market*

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Abstract

We examine consumer responses to the 2022 European Energy Crisis, using Norway's zonal electricity market and the start of a subsidy policy as a natural experiment. Employing administrative consumption records from over 1.5 million households and a difference-in-differences approach, we show that zones more interconnected with Europe experienced a 7–9% reduction in household consumption relative to zones less interconnected after the introduction of the subsidy. Using a triple-difference approach, we find that heterogeneity in treatment effects is driven by physical housing characteristics. We then apply a regression kink design on high-frequency data to measure the demand elasticity at the price point where the subsidy is binding. Altogether, we find that consumers reduced consumption even in the presence of the subsidy. This pattern suggests that consumers adapted to the new high-price environment and viewed the subsidy as temporary, rather than responding in a conventional way to the immediate price relief.

JEL codes: L51, Q41, Q48, H31

Keywords: consumer behavior, electricity markets, household electricity consumption, subsidies, government support policies.

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1 Introduction

The European Energy Crisis consisted of a period of time starting at the end of 2021 and through most of 2022 where energy prices exceeded historical averages in Europe. In particular, it caused an abnormal surge in wholesale electricity prices in almost all European markets.[1] Two main factors that contributed to this spike in prices were the reduced gas flows to Europe from Gazprom and that France became a net importer of electricity, drawing power from neighbors and adding massive demand to an already tight market.[2,3] The full invasion of Ukraine in March 2022 further exacerbated these effects.

In this paper we study a subsidy policy implemented in December 2021 to help consumers with the rising costs of electricity in Norway. The external supply shock from the crisis was transmitted through the electricity network of several countries and allows us to estimate causal effects of changes in electricity prices on electricity consumption and on the reaction of consumers to government policies designed to attenuate the impact of high prices.

We address two main questions. First, to what extent did a government subsidy that aimed at compensating consumers for the higher than usual prices in Norway affect electricity consumption? Second, was the consumers' response to the energy crisis nuanced by the presence of the subsidy?

Norway offers a unique setup to answer those questions because its market is segmented by zones—zonal pricing—and their respective levels of interconnectivity to the rest of Europe largely differ, providing a control-treatment environment within the *same* market.[4] This addresses potential concerns regarding heterogeneous preferences. We used administrative consumption records from over 1.5 million households in Norway and from January 2021 through December 2023. This dataset also contains household income, the surface of the dwelling, the number of rooms, and the building's year of construction. We complemented these data with wholesale electricity prices and weather conditions for Norway's five bidding zones. Consumers in Norway are exposed to electricity prices that reflect real-time wholesale prices, thus we concentrate on the overall effect of those shocks on households consumption

[1]See ECB (2022); Euronews (2025).

[2]Gazprom fulfilled long-term contracts but stopped selling spot gas (top-up supplies), likely to apply political pressure regarding the Nord Stream 2 pipeline. For a study on these supply cuts see Di Bella et al. (2024).

[3]France became a net exporter of electricity for the first time in 30 years. See www.banque-france.fr.

[4]As explained later in the paper, the treated group has a total of 5.2 GW of interconnection capacity with the rest of Europe, whereas the control group has virtually zero.

of electricity.

We proceed in two main steps. First, using the bidding zones that are the least connected to the rest of the European markets as a control group, we estimate an average treatment on the treated effect using both a static and a dynamic differences-in-differences approach using the start of the subsidy policy as the event time. The results show that consumers reacted to the subsidy by *lowering* consumption by 7 to 9% relative to the zones where the price increase was not present immediately in the month following the introduction of the policy. Moreover, from a dynamic differences-in-differences model we observe a sustained decrease in consumption in the eight months after the policy began relative to the control zones and to the pre-subsidy period. This is reminiscent of the effect of "public appeals" documented by Reiss and White (2008), where voluntary conservation reduced consumption as much as price increases did. In the Norwegian case, intense media coverage of the crisis likely acted as a similar non-price intervention.

Leveraging the rich microdata on household characteristics, we estimate the heterogeneous effects of the subsidy using a triple-difference model, where the third difference captures variation across specific household characteristic levels. The coefficient of interest identifies the differential treatment effect relative to a baseline category within the treated group. We find that treatment responses increase systematically with dwelling size and the number of rooms but are attenuated in newer buildings, a pattern consistent with differences in insulation quality and heating efficiency. Finally, while the policy affects electricity consumption for all households, the magnitude of this effect is significantly larger for higher-income households.

Second, government subsidies were implemented in the form of a one-sided subsidy-for-differences on consumption to compensate for the high-price levels. In other words, if the electricity spot price reached a level above a pre-established threshold, then the government subsidized a fixed percentage of the portion of the price above the threshold. This created a different control-treatment environment in which consumers can be in the treatment group when electricity prices are above the pre-established threshold (therefore, activating the subsidy) and consumers belong to the control group when the price is below that same threshold. We estimate this treatment effect using a kink regression design model (Card et al. (2015)). This method gives us estimates on the price elasticity of demand at the price threshold. At that point, we find a larger price elasticity than what it has been documented before for Norway.[5] Consistent with the difference-in-difference results, we find that demand for

[5] We also estimated price elasticities using a simple instrumental variable log-log regression. We find that

electricity became less inelastic with the introduction of the subsidy. Two hypotheses come to mind: consumers perhaps were unaware of the subsidy, or consumers are adapting to the new price regime because they know that is unclear whether the subsidy will be permanent or not. Based on anecdotal evidence from consumers in Norway, we think the most likely explanation is due to the latter.

Before the subsidy was implemented, electricity demand elasticities were between -0.1 and -0.4. When the policy started, consumption went down as shown in our difference-in-difference results. Consumers reduced their consumption in spite of a subsidy that covered between 80 and 90% of the price above the threshold. The threshold used in the subsidy definition is relatively high compared to pre-crisis electricity price levels. Therefore, even though there is a price subsidy in place, consumers are exposed to net prices that are in a more elastic region of the demand curve. When calculating elasticities using traditional methods such as log-log regressions with instrumental variables and the net price as the independent variable, we obtain elasticities that are two times larger than if we use the raw price, but still values of a demand that is highly inelastic. That occurs because a traditional instrumental variable regression does not take into account the actual structure of the subsidy. The use of the regression kink design explicitly takes into account the policy design. There we find elasticities around the threshold of between -1.1 and -0.6. At the same time, after-subsidy prices increased on average by 11% relative to the pre-subsidy period, which together with the elasticity values obtained, the predicted consumption drop in electricity is between 6.6 and 12.1%. That range of values is entirely consistent with our findings in the difference-in-difference analysis.

We conclude by analyzing the total costs—defined as revenue losses and government expenditure—of the current subsidy relative to a fixed-price counterfactual, inspired by the 'Norgespris' policy introduced in October 2025. We find that given the high price levels characterizing the early crisis period, a fixed-price policy would incur significantly higher total costs than the subsidy program. Moreover, this cost gap widens as consumer demand becomes more elastic.

demand is highly inelastic in some areas of the country before the policy was put in place. This is consistent with recent findings by Hofmann and Lindberg (2019) and is due to the high degree of electrification in Norway and thus the lack of energy substitutes for basic needs such as heating and common transportation needs such as electric vehicles. See Reiss and White (2005) for a general treatment of the estimation of elasticities in electricity markets.

Relations to the literature. Our contributions to the literature can be grouped into three main categories. The first concerns the set of studies that have employed a difference-in-differences approach to estimate causal outcomes in electricity markets. This is a challenging task due to the difficulty of finding a clean setting where a price shock affects a treatment group but not a control group within the same market. Reiss and White (2008) and Deryugina et al. (2020) are two notable examples of overcoming these identification challenges. Our contribution to this literature is the use of unequal levels of interconnection to outside markets to define valid control and treatment groups. Additionally, we employ a regression kink design (Card et al. (2015)) to measure elasticity at the kink point of the price curve defined by the subsidy policy. Because electricity pricing in our setting is based on hourly rates rather than increasing-block pricing, complications regarding marginal versus average prices (e.g., Ito (2014)) do not directly apply to our findings.

The second category relates to the economics of electricity transmission. Over the past few decades, there has been a trend towards increasing interconnectivity between different electricity markets to fully exploit complementarities in generation portfolios. This has been particularly evident in Europe, although several other jurisdictions have witnessed similar changes (Gonzales et al. (2023), Hausman (2024)). However, this increased interconnectivity exposes broader market regions to the same supply and demand shocks, potentially dampening the benefits of a diversified market reach.[6] Our results on consumption effects provide additional evidence on the consequences of varying levels of network integration, even when the policy framework remains constant.

The third category places our work in the context of recent studies on the European Energy Crisis. Using data from Finland, Ahlvik et al. (2025) exploit quasi-random contract expiration dates that exposed customers to higher prices if their contracts expired, or shielded them if they did not. This approach yields an elasticity estimate of -0.18. Similarly, Ajayi et al. (2024) use households moving to variable tariffs as an exogenous source of variation, comparing their consumption to those remaining on fixed tariff schemes in Great Britain. They find that households on variable tariffs reduced electricity consumption by 10% relative to the counterfactual. This drop in demand is at the upper end of our findings for Norway.[7] Using a similar identification strategy for industrial consumers in Italy, Alpino et al. (2024)

[6] Joskow and Tirole (2005), LaRiviere and Lyu (2022), and Lamp and Samano (2023) also study problems related to interconnection in electricity markets.

[7] Also in the United Kingdom but with different techniques, Levell et al. (2025) evaluate the changes to the price cap regulation and the introduction of a relief package for consumers during the Energy Crisis.

find significantly more inelastic responses.

Finally, Fabra and Montero (2022) analyze how the Energy Crisis caused significant wealth transfers from consumers to generators in the Iberian market, resulting in highly regressive effects. The study finds that the "Iberian solution" intervention reduced inframarginal rents for power plants while shielding consumers, offering a contrast to other European policies.[8]

Our contribution complements this literature by analyzing a distinct policy mechanism designed to mitigate the crisis' impact. The Norwegian subsidy program has no direct equivalent in other European markets. Unlike interventions that capped wholesale prices or targeted the generation sector, the Norwegian model directly subsidized retail prices for consumers while partially preserving marginal price signals. This provides a novel setting to evaluate the trade-off between shielding households from price shocks and maintaining incentives for conservation.

2 Regulatory and Historical Background

For nearly a century, Norwegian consumers have benefited from comparatively low energy prices, especially when compared to other European countries that rely more heavily on energy imports. This favorable situation is primarily attributable to the country's abundant supply of both fossil and renewable energy sources.[9] However, significant regional differences remain: electricity prices in Norway vary markedly between the north and the south, due to differences in supply, demand, and transmission capacity. To reflect these regional conditions, the electricity market is divided into five bidding zones (NO1–NO5), as shown in Figure 1. This zonal structure has been central to how recent price shocks were transmitted across the country.[10] Approximately 90% of households have contracts directly indexed to the day-ahead spot price, meaning that shocks in wholesale markets are almost immediately reflected in household bills.[11]

In October 2021, a sharp increase in wholesale electricity prices marked the beginning of an unprecedented price shock, which was further amplified in February–March 2022 follow-

[8] The "Iberian Solution" to the Energy Crisis consisted of capping the price of gas used for electricity generation in Spain and Portugal, which lowered market clearing prices. This policy targets the generation sector directly, as opposed to the policy studied in this paper, which targets the retail prices faced by consumers.

[9] See regjeringen.no, norskpetroleum.no, and eea.europa.eu.

[10] Zonal pricing is also used in other countries. See for instance Eicke and Schittekatte (2022).

[11] See SSB (2025); and NVE–RME: Norway's smart-meter journey.

Figure 1: Norway's electricity bidding zones (NO1–NO5).

Notes: The electricity market in Norway is divided in five interconnected bidding zones. Zones 3 and 4 were largely shielded from the energy crisis. Zones 1, 2, and 5 were impacted by electricity price increases.

ing Russia's invasion of Ukraine and the resulting turbulence in European energy markets. The southern zones: NO1 (East), NO2 (South), and NO5 (West) were hit hardest. Their integration with continental markets through interconnectors to Denmark, Germany, and the United Kingdom meant that domestic prices closely tracked the high levels abroad. At the same time, low water levels in southern hydropower reservoirs constrained supply, further fueling the surge.

By contrast, zones NO3 (Central) and NO4 (North) were largely shielded from the crisis. Their reservoirs were relatively well supplied, and crucially, these zones are not directly connected to continental Europe or the United Kingdom. In contrast, Southern Norway (NO1, NO2, and NO5) is tightly integrated with external electricity markets through a set of large subsea interconnectors, including Skagerrak 1–4 to Denmark (1,700 MW), NorNed to the Netherlands (700 MW), NordLink to Germany (1,400 MW), and the North Sea Link to the United Kingdom (1,400 MW).[12] All these links provide more than 5.2 GW of direct interconnection capacity to foreign markets in the southern zones, while NO3 and NO4 have no comparable direct international connections.

Those differences in interconnection capacity played a key role in the divergence of wholesale electricity prices across regions. While prices in NO3 and NO4 often remained a fraction of those observed in the South, at times close to zero, Southern Norway experienced historically high prices during the peak of the crisis in 2022. According to Statistics Norway, the average household electricity price (excluding taxes and grid rent) reached 214 øre/kWh in the third quarter of 2022, almost five times higher than the corresponding five-year average of about 44 øre/kWh, representing the highest price recorded since the quarterly price statistics began in 1998. Even after accounting for the government's electricity support scheme, introduced in December 2021, the total price paid by households averaged 141.5 øre/kWh, remaining about 30 percent above historical norms.

Importantly, these figures represent national averages and therefore mask substantial regional disparities. As emphasized by Statistics Norway, there has been a large and persistent price difference between Northern and Southern Norway, with households in the South exposed to much higher electricity prices throughout the crisis period.[13] As a result, Norwegian households mainly in the south have experienced high electricity bills, prompting many to become more price-aware in their daily consumption.

These extreme regional disparities led to an unusual government response. In December 2021, the government introduced a subsidy program that compensated households for the share of the electricity price above a fixed threshold (initially NOK 0.70 / kWh), later expanded in generosity and duration.

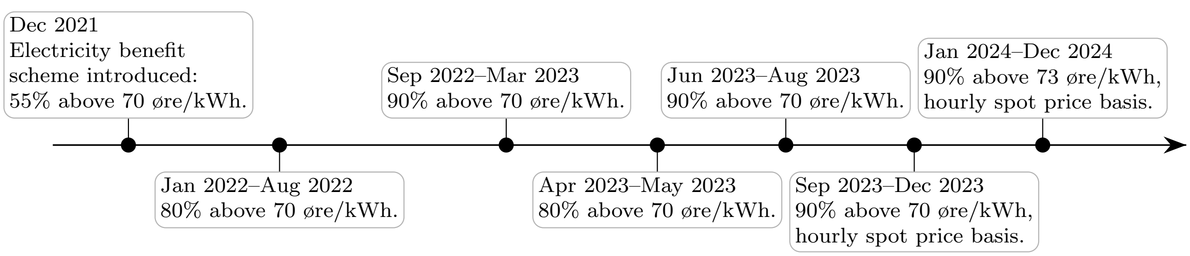
As these policy adjustments unfolded in step with market conditions, the government's support evolved in discrete stages, initial 55% coverage above the threshold (December 2021), expansion to 80% and then 90%, a shift from monthly to hourly settlement in September 2023, and higher thresholds in 2024–2025. The sequence is summarized in Figure 2. These extreme regional disparities prompted an unusual government response. In December 2021, the Norwegian government introduced a subsidy program intended to offset the worst price

[12] See www.statnett.no.

[13] See SSB (2023).

increases in the most affected regions. The policy compensated consumers for a portion of their electricity bill exceeding a fixed threshold initially set at NOK 0.70 per kWh. Over time, the program was expanded in terms of both generosity and duration. Compensation rates increased, and eligibility was extended to include farmers and housing cooperatives. As these policy adjustments unfolded in step with market conditions, the government's support evolved in discrete stages initial 55% coverage above the threshold (December 2021), expansion to 80% and then 90%, a shift from monthly to hourly settlement in September 2023, and higher thresholds in 2024–2025. The sequence is summarized in Figure 2.

Figure 2: Timeline of household electricity subsidy mechanisms in Norway, 2021–2024.



Notes: While the percentage amount covered by the subsidy fluctuated over time, the threshold above which the subsidy is active remained constant at 0.70 NOK / kWh throughout from the beginning of the policy until January 2024 when it was increased to 0.73 NOK / kWh.

The introduction of electricity subsidies was a significant policy change in Norway's energy market. Although the program was initially intended as a temporary relief measure, it quickly became one of the largest fiscal responses to the energy crisis in Europe. The program's rapid expansion reflected the severity of regional disparities and the government's efforts to protect households from unprecedented price shocks.

However, the program also raised important questions about efficiency and distribution. By compensating consumers above a fixed threshold, the program reduced incentives to reduce demand during periods of scarcity. At the same time, since only certain regions experienced extremely high prices, the subsidies reinforced the two-tier market structure. Understanding how households responded to these subsidies, whether by reducing, maintaining, or increasing their electricity consumption provides crucial insights into the interplay between market prices and government intervention.

3 Data

Our empirical strategy relies on two complementary datasets. We begin with monthly administrative household microdata, which provide the granularity needed to estimate causal effects of the subsidy on consumption and to characterize heterogeneity across households. We then introduce an hourly bidding-zone panel that we use to describe stylized facts about the policy and to estimate price elasticities in a framework that explicitly reflects the subsidy schedule. Due to confidentiality protections and the aggregation structure of the metering records, the household panel cannot be linked to the hourly zonal series at the household or meter level.

3.1 Household-level microdata

Our primary empirical analysis uses administrative household-level microdata to estimate the causal effect of electricity price changes and the subsidy on household consumption. These data form the basis of the difference-in-differences (DiD) analysis presented in section 4 and allow us to study heterogeneity in responses across income groups, housing characteristics, and household composition. The household-level microdata are observed at the monthly frequency and contain anonymized information on individual households' electricity consumption, combined with detailed socioeconomic and dwelling characteristics. These data are obtained from administrative registers and are accessed exclusively within a secure research environment.[14]

Household characteristics include annual household income, usable dwelling floor area, building year, number of rooms, and household size. To ensure interpretability and consistency across specifications, these variables are grouped into discrete categories reflecting economically meaningful thresholds. Household income is classified into quintiles based on the empirical income distribution, while dwelling and household characteristics follow categorical groupings provided by Statistics Norway and are further aggregated to ensure sufficient observations within each category.

The household-level microdata are used exclusively to analyze heterogeneity in treatment effects across income groups, housing characteristics, and household composition. Table 1 reports descriptive statistics for all household-level variables. Household and dwelling characteristics are obtained from administrative registers and merged with monthly electricity

[14] See https://www.microdata.no/.

consumption data accessed through Microdata.no. These consumption data are sourced from Elhub, Norway's national data hub for electricity metering, which aggregates metered usage for all end users connected to the grid.[15]

We next restricted the analysis to primary residential dwelling types, namely detached houses, semi-detached houses, and low-rise multi-unit dwellings. When households are associated with multiple metering points, electricity consumption is aggregated to the household level by summing consumption across all meters registered to the same household within the same municipality.[16]

Table 1: Descriptive statistics: household-level monthly data

	Mean	Std. Dev.	N	p1	p50	p99
Income (NOK)	802,749	482,075	53,181,832	191,478	719,287	3,036,267
Cons (KWh)	1502.1	1022.4	53,750,088	0	1273.1	5190.5
Log(Cons)	7.107	0.712	52,783,891	4.928	7.165	8.559
Usable floor area (m^2)	158.38	66.14	53,027,169	41	151	359
Household size (persons)	2.40	1.26	53,750,088	1	2	6
Building vintage	1971.6	32.9	52,551,434	1837	1977	2019
Number of rooms	4.62	1.58	49,675,929	1	4	9

Notes: The table reports descriptive statistics for household-level monthly microdata merged with electricity consumption records. All variables are observed at the household–month level. The sample contains approximately 1.5 million unique households (household–month observations aggregated over the sample period; the exact number varies slightly across variables due to missing values and sample restrictions). Percentiles are computed over the full estimation sample covering January 2021 to December 2023. Data for 2024 are excluded due to capacity constraints in the microdata.no research environment.

Because electricity demand in Norway is highly sensitive to temperature, weather conditions constitute an important confounding factor in the DiD analysis. We therefore control explicitly for weather variation when estimating household-level treatment effects. Hourly temperature data are obtained from the Norwegian Meteorological Institute and aggregated to the monthly level to match the frequency of the household electricity consumption data used in the differences-in-differences framework. Given the lack of more granular spatial coverage, we assign weather conditions at the bidding-zone level using one representative city per zone: Oslo (NO1), Stavanger (NO2), Trondheim (NO3), Tromsø (NO4), and Bergen

[15] See Elhub.no.

[16] Residential electricity consumption also reflects slow-moving household and dwelling characteristics, implying that adjustment to energy cost shocks may be gradual rather than immediate (Brounen et al., 2012).

(NO5). These monthly weather controls are included in all the differences-in-differences specifications to isolate price-driven consumption responses from weather-driven variation. From these temperature series, we construct heating and cooling degree days (HDD and CDD), defined relative to a 17°C baseline, which are included as controls in all the DiD regressions.[17]

3.2 High-frequency data

To complement the above household-level data, we use high-frequency electricity consumption data taken directly from Elhub for Norway's five bidding zones (NO1–NO5) over the period January 2021 to December 2024. Importantly, the two data sources, Microdata.no and Elhub.no, differ both in temporal resolution and in the level of aggregation. Electricity consumption data accessed directly from Elhub.no provide hourly consumption aggregated at the bidding-zone level and contain no household identifiers, which prevents tracking individual households or meters. By contrast, household-level electricity consumption data accessed through Microdata.no are based on Elhub's metering records but are available at the monthly frequency and are merged with anonymized socioeconomic and dwelling characteristics from administrative registers.

Accordingly, in the direct Elhub consumption data we observe the total volume of electricity consumed and the total number of metering points reporting consumption in each zone at the hourly level. These hourly consumption data are then merged with hourly day-ahead wholesale electricity prices sourced from Nord Pool, the Nordic electricity exchange operating the common power market for Norway and neighboring countries.[18] These prices are set one day in advance through market clearing and vary by bidding zone, reflecting both local hydrological conditions and interconnection constraints.

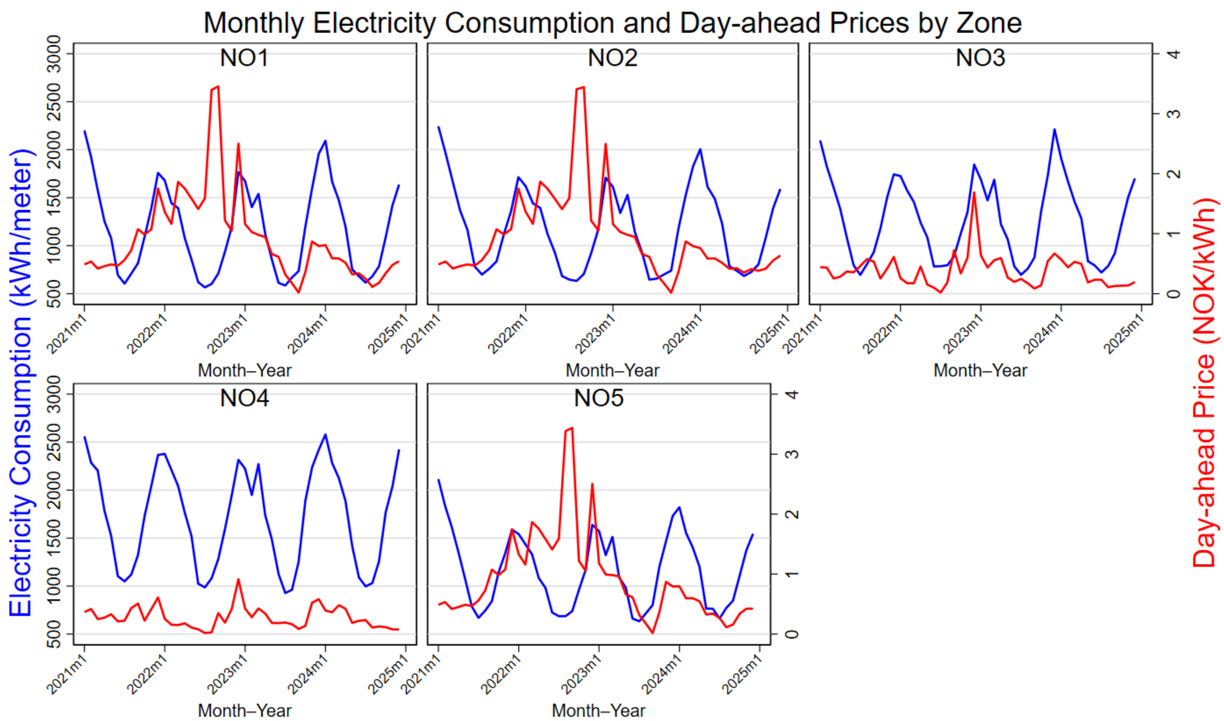
Figure 3 illustrates the evolution of monthly average electricity consumption and day-ahead prices across the five zones. Consumption (blue) follows a strong seasonal pattern, peaking in winter months and declining during summer, consistent with heating demand. Prices (red) show much greater regional variation: zones NO1, NO2, and NO5 in the South

[17]HDD and CDD are constructed from daily average temperature T_{zt} in zone z and period t relative to a baseline of 17°C. Specifically, $\text{HDD}_{zt} = \max\{0, 17 - T_{zt}\}$ and $\text{CDD}_{zt} = \max\{0, T_{zt} - 17\}$. A 17°C base is commonly used in Nordic applications; see, e.g., Cox et al. (2015) for Denmark and Hilliaho et al. (2015) for Finland.

[18]See nordpoolgroup.com. In the Nordic electricity market, the main wholesale electricity price is determined in the day-ahead auction operated by Nord Pool. The day-ahead price constitutes the spot price in Norway. After the day-ahead market clears, an intraday market allows for limited adjustments, but these trades involve relatively small volumes and do not replace the day-ahead price as the reference price for retail contracts.

experienced pronounced price spikes during the 2021–2023 crisis period, whereas NO3 (Central) and NO4 (North) remained largely insulated, with wholesale prices staying relatively low and stable. The observed divergence underscores the importance of analyzing the crisis at the zonal level rather than aggregating to the national average.

Figure 3: Monthly electricity consumption and average day-ahead prices by zone



Notes: The left-hand y-axis shows the average monthly electricity consumption per meter in each bidding zone (kWh), while the right-hand y-axis displays the average hourly day-ahead price per month (NOK/kWh). The graph presents these two variables over time for each bidding zone (NO1–NO5).

It is also important to control for other external factors that may influence electricity consumption independently of price. For example, temperature plays a key role as people naturally use more electricity when it is cold. In addition, to instrument for electricity price elasticity, we combine data from several independent sources. Specifically, we use hourly wind generation for each bidding zone in Norway from Elhub, reservoir filling levels at the national level from the ENTSO-E Transparency Platform[19] to capture hydrological conditions, and

[19] See entsoe.eu.

daily European natural gas prices proxied by the EGSI NCED Index from Bloomberg[20], which serves as an external benchmark given the strong coupling between gas and electricity prices in Europe.

The final dataset consists of hourly observations for five bidding zones (NO1–NO5) from January 2021 to December 2024, yielding a balanced panel of 175,320 observations. Total hourly electricity consumption in each zone is divided by the number of metering points reporting consumption to obtain average per-meter demand. All price series are expressed in NOK/kWh.

Table 2 summarizes descriptive statistics of key variables by zones. The average hourly electricity consumption per meter exhibits a range from approximately 1.6 kWh in Zones NO1, NO2, and NO5 to 2.4 kWh in Zone NO4, thereby indicating a higher baseline demand in the northern regions. Electricity prices also vary substantially across zones. For instance, Zones NO1, NO2, and NO5 face average prices close to 0.9 NOK/kWh, while Zones NO3 and NO4 exhibit considerably lower average prices. Thus, the observed price variations can be attributed to the presence of regional differences in market conditions. Temperature variation is also substantial, with mean values ranging from 3.9°C in Zone NO4 to 8.6°C in Zone NO2, and extreme minima below -20°C in some zones. Consistent with these patterns, heating degree days (HDD) are highest in Zones NO3 and NO4, while cooling degree days (CDD) remain low across all zones, thereby indicating that heating demand is the predominant factor influencing electricity consumption in Norway during the examined sample. The wind generation variable shows substantial and volatile hourly output (means from 87 to 662 MWh and large standard deviations), consistent with meaningful installed wind capacity and strong weather-driven intermittency across zones NO1–NO4. In contrast, NO5 has a lower number of observations and an hourly mean close to zero (max 0.006 MWh), indicating that there is less wind production recorded within the NO5 bidding area. In fact this area remains dominated by hydro and has historically had very limited wind capacity inside the zone.[21]

4 The Effect of the Subsidy on Consumption

In this section, we examine how electricity consumption responds to the subsidy policy and how these responses vary with exposure to the underlying supply shock. To do so, we estimate

[20]Retrieved from Bloomberg: Powernext Gas Spot Zeebrugge ZTP European Gas Spot Index (EGSIZPAD Index, source PEGAS, frequency daily, unit EUR/MWh).

[21]Norwegian Ministry of Energy (energifaktanorge.no) and ssb.no.

Table 2: Descriptive statistics by zone: hourly observations covering January 2021 through December 2024.

Variable	Mean	SD	Min	Max	N
Zone NO1					
Consumption (kWh)	1.602	0.690	0.527	3.889	34939
Electricity price (NOK)	0.923	0.853	0.000	7.767	34939
Temperature (°C)	7.432	8.651	-22.900	31.000	34939
HDD	10.049	7.927	0.000	39.900	34939
CDD	0.481	1.528	0.000	14.000	34939
Natural gas price index (NOK)	0.554	0.380	0.159	2.509	34939
Wind generation (MWh)	87.247	79.665	0.000	360.576	30530
Zone NO2					
Consumption (kWh)	1.620	0.645	0.581	3.795	34940
Electricity price (NOK)	0.944	0.843	0.000	8.983	34940
Temperature (°C)	8.625	7.681	-14.200	29.700	34940
HDD	8.813	7.034	0.000	31.200	34940
CDD	0.438	1.346	0.000	12.700	34940
Natural gas price index (NOK)	0.554	0.380	0.159	2.509	34940
Wind generation (MWh)	479.270	385.025	0.000	1371.671	30530
Zone NO3					
Consumption (kWh)	1.736	0.636	0.622	3.717	34940
Electricity price (NOK)	0.371	0.413	0.000	5.728	34940
Temperature (°C)	6.865	7.727	-17.500	30.400	34940
HDD	10.396	7.286	0.000	34.500	34940
CDD	0.261	1.090	0.000	13.400	34940
Natural gas price index (NOK)	0.554	0.380	0.159	2.509	34940
Wind generation (MWh)	661.693	515.687	0.000	1916.776	30530
Zone NO4					
Consumption (kWh)	2.365	0.775	0.780	4.376	34939
Electricity price (NOK)	0.280	0.292	0.000	4.901	34939
Temperature (°C)	3.916	7.277	-13.900	30.000	34934
HDD	13.218	6.976	0.000	30.900	34939
CDD	0.136	0.844	0.000	13.000	34939
Natural gas price index (NOK)	0.554	0.380	0.159	2.509	34939
Wind generation (MWh)	292.810	202.557	0.041	1009.746	30528
Zone NO5					
Consumption (kWh)	1.592	0.591	0.560	3.624	34939
Electricity price (NOK)	0.920	0.846	0.000	7.767	34939
Temperature (°C)	7.819	6.601	-11.400	29.600	34939
HDD	9.420	6.158	0.000	28.400	34939
CDD	0.240	1.065	0.000	12.600	34939
Natural gas price index (NOK)	0.554	0.380	0.159	2.509	34939
Wind generation (MWh)	0.001	0.001	0.000	0.006	26905

Notes: Statistics use all available observations per variable within each zone; missing values are excluded variable-wise. The natural gas price index is converted from EUR to NOK using year-specific exchange rates. Wind generation is reported in MWh (kWh/1000).

a DiD specification that exploits regional variation in exposure to the European energy crisis. Zones that are largely independent of electricity flows with the rest of Europe serve as the control group, while southern zones that are physically interconnected with other European electricity markets constitute the treated group. The empirical model is given by:

$$\log Y_{izt} = \beta_0 + \beta_1 \text{Post}_t + \beta_2 \text{Treated}_z + \beta_3 (\text{Post}_t \times \text{Treated}_z) + \mathbf{X}_{zt}\boldsymbol{\beta} + \delta_i + \alpha_z + \gamma_m + \eta_y + \varepsilon_{izt}, \quad (1)$$

where Y_{izt} denotes average electricity consumption of household i in zone z and month t. Post_t is an indicator equal to one for periods after December 2021, marking the introduction of the electricity subsidy scheme. Treated_z is an indicator equal to one for zones exposed to the electricity price increase (Zones NO1, NO2, and NO5). The interaction term ($\text{Post}_t \times \text{Treated}_z$) captures the DiD estimate of the treatment effect, and β_3 is therefore the main coefficient of interest. $\mathbf{X}_{zt}$ is a vector of weather-related control variables. Household fixed effects are denoted by δ_i, zone fixed effects by α_z, month fixed effects by γ_m, and year fixed effects by η_y.[22] The error term ε_{izt} captures idiosyncratic shocks at the household–zone–time level.

The validity of the DiD framework relies on the assumption that treated and control zones would have followed parallel trends in the absence of treatment. To assess this assumption, Figure 3 plots mean log electricity consumption by zone. The figure shows broadly similar consumption patterns prior to the onset of the subsidy. In particular, electricity consumption declines from January 2021 to January 2022 in bidding zones NO1, NO2, and NO5, while consumption in NO3 and NO4 does not exhibit a comparable reduction over the same period.

4.1 The start of the subsidy policy as the beginning of the treatment period

This subsection presents the baseline DiD estimates from Equation (1), where December 2021 is defined as the start of the treatment period. Table 3 reports the results using data from January 2021 through December 2023. Across all specifications, the coefficient on the interaction term (*Treated* × *Post*) is negative and statistically significant, indicating a reduction in electricity consumption in treated zones despite the introduction of the subsidy policy. The estimated effect is approximately 8 percent in most specifications, with the

[22] We include separate month and year fixed effects rather than a full set of month–year fixed effects in order to capture seasonal patterns. Since the sample spans January 2021 to December 2023, the post-policy indicator varies within both month and year dimensions and is therefore not absorbed by these fixed effects.

magnitude remaining stable after the inclusion of fixed effects and controls.[23] This results is consistent with evidence that household electricity demand may respond to salient policy interventions and public signals, in addition to standard marginal price incentives (Reiss and White, 2008; Jacobsen et al., 2012).[24]

The results also highlight the importance of including weather controls. In columns (4)-(5), the inclusion of temperature, heating degree days, and cooling degree days shows that the treatment effect remains robust to the inclusion of these controls, with only a modest reduction in magnitude (from –0.086 to approximately –0.07).

The post-treatment indicator (*Post*) is small and statistically insignificant in specifications without time fixed effects, indicating no uniform shift in consumption across zones after the treatment date. Once month–year fixed effects are included, however, the coefficient on *Post* becomes negative and statistically significant, reflecting the absorption of common aggregate time shocks that would otherwise be attributed to the post period. Similarly, the treated-zone indicator (*Treated*) is negative and statistically significant in specifications without zone fixed effects, indicating lower baseline consumption levels in treated zones relative to control zones. Once zone fixed effects are included, this indicator is absorbed and omitted from the regression, as it is time-invariant at the zone level.

Our findings confirm that the price differential stemming from the difference in the degree of interconnection for the two groups with the rest of Europe has quantifiable and economically important effects on electricity consumption.

4.2 Robustness checks: alternative control groups, time spans, and holiday homes

To further assess the robustness of the results, we test whether the results are sensitive to the choice of control group by re-estimating the DiD model using each control zone separately rather than pooling Zones 3 and 4.

Table A.3 reports the results when Zone 3 alone is used as the control group, while Table A.4 shows the corresponding results using Zone 4 only. In both cases, the dependent variable is the log of monthly electricity consumption per household. The treatment effect

[23]Using the coefficients from Table 3, the exact percentage change is between $100 \times (\exp(-0.07) - 1) = -6.76\%$ and $100 \times (\exp(-0.087) - 1) = -8.33\%$.

[24]Our findings are also related to evidence found using quasi-experimental data that consumers place substantial weight on persistent electricity price components when forming expectations and making long-term energy decisions, such as heating technology investments (Sahari (2019)).

Table 3: Differences-in-differences estimates of household electricity consumption

	(1)	(2)	(3)	(4)	(5)
Treated × Post	-0.087***	-0.087***	-0.087***	-0.070***	-0.068***
	(0.0005)	(0.0004)	(0.0005)	(0.0004)	(0.0002)
Post	0.0003	-0.086***	0.0002	-0.102***	-0.104***
	(0.0004)	(0.0007)	(0.0004)	(0.0007)	(0.0003)
Treated	-0.090***	-0.090***			
	(0.0004)	(0.0003)			
Temperature				-0.023***	-0.03***
				(0.0003)	(0.0001)
Temperature^2				0.0006	0.0006
				(4×10^{-6})	(2×10^{-6})
Heating Degree Days				-0.007***	-0.007***
				(0.0003)	(0.0001)
Cooling Degree Days				-0.030***	-0.027***
				(0.0003)	(0.0002)
Intercept	7.204***	7.744***	7.136***	7.780***	7.790***
	(0.0003)	(0.0004)	(0.0002)	(0.005)	(0.002)
Zone FE	No	No	Yes	Yes	Yes
Month & Year FE	No	Yes	No	Yes	Yes
Household FE	No	Yes	No	No	Yes
DV mean	7.107	7.107	7.107	7.107	7.107
Adj. R^2	0.005	0.601	0.005	0.610	0.610
N	52,783,891	52,783,891	52,783,891	52,783,891	52,783,891

Notes: The dependent variable is the logarithm of monthly average electricity consumption per meter (household). The sample covers the period from January 2021 to December 2023. Zones 1, 2, and 5 are treated, while Zones 3 and 4 serve as control zones. Columns (1)–(3) present baseline difference-in-differences specifications with alternative combinations of zone and time fixed effects. Column (4) augments the specification with weather controls (temperature, temperature squared, heating degree days, and cooling degree days). Column (5) further includes household fixed effects, absorbing time-invariant heterogeneity at the household level. Standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

remains negative and statistically significant, confirming that the observed demand reduction in treated zones is not driven by the composition of the control group. The magnitude of the effect is somewhat larger when Zone 4 (the northern zone with higher electricity consumption and colder climate) is used as the control, while Zone 3 yields smaller estimates. This outcome is not surprising, as demonstrated in Figure 3, Zone 4 experienced little or no price increase during the critical period of 2022–2023, whereas prices rose sharply in the treated zones, making Zone 4 a more comparable benchmark for identifying demand responses.

We also replicate the same exercise using only data up to August 2022, before the subsidy coverage was increased from 80% to 90%. The results, presented in Table A.5, Table A.6, and

Table A.7 are highly consistent with the baseline findings. The treatment effect remains negative and statistically significant across both specifications, further reinforcing the robustness of our conclusions.

The reliability of the findings is reinforced by the consistency of the results across these alternative specifications. Households in treated zones exhibited a systematic reduction in electricity consumption in response to rising prices, the definition of the control group as narrowly (Zone 3 or Zone 4) or more broadly (pooled controls), and the restriction of the sample to the pre-subsidy expansion period ending in August 2022 or its extension over the full horizon.

A distinctive feature of the Norwegian electricity support scheme is that it applied to primary residences but not to holiday homes (hytter). This institutional detail provides a useful robustness test of our main findings. If the subsidy dampened households' effective marginal price of electricity at their primary residence, then holding exposure to the price shock fixed, we should expect a comparatively stronger consumption response for holiday homes, where consumers faced the full market price without subsidy coverage.

We implement this test using Elhub metering data from January 2021 to December 2024 for cabins that are comparable in granularity to our baseline zonal series: hourly consumption at the metering-point level, aggregated to monthly averages per metering point within each bidding zone. A key limitation is that the data do not allow us to separate two conceptually distinct margins of adjustment. A decline in average consumption per metering point could reflect (i) reduced cabin occupancy (fewer stays during the high-price period), mechanically lowering consumption while the denominator includes all metering points, or (ii) unchanged occupancy but lower intensity of use (e.g., reduced heating and appliance use). While these two mechanisms have different welfare interpretations, both are behavioral responses to the price shock under non-subsidized pricing.

Table A.8 reports difference-in-differences estimates for cabins using the same specification as in Table 3. Consistent with temperature being a key driver of electricity demand, the model's explanatory power increases substantially, with an R^2 of 0.99 in Column 4. In this specification the effect is highly significant and implies a 16% reduction in consumption, which is notably larger than the 7–9% decrease estimated for subsidy-eligible households in the baseline results. At the same time, the cabin estimates should not be interpreted as a population-wide average effect: cabin ownership and usage are selective, and the outcome is an average over metering points rather than over households. Therefore, the cabin analysis is best interpreted as a robustness and external-validity check showing that consumers adjusted electricity use more strongly in settings where the subsidy did not apply.

4.3 Dynamic effects

While the differences-in-differences estimator gives the overall effect of the supply shock on consumption, it does not convey how such effect changes over time. The main motivation to expand the analysis is that it is an empirical question whether the supply shock had a long-lasting effect on demand or rather the magnitude of the effect changed over time.

To address that question, we constructed a series of time dummies indicating the number of months before and after the treatment. These are interacted with the treatment indicator to estimate the monthly impact relative to the baseline month (November 2021), which is omitted. The regression controls for zone and month-year fixed effects and clusters standard errors at the zone level. We estimate the following model:

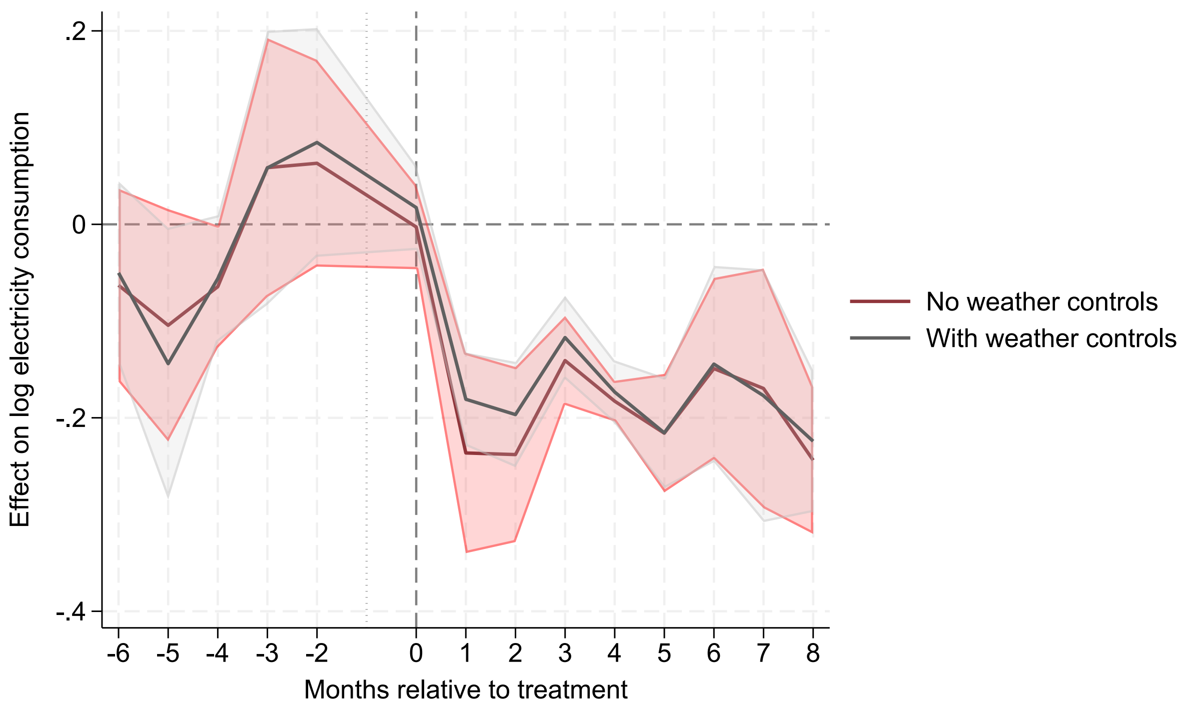
$$\log Y_{izt} = \sum_{\substack{k \neq -1 \\ k=-m}}^{M} \beta_k \big(\text{Treated}_z \times \mathbb{1}\{t = k\}\big) + \mathbf{X}_{zt}\boldsymbol{\beta} + \alpha_z + \gamma_m + \varepsilon_{izt}, \tag{2}$$

where $\log Y_{izt}$ denotes the log electricity consumption of household i in zone z and month t. The function $\mathbb{1}\{t = k\}$ is an event-time indicator equal to one if month t is k months relative to the treatment onset, with November 2021 ($k = -1$) omitted as the baseline period. m and M are the lower and upper bounds, respectively, of the months considered relative to the event. Treated_z is an indicator equal to one for treated zones (NO1, NO2, and NO5). $\mathbf{X}_{zt}$ is a vector of weather-related control variables. α_z denotes zone fixed effects, and γ_m denotes calendar-month fixed effects that control for seasonal consumption patterns common across years. Standard errors are clustered at the zone level. The error term ε_{izt} captures idiosyncratic shocks at the household-zone-time level.

In Figure 4 we show the results for this specification. The vertical line at period 0 marks the first month of treatment (December 2021). This event study plot shows the treatment dynamics within this period at the monthly level, with and without controls. The results of the two specifications give practically the same results.

Before December 2021, the treatment month, the event-study coefficients are not statistically different from zero, providing no evidence of differential pre-trends between treated and control zones and supporting the parallel trends assumption. Following the onset of the price spike, the estimates turn sharply negative from January 2022 onward and are statistically

Figure 4: Event Study: Dynamic Treatment Effects



Notes: Each line represents the effect on log average consumption for each month relative to the treatment date, data up to November 2022. Shaded areas represent the 95% confidence intervals.

significant across specifications. The implied demand reductions range from approximately 15 to 22 percent relative to the control zones, with the largest declines occurring in the first months after treatment. While the magnitude of the effect partially attenuates over time, consumption remains persistently lower for several months following the shock. Yet, short-run effects are larger in magnitude than the average treatment effect estimated using the static differences-in-differences specification, highlighting the importance of accounting for dynamic adjustment.

4.4 Heterogeneous effects

To examine heterogeneity in treatment effects, households are classified into discrete groups based on income, dwelling characteristics, and household composition. In all specifications, the lowest category within each dimension serves as the omitted reference group.

Household income is grouped into five categories based on the empirical distribution of annual household income. Specifically, we construct income quintiles such that each group contains approximately 20 percent of households. The resulting income thresholds range from households earning below NOK 407,635 in the lowest quintile to households earning NOK 1,096,594 or more in the highest quintile. Mean income increases monotonically across groups, from NOK 298,727 in the lowest quintile to NOK 1,531,810 in the highest quintile.

Dwelling size is measured by total usable floor area and categorized into standard size intervals, which are subsequently aggregated into five groups reflecting increasing dwelling size. Building age is defined by year of construction and grouped into five categories corresponding to distinct building vintages. These vintages capture differences in building regulations, insulation standards, and heating technologies over time, with the oldest buildings serving as the baseline category. Housing complexity is proxied by the number of rooms and grouped into five categories reflecting increasing dwelling size and layout complexity, dwellings with two rooms or fewer form the reference group.

Household composition is measured by the number of registered household members. Households are classified into five categories ranging from single-person households to households with five or more members, with single-person households serving as the reference category.

Table 4 reports triple-difference estimates obtained from regressions interacting treat households, post-treatment period, and household characteristics. The estimated coefficients capture differential treatment effects relative to the baseline category within the treated group.

The results indicate that heterogeneity in treatment effects is driven by physical housing characteristics. Treatment responses increase systematically with dwelling size and number of rooms, and are attenuated in newer buildings, consistent with differences in insulation quality and heating efficiency. In addition, we find strong heterogeneity in the treatment effect across income groups. While the policy reduces electricity consumption for all households, the effect is significantly larger for higher-income households. Relative to the lowest income quintile, households in the upper-middle income group reduce consumption by an additional 2 percentage points, and households in the highest income group by about 1.7 percentage points. Confirming that higher-income households have greater flexibility in adjusting electricity usage in response to price increases.

Table 4: Heterogeneous treatment effects by income and household characteristics

	Group				
	2	3	4	5	N
Income group	-0.011^{***}	-0.017^{***}	-0.0204^{***}	-0.017^{***}	52,244,018
Used space (bruksareal)	-0.0075^{***}	-0.0171^{***}	-0.0272^{***}	-0.0335^{***}	46,050,387
Building year (byggeår)	0.0013^{**}	0.0053^{***}	0.0196^{***}	0.0228^{***}	45,711,408
Number of rooms	-0.0116^{***}	-0.0165^{***}	-0.0209^{***}	-0.0307^{***}	43,196,934
Household size (persons)	-0.0122^{***}	-0.0149^{***}	-0.0149^{***}	-0.0183^{***}	46,680,509
Fixed effects	Household, Month, Year, Zone				

Notes: The table reports triple-difference coefficients from regressions interacting post-treatment status, treatment group, and household characteristics. The dependent variable is log electricity consumption. Group 1 is the omitted reference group in each dimension (lowest income, smallest dwelling, oldest buildings, fewest rooms, and single-person households). See Appendix Table A.9 for the construction of household characteristic groups. Coefficients represent differences in treatment effects relative to the baseline category within the treated group. Statistical significance is based on robust standard errors, not shown. $^{***}p < 0.01$, $^{**}p < 0.05$.

5 The Consequences of the Structure of the Subsidy

The electricity subsidy scheme was implemented in phases, each characterized by different coverage rates and price thresholds. In general, the subsidy *per kWh* at time t can be described as

$$\text{subsidy}_t = K_t \times \max\{0, p_t - p^*\},$$

where p_t is the electricity price at time t and p^* is the price threshold above which the subsidy is binding. The price to compute the subsidy, p_t, has been defined in slightly different ways at different phases of the policy as explained below, but for expositional purposes we will treat it as the spot price of electricity. The difference $p_t - p^*$, when positive, determines the subsidy spread. K_t is the coverage rate and is a constant between 0 and 1 that represents the amount of the spread that is reimbursed to consumers. As explained below, since December 2021, p^* has taken the values 0.70 and 0.73 at different points in time, and K_t has been set at 0.55, 0.80, and 0.90 at different points in time. In other words, the subsidy covers a percentage of the excess price. For example, a consumer pays 70 cents + 10% of the portion above 70 cents when $p^* = 0.70$. If $p_t = 70$ cents, the consumer pays 70 cents. If $p_t = 71$ cents, the consumer pays $70 + 0.1(1) = 70.1$ cents when $K_t = 0.90$.

Table 5 summarizes the subsidy design across the six phases. Up to Phase 4 (January

2022–August 2023), the subsidy was calculated using the monthly average electricity price. Beginning with Phase 5 (September 2023), the calculation shifted to the hourly spot price, which continued into Phase 6 (January–December 2024). Yet, the coverage rate increased from 55 percent in December 2021 (Phase 1) to 80 percent in early 2022 (Phase 2), and further to 90 percent between September 2022 and March 2023 (Phase 3). Coverage was temporarily reduced to 80 percent during April–May 2023 (Phase 4), before returning to 90 percent in June–December 2023 (Phase 5). In January 2024 (Phase 6), coverage remained at 90 percent, though the price threshold was slightly raised from 0.70 NOK/kWh to 0.73 NOK/kWh.

Table 5: Electricity subsidy phases

Phase	**Period**	**Coverage and Threshold**	**Basis**
1	Dec 2021	55% coverage above 0.70 NOK/kWh	Monthly avg. price
2	Jan–Aug 2022	80% coverage above 0.70 NOK/kWh	Monthly avg. price
3	Sep 2022–Mar 2023	90% coverage above 0.70 NOK/kWh	Monthly avg. price
4	Apr–May 2023	80% coverage above 0.70 NOK/kWh	Monthly avg. price
5	Jun–Aug 2023	90% coverage above 0.70 NOK/kWh	Monthly avg. price
6	Sep–Dec 2023	90% coverage above 0.70 NOK/kWh	Hourly spot price
7	Jan–Dec 2024	90% coverage above 0.73 NOK/kWh	Hourly spot price

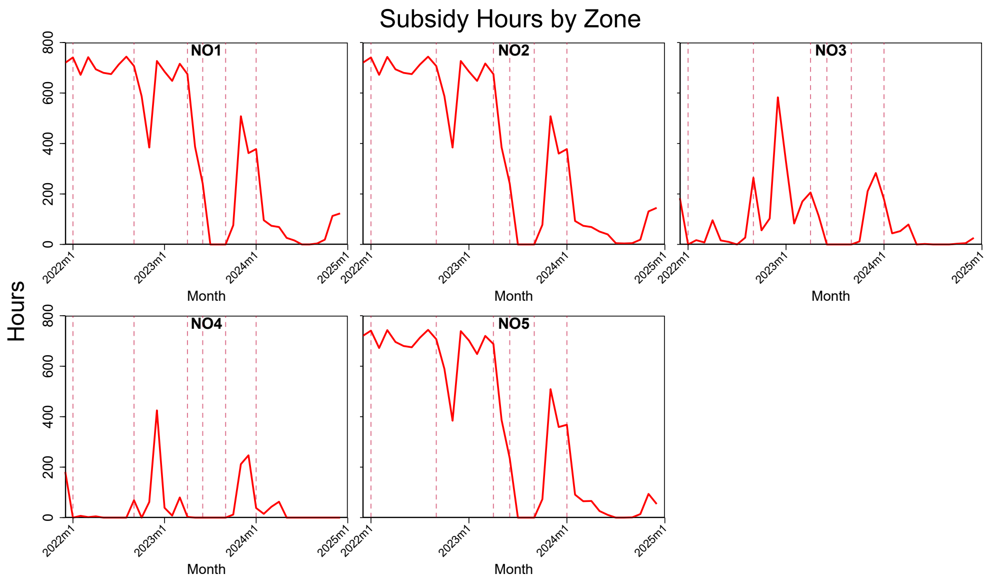
Notes: The subsidy threshold was constant throughout most of the sample period and was only slightly increased in January 2024. The calculation basis shifted from monthly average electricity prices (Phases 1–5) to hourly spot prices (Phases 6–7).

5.1 Three facts about the electricity subsidies in Norway

To illustrate how these rules translated into observable market outcomes, we present several descriptive figures.

1. The subsidy was active almost all the time right after the subsidy started. Figure 5 shows the frequency of subsidy hours per month in each zone, capturing the intensity of the scheme across time and zone.

Figure 5: Frequency of subsidy activity

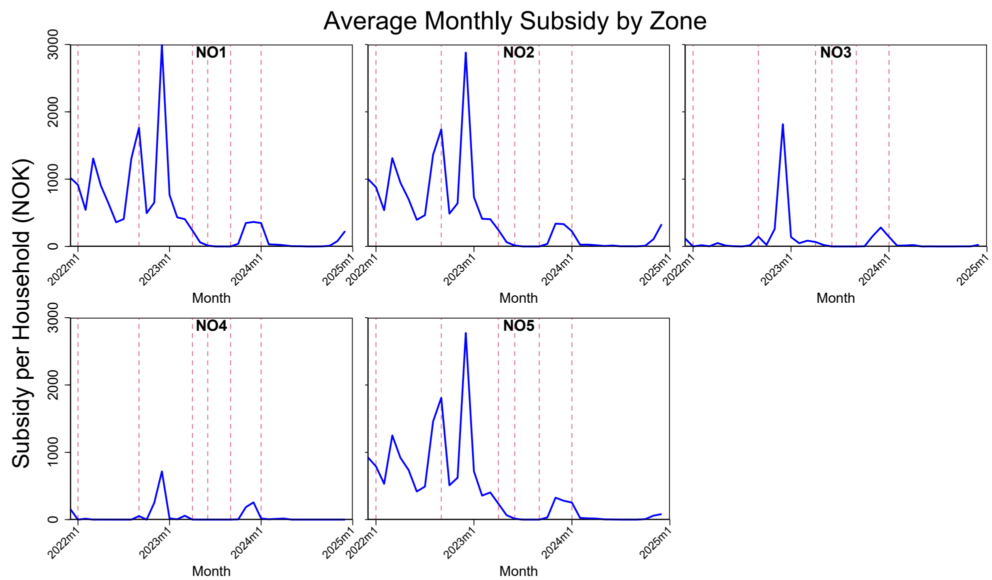


Notes: The figure shows the number of hours per month in which the subsidy was binding, by electricity zone. Treated zones (1, 2, and 5) experienced frequent subsidy hours due to higher wholesale prices, while control zones (3 and 4) show limited subsidy activity. Vertical lines reflect changes in the subsidy design (see Table 5).

Subsidy activity increased sharply from late 2021 onward, consistent with the introduction of the scheme, and remained concentrated in Zones 1, 2, and 5. In contrast, Zones 3 and 4 experienced limited subsidy exposure, reflecting lower average prices. The figure also illustrates the drop in subsidy hours during 2023 before a renewed increase in early 2024, in line with the price patterns observed in Figure 3.

2. Subsidy amounts were negligible after mid-2023. Figure 6 shows the average monthly subsidy by zone. Subsidy expenditures track both consumption levels and wholesale price volatility, with pronounced peaks during the winter of 2022–2023 when subsidies exceeded 2,500 NOK per household on average in the treated zones. Conversely, Zones 3 and 4, which experienced lower prices, received significantly less compensation. The heterogeneity in the subsidy compensation highlights the variation in treatment intensity across zones. Despite that hundreds of hours per month were eligible for the subsidy after mid-2023 (Figure 5), the monthly average subsidy amounts were largely negligible.

Figure 6: Subsidy expenditures



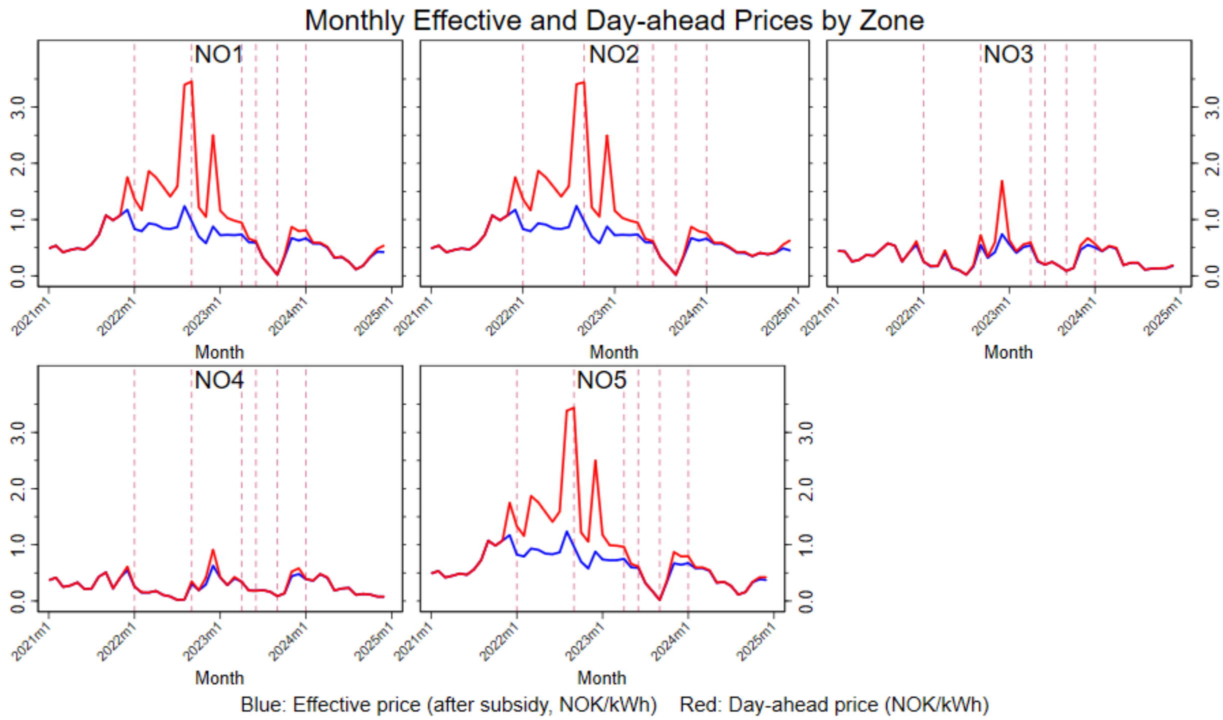
Notes: The figure shows average monthly subsidy compensation on electricity bills per household (NOK) across zones. Vertical dashed lines indicate changes in the subsidy design (see Table 5).

3. Spikes in prices were present only in the treated zones. Figure 7 shows the relationship between day-ahead market prices and the effective consumer prices after subsidies. The substantial gap between the two series highlights the extent to which subsidies shielded households from significant price increases across zones, particularly during the winter season of 2022–2023. The dashed vertical lines indicate the points at which the subsidy design underwent significant modifications, most notably the transition from a monthly average to an hourly spot calculation in September 2023.

5.2 A regression kink design

The definition of the subsidy gives place to a continuous price function with a change in slope (a kink). The slope of the relationship between the spot price and net price changes at the threshold p^*, but the level does not. We can use a regression kink design (RKD) (Card et al. (2015)) to exploit this change in slope. We assume that unobserved determinants of consumption (like temperature, wind, time of day) are smooth functions of the spot price. Therefore, any change in the slope of consumption with respect to the spot price at the threshold must be driven by the change in the slope of the price faced by the consumer.

Figure 7: Day-ahead market price vs. effective consumer price after the electricity subsidy



Notes: The effective price is defined by the policy as $p^* + (1-K)(p_t - p^*)$ whenever $p_t > p^*$, and equal to the hourly price otherwise, where p^* is the price threshold, K is the fraction paid by the government, and p_t is the hourly price. Dashed vertical lines mark changes in the subsidy design (Jan 2022, Sep 2022, Apr 2023, Jun 2023, Sep 2023, Jan 2024).

We estimate the change in the slope of log consumption (Y_t) relative to the assignment variable (p_t),

$$Y_t = \alpha + \tau_1(p_t - p^*) + \tau_2 \mathbb{1}(p_t > p^*) \times (p_t - p^*) + \mathbf{X}_t'\beta + \boldsymbol{\delta}_{.} + \epsilon_t \tag{3}$$

where p_t is the running variable (hourly price). $\boldsymbol{\delta}_{.}$ is a general representation for a variety of fixed effects and their combinations (by zone, hour of the day, and day of week). $\mathbf{X}_t'$ controls (Temperature, Heating Degree Days, etc).

The causal effect is identified by the ratio of the change in consumption slope to the change in price slope:

$$\eta_{RKD} := \frac{\text{change in slope of consumption at threshold}}{\text{change in slope of price at threshold}} = \frac{\tau_2}{K_t - 1},$$

where K_t is the coverage given by the subsidy. For example, when $K_t = 0.90$, the denominator is equal to -0.10.

The obvious concern with the running variable is that is endogenous: spot prices are determined by the intersection of supply and demand. The source of the bias is that high prices usually correlate with higher consumption (due to cold weather for instance). To address this concern, we added an extensive set of controls in the form of polynomials of temperature and other variables. This helps with identifying the residual consumption change driven by the price signal, distinct from the weather signal.[25]

We expect τ_1 (the baseline slope) to be negative and τ_2 (change in slope) to be positive. τ_1 captures the relationship between consumption and spot prices below the threshold, where consumers pay the full price. As the price of electricity rises, households typically reduce consumption or at least, they do not increase it. The demand curve slopes downward. This full exposure should discourage consumption. τ_2 is the flattening effect coefficient on price above the kink. This coefficient captures the difference between the slope above the threshold and the slope below the threshold. Because the consumer is protected from price spikes above p^*, their demand should become less responsive to the spot price. The relationship becomes flatter (closer to zero). In other words, we are moving from a steep negative slope (e.g., -0.5) to a flat negative slope (e.g., -0.05).

The RKD estimator is essentially asking the question, we see the price signal get weaker, did the consumption reaction also get weaker (positive change relative to trend)? Since the adverse effect of high prices on consumers was removed by the subsidy (the denominator), the reduction in usage usually caused by high prices disappeared (the numerator). The ratio of these two movements recovers the underlying negative relationship between price and quantity.

The top part of Table 6 shows the estimation results of Equation 3 for Phase 2 of the subsidy (Jan - Aug 2022), which is a period of time where the policy was binding most of the hours. We show three different specifications that include different combinations of fixed effects. The basis for the calculation of the subsidy during this phase is the monthly average price, however we use the hourly frequency data since otherwise we would have only a handful of observations during these 8 months of the Phase 2. The coefficients have the expected signs and are strongly statistically significant. The demand slope is fairly stable across the different specifications, while the coefficient on the "correction term" is slightly more sensitive to the addition of fixed effects. Although we used the hourly data for this

[25] Another potential concern is that the density of the running variable might exhibit bunching around the threshold. If this were the case, it would invalidate the RKD estimator. However, an examination of the price density shows no evidence of bunching around the threshold or elsewhere.

Table 6: Estimates of the regression kink design

	(1)	(2)	(3)
Price centered (τ_1)	-0.357**	-0.419**	-0.308**
	(0.154)	(0.190)	(0.126)
Price above thres. (τ_2)	0.808***	1.248***	0.724***
	(0.245)	(0.298)	(0.195)
N	518	518	518
R^2−adj.	0.85	0.76	0.88
DV mean	0.30	0.30	0.30
Zone FE	No	Yes	Yes
Hour of the day FE	Yes	No	Yes
Day of week FE	Yes	No	Yes
Semi-elasticity and elasticity values			
$\eta = \frac{\Delta \text{ slope of } \log q}{\Delta \text{ slope of } p}$	-1.010^{***}	-1.560^{***}	-0.905^{***}
	(0.306)	(0.372)	(0.244)
$\eta \times p^*$	-0.707^{***}	-1.092^{***}	-0.634^{***}
	(0.215)	(0.261)	(0.171)

Notes: First part of the table shows the results from Equation 3 for Phase 2 of the subsidy policy and using hourly data with a bandwidth of 0.30 NOK / kWh. Second part of the table shows the implied semi-elasticities and elasticities for each model. Standard errors obtained using the Delta method. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

estimation, the number of observations is small because of the bandwidth chosen of 30 øre, around the threshold.

The bottom part of Table 6 contains the semi-elasticities η calculated as explained above in this subsection. The standard errors were computed using the Delta method. We cannot directly compare demand elasticities obtained from traditional methods and the semi-elasticities found here without a conversion. The semi-elasticity estimator from the regression kink design follows the formula:

$$\eta_{RKD} = \frac{\Delta\text{Slope of } \ln(q)}{\Delta\text{Slope of } p}.$$

Because the dependent variable is in logs ($\log q$) and the independent variable is in levels (p), this ratio represents a semi-elasticity. To make this comparable to an elasticity, we multiply our RKD estimator by the price level at the point of estimation (the threshold p^*).

$$\epsilon_{RKD} = \text{Semi-Elasticity} \times p^* = \eta_{RKD} \times p^*.$$

The resulting elasticities are shown in the last row of the same table with standard errors calculated using the Delta method. The demand elasticities range, in absolute value, from 0.6 to 1.1, and should only be taken as the consequence of a local average treatment effect around the threshold defined by the policy.[26]

A vast literature has estimated demand elasticities for electricity in Norway prior to the implementation of the subsidy.[27] For completeness, we also conduct our own estimation and report our results in Appendix A.1. We employ a log-log model with prices instrumented by wind output and natural gas prices. We report elasticities for each zone separately across three samples: before the subsidy was implemented, during the subsidy period using raw prices, and during the subsidy period using prices net of the subsidy. While not central to our study, we estimated these elasticities to demonstrate that a traditional instrumental variable approach yields highly inelastic values for the subsidy period. These values are unrealistic given the reduction in consumption levels described in the previous section.[28] This discrepancy arises because traditional methods fail to account for the specific structure of the subsidy policy: the change of the slope of the price schedule.

From our differences-in-differences results in the previous section we know that consumers reduced demand despite a generous subsidy covering 80 to 90% of the price exceeding the fixed threshold. However, it is important to note that the threshold itself (0.70 NOK / kWh) and the prices above it are significantly higher than the levels to which consumers are accustomed. Specifically, during the period from January to November 2021–the 11 months preceding the policy–the overall average price was 0.54 NOK / kWh. This compares to an average of 1.13 NOK / kWh during Phase 2 of the subsidy using raw prices, and 0.60 NOK / kWh using net prices (post-subsidy). These averages represent increases of 107.5 and 11.3%, respectively, over historical price levels.

[26]It is useful to place this elasticity within the European context. Ahlvik et al. (2025) report an elasticity of −0.18 during the 2022 Energy Crisis in Finland when prices doubled. Although our estimated elasticities are at least three times larger, the underlying domestic policy in each study is very different but both point towards an economically important change in the responsiveness of consumers. Using data from Spain around the financial crisis of 2008, Romero-Jordán et al. (2016) estimate household elasticities around −0.15 to −0.25 due to an accumulated 63% increase in prices during that period. These elasticities are also an economically relevant increase in the consumers' responsiveness due to a price increase during a crisis.

[27]For instance, Hofmann and Lindberg (2019) estimate short-term elasticities between −0.011 and −0.075 for the Oslo region. Earlier aggregate studies such as Bye and Hansen (2008) and Johnsen (2001) document values between −0.02 and −0.05.

[28]We find that if we use the effective price as the independent variable and instrumented, we obtain elasticities that are about two times larger than if we use the raw price. But even in such a case, the elasticities are too low, in absolute value, to be consistent with the drops in consumption attributed to the policy.

Whether we rely on elasticities from the existing literature or our own elasticities in Table A.2, electricity demand in Norway appears highly inelastic. Such values, however, fail to predict the observed drop in demand following an 11.3% price increase.[29] If we instead use the elasticities obtained from the regression kink design in Table 6 (ranging from -1.1 to -0.63), an 11.3% increase in net price implies a reduction in quantity demanded of 7.1 to 12.4%. Recall that the static differences-in-differences analysis in Table 3 estimated a consumption drop of 7 to 9% attributable to the subsidy–a figure well within the range predicted by our regression kink design. Furthermore, when compared against the dynamic differences-in-differences results in Figure 4, these predicted changes generally fall within the upper bounds of the confidence intervals, demonstrating strong consistency across the two sets of results.

5.3 Implications for economic policy

Finally, we compare the subsidy policy against an alternative fixed-price policy. For each scenario, we calculate government expenditure and revenue losses, defining the latter as the difference between baseline revenue (without policy) minus the revenue with the policy in effect. We focus on Phase 2, and we assume a fixed price of 0.40 NOK/kWh inspired by the "Norgespris" policy introduced on October 1, 2025.[30]

Scenario 1: Subsidy program. This analysis focuses on the same subsidy program examined throughout the paper. Government spending is calculated as the sum of hourly expenditures, defined as the product of the hourly subsidy ($K \max\{0, p_t - p^*\}$) and the quantity demanded in that hour. Then we take the sum over all time periods.

To estimate revenue loss, we determine the counterfactual quantity demanded in the absence of the policy. We rely on the following formula:

$$Q_{NP,t} = Q_{S,t} \frac{p_{t,NP}^{\varepsilon_{NP}}}{p_{t,S}^{\varepsilon_S}}$$

[29]For example, with an elasticity of -0.08 (Hofmann and Lindberg (2019)), $\Delta\% q = -0.08 \times 11.3\% = -0.9\%$, which is ten times lower than the actual drop in demand due to the policy.

[30]The Norgespris is a government-introduced fixed-price option for household electricity consumption, allowing consumers to pay a predetermined price of 0.40 NOK/kWh (excluding VAT) instead of being fully exposed to spot market prices. The scheme was announced in response to prolonged price volatility following the energy crisis and is intended as an alternative to direct subsidy-based support. Unlike the electricity subsidy scheme, which applied only to primary residences, the Norgespris also covers secondary homes, including holiday houses. See regjeringen.no for details.

This expression is derived from a constant elasticity demand function. We assume the market size constant remains invariant between the subsidy and no-policy environments, while allowing the elasticities to differ; taking the ratio of the two demand expressions yields the formula above. Here, $Q_{NP,t}$ and $Q_{S,t}$ represent the quantity demanded in the no-policy and subsidy scenarios, respectively, with $Q_{S,t}$ set equal to the observed quantity. The numerator price is the no-policy price, which is observed in the data. The denominator price represents the net price under the subsidy, defined as:

$$p^* + (1 - K)(p_t - p^*)$$

whenever $p_t > p^*$, and equal to the hourly price otherwise. Finally, ε_{NP} denotes the elasticity in the no-policy environment; we vary this parameter as detailed below. For the subsidy elasticity, ε_S, we assume a conservative value of -0.6, consistent with the range of estimates obtained from our regression kink design results.

Scenario 2: Fixed price. Under this scenario, we require both the no-policy counterfactual quantity (calculated as in Scenario 1) and the quantity demanded under a fixed-price regime. To determine the latter, we adapt our demand formula as follows:

$$Q_{F,t} = Q_{S,t} \frac{p_F^{\varepsilon_F}}{p_{t,S}^{\varepsilon_S}}$$

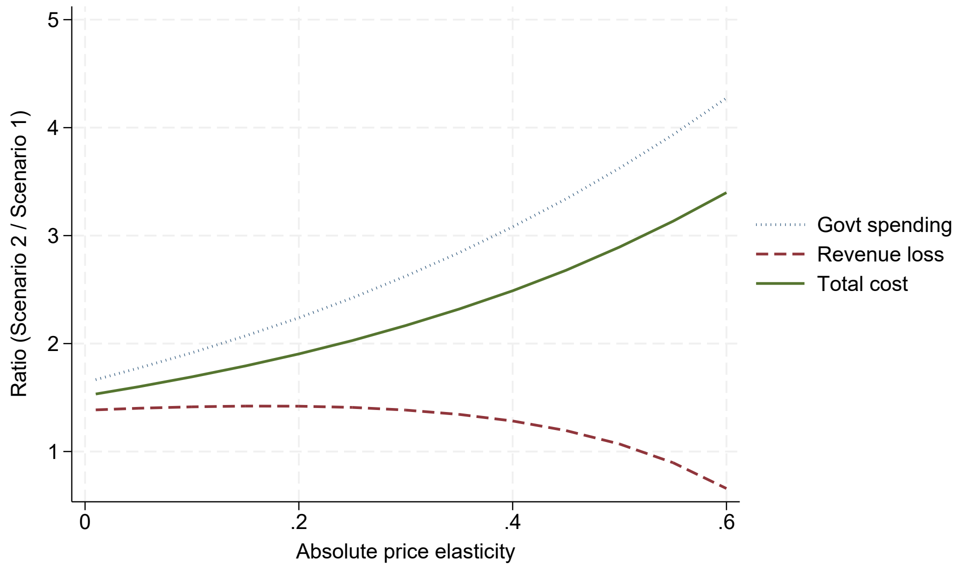
where $Q_{F,t}$, p_F, and ε_F represent the quantity demanded, the price, and the elasticity of demand in the fixed-price policy environment, respectively. For this analysis we set $p_F = 0.40$ and assume $\varepsilon_F = \varepsilon_S$.

Total government expenditure is calculated by aggregating the hourly costs, where the cost per kilowatt-hour is defined as $\max\{0, p_t - p_F\}$ multiplied by the quantity demanded at time t ($Q_{F,t}$).

Comparing the two scenarios. We define total policy costs as the sum of government expenditure and revenue losses. In Figure 8, we plot the ratio of total policy costs under the fixed-price scenario (S2) to the total policy costs under the subsidy program (S1) for various values of demand elasticity (ε_{NP}). We also plot separate ratios for government expenditure and revenue losses, defined analogously to the total cost ratio.

As the absolute value of elasticity increases, the ratio of total costs rises from a baseline greater than 1. In other words, a counterfactual fixed-price scheme (set at 0.40 NOK/kWh)

Figure 8: Relative policy costs under Scenario 2 versus Scenario 1



Notes: The figure plots the ratio of government spending, revenue losses, and total policy costs under Scenario 2 (fixed-price) relative to Scenario 1 (subsidy program) as a function of the absolute price elasticity of demand.

would have incurred substantially higher total fiscal and revenue costs than the actual Phase 2 policy. This gap widens as consumers become more price-sensitive. Intuitively, because prices in Phase 2 were generally higher than 0.40 NOK/kWh, consumers in the subsidy scenario (S1) reduced their consumption more than they would have under the lower fixed price of S2. This results in higher revenue losses in Scenario 1; consequently, the revenue loss ratio (S2/S1) declines and falls below 1 for high elasticity values. Conversely, government expenditure is higher in S2 because the implicit subsidy threshold is lower than in the actual policy. This causes the government spending ratio (S2/S1) to increase. In the aggregate, the government spending effect dominates, leading to an increasing total cost ratio. It is important to emphasize that these results are conditional on the specific price levels observed during Phase 2, which were significantly higher than the 0.40 NOK/kWh fixed price. Results would differ under alternative price trajectories.

6 Conclusion

In summary, we employed a difference-in-differences approach, finding that the introduction of the subsidy policy had a significant, immediate effect on household consumption. Zones more interconnected with Europe (NO1, NO2, and NO5) experienced a 7 to 9% greater reduction in electricity consumption compared to less-connected zones (NO3 and NO4) immediately following policy implementation. This effect proved robust across various specifications, including alternative control group definitions and varying sample periods. Furthermore, our dynamic analysis reveals a sustained decrease in consumption in the treated zones for several months, indicating a persistent behavioral response to the high-price environment.

Next, we analyzed the potential tensions inherent in a substantial subsidy program designed to shield consumers from high prices. Using a regression kink design, we assessed household behavior around the pre-established price threshold where the subsidy activates. We find a statistically significant coefficient regarding the change in the slope of the demand curve above the threshold; this quantifies and confirms the impact of the subsidy structure on demand curvature. This approach allows us to estimate demand elasticity locally around the policy's price threshold. We find a relatively elastic demand curve at this point, suggesting that a standard constant-elasticity model would have failed to capture consumer behavior in this specific price range.

Overall, our research provides causal evidence of household responses to a novel subsidy scheme following an unprecedented energy market shock. Consumers in highly exposed regions reacted swiftly by reducing demand. Crucially, while government subsidies provided financial relief, they did not dampen conservation efforts and may have even reinforced them by signaling the severity of the crisis. These findings offer insights for policymakers designing support schemes during energy crises, highlighting the complex interplay between market prices, government interventions, and short-term consumer responses.

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A Additional Figures and Tables

A.1 How price sensitive are consumers in Norway?

Electricity plays a uniquely important role in Norwegian households' energy use. According to Statistics Norway, a typical household consumes about 14,900 kWh of electricity annually, equivalent to roughly 1,240 kWh per month, and electricity accounts for nearly 80–90% of total household energy consumption.[31] This share is exceptionally high compared with most European countries, reflecting Norway's extensive electrification of heating and transportation and its reliance on hydropower. Because most homes use electric heating, consumption peaks sharply during the winter months.

A typical electricity bill consists of three roughly equal components: (1) grid rent (*nettleie*), which covers the cost of transporting electricity and maintaining the grid; (2) electricity costs, paid to suppliers based on the spot price and supplier margin; and (3) taxes and fees, including value-added tax (VAT), electricity taxes, and environmental charges. For illustration, a household using 1,300 kWh in a month with an average spot price of 1.20 NOK/kWh would pay around 1,560 NOK for electricity. Adding grid rent (approximately 520 NOK per month) and taxes (roughly 25% VAT plus excise charges) results in a total monthly bill of about 2,600 NOK.[32] Although this varies across bidding zones and seasons, it highlights that electricity spending represents a meaningful share of household budgets—around 5% of disposable income, given a median after-tax income of about 635,000 NOK in 2023.[33]

Because electricity dominates total energy use, fluctuations in electricity prices directly affect households' overall energy expenditures. This makes Norway an especially relevant setting for examining price sensitivity and understanding how consumers adjust their demand in response to changing electricity prices.

However, estimating this sensitivity is empirically challenging because electricity prices are *endogenous*. Prices are set in wholesale markets where supply and demand interact simultaneously—meaning that high prices may reflect high demand (for example, during cold weather), not necessarily a causal effect of prices on consumption. Ignoring this simultaneity would bias ordinary least squares (OLS) estimates of price elasticity toward zero. Moreover, unobserved regional shocks, such as sudden temperature drops or industrial demand shifts,

[31] SSB, 2024
[32] NVE.no
[33] SSB, 2024

can affect both consumption and prices, introducing further endogeneity.

To overcome these challenges, we employ a two-stage least squares (2SLS) approach that isolates exogenous price variation arising from the supply side. Specifically, we use the natural gas price index and wind energy generation as instruments for electricity prices. These variables capture cost-side shocks, fluctuations in generation costs and renewable output that influence wholesale electricity prices but are plausibly unrelated to local demand conditions. This instrumental variable strategy allows us to estimate short-run demand elasticities at a high (hourly) frequency while mitigating simultaneity bias. Specifically, we employ the following two-stage least squares (2SLS) approach.

First stage.

$$\log(\text{Price}_{hz}) = \pi_0 + \pi_1 \log(\text{NGas}_{hz}) + \pi_2 \log(\text{WGen}_{hz}) + \mathbf{X}_{hz}\boldsymbol{\pi} + \sigma_{\text{hod}} + \gamma_d + \lambda_m + \mu_y + \nu_{hz}. \quad (4)$$

Second stage.

$$\log(\text{Consumption}_{hz}) = \alpha + \beta \log(\widehat{\text{Price}_{hz}}) + \mathbf{X}_{hz}\boldsymbol{\beta} + \sigma_{\text{hod}} + \gamma_d + \lambda_m + \mu_y + \varepsilon_{hz}. \quad (5)$$

where h indexes *hours* and z indexes zones. $\mathbf{X}_{hz}$ includes temperature^2, heating-degree, and cooling-degree measures at the hourly frequency. We include fixed effects for hour-of-day (σ_{hod}), day-of-week (γ_d), month (λ_m), and year (μ_y). The endogenous variable $\log(\text{Price}_{hz})$ is instrumented with the natural gas price index and wind energy generation. All 2SLS regressions are estimated separately by zone.

The corresponding first-stage results reported in Table A.1 confirm the strong relevance of the instrument, with substantial explanatory power for variation in electricity prices. The Bloomberg EGSI day-ahead natural gas index (ln_EGSIZPAD) - a transparent benchmark built from executed spot trades across European gas hubs and used for EEX settlements - exhibits strong relevance, loading positively on electricity prices in Zones 1, 2, and 5 (coefficients 1.072, 0.917 and 0.968), while small negative loadings in Zones 3–4 likely reflect zone-specific market structure. Wind generation (ln_wind) is price-depressing in Zones 1–4 (−0.015 to −0.276) but slightly price-increasing in Zone 5 (0.035), consistent with localized congestion or balancing effects. Because wind generation coverage is sparse in Zone 5, with only 4,402 observations out of a total of 30,477 observations for the other variables, we also estimate a single-instrument first stage using natural gas only; the implied second-stage price elasticity remains negative and statistically significant, reinforcing our main conclusions. Instrument strength is uniformly high: the Kleibergen–Paap F-statistics range from 954 to 2,616 in Zones 1–4 and remain comfortably above conventional thresholds in Zone 5 (116), mitigating weak-instrument concerns. With rich time fixed effects (hour, day, month, year) and weather controls (squared temperature, HDD, CDD), model fit is solid ($R^2 = 0.365$–0.566), supporting the credibility of the subsequent 2SLS estimates and pointing to meaningful cross-zone heterogeneity.

Table A.1: First stage (OLS): Instrument relevance

	Zone 1	**Zone 2**	**Zone 3**	**Zone 4**	**Zone 5**
ln_EGSIZPAD	1.072***	0.917***	−0.189***	−0.052***	0.968***
	(0.015)	(0.015)	(0.016)	(0.014)	(0.064)
ln_wind	−0.015***	−0.093***	−0.250***	−0.276***	0.035***
	(0.004)	(0.004)	(0.005)	(0.006)	(0.010)
F excl. instr.	2,615	2,066	1,420	954	116
df num	2	2	2	2	2
df den	29,988	30,429	30,421	30,421	4,359
p-value	0.000	0.000	0.000	0.000	0.000
R-squared	0.428	0.436	0.368	0.365	0.566
N	30,036	30,477	30,469	30,469	4,402

Notes: Standard errors are reported in parentheses. The first-stage regressions include the same set of control variables and fixed effects as in the second-stage specifications. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Next, Table A.2 reports the hourly price elasticity for each zone during pre- and subsidy-period, computed through two stage least squares regressions with two instrumental variables, as described above.

Before the subsidy elasticities are about −0.05 to −0.47. Then subsidy starts and consumption goes down (as shown in Table 3). This means that consumers reacted to price increases even if the subsidy covered between 80 and 90% of the prices above the threshold. But still the threshold is relatively high: the effective price is relatively high compared to prices from before November 2021.

A.2 Robustness checks: Restricting the control group to one zone only

This appendix subsection reports robustness checks to the baseline difference-in-differences results presented in section 4. In the baseline specification, zones NO3 and NO4 are jointly used as the control group. To assess whether the results are sensitive to this choice, we re-estimate Equation 1 using each control zone separately. Table A.3 reports results using only zone NO3 as the control group, while Table A.4 reports results using zone NO4 as the

Table A.2: Price elasticities of electricity demand by zone and policy period

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Panel A: Pre-subsidy period ($\leq$ Nov 2021), raw prices					
ln(price)	-0.123^{***}	-0.204^{***}	-0.054^{***}	-0.469^{***}	-0.101^{***}
	(0.004)	(0.004)	(0.016)	(0.037)	(0.004)
Observations	7,722	7,989	7,987	7,986	7,991
Panel B: Subsidy period ($\geq$ Dec 2021), raw prices					
ln(price)	-0.026^{***}	-0.025^{***}	-0.063^{***}	-0.020^{***}	-0.022^{***}
	(0.001)	(0.001)	(0.002)	(0.001)	(0.006)
Observations	22,314	22,488	22,482	22,483	4,394
Panel C: Subsidy period ($\geq$ Dec 2021), effective prices					
ln(effective price)	-0.040^{***}	-0.039^{***}	-0.062^{***}	-0.019^{***}	-0.044^{***}
	(0.001)	(0.002)	(0.002)	(0.001)	(0.009)
Observations	22,314	22,488	22,482	22,483	4,394

Notes: The table reports IV estimates of the price elasticity of hourly electricity consumption by zone. The dependent variable is the logarithm of hourly electricity consumption. In Panel A, the endogenous regressor is the logarithm of electricity prices during the pre-subsidy period. In Panel B, the endogenous regressor is the logarithm of electricity prices during the subsidy period. In Panel C, electricity prices are replaced by the effective consumer price that accounts for the subsidy scheme. Electricity prices are instrumented using gas prices and wind generation. All specifications include temperature controls (HDD, CDD, and squared temperature), as well as hour-of-day and day-of-week fixed effects. Month fixed effects are included in Panels B and C. Standard errors are reported in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

sole control group.

Across both specifications, the estimated coefficient on the interaction term (*Treated* $\times$ *Post*) remains negative and statistically significant, and its magnitude is comparable to that obtained in the baseline specification reported in Table 3. This indicates that the main results are not driven by the particular choice of control zone.

A.3 Keeping data up to August 2022: Before the subsidy coverage changed from 80 to 90%

Table A.5 reports results similar to Table 3 but restricting the sample up to August 2022, which is the last month before the subsidy coverage changed from 80 to 90%. This addresses the potential concern that consumers' behavior changed once they were offered a slightly more generous subsidy. Using this restricted sample the coefficients vary between -0.081 to -0.097 across the different specifications.

Table A.3: DiD estimates of monthly household electricity consumption (Zone 3 as control)

	(1)	(2)	(3)	(4)	(5)
Treated × Post	-0.089***	-0.089***	-0.089***	-0.060***	-0.058***
	(0.0006)	(0.0005)	(0.0006)	(0.0005)	(0.0003)
Post	0.002***	-0.090***	0.002***	-0.116***	-0.117***
	(0.0005)	(0.0008)	(0.0005)	(0.0008)	(0.0004)
Treated	-0.012***	-0.012***			
	(0.0005)	(0.0004)			
Temperature				-0.027***	-0.027***
				(0.0003)	(0.0001)
Temperature^2				0.0008***	0.0008***
				(4×10^{-6})	(2×10^{-6})
Heating Degree Days				-0.009***	-0.009***
				(0.0003)	(0.0001)
Cooling Degree Days				-0.033***	-0.033***
				(0.0004)	(0.0002)
Intercept	7.127***	7.678***	7.136***	7.815***	7.807***
	(0.0004)	(0.0005)	(0.0003)	(0.005)	(0.002)
Zone FE	No	No	Yes	Yes	Yes
Month-Year FE	No	Yes	No	Yes	Yes
Household FE	No	No	No	No	Yes
DV mean	7.078	7.078	7.078	7.078	7.078
Adj.R^2	0.005	0.603	0.005	0.610	0.607
N	46,680,509	46,680,509	46,680,509	46,680,509	46,680,509

Notes: The dependent variable is the logarithm of monthly average electricity consumption per meter (household). The sample covers the period from January 2021 to December 2023. Zones 1, 2, and 5 are treated, while Zones 3 serves as control zone. Columns (1)–(3) report baseline difference-in-differences specifications with alternative combinations of zone and time fixed effects. Column (4) augments the specification with weather controls, including temperature, temperature squared, heating degree days, and cooling degree days. Column (5) further includes household fixed effects, absorbing time-invariant heterogeneity at the household level. Standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.4: DiD estimates of monthly household electricity consumption (Zone 4 as control)

	(1)	(2)	(3)	(4)	(5)
Treated × Post	-0.083***	-0.083***	-0.083***	-0.084***	-0.081***
	(0.0007)	(0.0006)	(0.0007)	(0.0006)	(0.0003)
Post	-0.003***	-0.083***	-0.003***	-0.097***	-0.10***
	(0.0006)	(0.0009)	(0.0006)	(0.0009)	(0.0004)
Treated	-0.203***	-0.203***			
	(0.0006)	(0.0005)			
Temperature				-0.013***	-0.013***
				(0.0003)	(0.0002)
Temperature^2				0.0007***	0.0007***
				(4×10^{-6})	(2×10^{-6})
Heating Degree Days				0.005***	0.005***
				(0.0003)	(0.0002)
Cooling Degree Days				-0.036***	-0.036***
				(0.0004)	(0.0001)
Intercept	7.318***	7.872***	7.136***	7.563**	7.573**
	(0.0005)	(0.0005)	(0.0002)	(0.006)	(0.003)
Zone FE	No	No	Yes	Yes	Yes
Month-Year FE	No	Yes	No	Yes	Yes
Household FE	No	No	No	No	Yes
DV mean	7.10	7.101	7.101	7.10	7.101
Adj.R^2	0.005	0.611	0.005	0.620	0.620
N	43,879,308	43,879,308	43,879,308	43,879,308	43,879,308

Notes: The dependent variable is the logarithm of monthly average electricity consumption per household. The sample covers the period from January 2021 to December 2023. Treatment starts in December 2021. Zones 1, 2, and 5 are treated, while Zone 4 serves as the control group. Columns (1)–(3) report baseline difference-in-differences specifications with alternative combinations of zone and time fixed effects. Column (4) augments the specification with weather controls, including temperature, temperature squared, heating degree days, and cooling degree days. Column (5) further includes household fixed effects, absorbing time-invariant heterogeneity at the household level. Standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Next, to assess simultaneously the influence of the choice of the control zone and the change in the amount of the subsidy, Table A.6 and Table A.7 show the results from Equation 1 using data up to August 2022 and using as control group only zone 3 or zone 4, respectively. In both cases, the coefficient remains stable and statistically significant at the level of the previous paragraph where we used as control group zones 3 and 4 together.

A.4 Electricity consumption: Holiday homes

Although consumers spend much less time in holiday homes as their second residency, we test for whether their consumption also dropped due to the implementation of the subsidy. Table A.8 presents the corresponding results for cabins, following the same specification as in

Table A.5: DiD estimates of monthly household electricity consumption
(sample up to August 2022)

	(1)	(2)	(3)	(4)	(5)
Treated × Post	-0.097***	-0.097***	-0.097***	-0.082***	-0.081***
	(0.0006)	(0.0005)	(0.0006)	(0.0005)	(0.0002)
Post	-0.006***		-0.006***		-0.092***
	(0.0005)		(0.0005)		(0.0002)
Treated	-0.090***	-0.090***			
	(0.0004)	(0.0003)			
Temperature				-0.023***	-0.023***
				(0.0003)	(0.0001)
Temperature^2				0.0004***	0.0004***
				(6×10^{-6})	(3×10^{-6})
Heating Degree Days				-0.011***	-0.010***
				(0.0003)	(0.0001)
Cooling Degree Days				-0.025***	-0.025***
				(0.0004)	(0.0002)
Intercept	7.204***	7.786***	7.128***	7.860***	7.874***
	(0.0003)	(0.0005)	(0.0002)	(0.006)	(0.003)
Zone FE	No	No	Yes	Yes	Yes
Month-Year FE	No	Yes	No	Yes	Yes
Household FE	No	No	No	No	Yes
DV mean	7.088	7.088	7.088	7.088	7.088
Adj.R^2	0.007	0.660	0.008	0.662	0.662
N	29,473,953	29,473,953	29,473,953	29,473,953	29,473,953

Notes: The dependent variable is the logarithm of monthly average electricity consumption per household. The sample covers the period from January 2021 through August 2022. Treatment starts in December 2021. Zones 1, 2, and 5 are treated, while Zones 3 and 4 serve as control zones. Columns (1)–(3) report baseline difference-in-differences specifications with alternative combinations of zone and time fixed effects. Column (4) augments the specification with weather controls, including temperature, temperature squared, heating degree days, and cooling degree days. Column (5) further includes household fixed effects, absorbing time-invariant heterogeneity at the household level. Standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3. This sample consists of hourly observations at the zonal level. The main coefficient of interest is larger in magnitude than in the main set of results. In particular, the coefficient in Column 4 is highly significant and represents a 16% decrease in consumption, in contrast with the 7 to 9% decrease in subsidy-eligible homes.

Table A.6: DiD estimates of monthly household electricity consumption (Zone 3 as control, sample up to August 2022)

	(1)	(2)	(3)	(4)	(5)
Treated × Post	-0.10***	-0.10***	-0.10***	-0.80***	-0.791***
	(0.0007)	(0.0006)	(0.0008)	(0.0007)	(0.0003)
Post	-0.003***		-0.003***		-0.094***
	(0.0007)		(0.0007)		(0.0002)
Treated	-0.012***	-0.012***			
	(0.0005)	(0.0004)			
Temperature				-0.025***	-0.025***
				(0.0004)	(0.0001)
Temperature^2				0.0008***	0.0008***
				(7×10^{-6})	(3×10^{-6})
Heating Degree Days				-0.007***	-0.007***
				(0.0004)	(0.0001)
Cooling Degree Days				-0.043***	-0.043***
				(0.0005)	(0.0002)
Intercept	7.127***	7.722***	7.128***	7.807***	7.803***
	(0.0004)	(0.0005)	(0.0002)	(0.007)	(0.003)
Zone FE	No	No	Yes	Yes	Yes
Month-Year FE	No	Yes	No	Yes	Yes
Household FE	No	No	No	No	Yes
Adj.R^2	0.009	0.661	0.009	0.665	0.665
DV mean	7.088	7.088	7.088	7.088	7.088
N	26,069,428	26,069,428	26,069,428	26,069,428	26,069,428

Notes: The dependent variable is the logarithm of monthly average electricity consumption per household. The sample covers the period from January 2021 through August 2022. Treatment starts in December 2021. Zones 1, 2, and 5 are treated, while Zone 3 serves as the control group. Columns (1)–(3) report baseline difference-in-differences specifications with alternative combinations of zone and time fixed effects. Column (4) augments the specification with weather controls, including temperature, temperature squared, heating degree days, and cooling degree days. Column (5) further includes household fixed effects, absorbing time-invariant heterogeneity at the household level. Standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.7: DiD estimates of monthly household electricity consumption (Zone 4 as control, sample up to August 2022)

	(1)	(2)	(3)	(4)	(5)
Treated × Post	-0.093***	-0.093***	-0.093***	-0.087***	-0.084***
	(0.0009)	(0.0007)	(0.0009)	(0.0007)	(0.0003)
Post	-0.011***		-0.011***	-0.067***	
	(0.0008)		(0.0008)	(0.0003)	
Treated	-0.203***	-0.203***			
	(0.0006)	(0.0005)			
Temperature				-0.007***	-0.007***
				(0.0004)	(0.0002)
Temperature^2				0.0003***	0.0003***
				(7×10^{-6})	(3×10^{-6})
Heating Degree Days				0.019***	0.019***
				(0.0004)	(0.0004)
Cooling Degree Days				-0.022***	-0.022***
				(0.0005)	(0.0002)
Intercept	7.318***	7.915***	7.128***	7.303	7.318
	(0.0005)	(0.0006)	(0.0002)	(0.007)	(0.003)
Zone FE	No	No	Yes	Yes	Yes
Month-Year FE	No	Yes	No	Yes	Yes
Household FE	No	No	No	No	Yes
DV mean	7.111	7.111	7.111	7.111	7.111
Adj.R^2	0.009	0.670	0.009	0.675	0.675
N	24,501,639	24,501,639	24,501,639	24,501,639	24,501,639

Notes: The dependent variable is the logarithm of monthly average electricity consumption per household. The sample covers the period from January 2021 through August 2022. Treatment starts in December 2021. Zones 1, 2, and 5 are treated, while Zone 4 serves as the control group. Columns (1)–(3) report baseline difference-in-differences specifications with alternative combinations of zone and time fixed effects. Column (4) augments the specification with weather controls, including temperature, temperature squared, heating degree days, and cooling degree days. Column (5) further includes household fixed effects, absorbing time-invariant heterogeneity at the household level. Standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.8: DiD estimates of electricity consumption for holiday homes (Monthly Data)

	(1)	(2)	(3)	(4)
Treated × Post	-0.151	-0.185	-0.151	-0.164***
	(0.913)	(0.123)	(0.916)	(0.031)
Post	2.351***		2.351***	
	(0.707)		(0.709)	
Treated	-0.109	-0.109		
	(0.802)	(0.108)		
Temperature				1.531***
				(0.178)
Temperature^2				0.0003
				(0.0004)
Heating Degree Days				1.543***
				(0.181)
Cooling Degree Days				-1.579***
				(0.228)
Intercept	4.557***	6.386***	4.491***	-19.863***
	(0.621)	(0.040)	(0.394)	(3.080)
Zone FE	No	No	Yes	Yes
Month-Year FE	No	Yes	No	Yes
Adj.R^2	0.09	0.983	0.098	0.99
N	240	240	240	240

Notes: The dependent variable is the logarithm of average electricity consumption across all cabin metering points within each zone and hour, and subsequently averaging to the monthly level using Elhub data. The sample covers the period from January 2021 to December 2024. Treatment starts in December 2021. Zones 1, 2, and 5 are treated, while Zones 3 and 4 serve as control zones. Columns (1)–(3) report baseline specifications with alternative combinations of zone and time fixed effects. Column (4) augments the specification with weather controls, including temperature, temperature squared, heating degree days, and cooling degree days. Standard errors are reported in parentheses and are clustered at the zone level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.9: Construction of household characteristic groups and summary statistics

Variable (Norwegian name)	Group	Definition	N
Household income (husholdningsinntekt, annual NOK)			
	1	Lowest income quintile: < 407,635	298,727
	2	407,635 – 609,894	510,336
	3	609,894 – 831,033	719,585
	4	831,033 – 1,096,594	953,284
	5	Highest income quintile: ≥ 1,096,594	1,531,810
Dwelling size (bruksareal, m^2)			
	1	Less than 50 m^2	869,001
	2	50–99 m^2	7,887,352
	3	100–149 m^2	13,771,869
	4	150–199 m^2	12,511,329
	5	200 m^2 or more	11,844,832
Construction period (byggeår)			
	1	Built before 1960	12,454,449
	2	Built 1960–1989	20,660,649
	3	Built 1990–2009	8,995,821
	4	Built 2010–2019	4,148,709
	5	Built 2020 or later	269,212
Number of rooms (antall rom)			
	1	1–2 rooms	3,155,721
	2	3–4 rooms	18,702,429
	3	5–6 rooms	16,682,043
	4	7–8 rooms	4,419,969
	5	9 rooms or more	996,123
Household size (antall personer)			
	1	1 person	1,201,641
	2	2 persons	1,521,057
	3	3 persons	877,562
	4	4 persons	1,127,399
	5	5 persons or more	619,757

Notes: Household income is grouped into quintiles based on the sample distribution; reported figures are mean income (NOK) within each quintile. All other variables are grouped using fixed thresholds, and reported figures are numbers of household–month observations. Group 1 is the omitted reference category in the heterogeneous treatment effect regressions.