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European Energy Crisis:
Did Electricity Prices Shock Real Estate Markets?

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Abstract

This paper investigates the impact of the 2021–2022 European energy crisis, a significant macro-financial shock, on homebuyer willingness-to-pay for energy-efficient homes in Norway. Leveraging the country's electricity market—characterized by five distinct regions with varying exposure to European power prices—as a quasi-experiment, we analyze how energy price shocks influence housing market dynamics. Applying a triple differences regression framework to real estate transactions, we find that home prices in regions affected by the shock fell significantly relative to unaffected regions, with single-family dwellings outside major cities experiencing the largest declines. While energy-efficient homes appeared less vulnerable, this effect was only marginally significant. Moreover, the negative price effects persisted despite the introduction of electricity price subsidies. These findings highlight the complex relationship between energy costs, housing market valuations, and buyer preferences, offering generalizable insights into the resilience of housing markets to macro-financial shocks and the role of policy interventions in mitigating their effects.

Keywords: energy price shock · housing market · energy efficiency · energy performance certificate · government subsidy · macro-financial shocks

JEL Classification: D12 · G14 · H23 · L94 · P18 · Q4 · R2 · R3

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1 Introduction

European energy markets faced a substantial crisis during 2021 and 2022 in the aftermath of the COVID-19 pandemic that was compounded by the outbreak of the Russian-Ukrainian war[1] and a sharp reduction in Russian gas supplies.[2] This situation was further exacerbated by the ongoing divestment from fossil fuels as part of long-term sustainability strategies, raising concerns that the transition may have outpaced the adoption of renewable energy sources.[3] As a result, wholesale prices for electricity and gas surged, leaving households burdened with rising costs for heating, cooling, transportation, and other energy-dependent necessities. The Norwegian housing market, with its distinctive electricity market structure and varied exposure to European power prices, offers a unique opportunity to explore how macro-financial shocks influence asset prices and risk perceptions in regional real estate markets. By examining how homebuyer preferences for energy efficiency evolve under price uncertainty, this study provides insights into market efficiency and the valuation of environmental attributes in housing assets. At first glance, the surge in energy spot prices may seem like a rational incentive to invest in energy-efficient homes.[4] Since these homes consume less energy, the impact of higher spot prices on total energy bills would be lower. This intuition is backed by a 2023 survey conducted by UK-based consultancy, Turley, suggesting that 39% of potential homebuyers would look to purchase a more energy-efficient home to cope with increasing energy costs following the 2022 energy crisis.[5]

Previous research has highlighted price stickiness in housing markets, suggesting that homebuyers may not always react rationally to macro-financial shocks (Fan, 2022; Tsai, 2013). Additionally, prior surveys indicate that under normal energy price conditions, energy efficiency tends to rank low among the priorities of homebuyers when choosing a property, contradicting the 2023 UK-survey (Amecke, 2012; Murphy, 2014). While earlier studies generally find that homes with higher Energy Performance Certificates (EPCs) command higher prices, the signaling effect of the EPC itself does not appear to have a significant direct influ-

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[1] See Pástor and Veronesi (2013) for a discussion of how political uncertainty exacerbates negative stock market impacts, particularly during poor economic times.

[2] Ready (2018) documents the dramatic impact of oil prices on stock markets.

[3] As discussed in International Monetary Fund's special feature, "Market Developments and the Pace of Fossil Fuel Divestment", available at `https://www.imf.org/en/Research/commodity-prices`.

[4] Ouimet and Tate (2020) suggests exposure to negative shocks might actually cause previously inattentive market participants to now pay more attention thereby causing them to make more optimal decisions moving forward.

[5] Survey results are available online at this website: `https://www.pbctoday.co.uk/news/energy-news/more-potential-house-buyers-looking-for-sustainable-homes-after-energy-crisis/`.

ence on sales prices (Aydin, Brounen, and Kok, 2020). EPCs could serve as proxies for other desirable, yet unobservable, attributes of a home, such as its overall condition (Olaussen, Oust, and Solstad, 2017). Although energy efficiency may not be a primary factor influencing homebuyer willingness-to-pay during periods of stable energy prices, this paper aims to explore whether this changes during an energy price shock. Specifically, we assess whether rising electricity costs are capitalized in the Norwegian housing market and how increases in electricity prices affect homebuyer willingness-to-pay for energy-efficient housing.

Norwegian households rely almost exclusively on electrical power for energy needs. Norway presents a unique setting to study the impact of energy efficiency and energy price shocks on house prices with its five distinct intra-national electricity markets that have limited cross-market transferability. The southern regions were heavily affected by the European energy crisis, as their electricity grids are connected to continental European power markets through cables. In contrast, northern Norway, largely isolated from other electricity markets, experienced an electricity surplus due to full water reservoirs.[6] This contrast in electricity provision creates an ideal context for a quasi-experimental investigation of how energy price shocks affect residential real estate markets, all within a single country with a uniform regulatory framework and consistent macroeconomic conditions.

We analyze Norwegian real estate transactions between September 2020 and September 2022. This period covers one year prior to, and one year during, the electricity price shock, which first impacted the southern region of the country in September 2021. To analyze the effect of this electricity price shock on house prices, we employ a triple differences regression framework. The third interaction focuses on energy efficiency, categorizing homes with an EPC rating between A and D as efficient, allowing us to assess whether the price shock had a different price impact on energy-efficient versus non-efficient homes.[7] Additionally, we explore how the electricity price shock affected different types of housing (i.e., single-family, semi-detached, row home, and apartments) and homes within and outside the largest metropolitan areas. We also use an event study to address the parallel trends assumption and to measure how long it took for the electricity price shock to influence house prices. Finally,

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[6] According to state-owned renewable energy company, Statkraft, 90% of the electricity produced in Norway comes from hydropower. For more information, see `https://www.statkraft.com/what-we-do/hydropower/`.

[7] Olaussen, Oust, and Solstad (2017) identify statistically significant price premiums for Norwegian homes labeled A through D. In our sample, this classifies approximately 40% of homes as energy efficient and the remaining 60% as inefficient.

we conduct several robustness checks to validate our findings. We apply propensity score matching to ensure more robust comparisons between homogeneous treatment and control groups. Furthermore, using a border discontinuity approach, we leverage the distinct borders between electricity spot price markets to match units in similar climate zones but separated by these market boundaries. This approach helps to isolate the effects of the price shock on house prices for more versus less efficient homes. In the final robustness check, we conduct placebo tests to ensure that our findings are not the result of random fluctuations in housing prices unrelated to the electricity price shock.

Our findings show that homes sold for lower prices in regions impacted by the electricity price shock. This effect was more pronounced and statistically significant for single-family dwellings, while it remained insignificant within the largest cities. The small positive price effect observed for apartments in the southern regions suggests a shift in demand, likely reflecting substitution from single-family houses to apartments. The home price impact of the electricity shock began to manifest quickly, but only reached its maximum after approximately four months. This timing aligns with the introduction of the public electricity price subsidy. However, the negative price effect in the affected regions persisted even after the policy change, suggesting that the subsidy had little effect on mitigating the decline in house prices. The signs and coefficients of the border discontinuity regressions align with our main findings, although the low sample sizes of transactions in these remote, nature-defined boundary areas presents challenges for achieving statistical significance. The propensity score-matched sample and placebo tests corroborate the main results. Regarding energy efficiency, our analysis suggests that the negative relation between the electricity price shock and house prices was less severe for energy-efficient homes, indicating that demand for energy-efficient housing may have risen as energy costs increased. However, this third interaction was only positive and statistically significant for single-family houses. Additionally, we find no clear evidence that the heating source had any notable effect on house prices.

The results contribute to the growing body of literature on energy-efficiency labels and the way homebuyers account for energy costs and efficiency in housing markets. Our findings suggest that rising energy-related living costs may constrain homebuyers' budgets, thereby limiting their ability to pay for homes in affected regions. However, the influence of energy efficiency on house prices remains ambiguous for non-single-family homes. This is consistent with previous research indicating, that energy efficiency is not a top priority for homebuyers when selecting a property (Amecke, 2012; Aydin, Brounen, and Kok, 2020; Murphy, 2014; Olaussen, Oust, and Solstad, 2017). Moreover, given that the Norwegian housing market operates under an English auction format, our findings add to the discussion on auction theory under budget constraints (Olaussen, Oust, and Sønstebø, 2018; Shen, Pretorius, and Chau, 2018). Buyers facing tighter financial limits may adopt more conservative bidding strategies. From a policy perspective, the results indicate that relatively lower sales prices for single-family homes in rural areas in the South persisted despite the introduction of electricity price subsidies. This outcome is plausible, however, as the southern regions continued to face disproportionately high electricity costs, even after subsidies were implemented.

The remainder of the paper is organized as follows: Section 2 provides a review of the relevant literature and the background on the electricity price shock in Norway. Section 3 details the data, followed by Section 4, which outlines the research design and presents the results. Section 5 offers robustness checks and, finally, Section 6 presents the concluding remarks.

2 Literature and Background

This section provides an overview of the relevant literature and background essential to understanding the context behind this study. We begin with a review of related literature, examining research on the impact of energy efficiency on property values, the role of energy performance labels, and how external factors like energy price shocks influence housing markets. Next, we discuss the structure of the Norwegian electricity market, focusing on its distinct regional segmentation, which creates variability in electricity costs across regions. We then address the 2021–2022 electricity price shock in Norway, detailing the price trends, government responses, and behavioral changes in electricity consumption. Finally, we describe the Norwegian housing market.

2.1 Related Literature

The impact of energy efficiency on residential real estate prices has been extensively researched.[8] Home energy-efficiency labeling policies aim to increase awareness of building energy efficiency and incentivize eco-friendly upgrades by offering economic benefits. Improving a property's energy performance generally leads to higher transaction prices. Con-

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[8] Increased environmental consideration has raised awareness about energy as in Chen and Lu (2018), Bolton and Kacperczyk (2021), Ilhan, Sautner, and Vilkov (2021), Bolton and Kacperczyk (2023) and Zhang (2024) while environmental change on asset prices is a focus of Choi, Gao, and Jiang (2020), Baldauf, Garlappi, and Yannelis (2020), Krueger, Sautner, and Starks (2020), Bakkensen and Barrage (2022), and Bartram, Hou, and Kim (2022).

sistent with this belief, studies have documented price premiums for energy-efficient homes in countries such as the Netherlands, England, Spain, and the United States (Brounen and Kok, 2011; de Ayala, Galarraga, and Spadaro, 2016; Fuerst et al., 2015; Kahn and Kok, 2014; Walls et al., 2017). The literature further suggests that energy-efficient buildings are associated with a lower probability of mortgage default, particularly for lower-income households, which could be due to energy savings that free up cash flow (Billio et al., 2022).

However, survey-based research, including Murphy (2014) and Amecke (2012), presents a different perspective. These studies suggest that in the Netherlands and Germany, EPC labels have limited influence on homebuyers during price negotiations. Amecke (2012) finds that German homebuyers prioritize other property features—such as location, price, balcony, garden, condition, size, construction method, and parking space—over energy efficiency.

This discrepancy seemingly highlights a contradiction in the literature regarding the price impact of energy efficiency disclosure through energy-efficiency labels. While quantitative studies report price premiums for higher energy-efficiency ratings, surveys reveal that consumers give the label minimal attention when purchasing homes. Aydin, Brounen, and Kok (2020) address potential methodological limitations in studies showing EPC-related price premiums, noting issues with omitted variables and multicollinearity between energy efficiency and other dwelling characteristics. Their regression discontinuity analysis suggests that, although energy efficiency is capitalized into house prices, the direct signaling effect of a higher EPC label has no statistically significant impact on sales prices.

In the context of the Norwegian housing market, Olaussen, Oust, and Solstad (2017) examine the effect of EPCs on house prices. By leveraging the abrupt introduction of EPC labeling in 2010, the authors explore whether the credential influenced sales prices after implementation. Their findings reveal a statistically significant price premium for homes with higher energy labels; however, this premium also existed before the introduction of the labeling system. Olaussen, Oust, and Solstad (2017) suggest the price premium is likely driven by other factors, such as the overall quality of the home, rather than the EPC label alone.

In a follow-up study, Olaussen et al. (2019) shift their focus to the present value of future energy costs, rather than the EPC label itself, to assess the same effect. This analysis incorporates fluctuations in electricity spot prices and interest rates over time. Once again, the authors find no significant change in the valuation of energy efficiency before and after the introduction of EPCs, indicating that the label was not capitalized into Norwegian house prices. These findings suggest that, consistent with the literature from other markets, Norwegian homebuyers do not heavily factor EPCs into their purchasing decisions. However, this effect has not yet been studied in a period of extreme energy prices.

When it comes to the effect of energy price shocks, Olaussen, Oust, and Sønstebø (2018) further investigate the impact of different market conditions on the Norwegian housing market. Specifically, they examine bidding strategies in a submarket with a high concentration of petroleum workers following the oil price collapse from 2014–2016. The study finds that homebuyers in declining markets are more likely to set a predefined maximum price limit and adopt less aggressive bidding strategies in residential auctions compared to those in booming markets. Wu, Sexton, and Zilberman (2019) suggest that the gasoline price shock from 2005–2008 increased commuting costs and reduced home values in the US, especially in suburban areas, as homeowners struggle to absorb higher energy expenses, leading to increased foreclosures. According to Costa and Kahn (2011), homes built during periods of low electricity prices have higher long-term electricity consumption, indicating that energy prices at the time of construction may affect future behavior.

Various policy approaches can be implemented to promote energy efficiency. Real-time feedback on electricity consumption has been found to increases household price elasticity of demand, leading to a reduction in electricity usage compared to households that only experience price increases (Aydin, Brounen, and Kok, 2018; Jessoe and Rapson, 2014). Allcott (2011) finds a similar effect for Home Energy Reports sent to households, comparing the household's energy use to that of their neighbors. This supports the idea that households are willing to reduce their energy use when more information is provided. Alberini and Towe (2015) further find that policies such as home energy auditing and discounts on heat pumps significantly reduce household energy consumption patterns.

Another policy approach involves pricing strategies, such as non-linear tariffs, which are proposed to help ensure access to a basic level of electricity for all. However, consumers have been found to respond to average electricity prices rather than marginal or expected marginal prices, leading to inefficiencies in such non-linear pricing (Ito, 2014). Non-linear electricity pricing structures, such as increasing-block tariffs, are further found to cause some income redistribution, but more importantly contributing to substantial economic inefficiencies (Borenstein, 2012). Shaffer (2020) find that consumers often misunderstand non-linear tariffs, leading to exaggerated reductions in consumption and significant welfare losses.

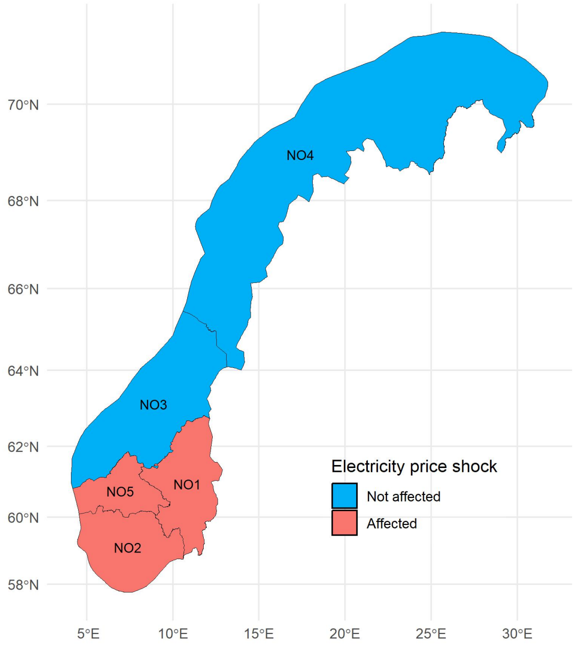
A final, well-documented factor influencing housing market dynamics during economic shocks is price stickiness. Fan (2022) explores this in the context of uncertainty shocks in China's housing market, demonstrating that housing prices tend to adjust slowly in response to demand shocks, exacerbating market fluctuations and delaying price convergence. The study emphasizes that housing price stickiness creates deeper and more prolonged market volatility, particularly in periods of heightened uncertainty, such as post-crisis environments. Price stickiness may result from irrational price anchoring as a loss aversion strategy in uncertain markets (Tsai, 2013).

2.2 Norwegian Electricity Market

The Norwegian electricity market is segmented into five distinct electricity price regions. These regions operate effectively as separate markets due to limited grid transferability capacity, which prevents the creation of a unified market encompassing the entire country. The five regions, as shown in Figure 1, are the Southeast (NO1), Southwest (NO2), Middle (NO3), North (NO4), and West (NO5), and are exclusively used for the electricity market. The electricity price in each region is determined independently on the Nord Pool exchange to balance supply and demand. As a result, prices can differ across the country, with some areas experiencing an electricity surplus while others face a deficit.

The number of homes varies among electricity price regions. The NO1 region includes the Norwegian capital, Oslo, and is the most populated area. The NO4 region in the North is the largest region in terms of size but has lower population density and is the second smallest in terms of number of homes. The NO4 electricity price region is the only one where electricity

Figure 1: Electricity price regions in Norway



Notes: Each region functions like a separate market with a spot price determined by intra-regional supply and demand. The legend shows which regions were affected and not affected by the 2021–2022 electricity price shock. Source: Maps by the Norwegian Water Resources and Energy Directorate.

consumption is not subject to VAT and other consumption taxes.[9] The number of homes in each region are extracted from the Norwegian land cadaster in 2023 and represents all primary households in the country.[10] This includes three possible tenure forms; freeholder ownership, shareholder ownership, and leasing.[11] Housing units are further separated into four home types: apartments, single-family houses, semi-detached houses, and row homes.

End users in the electricity market can choose among various suppliers and contract types, although real-time spot price contracts are the norm.[12] In these contracts, consumers pay the electricity spot price from Nord Pool plus taxes and a mark-up. Payments are made via a delayed monthly bill, where the average spot price for the electricity consumed is multiplied by the amount used.[13] Consequently, two identical homes may incur different average monthly electricity prices depending on the time of day they consumed most of their electricity, with daily peaks typically occurring in the mornings and late afternoons/evenings.

Most electricity transferred from North to South in Norway flows through Sweden. Additionally, most cross-border import and export occur through the southern regions (NO1 and NO2), making prices in these areas more susceptible to fluctuations in other countries. Hydropower is the primary source of electricity supply, resulting in minimal intra-day variation but significant seasonal differences. Since a substantial portion of household energy consumption is for heating, demand is highly temperature dependent.

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[9] The VAT handbook describes tax exemptions at `https://www.skatteetaten.no/rettskilder/type/handboker/merverdiavgiftshandboken/2023/M-6/M-6-6/M-6-6.2/` and rates are spelled out at `https://www.skatteetaten.no/en/business-and-organisation/vat-and-duties/excise-duties/about-the-excise-duties/electrical-power-tax/`. The total price for electricity consumption is composed of three components: the electricity price (normally spot price + mark-up), a grid fee, and taxes. The taxes are further divided into a 25% VAT, a fixed per-kWh rate electrical power tax, and a fixed per-kWh fee paid to the energy fund. The Norwegian Water Resources and Energy Directorate has a series of useful question and answers at `https://www.nve.no/reguleringsmyndigheten/kunde/stroem/spoersmaal-og-svar-om-stroem/` and `https://www.nve.no/reguleringsmyndigheten/regulering/nettvirksomhet/nettleie/nettleie-for-forbruk/`. Homes in the NO4 region are exempt from the VAT and the electrical power tax due to the harsher climate (per the handbook mentioned above).

[10] This excludes cabins and other types of holiday homes.

[11] Shareholder ownership in housing cooperatives means a cooperative legally owns the property, while shareholders have the right to live in units. This common ownership form avoids a 2.5% document tax, making it cost-effective, particularly for short-term tenure. Living units come with shared debt, usually incurred during construction or renovation, which is added to the sales price to determine a total price.

[12] In 2020, Statistics Norway posted a report about record low electricity prices (in the second quarter) split out by those categories. It is available at `https://www.ssb.no/energi-og-industri/artikler-og-publikasjoner/veldig-lav-strompris-i-2.kvartal`.

[13] See the questions and answers at `https://www.skatteetaten.no/en/business-and-organisation/vat-and-duties/excise-duties/about-the-excise-duties/electrical-power-tax/`.

Table 1: Average yearly electricity spot prices

Region	Prior to shock (NOK/kWh)	During shock (NOK/kWh)	During shock, subsidy adjusted (NOK/kWh)
North (NO3, NO4)	0.26	0.25	0.25
South (NO1, NO2, NO5)	0.37	1.57	0.99

Notes: This table shows average yearly electricity spot prices in the year prior to and the year of the electricity price shock. As shown, the increase in average electricity price was sharp in the South, whereas prices in the North remained stable. After deducting the subsidized portion of the electricity cost following the policy change in January 2022, the difference between the South and the North is clear. Source: Author calculations using electricity price data Norwegian power supplier, Fjordkraft, September 2020–September 2022.

2.3 Electricity Price Shock

Norwegian summers are typically associated with low electricity prices. However, in August 2021, average monthly electricity spot prices in the southern-most three Norwegian electricity price regions (NO1, NO2, and NO5) soared to 0.7 NOK per kWh, which was three times higher than the usual summer rate and exceeded even typical winter prices, which could reach between 0.40–0.50 NOK per kWh. This marked the beginning of a prolonged increase in electricity prices rather than a temporary spike. The middle (NO3) and northern (NO4) regions were not affected due to limited transferability, power surplus, and lower dependency on neighboring countries.[14] This upward trend continued throughout the fall of 2021 and into the spring of 2022, culminating in a peak in August 2022. The rise, particularly in the southernmost regions, is easily discernible with energy spot prices increasing quickly after the first vertical dashed line in Figure 2.

After considerable media attention and public concern in the fall of 2021, the Norwegian government introduced a long-awaited financial support initiative for residential households. Effective from December 22, 2021, this initial program reimbursed 55% of the monthly electricity expenses exceeding 0.7 NOK per kWh, excluding VAT, effectively augmenting the

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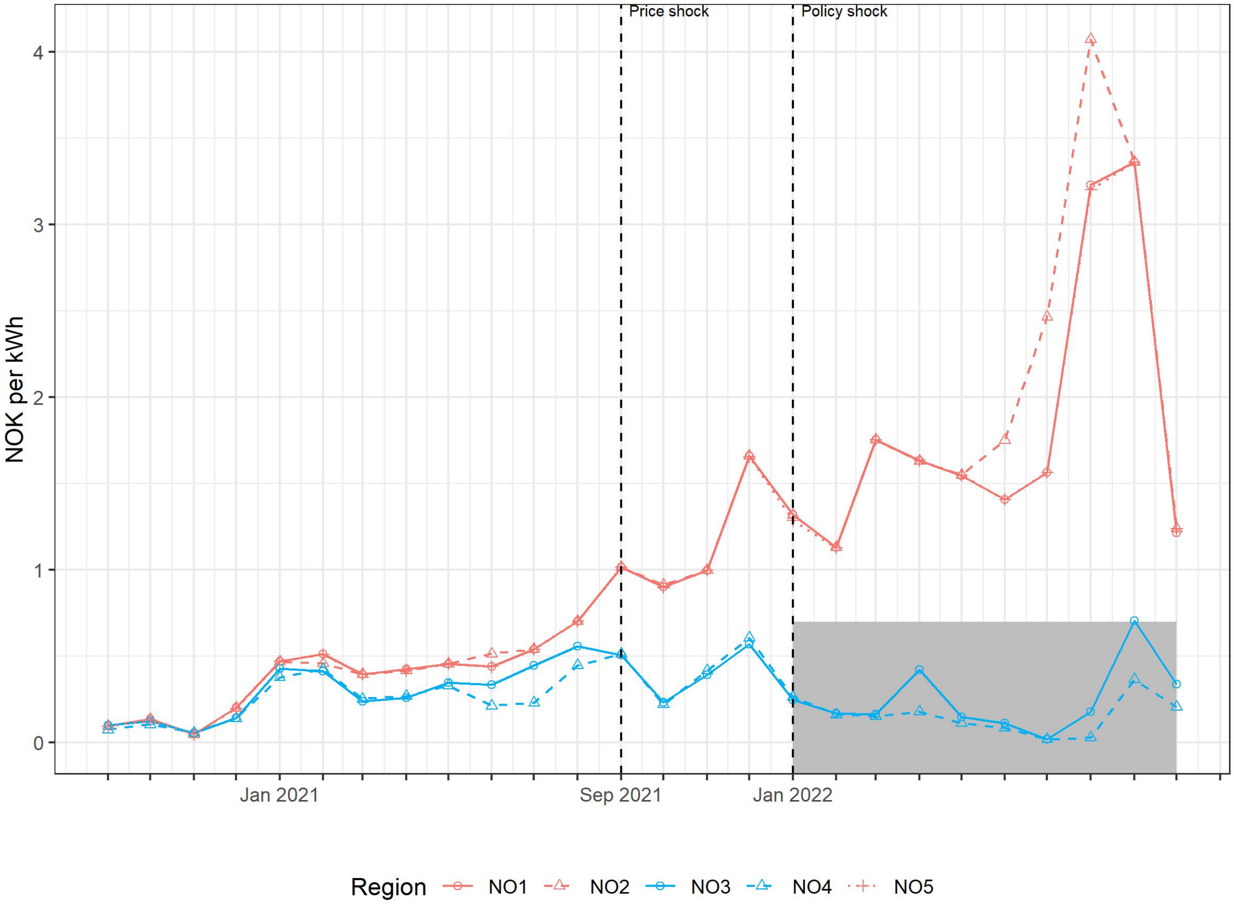
[14] The three southern electricity price regions are, directly or indirectly, connected to the European power grid. The Russian invasion of Ukraine and gas crises in countries like Germany drove up demand and prices.

Figure 2: Average monthly electricity spot prices for the different price regions



Notes: The vertical axis shows the average electricity price per month in NOK per kWh. The grey rectangle indicates the NOK 0.7 threshold above which 80% of the households' electricity expenses were refunded from January 2022. Regions NO3 and NO4 in blue were not affected by the electricity price shock. Source: Electricity spot price data from Norwegian power supplier, Fjordkraft, January 2020–October 2022.

first price tranche of energy bills.[15] Since most households pay delayed monthly electricity bills based on spot prices, the financial aid was calculated as 55% of the difference between the household's average monthly electricity expenditure and the 0.7 NOK threshold.[16] Shortly thereafter, effective January 8, 2022, the compensation rate for expenses exceeding 0.7 NOK was increased to 80%.[17] This rate remained in place until September 1, 2022, when it was further increased to 90%.[18] During the summer months of 2023, the rate was reverted to 80%.[19] It is important to note that the 0.7 NOK threshold is high compared to historical electricity prices, as electricity spot prices rarely exceeded this level prior to the electricity price shock.[20] Nevertheless, with average monthly prices reaching over 3 NOK per kWh in 2022, consumers still faced significantly higher electricity bills despite the support measures.[21] Although the policy change was nationwide, regions in the middle and North rarely benefited, as their average electricity spot prices remained below the 0.7 NOK threshold. Table 1 displays the average electricity spot prices for the northern and southern regions before and during the electricity price shock. The final column presents the average prices post-subsidy,

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[15] The Norwegian Government outlined (what it thought would be) a temporary benefit scheme for households as a result of extraordinary electricity expenses at `https://www.regjeringen.no/no/aktuelt/endret-stonadsordning-for-husholdninger-som-folge-av-ekstraordinare-stromutgifter/id2893331/`. The NOK 0.7 threshold for the subsidy was for the electricity spot price in the electricity price region, excluding supplier mark-up, grid fees, and taxes. An alternative approach would have been to cap the electricity prices after the 0.70 NOK level. Various examples in the literature compare the effectiveness of price caps versus fixed subsidies in response to energy/price shocks, e.g., Gros (2022).

[16] The arrangement was administered through local grid companies and operated via automatic deduction in delayed monthly electricity bills. The Norwegian government's temporary electricity support schemes are described at `https://www.regjeringen.no/no/tema/energi/regjeringens-stromtiltak/id2900232/`.

[17] The government's increase in electricity support is described at `https://www.regjeringen.no/no/aktuelt/regjeringen-oppjusterer-sikringsordningen-og-gir-folk-mer-stromstotte/id2894979/`.

[18] The additional support is announced at `https://www.regjeringen.no/no/aktuelt/regjeringen-foreslar-a-oke-stromstotten-for-september/id2929545/`. A month later, the government announced a continuation into 2023 at `https://www.regjeringen.no/no/aktuelt/vil-forlenge-stromstotten-til-husholdninger-ut-2023/id2930621/`.

[19] The compensation rate for consumption above NOK 0.7/kWh was reverted to 80% in April 2023, due to reduced need for electrical heating during the warmer months.

[20] According to data from electricity supplier Fjordkraft on spot prices from 2013 to 2024, the average monthly electricity spot price never reached NOK 0.7 per kWh between January 2013 and the start of the price shock in August 2021 in any of the five electricity price regions. The highest monthly electricity spot price during this period was recorded in January 2018, at NOK 0.54 per kWh in the three southern regions.

[21] According to data from electricity supplier Fjordkraft on spot prices, the average monthly threshold of NOK 0.7 per kWh was breached every month from August 2021 to July 2023 in the southern regions (NO1, NO2, and NO5). For comparison, the average monthly spot price in the NO3 region only exceeded NOK 0.7 per kWh twice, and the NO4 region only once, over the same two-year period.

illustrating the adjusted costs after government financial aid is applied.[22]

The support program covered all primary households, regardless of ownership status. Typically, tenants under net lease agreements independently subscribe to electricity plans and pay for their individual consumption. The support mechanism also applied to housing cooperatives, where shareholders pay electricity expenses through their monthly common costs. Additionally, students residing at a different address than their parents were granted extra support of 4,500 NOK through various payments in 2022. Furthermore, the government opted to extend electricity support to energy-intensive businesses in the latter half of 2022 through the "energy subsidy scheme".[23] This scheme for energy-intensive businesses was not continued into 2023.

A natural consequence of its harsher climate, the northern part of Norway usually consumes more electricity than the rest of the country, as shown in Panel A of Figure 3. The winter of 2021 was cold compared to 2022, explaining some of the higher electricity consumption. During winter, the demand for electricity is predominantly driven by low temperatures and the need for heating, making it challenging to significantly reduce consumption unless temperatures rise. In contrast, in the warmer months from April to September, it is easier to decrease consumption during periods of high electricity prices. Panel B of Figure 3 indicates that despite the peak electricity prices in the summer of 2022, the NO3 and NO4 regions maintained similar levels of electricity consumption as the previous year. Notably, the NO3 region experienced a 14% increase in electricity consumption from July 2021 to July 2022. However, the other regions (NO1, NO2, and NO5), which were impacted by the electricity price shock, showed a reduction in electricity consumption of up to 20% over the same period. Except for NO5 in July 2022, all the southern regions consistently consumed less electricity during the summer of 2022 compared to the previous year. This trend indicates a willingness to reduce consumption during periods of high spot prices.[24]

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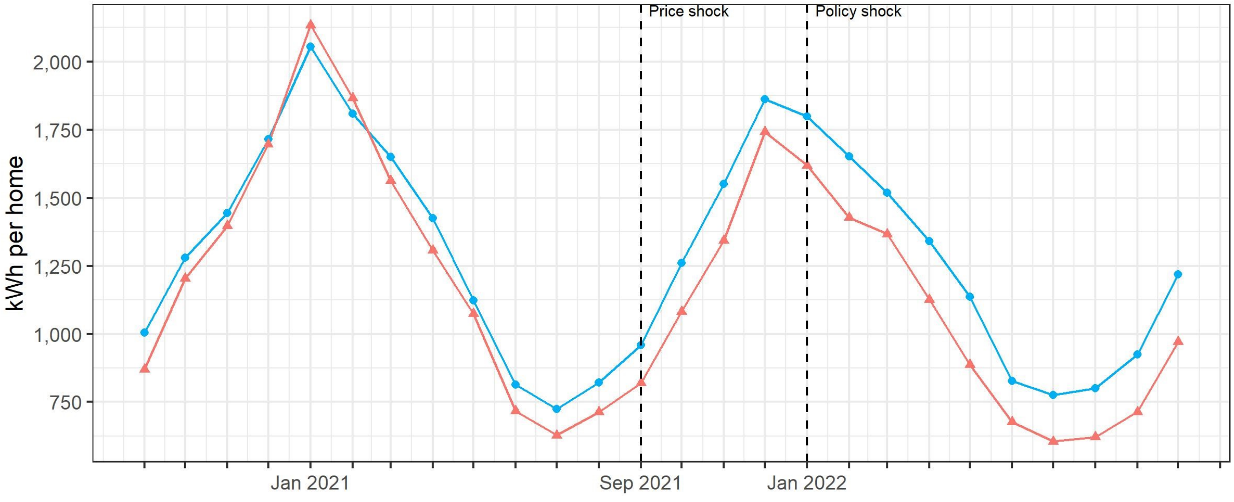
[22] This paper's subsidy is always a fixed amount per kWh hour, which encourages energy efficiency because the subsidy reduces costs based on usage, but it could distort behavior for owners of high-cost homes (either larger or low-efficiency) if the limit is set too high. Other subsidy options could have been a price cap (which would stabilize demand for low-efficiency homes by capping energy costs), fixed dollar transfer (which would provide uniform relief while weakening any preference for high-efficiency homes), or a proportional transfer (which would benefit high-cost homes more while potentially inducing demand for low-efficiency homes).

[23] Businesses with an electricity cost that amounted to at least 3% of their revenue in the first half of 2022 were eligible for support. More efforts are described at `https://www.regjeringen.no/no/tema/energi/regjeringens-stromtiltak/id2900232/`.

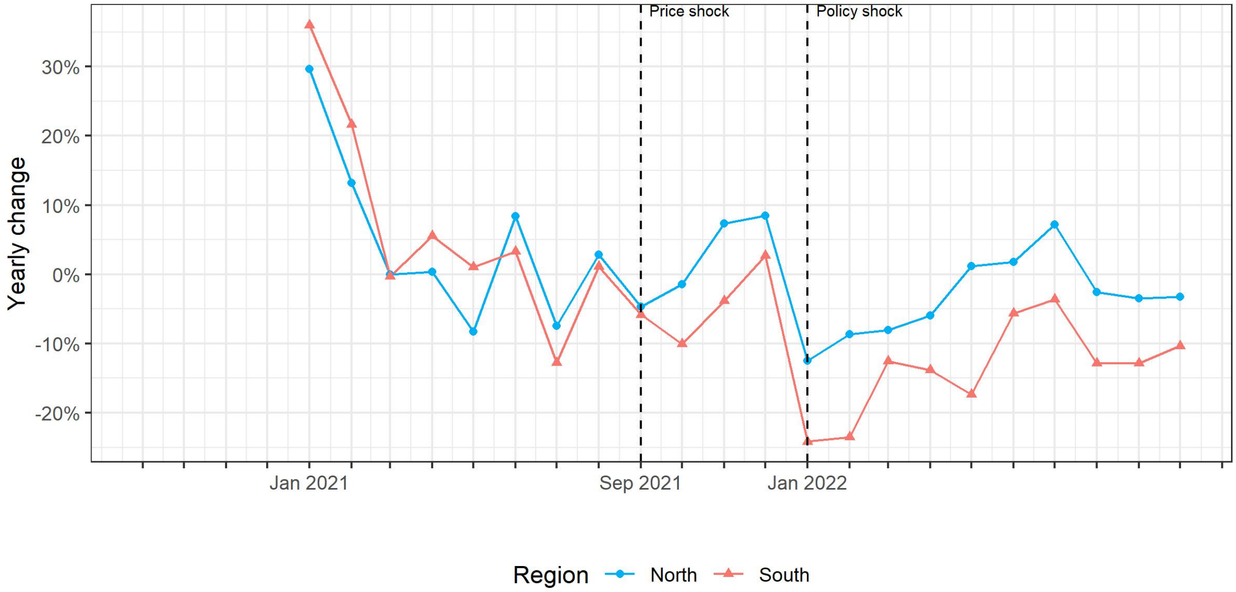
[24] These results do not control for differences in weather across these time periods.

Figure 3: Average electricity consumption per household for the different price regions

Panel A: Electricity consumption



Panel B: Year-over-year change in electricity consumption



Notes: Panel A gives the average monthly electricity consumption per household in kWh. Panel B shows the monthly percentage year-over-year change in electricity consumption for the different electricity price regions. North consists of electricity price regions NO3 and NO4. Electricity consumption data for 2019 is not available for primary residency homes specifically, due to lack of separation between different end-user segments. The year-over-year time series can thereby only start in 2021. Source: Statistics Norway electricity consumption data from January 2020–October 2022.

These trends are supported by Dalen and Halvorsen (2022), who report that the proportion of disposable income allocated to electricity expenses in the South increased from 3.2% to 7.7% for the lowest-earning decile, and from 1.3% to 3.3% for the middle decile, between the winters of 2020–2021 and 2021–2022. In contrast, in the northern regions unaffected by the electricity price shock, the share of disposable income spent on electricity costs remained stable at approximately 2% for the lowest-income households and 1% for middle-income households. Additionally, their paper employs a panel model with fixed effects, based on the methodology of Dalen and Halvorsen (2022), to estimate electricity consumption, adjusting for temperature fluctuations and the impact of COVID-19. Dalen and Halvorsen (2022), further compare the expected electricity consumption—assuming spot prices had stayed constant at the average of the previous two years—with actual consumption and find that households in southern Norway used up to 1% less electricity during the winter of 2021–2022 than anticipated. This reduction was most pronounced in single-family homes.

2.4 Norwegian Housing Market

The Norwegian housing market is characterized by a high share of homeownership, with 77% nationwide and around 70% in the three largest cities: Oslo, Bergen, and Trondheim. In 2022, this high homeownership rate was accompanied by an average debt ratio of 247% of gross yearly income.[25] The maximum allowable mortgage debt ratio is five times gross yearly income. EPCs in Norway cover ratings from A to G, with A being the best and G the worst, and a heating score from green to red, with green being the best and red being the worst. The energy label is based on the estimated energy consumption for normal use of the unit, while the heating score depends on the type of heating system used. For example, a poorly insulated home with a heat pump might have a low EPC but a good heating score.

Figures 4 and 5 show estimated energy consumption and sales prices, both per m^2 of sold units, with the aim of visualizing the purchase trends in the Norwegian housing market following the electricity price shock. As illustrated in Figure 4, there was a general reduction in estimated energy consumption for homes sold starting from the onset of the electricity

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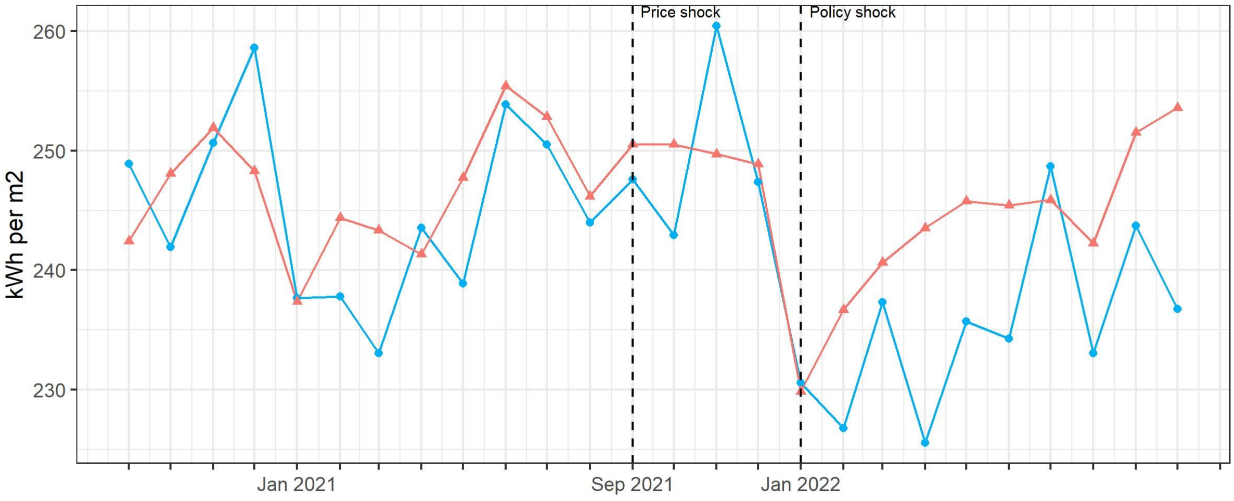
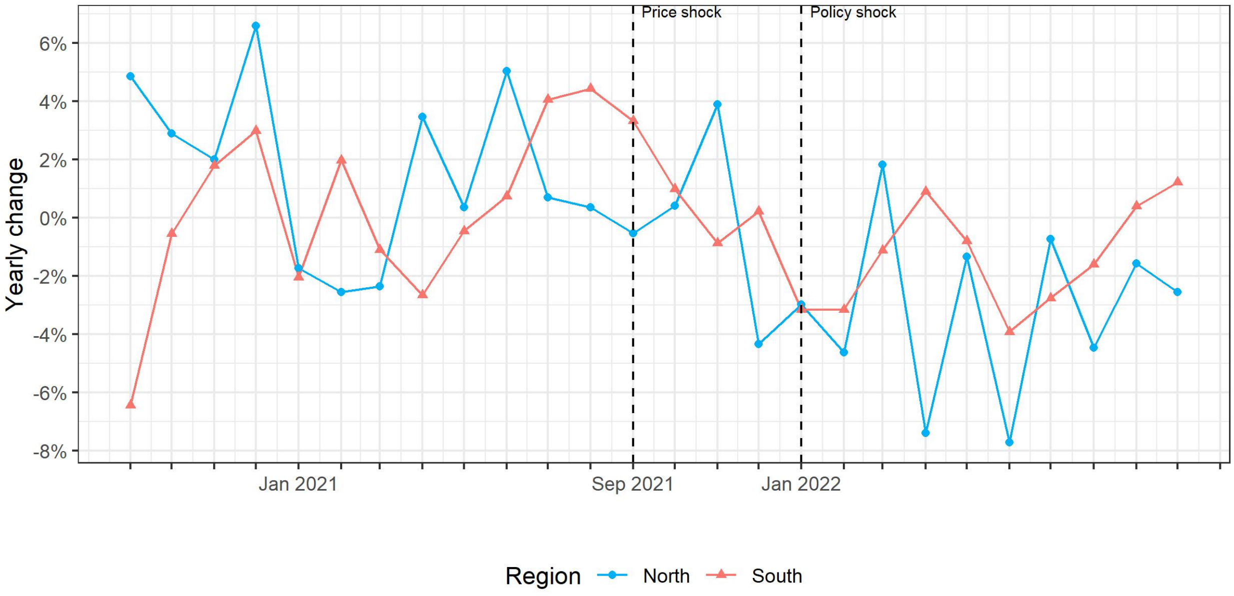
[25] Data tables for homeownership and debt-income ratio are available on the Statistics Norway website at `https://www.ssb.no/en/statbank/table/11084` and `https://www.ssb.no/en/statbank/table/09477`. The residential homes market operates using an open, ascending bid, English auction format.

Figure 4: Average monthly energy efficiency of sold units

Panel A: Estimated energy consumption of sold homes



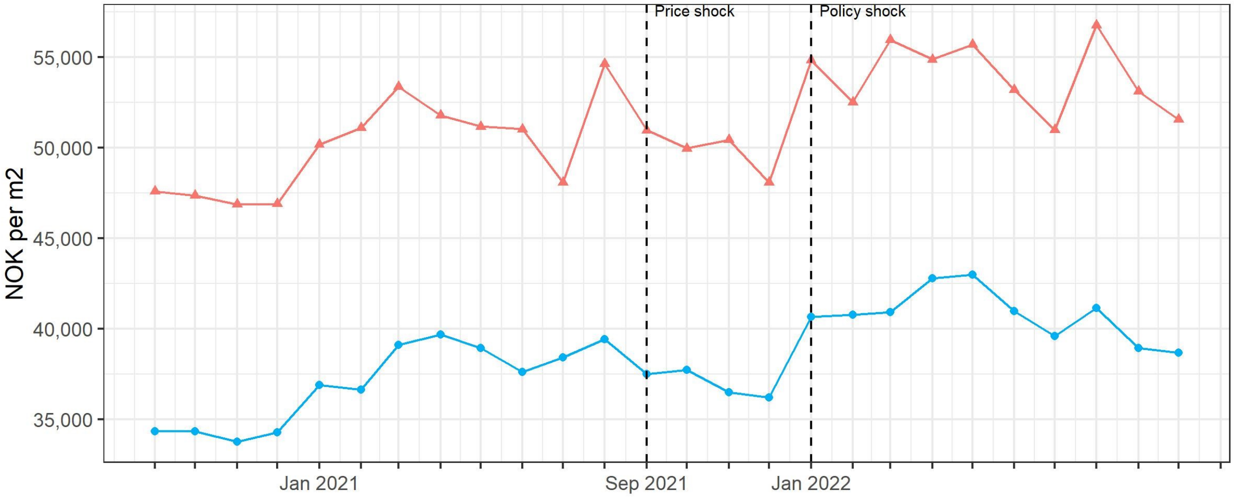
Panel B: Year-over-year change in estimated energy consumption



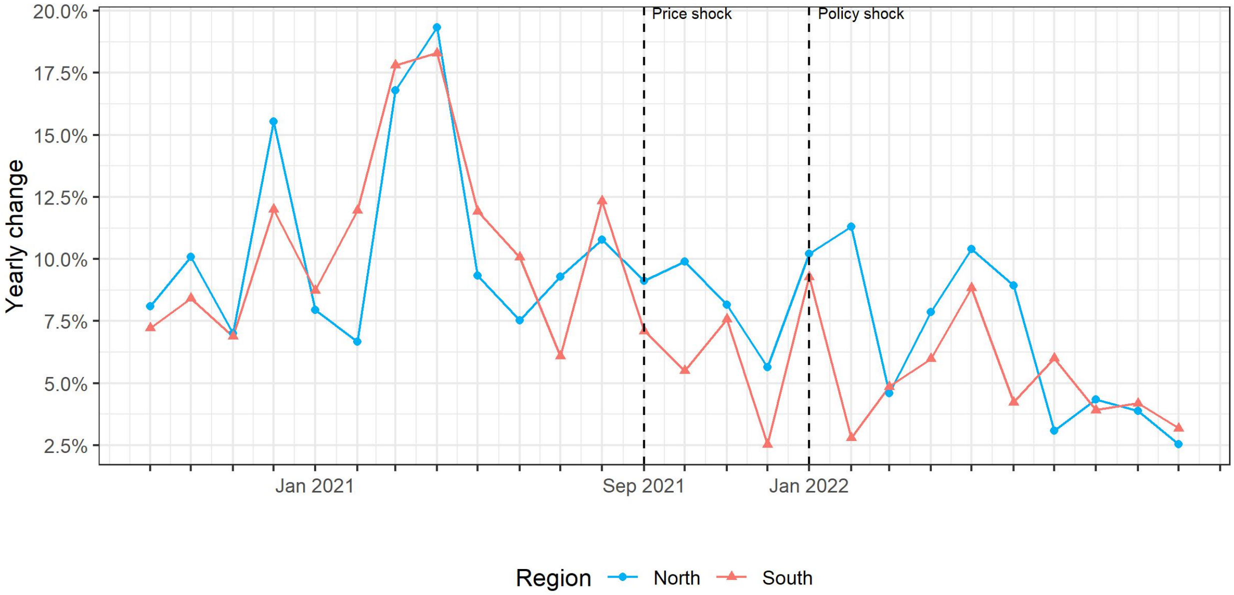
Notes: Panel A shows the energy efficiency of homes sold in terms of average monthly estimated kWh per m^2 for the North versus the South of Norway. North consists of electricity price regions NO3 and NO4. Panel B shows the monthly year-over-year change in estimated energy efficiency of homes sold in the same regions. Source: Ambita AS housing data with Enova energy performance certificates, September 2020–September 2022.

Figure 5: Average monthly house price per m^2 of sold units

Panel A: Price of sold homes



Panel B: Year-over-year change in price



Notes: Panel A shows the average monthly price in NOK per m^2 of homes sold for the North versus the South of Norway. The North consists of electricity price regions NO3 and NO4. Panel B shows the monthly year-over-year percentage change. Source: Ambita AS housing data, September 2020–September 2022.

price shock in August 2021.[26] However, when comparing the year-over-year relative change in estimated energy use in southern regions with the North, there is no clear difference between the two parts of Norway. In several of the months between September 2021 and September 2022, the reduction in estimated energy use per m^2 was even more pronounced in the northern regions, unaffected by the electricity price shock. This counterintuitive relation suggests capitalization of expected future electricity costs may not be the sole driver for choice of energy-efficient housing. Alternatively, it could suggest that homebuyers in the North were affected by the extensive media coverage of the price shock and feared a similar increase in electricity prices as the one facing the South.

For average monthly house sales prices per m^2 in Figure 5, on the other hand, we see more of a difference between the North and South. Panel B shows that in almost all of the months following the commence of the electricity price shock, the growth in prices of homes sold was lower in the South. This is more in line with the economic intuition that households in the South were more financially constrained due to increased electricity bills, and consequently had reduced purchasing power compared with households in the North.

We can further analyze the largest city in each of the three electricity price regions: Oslo (NO1), Stavanger (NO2), Trondheim (NO3), Tromsø (NO4), and Bergen (NO5). The cities are defined by their overlapping municipalities and postal areas. We remove some outlying house transactions based on geocoded coordinates. Oslo, Stavanger, and Bergen, located in the southernmost electricity price regions, were significantly more affected by the electricity price shock than Trondheim and Tromsø. We define a pre-electricity shock period in the year from September 2020 to August 2021 and the shock period as September 2021 to August 2022. Figures 9–13 in the Appendix display the spatial distributions of average sales prices and estimated energy consumption of sold homes for the five cities.[27] However, following the electricity price shock, there are no clear trends indicating that homebuyers purchased more

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[26] The majority of energy consumption in Norwegian households comes from electrical power. In 2021, 84% of the energy used by Norwegian households came from electricity, with biofuels and district heating accounting for the remaining 13% and 3%, respectively. For comparison, electricity comprised only 25% of the average household energy consumption across the European Union (see a Statistics Norway background report at `https://www.ssb.no/energi-og-industri/energi/artikler/varmepumper-reduserer-utgiftene-til-stromavhengige-nordmenn`).

[27] The estimated energy consumption is a theoretical figure based on the Enova estimates per m^2 and the size of the home measured as total interior livable area. The numbers might therefore overestimate the true consumption as households typically will not always heat the entire interior livable area. Yet, they serve as reasonable indicators of the general energy efficiency of homes sold in a specific time and area.

energy efficient homes in some cities compared to others. House prices also appear to have risen similarly across the North-South-boundary.

3 Data

The housing data used in this study come from real estate transactions in Norway from 1991 through August 2023. The dataset, provided by the Norwegian PropTech company Ambita AS, combines information from several sources, including the Norwegian land register, the Norwegian cadaster, sales advertisements on Finn.no, and energy efficiency performance information from ENOVA. Initially, the raw dataset contained over 3 million housing transactions. For our analysis, we narrow the scope to a sample covering the period from September 2020 to September 2022, which includes one year before and after the start of the dramatic increase in electricity prices. We also restrict the sample to properties with valid energy and heating scores available in the Enova database before the sale. Monthly data on electricity consumption for households is gathered from Statistics Norway, while electricity spot prices are from power supplier Fjordkraft.[28]

Because much of the housing data are manually entered in sales advertisements and databases, the dataset is susceptible to errors and missing values. Therefore, we conduct thorough data cleaning before proceeding with the analysis. After this process, 86,105 transactions remain. We excluded sales with a total price exceeding NOK 30,000,000 or a price per m^2 over NOK 200,000, as these likely represent data entry errors. Additionally, we remove records without a registered transaction date, properties smaller than 10 m^2 or larger than 700 m^2, homes with more than 20 rooms or more than 5 bathrooms, and properties older than 150 years. We also discard records with incorrect geographic coordinates and exclude holiday homes, such as cabins, and properties partially used for commercial purposes, including workshops and retail stores. This data cleaning reduces the sample size by 18,290 observations.

Table 2 provides descriptive statistics for selected property attributes within the dataset. These attributes are further complemented with geographic coordinates, county codes, municipality codes, ZIP codes, city districts, sales month, and sales year. The sample is largely apartment or detached single-family homes with uniform energy scores (the top A rating is uncommon) and located in affected areas (only 7% are in the most northern region NO4).

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[28] Electricity data is publicly available on the following websites: `https://www.ssb.no/statbank/table/14092/` and `https://www.fjordkraft.no/strom/strompriser/historiske-strompriser/`.

Table 2: Descriptive statistics

Numerical	N	Mean	Std. Dev.	Min	Pctl. 25	Pctl. 50	Pctl. 75	Max
Total price	86,105	4,478,166	2,758,481	405,000	2,787,545	3,777,735	5,331,930	30,000,000
Price per m^2	86,105	45,097	26,186	1,572	26,503	37,975	56,760	200,000
Size	86,105	115	59	12	69	105	148	679
Age	86,105	41	32	0	13	37	59	150
Rooms	86,105	3.10	1.80	1.00	1.00	3.00	4.00	17.00
Bathrooms	86,105	1.20	0.45	1.00	1.00	1.00	1.00	5.00
Distance to industry	86,105	450	514	2	186	328	550	18,400
Floor index	86,105	0.61	0.27	0.00	0.38	0.50	1.00	1.00
Categorical	N	%						
Unit type	86,105							
... Apartment	34,078	40%						
... House	33,676	39%						
... Semi-detached	9,389	11%						
... Row home	8,962	10%						
Energy score	86,105							
... A	958	1%						
... B	9,086	11%						
... C	11,979	14%						
... D	12,957	15%						
... E	12,346	14%						
... F	16,560	19%						
... G	22,219	26%						
Heating score	86,105							
... Red	23,612	27%						
... Orange	30,856	36%						
... Yellow	18,292	21%						
... Light green	1,874	2%						
... Green	11,471	13%						
Electricity market	86,105							
... NO1	40,514	47%						
... NO2	21,457	25%						
... NO3	10,115	12%						
... NO4	6,435	7%						
... NO5	7,584	9%						

Notes: This table presents the descriptive statistics for the final housing dataset after cleaning. The dataset consists of homes listed as primary residency units sold within our sampling period. Only homes with an energy performance certificate from Enova prior to the sale are included. Price is measured in NOK and size in m^2. Distance to industry is computed as the straight air line distance between the home and the closest industrial building. The relative floor index is computed as the floor of the dwelling divided by the total number of floors in the building. Electricity market data is merged with the housing data based on geographic coordinates and maps from the Norwegian Water Resources and Energy Directorate. Source: Ambita AS housing data and maps over electricity spot regions by the Norwegian Water Resources and Energy Directorate, September 2020–September 2022.

Table 3: Normal yearly energy/electricity use for different home types

House type	Energy use (kWh/m^2)	Size (m^2)	Electricity use (kWh/home)
Apartment	216	68	11,855
House	280	162	36,550
Semi-detached	233	121	23,748
Row home	239	109	21,660
All homes	245	115	23,831

Notes: This table shows average estimated energy consumption per m^2 for homes in our sample, as well as average sizes, for different house types. Based on these figures, and the fact that on average 84% of the energy consumption of Norwegian households comes from electrical power, we estimate the average electricity consumption for normal use of different house types in kWh. Estimates assume that all of the interior floor area is heated. Source: Author calculations based on Statistics Norway and Ambita AS housing data with Enova energy performance certificates, September 2020–September 2022.

Table 3 shows the mean estimated kWh required per m^2, mean size, and mean kWh required per home for normal living in different types of homes sold in our dataset. Single-family houses, on average, require noticeably more energy than other housing types. Apartments require the least amount of energy. Note that the average normal energy usage per home is a predicted value based on the Enova energy certification, assuming that all rooms are heated.[29] In many cases, the heated floor area is lower than the total internal floor area, meaning that the per-home number may be somewhat biased upwards.

4 Research Design and Results

This section presents the research design and findings, detailing the analytical approach and empirical results. First, we implement a triple differences model to estimate the effect of energy efficiency on housing prices in regions impacted by high electricity prices. Subsequently, we extend the analysis using a subgroup analysis design, examining price effects for homes of different types. Finally, we conduct a temporal analysis, employing an event study framework to capture the evolution of price effects and the impact of a policy shock on housing markets.

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[29] Calculations follow the Norwegian standard NS 3031:2014, available at `https://online.standard.no/en/ns-3031-2014`.

4.1 Triple Differences Regression

To estimate the average price effect of energy efficiency in regions with high electricity prices, we first implement a triple difference model. The regression is estimated as:

$$\begin{aligned} \ln P_{it} = \beta_0 &+ \beta_1 \text{Treat}_i \times \text{Post}_t + \beta_2 \text{Treat}_i \times \text{Energy}_i + \beta_3 \text{Post}_t \times \text{Energy}_i \\ &+ \beta_4 \text{Treat}_i \times \text{Post}_t \times \text{Energy}_i + \beta_5 X_{it} + \mu_{gt} + \epsilon_{it} \end{aligned} \tag{1}$$

In this equation, lnP_{it} represents the natural logarithm of the price per m^2 for home i sold in month t. The variable $Treat_i$ is a binary indicator equal to one if home i is located in one of the electricity price areas NO1, NO2, or NO5, and is thus impacted by the electricity price increase. $Post_t$ is a binary indicator set to one if the sale occurred during the period when electricity prices diverged between the South and North regions, specifically from September 2021 to September 2022. $Energy_i$ is an indicator equal to one for homes with energy labels A–D. X_{it} denotes a vector of housing characteristics, including size, age, number of rooms, number of bathrooms, distance to the nearest industrial building, a relative floor index (unit floor divided by total number of floors in the building) in logarithmic form, and housing type. Finally, μ_{gt} captures spatial and temporal fixed effects, such as counties, municipalities, city districts, and the interaction between year and month.

The model is estimated using various treatment and control groups. Model 1 utilizes data from the entire country, with NO1, NO2, and NO5 as treatment groups and NO3 and NO4 as control groups. Model 2 focuses exclusively on regions near the border between the South and North, with NO1 and NO2 as treatment groups and NO3 as the control group. Model 3 excludes the largest cities within each price area, whereas Model 4 specifically examines these larger cities. The cities are Oslo, Stavanger, Trondheim, Tromsø, and Bergen, corresponding to NO1, NO2, NO3, NO4, and NO5, respectively.

The initial regression results are presented in Table 4. The Post×Treat coefficients are both statistically significant and negative, with values of -0.017 for Model 1 and -0.025 for Model 2. This suggests homes sold in the NO1 and NO5 regions during the electricity price shock were, on average, sold at prices 2.5% lower than comparable properties in NO3. Given the mean sales price per square meter from Table 1 is approximately NOK 45,000, this 2.5% difference translates to about NOK 1,125 per square meter. For an average home size of 115 square meters, this amounts to a total difference of approximately NOK 129,375.

Table 4: Triple differences regression results for initial regressions

	(1)	(2)	(3)	(4)
Sample	Full country	NO1, NO5, NO3	Not biggest cities	Only biggest cities
Dependent variable	$\ln(P_{it})$	$\ln(P_{it})$	$\ln(P_{it})$	$\ln(P_{it})$
Energy	0.142***	0.151**	0.149***	0.093*
	(0.017)	(0.021)	(0.018)	(0.042)
Post×Treat	-0.017**	-0.025***	-0.015*	-0.003
	(0.006)	(0.001)	(0.006)	(0.004)
Post×Energy	-0.004**	-0.005**	-0.004	0.012
	(0.001)	(0.001)	(0.003)	(0.008)
Treat×Energy	-0.108***	-0.121***	-0.110***	-0.076
	(0.014)	(0.002)	(0.013)	(0.040)
Post×Treat×Energy	0.011*	0.016***	0.006	0.002
	(0.004)	(0.002)	(0.004)	(0.008)
Housing attributes	Yes	Yes	Yes	Yes
Year×Month FE	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	No	Yes
City district FE	Yes	Yes	Yes	No
Observations	86,105	58,213	66,227	19,878
Adjusted R^2	0.841	0.857	0.754	0.803

Notes: The coefficients represent the percentage effect on price per m^2 from a triple differences model for different . samples. NO1, NO3, and NO5 represent the electricity price regions next to the North-South border, where NO1 and NO5 were affected by the electricity price shock, and NO3 was not. Biggest cities are defined as the largest metropolitan areas in each electricity price region. The models have fixed effects for the interaction between year and month, as well as varying combinations of county, municipality, and city district fixed effects. Robust standard errors, clustered at the electricity price region level, are in parentheses. *p<0.1; **p<0.05; ***p<0.01. Source: Author calculations using Ambita AS housing data, September 2020–September 2022.

For context, Table 1 shows that average electricity spot prices in southern Norway rose from 0.37 NOK/kWh to 0.99 NOK/kWh during the electricity price shock. Table 2 reveals that an average home in the dataset requires 23,831 kWh of electricity for normal use, including heating all rooms. The resulting annual increase in energy bills for a typical home in the southern region, following the price hike, is around NOK 14,776 (as detailed in Table 10 of the Appendix). However, as noted in Subsection 2.3, homeowners in the South managed to reduce their electricity consumption during the price shock. The figure of NOK 14,776, based on normal usage for homes sold during the two-year study period, may therefore be slightly inflated. Additionally, the national average annual increase in electricity costs per home from 2020 to 2022 was approximately NOK 9,500.[30] Since this figure is a national average, and given that around 20% of Norwegian homes in NO3 and NO4 experienced little to no price increase, the estimated annual cost increase for homes in the southern regions is closer to NOK 11,875, or about 9.3% of the average difference in house prices. Interestingly, no significant price differences are observed between homes in the northern and southern regions for those located in major cities. This could be attributed to the higher prevalence of apartments and the use of district heating in these urban areas.

The coefficient for the third interaction with Energy (the average treatment effect) is positive, though statistically significant at the 1% level only in Model 2. This suggests the negative impact on house prices in southern Norway during the electricity price shock was less severe for energy-efficient homes. As for the Post×Treat price effect, the interaction with Energy is insignificant in the biggest cities. While the coefficient is only statistically significant at the 10% level for the entire country, its positive sign aligns with the expectation. The finding suggests that reduced electricity costs from energy-efficient homes may indeed have been reflected in transaction prices during the electricity price shock.

We repeat the model specification using NO1 and NO5 as the treatment group and NO3 as the control group, this time focusing on different housing types. The results, presented in Table 5, suggest the absence of a significant effect in the largest cities may be partially explained by the lower proportion of single-family houses. As shown in Table 5, when the analysis is restricted to single-family houses, the Post×Treat coefficient is -0.04, which is statistically significant at the 5% level. This finding is plausible, as single-family homes tend to consume

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[30] See the Statistics Norway report at `https://www.ssb.no/energi-og-industri/energi/artikler/hva-er-gjennomsnittlig-stromforbruk-i-husholdningene`.

Table 5: Triple differences regression results for different home types

	(1)	(2)	(3)	(4)
Sample	House	Semi-detached	Row Home	Apartment
Dependent variable	$\ln(P_{it})$	$\ln(P_{it})$	$\ln(P_{it})$	$\ln(P_{it})$
Energy	0.178**	0.079*	0.063***	0.067**
	(0.032)	(0.024)	(0.005)	(0.012)
Post×Treat	-0.040***	0.020*	-0.003	0.008**
	(0.001)	(0.007)	(0.003)	(0.001)
Post×Energy	-0.027***	0.042***	0.006**	0.034***
	(0.001)	(0.002)	(0.001)	(0.000)
Treat×Energy	-0.144***	-0.060**	-0.049***	-0.033*
	(0.001)	(0.008)	(0.001)	(0.009)
Post×Treat×Energy	0.039**	-0.037**	0.010	-0.020**
	(0.004)	(0.006)	(0.007)	(0.002)
Housing attributes	Yes	Yes	Yes	Yes
Year×Month FE	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes
City district FE	Yes	Yes	Yes	Yes
Observations	20,171	6,012	5,985	26,045
R^2	0.738	0.807	0.831	0.836

Notes: The coefficients represent the percentage effect on price per m^2 from a triple differences model for different housing types in NO1, NO3, NO5. These are the electricity price regions next to the North-South border, where NO1 and NO5 were affected by the electricity price shock while NO3 was not. The models have fixed effects for the interaction between year and month, as well as county, municipality, and city district fixed effects. Robust standard errors, clustered at the electricity price region level, are in parentheses. *p<0.1; **p<0.05; ***p<0.01. Source: Author calculations using Ambita AS housing data, September 2020–September 2022.

more electricity and were more affected by the increase in electricity prices. In contrast, the difference in sales prices is positive or insignificant for the other home types. This may suggest a general shift in demand towards housing types with lower energy consumption. For single-family houses, the average treatment effect coefficient for the interaction with Energy is positive. However, for semi-detached homes and apartments, the interaction with Energy is negative and significant at the 5% level. We interpret this result as evidence the fixed rate subsidy induces a demand substitution to single-family detached homes (away from semi-detached or apartment units) because higher energy usage (see Table 3) is subsidized.

The 4% difference in sales prices per square meter for single-family houses translates to an average price difference of approximately NOK 207,500. However, the average single-family home saw an annual increase in electricity costs of approximately NOK 18,000 between 2020 and 2022, which represents about 8.7% of the difference in house prices between northern and southern regions.[31] Estimates for single-family houses in our sample indicate that the increase in electricity costs for normal use, assuming all rooms are heated and no electricity-saving measures are implemented, could be as high as NOK 22,661. For further details on other housing types, refer to Table 10 in the Appendix.

The results suggest that tighter budget constraints, driven by increased electricity costs in southern Norway, influenced homebuyers' willingness to pay for housing. Homeowners in the treated regions during the intervention period faced not only standard household expenses and mortgage payments but also significantly higher utility bills due to elevated electricity costs. As a larger portion of disposable income was directed toward utility costs, less remained available for mortgage-related expenses. This could lead to a reduction in homebuyers' willingness to pay for homes.

However, the difference in treatment effects between energy-efficient and non-efficient homes appears to be present and positive only for single-family homes, with no significant effect observed in the largest cities. Additionally, the standard errors vary across regressions, suggesting some uncertainty in these estimates. Consequently, the price effect of energy efficiency is less pronounced than the overall price impact of being located in the southern region during the electricity price shock. A possible explanation is that homebuyers adjusted

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[31] Again taken from the Statistics Norway report at `https://www.ssb.no/energi-og-industri/energi/artikler/hva-er-gjennomsnittlig-stromforbruk-i-husholdningene`.

their overall budgets to accommodate higher utility costs but maintained their preferences for housing characteristics within these new constraints. Given that purchasing a home is a long-term decision, and the electricity price shock could be perceived as temporary, it is plausible that homebuyers adapted their budgets rather than shifting their preferences for specific house features such as location, house type, size, and so forth.

4.2 Temporal Effect and Policy Shock

Next, we employ an event study model specification to assess how long it took for the house price effect to manifest. In addition to examining the response time of the housing market, another source of temporal heterogeneity during the sample period was the policy change. This shock, as illustrated in Figure 2, occurred in early January 2022. Importantly, during the initial four months following the electricity price surge, no subsidies were provided for electricity consumption. The event study setup allows us to study potential time variations in the price effects, and verify the parallel trends assumptions of Equation (1). Specifically, we use a model in which NO1 and NO5 are designated as the treatment groups, with NO3 serving as the control group. The formula for the event study is shown in Equation (2):

$$\begin{aligned}\ln P_{it} = \beta_0 &+ \sum_{k \neq -3} \delta_k D_{k,t} \times \text{Treat}_i + \beta_2 \text{Treat}_i \times \text{Energy}_i + \sum_{k \neq -3} \eta_k D_{k,t} \times \text{Energy}_i \\ &+ \sum_{k \neq -3} \gamma_k D_{k,t} \times \text{Treat}_i \times \text{Energy}_i + \beta_5 X_{it} + \mu_{gt} + \epsilon_{it} \qquad (2)\end{aligned}$$

where $D_{k,t}$ are event-time indicators that reflect periods relative to the intervention, and δ_k and γ_k measure the price effects of being located in the South and being energy efficient in the South for each period k.[32] These effects are computed using $T-3$, i.e., three months before the start of the electricity price shock, as a reference. η_k controls for monthly changes in demand for energy efficiency across Norway. Other terms are the same as in Equation (1).

The regression results in Panel A of Figure 6 indicate that the price effect for homes in the southern electricity price regions was negative, but statistically indistinguishable from zero, two months before the onset of the electricity price shock. This early impact is not entirely surprising, as pinpointing the exact start of the shock is challenging. Southern Norway had experienced elevated electricity prices relative to the North since the start of 2021, although

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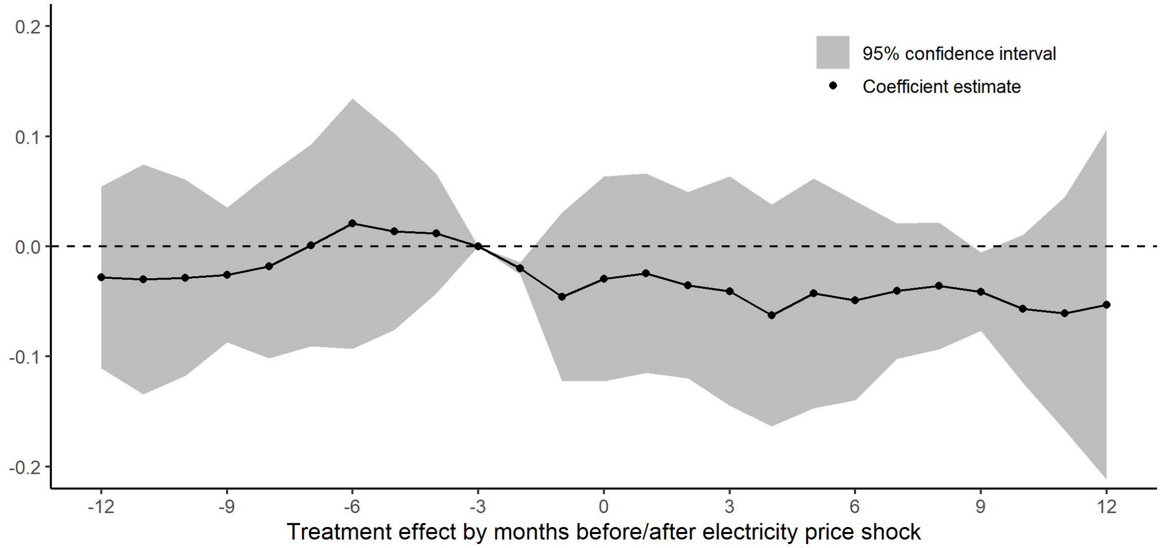
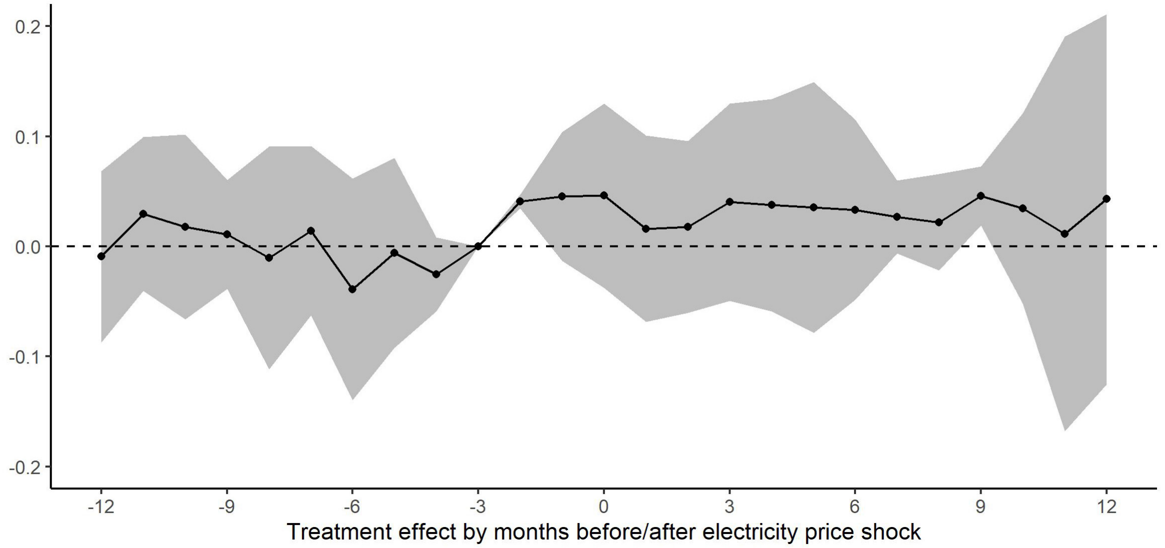
[32] The likelihood ratio test, comparing models with different temporal frequencies (monthly, bi-monthly, and tri-monthly period coefficients), indicates that the differences in model fit are not statistically significant ($p > 0.1$). The choice of temporal aggregation does not substantially affect the fit of the event study model.

Figure 6: Event study results

Panel A: Coefficient estimates for Post×Treat interaction



Panel B: Coefficient estimates for Post×Treat×Energy interaction



Notes: This figure shows the results of the event study with electricity price regions NO1 and NO5 as the treatment and NO3 as the control (see Table 4, Column 2) by plotting the changing trend in home prices between the treatment and control groups relative to a reference point of two months prior to the electricity price shock. Panel A shows the coefficient estimates and corresponding 95% confidence intervals for the Post×Treat interaction, while Panel B does the same for the Post×Treat×Energy triple interaction. Source: Author calculations using Ambita AS housing data with Enova energy performance certificates, September 2020–September 2022.

the largest disparities began in September 2021. Notably, the coefficient estimates start to decline as early as July–August 2021. They remain negative throughout the year of the electricity price shock, with a marked decline from September 2021 to January 2022. The price gap between southern and northern regions widened as the shock continued.

Regarding energy efficiency, Panel B of Figure 6 presents the monthly estimates for the price effect of energy-efficient homes in southern Norway throughout the electricity price shock. Notably, the prices of energy-efficient homes in the South began to rise almost concurrently with the overall decline in housing prices in the same regions, becoming evident from July 2021. The price effect of energy efficiency for homes in the southern electricity markets further consistently remained positive throughout the year of the electricity price shock.

The disparity in sales prices between northern and southern homes appears to reach its lowest point around the policy intervention in January 2022. As shown in Panel A of Figure 6, the Post×Treat coefficient estimate increased slightly in the months following the subsidy's introduction. However, the change in coefficient estimates is modest, making it difficult to confirm definitively whether the minimum estimate in January 2022 resulted from the policy change. Furthermore, as seen in Panel B of Figure 6, the policy change after four months does not appear to have influenced homebuyers' willingness to pay for energy-efficient homes in the affected regions. Although the subsidy covered 80% of electricity costs above 0.7 NOK/kWh, the cost differential between the North and South remained. Figure 2 shows that the NO3 and NO4 regions did not surpass the 0.7 NOK/kWh threshold, whereas net electricity prices—after subsidy adjustments—remained elevated in the NO1, NO2, and NO5 regions. Consequently, it is reasonable that the coefficient estimates stayed negative, albeit with a slightly reduced magnitude, also after the policy change.

The Fan (2022) analysis reinforces that government interventions, such as electricity price subsidies, often have limited capacity to mitigate broader impacts of macroeconomic shocks on housing markets. The case of Norway's subsidies in early 2022 illustrates this limitation, as the temporary financial relief provided to households did not prevent the continued downward pressure on house prices. This suggests that while subsidies can ease immediate financial strain, they may be insufficient to counteract the prolonged effects of price stickiness and market inertia, which delay the housing market's adjustment to external shocks.

The results in Figure 6 indicate house prices took approximately four months from the onset of the substantial electricity price disparity between southern and northern regions in September 2021—or nearly a year from the initial, smaller disparity beginning in January 2021—to fully adjust and reach their peak in response to the 2021–2022 electricity price shock. This delay aligns with the concept of price stickiness, implying that adjustments are gradual. These findings could suggest homebuyers initially perceived the shock as temporary, or that rising energy costs would not have a lasting effect on their household budgets.

5 Robustness Checks

In this section, we conduct robustness checks to evaluate the reliability of our main findings. We first apply propensity score matching (PSM) to address potential heterogeneity between the treatment and control groups, aiming to ensure comparability by balancing key observable characteristics. Next, we use a border discontinuity design, examining homes located close to the North-South electricity price border to isolate the effects of differing energy costs on house prices. We finally perform placebo tests to verify that our results are not driven by random variations in housing prices unrelated to the electricity price shock.

5.1 Propensity Score Matching

To address heterogeneity between the control and treatment groups, we apply propensity score matching. The original sample includes properties from NO1, NO2, and NO3. Propensity scores are estimated using logistic regression, with matching conducted based on the nearest propensity score using a one-to-one matching ratio. Additionally, a caliper of 0.01 times the standard deviation of the propensity score is used to improve the quality of matches. The matching is done in the full sample based on size, age, number of rooms, number of bathrooms, distance to industry, floor index, unit type, and energy label.

Panel A of Figure 7 illustrates the distribution of propensity scores for both the matched and unmatched properties. As shown, the majority of control units are successfully matched with treated units. Panel B of Figure 7 displays the pairwise standardized mean differences for each numerical variable in the original and matched data samples. The "distance" label on the vertical axis in Panel B represents the overall average difference in propensity scores between treatment and control group observations. This overall distance, along with the distances for individual variables, is reduced in the propensity score matched sample, suggesting a more homogeneous data sample.

Table 6: Propensity score matching

Panel A: Pairwise sample comparison						
	Pre-matched			Matched		
Variables:	Control	Treated	*t*-stat	Control	Treated	*t*-stat
Size	119.34	109.10	16.56***	119.30	120.30	-1.22
Age	37.29	42.14	-15.01***	37.22	37.42	-0.45
Rooms	3.12	3.06	2.85***	3.12	3.14	-0.88
Bathrooms	1.18	1.20	-4.65***	1.18	1.19	-0.75
Distance to industry	506.52	431.99	11.86***	494.75	480.83	1.96*
Floor index	0.60	0.61	-3.33***	0.60	0.61	-2.04**
Observations	10,115	48,098		10,086	10,086	

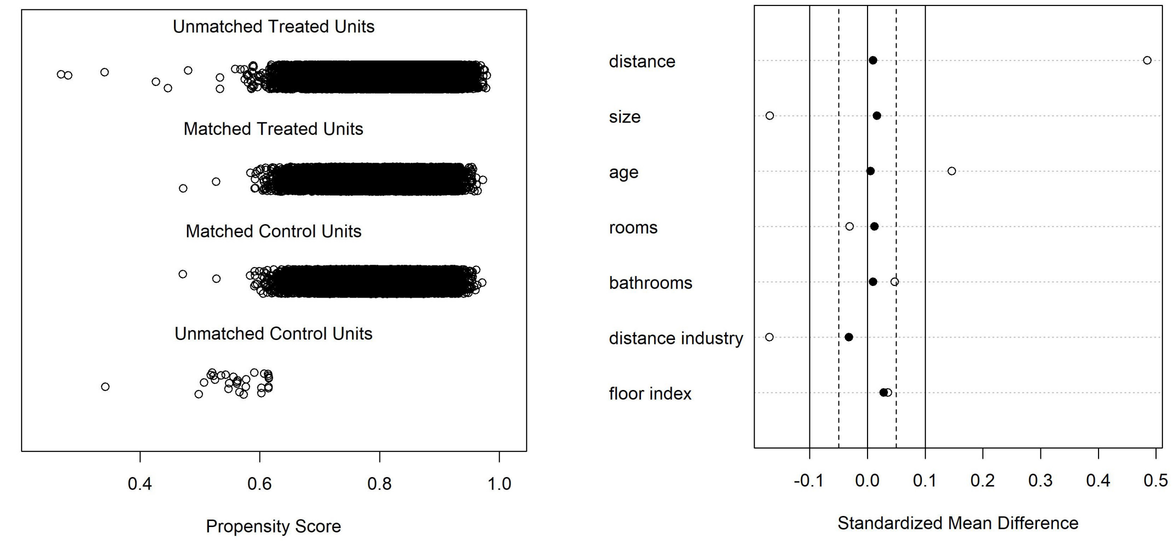
Panel B: Triple differences regression results with propensity score matched sample		
	(1)	(2)
Sample	NO1, NO5, NO3	PS matched sample
Dependent variable	$\ln(P_{it})$	$\ln(P_{it})$
Energy	0.151**	0.119*
	(0.021)	(0.035)
Post×Treat	-0.025***	-0.031***
	(0.001)	(0.003)
Post×Energy	-0.005**	-0.006*
	(0.001)	(0.002)
Treat×Energy	-0.121***	-0.130***
	(0.002)	(0.007)
Post×Treat×Energy	0.016***	0.024**
	(0.002)	(0.004)
Housing attributes	Yes	Yes
Year×Month FE	Yes	Yes
County FE	Yes	Yes
Municipality FE	Yes	Yes
City district FE	Yes	Yes
Observations	58,213	20,172
R^2	0.857	0.828

Notes: Panel A shows the average variable values for size, age, number of rooms, number of bathrooms, distance to industry, and relative floor in the control and the treatment groups before and after matching. Matching is done one-to-one by propensity score with a caliper of 0.01. Propensity scores are estimated using the mentioned variables and the categorical energy labels. Test statistics are from two sided *t*-tests. The coefficients in Panel B represent the percentage effect on price per m2 from a triple differences model for different samples. NO1, NO3, NO5 represent the electricity price regions next to the North-South border, where NO1 and NO5 were affected by the electricity price shock while NO3 was not. PS matched sample is the matched sample from the propensity score matching in Panel A. The models have fixed effects for the interaction between year and month, as well as varying combinations of county, municipality, and city districts fixed effects. Robust standard errors, clustered at the electricity price region level, are in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Source: Author calculations using Ambita AS housing data, September 2020–September 2022.

Figure 7: Propensity score matching

Panel A: Distribution of propensity scores

Panel B: Pairwise sample comparison



Notes: This figure illustrates the propensity score matching procedure. Panel A shows the distribution of the propensity scores of matched and unmatched homes. Panel B shows the standardized mean differences between treatment and control groups across different home characteristics for the original and the treated samples. Source: Author calculations using Ambita AS housing data, September 2020–September 2022.

In Panel A of Table 6, we further assess these reduced differences between the control and treatment groups by conducting t-tests. The results show that, in the propensity score matched sample, the differences between the treatment and control groups are smaller across all numerical variables. Specifically, there are no statistically significant differences in size, age, number of rooms, or number of bathrooms between the two groups. Although there remain slight post-matching differences in distance to industry and floor index, these differences are smaller in the PSM sample.

Panel B of Table 6 shows the regression results for both the reference model with all homes sold in NO1, NO5, and NO3 and the new model using the propensity score matched treatment and control groups. The results are similar for the new model with more homogeneous groups, supporting our findings from Section 4.

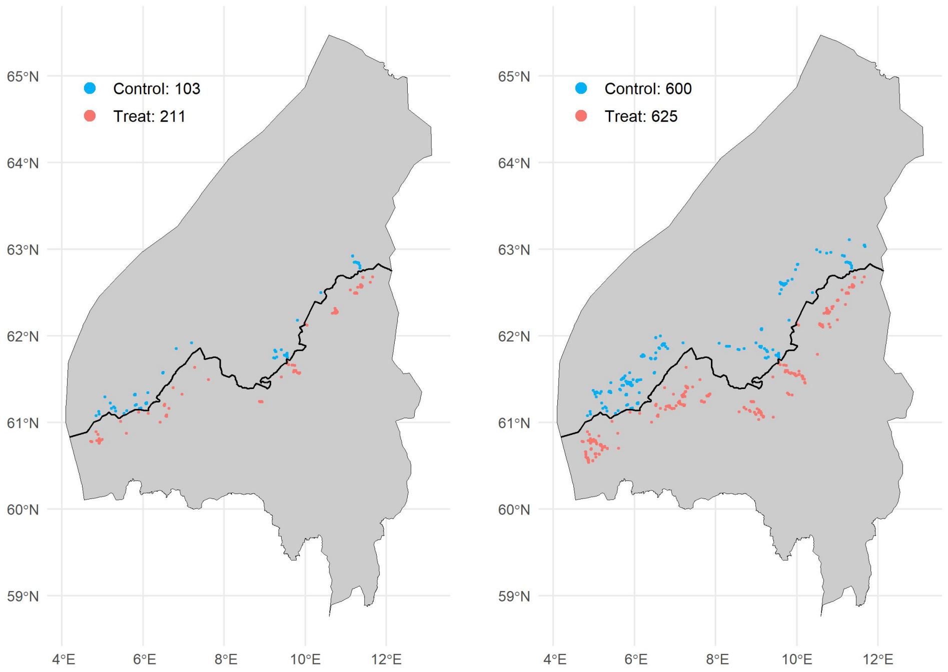
5.2 Border Discontinuity

We next employ a border discontinuity approach, focusing on homes located within a specific distance from the border between the North and South regions. The rationale behind this approach is that homes sold near the border are likely to be similar in terms of location,

Figure 8: Spatial distribution of home sales for different border discontinuity bandwidths

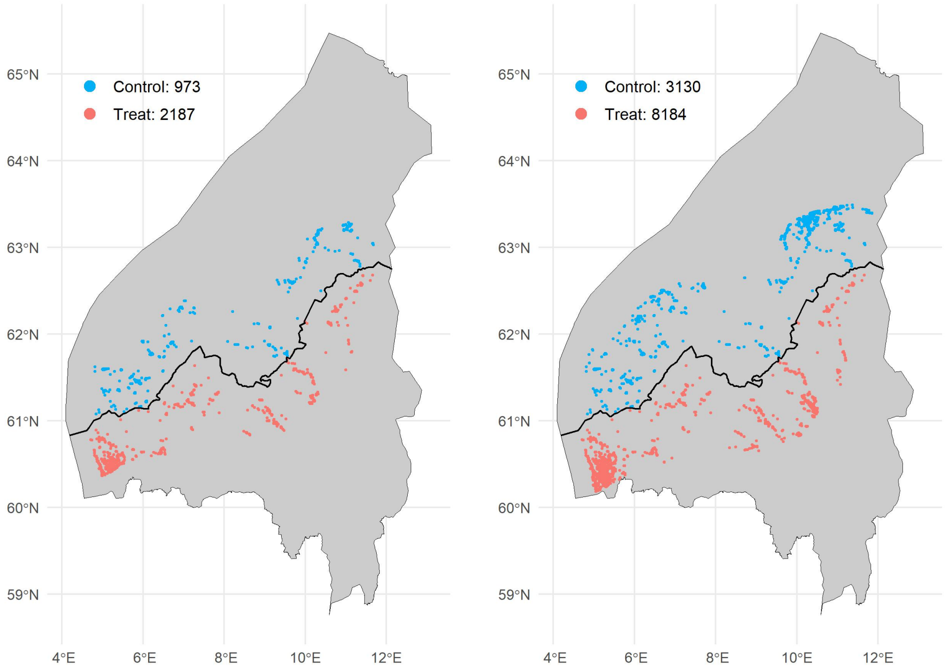
Panel A: 20 km from border

Panel B: 40 km from border



Panel C: 60 km from border

Panel D: 80 km from border



Notes: This figure shows a map over electricity price regions NO1, NO5, and NO3 with house transactions that took place within different distance bandwidths from the border between South and North. Treated homes, south of the border, are marked in blue, while control home, north of the border, are in red. Source: Author calculations using Ambita AS housing data and maps from the Norwegian Water Resources and Energy Directorate.

Table 7: Border discontinuity regression results

	(1)	(2)	(3)	(4)
Sample	20 km	40 km	60 km	80 km
Dependent variable	$\ln(P_{it})$	$\ln(P_{it})$	$\ln(P_{it})$	$\ln(P_{it})$
Energy	0.025	0.066	0.152*	0.162*
	(0.054)	(0.028)	(0.038)	(0.052)
Post×Treat	-0.038	0.034*	-0.028*	-0.055**
	(0.055)	(0.011)	(0.007)	(0.010)
Post×Energy	0.132	0.040**	0.021*	-0.007*
	(0.056)	(0.007)	(0.006)	(0.002)
Treat×Energy	0.004	0.002	-0.129*	-0.126*
	(0.012)	(0.059)	(0.044)	(0.032)
Post×Treat×Energy	-0.163	-0.037*	0.018	0.023
	(0.119)	(0.011)	(0.017)	(0.013)
Housing attributes	Yes	Yes	Yes	Yes
Year×Month FE	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes
City district FE	Yes	Yes	Yes	Yes
Observations	314	1,225	3,160	11,314
R^2	0.671	0.737	0.746	0.776

Notes: The coefficients represent the percentage effect on price per m^2 from a border discontinuity triple differences model with samples consisting of different bandwidths from the North-South border. The South, represented by electricity price regions NO1 and NO5, was affected by the electricity price shock while the North, represented by NO3, was not. The models have fixed effects for the interaction between year and month, as well as county, municipality, and city district fixed effects. Robust standard errors, clustered at the electricity price region level, are in parentheses. $^*p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$. Source: Author calculations using Ambita AS housing data, September 2020–September 2022.

climate, and to some extent, housing characteristics. The primary distinguishing factor between these homes is their position relative to the border, and thus their electricity prices. The model specification remains consistent with Equation (1), with homes south of the border considered as the treatment group and those north of the border as the control group.

Distance is the straight-line measure from each home to the nearest border point. However, because the borders between the electricity price markets are primarily determined by natural and geological features—such as fjords or mountains—that hinder the construction of a grid network for electricity transfer, there are naturally few homes situated in close proximity to the border. Consequently, only 314 homes located within 20 kilometers of the border were sold between September 2020 and September 2022. The corresponding figures for bandwidths of 40, 60, and 80 km were 1,225, 3,160, and 11,314, respectively. Figure 8 gives a graphical representation of the transactions that took place within different distances from the border.

The regression results for the border discontinuity approach with varying bandwidths are in Table 7. As suspected, with small sample sizes, the standard errors are large. The Post×Treat coefficient is only statistically significant at the 1% level when homes are within 80 km of the border. The signs and the coefficients are mostly consistent with the results in Subsection 4.1, indicating that homes sold for less in the South during the electricity price shock. The interaction with Energy is positive for the 60 and 80 km bandwidths, but not statistically significant.

5.3 Placebo Tests

We conduct placebo regressions with results presented in Table 8. In the first model, NO4 is the treatment group and NO3 is the control group. In the second model, we randomly assign municipalities within the two northernmost electricity price regions into treatment and control groups, with half of the municipalities designated as treatment and the other half as control. In both models, all homes remain unaffected by the electricity price shock. As anticipated, the results in Table 8 show no significant Post×Treat effect or differences in effects between energy-efficient and non-efficient homes in Model 2, where treatment groups were randomly assigned to different municipalities. However, there is a small, significant difference in home prices between regions NO3 and NO4 during the electricity price shock, with prices in NO3 rising more than in NO4 over the one-year sampling period. Notably, this price difference does not vary between energy-efficient and non-efficient homes.

Table 8: Placebo treatment groups

	(1)	(2)
Sample	NO3, NO4	Random municipalities
Dependent variable	$\ln(P_{it})$	$\ln(P_{it})$
Energy	0.062	0.090
	(0.015)	(0.043)
Post×Treat	-0.008***	0.001
	(0.000)	(0.012)
Post×Energy	-0.007*	-0.015
	(0.001)	(0.004)
Treat×Energy	0.012	-0.047
	(0.003)	(0.051)
Post×Treat×Energy	-0.002	0.015*
	(0.001)	(0.001)
Housing attributes	Yes	Yes
Year×Month FE	Yes	Yes
County FE	Yes	Yes
Municipality FE	Yes	Yes
City district FE	Yes	Yes
Observations	16,550	16,550
R^2	0.782	0.782

Notes: The coefficients represent the percentage effect on price per m^2 from triple differences models with placebo treatment groups. In the first model, the treatment group is defined as homes sold in electricity price region NO4 and the control group is homes in NO3. Neither of these regions were affected by the electricity price shock. In the second model, we draw random municipalities within the NO3 and NO4 regions assigned as treatment and control groups. The models have fixed effects for the interaction between year and month, as well as county, municipality, and city district fixed effects. Robust standard errors, clustered at the electricity price region level, are in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Source: Author calculations using Ambita AS housing data, September 2020–September 2022.

6 Conclusions

The impact of energy efficiency on house prices has been extensively discussed in the literature. Although there is broad consensus that energy-efficient properties tend to sell at a premium compared to less efficient ones, it remains challenging to determine how much of this premium is attributed to the capitalization of reduced energy costs as opposed to factors like overall property condition and other correlated, desirable housing attributes. Survey-based studies have suggested that energy efficiency is not a top priority for homebuyers in periods of stable energy prices. However, to the best of our knowledge, previous research has not fully explored the impact of energy efficiency on house prices during periods of energy price shocks. This study addresses that gap by analyzing a dataset of 86,105 housing transactions in Norway, offering a detailed investigation into how the 2021–2022 European energy crisis, leading to sharply rising electricity spot prices, affected the Norwegian housing market. In particular, it aims to examine how energy efficiency was capitalized in house prices during this period of regional economic stress. Norway's unique structure of five distinct electricity price markets, where only the three southernmost regions were significantly impacted by the European energy crisis, offers an ideal quasi-experimental setting to assess the effects of electricity price shocks on house prices. By employing a triple differences regression framework, we are able to effectively isolate the specific effects of the electricity price shock, while controlling for regional variations, housing types, and different levels of energy efficiency.

Our findings demonstrate that energy price shocks disrupt housing market valuations, reflecting changes in asset pricing dynamics for residential real estate. The relatively muted response to energy efficiency suggests potential inefficiencies in how market participants incorporate energy costs into housing valuations. This highlights the need for further exploration of risk and pricing in the context of real estate as a financial asset. Regions exposed to the electricity price shocks—specifically in southern Norway—experience significant declines in house prices compared to regions that were unaffected by the price surge, in the northern parts of the country. Outside the varying electricity prices, the macroeconomic and political context remain similar across all the country. The identified decline in home prices was most pronounced for single-family houses located outside major metropolitan areas, where the increase in electricity costs imposed more substantial financial burdens on households. The relative decrease in home prices in the South is validated by border discontinuity regressions, propensity score matching, and placebo treatment groups.

In addition to the overall decline in house prices in southern Norway, the results indicate that energy-efficient homes are less affected by the price reduction. However, this effect is only marginally significant, suggesting that while energy efficiency may provide some protection against rising energy costs, other home characteristics—such as location, size, and home type—continue to play a more influential role in determining housing prices. This finding is consistent with the previous research, which highlights that while energy efficiency is important, it is not always the primary factor driving homebuyer decisions. A possible explanation for the observed price decline in southern Norway, coupled with the limited price differential between energy-efficient and non-efficient homes, could be that homebuyers adjusted their budgets in response to a reduced share of disposable income available for mortgage payments due to higher energy costs. However, when restricted to purchase within these adjusted budget constraints, homebuyers may have chosen to prioritize other property characteristics over energy efficiency. Purchasing a home is a long-term financial decision, whereas an energy price shock is typically viewed as more temporary. This perspective may explain why homebuyers could have continued to place greater emphasis on factors, rather than making energy efficiency the focal point of their decisions during the crisis.

Another key insight is the housing market's delayed response to the electricity price shock. Home price effects do not reach their peak until four months after the start of the substantial electricity price surge, indicating a degree of price stickiness in the market. This finding aligns with existing literature on asset price stickiness, which suggests markets often take time to adjust to new economic conditions. Additionally, the electricity price subsidy introduced in January 2022 appears to have had little effect on mitigating the decline in house prices. Despite the subsidy, significant differences in electricity spot prices between the northern and southern regions persisted, making this outcome plausible. From a policy perspective, these findings underscore the potential limitations of government subsidies aimed at alleviating the impact of rising energy costs. While the household support in southern Norway helped reduce some immediate financial burden, the ongoing and increasing regional disparities in electricity prices continued to exert downward pressure on house prices in affected areas. This suggests that even if subsidies offer short-term relief, they may not fully counteract the broader effects of prolonged energy price shocks. Understanding the effectiveness of public support is critical to designing interventions that mitigate the adverse impacts of such shocks. However, the success of these interventions is shaped by underlying factors such as regional heterogeneity, buyer preferences, and the design of policy measures. The mechanisms explored in this study give valuable insights for countries facing similar global disruptions, including energy crises or other resource shortages. The generalizability of these findings is particularly relevant for places with high energy dependence or fragmented markets, where tailored policy responses may be required to address both short- and long-term challenges.

In conclusion, the 2021–2022 European energy crisis had a measurable impact on the Norwegian real estate market, with home prices in affected regions declining significantly relative to unaffected areas. While energy efficiency may have offered some protection against price declines, specifically for single-family homes, its role in determining house prices may have been secondary to other home characteristics. Future research could explore the enduring effects of these macroeconomic shocks and the role of other factors, such as evolving preferences for energy efficiency, in shaping transnational market outcomes.

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Appendix

A.1 Heatmaps for largest metropolitan areas

The heatmaps in this appendix display sales prices per m^2 and estimated energy consumption per home sold for the biggest city in each of the five electricity markets. NO1: Oslo, NO2: Stavanger, NO3: Trondheim, NO4: Tromsø, NO5: Bergen.

A.2 Heating score

We now shift our focus from energy label to heating score. The heating score of a home gives a color score from red to green, indicating how much of the home can be heated using carbon-friendly heating sources. If the home can be heated, fully or partially, using low carbon/renewable sources such as heat pumps, solar power, and district heating, the heating score will be greener. Homes solely relying on electricity or fireplaces will be more red. There is no fixed relation between the energy label and the heating score, as a unit with high energy consumption but a low carbon heating system can receive a green heating score and energy label F. We run the triple differences model with heating efficiency rather than energy efficiency in the third interaction, as shown here:

$$\begin{aligned} lnP_{it} = \beta_0 + \beta_1 Treat_i \times Post_t + \beta_2 Heat_i \times Post_t \\ + \beta_4 Treat_i \times Post_t \times Heat_i + \beta_5 X_{it} + \mu_{gt} + \epsilon_{it} \end{aligned} \tag{3}$$

where $Heat_i$ is a binary indicator taking the value one if home i has a green, light green, or yellow heating score, and 0 otherwise. The rest of the model is identical to the one specified in Equation (1). The regression results with heating score are presented in Table 9, finding no significant difference between homes with low-carbon and high-carbon heating sources.

A.3 Increased electricity bills in the South of Norway

Table 10 shows the average estimated increases in electricity bills during the electricity price shock for normal use of sold units in our data sample. Costs are calculated by multiplying average estimated energy consumption per home with average yearly spot prices after adjusting for the subsidy. The estimated energy consumption does not take into account energy savings made by the households. It also assumes that electrical power constitutes 84% of the total energy consumption, which is the case for the average Norwegian household.[33]

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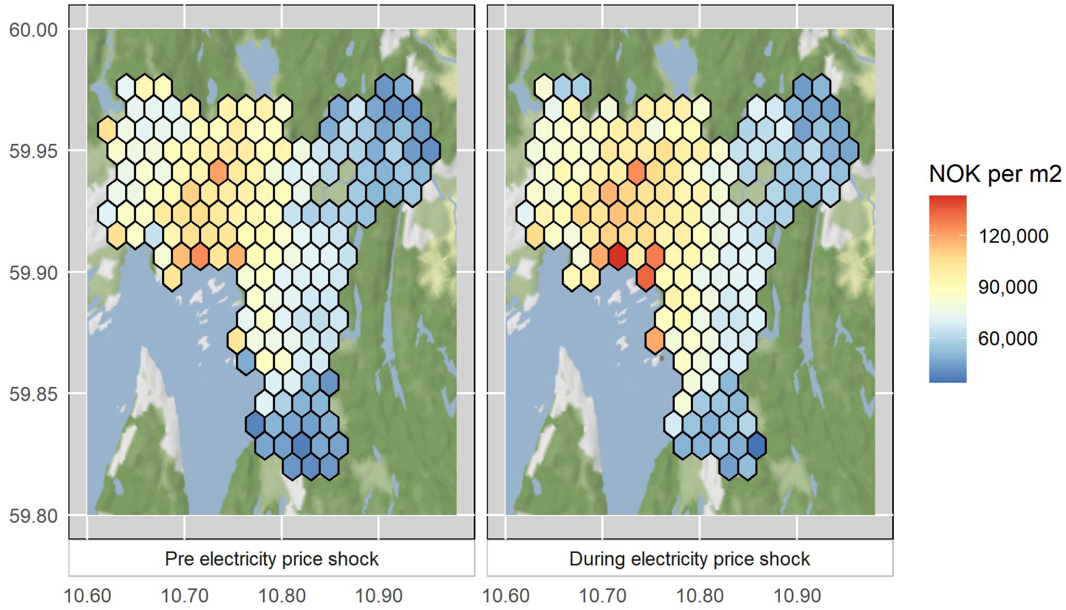
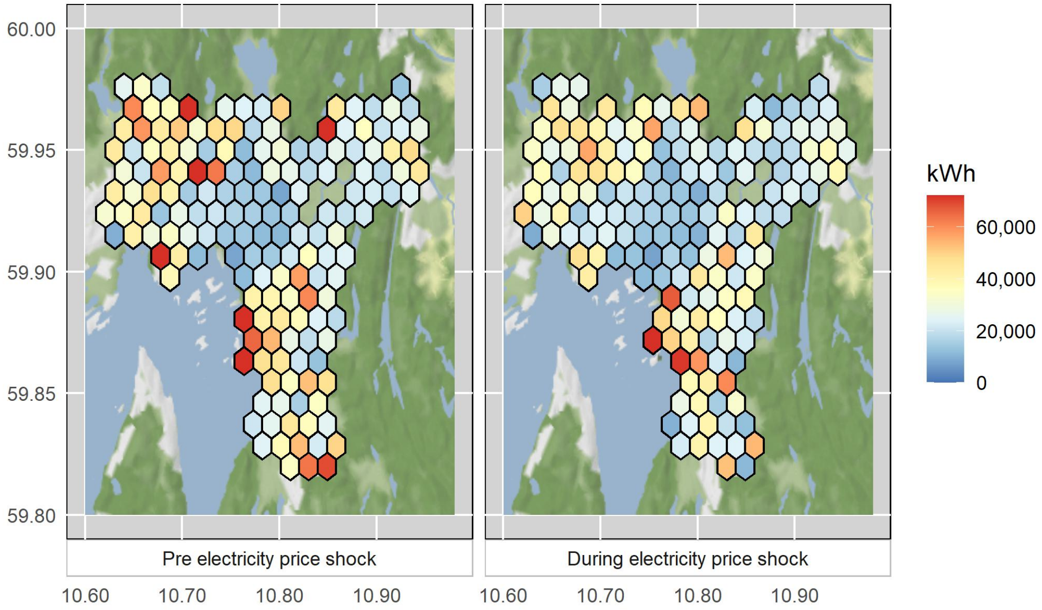
[33] The number is confirmed in a Statistics Norway report from 2021 at `https://www.ssb.no/energi-og-industri/energi/artikler/varmepumper-reduserer-utgiftene-til-stromavhengige-nordmenn`.

Figure 9: Price and energy efficiency of sold homes in Oslo (NO1)

Panel A: Price of sold homes



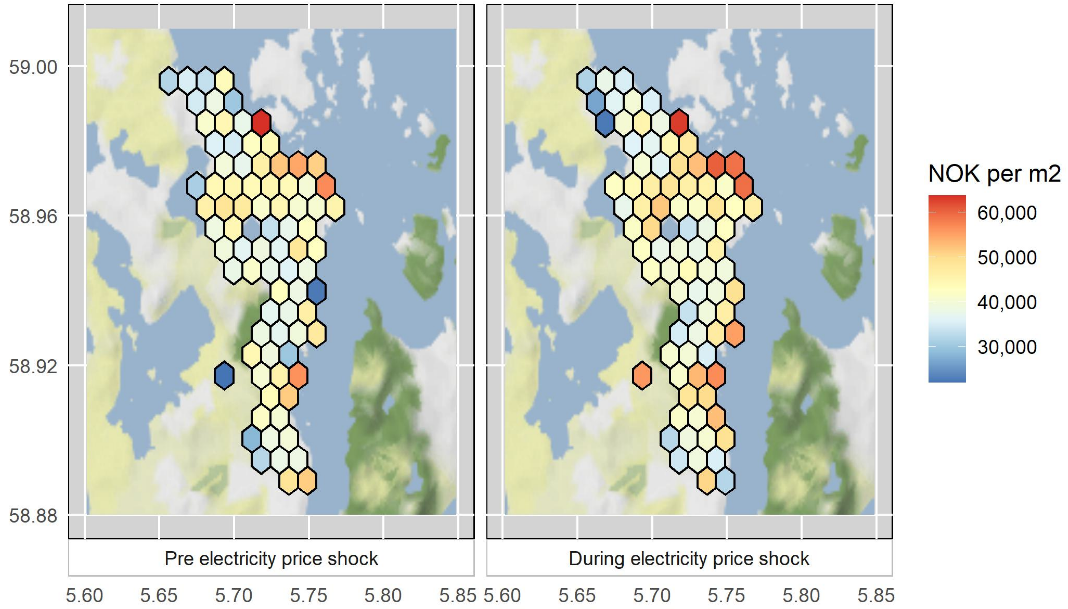
Panel B: Estimated energy consumption of sold homes



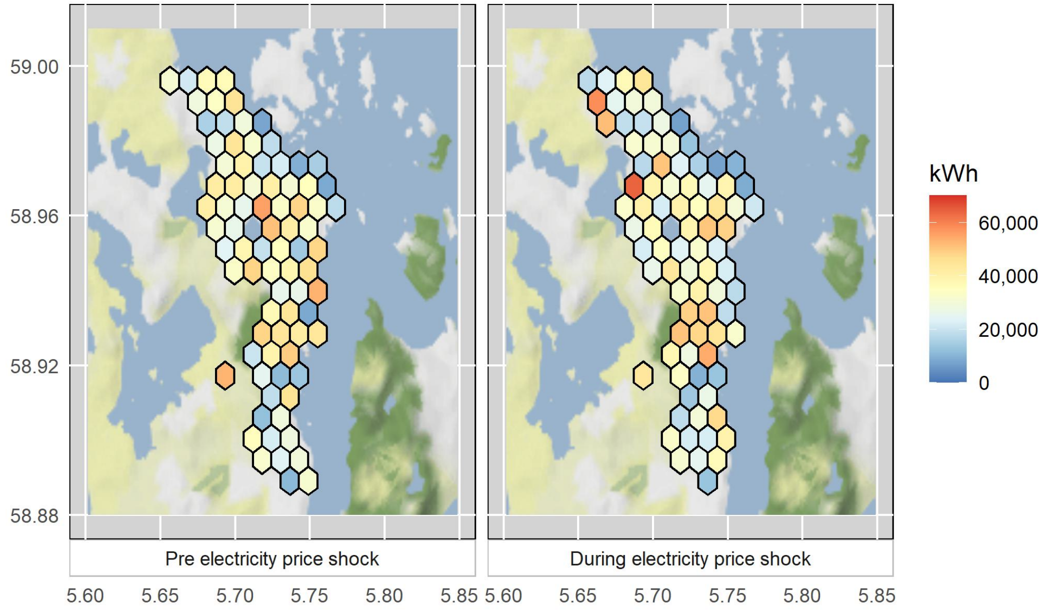
Notes: Panel A shows the average sales price per m^2 of homes sold in Oslo (NO1) in the year before (September 2020 to August 2021) and the year after (September 2021 to August 2022) the start of the electricity price shock. Panel B shows the average estimated energy consumption of sold homes over the same two periods. Source: Ambita AS housing data with Enova energy performance certificates.

Figure 10: Price and energy efficiency of sold homes in Stavanger (NO2)

Panel A: Price of sold homes



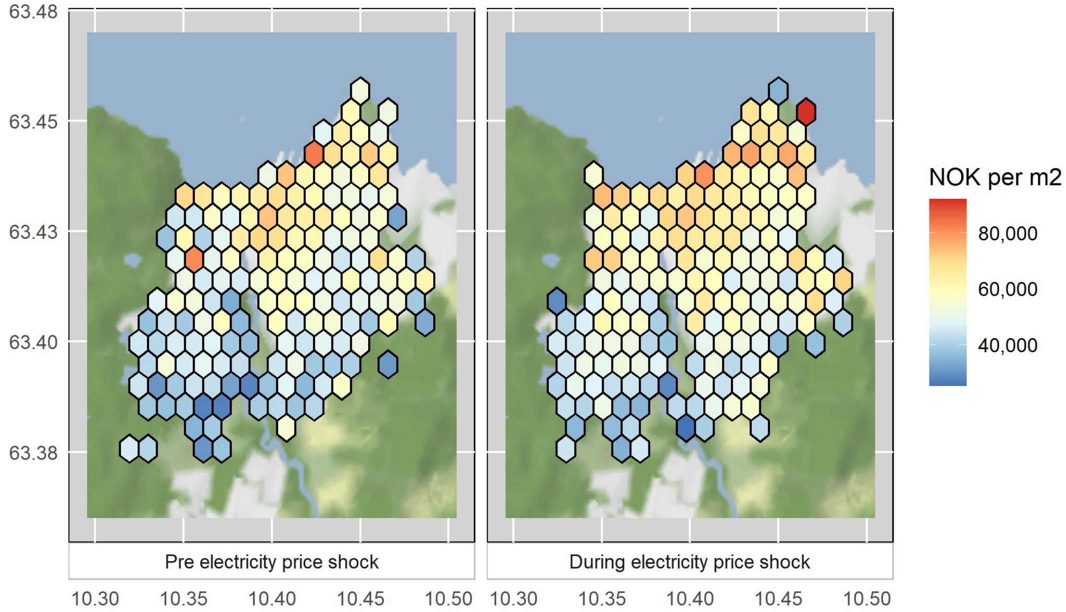
Panel B: Estimated energy consumption of sold homes



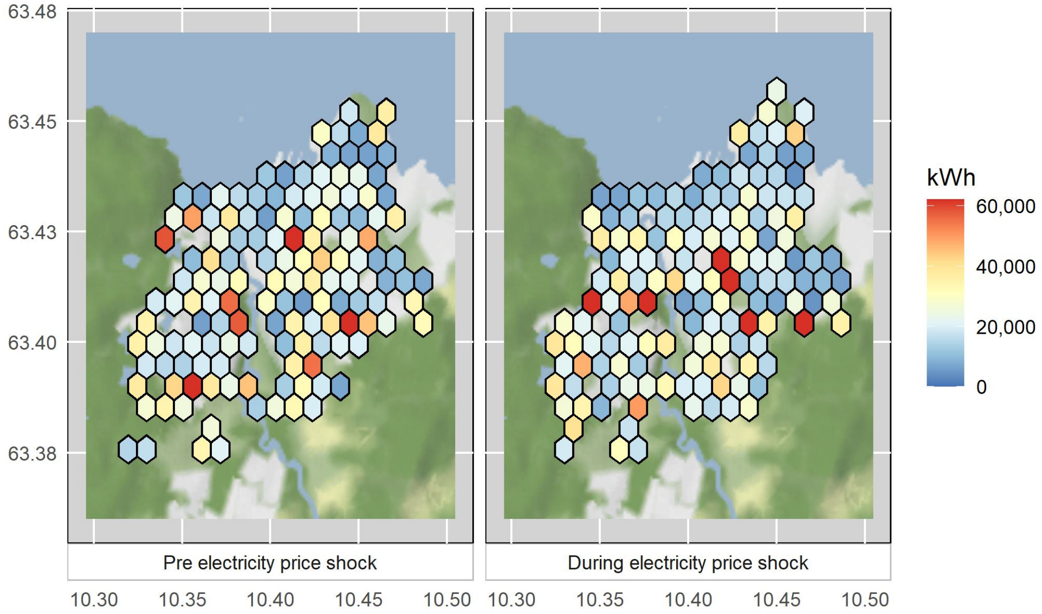
Notes: Panel A shows the average sales price per m^2 of homes sold in Stavanger (NO2) in the year before (September 2020 to August 2021) and the year after (September 2021 to August 2022) the start of the electricity price shock. Panel B shows the average estimated energy consumption of sold homes over the same two periods. Source: Ambita AS housing data with Enova energy performance certificates.

Figure 11: Price and energy efficiency of sold homes in Trondheim (NO3)

Panel A: Price of sold homes



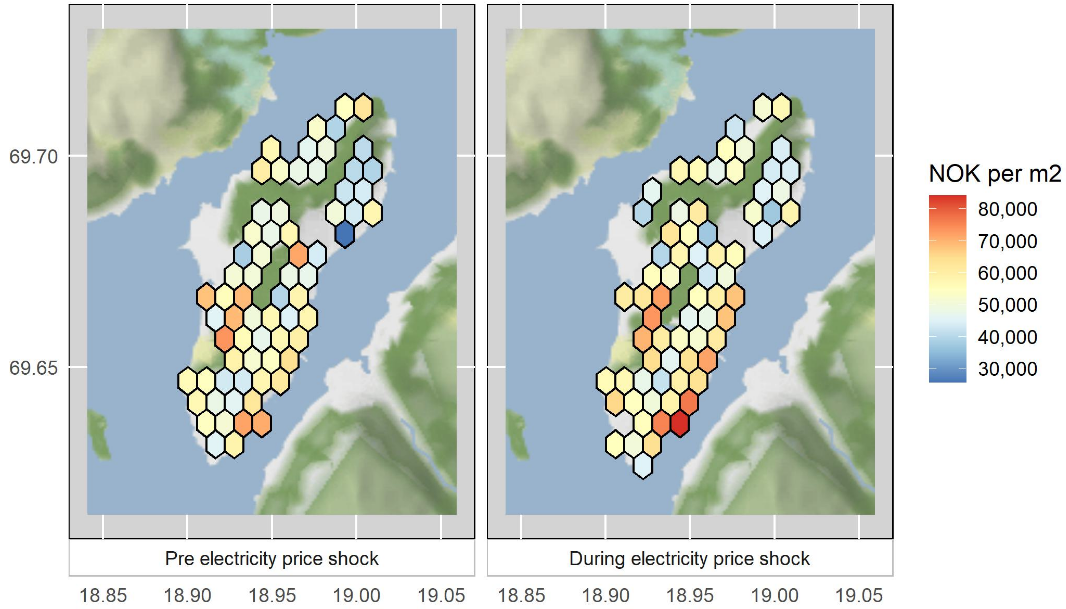
Panel B: Estimated energy consumption of sold homes



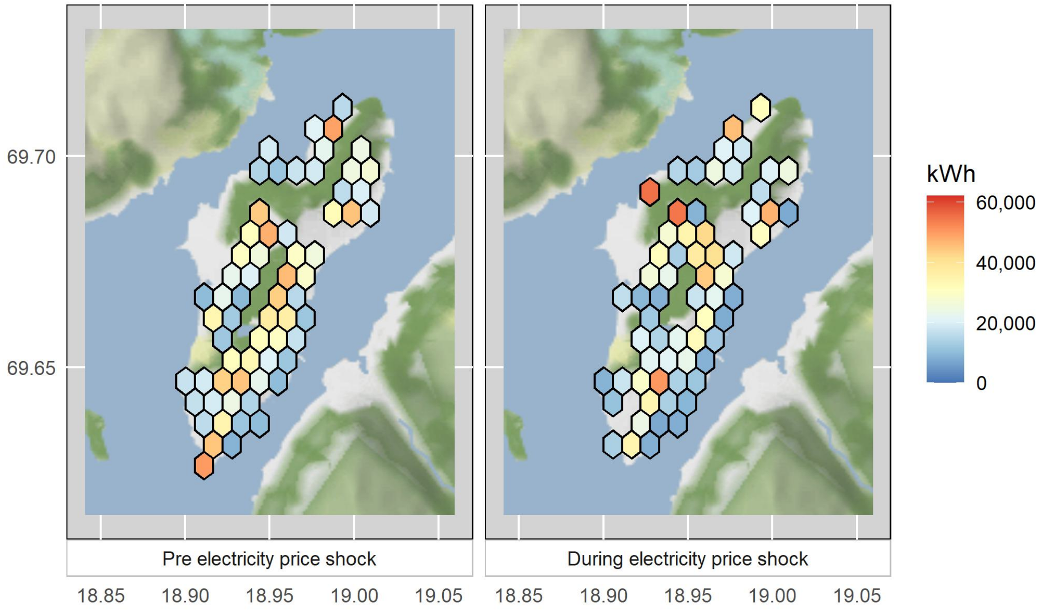
Notes: Panel A shows the average sales price per m^2 of homes sold in Trondheim (NO3) in the year before (September 2020 to August 2021) and the year after (September 2021 to August 2022) the start of the electricity price shock. Panel B shows the average estimated energy consumption of sold homes over the same two periods. Source: Ambita AS housing data with Enova energy performance certificates.

Figure 12: Price and energy efficiency of sold homes in Tromsø (NO4)

Panel A: Price of sold homes



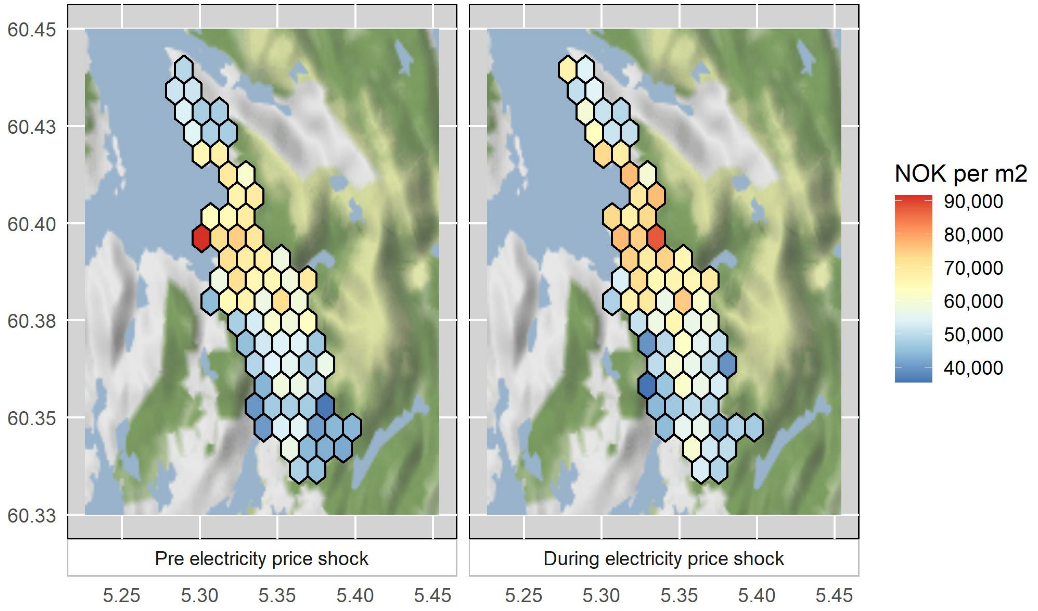
Panel B: Estimated energy consumption of sold homes



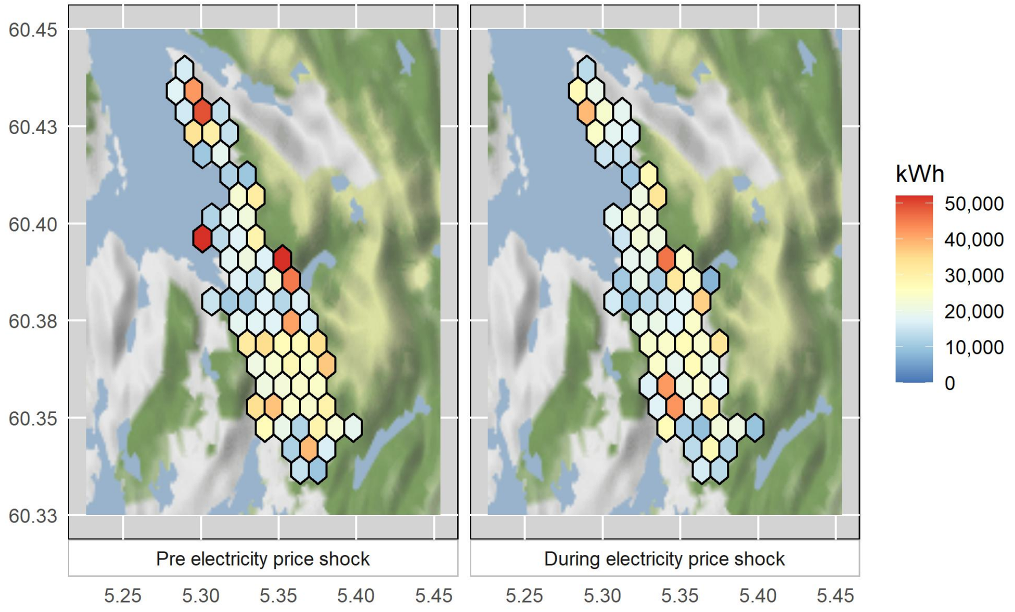
Notes: Panel A shows the average sales price per m^2 of homes sold in Tromsø (NO4) in the year before (September 2020 to August 2021) and the year after (September 2021 to August 2022) the start of the electricity price shock. Panel B shows the average estimated energy consumption of sold homes over the same two periods. Source: Ambita AS housing data with Enova energy performance certificates.

Figure 13: Price and energy efficiency of sold homes in Bergen (NO5)

Panel A: Price of sold homes



Panel B: Estimated energy consumption of sold homes



Notes: Panel A shows the average sales price per m^2 of homes sold in Bergen (NO5) in the year before (September 2020 to August 2021) and the year after (September 2021 to August 2022) the start of the electricity price shock. Panel B shows the average estimated energy consumption of sold homes over the same two periods. Source: Ambita AS housing data with Enova energy performance certificates.

Table 9: Triple differences regression results with heating score

	(1)	(2)	(3)	(4)
Sample	Full country	NO1, NO5, NO3	Not biggest cities	Only biggest cities
Dependent variable	$\ln(P_{it})$	$\ln(P_{it})$	$\ln(P_{it})$	$\ln(P_{it})$
Heat	-0.015	-0.026**	-0.008	0.032***
	(0.015)	(0.005)	(0.012)	(0.008)
Post×Treat	-0.010*	-0.013**	-0.009	-0.005
	(0.004)	(0.002)	(0.004)	(0.012)
Post×Heat	0.012	0.017***	0.009*	0.016
	(0.006)	(0.000)	(0.004)	(0.011)
Treat×Heat	0.026	0.033**	0.036**	-0.027***
	(0.018)	(0.007)	(0.012)	(0.008)
Post×Treat×Heat	-0.009	-0.014**	-0.013**	-0.003
	(0.006)	(0.002)	(0.004)	(0.012)
Housing attributes	Yes	Yes	Yes	Yes
Year×Month FE	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	No
City district FE	Yes	Yes	No	Yes
Observations	86,105	58,213	66,227	19,878
Adjusted R^2	0.839	0.855	0.752	0.802

Notes: The coefficients represent the percentage effect on price per m^2 from a triple differences model for different samples, where the third interaction is with heating efficiency. Heating efficiency comes from the Enova certificates, indicating how much of the home can be heated using carbon-friendly heating sources. NO1, NO3, NO5 represent the electricity price regions next to the North-South border, where NO1 and NO5 were affected by the electricity price shock while NO3 was not. Biggest cities are defined as the largest metropolitan areas in each electricity price region. The models have fixed effects for the interaction between year and month, as well as varying combinations of county, municipality, and city districts fixed effects. Robust standard errors, clustered at the electricity price region level, are in parentheses. *$p<0.1$; **$p<0.05$; ***$p<0.01$. Source: Author calculations using Ambita AS housing data, September 2020–September 2022.

Table 10: Increase in electricity costs in NOK from normal use

House type	Electricity cost (Spot price = 0.37)	Electricity cost (Spot price = 0.99)	Difference
Apartment	4,386	11,736	+7,350
House	13,524	36,185	+22,661
Semi-detached	8,787	23,511	+14,724
Row home	8,014	21,443	+13,429
All types	8,817	23,593	+14,776

Notes: This table shows the average increase in annual electricity costs for different types of homes based on two spot prices: NOK 0.37 and NOK 0.99 per kWh. The difference represents the additional cost in NOK from the lower to the higher spot price in the South of Norway after adjusting for the subsidy. For comparison, in 2021, Norwegian households with a mortgage paid an average of NOK 120,622 annually (`https://www.ssb.no/en/statbank/table/14066`), while the average rental cost for a three-room home was NOK 133,680 per year (`https://www.ssb.no/en/statbank/table/09895`). Source: Author calculations using Ambita AS housing data with Enova energy performance certificates, electricity spot prices from Norwegian power supplier Fjordkraft, and electricity share of total energy consumption from Statistics Norway. Housing and electricity price data are from September 2020–September 2022.