Accelerating Building Decarbonization: A Homeowners Policy Framework for Energy Retrofit Programs

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1.Introduction

Background Information

Energy Efficiency Adoption in the Netherlands: Progress and Challenges Toward 2030 Climate Targets

The Netherlands is on one of Europe's most ambitious residential energy transitions, with one in three Dutch households now using clean energy technologies. Between 2018 and 2023, the country witnessed dramatic growth in energy efficiency adoption, driven by strengthened climate legislation, the 2022-2023 energy crisis, and evolving subsidy frameworks. However, significant challenges remain in achieving the legally binding target of 55% greenhouse gas reduction by 2030, with current policies projected to deliver only 38-48% reduction.

Dutch Energy Transition Accelerates Amid Policy Evolution

The Netherlands' energy transition gained momentum following the 2019 Climate Act, which established legally binding targets of 49% GHG reduction by 2030 (later increased to 55%) and 95% by 2050 (updated to net-zero) (Global Compliance News, 2019; IEA, 2024). The Dutch Climate Agreement (Klimaatakkoord) set specific residential sector goals: 1.5 million homes to become natural gas-free by 2030, with 30,000-50,000 existing homes transitioning annually (PBL Netherlands Environmental Assessment Agency, 2023).

Solar panel adoption emerged as the clear success story, with 2 million households (52.7% of all family house owned dwellings) installing panels by 2023. Heat pump deployment also accelerated dramatically, reaching 1.9 million units by end-2022, up from fewer than 10,000 in the 1990s (IEA, 2020). The energy label distribution transformed significantly, with A-label homes increasing from under 200,000 in 2015 to 1.7 million in 2023 (Rijksoverheid, 2023).

The 2022-2023 energy crisis catalysed behavioural changes and technology adoption. Natural gas consumption fell to its lowest level in 50 years, while households achieved unprecedented energy savings (Deloitte, 2023).

Understanding Heat Loss Patterns in Dutch Residential Buildings

A critical foundation for effective energy efficiency improvements lies in understanding where and how Dutch homes lose heat. Research from multiple Dutch sources reveals distinct heat loss patterns that shape renovation priorities and potential energy savings.

Heat Loss Distribution by Building Component

Dutch residential buildings exhibit specific heat loss characteristics that differ from international averages due to the country's prevalent construction methods and climate:

Table 1.1: *Heat loss distribution by building component in Dutch residential dwellings (Sources: Renovatie Totaal, 2024; Milieu Centraal, 2023a; Handel Bouw Advies, 2023)*

Building Component	Heat Loss	Surface Area	Notes
Roof/Attic	30%	25-30%	Largest heat loss due to rising warm air
Walls/Facades	25%	60-65%	78% of Dutch facades are cavity walls
Ventilation/Air Leakage	17%	N/A	Major issue in pre-1992 homes
Floor/Crawl Space	15%	15-20%	Often neglected but significant loss
Windows/Doors	13%	10-15%	Up to 20% with single glazing

This distribution reveals that while roofs account for the largest single source of heat loss (30%), the combined effect of walls and air infiltration represents 42% of total heat loss. The relatively lower percentage through windows (13%) compared to international averages reflects the Netherlands' widespread adoption of double glazing since the 1980s, though homes with single glazing can still lose up to 20% of heat through windows.

Construction Period Impacts on Heat Loss

The effectiveness of heat loss reduction measures varies significantly based on the construction period:

- Pre-1980 homes: Experience 2.5x higher total heat loss than modern homes, with windows potentially accounting for up to 40% of losses
- 1992-2013 homes: With RC values of 2.5, these homes are reasonably suited for heat pump installation, but benefit from additional insulation
- Post-2022 homes: Built to BENG standards with RC values of 4.7-6.3, these homes are optimized for low-temperature heating systems

Measures that Drive Residential Efficiency Improvements

Dutch homeowners face a landscape of energy efficiency options, each targeting specific heat loss pathways identified above.

HR++ glass represents the most accessible upgrade for many homes, directly addressing the 13-20% heat loss through windows. Costing €260 per m^2 on average, a typical $14m^2$ installation saves 322 m^3 of gas annually (€457 at current prices), achieving payback in 7.9 years. With 85% of Dutch homes already having double glazing, the focus has shifted to high-performance upgrades that can reduce Glass windows heat loss to below 10% (Verbouwkosten, 2023a).

Insulation measures target the major heat loss pathways through building envelope. Cavity wall insulation addresses the 25% heat loss through walls, offering the fastest payback (3-5 years) at €12-40 per m^2. This measure is particularly effective given that 78% of Dutch facades are cavity walls. Roof insulation (€50-110 per m^2) tackles the largest single heat loss source (30%), reducing gas consumption by 340 m^3 annually.

Floor insulation costs €1,900 professionally installed and addresses the 15% heat loss through floors, but faces adoption barriers - only 60% of floor area in Dutch homes is insulated, with pre-1980 homes particularly underserved at 33% (Verbouwkosten, 2023b; CLO, 2018).

Solar panels have become the Netherlands' energy efficiency success story. A typical 10-panel system (€3,500-6,200) generates 3,960 kWh annually, saving €1,077 at current electricity prices (Zonneplan, 2025; Zonnepanelen.net, 2025). The 4.3-year payback period - aided by 0% VAT since 2023 - has driven adoption to 33% of households. However, the planned phase-out of net metering (salderingsregeling) by 2027 will extend payback periods to 12-14 years (Belastingdienst, 2023).

Heat pumps remain the most expensive option (€7,000-25,000 installed) but offer transformative potential by addressing all heating-related losses simultaneously. Hybrid systems reduce gas consumption by 60-70%, while full-electric systems eliminate it entirely. However, effective heat pump operation requires addressing major heat loss pathways first - homes should achieve minimum RC values of 2.5 for walls, 3.5 for roofs, and HR++ glazing before installation (Consumentenbond, 2023). Despite 25% annual growth, heat pumps serve only 1.4% of homes as primary heating, constrained by high costs and insulation requirements (ODYSSEE-MURE, 2023).

Current Government Subsidies

The Dutch subsidy landscape underwent a significant transformation during 2018-2023, with programs increasingly aligned to address identified heat loss priorities. The transition from the SEEH scheme (€56 million, 2016-2022) to the expanded ISDE program saw funding grow from €290 million in 2022 to €600 million in 2024 (IEA, 2022; Van Draeckeburgh, 2023).

The ISDE covers heat pumps (€500-€13,200 depending on type and capacity), insulation measures targeting all major heat loss pathways, and heat network connections. Key policy innovations include doubled subsidies for combining multiple measures - recognizing that comprehensive approaches addressing multiple heat loss sources achieve better results - bonuses for bio-based materials, and relaxed requirements for monument buildings (RVO, 2025). The 2024 restructuring prioritized heat pumps with €1,250 base subsidies plus €225/kW capacity bonuses.

Tax incentives proved equally important in driving adoption of measures addressing specific heat loss areas. The 0% VAT rate on solar panels (permanent from 2023) and 9% VAT on insulation labor (versus standard 21%) significantly improved project economics for measures targeting the building envelope (Belastingdienst, 2023; Warmtepomp-gids, 2023). Temporary 6% VAT rates for heat pumps (2022-2024)(expired on December 31, 2024) provided additional stimulus during the energy crisis (Milieu Centraal, 2023).

Housing Diversity and Heat Loss Patterns

The Netherlands' 4.5 million owner-occupied dwellings present diverse efficiency challenges, with heat loss characteristics varying significantly by housing type and construction period. Row houses represent the largest segment at 35% (1.6 million units), followed by detached houses (21%), apartments (16%), corner houses (15%), and semi-detached homes (13%).

For the 3.75 million family dwellings (excluding apartments), construction period analysis reveals an aging housing stock with distinct thermal performance implications: post-1991 dwellings account for 28.9% of the stock, while homes built between 1945-1974 comprise 27.4%, and those from 1974-1991 represent 25.3%. Notably, 18.4% of family dwellings predate 1945, presenting particular retrofit challenges due to heritage considerations and construction methods. This distribution of housing types and construction periods directly impacts heat loss patterns and necessitates differentiated renovation strategies

Energy consumption patterns correlate strongly with dwelling type and exposed surface area. Detached houses consume 2,100-2,400 m^3 gas annually - nearly three times apartments' 800-1,000 m^3. This difference reflects varying heat loss profiles:

• Detached houses: All surfaces exposed, resulting in higher heat loss through roof (30%), walls (25%), and floors (15%)
• Terraced houses: Reduced wall heat loss due to shared party walls, but similar roof and floor losses

Construction Period Analysis and Heat Loss

Construction period analysis reveals clear efficiency trajectories aligned with evolving insulation standards:

Table 1.2: *Construction Period Analysis*

Period	Typical Energy Label	Gas Consumption	Heat Loss Characteristics
Pre-1945	G	12.9 m^3/m^2/year	Minimal insulation, 40% window losses possible
1945-1974	E-F	10.5 m^3/m^2/year	Basic improvements, high air infiltration
1975-1991	D-E	9.2 m^3/m^2/year	First insulation standards, cavity walls common
1992-2005	C-D	8.1 m^3/m^2/year	RC 2.5 standard, double glazing prevalent
Post-2006	A-B	7.5 m^3/m^2/year	Modern standards, comprehensive insulation

The 1975-1991 period marked the introduction of mandatory insulation standards and widespread cavity wall construction, creating a natural division in the housing stock's heat loss reduction potential (Housing Standardisation, 2023).

Regional variations reflect both housing composition and climate factors. Northern provinces (Friesland, Groningen, Drenthe) show higher consumption due to detached house prevalence and climate, while urban centers benefit from apartment density and reduced heat loss through shared walls. The concentration of energy poverty in northeast Groningen, Zuid-Limburg, and major cities highlights equity challenges in addressing heat loss in older, poorly insulated housing stock (CBS, 2024a).

Current Behavioural Insights

Research identifies the "hassle factor" as the primary barrier to energy efficient renovations - the perceived effort, disruption, and complexity of comprehensive insulation projects outweighs potential benefits for many homeowners. This encompasses time investment for understanding heat loss patterns, selecting appropriate measures, subsidy applications, contractor selection, and daily routine disruptions during implementation (Ebrahimigharehbaghi et al., 2019; Ebrahimigharehbaghi et al., 2022).

Many homeowners lack awareness of their specific heat loss profile. While they may notice cold drafts or high energy bills, the invisible nature of heat loss through roofs, walls, and infiltration means renovation decisions often focus on visible elements like windows, despite these representing only 13% of total heat loss.

Key trigger points for heat loss reduction investments include end-of-life heating system replacement (when comprehensive insulation makes heat pumps viable), home purchases (when energy labels reveal heat loss issues), and major renovations initially planned for non-energy reasons. Gender, age, education level, and building type significantly predict adoption likelihood, with previous renovation experience positively influencing future heat loss reduction decisions (Ebrahimigharehbaghi et al., 2022).

The "block leader effect" demonstrates powerful social influence - residents within 200 meters of community energy leaders show 4x higher probability of implementing community-led energy retrofits. This neighbourhood ambassador model, validated by TU Eindhoven research, suggests optimal distribution strategies for catalysing community-wide adoption of insulation improvements (BEL TU/e, 2023).

2. Objectives

This document examines the multifaceted factors that influence homeowners' behaviour in their journey of adapting energy-efficient retrofits into their homes. Hereby is the twofold objective of the document:

The first objective is to disentangle how the complex interplay between financial, sociodemographic, dwelling characteristics, seasonal effects, and how retrofits are offered affects homeowners' decisions.

The second objective is to provide policymakers, municipalities, and stakeholders involved in the energy transition with actionable data-driven insights that would accelerate the energy transition in the built environment for homeowners in the Netherlands, thus reaching the climate targets set beforehand in an efficient and targeted manner.

3. Research Framework

What This Research Is About

This research examines the drivers behind Dutch household decisions to install energy-saving measures (insulation, solar panels, heat pumps) between 2019 and 2023. The analysis draws on 38,762 actual leads - households that engaged with energy retrofit services - to identify which factors determine whether households proceed with energy efficiency investments: financial capacity, housing characteristics, socio-demographic profiles, and contextual elements. Rather than relying on stated intentions or hypothetical scenarios, this research analyses actual market behaviour and completed installations.

Data Sources and Integration Strategy

This research combines commercial market data with CBS microdata. The foundation began with Reimarkt's customer journey and product installation data, capturing real homeowner behaviour in the energy efficiency market. This was expanded to include data from two additional one-stop shop operators with distinctly different business models: Winst Uit Je Woning (WUJW), which operates through direct collaboration with Dutch municipalities, and Bureau voor Verduurzamen (BvV), which operates as a market-based one-stop shop. It is noted that, recently, BvV has undergone a change in this regard in response to new central government policy. Since 2024, municipalities have been placed in the lead (“regie”) role by the national government, which means that much of BvV's work currently takes place within municipal frameworks.

Across these three one-stop shop providers, the dataset captures 38,762 leads between 2019 and 2023. The multi-company approach captures different operational models within the one-stop shop landscape. While all three organizations provide integrated energy retrofit services, their market approaches differ substantially. WUJW operates through formal municipal partnerships, leveraging municipal credibility and outreach infrastructure. BvV (until 2024) and Reimarkt operate through market-based approaches, using diverse channels and execution strategies while still providing advice, contractor coordination, and quality assurance that characterizes the one-stop shop model.

The lead data was enriched with CBS microdata at the household level, adding detailed information on actual energy consumption patterns (electricity and gas usage), housing costs and property valuations, socio-demographics, and (financial) wealth data. The final integrated dataset contains 38,762 unique household records spanning 2019-2023, linking customer data with detailed socio-economic and housing profiles from CBS. This integration creates an analytical framework where household decisions can be understood not just in terms of who they are and what they own, but also in terms of how they were approached and what specific circumstances triggered their choices.

Data Quality and Analytical Sample

Beginning with 69,536 household records, we implemented an outlier detection technique using Median Absolute Deviation (MAD) methods, reducing the sample to 62,773 records. Missing data in critical variables - particularly energy consumption and income measures – were solved using imputation methods, including random forest methods and Multiple Imputation by Chained Equations (MICE). However, diagnostic checks revealed that imputed values for energy consumption variables lacked sufficient reliability. Rather than proceeding with questionable estimates, these cases were excluded from the analysis.

After removing duplicate households contacted within the same month (same households that have requested products within a short time span but coded in the one-stop-shop CRM data as separate leads) and ensuring data completeness, the final analytical sample contains 38,762 households. This conservative approach represents a deliberate trade-off: sacrificing records with missing or unreliable information to maintain data integrity. For policy analysis, this decision is appropriate - it's preferable to have robust findings from a clean sample than to risk policy recommendations based on statistically unreliable estimates. The sample is substantial (38,762 households across 314 municipalities over five years) and provides sufficient statistical power for detailed segmentation analysis. These households actively engaged with the energy retrofit market between 2019 and 2023 through one of the three participating one-stop shops.

What Drives Energy Efficiency Decisions: The Analytical Framework

Financial capacity emerges as a central theme and is measured through multiple complementary indicators. Financial welfare categories (derived from CBS wealth data) capture household position in the Dutch wealth distribution across five categories: 0-20 (lowest quintile), 21-40, 41-60 (middle, used as reference), 61-80, and 81-100 (highest quintile). This holistic wealth measure incorporates both liquid and illiquid assets, including property equity, investments, and business ownership.

Financial capacity is further characterized by mortgage position, which categorizes households from no debt (the reference category, representing debt-free ownership) through low debt (€0-€100,000), medium debt (€100,000-€250,000), to high debt (exceeding €250,000). The analysis also includes whether households hold construction deposits (bouwdepot), indicating available liquid funds specifically designated for renovation purposes. A third financial dimension - utility cost ratio to income - measures what percentage of household income is consumed by energy costs, categorized as very low (under 10%), low (10-20%), reference (20-30%), high (30-40%), very high (40-50%), and extreme (over 50%). Together, these variables paint a nuanced picture: a household might rank high in wealth but carry substantial mortgage debt and face high utility cost burdens, creating different capacities for discretionary renovation investment.

Housing characteristics operate not just as control variables but as fundamental determinants of both renovation need and feasibility. The analysis recognizes dwelling type differences, with row houses serving as the reference category against which corner houses, detached houses, and semi-detached houses are compared. Dwelling size is included to capture scale effects. The presence of district heating is captured as a binary indicator, recognizing that these households face fundamentally different energy system constraints and opportunities. The construction period plays a crucial role, with homes built during 1974-1991 serving as the reference category, compared against older properties (before 1945, 1945-1974) and newer construction (after 1991). These construction periods correspond to different building standards, insulation practices, and technical characteristics that affect both renovation need and feasibility.

The analysis recognizes that a 90m^2 dwelling means something entirely different for a row house versus a detached house, leading to type-specific median centering of continuous variables. Current energy consumption (actual metered data from CBS) serves dual purposes: it indicates both the potential for energy savings from efficiency improvements and may proxy for household energy awareness or climate concern. Property age and construction period interact with these consumption patterns—older homes typically consume more energy but may also face greater technical challenges for certain retrofits.

The household profile dimension extends beyond simple demographics to capture life stage and educational attainment, variables that may influence both financial planning horizons and receptivity to technical information about energy efficiency. Age composition is captured through detailed categories, with households aged 35-64 as the reference group, compared against young (18-34), young/middle-aged (18-64), elderly (60-79), very elderly (80+), mixed age adults, and middle-aged/elderly (35-79) configurations. Educational attainment, with upper secondary education as reference, ranges from primary/lower secondary through secondary vocational, bachelor's degrees, to advanced degrees (master's/doctoral). Household composition, using couples with children as reference, includes single persons, single parents, couples without children, and other combinations. Dwelling occupation duration, with 20+ years as reference, tracks how long households have lived in their current home through categories of less than 2 years, 2-5 years, 5-10 years, 10-15 years, and 15-20 years, capturing both familiarity with the property and likely investment horizons.

Critically, the analysis tracks both pre-existing energy measures (solar panels, floor insulation, glass insulation, wall insulation, roof insulation) and expressed interest in specific improvements (interest in solar panels, floor insulation, glass insulation, wall insulation, roof insulation, heat pumps), recognizing that households with partial retrofits may behave differently—either exhibiting renovation momentum or having already addressed their priority concerns.

One-Stop Shop Business Models and Market Approaches

A particularly valuable aspect of this research is its ability to compare different operational models within the one-stop shop landscape and the pathways households take toward energy efficiency investments. Among the 38,762 leads captured between 2019 and 2023, the distribution across operators reveals distinct market positions:

WUJW contributes 16,976 leads (44% of total) through its municipality-collaborative model, achieving 2,703 conversions for a 15.9% conversion rate. This municipality-collaborative approach represents one model for delivering integrated energy retrofit services, and WUJW's municipality channel serves as the reference category for all lead channel comparisons.

BvV operates through a resident-focused execution model and is responsible for 17,479 leads (45% of total), achieving 3,477 conversions for a 19.9% conversion rate. This relatively strong result stems from a pragmatic, execution-oriented model — direct homeowner support, close coordination with contractors, and digital pricing and recording tools that streamline decision-making. As a result, BvV employs diverse marketing strategies: third-party lead channels (purchased or aggregated leads from other sources), digital channels (online marketing, website inquiries, social media), direct channels (door-to-door canvassing, telephone outreach), municipality channels (working with municipalities but through commercial arrangements), referrals/ambassadors (word-of-mouth, customer referrals), meetings/events (trade shows, information sessions), and other channels. On the other hand, Reimarkt contributes 4,307 leads (11% of total) with 266 conversions for a 6.2% conversion rate, using a commercial channel mix including flyer/letter distribution (direct mail campaigns), referrals/ambassadors (word-of-mouth, customer referrals), meetings/events (trade shows, information sessions), and other market-based approaches.

The analysis also captures product request complexity through two related variables: the number of products requested by the household and a quadratic term (number of products squared), allowing for non-linear relationships where households requesting multiple products simultaneously may behave differently than simple counts would suggest - either showing greater commitment or facing greater decision complexity.

Geographic and Temporal Context

The geographic dimension operates at the municipality level, with fixed effects for 314 municipalities capturing local housing market conditions, existing building stock characteristics, and local policy environments, including municipal energy transition strategies or building regulations. Additionally, urbanity is categorized into five levels: extremely urbanized (2,500+ persons per km^2, used as reference), strongly urbanized (1,500-2,500 per km^2), moderately urbanized (1,000-1,500 per km^2), hardly urbanized (500-1,000 per km^2), and not urbanized (under 500 per km^2). This captures not just administrative boundaries but also settlement density patterns that may affect renovation markets, contractor availability, and household preferences.

Temporal controls operate at two levels. Annual effects track temporal trends across 2019 (reference year), 2020, 2021, 2022, and 2023, capturing the evolution during this period, including the 2021-2022 energy price crisis and policy changes. Monthly seasonality accounts for within-year variation in renovation decisions through indicators for all twelve months, recognizing that households may prefer certain seasons for construction work or that outreach effectiveness varies by time of year.

These temporal dimensions are critical for interpretation - patterns observed during periods of extreme energy price volatility may differ from steady-state behaviour, and understanding these dynamics informs whether current adoption rates are sustainable or represent temporary responses to crisis conditions.

Analytical Approach

The statistical methodology employs multivariate logistic regression with Firth's penalization to address separation issues that arise when modelling rare events with multiple categorical variables and interactions. This is particularly important given that some company-channel combinations have sparse data - for instance, certain channels used exclusively by one operator yielded fewer than 20 observations for specific product types. The Firth approach prevents coefficient explosion in these sparse cells while producing stable, interpretable parameters.

A methodological challenge arose from structural multicollinearity between company indicators and marketing channels. WUJW exclusively uses municipality-based outreach through its collaborative model, while the other one-stop shops employ multiple channels with minimal overlap. Rather than simply dropping variables, we implemented a constrained effects model treating WUJW's municipality channel as baseline and activating other channel indicators (digital, flyer/letter, municipality non-WUJW, referrals/ambassadors, direct channels, third-party channels, other channels, meetings/events) only for commercial operator observations. This preserves the ability to estimate both operator main effects and channel-specific effects within the commercial operator variation.

Standard errors are clustered at the municipality level, acknowledging that unobserved factors may correlate within both geographic areas, with these correlation patterns varying across different municipalities. This clustering strategy produces conservative inference that accounts for the true error structure rather than assuming independent observations.

Dwelling Segment-Specific Analysis Strategy

In addition to the pooled analysis, this research employs dwelling-type-specific models estimated separately, whereby row houses and corner houses are combined, and detached and semi-detached houses are combined. This segmentation recognizes that the drivers of energy efficiency adoption may operate differently across housing types. Row houses and corner houses face different technical constraints (shared building systems) and have different energy consumption patterns than detached houses. This segment-specific approach produces clearer, more actionable insights than forcing all housing types into a single model.

Variable Preparation for Analysis

The continuous variables in this analysis undergo careful preparation to ensure they work well in the statistical models while remaining interpretable for policy purposes. Energy consumption variables (electricity and gas) and property values are transformed and centered around the median for each specific housing type. This approach means that when we examine the effects of energy consumption, we're comparing households to others with similar dwelling types - comparing row houses to row houses, detached houses to detached houses - which provides more meaningful insights for understanding renovation behaviour.

For dwelling size and utility costs, logarithmic transformations account for the fact that these variables don't operate in a simple linear fashion - the difference between a very small and medium-sized dwelling may matter more than the difference between medium and large dwellings. These preparations ensure that the statistical relationships we observe reflect genuine behavioural patterns rather than artifacts of how variables are measured, while maintaining interpretability for policy application.

Conclusion

This research integrates commercial market data covering 38,762 leads from three one-stop shop operators with CBS micro data, analysing actual installation decisions to understand how financial capacity, dwelling characteristics, household demographics, temporal patterns, and service delivery models interact to shape retrofit adoption. The balanced representation between municipality-collaborative operations (WUJW, 44% of leads, 15.9% conversion) and largely market-based one-stop shops (BvV 45% of leads, 19.9% conversion; Reimarkt 11% of leads, 6.2% conversion) reveals substantial variation in conversion effectiveness across operational approaches and marketing channels. The variation in conversion rates (ranging from 6.2% to 19.9%) suggests that operational differences—such as implementation methods, digital infrastructure, and contractor coordination approaches may play a role.

The comprehensive variable set captures financial positioning through wealth quintiles, mortgage categories, utility burden, and construction deposits; housing context through dwelling type, size, construction period, and district heating; demographics through age profile, education, household composition, and occupation duration; renovation context through pre-existing measures and expressed interests; and service delivery through channel strategies and product bundling. This framework enables understanding of which household characteristics facilitate or impede conversion across different housing segments and operational models, with municipality fixed effects, urbanity categories, and temporal controls (annual effects, monthly seasonality) accounting for geographic variation, settlement density patterns, and dramatic energy market shifts during the observation period.

For policymakers, this provides evidence for targeting strategies toward specific household segments (low financial welfare quintiles, high utility burden, lower education, older construction, specific dwelling types), operational design choices between municipality-collaborative and market-based models (noting that the 2024 governance changes placed municipalities in formal coordination roles while maintaining a role for market-based operators in program delivery, as municipalities require implementation capacity and operational infrastructure), channel strategy optimization for different segments, and realistic expectations about conversion rates. The findings inform resource allocation decisions about public investment in direct service provision versus market enablement, while revealing whether comprehensive versus incremental retrofit approaches differ in effectiveness. The conservative analytical approach - complete case analysis, appropriate error clustering, Firth penalization - prioritizes reliability for policy decisions with real resource implications, though extrapolation should account for sample selection (households choosing these providers) and temporal context (including crisis-driven responses during 2021-2023 that may not persist under normalized conditions).

Chapter 4 - Results and findings

This chapter presents a comprehensive analysis of household energy efficiency retrofit adoption through Dutch one-stop shops, examining both descriptive patterns and multivariate model-based results. The analysis addresses fundamental questions about which households participate and adapt, what products they request and ultimately purchase, how demographic and dwelling characteristics influence conversion, and where systematic barriers prevent successful adoption.

The results are organised into two complementary sections. Section 4.1 provides descriptive statistics that document baseline patterns across five dimensions: product request and purchase behaviour, co-occurrence patterns revealing bundling preferences, customer returning behaviour, household and dwelling characteristics compared to population benchmarks, and lead channel performance by demographics. These descriptive analyses establish the empirical foundation and identify key trends requiring deeper investigation.

Section 4.2 presents model-based analysis results that isolate the independent effects of household characteristics, dwelling attributes, financial variables, energy consumption patterns, and expressed interests on the odds of adopting each of six energy efficiency measures (solar panels, heat pumps, floor insulation, wall insulation, roof insulation, and glass insulation). By employing Firth's penalized logistic regression with controls for confounding factors, this multivariate approach reveals separate effects of variables that cannot be discerned from bivariate descriptive statistics alone. Together, these complementary analytical strategies provide comprehensive insights into the determinants of energy efficiency retrofits adoption and the barriers preventing broader adoption success.

4.1 Descriptive statistics

Before proceeding to multivariate modeling, this section presents descriptive analysis of the dataset across five dimensions:

- **Products requested and purchased** - examining request patterns, purchase behaviour, and bundle sizes
- **Product co-occurrence behaviour** - analysing which products are requested and purchased together
- **Customer returning behaviour** - tracking repeat engagement and timing patterns
- **Household and dwelling characteristics** - comparing lead demographics to population benchmarks
- **Lead channel performance by demographics -** comparing lead demographics conversion through different lead channels

These analyses establish baseline patterns, identify key trends, and document important conversion metrics before the more rigorous model-based analysis in section 4.2.

4.1.1 Products requested and purchased

Understanding the relationship between household requests and actual purchases is fundamental. This section examines both the aspirational retrofit plans households initially request and the more modest implementations they ultimately complete. We will be analysing the gap between intention and action across different product combinations and bundle sizes.

4.1.1.1 Overall request and purchase patterns

Table 4.1: *Summary statistics: the average number of products requested per lead, the distribution between single and multiple product requests, and comparative success rates* [1]

Total leads	Avg products per lead	Single product %	Multiple product %	Single conversion rate (%)	Multiple conversion rate (%)
35,028	1.64	58.3	41.7	14.9	22.1

Note: *This analysis includes 35,028 leads from WUJW, and BvV with complete product request data. Reimarkt leads are excluded from this table because product request data was not available in their system (approximately 3,734 records).*

Table 4.1 presents summary statistics on product requests. Households request an average of 1.64 products per lead, with 58.3% requesting a single product and 41.7% requesting multiple products. The multiple product conversion rate of 22.1% exceeds the single product rate of 14.9% by 7.2 percentage points.

To verify whether this difference is statistically significant, we conducted a chi-square test using the frequency counts of conversions and non-conversions for single versus multiple product requests: 3,043 of 20,390 single-product requests converted (14.9%) compared to 3,238 of 14,638 multiple-product requests (22.1%). The test results ($\chi^2 = 299.39$, $p < 0.001$) confirm that this difference is statistically significant. This higher conversion rate includes partial conversions where households purchase only some of the products they initially requested, as detailed in Table 4.2.

[1] *Note: This analysis includes 35,028 leads from WUJW and BvV, and Reimarkt product orders with complete product request data. Reimarkt leads are excluded from this table because product request data was not available in their system (around 3734 records).

4.1.1.2 Products requested: bundle size and success rates

***Table 4.2**: Frequency of leads by the number of products **requested** and complete success rates (purchasing all requested products) and partial success rates (purchasing at least one but not all requested products).*

Products Requested	Frequency	%	Complete Success Rate	Partial Success Rate
1	20390	58.2	14.9	0
2	9475	27.1	7.3	11.7
3	3237	9.2	1.9	26.0
4	1226	3.5	0.2	27.5
5	641	1.8	0	28.2
6	59	0.2	0	28.8
Total	**35028**	**100**		

Note: The complete success rate represents purchasing all requested products, while the partial success rate represents purchasing at least one but not all requested products.

Table 4.2 shows the relationship between the number of products requested and conversion rates. The frequency of leads declines with the number of products requested: 58.2% request one product, 27.1% request two, 9.2% request three, and 5.5% request four or more.

Complete conversion rates (purchasing all requested products) decline from 14.9% for single-product requests to 7.3% for two products, 1.9% for three products, and approach zero for requests of four or more products. Partial conversion rates (purchasing at least one but not all requested products) increase with request complexity, rising from 11.7% for two products and stabilizing at 25-29% for requests of three or more products.

The average number of products requested per lead is 1.64 (SD = 0.94) with a median of 1.0 products. The 75th percentile at 2 products indicates that three-quarters of all leads involve two or fewer requested products.

4.1.1.3 Products actually purchased

***Table 4.3:** The frequency of completed purchases by the number of products **purchased**, along with average expenditure levels for each category.*

Products Purchased	Frequency	%	Average amount spent (EUR)*[2]
1	5183	82.7	4297
2	986	15.7	5411
3	97	1.5	7215
4	4	0.06	9431
Total	**6,270**	100%	4,521

Note: Average expenditure figures are based on Reimarkt and BvV transaction values of orders only. WUJW data are excluded due to incomplete order value records

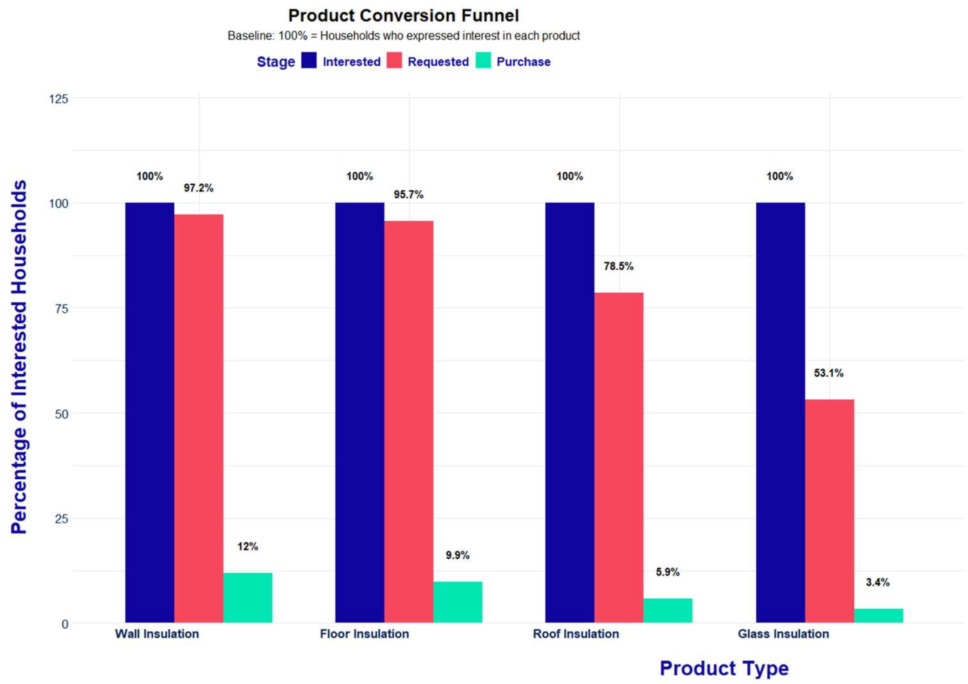
Table 4.3 demonstrates a strong tendency toward single-measure adoption rather than comprehensive retrofit strategies. Approximately 82.7% of successful conversions involved purchasing only one energy efficiency product, with a mean expenditure of €4,297. The proportion of households adopting multiple measures declines sharply - 15.7% purchased two products, and only 1.6% purchased three or more.

Mean expenditure increases with the number of products purchased (€4,297 for one product, €5,411 for two, €7,215 for three, €9,431 for four), demonstrating economies of scope in bundled installations. However, the sample size for three- and four-product purchases is limited (n=101), suggesting that comprehensive deep retrofits remain rare in practice despite their potential for greater energy savings and long-term value.

[2] Average expenditure based on Reimarkt and BvV transaction values of orders only. WUJW data excluded due to incomplete order value records.

4.1.1.4 Product-Specific conversion funnel

***Figure 4.1**: Product Conversion Funnel from Interest to Purchase*



Note: This figure excludes data from Winst uit je Woning (WUJW) because their system does not track household interest expressions ("interested" status). The figure therefore, includes only data from Bureau voor Verduurzamen (BvV) and Reimarkt, where the three-stage funnel (interested→ requested→ purchased) is systematically recorded. The exclusion of WUJW particularly affects solar panels and heat pumps volumes, as WUJW had substantially higher transaction volumes for these products compared to BvV and Reimarkt. Therefore, the percentages shown for solar panels and heat pumps in this figure represent only a subset of total market activity and substantially understate their actual funnel volumes across all three parties.

Figure scope: This figure tracks only households that initially expressed interest in a specific product, following their progression through formal request and purchase stages. There are instances where households requested products without expressing interest first—these cases are excluded from this funnel visualization to maintain a clear interpretation of interest-driven conversion pathways. The figure, therefore, represents a subset of total requests and purchases, specifically those originating from households who began by expressing interest.

Figure 4.1 displays the three-stage conversion funnel for each energy efficiency measure, showing the number of households at each stage: those who expressed interest (blue, 100% baseline), those who subsequently formally requested the measure (red), and those who completed a purchase (green). Percentages indicate conversion rates relative to the initial interested population.

Observed patterns:

Initial interest volumes: Wall insulation shows the highest initial interest (6,478 households), followed by floor insulation (5,416 households), roof insulation (1,497 households), and glass insulation (382 households).

Interest-to-request conversion: Insulation products show markedly different patterns than solar panels and heat pumps. Wall insulation achieves 97.2% interest-to-request conversion (6,294 of 6,478 interested households), floor insulation reaches 95.7% (5,182 of 5,416), roof insulation attains 78.5% (1,175 of 1,497), and glass insulation shows 53.1% (203 of 382). These high conversion rates indicate that once households express interest in insulation measures, they overwhelmingly proceed to formal requests**.**

Request-to-purchase conversion (among initially interested households): Among households who initially expressed interest, final purchase rates vary considerably by product. Wall insulation achieves 12.0% interest-to-purchase conversion (776 of 6,478 initially interested), floor insulation reaches 9.9% (535 of 5,416), roof insulation attains 5.9% (88 of 1,497), and glass insulation shows 3.4% (13 of 382).

Product-specific funnel characteristics:

High-volume, high-conversion insulation products (wall and floor): Wall and floor insulation demonstrate both high initial interest volumes and remarkably high interest-to-request conversion rates (97.2% and 95.7%, respectively). However, request-to-purchase conversion is more modest, resulting in 12.0% and 9.9% overall interest-to-purchase rates. The funnel pattern indicates that nearly all interested households proceed to formal requests, but most attrition occurs between the request and purchase stages.

Medium-volume insulation products (roof and glass): Roof insulation shows moderate interest-to-request conversion (78.5%) and achieves 5.9% overall interest-to-purchase conversion. Glass insulation displays lower interest-to-request conversion (53.1%) and the lowest interest-to-purchase rate among insulation products (3.4%), indicating substantial attrition at the request stage.

***Figure 4.2**: Conversion rates by product type (percentage of households that requested each product and subsequently purchased it)*

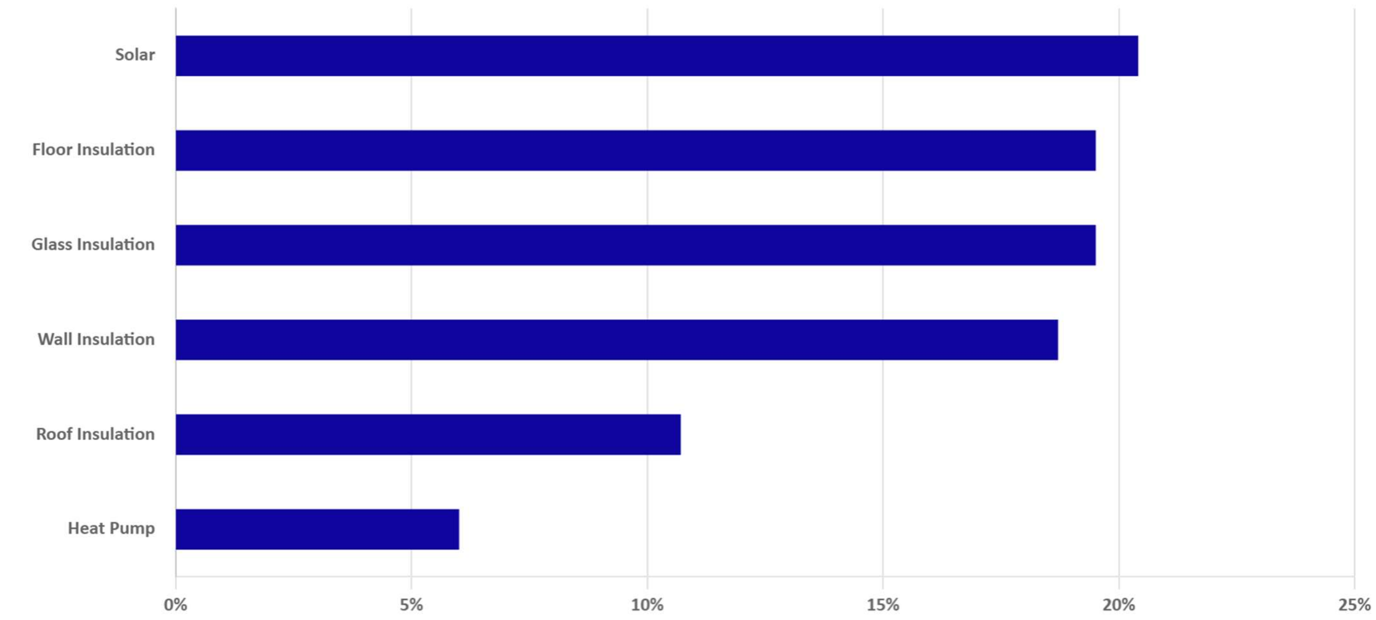


Figure 4.2 presents product-specific conversion rates, revealing variation in converting initial interest into completed installations. Solar panels achieve the highest conversion rate at approximately 22%, followed by floor insulation, glass insulation, and wall insulation at approximately 20% each. Roof insulation converts at a notably lower rate of approximately 11%, while heat pumps show the lowest conversion rate at approximately 4%. These conversion rate differences likely reflect varying combinations of technical complexity, upfront costs, perceived benefits, and implementation barriers.

4.1.2 Product co-occurrence analysis

This section examines how frequently households bundle different energy efficiency products together, both in their initial requests and in their final purchases. By comparing request patterns with purchase behaviour, we can identify which product combinations households consider together, which pairings they ultimately commit to, and where significant gaps exist between intention and action. This section uses both frequency counts and lift ratios - a statistical measure that reveals whether products are bundled together more or less often than random chance would predict - to uncover meaningful associations between products.

4.1.2.1 Associations between products

Table 4.4: *Lift ratios for **requested** product pairs, where values above 1.0 indicate products are requested together more often than expected by chance, and values below 1.0 indicate less frequent request pairing than expected.*

	Solar	Heat	Floor	Wall	Roof	Glass
Solar	1.00	5.91	0.59	0.38	0.44	1.09
Heat	5.91	1.00	0.70	0.13	3.99	1.74
Floor	0.59	0.70	1.00	4.87	3.33	1.51
Wall	0.38	0.13	4.87	1.00	5.09	1.03
Roof	0.44	3.99	3.33	5.09	1.00	2.45
Glass	1.09	1.74	1.51	1.03	2.45	1.00

Table 4.5: *Lift ratios for **purchased** product pairs, where values above 1.0 indicate products are purchased together more often than expected by chance, and values below 1.0 indicate less frequent co-purchase than expected.*

	Solar	Heat	Floor	Wall	Roof	Glass
Solar	1.00	5.78	0.51	0.30	0.28	1.63
Heat	5.78	1.00	0.19	0.03	0.79	0.81
Floor	0.51	0.19	1.00	1.06	0.58	0.62
Wall	0.30	0.03	1.06	1.00	0.83	0.39
Roof	0.28	0.79	0.58	0.83	1.00	0.74
Glass	1.63	0.81	0.62	0.39	0.74	1.00

Tables 4.4 and 4.5 display lift ratios for pairing products requested (Table 4.4) and pairing products purchased (Table 4.5). The lift ratio analysis applies only to these bundled transactions/products. A lift ratio of 1.0 represents the baseline where products co-occur at rates expected by random chance. Lift ratios above 1.0 indicate products are bundled together more frequently than expected, while ratios below 1.0 indicate products are bundled together less frequently than expected. For example, consider the first column for solar panels. If a homeowner who is purchasing two products purchases a solar panel, the probability that this homeowner will also purchase glass insulation increases by 63% (lift ratio 1.63).

In requested bundles: The Solar panel - Heat pump combination shows the highest lift at 5.91, suggesting that these products are bundled nearly six times as often as random chance would predict. Wall-Roof (5.09), Wall-Floor (4.87), Heat pump-Roof (3.99), and Floor-Roof (3.33) also show strong positive associations. On the other hand, Solar-Wall (0.38), Solar-Roof (0.44), Solar-Floor (0.59), and Heat pump-Wall (0.13) show negative associations, meaning they occur together less often than expected.

In completed purchases, the Solar panel - Heat pump combination maintains the highest lift at 5.78, indicating these products are purchased together nearly six times more often than expected. Solar-Glass (1.63) also shows a positive association. Wall and floor exhibit a modest yet positive association with a lift ratio of 1.06. Strong negative associations include Heat pump-Wall (0.03), Heat pump-Floor (0.19), Solar-Roof (0.28), Solar-Wall (0.30), Wall-Glass (0.39), Solar-Floor (0.51), Floor-Roof (0.58), Floor-Glass (0.62), Roof-Glass (0.74), Heat pump-Roof (0.79), Heat pump-Glass (0.81), and Wall-Roof (0.83).

Comparing the lift-ratio matrices of purchased products with requested product bundles, several observations can be made:

Floor-Glass relationship: When Floor insulation is present in a requested bundle, the probability that Glass insulation is also included increases by 51% (lift ratio 1.51). However, when Floor is present in a completed purchase, the probability that Glass is also included is 38% below baseline (lift ratio 0.62). This indicates a substantially reduced probability of Glass bundling with Floor in completed purchases compared to requested bundles.

Glass bundling patterns: When Glass is present in requested bundles, the probability of Heat pump (1.74) and Roof (2.45) being included all increase. Yet in completed purchases, these probabilities change significantly, with Heat pump (0.81) and Roof (0.74) falling below the baseline, while Solar increases substantially (1.63).

Solar-Heat pump relationship: When a Solar panel is present in a requested bundle, the probability of a Heat pump being included increases by 491% (lift ratio 5.91). When a Solar panel is present in a completed purchase, the probability of a Heat pump being purchased at the same time increases by 478% (lift ratio 5.78). This strong association remains consistently high from request to purchase.

Wall-Floor relationship: When Wall insulation is present, the probability of Floor insulation being included increases substantially by a factor of 4.87 in requested bundles, but only by a factor of 1.06 in completed purchases, indicating this requested pairing doesn't often convert concurrently to actual purchases together.

4.1.2.2 Overall pattern we can observe

The comparison between requested and purchased product bundles reveals differences in lift ratios across product pairings. The Solar panel-Heat pump combination maintains high lift ratios in both requests (5.91) and purchases (5.78).

Several product pairings show substantial declines in lift ratios from requests to purchases:

- Wall-Floor: 4.87 in requests to 1.06 in purchases
- Wall-Roof: 5.09 in requests to 0.83 in purchases
- Floor-Glass: 1.51 in requests to 0.62 in purchases
- Heat pump-Roof: 3.99 in requests to 0.79 in purchases
- Floor-Roof: 3.33 in requests to 0.58 in purchases

One product pairing shows an increase in lift ratio from requests to purchases:

- Solar-Glass: 1.09 in requests to 1.63 in purchases

These patterns show that requested product combinations do not consistently translate into the same combinations in completed purchases. The Solar-Heat pump pairing maintains its association strength, while most insulation combinations (Wall-Floor, Wall-Roof, Floor-Glass, Floor-Roof) show reduced co-occurrence in purchases compared to requests. Solar-Glass shows the opposite pattern, with stronger co-occurrence in purchases than in requests. A drop in lift ratio may indicate a competition relationship between products, possibly influenced by constraints (e.g., budget constraints) or exchangeability (one product can satisfy the energy saving objective).

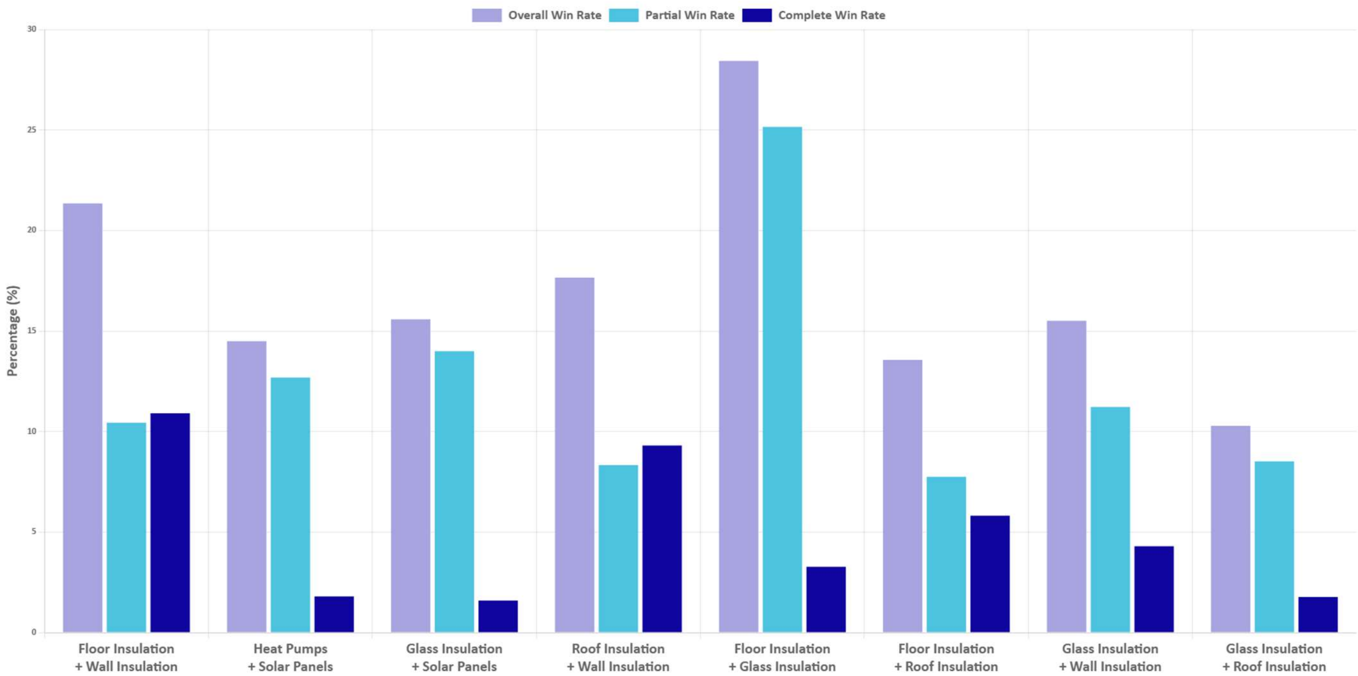
4.1.2.3 Specific product combinations and performance

Having established the overall patterns of request complexity and purchase simplification, we now examine in more detail which specific product combinations households request and how successfully these bundles convert.

Figure 4.3: *Frequency of leads and completed purchases for the most common two-product bundles.*

Figure 4.3 displays the absolute frequency of leads (requests) versus completed conversions for the most common two-product combinations. The Floor Insulation + Wall Insulation bundle shows approximately 4,600 leads and approximately 1,000 conversions. Heat Pumps + Solar Panels show approximately 1,100 leads and approximately 150 conversions. Glass Insulation + Solar Panels show approximately 700 leads and approximately 100 conversions. Floor Insulation + Glass Insulation shows approximately 500 leads, Roof Insulation + Wall Insulation approximately 600 leads, Floor Insulation + Roof Insulation approximately 450 leads, Glass Insulation + Wall Insulation approximately 300 leads, and Glass Insulation + Roof Insulation approximately 280 leads, each with proportionally smaller conversion volumes.

Figure 4.4*: Conversion rate breakdown for two-product bundles showing overall, partial, and complete conversion rates*



Note: *The* ***Complete win rate (Conversion rate)*** *represents the percentage of leads that resulted in a successful sale of one or both products in the bundle. It is the sum of:*

- ***Partial Rate:*** *Percentage of leads that purchased only part of the requested bundle (purchased only one product)*
- ***Complete Rate:*** *Percentage of leads that purchased the complete bundle as requested (purchased all products)*

For example, a 21.4% Complete win rate (Conversion rate) means that 21.4% of all leads requesting that specific bundle resulted in a sale (either partial or complete).

Figure 4.4 presents the conversion rate structure for each two-product bundle, decomposing overall conversion rates into partial conversions (purchasing one product only) and complete conversions (purchasing both products). Floor Insulation + Glass Insulation shows the highest overall conversion rate at 28.4%, composed of 25.2% partial conversions and 3.3% complete conversions. Floor Insulation + Wall Insulation (n=4,647) achieves an overall conversion rate of 21.4%, with 10.4% partial conversions and 10.9% complete conversions.

Bundles including heat pumps show lower conversion rates: Glass Insulation + Heat Pumps achieves 6.6% overall conversion (6.6% partial, 0.0% complete), while other heat pump combinations range from 10.2% to 19.6% overall conversion with complete conversion rates of 1.7-2.6%. Bundles including solar panels show overall conversion rates of 14.5-23.8% with complete conversion rates of 1.6-6.3%.

Across all two-product bundles, partial conversions substantially exceed complete conversions (11.7% versus 7.26% on average from Table 4.2), indicating that two-product requests frequently represent aspirational plans that are scaled back during implementation rather than fully realized as comprehensive investments. This pattern is particularly pronounced for bundles combining different product categories (heat pumps with insulation, solar panels with insulation) compared to bundles within the same category (multiple insulation types together).

4.1.3 Customer returning behaviour

While most households make only a single purchase attempt, a subset returns for additional products or renewed attempts at previously unconverted leads. This section examines how frequently households return, when they return, what products they choose on subsequent attempts, and how their success rates evolve across multiple engagement cycles.

Note on data scope: This section excludes WUJW because their municipality-collaborative model operates through discrete municipal campaigns with defined timeframes. Once a campaign is concluded in a given municipality, households in that area have no opportunity to return for additional engagement, as WUJW does not maintain ongoing commercial operations independent of municipal partnerships. The analysis, therefore, focuses on 21,776 household entries from BvV and Reimarkt, representing market-based one-stop shops where households can return at any time for additional products or renewed attempts.

4.1.3.1 Overall returning customer patterns

***Table 4.6**: Total number of entries (attempts) by households, the number of wins achieved at each entry stage, conversion rates, and the average number of products requested per entry (Excluding WUJW)*

Entry number	Total entries	Wins	Conversion rate	Average product
1	20863	2807	13.5	1.38
2	848	155	18.3	1.26
3	65	5	7.7	1.30

Table 4.6 shows statistics of the number of entries (attempts) by households. The vast majority of household engagement involves a first entry, with 20,863 initial attempts representing 95.8% of all entries and achieving a 13.5% conversion rate. However, 848 households (3.9%) returned for a second attempt, showing a notably higher conversion rate of 18.3%. A small group of 65 households (0.3%) persists to a third entry, though their conversion rate drops significantly to 7.7% and an approximately equal average number of products requested (1.30).

4.1.3.2 Timing of re-engagement and success rates

Beyond examining whether households return, we analyse when they return and how conversion rates differ based on the timing of re-engagement. Tables 4.7 and 4.8 break down returning households by the time elapsed between their first entry and subsequent attempts, comparing patterns between households that converted on their first attempt versus those that did not.

***Table 4.7**: Returning households by the time elapsed between their first entry and subsequent attempts: frequency, percentage distribution, number of wins, average products requested, and conversion rates for each time window. (Excluding WUJW)*

Re-engagement Timing	Frequency	%	wins	Conversion rate
First Entry	20863	95.8	2807	13.5
Next Month	183	0.8	50	27.3
Within 3 Months	109	0.5	27	24.8
Within 6 Months	115	0.5	20	17.4
Within 1 year	217	1.0	30	13.8
Within 2 years	172	0.8	17	9.9
Within 4 years	104	0.5	14	13.5
Over 5 years	23	0.1	4	17.4

***Table 4.8**: Return behaviour comparison between first-time converters and non-converters by re-engagement timing (Excluding WUJW)*

Re-engagement Timing	First-Time Converters				First-Time Non-Converters			
	Frequency	%	Avg Products Requested	Conversion Rate (%)	Frequency	%	Avg Products Requested	Conversion Rate (%)
Next Month	54	32.9	1.23	64.8	128	17.0	1.10	11.7
Longer than 1 Month	110	67.1	1.16	39.1	625	83.0	1.33	10.9
Total	**164**	**100.0**	**1.18**	**47.6**	**753**	**100.0**	**1.29**	**11.0**

*Note: "Longer than 1 Month" category combines "Within 3 Months" through "Over 5 years" due to small cell sizes. Percentages represent the distribution of return timing within each group. Total conversion rates are calculated as follows: first-time converters show 47.6% (78 wins from 164 returns) and first-time non-converters show 11.0% (83 wins from 753 returns). The average products requested for "Longer than 1 Month" is calculated as a weighted average across merged time periods. **Terminology Note**: The behaviour described here—where first-time converters return for additional purchases—mostly constitutes "upselling" (encouraging existing customers to purchase additional products). This should be distinguished from "retargeting," which refers to re-engaging households that did not convert on their initial visit. Both strategies have distinct policy implications: upselling leverages existing customer relationships and the ISDE subsidy for multiple products, while retargeting requires different outreach approaches to address the original barriers to conversion.*

Table 4.8 shows different return patterns based on first-attempt outcomes. Among returning households:

First-time converters: 32.9% return within the next month, while 67.1% return after more than one month. Conversion rates differ substantially by timing: next-month returns achieve 64.8% conversion (35 wins from 54 attempts), while returns after more than one month show 39.1% conversion (43 wins from 110 attempts). On average, first-time converters request 1.18 products when they return.

First-time non-converters: 17.0% return within the next month, while 83.0% return after more than one month. Conversion rates remain substantially lower than first-time converters: next-month returns achieve 11.7% conversion (15 wins from 128 attempts), while returns after more than one month show 10.9% conversion (68 wins from 625 attempts). On average, first-time non-converters request 1.29 products when they return, slightly more than first-time converters.

Households that converted on their first attempt show higher conversion rates on subsequent attempts compared to households that did not convert on their first attempt, across most time windows.

Comparison of first-time converters vs. non-converters: Households that converted on their first attempt show substantially higher conversion rates on subsequent attempts compared to households that did not convert on their first attempt (47.6% vs. 11.0% overall). A chi-square test confirms this 36.5 percentage point difference is highly statistically significant ($\chi^2 = 121.70$, df = 1, $p < 0.001$), with a medium-to-large effect size (Cramér's V = 0.364), indicating both statistical and practical significance. This pattern holds both for next-month returns (64.8% vs. 11.7%) and returns after more than one month (39.1% vs. 10.9%).

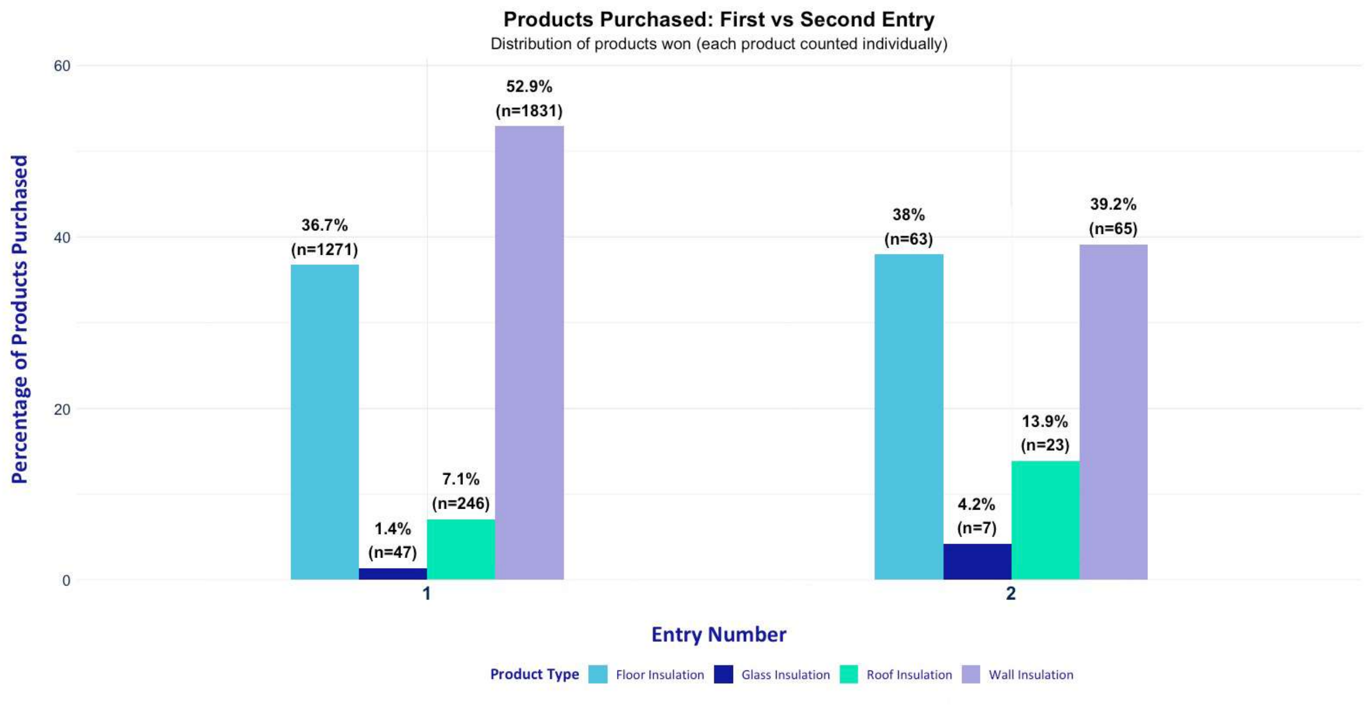
Returning vs. first entry households: Returning households show a conversion rate of 17.6% (162 wins from 923 attempts), compared to households at their first entry at 13.5% (2,807 wins from 20,863 attempts). A chi-square test confirms this 4.1 percentage point difference is statistically significant ($\chi^2 = 12.26$, df = 1, p = 0.00046). The effect size is very small (Cramér's V = 0.024), indicating that while returning households show a higher conversion rate, the absolute magnitude of the difference is relatively small.

Note on explaining the returning behaviour. The significant higher conversion rate of first-time converters compared to first-time non-converters may be influenced by the current ISDE subsidy program, especially when the second entry occurs within the next month. This subsidy program offers customers a discount on a second product, making it more attractive to buy a second product shortly after the first, as elaborated on by the energy consultant during house visits. Furthermore, the binding of the client to the company tends to be stronger when a product has been bought for the first time, which can additionally explain the increased conversion rate for first-time converters.

4.1.3.3 Product choices across multiple attempts

Having established when households return and how successful those returns are, we now examine what products they choose on subsequent attempts and how these choices differ from their initial requests.

***Figure 4.5**: The distribution of product and bundle choices across first and second attempts for first and second time returning households only. (excluding WUJW)*



***Note**: due to excluding WUJW - the main party promoting solar panels and heat pumps - the main share of these products in the figure dropped drastically.*

Figure 4.5 displays the distribution of products purchased across first and second entry attempts. The analysis examines successful conversions, showing what products returning households purchase on subsequent attempts.

At first entry conversions, wall insulation comprises 52.9% (n=1,831), floor insulation 36.7% (n=1,271), roof insulation 7.1% (n=246), and glass insulation 1.4% (n=47).

At second entry conversions, wall insulation comprises 39.2% (n=65), floor insulation 38.0% (n=63), roof insulation 13.9% (n=23), and glass insulation 4.2% (n=7).

Comparing first and second entry conversions, wall insulation decreases from 52.9% to 39.2%, floor insulation increases from 36.7% to 38.0%, roof insulation increases from 7.1% to 13.9%, glass insulation increases from 1.4% to 4.2%, solar panels increase from 1.7% to 3.0%, and heat pumps increase from 0.1% to 1.8%.

This pattern may suggest that households that successfully purchased wall or floor insulation on their first attempt often return to complete their building envelope improvements by adding complementary insulation measures. The increase in heat pump purchases at second entries (from 0.1% to 1.8%), despite remaining a small absolute share, may reflect that some households address building envelope performance before upgrading heating systems - a technically rational sequence that improves heat pump efficiency.

4.1.4 Household and dwelling characteristics

The success of one-stop shops depends not only on product offerings and pricing strategies but also on understanding who participates and who remains excluded. This section examines the demographic and dwelling characteristics of leads, comparing them against national homeownership population benchmarks to identify systematic representation gaps. By analysing household age profiles, family composition, dwelling types, and how these patterns vary across different lead acquisition channels, we can uncover whether the one-stop shops effectively reach all homeowner segments or inadvertently exclude certain population groups. Chi-square tests are used throughout to determine whether observed differences between lead distributions and population distributions are statistically significant or merely due to random chance.

Note on Conversion Rate Interpretation: The conversion rates presented in these tables are descriptive statistics representing simple averages across all products and household/dwelling characteristics. These statistics should not be used to draw causal conclusions about household composition effects on renovation success, as they do not account for confounding factors such as dwelling type, income, or geographic location.

In the model-based analysis presented in the following section, conversion rates are examined more rigorously through:

- Product-specific analysis - disaggregating conversion rates for individual measures (solar panels, heat pumps, wall insulation, floor insulation, etc.) to identify which renovations different household types complete
- Multivariate regression controlling for household and dwelling characteristics - isolating the independent effect of household composition while holding constant factors like housing type, dwelling size, construction year, and socioeconomic variables

This controlled analysis provides more reliable insights for both explaining observed patterns and predicting future adoption. The descriptive statistics here serve primarily to document the baseline patterns in the data before conducting more causal analysis

4.1.4.1 Household age

This section examines the age distribution of homeowners engaging with one-stop shops, comparing lead composition against the Dutch homeowner population to identify which age groups are over- or underrepresented, and analysing whether conversion rates vary systematically by age category.

Table 4.9 *Age distribution of homeowners for the Dutch population (all family dwellings, year 2023) and the leads, actual-to-expected ratios, and conversion rates.*

Household Age	Population (N)	Population %	Leads % of Total	Actual/Expected Ratio	Conversion Rate
Young (18-34)	310,881	8.3%	10.4%	1.25	0.16
Middle-aged (35-64)	2,250,735	60.0%	61.9%	1.03	0.16
Elderly-aged (65-79)	929,011	24.8%	23.9%	0.97	0.19
Elderly-aged (80+)	260,090	6.9%	3.8%	0.55	0.22
Total	**3,752,408**	100%	100%		

Note*: Population data represents all family dwellings (excluding apartments) for homeowners in the Netherlands, 2023. The Actual/Expected Ratio is calculated by dividing the percentage of leads in each household type by the percentage of that household type in the population. A ratio of 1.0 indicates perfect proportional representation, values above 1.0 indicate overrepresentation in leads, and values below 1.0 indicate under-representation. For example, Young (18-34) households have a ratio of 1.25 (10.36% ÷ 8.29%), meaning they are overrepresented by 25% above of what would be expected based on their population share.*

Figure 4.6: *Population Distribution vs Leads Distribution: age category distributions.*

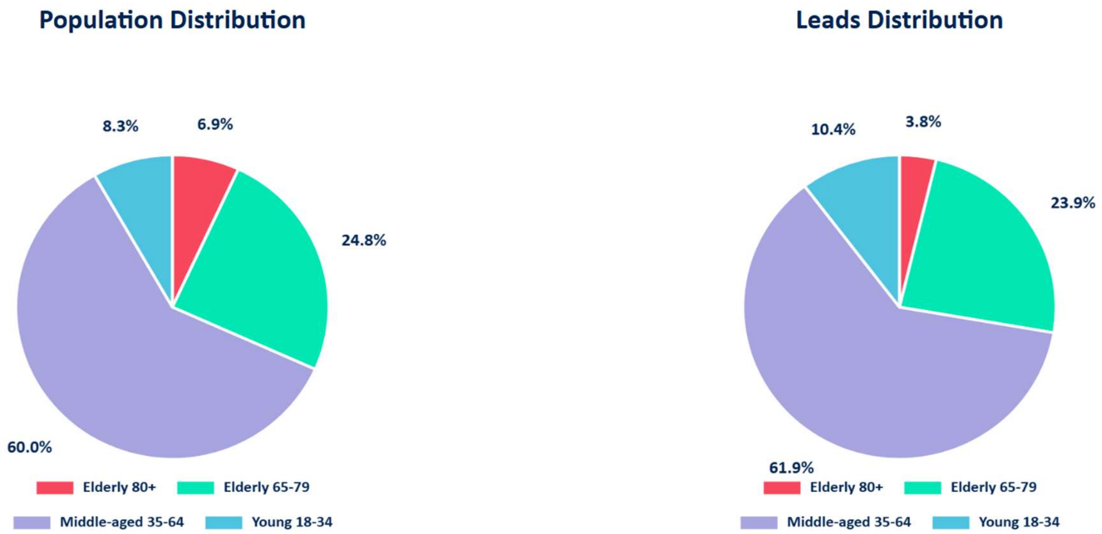


Table 4.9 shows the age distribution of homeowners for the Dutch population (all family dwellings, year 2023) and the leads across four age categories: 80+, 65-79, 35-64, 18-34. Related to the distribution of leads, the conversion rates and actual-to-expected ratios are also shown to identify which age groups are over- or underrepresented. Figure 4.6 shows the statistics graphically.

Young adults (18-34) comprise 10.4% of leads versus 8.29% of the population (ratio = 1.25, 25% more than expected). Middle-aged (35-64) comprise 61.9% of leads versus 60.0% of the population (ratio = 1.03, 3% more than expected). Elderly-aged (65-79) comprise 23.9% of leads versus 24.8% of the population (ratio = 0.97, 3% fewer than expected). Elderly-aged (80+) comprise 3.79% of leads versus 6.93% of the population (ratio = 0.55, 45% fewer than expected).

To verify whether these representation patterns are statistically significant, we conducted a chi-square test comparing the age distribution of leads against the population distribution. The test results ($\chi^2 = 772.36$, df = 3, $p < 0.001$) confirm that the age distribution of leads differs significantly from the population distribution.

Conversion rate differences across age categories

Conversion rates vary systematically across age categories. Elderly-aged 80+ achieve the highest conversion rate at 22%, followed by elderly-aged 65-79 at 19%, middle-aged 35-64 at 16%, and young 18-34 at 16%.

Comparing observed conversions against expected conversions assuming age does not affect conversion rates (overall average: 16.6%), we see that elderly-aged 80+ show 30% more conversions than expected, elderly-aged 65-79 show 11% more, middle-aged 35-64 show 6% fewer, and young 18-34 show 4% fewer.

To examine whether these conversion rate differences are statistically significant, we conducted a chi-square test of independence on the cross-tabulation of age category by conversion outcome. The chi-square test results ($\chi^2 = 64.47$, df = 3, $p < 0.001$) indicate that conversion rate differences are statistically significant. The standardized residuals show which specific age categories differ significantly from the overall average (using the ±2.0 threshold): elderly-aged 80+ (+5.12), elderly-aged 65-79 (+5.56), and middle-aged 35-64 (-6.23) all show statistically significant differences. Young 18-34 (-1.06) does not show a statistically significant difference from the overall average.

Overall pattern

Both representation patterns and conversion rates differ significantly across age categories. Elderly-aged 80+ are underrepresented in leads (45% below expected) and show the highest conversion rate (30% above expected). Elderly-aged 65-79 are slightly underrepresented (3% below expected) and show elevated conversion rates (11% above expected). Middle-aged 35-64 are slightly overrepresented (3% above expected) and show lower conversion rates (6% below expected). Young 18-34 are overrepresented (25% above expected) and convert at rates not significantly different from the overall average (4% below expected, not statistically significant).

Note on conversion rate analysis: The chi-square test and conversion rates presented identify statistically significant differences between age categories in conversion patterns. These statistics do not establish causal relationships or account for confounding factors. The model-based analysis in Section 4.2 examines conversion drivers through multivariate regression modeling, controlling for dwelling type, property characteristics, geographic location, and socioeconomic variables to isolate the independent effect of age on conversion rates.

4.1.4.2 Household composition

Having established age-based disparities, we now examine the relationship between household family structure and one-stop shop participation, which may indicate that certain household types face systematic barriers to engagement.

***Table 4.10**: Household Composition – 2022 homeowners population vs Leads: conversion rates, actual-to-expected ratios.*

Household Composition	Population (N)	Population %	Leads % of Total	Actual/Expected Ratio	Conversion rate
Single-Person only	665,385	18.1%	15.7%	0.87	0.20
Couple with no children	1,335,575	36.3%	37.2%	1.02	0.17
Couple with children	1,495,650	40.6%	41.4%	1.02	0.15
Single Parent	186,165	5.1%	5.7%	1.13	0.16
Total	**3,682,775**	100%	100%		

***Note**: The Actual/Expected Ratio is calculated by dividing the percentage of leads in each household type by the percentage of that household type in the population. A ratio of 1.0 indicates perfect proportional representation, values above 1.0 indicate over-representation in leads, and values below 1.0 indicate under-representation. For example, single-person households have a ratio of 0.87 (15.67% ÷ 18.1%), meaning they are underrepresented at only 13% below of what would be expected based on their population share.*

Source:
Population data source: Statistics Netherlands (CBS) Kenmerken van woningen bewoond door particuliere huishoudens (Characteristics of dwellings occupied by private households) https://www.cbs.nl/nl-nl/maatwerk/2023/51/kenmerken-van-woningen-bewoond-door-particuliere-huishoudens Reference year: 2022

***Figure 4.7**: Population Distribution vs Leads Distribution: household types distributions*

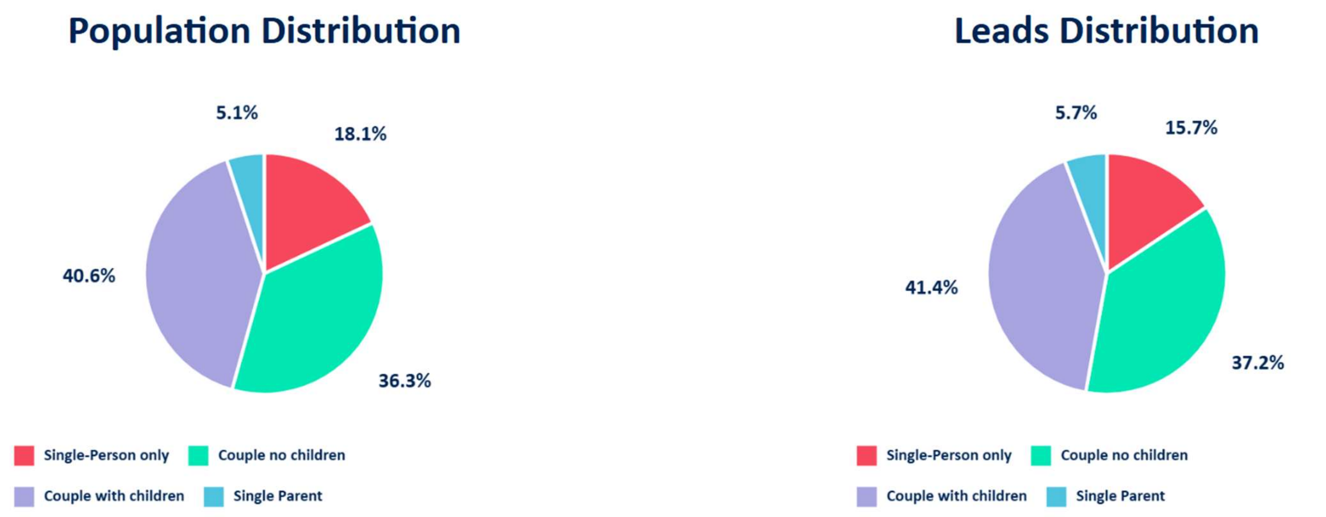


Table 4.10 compares household composition in the Dutch homeowner population with the composition of households engaging with one-stop shops. Couples with children comprise 41.4% of leads versus 40.6% of the population (ratio = 1.02, 2% more than expected). Couples without children represent 37.2% of leads versus 36.3% of the population (ratio = 1.02, 2% more than expected). Single parents represent 5.7% of leads versus 5.1% of the population (ratio = 1.13, 13% more than expected). Single-person households comprise 15.7% of leads versus 18.1% of the population (ratio = 0.87, 13% fewer than expected).

To verify whether these representation patterns are statistically significant, we conducted a chi-square test comparing the household composition distribution of leads against the population distribution. The test results ($\chi^2 = 169.25$, df = 3, $p < 0.001$) confirm that the household composition of leads differs significantly from the population distribution.

The contribution to this chi-square statistic reveals that single-person household underrepresentation accounts for 73.5% of the total distribution difference, single-parent overrepresentation contributes 18.1%, couples with children contribute 3.8%, and couples without children contribute 4.6%.

Conversion rate differences across household types

Conversion rates vary across household compositions. Single-person households achieve a conversion rate of 19.6% (1,178 conversions out of 5,995 leads), couples without children 17.2% (2,440 out of 14,212), single parents 16.3% (358 out of 2,195), and couples with children 15.1% (2,397 out of 15,847). The range between the highest and lowest conversion rates spans only 4.5 percentage points.

Comparing observed conversions against expected conversions assuming household type does not affect conversion rates (overall average: 16.7%), single-person households show 17.9% more conversions than expected (1,178 observed versus 999 expected), couples without children show 3.0% more (2,440 versus 2,368), couples with children show 9.2% fewer (2,397 versus 2,640), and single parents show 2.1% fewer (358 versus 366).

To examine whether these conversion rate differences are statistically significant, we conducted a chi-square test of independence on the cross-tabulation of household type by conversion outcome. The chi-square test results ($\chi^2 = 68.29$, df = 3, $p < 0.001$) indicate that conversion rate differences are statistically significant. The standardized residuals show which specific household types differ significantly from the overall average (using the ±2.0 threshold): single-person households (+6.76), couples with children (-6.78), and couples without children (+2.04) all show statistically significant differences. Single parents (-0.46) do not show a statistically significant difference from the overall average.

Overall pattern

Both representation patterns and conversion rates differ significantly across household types. Single-person households are underrepresented in leads (13.4% below expected) and show higher conversion rates (17.9% above expected). Couples with children achieve near-proportional representation (2.0% above expected) but show lower conversion rates (9.2% below expected). Couples without children achieve near-proportional representation (2.4% above expected) and show higher conversion rates (3.0% above expected). Single parents are overrepresented (12.5% above expected) and convert at approximately the expected rate (2.1% below expected).

Note on conversion rate analysis: The chi-square test and conversion rates presented in this section are descriptive statistics that identify whether statistically significant differences exist between household types in their lead-to-win conversion patterns. However, these statistics do not establish causal relationships or account for confounding factors that may explain why different household types convert at different rates.

4.1.4.3 Dwelling type

Beyond household demographics, the physical characteristics of dwellings themselves have relationships with one-stop shop participation. We now examine the relationships between dwelling type and lead generation and conversion, which may indicate whether certain housing configurations face systematic barriers to engagement.

***Table 4.11**: Housing Type – National Homeowner Dwellings Stock Distribution (2023) vs Leads: conversion rates and representation ratios.*

Housing Type	Population (N)	Population %	Leads % of Total	Actual/Expected Ratio	Conversion rate
Row house	1,564,065	41.7%	46.1%	1.11	0.18
Detached house	915,122	24.4%	17.5%	0.72	0.14
Corner house	681,540	18.2%	22.6%	1.24	0.16
Semi-detached house	589,215	15.7%	13.9%	0.88	0.15
Total	**3,749,942**	100%	100%		

***Note**: Population data represents all family dwellings (excluding apartments) for homeowners in the Netherlands, 2023. The Actual/Expected Ratio is calculated by dividing the percentage of leads in each dwelling type by the percentage of that dwelling type in the population. A ratio of 1.0 indicates perfect proportional representation; values above 1.0 indicate overrepresentation in leads, and values below 1.0 indicate underrepresentation. For example, corner houses have a ratio of 1.24 (22.58% ÷18.17%), meaning they are overrepresented by 24% above of what would be expected based on their population share.*

***Figure 4.8:** National Homeowner Dwellings stock Distribution (2023) vs Leads Distribution: dwellings types distributions*

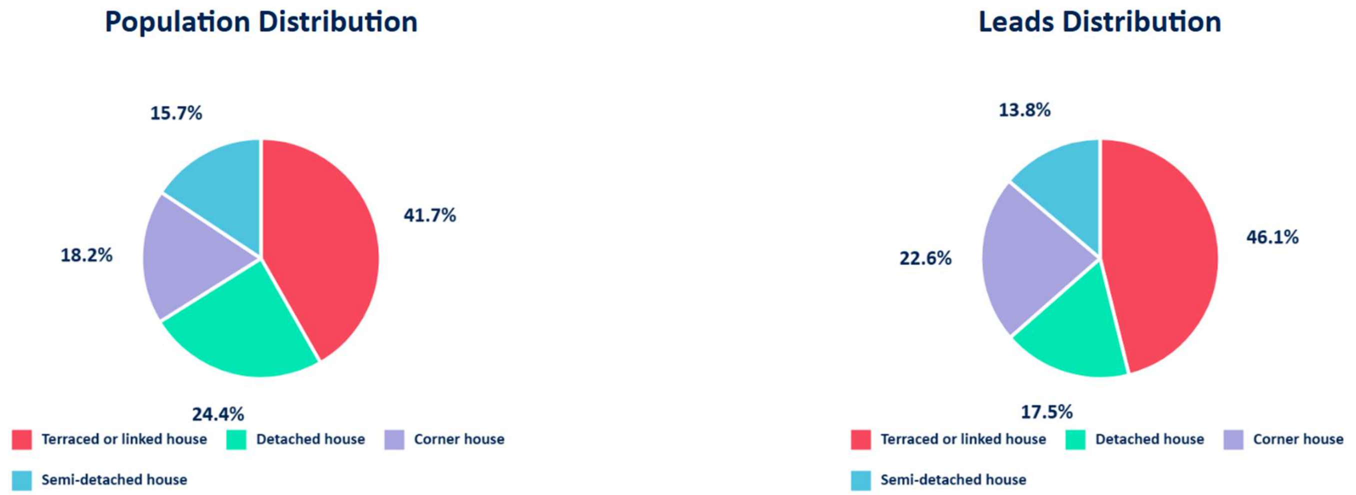


Table 4.11 compares dwelling type distribution in the Dutch homeowner dwelling stock with the composition of dwellings of households engaging with one-stop shops. Corner houses show the strongest over-representation at 22.6% of leads versus 18.2% of the population (ratio = 1.24, 24.3% more than expected). Row houses show overrepresentation at 46.1% of leads versus 41.7% of the population (ratio = 1.11, 10.6% more than expected). Detached houses show substantial underrepresentation at 17.5% of leads versus 24.4% of the population (ratio = 0.72, 28.5% fewer than expected). Semi-detached houses show modest under-representation at 13.9% of leads versus 15.7% of the population (ratio = 0.88, 11.9% fewer than expected).

To verify whether these representation patterns are statistically significant, we conducted a chi-square test comparing the dwelling type distribution of leads against the population distribution. The test results (χ^2 = 1,440.61, df = 3, $p < 0.001$) confirm that the dwelling type distribution of leads differs significantly from the population distribution.

The contribution to this chi-square statistic reveals that detached houses' underrepresentation accounts for 53.0% of the total distribution difference, making it the primary driver. Corner house overrepresentation contributes 28.6%, row house over-representation contributes 12.5%, and semi-detached house under-representation contributes 5.9%.

Conversion rate differences across dwelling types

Conversion rates vary across dwelling types. Row houses achieve the highest conversion rate at 18.3% (3,249 conversions out of 17,801 leads), followed by corner houses at 16.4% (1,425 out of 8,715), semi-detached houses at 14.9% (798 out of 5,345), and detached houses at 14.2% (954 out of 6,741). The range between the highest and lowest conversion rates spans 4.1 percentage points.

Comparing observed conversions against expected conversions assuming dwelling type does not affect conversion rates (overall average: 16.7%), row houses show 9.6% more conversions than expected (3,249 observed versus 2,963 expected), detached houses show 15.0% fewer (954 versus 1,122), corner houses show 1.8% fewer (1,425 versus 1,451), and semi-detached houses show 10.3% fewer (798 versus 890).

To examine whether these conversion rate differences are statistically significant, we conducted a chi-square test of independence on the cross-tabulation of dwelling type by conversion outcome. The chi-square test results ($\chi^2 = 75.18$, df = 3, $p < 0.001$) indicate that conversion rate differences are statistically significant. The standardized residuals show which specific dwelling types differ significantly from the overall average (using the ±2.0 threshold): row houses (+7.83), detached houses (-6.05), and semi-detached houses (-3.63) all show statistically significant differences. Corner houses (-0.84) do not show a statistically significant difference from the overall average.

Conclusion

Both representation patterns (in the population and the leads) and conversion rates differ significantly across dwelling types. This pattern is similar to household composition analysis (Section 4.1.5), where both representation and conversion rates also varied significantly. Corner houses are overrepresented in leads (24.3% above expected) and convert near the expected rate (1.8% below expected). Row houses are overrepresented (10.6% above expected) and show higher conversion rates (9.6% above expected). Detached houses are underrepresented (28.5% below expected) and show lower conversion rates (15.0% below expected). Semi-detached houses are underrepresented (11.9% below expected) and show lower conversion rates (10.3% below expected).

Note on explaining dwelling type representation. The representation of particular dwelling types in leads compared to the population can be affected by the marketing strategies of companies. Companies may select neighbourhoods based on the composition of housing types. The targeted housing types will then be overrepresented and others underrepresented as a result. So, the differences cannot be readily interpreted as reflecting a difference in interest in energy retrofitting or the OSS approach.

4.1.4.4 Demographic patterns: a summarizing takeaway

The demographic analysis reveals that both lead generation and conversion rates vary significantly across age, household composition, and dwelling type. Certain segments show dual patterns of underrepresentation combined with elevated conversion rates: elderly-aged 80+ (45% fewer leads than expected, but 30% higher conversion rate), single-person households (13% fewer leads, but 18% higher conversion rate), and detached houses (29% fewer leads, but lower conversion). Conversely, other segments show overrepresentation with average or below-average conversion: young 18-34 households (25% more leads, conversion rate not significantly different from average), single parents (13% more leads, conversion rate not significantly different from average), and corner houses (24% more leads, conversion rate not significantly different from average). Middle-aged 35-64 households and couples with children achieve proportional representation but convert below average (6% and 9% below average, respectively), while row houses show both over-representation (11% above expected) and elevated conversion (10% above average). These patterns indicate that current lead generation reaches some segments disproportionately while missing others that demonstrate strong conversion performance when engaged.

4.1.5 Lead channel performance by demographics

The previous sections established systematic disparities in which demographic groups engage with one-stop shops. This section examines whether these demographic patterns vary across different lead generation channels, revealing which marketing approaches successfully reach underserved segments and which channels may inadvertently exclude high-converting demographic groups.

4.1.5.1 Household age composition by lead channel

***Figure 4.9**: Age composition by lead channel: Breaks down leads by both age category and acquisition channel (municipalities, 3rd party lead services, digital marketing, direct marketing, referrals, unknown), showing percentages for each age combination.*

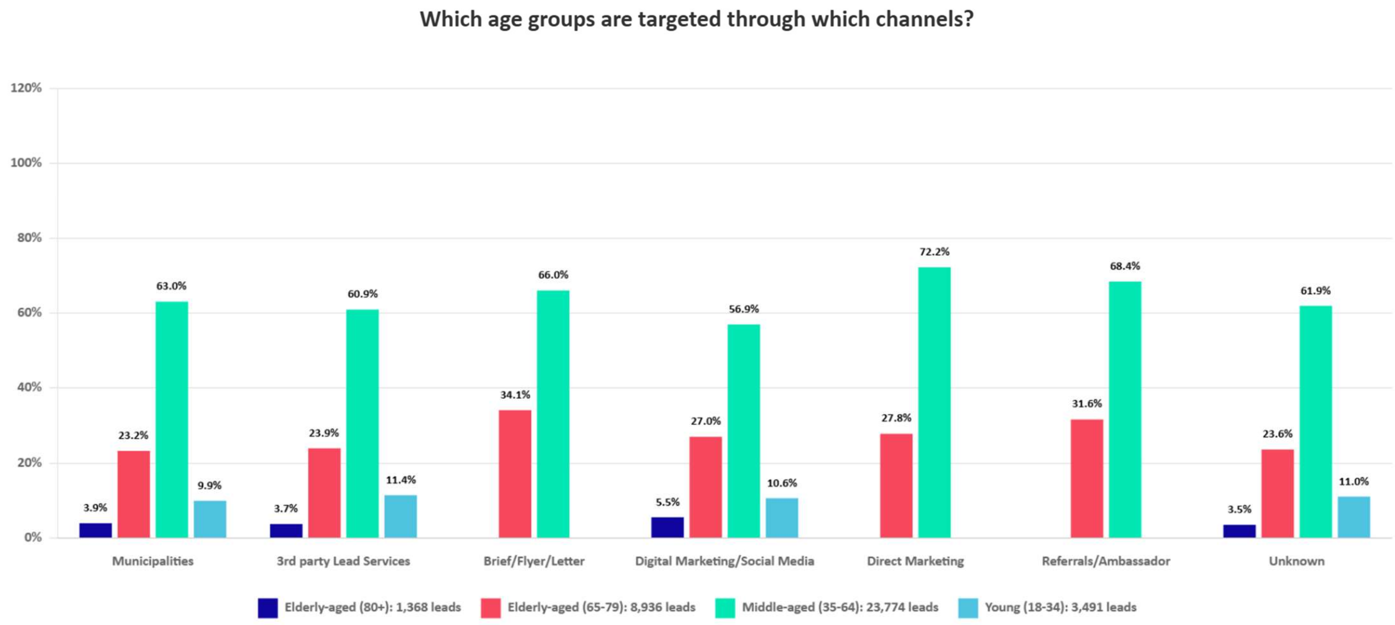


Figure 4.9 displays the age composition within each lead channel, showing what percentage of each channel's leads come from different age groups. For example, 63.0% of all Municipalities leads are from middle-aged adults (35-64), while 23.2% are from elderly adults (65-79). The percentages for each channel add up to 100%, revealing which age demographics each channel attracts.

Methodological note: Groups with fewer than 10 observations have been omitted due to the CBS export policy for statistical disclosure control. This explains why some age groups show 0% or are absent from certain channels.

Middle-aged adults (35-64) dominate all channels, consistently representing 57% to 72% of each channel's leads. This group is especially concentrated in Direct Marketing (72.2%) and Referrals/Ambassador (68.4%), suggesting these channels are particularly effective at reaching this demographic group.

The elderly population (65-79) forms the second-largest segment across channels, making up 23-34% of leads in most channels, with Brief/Flyer/Letter showing the highest concentration at 34.1%.

Younger adults (18-34) show a modest but consistent presence in Municipalities (9.9%), Third-Party Services (11.4%), and Digital Marketing (10.6%), but are absent from Direct Marketing and Referrals/Ambassador programs (note: zero presence may be due to CBS data suppression rules for small sample sizes).

The oldest demographic group (80+) has minimal representation across most channels (under 6%), appearing most in Digital Marketing (5.5%) and Municipalities (3.9%), and is completely absent from several channels due to insufficient sample sizes, suggesting limited outreach to this age group overall.

4.1.5.2 Household composition by lead channel

***Figure 4.10**: Household composition by lead channel.*

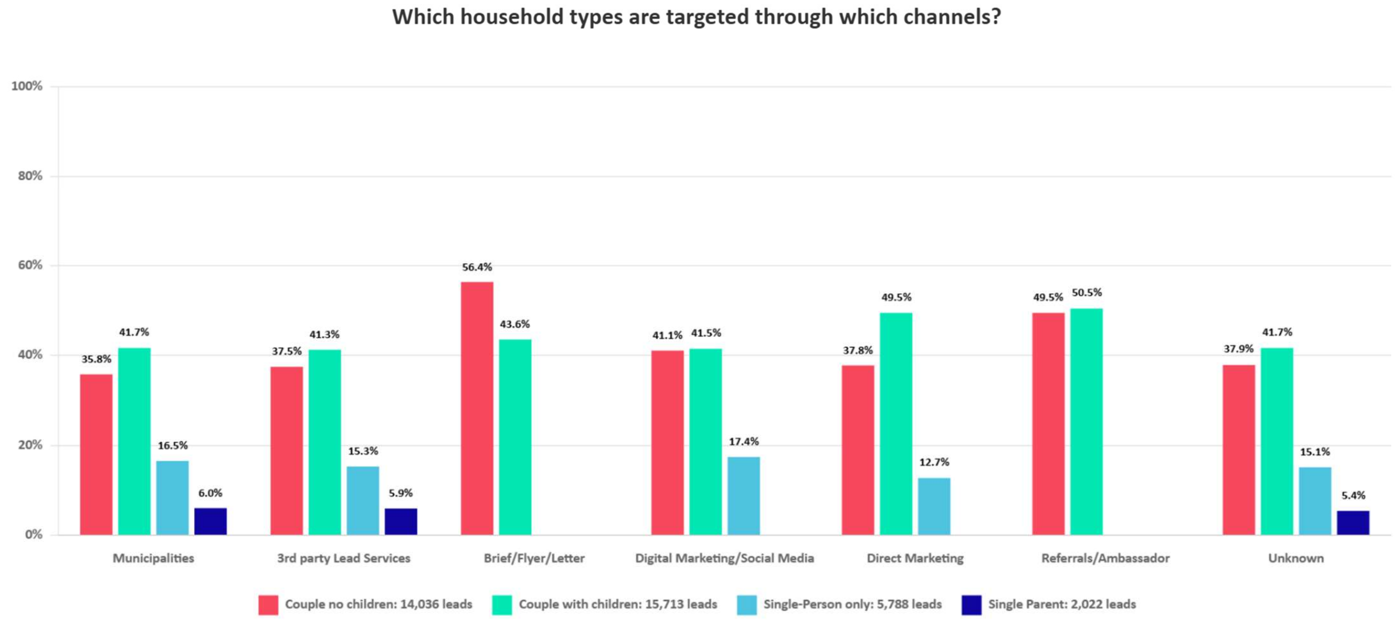


Figure 4.10 displays the household composition within each lead channel, showing what percentage of each channel's leads come from different household types. For example, 41.7% of all Municipalities leads are from couples with children, while 35.8% are from couples without children. The percentages for each channel add up to 100%, revealing which household types each channel naturally attracts.

Methodological note: Groups with fewer than 10 observations have been omitted due to the CBS export policy for statistical disclosure control. This explains why some household types show 0% or are absent from certain channels.

Couples (both with and without children) dominate all lead channels, representing 77% to 100% of each channel's leads. Couples with children show particularly strong representation in Direct Marketing (49.5%) and Referrals/Ambassador (50.5%), while couples without children are especially concentrated in Brief/Flyer/Letter (56.4%) and Referrals/Ambassador (49.5%), suggesting these channels are highly effective at reaching couple households.

Single-person households form a significant secondary segment across most channels (13-17%), showing consistent presence in Municipalities (16.5%), Third-Party Services (15.3%), Digital Marketing (17.4%), and Unknown channels (15.1%), but are completely absent from Brief/Flyer/Letter and Referrals/Ambassador programs (this may be due to CBS data suppression rules).

Single-parent households represent a smaller but measurable segment (5-6%) in Municipalities, Third-Party Services, and Unknown channels, but are entirely absent from Brief/Flyer/Letter, Digital Marketing, Direct Marketing, and Referrals/Ambassador channels, likely due to CBS's minimum observation requirements for data disclosure.

The data reveals that traditional couple households (with or without children) are the primary responding demographic group across all channels, accounting for approximately 79% of all leads, while single-person households and single parents remain underrepresented in several key channels.

4.2 Model-Based analysis results

The descriptive analyses in previous sections revealed important patterns in product requests, purchase behaviour, household characteristics, and customer journey progression. However, these bivariate relationships cannot disentangle the independent effects of different factors or account for confounding variables. For example, while we observed that elderly households show a high conversion rate, we cannot determine whether age itself drives this pattern or whether it reflects correlated factors like dwelling type, income, or existing energy measures. Similarly, the observed differences in conversion rates across household compositions may be confounded by variations in dwelling size, construction year, or geographic location.

This section addresses these limitations through multivariate logistic regression modeling that isolates the independent effect of each household and dwelling characteristic while holding all other factors constant. We employ Firth's penalized maximum likelihood method with clustered standard errors at the municipality level to ensure robust parameter estimates despite the complexity of our model, which includes over 30 main effects, interaction terms, and fixed effects. This approach allows us to rigorously examine product-specific adoption patterns - disaggregating conversion rates for individual measures (solar panels, heat pumps, wall insulation, floor insulation, roof insulation, glass insulation) to identify which household types, dwelling characteristics, financial positions, and energy consumption patterns independently predict successful completion of different renovation types. By controlling for pre-existing energy measures, expressed interest in specific products, lead acquisition channels, temporal factors, and geographic context, we can provide more reliable insights for both explaining observed conversion patterns and predicting future participation in one-stop shops.

The reader should take into account that we had estimated three models, one for all family dwellings, a second for detached/semidetached dwellings, and the third one for row/corner dwellings. The all-family dwelling model captures the overall general effect across all dwelling types. However, in reality, it takes into account the unique characteristics of each of these dwellings. Row/corner dwellings have shared walls and therefore exhibit different energy consumption patterns and physical characteristics than for detached/semidetached dwellings. Given the pronounced differences, the three models' approach should capture these effects. This segment-specific approach produces clearer, more actionable insights than forcing all housing types into a single model.

4.2.1 Dwelling characteristics

This section focuses on physical dwelling characteristics. The analysis results in this part shed light on how these characteristics affect the likelihood of implementing specific energy efficiency measures (products). The products studied include solar panels, heat pumps, and various types of insulation (floor, wall, glass, and roof insulation). The analysis identifies several dwelling characteristics that significantly affect the odds of adopting these measures: construction year, dwelling size and type, the presence of district heating, energy and gas consumption and the existence of preexisting energy measures.

Table 4.12: *Estimated effects of dwelling characteristics on conversion odds for each product*

Variable Category / Specific Variable	Solar Panels	Floor Insulation	Wall Insulation	Glass Insulation	Heat Pumps	Roof Insulation
Pre-existing Measures	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC
Solar panels preexisting	1.79*** / 1.19*** / 1.86***	0.21*** / - / 0.20**	0.21*** / - / 0.23***	0.35*** / - / 0.39***	1.52*** / 1.73*** / 1.46***	
Floor insulation preexisting	2.22*** / 2.47*** / 2.05***	-7.38*** / -6.01*** / -7.70***			1.24*** / 1.65*** / 0.97***	0.92*** / - / 0.97***
Glass insulation preexisting	2.16*** / 2.22*** / 2.08***		0.53** / 0.49*** / -	-6.70*** / -5.97*** / -6.58***	1.10*** / 1.31*** / 0.96***	0.86** / 1.34*** / -
Wall insulation preexisting	1.90*** / 3.17*** / 1.51***		-8.55*** / -7.83*** / -8.30***	- / 0.73** / -	1.63*** / 1.54*** / 1.09***	
Roof insulation preexisting	1.47*** / - / -					
Construction Period (Ref: 1974-1991)	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC
Before 1945					-0.33** / - / -	
From 1945 to 1974	-0.29*** / - / -0.28***					0.37** / 0.60** / -
After 1991		-0.71*** / - / -0.90**	-0.67*** / - / -1.31***			
Dwelling Type	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC
Corner house (Ref: Row)	-0.21** / - / -				- / - / 0.51**	
Detached house (Ref: Row)		-0.41*** / - / -				0.52*** / - / -
Semi-detached (Ref: Row in AF, RC/ Detached in DS)		-0.35*** / - / -		- / -0.46*** / -	0.56*** / - / -	
Dwelling Size & Other Characteristics	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC
Dwelling size (log transformed)				-1.03*** / -0.83*** / -0.94***	0.58* / - / 1.59**	
Has district heating	0.61** / - / 0.64**		- / 1.56** / -	- / 2.18*** / -	-2.88*** / -2.49*** / -2.54***	
Energy consumption (centred)			0.01** / - / -		0.03**/-/-	
Gas consumption (centred)					- / -0.01** / -	

Notes:
*- Significance levels: *** p<0.001, ** p<0.01, * p<0.05*
- Empty cells (-) indicate a variable not included in that model or not statistically significant
- AF = All Family Dwellings, DS = Detached/Semi-detached, RC = Row/Corner houses

4.2.1.1 District heating

District heating serves approximately 3.8% of Dutch family dwellings (141,977 homes out of 3,772,015) (CBS Microdata, 2023; see Table A.29). The distribution of district-heated homes shows distinct patterns: 69.9% were built after 1991, 28.2% between 1974-1991, 1.3% between 1945-1974, and 0.6% before 1945. By dwelling type, row houses comprise 65.9% of district-heated homes, corner houses 20.8%, semi-detached houses 7.0%, and detached houses 6.4% (CBS Microdata, 2023; see Table A.30, A 31).

Households connected to district heating exhibit distinct adoption patterns compared to those without.

Heat pumps and solar panels: Dwellings with district heating show a higher odds of solar panel adoption (especially in the Row/Corner houses segment). A likely explanation is that district heating is relatively expensive, which creates stronger financial incentives to invest in energy-generation alternatives. In contrast, dwellings show a much lower odds of adopting a heat pump. A likely explanation is that, although district heating can be expensive, households have already made an investment or are locked into the system. Installing a heat pump would require substantial additional costs without necessarily allowing disconnection from district heating, leading to double payment for heating infrastructure. Therefore, from a financial perspective, heat pump installation is unattractive in these cases. One other explanation might be the hassle of disconnecting from district heating (a system already in place) or compatibility and installation issues.

Glass and wall insulation: District-heated homes show increased adoption rates for glass and wall insulation. This is visible for the detached and semi-detached dwellings. The glass insulation effect is especially pronounced, with district-heated detached and semi-detached homes showing nearly 9 times higher conversion odds than the baseline for glass insulation and 4.76 times higher conversion odds than the baseline for wall insulation.

This creates a clear pattern: households connected to district heating systems likely want to compensate for high energy heating costs by investing in envelope improvements and solar panels. Data from the detached and semi-detached housing segments indicate that heating costs are, on average, approximately 33% higher compared to gas-connected homes (€299 vs. €225 monthly in 2023), providing a strong financial motivation.

4.2.1.2 Construction period

As of 2023, post-1991 dwellings represent 28.9% of all family (excluding apartments) housing stock (1,084,151 units). Mid-century homes built between 1945 and 1974 follow closely at 27.4% (1,027,549 units), while dwellings from the 1974–1991 period account for 25.3% (949,915 units). The remaining 18.4% of the stock is comprised of 690,793 pre-1945 dwellings (CBS Microdata, 2023; see Table A.14).

The results show distinct patterns of energy measure adoption related to the construction period.

Roof Insulation: Dwellings constructed between 1945 and 1974 show a higher conversion odds of roof insulation. The effect is notably strong for detached and semi-detached properties (45-82% higher odds). In these mid-century houses, roofs were typically constructed with no insulation at all until 1975, when the first minimal insulation requirements were introduced following the 1973 oil crisis (PapaGreen, n.d.). These roofs contained structural wooden roof boarding (*dakbeschot*), not insulation layers. However, adding interior insulation to these originally uninsulated assemblies can trap moisture between layers, risking wood rot and structural damage, which is a serious technical concern well-documented in Dutch building physics literature (Recticel Insulation, n.d.).

Floor insulation: Newer dwellings (built after 1991) show a lower conversion odds of floor insulation. A possible explanation of this difference is that *older* dwellings (before 1991) often have crawl spaces beneath the floor that facilitate installation.

Wall insulation: Newer dwellings (built after 1991) show significantly lower adoption odds for wall insulation. This can be explained by the fact that modern construction standards already include well-insulated walls, leaving little room or need for improvement. In many newer houses, cavity insulation is either already present or technically not feasible, and the potential energy savings from further insulation are limited. As a result, households have little incentive to adopt this measure.

Heat Pumps: Pre-1945 homes show 28% lower heat pump conversion odds. This likely reflects technical and economic barriers: older houses generally have higher heat demand, poorer insulation, and less space for heat pump installation. In addition, these older houses more often have heritage restrictions and complex retrofit requirements, which make implementation more difficult and costly.

Solar Panels: Homes built in 1945-1974 show 24-25% lower solar panel conversion odds compared to the 1974-1991 baseline. It is not clear what the explanation for this could be. Possibly, it may reflect the roof characteristics of houses of this age (condition, construction).

In summary, the results indicate different patterns of energy retrofitting priorities related to construction eras. The construction period effects are substantial, indicating these represent probably real technical constraints, not preferences that better information could overcome.

4.2.1.3 Dwelling size

Solar Panels - no effect of size: Dwelling size shows no significant relationship with solar panel adoption. This confirms a unique technical characteristic of solar panels, namely, their technical feasibility across all housing types without dependence on thermal envelope quality or building characteristics. An 80m^2 row house and a 200m^2 detached home face similar installation considerations.

Heat Pumps: A positive relationship is observed between dwelling size and heat pump adoption in row houses (dwelling size shows no significant effect in detached/semi homes). Larger homes have higher heating demands, making heat pumps more cost-effective and reducing payback periods. This suggests that heat pump adoption is largely driven by financial considerations.

Glass Insulation: Glass insulation shows a significantly lower conversion odds in larger homes across all dwelling types. Glass insulation costs on average €130-170/m^2 for HR++ glass, including installation, and scales directly with window area.

Note. A typical 80m^2 row house with 15-20m^2 of window area requires €2,000-3,400 for HR++ glass replacement, while a 200m^2 detached home with 30-45m^2 of windows requires €4,000-7,500. With annual energy savings of €200-400, depending on heating patterns and gas prices, payback periods typically range from 8-10 years. While the investment remains economically sound, the larger upfront capital requirement - though proportionally similar per square meter - may create a liquidity barrier that deters many homeowners despite the long-term savings.

4.2.1.4 Dwelling type

Compared to row houses, detached houses have a higher odds of adopting roof insulation but a lower odds of adopting floor insulation. This pattern can be explained by differences in technical feasibility and energy-saving potential. Detached dwellings generally have larger roof surfaces and more direct exposure to external heat loss compared to row houses. Because of this, roof insulation offers greater energy-saving potential in detached homes. Detached houses lose more heat through the roof and often have higher total energy demand. Floor insulation, however, tends to be more complex and expensive in detached dwellings due to the lack of accessible crawl spaces. This may be the explanation for the lower adoption rate.

Furthermore, corner houses show a negative odds of adopting solar panels compared to row houses, though the underlying cause for this remains undetermined. In contrast, corner houses exhibit a positive increased odds of adopting heat pumps. This trend is likely driven by the additional external walls inherent to corner properties; these surfaces contribute to greater heat loss than that experienced by mid-row neighbours, making the transition to efficient heat pump technology more economically attractive.

Compared to row houses, semi-detached houses have a higher odds of adopting a heat pump, but a lower likelihood of adopting floor insulation. This follows a familiar logic: because semi-detached homes have higher total energy demands than row houses, the financial case for a heat pump—characterised by larger absolute savings and shorter payback periods—becomes significantly more compelling. Regarding the lower likelihood of floor insulation, this may be due to the larger floor areas inherent in semi-detached designs, which can increase the complexity and upfront cost relative to row houses.

4.2.1.5 Preexisting measures

This section examines how the existing technical state of the dwelling, related to energy efficiency measures, influences the adoption of additional measures. The measures may either have been implemented by the household before or have already been there when they moved to the dwelling. Effects of "Pre-existing Measures" on conversion likelihood thus give information about the technical dependencies between measures as well as priorities of energy investments assigned by homeowners.

The analysis results reveal several significant effects. A first notable observation is that the presence of solar panels strongly increases the odds of adopting additional measures. This also holds, albeit to a somewhat lesser extent, for glass insulation. Specifically, we see that households with existing solar panels show significantly elevated adoption across nearly every other measure examined:

- Floor insulation: 22.1%-23.4% higher odds
- Glass insulation: 42-48% higher odds
- Wall insulation: 23-26% higher odds
- Heat pumps: 4.3-5.6 times higher odds than the baseline

This pattern likely indicates that solar panel ownership reflects a broader pro-environmental or energy-conscious attitude. The heat pump relationship is particularly strong, possibly reflecting both attitude (environmental commitment) and economics (solar panels offset heat pump electricity costs, improving the financial case). Consequently, policies promoting solar panels may have a broader activation effect on household energy retrofitting behaviour. An exception is roof insulation. This measure does not show a significant relationship with pre-existing solar panels, reinforcing the idea that roof insulation is a somewhat stand-alone type of measure, not so much connected to other measures. Its high cost (€2,000-6,000) and disruptive installation process (scaffolding, interior access, noise) may deter integration with other measures.

Preexisting insulation measures have a positive effect on the adoption of heat pumps. The impact on the conversion odds is quite strong across the different insulation measures:

- Floor insulation existing: 2.6-5.2 times as big
- Glass insulation existing: 2.6-3.7 times as big
- Wall insulation existing: 3.0-5.1 times as big

Insulation measures are often a prerequisite for heat pump installation, as heat pumps rely on low-temperature heating (45-55°C) and therefore function efficiently only in well-insulated houses.

Between insulation measures, we also see generally positive effects. Households completing one major envelope improvement become significantly more likely to adopt others. The strongest complementary effects appear in detached and semi-detached homes, particularly for glass-wall insulation combinations (107% higher odds).

4.2.1.6 Energy and gas consumption

Energy consumption shows a significant positive relationship with heat pump adoption as well as wall insulation in the All Family Dwellings model. A slightly higher energy consumption is associated with an increased odds of heat pump adoption. This pattern aligns with the economic rationale for heat pump investment: households with higher energy consumption have greater potential for absolute cost savings, which improves the financial case for heat pump adoption and reduces payback periods. Homes with higher heating demands stand to benefit more from the efficiency gains offered by heat pumps, making the substantial upfront investment more economically attractive.

No significant effects of energy consumption are observed for other energy efficiency measures in the models. This suggests that for insulation measures and solar panels, the adoption decision is not primarily driven by current energy consumption levels. Instead, other factors play more roles in determining adoption patterns for these products.

Gas consumption shows a slightly negative, significant relationship with heat pump adoption in the Detached/semi-detached model. This may seem counterintuitive, though the underlying cause for this remains undetermined.

4.2.2 Household characteristics

This section presents model estimation results showing how household characteristics influence the odds that particular energy efficiency measures are implemented in dwellings. Table 4.13 shows the estimated effects of the household characteristics considered in this part. The results indicate that education level, household composition, and dwelling occupation period play a role in determining adoption behaviour, although the strength and direction of these effects vary across measures.

Table 4.13: *Estimated effects of household characteristics on conversion odds for each product*

Variable Category / Specific Variable	Solar Panels	Floor Insulation	Wall Insulation	Glass Insulation	Heat Pumps	Roof Insulation
Age Profile (Ref: 35-64)	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC
Young (18-34)						
Young/middle-aged (18-64)				0.25** / - / -		
Elderly (60-79)					- / 1.05** / -	
Very elderly (80+)						
Mixed age adults			-0.53** / - / -0.73**			- / - / 0.65**
Middle-aged/elder (35-79)			- / 0.40** / -			
Education (Ref: Upper secondary)	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC
Primary/lower secondary						
Secondary vocational						- / 1.13 *** / -
Bachelor's degree						- / 0.83** / -
Advanced degree (Master's/PhD)	- / 0.95** / -		- / 0.54** / -			
Unknown						
Household Composition (Ref: Couple with children)	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC
Single person only		0.29** / 0.46** / -				- / - / 0.51**
Single parent					- / 1.10** / -	
Couple no children						
Other combinations						
Dwelling Occupation Duration (Ref: 20+ years)	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC
Less than 2 years	- / 0.89** / -					0.47** / 0.74** / -
2-5 years						0.45*** / 0.64** / -
5-10 years					- / 0.77** / -	0.32** / - / -
10-15 years				- / 0.98*** / -	- / 0.83** / -	
15-20 years						0.42*** / - / 0.40**
Interest in Measures	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC
Solar panels interested		- / 1.47** / -				- / - / 1.13**
Floor insulation interested	- / - / 0.46**	1.60*** / 1.45*** / 1.65***	-0.38*** / -0.49*** / -0.36***	- / -0.55** / -	1.26*** / - / -	-0.90*** / -1.11*** / -0.84***
Glass insulation interested	-1.79** / - / -			2.39*** / 1.67*** / 2.43***		
Wall insulation interested	-1.56*** / - / -		1.32*** / 1.31*** / 1.28***	-0.71*** / - / -0.65***	-2.88*** / - / -2.45**	-0.45** / -0.51** / -0.48**
Roof insulation interested	- / - / -0.76**		-0.51*** / - / -0.59***			1.63*** / 1.53*** / 1.75***
Heat pump interested	- / - / 2.02***			- / 1.68*** / -	4.10*** / - / 3.42***	- / 1.25* / 0.88*

Notes:
- Significance levels: *** p<0.001, ** p<0.01, * p<0.05
- Empty cells (-) indicate variable not included in that model or not statistically significant
- AF = All Family Dwellings, DS = Detached/Semi-detached, RC = Row/Corner houses

4.2.2.1 Education

Households with a higher education level show a slightly higher odds of adopting solar panels and wall insulation in detached/semi-detached models. A likely explanation is that higher-educated individuals tend to be more proactive in seeking information, comparing options, and consulting experts. They may therefore be less deterred by the complexity of these measures. The effects are most visible for solar panels and wall insulation, which are measures that represent the largest adoption volumes overall. Roof insulation shows a different pattern. For this measure, a practice-oriented (vocational) education appears to have a positive effect, as well as for a Bachelor's degree. It is not clear what the explanation of this could be.

4.2.2.2 Age

Unlike education or dwelling characteristics, age shows no consistent pattern across measures. Some specific combinations show statistical significance, e.g., elderly households in detached and semi-detached homes show increased heat pump adoption, but no systematic relationship emerges. The low representation of the elderly (see Section 4.1) does indicate low action rates in this elderly age group, suggesting that the elderly generally face barriers to initial engagement. Once activated, however, the conversion odds in this group is not lower than that of younger age groups after controlling for other factors.

4.2.2.3 Household composition

No clear or consistent effects are found for household composition. While it might be expected that households with (young) children would be less inclined to undertake major home improvements due to financial constraints or practical disruption, the data do not support this assumption. Single-person households do show an increased odds of conversion for floor insulation and roof insulation (only row houses). But the effects are not strong. While heat pumps do show an increased odds of conversion for single parents, the effect is only significant for detached/semi-detached dwellings. All in all, compared to the baseline (Couples with children) the findings here suggest that family structure alone is not a key determinant of energy-efficiency investment behaviour.

4.2.2.4 Dwelling occupation duration

The period of dwelling occupation - how long the household has lived in the home - shows some association with adoption odds, particularly for roof insulation and solar panels.

Solar Panels: The odds of adopting solar panels is highest among recent movers in detached/semi-detached dwellings, particularly within the first two years of occupancy. This indicates that households often evaluate energy-related investments when settling into a new home. Given that solar panels can act as a gateway measure, stimulating interest in other energy efficiency improvements, targeting recent movers with incentives or information campaigns could be a particularly effective policy strategy.

Roof Insulation: Adoption of roof insulation seems to follow a life-cycle pattern. Roof insulation is most often considered in the early years of occupancy (within 10 years) and again during major renovation phases (around 15–20 years after moving in). Beyond 20 years, adoption rates decline, suggesting that households tend to accept the dwelling's condition and are less inclined to make further major improvements.

4.2.2.5 Interested-in variables

These variables capture whether households expressed interest in specific measures (regardless of whether they adopted them). Clearly, we expect that a shown interest in a particular measure leads to an increase in the conversion of that measure. The strength of this relationship is not equal across the different measures. A relatively weak relationship may indicate that homeowners start the customer journey generally with limited or wrong information about the impacts of the measure, and after being better informed, they discontinue. Conversely, a strong relationship indicates a well-informed decision to start the journey.

The effect of being interested in the product is strongest for Glass insulation and Heat pumps: being interested in the product strongly increases the odds of eventually converting to that product. This indicates that for heat pumps and glass insulation, homeowners who enter as leads are generally well-informed and know what they want. The effect is particularly large for heat pumps. For the other products - Floor, Roof, and Wall insulation - the effects are moderate, indicating that homeowners, after having received more information, more often change their mind and discontinue. [3]

The cross-relationships between a measure shown to be of interest with the adoption odds of another measure reveal how households think about measure combinations. A positive relationship offers evidence for an increased tendency to combine the products. The results indicate that positive cross-relationships occur related to Floor insulation: being interested in floor insulation increases odds probabilities of solar panels and heat pumps, indicating that floor insulation is more often combined with these products. The reverse also holds: an interest in solar panels also increases the odds of adopting floor insulation; for heat pumps, this occurs as well, albeit that there the effect is significant only in the row/corner housing segment.

It should be noted that these positive regression coefficients contrast with the lift ratios presented in section 4.1, where floor insulation shows low co-purchase rates with both solar panels (0.51 in actual purchases) and heat pumps (0.19 in actual purchases). Apparently, even though an interest in floor insulation increases the likelihood of heat pumps, they are not likely to be purchased together. This suggests that a sequential order exists among these products, reducing the odds that they are purchased together at the same time or that the products are exchangeable. The same holds for solar panels. Hence, an interest in another product (floor insulation) can be a good indicator for the likelihood of choosing the product (heat pump, solar panel) even though the likelihood of being purchased together at the same time, that is, during the same encounter with the one-stop shop, is low. The other way round is also possible - the high probability of co-occurrence of Solar panels and Heat pumps in purchases (see table 4.5), does not translate into a positive relationship between interest in Solar panels and buying a Heat pump or vice versa.

Negative relationships exist as well. The strongest negative effect appears on the level of interest in wall insulation. This interest strongly reduces heat pump adoption (94-91% lower odds). This suggests that households that are planning wall insulation aren't considering heat pumps, possibly because they're still addressing basic envelope deficiencies. Furthermore, we see negative effects of an interest in glass or wall insulation on the probability of adopting solar panels. In the case of glass insulation, this contrasts with the positive lift ratio (1.63) observed in section 4.1.2.1. However, for wall insulation, this negative effect aligns with the low lift ratio (0.30) observed in the same section, confirming that these products are rarely combined. Such negative effects may indicate competition effects. As we have seen (Table 4.3), by far the most win cases involve single-product transactions, which indicates a preference for one major improvement at a time in energy retrofitting of the home. Therefore, displaying an interest in one product decreases the probability of buying another product.

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[3] Due to an oversight in model specification, the variable indicating interest in solar panels was not included in this analysis. This omission should be considered when comparing results across product models.

4.2.3 Financial context

This section presents the model results on how financial characteristics affect the likelihood that homeowners implement specific energy retrofitting measures once they have become active in exploring options. The results show that debt level, financial welfare, utility cost burden, and the presence of a construction deposit each play a role in shaping investment behaviour, though their effects differ by measure type.

Table 4.14: *Estimated effects of households' financial context on conversion odds for each product*

Variable Category / Specific Variable	Solar Panels	Floor Insulation	Wall Insulation	Glass Insulation	Heat Pumps	Roof Insulation
Mortgage Position (Ref: No debt)	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC
Low debt (0-100k)						
Medium debt (100-250k)				-0.33** / - / -		
High debt (>250k)		- / -0.67*** / -		-0.44*** / -0.89*** / -0.32**		- / -0.68** / -
Mortgage: No data						- / -1.75** / -
Has a construction deposit		- / -1.16** / -				
Financial Welfare (Ref: 41-60)	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC
Category (0-20)				- / 1.62*** / -		- / - / 1.25**
Category (21-40)				- / 0.59*** / -		
Category (61-80)						
Category (81-100)			- / - / 0.27**			
Utility cost ratio to income (Ref: 20-30%)	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC	AF / DS / RC
Very low (<10%)					- / - / 0.69***	
Low (10-20%)	- / -0.53** / -	- / 0.39** / -		- / 0.59** / -		
High (30-40%)	0.25*** / - / -			-0.29** / - / -0.30**		
Very high (40-50%)			- / - / 0.43**			
Extreme (>50%)					1.28** / 1.40** / -	
No data					1.33** / - / 1.30**	- / - / -1.70**

Notes:
*- Significance levels: *** p<0.001, ** p<0.01, * p<0.05*
- Empty cells (-) indicate a variable not included in that model or not statistically significant
- AF = All Family Dwellings, DS = Detached/Semi-detached, RC = Row/Corner houses

4.2.3.1 Debt

General statistics show that debt level doesn't prevent activation: High-debt households represent 22.5% of leads. The model results show relationships with conversion odds.

Households carrying mortgages above €250,000 face reduced odds of purchasing certain insulation measures: their odds of adopting floor insulation drops by 49% in detached and semi-detached dwellings, glass insulation odds falls by 36% across all dwelling types (59% lower in detached/semi-detached homes, 27% lower in row/corner houses), and roof insulation odds decreases by 49% in detached and semi-detached properties. Even medium debt levels (€100,000-€250,000) depress glass insulation odds by 28% across all dwelling types.

This suggests that the willingness to invest in the dwelling increases as financial pressure decreases. Households with high debt levels are less likely to invest, as is particularly noticeable in the case of floor insulation and glass insulation. These measures tend to offer less immediate and visible financial returns compared to, for example, solar panels. This might be the reason that the financial possibilities are particularly strong for these latter products. For highly indebted households, the combination of limited financial capacity and less tangible short-term benefits appears to strongly discourage investment.

4.2.3.2 Financial welfare

Financial welfare is a composite indicator of income level and savings. This measure is defined by CBS as a household's overall economic position by combining both their standardized disposable income and net wealth. Households are ranked based on the sum of their cumulative share in total national income and their cumulative share in total national wealth and are then divided into 100 percentile groups. A value of 1 represents the lowest 1% of financial welfare, 50 represents the median, and 100 represents the highest 1%. This measure provides a more comprehensive assessment than income or wealth alone, as it captures both current earning capacity and accumulated assets, making it particularly relevant for homeowners who may have high incomes but also high mortgage debt, or conversely, low incomes but substantial home equity.

No clear effects of financial welfare on conversion are observed. While households with high welfare levels are overrepresented among active households (in the leads), with the segment (81-100) representing 36.5%, their welfare status does not significantly influence actual adoption once activated. This finding suggests that financial welfare primarily affects activation, not conversion. In other words, financially well-off households are more likely to explore energy retrofitting options, but once they are active, they adopt measures at similar rates to others. This insight is important for policy: it implies that financial compensation schemes may be more effective at activating interest rather than increasing conversion among already motivated households.

On the other hand, the proportion of low-welfare households is small both in the leads (9.8%) (CBS Microdata, 2023; See Table A.7) and the general population (9.2%) (CBS Microdata, 2023; See Table A.15). This indicates that this group is not more difficult to activate than other groups. We do not see effects of low welfare on conversion rates, indicating that, also here, low welfare status does not affect conversion.

4.2.3.3 Utility cost ratio to income

The ratio of utility costs to income is a proxy for energy poverty - the higher the ratio, the higher the risk of energy poverty. The level of the ratio has several significant effects on the adoption of solar panels and glass insulation.

Solar Panels. There is a positive relationship between a high utility-cost ratio and the conversion odds of solar panels. This suggests that reducing the energy bill, which is more urgent when the utility costs burden is high, is a primary motivation for solar panels.

Glass Insulation: There is a negative relationship between a high utility cost ratio and the conversion odds of glass insulation. This suggests that energy cost saving is not the main driver for adopting this measure. Glass insulation is relatively expensive, and the financial benefits are less immediate or visible. Probably, glass insulation is more strongly motivated by improving comfort instead of lowering the energy bill. This may also hold for wall insulation, but wall insulation is way cheaper and easier.

Heat Pumps: There is a noticeable, pronounced, strong positive effect of Extreme (>50%) utility costs burden for all family dwellings and detached/semi-detached for heat pumps, this suggests that the need to save on energy costs is a trigger.

4.2.3.4 Construction deposit

In the analysis, the influence of the presence of a construction deposit (in Dutch called bouwdepot) was also examined. Households with a construction deposit are only a small group among the active leads, and this group is also small in the general population (around 3.4%) (CBS Microdata, 2023; see Table A.21). The presence of a construction deposit does not affect conversion probabilities, indicating that it plays no role in the final decision once homeowners have entered the decision process.

4.2.4 Location and time period

In this section, we examine the impact of spatial and temporal context variables on the odds of conversions for each of the products. The spatial variables considered include the degree of urbanity within the municipality and the size of the municipality. In terms of temporal factors, we examine the year and month of the moment the homeowner enters as a lead. The temporal variables (year and month) are primarily included in the models to control for time-related effects, particularly the timing of marketing campaigns and promotional actions undertaken by the participating one-stop shop parties. The patterns observed in these variables may therefore reflect both seasonal factors and party-specific campaign timing. Table 4.15 shows the results of the analysis with respect to these variables.

Table 4.15: *Estimated effects of location and time period on conversion odds for each product*

Variable Category / Specific Variable	Solar Panels	Floor Insulation	Wall Insulation	Glass Insulation	Heat Pumps	Roof Insulation
Annual Effects (Ref: 2019)	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**
2020						0.55*** / - / 0.57**
2021				0.96*** / 1.94*** / -		
2022		-0.54*** / - / -0.56***	-0.57*** / - / -0.66***	- / 1.67*** / -		
2023		-1.62*** / -0.84** / -1.81***	-1.75*** / -1.21*** / -1.92***	- / 1.40*** / -		-0.93** / - / -0.96**
Monthly Seasonality	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**
January						
February					-3.34*** / -2.14** / -2.90***	
March		Reference	Reference	Reference	-2.32*** / -2.57*** / -2.11***	-0.69** / - / -1.10***
April				- / 0.83** / -0.49**		-0.94*** / - / -1.22***
May	Reference				-1.55*** / - / -1.86***	
June	- / -0.48** / -					
July	0.41** / - / 0.44**			-0.79*** / - / -0.79***	-1.64** / - / -1.79***	
August	0.97** / - / 1.33***			- / 1.26** / -	-/-2.04**/-	
September				-/1.29***/-	-0.48** / - / -	- / - / -0.70**
October				- / 0.89** / -0.67**	Reference	
November						Reference
December	0.56*** / - / 0.55***					
Urbanity categories (Ref: Extremely urbanized: 2,500 or more per km2)	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**
Strongly urbanized (1500-2500) per km2			- / -0.51** / -		- / -1.37** / -	
Moderately urbanized (1000-1500) per km2					- / - / -0.75**	
Hardly urbanized (500-1000) per km2						
Not urbanized (<500) per km2					- / -1.44** / -	

Notes:
*- Significance levels: *** p<0.001, ** p<0.01, * p<0.05*
- Empty cells (-) indicate variable not included in that model or not statistically significant
- AF = All Family Dwellings, DS = Detached/Semi-detached, RC = Row/Corner houses
*- The **monthly seasonality** reference categories vary by product: Solar panels (May), Floor/Wall/Glass insulation (March), Heat pumps (October), Roof insulation (November)*

4.2.4.1 Year

For glass insulation, the analysis reveals a significant increase in the year 2021. This may have been an effect of local and regional programs offering subsidies for HR++ or triple glazing, which became available in 2021. For floor, wall, and partly roof insulation, the analysis reveals various negative effects in recent years, 2022 and especially 2023. Floor insulation shows declining adoption in 2022 and 2023 across all dwelling types. Wall insulation similarly shows declining adoption in 2022 and 2023 across all dwelling types. Roof insulation shows declining adoption in 2023 in All Family Dwellings and Row/Corner houses. It is not clear what the explanation for this decline is. A tentative explanation points to the energy price crisis of 2022, which caused sharply rising prices of construction materials and labour that affected the costs of these insulation measures. Possibly, the increased costs reduced the attractiveness of these products and drew attention toward measures with immediate and visible financial returns, such as solar panels and heat pumps. Furthermore, the two-measure requirement by the ISDE subsidy (homeowners needed at least two measures to qualify for subsidies) may have had an impact. This created higher investment thresholds during that period.

An additional explanation for the lower conversion odds in 2022-2023 may be found in the supply chain disruptions documented in the Dutch insulation market during this period. According to market data (Rijksdienst voor Ondernemend Nederland [RVO], 2024), a "bullwhip effect" occurred in 2022-2023, where traders and installers hoarded insulation materials in 2022 due to fears of shortages and rising prices, followed by inventory corrections in 2023. This supply chain distortion likely created price volatility and availability uncertainty that discouraged homeowners from proceeding with purchases after initial inquiries. Notably, glass insulation was unaffected by these supply chain issues as it operates on a made-to-order basis rather than through inventory systems, which may partially explain why glass insulation maintained stable conversion odds while floor, wall, and roof insulation materials experienced significantly lower conversion odds compared to the reference period.

4.2.4.2 Month

The analysis reveals significant seasonal (month) effects for several products. Solar panels show a clear peak in the summer months (July and August), reflecting favourable weather conditions and longer daylight hours that make installation and energy generation more attractive. Solar panels also show an increased conversion rate in December. Closer inspection of the data reveals that this is probably due to a sudden peak in solar panel purchases in December only in one year (2019) and for one party (Reimarkt). This December effect for solar panels appears to be driven by a specific marketing campaign undertaken by Reimarkt during this period, demonstrating that targeted promotional actions can influence adoption rates regardless of seasonal factors. This indicates that campaigning has an effect no matter what the time of year is, even in typically less favourable periods like December. In contrast, heat pumps display increased demand during late autumn and early winter (October to January), when heating needs become more apparent.

Other measures show little or no evidence of seasonal variation. Floor, wall, and roof insulation display no significant month effects, while glass insulation shows a slight decline in July and roof insulation a temporary decrease in March and April. Overall, these patterns suggest that only technologies directly linked to seasonal energy use or installation conditions exhibit clear temporal fluctuations in adoption.

4.2.4.3. Urbanity

The urban density of the residential location shows a tendency of increased odds of conversion odds generally for the very high urbanization areas, in the sense that all effects found are negative relative to this location segment. The effects found are, however, modest and do not show a consistent pattern as they occur in specific housing segments only (detached or row houses).

4.2.4.4. Municipality size

Table 4.16: *Correlation between municipality constant estimates and municipality population size for each product*

Variable Category / Specific Variable	Solar Panels	Floor Insulation	Wall Insulation	Glass Insulation	Heat Pumps	Roof Insulation
Correlation with Population	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**
Pearson r	0.10 / -0.25 /-0.11	**-0.29***** / -0.07 / -0.06	-0.07 / -0.10 / -0.24	**-0.47***** / -0.35. / -0.39*	- / 0.17 / 0.17	-0.20. / 0.58 / -0.30

Notes:
*- Significance levels: *** p<0.001, ** p<0.01, * p<0.05*
- Empty cells (-) indicate a variable not included in that model or not statistically significant
- AF = All Family Dwellings, DS = Detached/Semi-detached, RC = Row/Corner houses

Furthermore, we tested whether municipality population size correlates with product adoption rates (Table 4.16). For each product, we calculated the correlation between municipality population and the constants related to municipalities from regression models. The constants indicate for each municipality the effect of the municipality on the conversion odds for the product concerned.

Only two products show statistically significant correlations. Glass insulation for all family dwellings shows a negative correlation with municipality population size. Floor insulation for all family dwellings shows a moderate negative correlation. Both indicate that a larger population size of municipalities has a significantly negative effect on adoption rates after controlling for other factors. All other products and dwelling type combinations show weak, non-significant correlations, meaning municipality size doesn't have an effect on adoption patterns.

4.2.5 Products and marketing

Homeowners engage with a one-stop shop requesting a single product or multiple products. In this section, we consider the relationship between the number of requested products and the conversion rate for each product. Furthermore, the channel through which the homeowner enters the one-stop shop is analysed to establish whether the channel has an impact on the choice of product and the odds of eventually buying the product.

Table 4.17: *Estimated effects of products and marketing on conversion odds for each product*

Variable Category / Specific Variable	Solar Panels	Floor Insulation	Wall Insulation	Glass Insulation	Heat Pumps	Roof Insulation
Product Request Complexity	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**
Number of products requested		1.33*** / 1.75*** / 1.20***	1.36*** / 1.47*** / 1.36***	0.65*** / - / 0.66***	-0.64** / - / -	1.41*** / 1.70*** / 1.29***
Number of products requested^2 (Quadratic)		-0.21*** / -0.28*** / -0.19***	-0.20*** / -0.25*** / -0.19***	-0.08*** / - / -0.08**	0.13*** / - / 0.11**	-0.15*** / -0.21*** / -
Lead Channels And Marketing Sources (Ref Winst uit je Woning municipality channel)	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**	**AF / DS / RC**
Digital channel		0.60** / - / -		-0.76*** / - / -1.20***	-2.2*** / - / -	- / - / 1.01**
Flyer/Letter	2.11** / - / 2.09**			-1.03** / - /-		- / - / 1.59**
Municipality channel (not WUJW)			-0.59** / - / -			- / 1.14** / -
Referrals/Ambassador			1.09*** / 1.26** / -	- / 2.92*** / -1.44***		- / - / 1.44***
Direct channel (Door to door/phone call)			-0.71* / -0.75* / -	- / 2.74*** / -0.88***		
Third-party channels				-1.10*** / - / -1.51***		
Other channel	- / - / 2.03***	- / 1.83*** / -			-0.88** / - / -	- / 1.30** / 1.60**
Meetings/Events					-1.33** / - / -	-/-/-

Notes:
- Significance levels: *** p<0.001, ** p<0.01, * p<0.05
- Empty cells (-) indicate a variable not included in that model or not statistically significant
- AF = All Family Dwellings, DS = Detached/Semi-detached, RC = Row/Corner houses

4.2.5.1 Number of products requested

This variable simply counts how many different products a customer asks for in one go. The quadratic term of this variable is included to allow for a curved (non-linear) relationship. A negative effect of the quadratic term means that the marginal value of additional products diminishes, and a positive effect indicates an increasing marginal value. The quadratic term appears to have a negative value of the coefficient in general. This indicates diminishing marginal values of the number of requested products. In words: households requesting more than one product have a higher odds of converting to the product considered, but with an increasing number of requested products, this effect diminishes. Depending on the size of the negative coefficient, the success rate may even start to decrease at some point. Then, there is an optimum number of requested products in terms of the conversion odds of the product considered. E.g., a possible scenario is that a bundle of 2-3 products together tends to have the highest success rates (e.g., because they're serious and committed), but when someone requests 4 or more products at once, success starts dropping (e.g., because the project becomes too complex and expensive).

Generally, across products, the positive value of the linear term and the negative value of the quadratic term indicate a curved non-linear relationship with decreasing size of the positive effect of the number of requested products. Thus, households requesting more than one energy improvement show a higher conversion odds for any single product. Exceptions are solar panels and heat pumps. For solar panels, there is no significant effect of bundle size. For heat pumps, the odds of conversion odds decreases if more than one product is requested. Apart from these two exceptions, for all products, the conversion odds increase when homeowners enter with multiple product requests in (small) instead of just one.

4.2.5.2 Lead channels and marketing sources

The effects of the market channel shown in the table are expressed relative to the reference category 'Municipality - Winst uit je Woning', which serves as the baseline for comparison. A positive value means that the channel increases the conversion odds, and a negative value means that it decreases the odds compared to this reference. It appears that the effects of Channel differ considerably depending on the product.

The following effects are found.

- Solar Panels: Sending letters or flyers works significantly better than the baseline for Solar panels (though no effect was detected for detached/semi-detached homes). "Other" channels also outperform the baseline, but only for row/corner houses.
- Floor Insulation: Digital channels work better than the baseline for floor insulation. "Other" channels also show an increase in conversion odds compared to the baseline, but only for detached and semi-detached homes.
- Wall Insulation: Referrals and ambassador programs work much better than the baseline. The municipality channel (not WUJW) shows a negative effect on conversion rates for this product.
- Glass Insulation: Results depend strongly on housing type. The channels Referrals and Direct-contact work better for detached and semi-detached homes, and worse for row/corner houses. Digital channels and third-party channels consistently work worse than the baseline, regardless of housing type.
- Heat Pumps: Digital channels work much worse than the baseline. "Other" and "Meeting and events" also work less effectively for heat pumps.

- Roof Insulation: Several channels outperform the baseline depending on which homes are targeted. Digital channels, Letters/flyers, and Referrals/Ambassadors all work better for row/corner houses. Municipality channels work better for detached/semi-detached homes. The "other" category works better for detached/semi-detached and row/corner houses individually.

The results mean that there is no single marketing channel that works best for all products and housing types - effectiveness depends heavily on what product is promoted and which housing segment is targeted. Physical mail (letters/flyers) outperforms the baseline for solar panels, while digital channels work poorly for heat pumps and floor insulation. Referrals and ambassadors consistently perform better than the baseline for wall insulation, but show mixed results for other products. The most interesting finding is that the same marketing approach can produce opposite results in different housing types: for glass insulation, municipality channels, referrals, and direct contact all work much better than the baseline in detached/semi-detached homes, but worse in row/corner houses. Heat pumps are particularly challenging, with nearly every alternative channel underperforming the baseline.

Chapter 5 - Policy recommendations

This chapter discusses and expands on the 4.2 section to furnish policy recommendations intended for policymakers.

5.1 Increasing (re-)activation impact of the overall One Stop Shops (OSS) approach

Enhancing the impact of one-stop shops (OSS) requires distinguishing between two distinct challenges: activation (generating leads from the homeowner population) and conversion (translating leads into completed purchases). The analysis reveals that factors influencing these two stages differ substantially: characteristics that predict who enters the journey do not necessarily predict who completes a purchase.

Who is the target audience of an OSS-approach?

Household age

Comparing the leads data to the population data, we find that (see Table 4.9):

- Young adults (18-34) are somewhat overrepresented: 10.4% of leads versus 8.3% of the population (25% more than expected).
- Middle-aged (35-64) are equally represented: 61.9% of leads versus 60.0% of the population.
- Elderly-aged (65-79) are equally represented: 23.9% of leads versus 24.8% of the population.
- Elderly-aged (80+) are underrepresented: 3.8% of leads versus 6.9% of the population (45% fewer than expected).

Conversion rates vary systematically across age categories. Elderly individuals aged 80+ achieve the highest conversion rate at 22%, followed by those aged 65-79 at 19%, middle-aged individuals aged 35-64 at 16%, and young individuals aged 18-34 at 16%.

Household composition

Comparing the leads data to the population data, we find that (see Table 4.10):

- Couples with children are equally represented: 41.4% of leads versus 40.6% of the population.
- Couples without children are equally represented: 37.2% of leads versus 36.3% of the population.
- Single parents are somewhat overrepresented: 5.7% of leads versus 5.1% of the population (13% more than expected).
- Single-person households are somewhat underrepresented: 15.7% of leads versus 18.1% of the population (13% fewer than expected).

Conversion rates vary across household compositions. Single-person households achieve a conversion rate of 19.6%, couples without children 17.2%, single parents 16.3%, and couples with children 15.1%.

Dwelling type

Comparing the leads data to the population data, we find that (see Table 4.11):

- Corner houses are overrepresented: 22.6% of leads versus 18.2% of the population (24.3% more than expected).
- Row houses are overrepresented: 46.1% of leads versus 41.7% of the population (10.6% more than expected).
- Detached houses are underrepresented: 17.5% of leads versus 24.4% of the population (28.5% fewer than expected).
- Semi-detached houses are somewhat under-represented: 13.9% of leads versus 15.7% of the population (11.9% fewer than expected).

Conversion rates vary across dwelling types. Row houses achieve the highest conversion rate at 18.3%, followed by corner houses at 16.4%, semi-detached houses at 14.9%, and detached houses at 14.2%.

Returning behaviour

The vast majority of household engagement involves a first entry, with 95.8% of all entries. However, 3.9% returned for a second attempt. A small group of only 0.3% persists to a third entry.

Returning vs. first entry households: Returning households show a conversion rate of 17.6%, compared to households at their first entry at 13.5%. Households that converted on their first attempt show substantially higher conversion rates on subsequent attempts compared to households that did not convert on their first attempt (47.6% vs. 11.0% overall).

Recommendation targeting groups to increase volume:

- An OSS approach seems to be interesting to start the customer journey for the largest target groups: people with children between 34 and 65, living in row or corner houses. It can possibly be optimized further using a more direct marketing strategy for the 80+ group and single-person households.
- The underrepresentation of detached and semi-detached dwellings can be a result of marketing (mainly targeting these houses), but can also mean these households are less likely to be interested in an OSS approach. If marketing data becomes available, this can be further investigated in future research.

- Being interested/overrepresented in volume doesn't mean these groups are more or less likely to convert to a deal. The numbers show that different groups (probably by a combination of factors) can act very differently in the customer journey. In policy, one should try to optimize, taking both volume and conversion into account.
- Use retargeting as a strategy for acceleration: first-time converting customers have a significantly higher chance of converting the second time. In this case, one should retarget sooner rather than later. Using this as a strategy is especially relevant in the context of people mainly adopting only one measure, as explained in this document.
- OSS could shift from a linear "find-convert-close" model to a cyclical "Gateway-Re-activate-Deepen" model. Automated follow-up protocols could target previous purchasers, with messaging tailored to the logical next-step measure (e.g., target PV owners with a Heat Pump consultation package). Also, it could substantially increase total retrofit volumes without requiring new customer acquisition.
- Upselling, where existing customers are encouraged to adopt additional measures beyond their initial purchase, represents a significant opportunity. This could occur during energy consultation visits or follow-up contact after installation. This is critical because the ISDE subsidy for multiple products may still apply, providing a strong financial incentive for the customer to act quickly.

5.2 Increasing conversion for each product

5.2.1 Solar panels

How do solar panels influence other products?

Solar panels are most often bought as a single product. When combined, it is most often purchased together with a heat pump and glass insulation. The presence of Solar panels increases the conversion to heat pumps and insulation measures. Solar panels function as a gateway measure - households with existing solar installations show a higher likelihood of adopting heat pumps, floor, wall, and glass insulation measures. Solar panels enhance the attractiveness of a heat pump by providing the low-cost electricity needed to power it.

Recommendation to improve lead-deal conversion: Solar panels

- Use solar panels for acceleration: The presence of solar panels has a positive impact on the adoption of all products (except roof insulation) and, even, on adopting more solar panels. 52.7% (as of 2023) of all family dwelling homeowners in the Netherlands have Solar panels, which can make up a target group wide open that can be strategically used to accelerate the energy transition.
- Position solar panels as "Phase 1" in retrofit pathways, with clear communication about follow-up measures. Offer package deals where solar installers can schedule future insulation assessments.

Who buys it?

Households are more likely to buy solar panels when they:

- Have recently moved (< 2 years) - new residency is a trigger to consider solar panels.
- Have high utility costs relative to income - saving on the energy bill is a motivation to consider solar panels.
- Are higher educated - higher-educated individuals tend to be more proactive in seeking information, and may be less deterred by the complexity of measures like solar panels.
- Have an interest in heat pumps - solar panels enhance the benefits of a heat pump.

This suggests that motivations for solar panels are often financial, and the product is viewed as a way to invest in the home, as part of a package (heat pump), while the costs of acquiring information might be a barrier.

There are no clear relationships between the odds of buying solar panels and dwelling characteristics. This confirms the technology independence of solar panels – there are no specific technical requirements for solar panels that play a role.

Recommendation to improve lead-deal conversion: Solar panels

Insight: Households are more likely to buy solar panels when they:

- Recently moved (< 2 years)
- Have high utility costs relative to income
- Are highly educated
- Show interest in heat pumps

Recommendations:

- New movers program: Send welcome letters with solar incentives to households that recently registered at a new address.
- Align to financial motivation: Provide personalized savings calculators showing payback periods.
- Bundle with Heat Pumps: Offer combined rebates for solar panels + heat pumps.

When/how to sell it?

Using a flyer or letter increases the effectiveness of actions to sell Solar Panels. It may be that textual information better meets the need for information for the decision.

The summer months, July and August, seem to be the best season to promote Solar panels. This may reflect the favourable weather conditions and longer daylight hours for solar panel effectiveness. **Caution**: the seasonality effects we found may be influenced by actions of one-stop shops to intensify campaigns for solar panels in summer months (due to the lack of information on actions in the model, which does not control for this).

Recommendation to improve lead-deal conversion: Solar panels

- Remove information barriers: Develop clear, concise flyers and letters explaining: Financial benefits, installation process, maintenance requirements
- Timing: Leverage the summer season when demand for solar panels is greater.
- Messaging strategy: adopt a financial focus stressing financial benefits ("Cut your energy bills - solar panels pay for themselves in just a few years.") and investment framing ("Increase your home's value and energy independence").

5.2.2 Wall insulation

Wall insulation commands the retrofit market with 17,606 leads – more than any other measure. It addresses 25% of home heat loss through simple cavity filling, costs less than floor insulation, and takes just one day to install. Yet it suffers from being completely invisible once installed, making its benefits intangible compared to solar panels or heat pumps.

How does wall insulation influence other products?

Wall insulation is considered one of the more basic energy measures: the presence of wall insulation boosts the adoption of other products, especially solar panels, heat pumps, and glass insulation. In purchases, wall insulation strongly competes with other products: being interested in wall insulation strongly suppresses the likelihood of all other products.

Recommendation to improve lead-deal conversion: Wall insulation

Position wall insulation as a foundational step in energy transition programs. Since its presence boosts the adoption of other measures (solar panels, heat pumps, glass insulation), municipalities can:

- Develop step-by-step renovation plans starting with wall insulation, followed by complementary measures.

Who buys it?

There are no clear relationships between the odds of buying wall insulation and household characteristics. Financial factors do play a role, albeit minor - an incentive to reduce energy costs when the costs are high relative to income can be a trigger. Furthermore, the costs of implementing wall insulation might be a threshold - a higher welfare level increases the conversion odds. There is no relationship with occupancy duration. More than other products, being interested in the product is a strong predictor of adopting wall insulation. Adoption is influenced by construction year – newer dwellings (> 1991) display a lower likelihood. In many newer houses, cavity insulation is either already present or technically not feasible. As a result, households in newer dwellings have little incentive to adopt this measure.

Recommendation to improve lead-deal conversion: Wall insulation

- Consider tiered subsidies or low-interest loans for wall insulation, especially for households with lower welfare levels.
- Target households with high energy costs relative to income, as they are more likely to respond to cost-saving incentives.
- Focus campaigns on dwellings built before 1991, where cavity insulation is often absent and technically feasible.
- For newer homes, shift focus to other measures (e.g., solar panels, heat pumps) since wall insulation is less relevant.

When/how to sell it?

Season does not show an influence – we find no seasonality effects. The marketing channel does matter. Promoting wall insulation by a referent/ambassador significantly increases the odds of conversion, whereas direct marketing (door-to-door, phone calls) performs poorly. This suggests a particularly strong trust factor in responsiveness to promotions for wall insulation.

Recommendation to improve lead-deal conversion: Wall insulation

Be aware that the use of direct marketing (door-to-door, cold calls) may not be the best approach for wall insulation. Instead, consider for this product:

- Implement ambassador programs where satisfied homeowners share experiences.
- Partner with local community organisations or neighbourhood energy coaches to build trust.
- Promote through peer networks and social proof campaigns.

5.2.3 Floor insulation

Floor insulation represents the second-highest volume measure with 14,737 leads and achieves a 15.0% conversion rate. It addresses approximately 15% of home heat loss through crawl space insulation, typically costs €2,000-4,000, and can be completed in 1-2 days with minimal disruption to daily life.

How does floor insulation influence other products?

The presence of floor insulation increases the adoption of solar panels, heat pumps, and roof insulation. Technically, it is necessary for heat pump efficiency. The positive effects on other measures indicate that it functions as an activator for additional retrofitting measures.

Recommendation to improve lead-deal conversion: Floor insulation

- Emphasize floor insulation as a key prerequisite for heat pump efficiency and an activator for other measures (solar panels, roof insulation).
- Integrate floor insulation into comprehensive retrofit packages that include heat pumps and roof insulation.

Who buys it?

Floor insulation appeals to comfort-seeking households and has characteristics of a luxury good – the conversion odds of buying floor insulation increase when the household has low debt and sufficient disposable income (low ratio of utility costs to income). Conversion odds are higher for single-person households. It is lower in the detached or semi-detached housing segments. Finally, there is a positive link with heat pump – an interest in floor insulation increases the conversion to a heat pump.

Recommendation to improve lead-deal conversion: Floor insulation

Frame floor insulation as a comfort-enhancing upgrade rather than purely an energy-saving measure. Focus on households with:

- Low debt and sufficient disposable income (low ratio of utility costs to income).
- Single-person households, as they show higher conversion odds.
- Prioritize row/corner homes where conversion odds is higher.

When/how to sell it?

Season appears not to have an effect. The channel used does not have a significant effect on conversion rates either, with only one exception – digital media shows higher effectiveness.

5.2.4 Roof insulation

Roof insulation shows 5,166 leads with a modest 7.84% conversion rate – the lowest among all insulation measures. Despite representing 15-25% of home heat loss, roof insulation faces unique barriers: high costs (€2,000-6,000), disruptive installation requiring scaffolding, clearing the attic, and interior access, and technical complexity with moisture management concerns.

How does roof insulation influence other products?

Only 51.6% purchase roof insulation alone - the lowest single-product rate among all measures - indicating roof buyers pursue broader envelope improvements simultaneously. The odds increase if the glass and floor insulation are preexisting. But in contrast to other products, it does not show a significant relationship with preexisting solar panels. Roof insulation competes with Floor and Wall insulation – when interested in the latter products, the odds of roof insulation are much lower.

Recommendation to improve lead-deal conversion: Roof insulation

Since roof insulation is relatively less often purchased alone (only 51.6%), position it as part of broader envelope improvement programs:

- Offer bundled incentives for roof insulation combined with wall and floor insulation.
- Provide integrated renovation advice to reduce competition between insulation measures.

Who buys it?

Occupation duration influences the adoption of roof insulation. It seems to follow a life-cycle pattern. Roof insulation is most often considered in the early years of occupancy (within 10 years) and again during major renovation phases (around 15–20 years after moving in). Beyond 20 years, adoption rates decline, suggesting that households tend to accept the dwelling's condition and are less inclined to make further major improvements. Education level and income level have an influence. Practice-oriented (vocational) education and a lower income (welfare) level both have a positive effect. It is not clear what the explanation of this could be.

Dwellings constructed between 1945 and 1974 show a higher conversion odds of roof insulation. This has probably a technical reason. In these mid-century houses, roofs were typically constructed with no insulation at all until 1975, when the first minimal insulation requirements were introduced. However, adding interior insulation to these originally uninsulated assemblies can trap moisture between layers, risking wood rot and structural damage.

Detached houses have a higher odds of adopting roof insulation. Detached dwellings generally have larger roof surfaces and more direct exposure to external heat loss compared to row houses. Because of this, roof insulation offers greater energy-saving potential in detached homes.

Recommendation to improve lead-deal conversion: Roof insulation

Target homes with high technical potential:

- Focus on dwellings built between 1945 and 1974, where roofs were typically uninsulated.
- Prioritize detached houses, as they have higher energy-saving potential due to larger roof surfaces.

Align campaigns with life-cycle renovation moments:

- Target households within 10 years of moving in or during major renovation phases (15–20 years).

When/how to sell it?

There is no particular season when best to sell roof insulation. Roof insulation does not show clear seasonality effects. There is only a modest decrease in March and April. This may reflect that, like other insulation measures, the technology is not directly linked to seasonal energy use or installation conditions. The marketing channel does matter. Several channels outperform the baseline depending on which homes are targeted. Digital channels, Letters/flyers, and Referrals/Ambassadors all work better for row/corner houses. Municipality channels work better for detached/semi-detached homes.

Recommendation to improve lead-deal conversion: Roof insulation

Be aware that the optimal marketing channel may vary by housing type:

- Row/corner houses**:** Digital campaigns, letters/flyers, and ambassador programs.
- Detached/semi-detached houses**:** Municipality-led channels (e.g., official letters, local energy coaches).

5.2.5 Glass insulation

How does glass insulation influence other products?

The presence of glass insulation strongly increases the likelihood of adopting additional measures. Floor insulation is the only measure that is not influenced. Conversely, other measures (except Solar panels) do not influence the adoption of glass insulation. This pattern indicates that glass insulation is considered a basic measure, considered a first action towards the aim of retrofitting the house.

Recommendation to improve lead-deal conversion: Glass insulation

Use glass insulation for acceleration: Glass insulation acts as a gateway measure - it strongly increases the likelihood of adopting additional measures (except floor insulation), while other measures (except solar panels) do not increase glass adoption. It’s typically a first action toward retrofitting and is comfort-driven rather than purely financial.

- Position glass insulation as "Phase 1" in retrofit pathways, with clear communication about follow-up measures, especially for heat pumps, as it addresses the envelope first requirement.

Who buys it?

Households with high debt levels are less likely to invest in glass insulation. The measure tends to offer less immediate and visible financial returns compared to, for example, solar panels. For highly indebted households, the combination of limited financial capacity and less tangible short-term benefits may strongly discourage such an investment.

Energy cost saving does NOT seem to be the main driver for adopting glass insulation. There is a negative relationship between a high utility cost ratio and the adoption of glass insulation. Glass insulation is relatively expensive, and the financial benefits are less immediate or visible. Probably, glass insulation is more strongly motivated by improving comfort.

The positive effect of low income (welfare) on glass insulation is hard to explain. It might be an effect of offering a subsidy selectively to low-income households, as part of an action. This would increase the conversion rate specifically for this group. The lack of information on actions implemented again limits the possibility of controlling for this in the model.

Dwelling characteristics also have an influence. Glass insulation shows a significantly lower conversion odds in larger homes across all dwelling types. This is likely related to costs. The costs for glass insulation scale directly with window area making the investment for large dwellings more costly.

Recommendation to improve lead-deal conversion: Glass insulation

- Emphasizing comfort benefits (thermal comfort, reduced drafts, condensation control, and noise reduction) is likely more effective than stressing financial benefits
- Be aware that implementation costs can be a barrier, especially for larger homes

When/how to sell it?

There is no clear season where conversion rates are higher; only the months of August and September show a consistent increase in conversion to Glass. The upcoming winter season may be a trigger to invest in better insulation of windows.

The market channel used does influence conversion to Glass. Digital media and flyers/letters are less effective. A remarkable finding: the same marketing approach can produce opposite results in different housing types: for glass insulation, municipality channels, referrals, and direct contact all work much better than the baseline in detached/semi-detached homes, but worse in row/corner houses. It suggests that the way trust through a personal approach is experienced works out quite differently in detached and row houses.

Recommendation to improve lead-deal conversion: Glass insulation

Be aware that channel effectiveness may vary by housing type:

- Detached/semi-detached: Municipality channels, referrals/ambassadors, and direct contact may work better than baseline.
- Row/corner houses: Digital channels and letters/flyers may perform better; municipality/referrals/direct contact may perform worse than baseline.

Utilizing natural time-of-year moments when demand is high may improve conversion

- The August – September window shows an increased interest in Glass insulation

5.2.6 Heat pump

Heat pumps represent the most advanced retrofit. With 81.9% purchasing as a single product, this measure requires substantial household commitment.

How does a heat pump influence other products?

Heat pump clearly depends on the existence of good insulation: preexisting insulation measures have a quite strong positive impact on the adoption of heat pumps (the only exception is roof insulation). Furthermore, there is no evidence of competition - an interest in a heat pump increases conversion to almost all other products. Particularly notable is a strong association with solar panels: an interest in heat pumps increases the likelihood of buying solar panels. Heat pumps and solar panels are relatively frequently combined in a deal. Moreover an interest in an floor insulation increases the odds for heat pump.

Recommendation to improve lead-deal conversion: Heat pump

Be aware that Heat pumps depend on good insulation and often pair with solar panels.

- Encourage insulation upgrades before heat pump installation.
- Offer combined packages for heat pumps + solar panels and/or insulation measures.

Who buys it?

There are no strong relationships with socio-demographic characteristics. While heat pumps do show an increased odds of conversion for single parents, the effect is only significant for detached/semi-detached dwellings. Financial considerations do play a role. A strong positive effect of a high utility costs ratio suggests that the need to save on energy costs is a trigger to consider a heat pump. A high energy consumption level is furthermore a trigger.

Also feasibility and technical state of the dwelling play a role. Pre-1945 homes show lower heat pump conversion odds. This likely reflects technical and economic barriers: older houses generally have higher heat demand, poorer insulation, and less space for heat pump installation. In addition, these older houses more often have heritage restrictions and complex retrofit requirements, which make implementation more difficult and costly. The positive relationship with dwelling size further points to energy cost saving as a major motivation.

Recommendation to improve lead-deal conversion: Heat pump

Financial benefits - high utility cost ratio and high energy consumption – are a primary motive for adoption. To support this:

- Offer personalized savings calculators showing potential cost reductions.
- Increase awareness of the availability of subsidies to cover the costs of investment.

Address technical barriers in older homes: Pre-1945 homes face feasibility and cost challenges.

- Encourage phased retrofits: insulation first, then heat pump.

Focus on detached/semi-detached homes

- Prioritize outreach to detached/semi-detached homes.

When/how to sell it?

Season has an influence – heat pumps display an increased conversion odds during late autumn and early winter (October to January), when heating needs become more apparent. The marketing channel also has an influence. Digital channels work much worse than the baseline. Meetings and events also work less effectively for heat pumps.

Recommendation to improve lead-deal conversion: Heat pump

Utilizing natural time-of-year moments when demand is high may improve conversion

- Be aware that Digital channels and "meetings/events" may not be the best approach for a heat pump.
- The October–January window, when heating needs are most salient, shows an increased interest in Heat pumps.

5.3 Increasing multi-product adoption

A central objective of the energy transition is the realization of "deep retrofits"—comprehensive renovations that combine multiple measures to maximize energy performance. However, the analysis reveals a significant "Bundle Gap" between this aspiration and market reality. While 41.7% of households initially request multiple products, only 1.6% of successful conversions involve the purchase of three or more products. Furthermore, 82.7% of all completed transactions involve only a single measure.

Since simultaneous purchases frequently fail, possibly due to complexity or budget constraints, policy strategy could focus on facilitating sequential adoption, leveraging the strong technical and behavioural links identified between specific measures.

5.3.1 Leveraging "Gateway" measures and pre-existing infrastructure

The multivariate analysis indicates that distinct "gateway measures" exist, where ownership of one technology significantly accelerates the adoption of subsequent measures. These dependencies provide a roadmap for targeted cross-selling.

- The Solar-Heat Pump combination: Existing ownership of solar panels is the strongest predictor for heat pump adoption, increasing the odds of adoption by 4.3 to 5.6 times compared to the baseline. This suggests that solar panel owners have both the technical infrastructure (electricity generation) and the behavioural alignment to adopt electrification technologies.
- The envelope-first logic: Pre-existing insulation is strongly associated with increased heat pump adoption odds. Households with existing floor, wall, or glass insulation are 2.6 to 5.2 times higher odds to adopt a heat pump. This is in line with the approach where envelope insulation measures precede system upgrades.
- Insulation clustering: Households with one insulation measure are significantly more likely to adopt others. Specifically, in detached homes, existing glass insulation is associated with a 107% higher odds of adoption of wall insulation.

Recommendation: OSS could utilize the sequence relationships between measures. For example, a dedicated campaign targeting solar panel owners with heat pump offers may increase conversion rates.

5.3.2 Capitalizing on expressed interest patterns

The analysis of "interested-in" variables reveals that a household's initial interest in one product is often a signal for the potential adoption of another, even if they are not purchased simultaneously.

- Cross-product signals: An expressed interest in Floor Insulation increases the conversion odds for both Solar Panels and Heat Pumps. This suggests that floor insulation often serves as a trigger point for broader renovation planning.
- Competition effects: Conversely, negative associations exist. Interest in Wall Insulation reduces heat pump conversion odds by over 90%. This indicates that households focusing on basic envelope insulation (wall insulation) are generally not yet interested in complex system changes, suggesting that marketing heat pumps to this specific segment is inefficient.

5.3.3 From simultaneous bundling to sequential

The data on returning behaviour confirms that sequential adoption is the more likely way home-owners implement energy retrofitting.

- Households that successfully completed one purchase are more likely to return. First-time converters show a 47.6% conversion rate on subsequent visits - nearly four times the rate of first-time entrants (13.5%).
- Returning customers demonstrate a broadened scope of investment, which is largely in line with the sequential relationships between products mentioned before. While Wall Insulation remains a primary choice (39.2% of second purchases), its dominance fades significantly compared to the first entry (52.9%). Conversely, relative shares for Roof Insulation double (7.1% to 13.9%), and Heat Pumps see a strong increase in share (0.1% to 1.8%).

The current policy focusing on incentivizing simultaneous measures (e.g., subsidies requiring two measures at once) may be complemented by facilitating a **Step-by-Step approach** to retrofitting:

1. **Secure the first win:** Prioritize the conversion of the primary request (e.g., Wall Insulation) to establish trust and customer status.
2. **Automated re-activation:** Trigger re-engagement campaigns within one month of completion, offering the statistically next-best measure (e.g., offering Roof Insulation to recent Wall Insulation customers).

Annex

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A.1 Supplementary tables

A.1.1 Overall sample characteristics

Table A.1: *Overall conversion rates by dwelling type (in sample)*
This table shows the total number of leads, wins, losses, and conversion rates for each dwelling type (row house, detached house, corner house, semi-detached house) in the complete sample.

Dwelling Type	Total Leads	Wins	Lost	Win Rate
Row house	17,801	3,249	14,552	0.18
Detached house	6,741	954	5,787	0.14
Corner house	8,715	1,425	7,290	0.16
Semi-detached house	5,345	798	4,547	0.15
Total	**38,602**	**6,426**	**32,176**	

Table A.2: *Overall conversion rates by household composition (in sample)*
This table presents the distribution of leads, wins, losses, and conversion rates across different household composition categories (single-person, couple with/without children, single parent, other).

Household Composition Category	Total Leads	Percentage	Wins	Lost	Win Rate
Single-Person only	5,995	15.5%	1,178	4,817	0.20
Couple no children	14,212	36.7%	2,440	11,772	0.17
Couple with children	15,847	40.9%	2,397	13,450	0.15
Single Parent	2,195	5.7%	358	1,837	0.16
Other household combinations	500	1.3%	72	428	0.14
Total	**38,749**	**100.0%**	**6,445**	**32,304**	

Table A.3: *Overall conversion rates by age profile (in sample)*
This table shows the distribution of leads, wins, losses, and conversion rates across different household age categories (young, middle-aged, elderly).

Dwelling Age Profile	Total Leads	Percentage	Wins	Lost	Win Rate
Young (18-34)	3,938	10.2%	632	3,306	0.16
Middle-aged (35-64)	23,545	60.8%	3,699	19,846	0.16
Elderly-aged (65-79)	9,090	23.5%	1,685	7,405	0.19
Very Elderly-aged (80+)	1,442	3.7%	311	1,131	0.22
Mixed-age adults	734	1.9%	118	616	0.16
Total	**38,749**	**100.0%**	**6,445**	**32,304**	

Table A.4: *Overall conversion rates by mortgage position (in sample)*
This table displays the distribution of leads, wins, losses, and conversion rates across different mortgage debt categories.

Mortgage Position	Total Leads	Percentage	Wins	Lost	Win Rate
No mortgage	5,082	13.1%	978	4,104	0.19
Low debt (0-100K)	7,356	19.0%	1,406	5,950	0.19
Medium debt (100-250k)	17,060	44.0%	2,770	14,290	0.16
High debt (>250k)	8,730	22.5%	1,219	7,511	0.14
Positive equity	111	0.3%	22	89	0.20
No data	373	1.0%	45	328	0.12
Total	**38,712**	**100.0%**	**6,440**	**32,272**	

Table A.5: *Overall conversion rates by housing cost burden (in sample)*
This table shows the distribution of leads, wins, losses, and conversion rates across different housing cost burden categories.

Cost Burden	Total Leads	Percentage	Wins	Lost	Win Rate
Affordable (<30%)	34,281	88.5%	5,776	28,505	0.17
Moderate (30%-40%)	2,296	5.9%	367	1,929	0.16
Stretched (40%-50%)	686	1.8%	106	580	0.15
Overburdened (50%-100%)	187	0.5%	21	166	0.11
No Data	1,299	3.4%	175	1,124	0.13
Total	**38,749**	**100.0%**	**6,445**	**32,304**	

Table A.6: *Overall conversion rates by utilities cost burden (in sample)*
This table presents the distribution of leads, wins, losses, and conversion rates across different utility cost burden categories.

Utilities Cost Burden	Total Leads	Percentage	Wins	Lost	Win Rate
Very low (<10%)	2,910	7.5%	437	2,473	0.15
Low (10%-20%)	13,197	34.1%	2,126	11,071	0.16
Average (20%-30%)	11,859	30.6%	1,925	9,934	0.16
High (30%-40%)	6,122	15.8%	1,114	5,008	0.18
Very high (40%-50%)	2,711	7.0%	533	2,178	0.20
Extreme (>50%)	683	1.8%	138	545	0.20
No Data	1,267	3.3%	172	1,095	0.14
Total	**38,749**	**100.0%**	**6,445**	**32,304**	

Table A.7: *Overall conversion rates by Dwelling financial welfare category (in sample)*
This table presents the distribution of leads, wins, losses, and conversion rates across different financial welfare categories.

Financial Welfare Category	Total Leads	Percentage	Wins	Lost	Win Rate
No Data	373	1%	45	328	0.12

(0-20)	259	0.7%	35	224	0.14
(61-80)	11857	30.6%	1888	9969	0.16
(41-60)	8720	22.5%	1510	7210	0.17
(81-100)	14145	36.5%	2347	11798	0.17
(21-40)	3395	8.8%	620	2775	0.18
Total	**38,749**	**100.0%**	**6,445**	**32,304**	

Table A.8: *Household composition by lead channel (in sample)*

This table shows how different household types are distributed across lead acquisition channels, with lead counts, percentages, wins, losses, and conversion rates for each combination.

Lead Channel	Household Type	Total Leads	% of Total	Wins	Lost	Conversion Rate
Municipalities						
	Couple no children	6,377	17.0%	1,268	5,109	0.20
	Couple with children	7,442	19.8%	1,265	6,177	0.17
	Single-Person only	2,938	7.8%	704	2,234	0.24
	Single Parent	1,076	2.9%	224	852	0.21
	Subtotal	**17,833**	**47.5%**	**3,461**	**14,372**	**0.19**
3rd Party Lead Services						
	Couple no children	3,171	8.4%	339	2,832	0.11
	Couple with children	3,493	9.3%	350	3,143	0.10
	Single-Person only	1,297	3.5%	139	1,158	0.11
	Single Parent	502	1.3%	40	462	0.08
	Subtotal	**8,463**	**22.5%**	**868**	**7,595**	**0.10**
Brief/Flyer/Letter						
	Couple no children	524	1.4%	27	497	0.05
	Couple with children	405	1.1%	12	393	0.03
	Subtotal	**929**	**2.5%**	**39**	**890**	**0.04**
Digital Marketing/Social Media						
	Couple no children	519	1.4%	90	429	0.17
	Couple with children	525	1.4%	87	438	0.17
	Single-Person only	220	0.6%	43	177	0.20
	Subtotal	**1,264**	**3.4%**	**220**	**1,044**	**0.17**
Direct Marketing (Door to Door and Phone calls)						
	Couple no children	272	0.7%	64	208	0.24
	Couple with children	356	0.9%	62	294	0.17
	Single-Person only	91	0.2%	25	66	0.27
	Subtotal	**719**	**1.9%**	**151**	**568**	**0.21**
Referrals/Ambassador						
	Couple no children	50	0.1%	25	25	0.50
	Couple with children	51	0.1%	14	37	0.27
	Subtotal	**101**	**0.3%**	**39**	**62**	**0.39**
Unknown						
	Couple no children	3,123	8.3%	614	2,509	0.20
	Couple with children	3,441	9.2%	597	2,844	0.17
	Single-Person only	1,242	3.3%	244	998	0.20
	Single Parent	444	1.2%	75	369	0.17
	Subtotal	**8,250**	**22.0%**	**1,530**	**6,720**	**0.19**
Total		**37,559**	**100%**	**6,308**	**31,251**	**0.17**

Table A.9: *Age composition by lead channel (in sample)*
This table breaks down leads by both age category and acquisition channel, showing total leads, percentages, wins, losses, and conversion rates for each combination.

Lead Channel	Age Category	Total Leads	% of Total	Wins	Lost	Conversion Rate
Municipalities						
	elderly-aged (80+)	692	1.8%	193	499	0.28
	elderly-aged (65-79)	4,111	10.9%	906	3,205	0.22
	middle-aged (35-64)	11,159	29.7%	1,994	9,165	0.18
	young (18-34)	1,751	4.7%	330	1,421	0.19
	Subtotal	**17,713**	**47.1%**	**3,423**	**14,290**	**0.19**
3rd Party Lead Services						
	elderly-aged (80+)	314	0.8%	33	281	0.11
	elderly-aged (65-79)	2,006	5.3%	205	1,801	0.10
	middle-aged (35-64)	5,112	13.6%	523	4,589	0.10
	young (18-34)	959	2.6%	110	849	0.11
	Subtotal	**8,391**	**22.3%**	**871**	**7,520**	**0.10**
Brief/Flyer/Letter						
	elderly-aged (65-79)	333	0.9%	13	320	0.04
	middle-aged (35-64)	645	1.7%	26	619	0.04
	Subtotal	**978**	**2.6%**	**39**	**939**	**0.04**
Digital Marketing/Social Media						
	elderly-aged (80+)	74	0.2%	11	63	0.15
	elderly-aged (65-79)	360	1.0%	58	302	0.16
	middle-aged (35-64)	759	2.0%	134	625	0.18
	young (18-34)	142	0.4%	25	117	0.18
	Subtotal	**1,335**	**3.6%**	**228**	**1,107**	**0.17**
Direct Marketing (Door to Door and Phone calls)						
	elderly-aged (65-79)	181	0.5%	56	125	0.31
	middle-aged (35-64)	469	1.2%	87	382	0.19
	Subtotal	**650**	**1.7%**	**143**	**507**	**0.22**
Referrals/Ambassador						
	elderly-aged (65-79)	37	0.1%	17	20	0.46
	middle-aged (35-64)	80	0.2%	26	54	0.32
	Subtotal	**117**	**0.3%**	**43**	**74**	**0.37**
Other						
	middle-aged (35-64)	152	0.4%	10	142	0.07
	Subtotal	**152**	**0.4%**	**10**	**142**	**0.07**
Unknown						
	elderly-aged (80+)	288	0.8%	62	226	0.22
	elderly-aged (65-79)	1,945	5.2%	419	1,526	0.22
	middle-aged (35-64)	5,093	13.6%	890	4,203	0.17
	young (18-34)	907	2.4%	150	757	0.17
	Subtotal	**8,233**	**21.9%**	**1,521**	**6,712**	**0.18**
Total		**37,569**	**100%**	**6,278**	**31,291**	**0.17**

A.1.2 Population benchmarks (2023)

Table A.10: *Dwelling types for all homeowners in the Netherlands (2023)*
This table shows the distribution of dwelling types across all homeowner households in the Netherlands as of 2023.

Dwelling Type	Total	Percentage
Row house	1,564,065	35.10%
Detached house	915,122	20.53%
Apartment	704,101	15.80%
Corner house	681,540	15.29%
Semi-detached house	589,215	13.22%
Unknown	2,466	0.06%
Total	**4,456,509**	**100.00%**

Table A.11: *Age profile for all homeowner dwellings (2023)*
This table presents the age distribution of homeowner households across all dwelling types in the Netherlands as of 2023.

Dwelling Age Profile	Total	Percentage
Middle-aged (35-64)	2,583,744	57.98%
Elderly-aged (65-79)	1,114,542	25.01%
Young (18-34)	411,413	9.23%
Very Elderly-aged (80+)	344,720	7.74%
Mixed-age adults	2,090	0.05%
Total	**4,456,509**	**100.00%**

Table A.13: *Construction period distribution for all homeowner dwellings (2023)*
This table shows the distribution of construction periods for all homeowner dwellings in the Netherlands as of 2023.

Construction Period	Total	Percentage
After 1991	1,354,750	30.40%
Between 1945 and 1974	1,190,825	26.72%
Between 1974 and 1991	1,055,015	23.67%
Before 1945	855,919	19.21%
Total	**4,456,509**	**100.00%**

Table A.14: *Construction period distribution for family dwellings (excluding apartments) (2023)*
This table presents the distribution of construction periods specifically for family dwellings (excluding apartments) in the Netherlands as of 2023.

Construction Period	Total	Percentage
After 1991	1,084,151	28.89%
Between 1945 and 1974	1,027,549	27.39%
Between 1974 and 1991	949,915	25.32%
Before 1945	690,793	18.41%
Total	**3,752,408**	**100.00%**

***Table A.15:** Financial welfare categories for family dwellings (excluding apartments) (2023)*
This table shows the distribution of homeowner households across financial welfare percentile categories for family dwellings in the Netherlands as of 2023.

Financial Welfare Category	Total	Percentage
(81-100)	1,319,405	35.16%
(61-80)	1,164,985	31.05%
(41-60)	922,978	24.60%
(21-40)	313,972	8.37%
(0-20)	31,068	0.83%
Total	**3,752,408**	**100.00%**

***Table A.16:** Utilities cost burden for all homeowner dwellings (2023)*
This table presents the distribution of utility cost burdens across all homeowner households in the Netherlands as of 2023.

Utilities Cost Burden	Total	Percentage
Average (20%-30%)	1,338,715	30.04%
Low (10%-20%)	1,323,610	29.70%
High (30%-40%)	780,879	17.52%
Very low (<10%)	421,741	9.46%
Very high (40%-50%)	366,435	8.22%
Extreme (>50%)	132,008	2.96%
No Data	93,121	2.09%
Total	**4,456,509**	**100.00%**

***Table A.17:** Utilities cost burden for family dwellings (excluding apartments) (2023)*
This table shows the distribution of utility cost burdens specifically for family dwelling homeowners in the Netherlands as of 2023.

Utilities Cost Burden	Total	Percentage
Average (20%-30%)	1,107,774	29.52%
Low (10%-20%)	1,069,342	28.50%
High (30%-40%)	686,572	18.30%
Very high (40%-50%)	346,288	9.23%
Very low (<10%)	343,408	9.15%
Extreme (>50%)	128,363	3.42%
No Data	70,661	1.88%
Total	**3,752,408**	**100.00%**

***Table A.18:** Housing cost burden for all homeowner dwellings (2023)*
This table displays the distribution of total housing cost burdens across all homeowner households in the Netherlands as of 2023.

Cost Burden	Total	Percentage
Affordable (<30%)	4,083,714	91.63%
Moderate (30%-40%)	214,379	4.81%
Stretched (40%-50%)	65,066	1.46%
Overburdened (50%-100%)	63,103	1.42%
Exceed income (>100%)	25,171	0.56%
No Data	5,076	0.11%
Total	**4,456,509**	**100.00%**

***Table A.19:** Housing cost burden for family dwellings (excluding apartments) (2023)*
This table presents the distribution of total housing cost burdens specifically for family dwelling homeowners in the Netherlands as of 2023.

Cost Burden	Total	Percentage
Affordable (<30%)	3,462,922	92.29%
Moderate (30%-40%)	167,836	4.47%
Stretched (40%-50%)	50,266	1.34%
Overburdened (50%-100%)	48,494	1.29%
Exceed income (>100%)	19,048	0.51%
No Data	3,842	0.10%
Total	**3,752,408**	**100.00%**

***Table A.20:** Mortgage position for family dwellings (excluding apartments) (2023)*
This table shows the distribution of mortgage debt levels across family dwelling homeowners in the Netherlands as of 2023.

Mortgage Position	Total	Percentage
Medium debt (100-250k)	1,501,028	40.01%
High debt (>250k)	877,219	23.38%
Low debt (0-100K)	744,930	19.85%
No mortgage	612,779	16.33%
Positive equity	11,015	0.29%
Strong positive equity (>50k surplus)	5,437	0.14%
Total	**3,752,408**	**100.00%**

***Table A.21:** Construction deposit ownership for family dwellings (excluding apartments) (2023)*
This table presents the proportion of family dwelling homeowners with construction deposits in the Netherlands as of 2023.

Has Construction Deposit	Total	Percentage
Has Construction Deposit: No	3,602,837	96.01%
Has Construction Deposit: Yes	149,571	3.99%
Total	**3,752,408**	**100.00%**

***Table A.22:** Dwelling type distribution comparison - Sample vs. population*
This table compares the distribution of dwelling types between the study sample and the general Dutch homeowner population, showing representation ratios.

Housing Type	Population (N)	Population %	Leads % of Total	Representation Ratio	Conversion Rate
Row house	1,564,065	41.71%	46.11%	1.11	0.18
Detached house	915,122	24.41%	17.46%	0.72	0.14
Corner house	681,540	18.17%	22.58%	1.24	0.16
Semi-detached house	589,215	15.71%	13.85%	0.88	0.15
Total	**3,749,942**	**100%**	**100%**		

A.1.3 Solar panel characteristics

Table A.23: *Solar panel ownership for family dwellings (excluding apartments) (2023)*
This table shows the proportion of family dwelling homeowners with solar panels installed in the Netherlands as of 2023.

Solar Panels	Total	Percentage
Has Solar Panels: Yes	2,021,677	52.69%
Has Solar Panels: No	1,814,561	47.31%
Total	**3,836,238**	**100.00%**

Table A.24: *Solar panel ownership in sample (as of in 2023)*
This table presents the proportion of households in the study sample with solar panels installed.

Solar Panels	Total	Percentage
True	16,841	48.28%
False	16,783	48.12%
Unknown	1,257	3.60%
Total	**34,881**	**100.00%**

Table A.25*: Age profile for solar panel owners in all family dwellings (excluding apartments) (2023)*
This table displays the age distribution of family dwelling homeowners who have solar panels installed as of 2023.

Dwelling Age Profile	Total	Percentage
Middle-aged (35-64)	1,285,639	63.59%
Elderly-aged (65-79)	510,651	25.26%
Young (18-34)	155,808	7.71%
Very Elderly-aged (80+)	67,811	3.35%
Mixed-age adults	1,768	0.09%
Total	**2,021,677**	**100.00%**

Table A.26: *Construction period for all family dwellings with solar panels (excluding apartments) (2023)*
This table shows the distribution of construction periods among family dwellings that have solar panels installed as of 2023.

Construction Period	Total	Percentage
After 1991	699,572	35.13%
Between 1974 and 1991	517,923	26.01%
Between 1945 and 1974	488,347	24.53%
Before 1945	285,344	14.33%
Total	**1,991,186**	**100.00%**

Table A.27: *Dwelling type distribution for solar panel owners (excluding apartments) (2023)*
This table presents the distribution of dwelling types among family dwelling homeowners with solar panels in 2023.

Dwelling Type	Total	Percentage
Row house	738,548	37.09%
Detached house	554,267	27.84%
Corner house	359,964	18.08%
Semi-detached house	337,094	16.93%
Unknown	1,313	0.07%
Total	**1,991,186**	**100.00%**

Table A.28: *Financial welfare for solar panel owners in family dwellings (excluding apartments) (2023)*
This table shows the distribution of financial welfare categories among family dwelling homeowners with solar panels as of 2023.

Financial Welfare Category	Total	Percentage
(81-100)	812,730	40.82%
(61-80)	628,286	31.55%
(41-60)	420,770	21.13%
(21-40)	119,941	6.02%
(0-20)	9,459	0.48%
Total	**1,991,186**	**100.00%**

A.1.4 District heating characteristics

Table A.29 *District heating connection for family dwellings (excluding apartments) (2023)*
This table shows the proportion of family dwelling homeowners connected to district heating systems in the Netherlands as of 2023.

District Heating	Total	Percentage
Has District Heating: No	3,630,038	96.24%
Has District Heating: Yes	141,977	3.76%
Total	**3,772,015**	**100.00%**

Table A.30: *Construction period for family dwellings with district heating (excluding apartments) (2023)*
This table displays the distribution of construction periods among family dwellings connected to district heating as of 2023.

Construction Period	Total	Percentage
After 1991	99,235	69.90%
Between 1974 and 1991	40,076	28.23%
Between 1945 and 1974	1,848	1.30%
Before 1945	818	0.58%
Total	**141,977**	**100.00%**

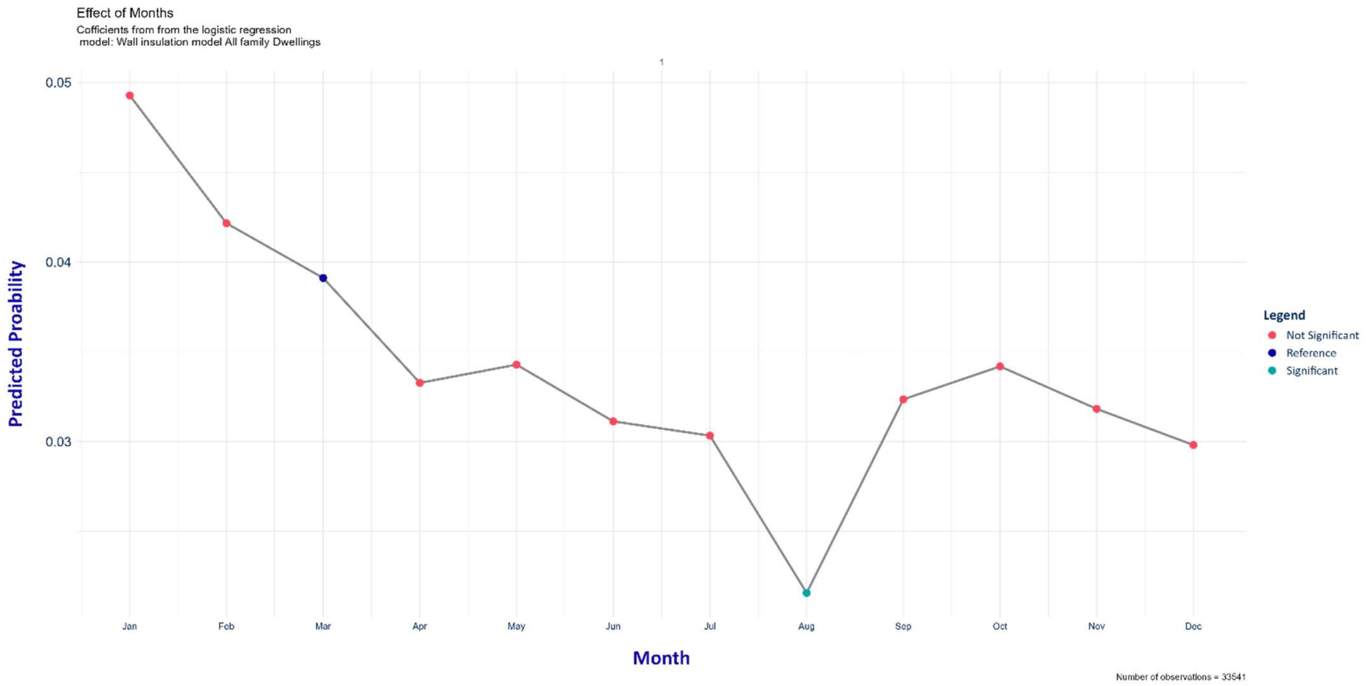
Table A.31: *Dwelling type distribution for district heating connections (excluding apartments) (2023)*
This table presents the distribution of dwelling types among family dwellings connected to district heating systems as of 2023.

Dwelling Type	Total	Percentage
Row house	93,561	65.90%
Corner house	29,463	20.75%
Semi-detached house	9,871	6.95%
Detached house	9,054	6.38%
Unknown	28	0.02%
Total	**141,977**	**100.00%**

A.2 Temporal effects visualization

Figure A.7.1*: Monthly seasonal effects on wall insulation adoption probability (All Family Dwellings)*

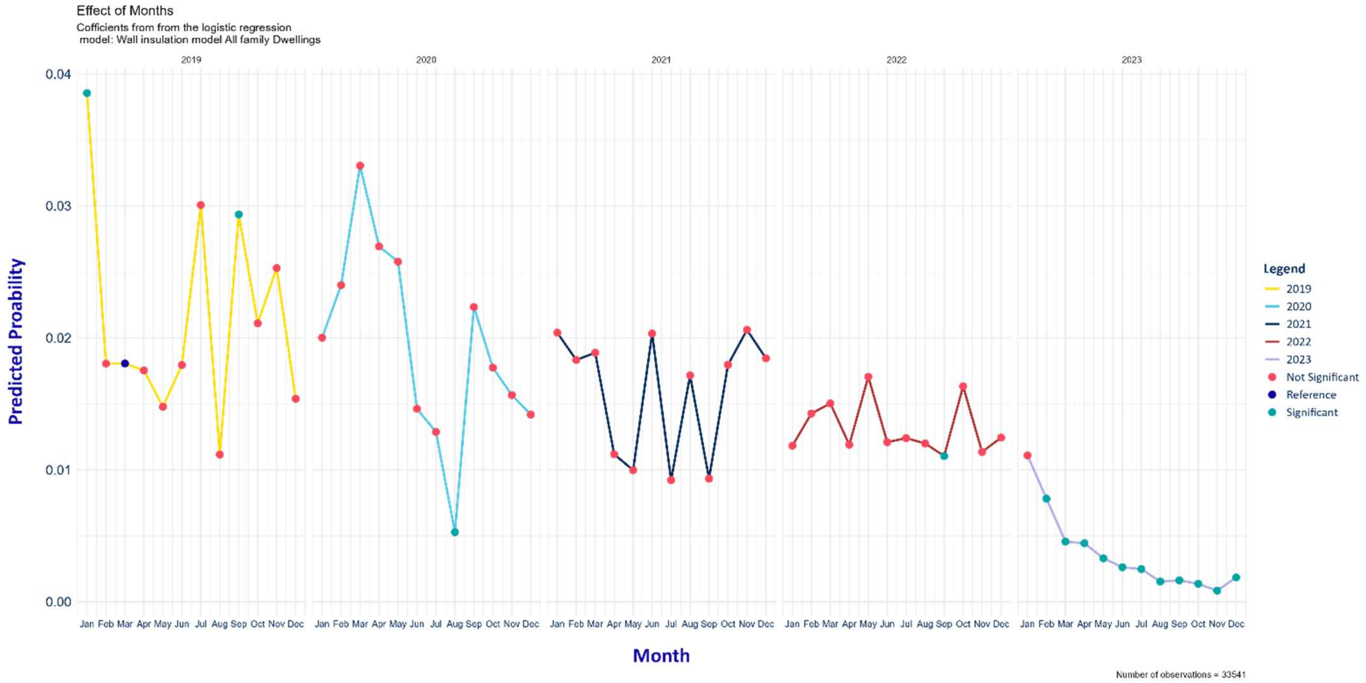
This figure displays the predicted probability of wall insulation adoption by month, showing seasonal patterns with March as the reference month (indicated by blue reference points). Red points indicate months with non-significant effects, while cyan points show statistically significant differences from the reference month.



Note: Coefficients from the logistic regression model for wall insulation in All Family Dwellings. March serves as the reference category. The figure shows relatively stable adoption probabilities across most months (ranging from approximately 0.029 to 0.049), with August showing a significant decrease (cyan point at approximately 0.023)

Figure A.7.2: *Combined year and month effects on wall insulation adoption probability (All Family Dwellings)*

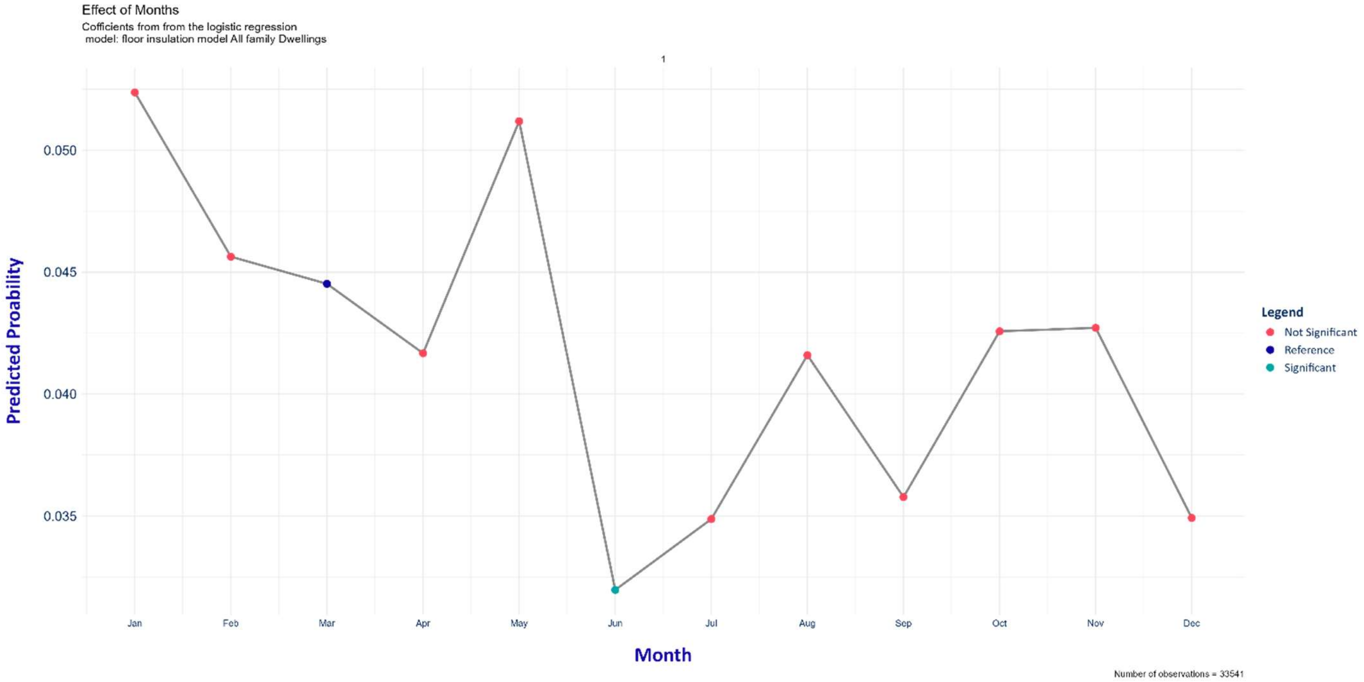
This figure shows the predicted probability of wall insulation adoption across all months from 2019 to 2023, illustrating both seasonal patterns within years and declining trends across years. Each year is represented by a different colored line, with significance levels indicated by point colors (red = not significant, blue = reference month, cyan = significant).



Note: Coefficients from the logistic regression model for wall insulation in All Family Dwellings. The figure demonstrates the decline in wall insulation adoption probability starting in 2022, with predicted probabilities decreasing from approximately 0.01-0.04 in 2019-2021 to 0.001-0.012 in 2023. This visualization complements the year effects discussion in Section 4.2.4, showing how temporal patterns manifest across the entire study period.

Figure A.7.3*: Monthly seasonal effects on floor insulation adoption probability (All Family Dwellings)*

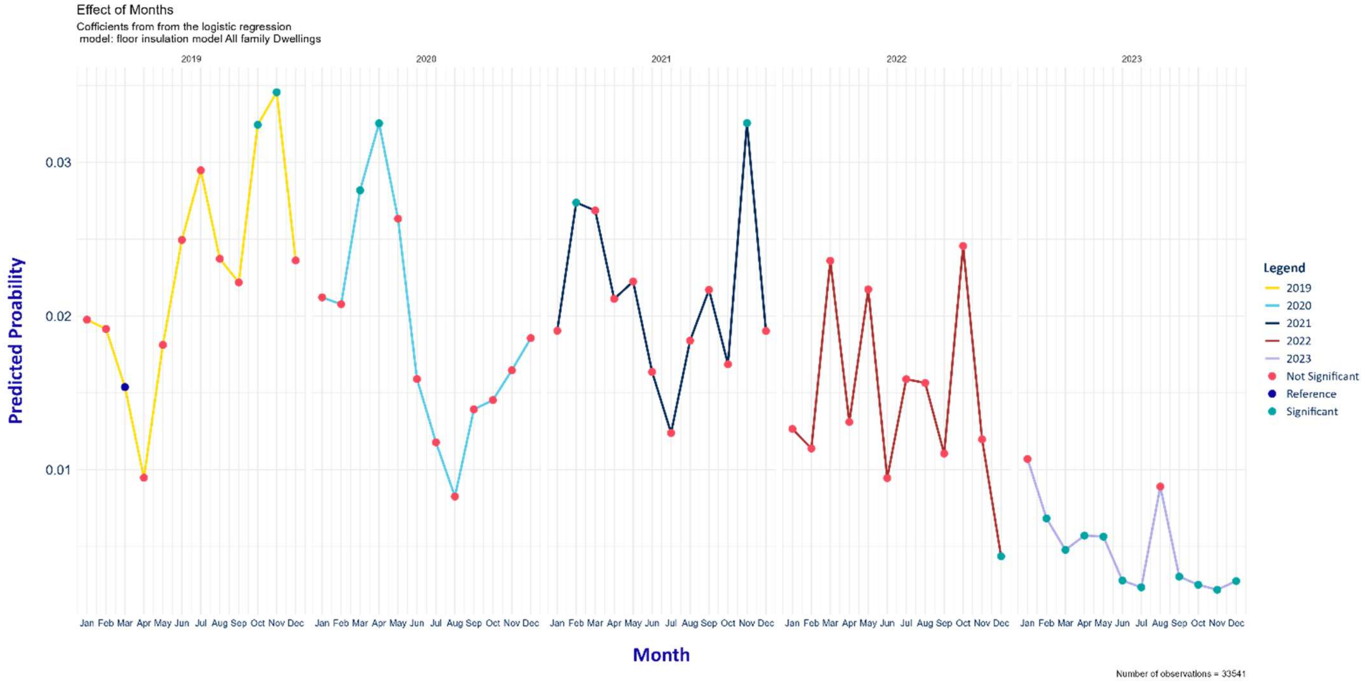
This figure displays the predicted probability of floor insulation adoption by month, showing seasonal patterns with March as the reference month (indicated by blue reference points). Red points indicate months with non-significant effects, while cyan points show statistically significant differences from the reference month.



Note: Coefficients from the logistic regression model for floor insulation in All Family Dwellings. March serves as the reference category. The figure shows considerable variation across months (ranging from approximately 0.032 to 0.052), with June showing a significant decrease (cyan point at approximately 0.032). Unlike wall insulation, floor insulation shows more pronounced seasonal fluctuation, with peaks in January (0.052) and May (0.052) and a notable trough in June.

Figure A.7.4: *Combined year and month effects on floor insulation adoption probability (All Family Dwellings)*

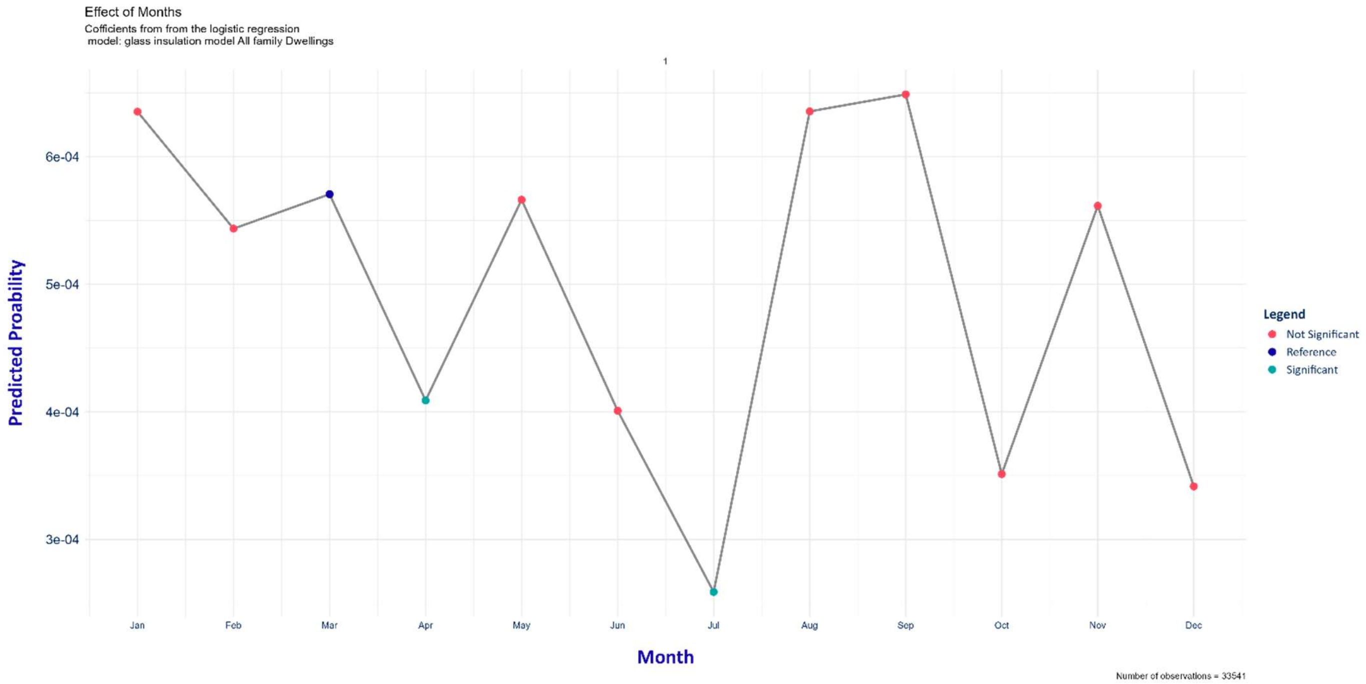
This figure shows the predicted probability of floor insulation adoption across all months from 2019 to 2023, illustrating both seasonal patterns within years and declining trends across years. Each year is represented by a different colored line, with significance levels indicated by point colors (red = not significant, blue = reference month, cyan = significant).



Note: Coefficients from the logistic regression model for floor insulation in All Family Dwellings. The figure demonstrates a similar decline pattern to wall insulation, with predicted probabilities decreasing sharply in 2022-2023. Floor insulation shows predicted probabilities ranging from approximately 0.010-0.034 in 2019-2021, declining to 0.003-0.009 in 2023. The seasonal patterns remain visible within each year, with multiple significant months (cyan points) particularly in 2019-2021, indicating that temporal effects were more pronounced in earlier years before the overall decline dominated.

Figure A.7.5: *Monthly seasonal effects on glass insulation adoption probability (All Family Dwellings)*

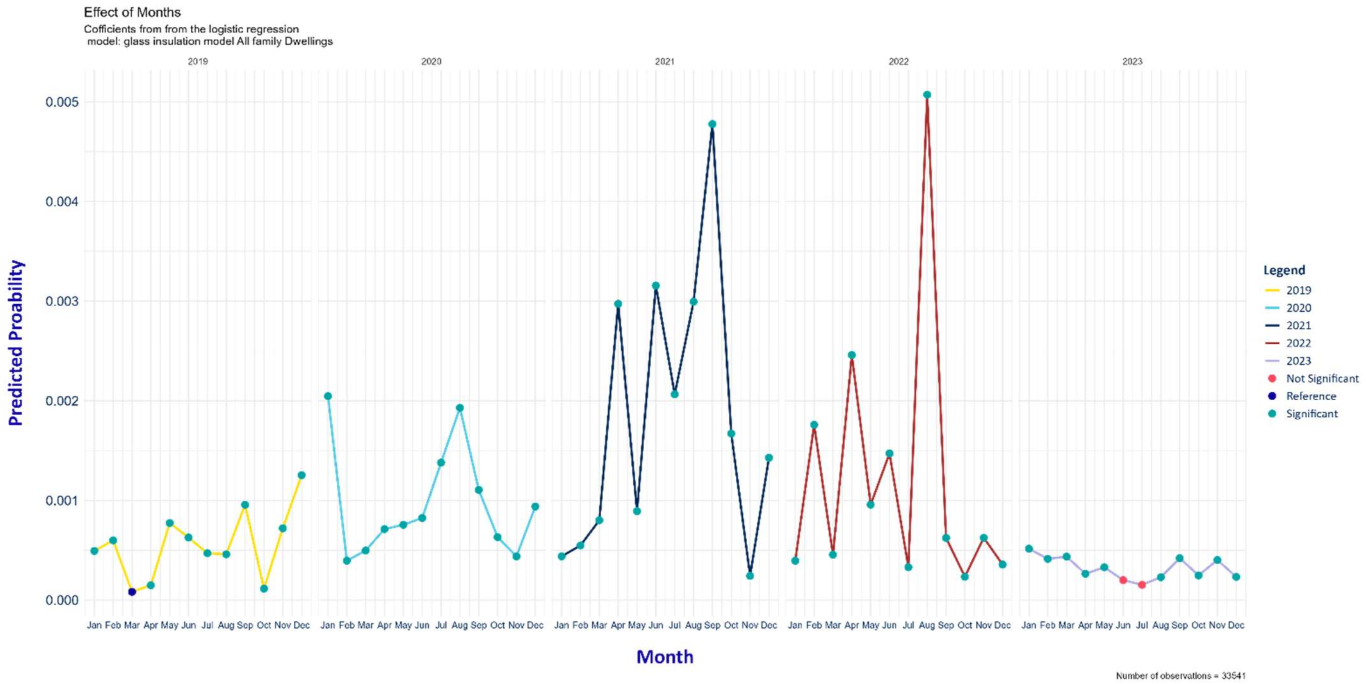
This figure displays the predicted probability of glass insulation adoption by month, showing seasonal patterns with March as the reference month (indicated by blue reference points). Red points indicate months with non-significant effects, while cyan points show statistically significant differences from the reference month.



Note: Coefficients from the logistic regression model for glass insulation in All Family Dwellings. March serves as the reference category. The figure shows considerable variation across months, with significant decreases in April and July marked by cyan points. Glass insulation shows distinct seasonal patterns with peaks in January , August-September, and November, and notable troughs in April and July.

Figure A.7.6: *Combined year and month effects on glass insulation adoption probability (All Family Dwellings)*

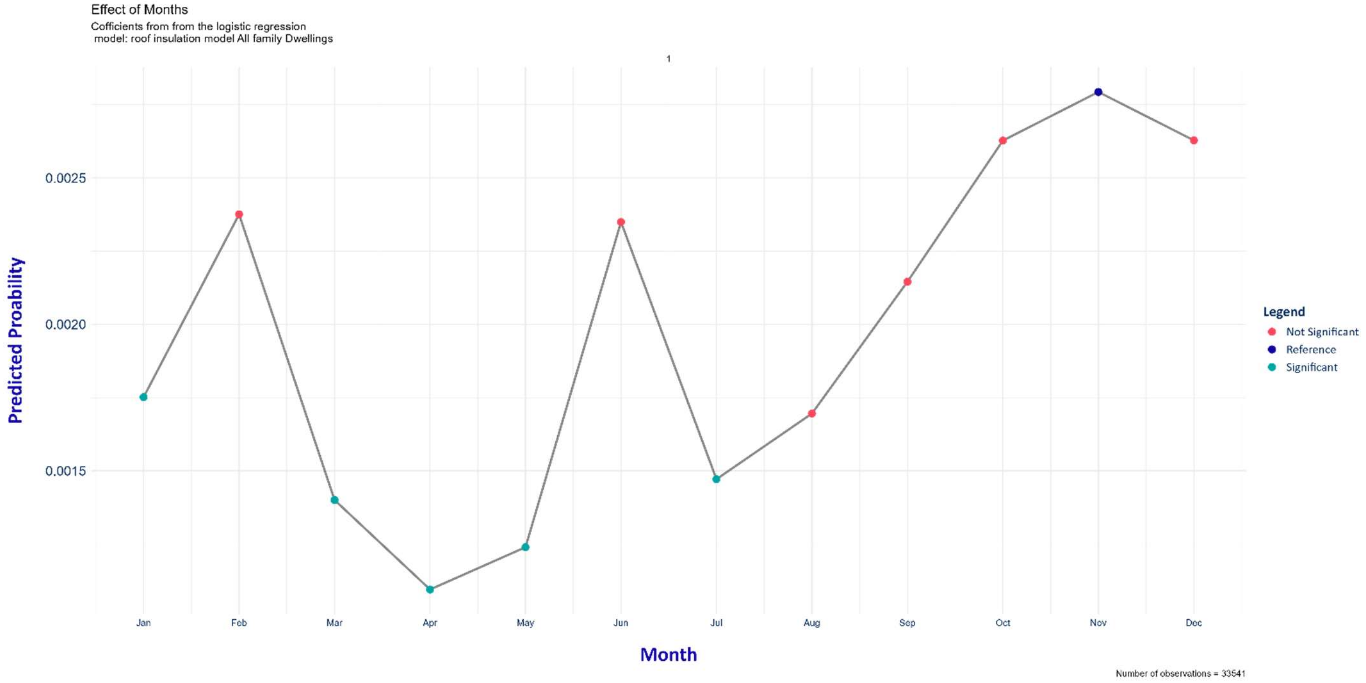
This figure shows the predicted probability of glass insulation adoption across all months from 2019 to 2023, illustrating both seasonal patterns within years and trends across years. Each year is represented by a different colored line, with significance levels indicated by point colors (red = not significant, blue = reference month, cyan = significant).



Note: Coefficients from the logistic regression model for glass insulation in All Family Dwellings. The figure demonstrates a distinctive pattern compared to wall and floor insulation: glass insulation shows a marked increase in 2021 (black line, ranging from 0.0009 to 0.0048), consistent with the expansion of the ISDE subsidy scheme discussed in Section 4.2.4. This 2021 peak includes multiple significant months (cyan points), particularly notable spikes in July (0.0048) and September (0.0052). The 2022 period (red line) shows elevated adoption probabilities ranging from 0.0003 to 0.0052, with a dramatic peak in September 2022. Subsequently, 2023 (purple line) shows relatively stable but lower adoption probabilities (ranging from 0.0002 to 0.0007), indicating the sustained effect of the 2021 policy changes despite some decline from the 2021-2022 peaks. Unlike wall and floor insulation which show continuous decline in 2022-2023, glass insulation demonstrates policy-driven variation with the 2021 subsidy expansion creating a persistent elevation above 2019-2020 baseline levels.

Figure A.7.7*: Monthly seasonal effects on roof insulation adoption probability (All Family Dwellings)*

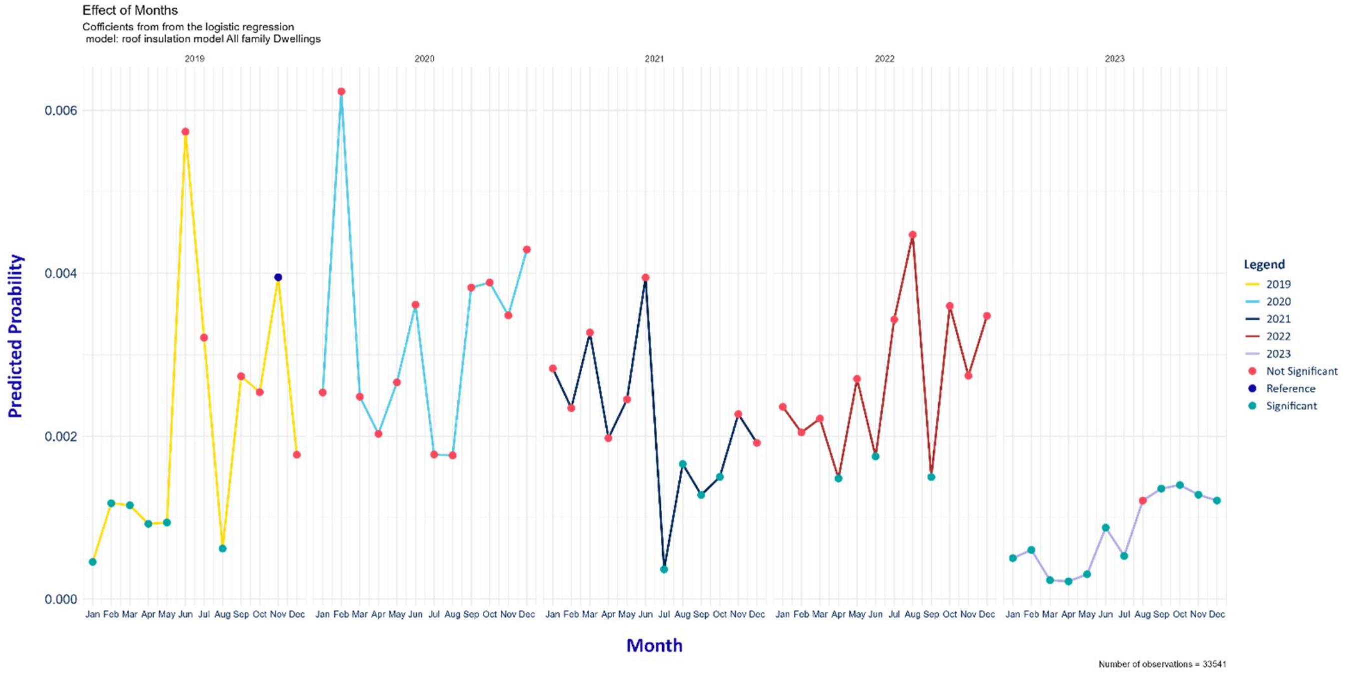
This figure displays the predicted probability of roof insulation adoption by month, showing seasonal patterns with November as the reference month (indicated by blue reference points). Red points indicate months with non-significant effects, while cyan points show statistically significant differences from the reference month.



Note: Coefficients from the logistic regression model for roof insulation in All Family Dwellings. November serves as the reference category. The figure shows substantial variation across months (ranging from approximately 0.0011 to 0.0028), with significant decreases marked by cyan points in January (0.0017), March (0.0014), April (0.0011), May (0.0012), and July (0.0015). Roof insulation displays a seasonal pattern with lowest adoption probabilities in spring (March-May, ranging 0.0011-0.0014) and highest in late autumn (November reference at 0.0028).

Figure A.7.8*: Combined year and month effects on roof insulation adoption probability (All Family Dwellings)*

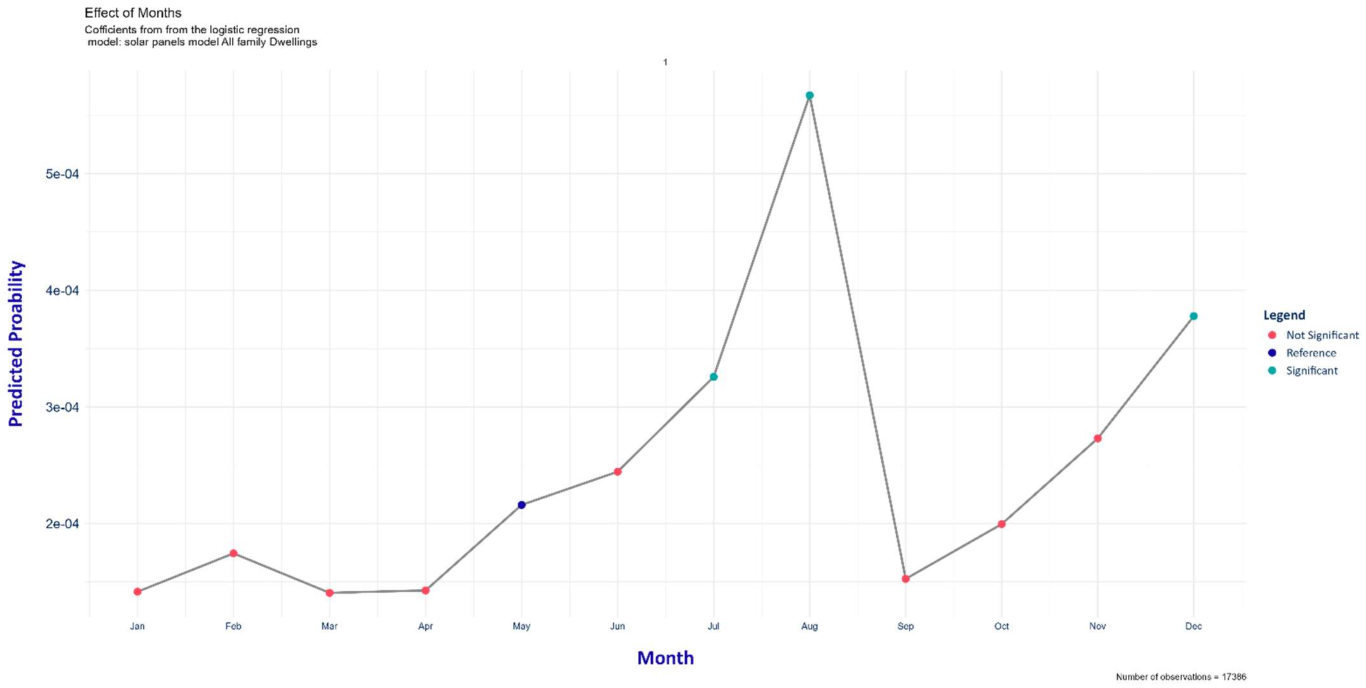
This figure shows the predicted probability of roof insulation adoption across all months from 2019 to 2023, illustrating both seasonal patterns within years and trends across years. Each year is represented by a different colored line, with significance levels indicated by point colors (red = not significant, blue = reference month, cyan = significant).



Note: Coefficients from the logistic regression model for roof insulation in All Family Dwellings. The figure demonstrates several patterns: 2019 (yellow line) shows relatively stable adoption ranging from 0.0007 to 0.0057 with a notable February peak. 2020 (cyan line) shows the highest overall adoption levels, consistent with the significant positive 2020 year effect reported in Table 4.2.4.1, with a April peak reaching 0.0065 and elevated probabilities throughout (0.0017-0.0065). The 2021 period (black line) shows moderate adoption levels (0.0018-0.0043) with visible seasonal fluctuation. Subsequently, 2022 (red line) demonstrates considerable volatility with adoption ranging from 0.0015 to 0.0047, showing multiple peaks but no consistent decline. Finally, 2023 (purple line) shows the substantial decline referenced in Section 4.2.4, with adoption probabilities collapsing to 0.0002-0.0015, *representing a 61-62% decrease as reported in the text. The seasonal patterns remain visible within each year, particularly the spring trough (March-May) that appears consistently across multiple years, with numerous significant months (cyan points) especially in 2020-2021.*

Figure A.7.9*: Monthly seasonal effects on solar panel adoption probability (All Family Dwellings)*

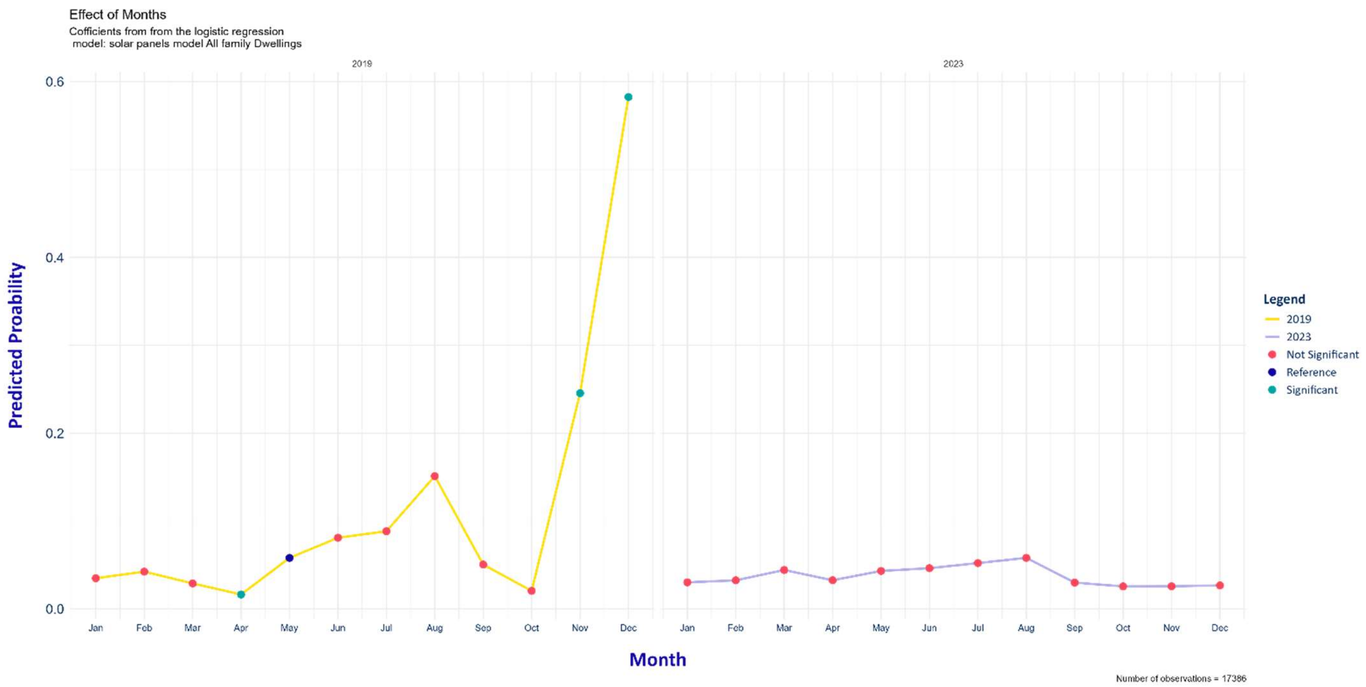
This figure displays the predicted probability of solar panel adoption by month, showing seasonal patterns with May as the reference month (indicated by blue reference points). Red points indicate months with non-significant effects, while cyan points show statistically significant differences from the reference month.



Note: Coefficients from the logistic regression model for solar panels in All Family Dwellings. May serves as the reference category. The figure shows substantial seasonal variation, with significant increases marked by cyan points in July , August , and December. Solar panels display a pronounced summer peak with adoption probability increasing steadily from May through July-August, reaching maximum in August. The December spike is particularly notable and, as discussed in Section 4.2.4, reflects a specific marketing campaign by Reimarkt demonstrating that promotional actions can influence adoption regardless of seasonal factors.

Figure A.7.10*: Combined year and month effects on solar panel adoption probability (All Family Dwellings)*

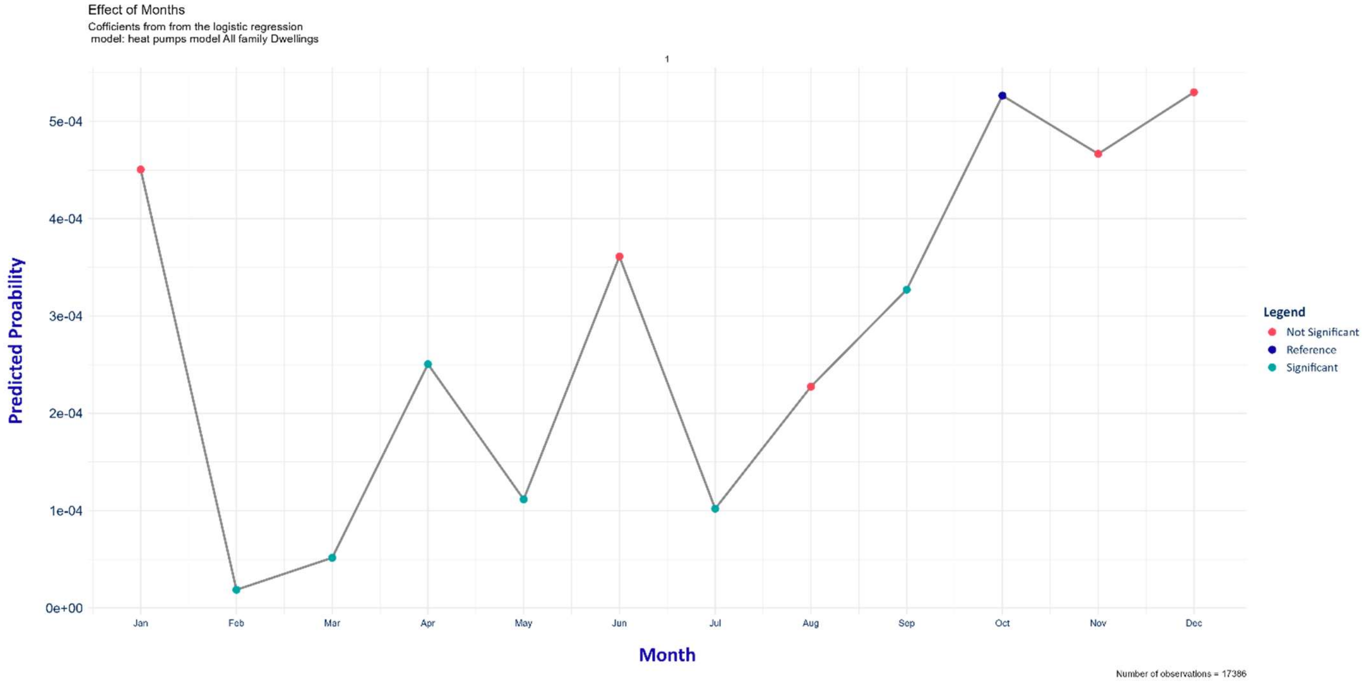
This figure shows the predicted probability of solar panel adoption across all months from 2019 to 2023, illustrating both seasonal patterns within years and trends across years. Each year is represented by a different colored line, with significance levels indicated by point colors (red = not significant, blue = reference month, cyan = significant).



Note: Coefficients from the logistic regression model for solar panels in All Family Dwellings. The figure reveals a temporal pattern unique to solar panels compared to insulation products. The 2019 period (yellow line) shows moderate adoption probabilities (0.02-0.15) with considerable monthly variation and multiple significant months (cyan points), culminating in an extraordinary December peak reaching 0.58 (58% predicted probability) - the highest adoption probability observed for any product-month combination in the entire *study. This December 2019 spike, significantly exceeding all other months by a factor of 3-4, reflects the Reimarkt marketing campaign discussed in Section 4.2.4. Subsequently, 2023 (purple line) shows uniformly low and stable adoption probabilities (0.03-0.05) with no significant monthly effects, representing a collapse from 2019 levels.*

Figure A.7.11*: Monthly seasonal effects on heat pump adoption probability (All Family Dwellings)*

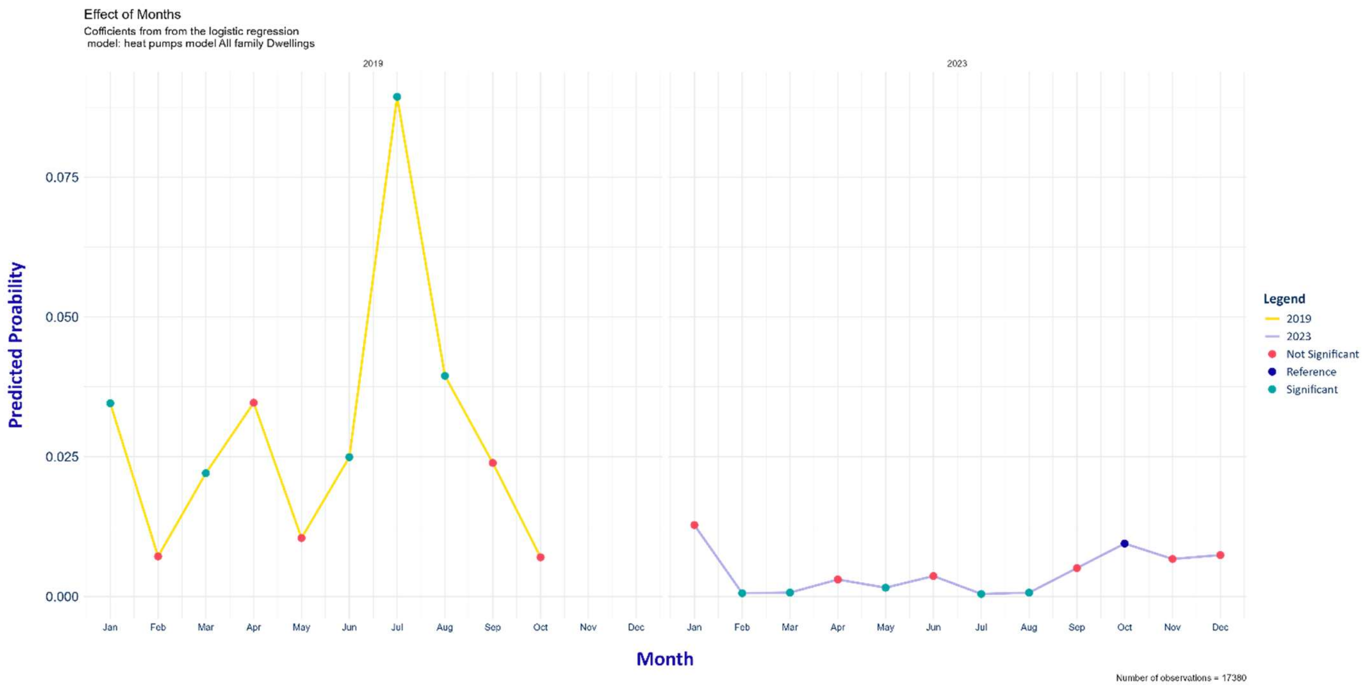
This figure displays the predicted probability of heat pump adoption by month, showing seasonal patterns with October as the reference month (indicated by blue reference points). Red points indicate months with non-significant effects, while cyan points show statistically significant differences from the reference month.



Note: Coefficients from the logistic regression model for heat pumps in All Family Dwellings. October serves as the reference category. The figure shows seasonal variation , with significant decreases marked by cyan points in February , March , May , July , and September.

Figure A.7.12*: Combined year and month effects on heat pump adoption probability (All Family Dwellings)*

This figure shows the predicted probability of heat pump adoption across all months from 2019 to 2023, illustrating both seasonal patterns within years and trends across years. Each year is represented by a different colored line, with significance levels indicated by point colors (red = not significant, blue = reference month, cyan = significant).



Note: Coefficients from the logistic regression model for heat pumps in All Family Dwellings. The figure reveals a temporal pattern showing market decrease between 2019 and 2023. The 2019 period (yellow line) demonstrates substantial adoption probabilities ranging from 0.008 to 0.088, with a July peak reaching 0.088 (8.8% predicted probability) marked by a cyan significant point. The 2019 pattern shows multiple significant months (cyan points in January, February, March, June, July, August) and considerable volatility, indicating an active market responsive to both seasonal factors and other influences. In sharp contrast, 2023 (purple line) shows uniformly depressed adoption probabilities ranging only from 0.0007 to 0.012, representing a 85-95% collapse from 2019 levels. The 2023 pattern is nearly flat with minimal monthly variation and no significant monthly effects.

A.3 Logistic regression results

Logistic regression results used in this analysis can be accessed on this link https://mohamed-elsaady.github.io/cross_results_table/mohamed_elsaady_thesis_predicting_homeowner_retrofit_decisions_logistic_regression_results.pdf