Unequal Income Effects of Home Insulation and Heat Pump Adoption across Heterogeneous Households

A Microsimulation Analysis for the Netherlands

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Contents

- Methods: microsimulation
- Income effects of home improvements
  - Current paper: insulation
  - Extension: combination heatpumps
- Take-aways

Research question

- Concerns about **inequality in the energy transition**: affordability and capacity of households to invest
  - What about poor households? What about households in poorly insulated homes?
- Dutch context **voluntary nature**: what **financial incentives** does current policy provide households to invest in (or to agree with) home improvements?
  - Especially relevant for home owners and tentants in commerical housing

- **Key question**: what are the income effects of individual home improvements for Dutch households?
  - Which options are financially viable for households, given current policy and price expectations?
  - How does this vary between groups of households?

Main take-aways

1. **Our microsimulation reveals huge heterogeneity in income effects of home improvements**
   - No one-size-fits-all solution
2. **Extensive insulation alone is not cost-effective for majority of Dutch households**
   - Imposing a simple norm to extensively insulate homes may adversely affect low-income households
3. **But, >90% of households are better off doing home improvements with current policies and price expectations**
   - Heatpumps, combined with extensive insulation if necessary, are cost-effective for the vast majority of Dutch households
4. **Current policies have a major contribution to providing financial incentives to households for individual home improvement**
   - Without subsidies for insulation and heatpumps, the majority of households would be better off with no or weaker home improvements

The Dutch context

- Natural endowment: natural gas discovered in 1960s
  - Large-scale production for domestic use and export
  - Result: majority of Dutch homes heated with natural gas (individual gas kettles)
- Cheap energy, cheap heating, little attention to insulation…
  - Large share of homes with poor energy quality
  - Energy crisis of past years has spurred insulation efforts
  - Social housing sector frontrunner (!)
- Collective options limited: district heating only ~7% of Dutch homes
  - Much lower coverage in family homes, more so in appartment/flat buildings
  - Currently hotly debated in parliament – ownership of networks, legal framework costs to households

Research agenda

- Step 1: methodological challenges in determining energy savings
  - Existing work: back-of-the-envelope with stylized homes and households
  - Enormous variety in quality of homes
  - Large heterogeneity in energy consumption, even conditional on home
  - Policy question: ex-ante unclear who benefits/loses financially
- Solution: microsimulation with the real housing stock of the Netherlands
  - HESTIA microsimulation model (developed by PBL, TNO)

Research agenda

Step 2: financial benefits/costs for households – who lives in these homes?

- Do investements pay off?
- Who benefits, who loses?
- Ownership type dependent, hh income, wealth, age, hh composition, etc.

- Solution: combine energy savings of home improvement with household energy bill using microdata for all Dutch households in the Netherlands
- Mimosi model (used for purchasing power simulation, CPB)

Methods and approach

- HESTIA: microsimulation of home improvement for ~5 million homes per improvement option
  - Starting with extensive insulation to the ‘Insulation Standard’
  - Extension: adding hybrid and electric heatpumps
- Mimosi : net costs and benefits for each household, including subsidies and fiscal benefits
  - Microdata for ~5 mln Dutch households through Statistics Netherlands
  - Stimulating policies: 30% subsidy on insulation and heatpumps, ‘free’ insulation for current households in social housing (Nationale Prestatieafspraken)
  - Fiscal effects: mortgage interest deductability, rent subsidy
- ‘What-if’ approach: all homes undergo improvement under scenario
  - Households/landlords take measures, assuming no barriers to financing or willingness

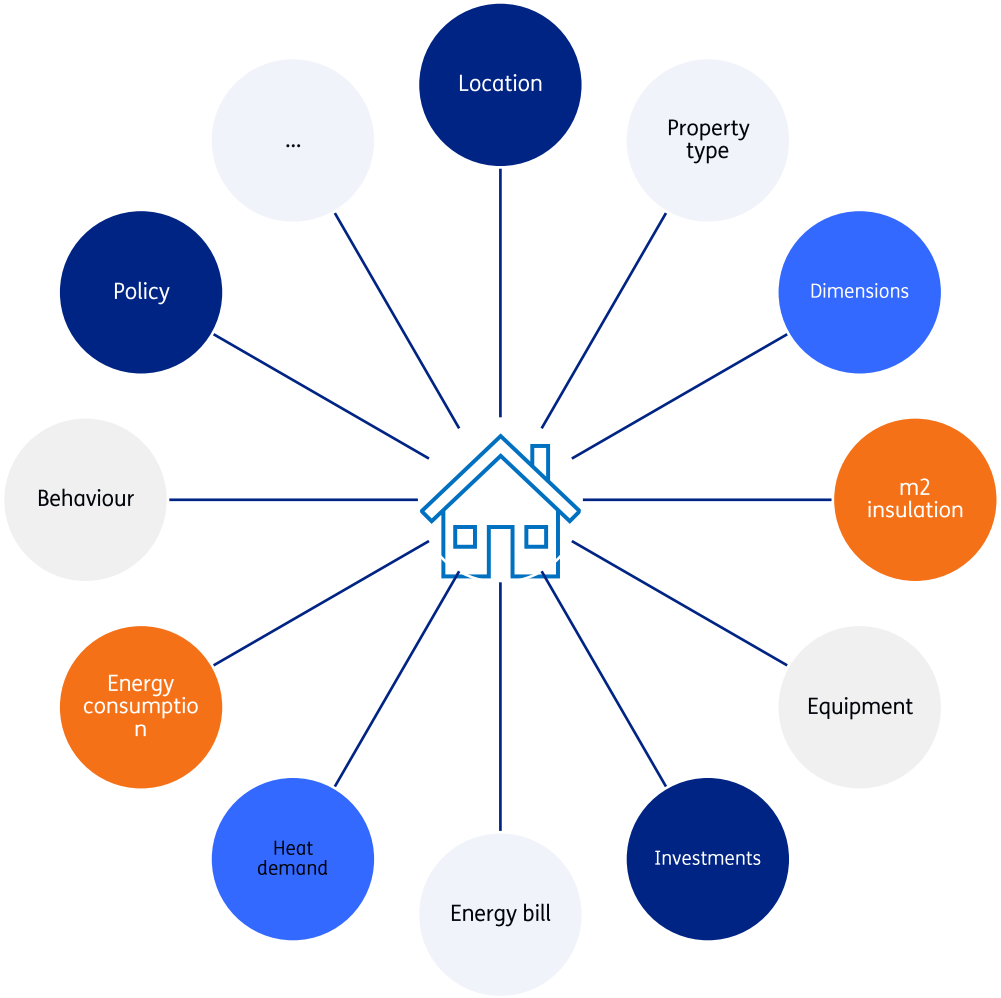
Hestia

Planbureau voor de Leefomgeving

Policy assessments on Micro level with Hestia

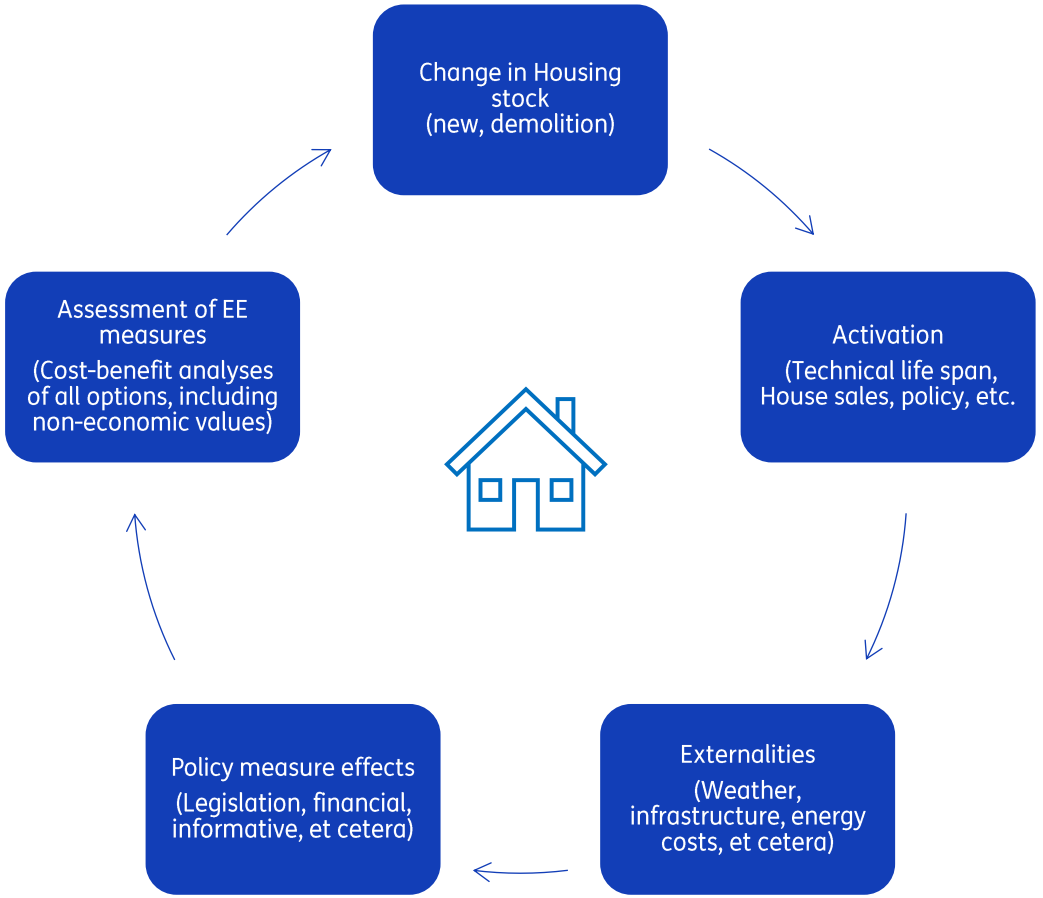
TNO innovation for life

Hestia contains lots of data on object level

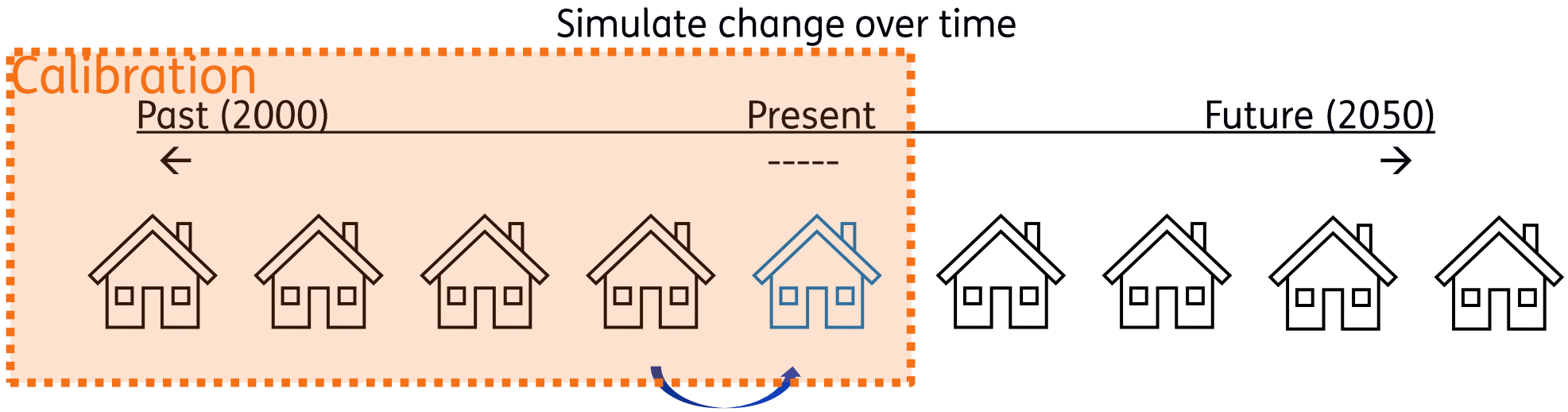


Physical modelling of energy use based on technical characteristics

Simulating annual change

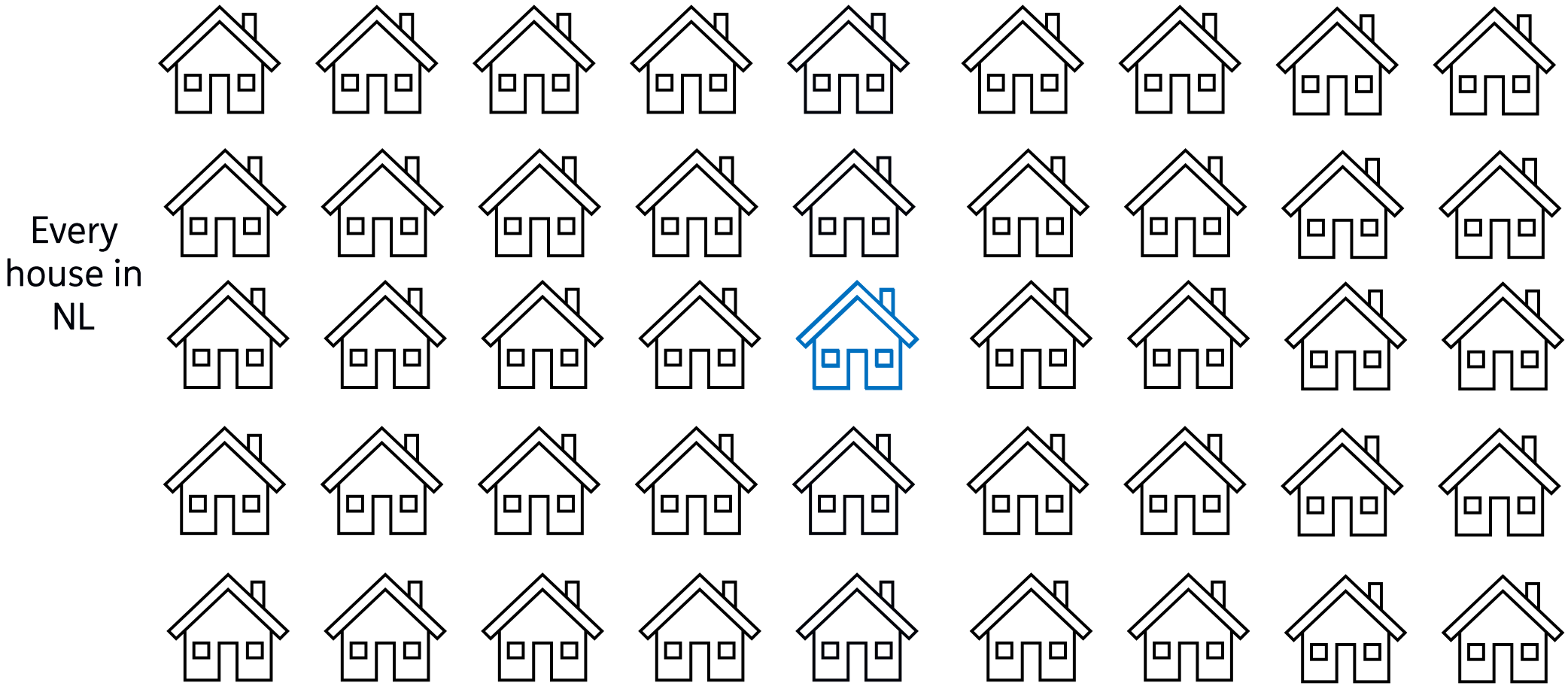


Simulating annual change

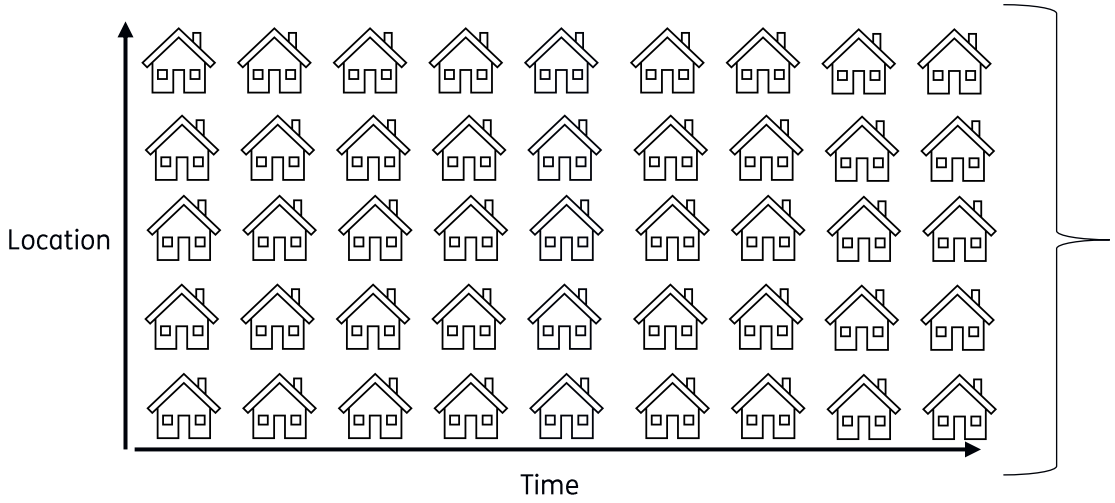


- Annual:
  - Change in energy consumption
  - Energy savings
  - Investments
  - Labour demand
  - Material demand
  - …

Hestia contains every house in the Netherlands

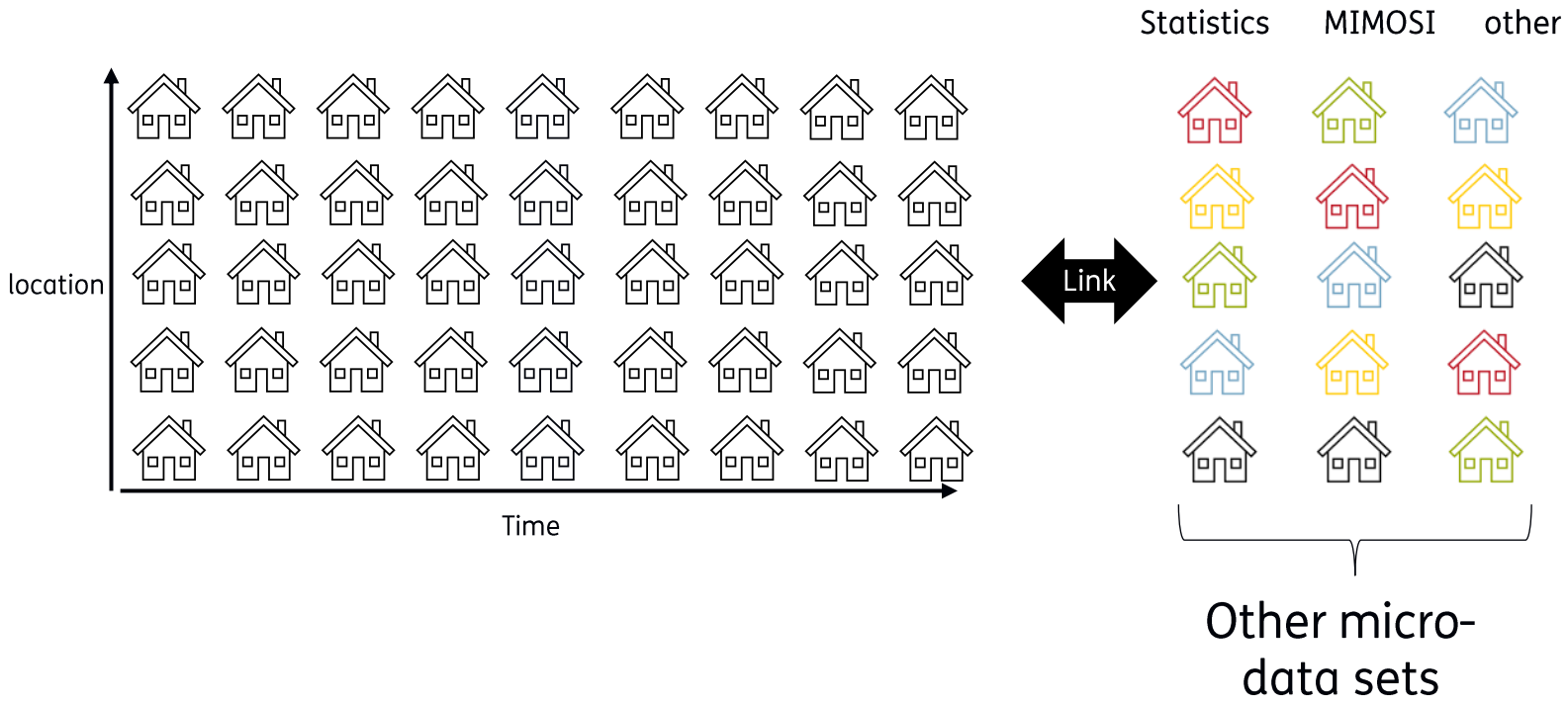


Creating a Micro-data set for analyses



Micro-data set Dutch Housing stock

Micro-data analyses



Micro-data analyses

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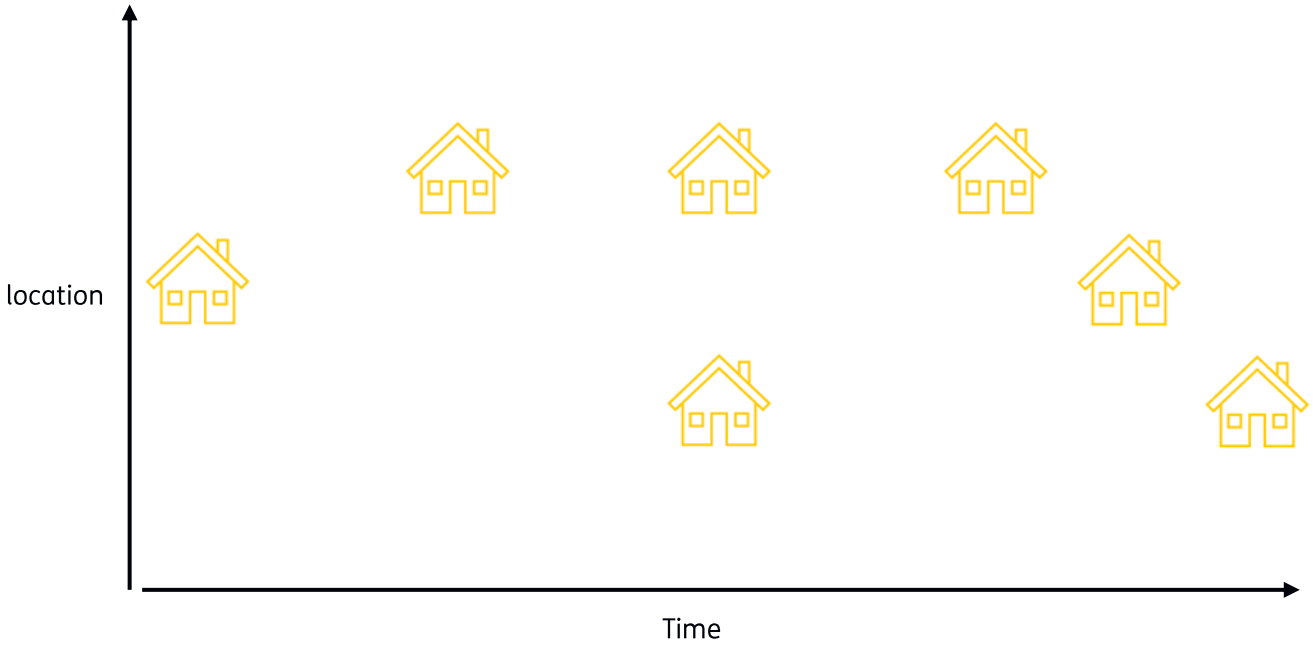
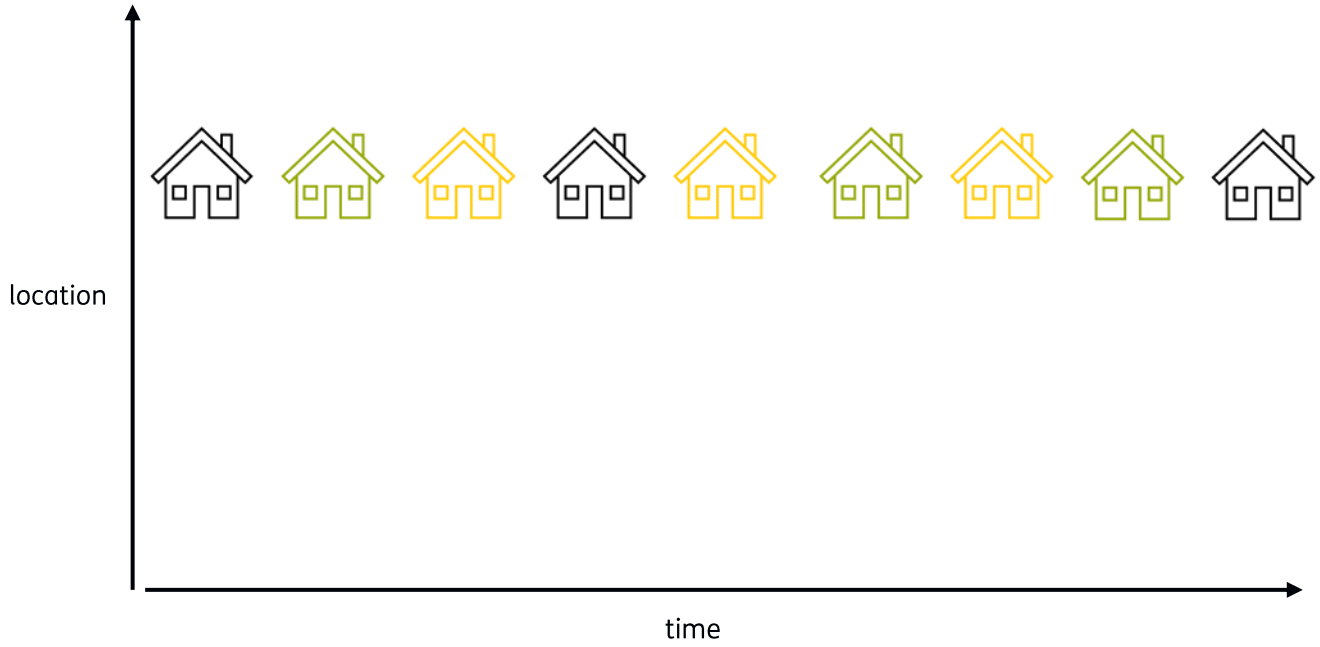


Select groups based on

household type

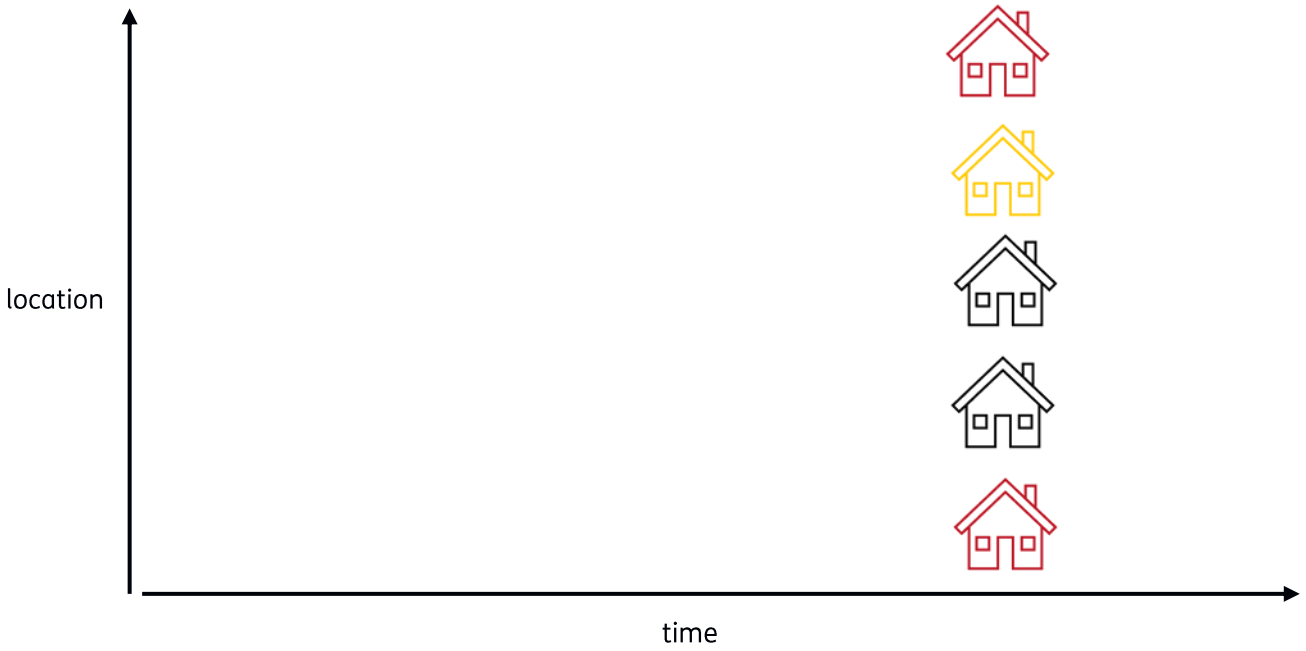
Micro-data analyses



Select groups based on

location

Micro-data analyses



Select groups based on

year

Income effects

Investment costs – energy saving, corrected for other effects

$$Income\ effect = \frac{\Delta\ Housing\ costs + \Delta\ Energy\ costs + \Delta\ Other\ disposable\ income}{Disposable\ income\ (before\ insulation)}$$

Housing costs : * investment costs insulation
* investment subsidies
* additional mortgage payments
* rent increase

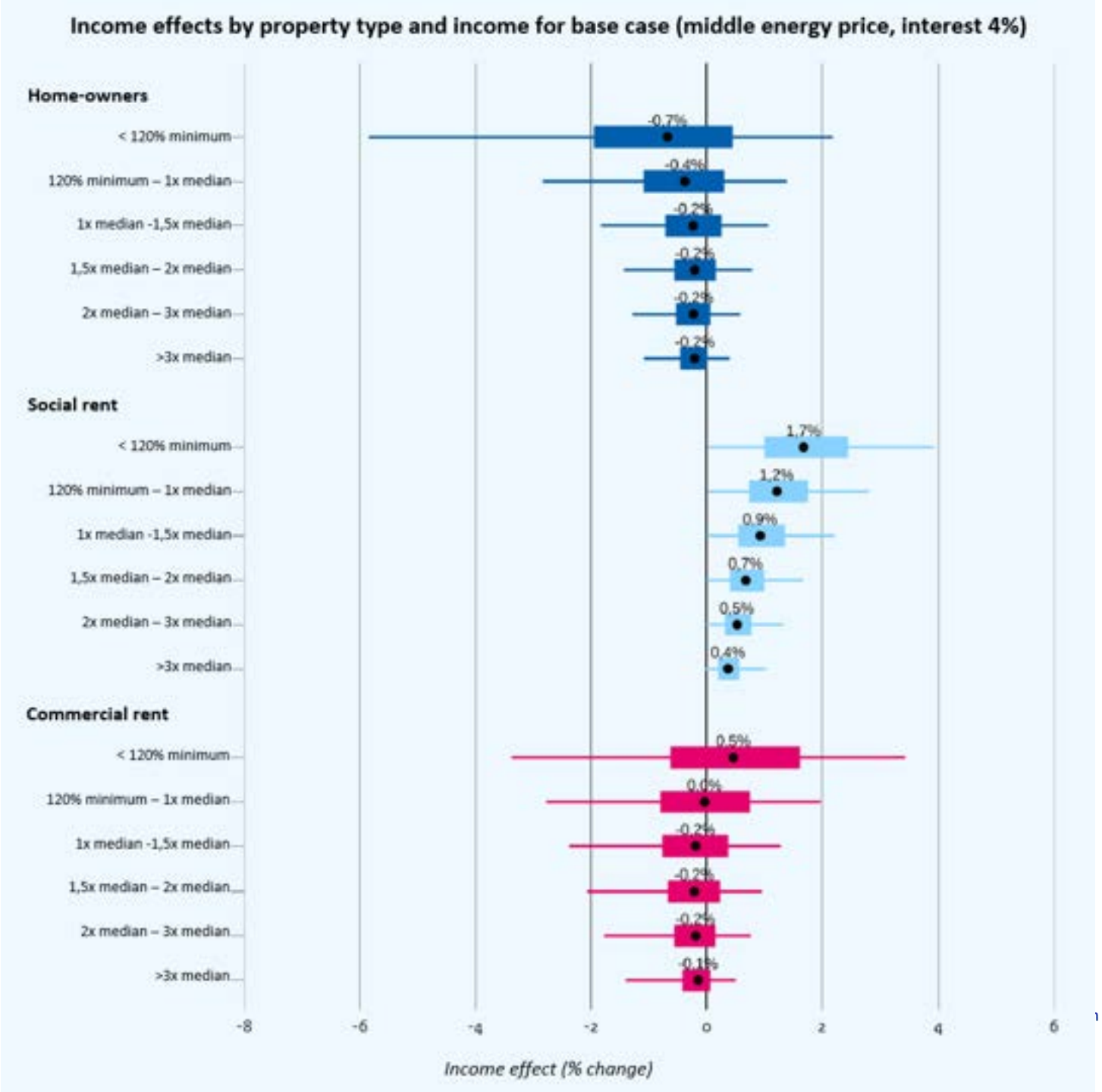
Disposable income : * mortgage interest deduction
* rent subsidies

Assumptions

- Home-owners finance investment through a mortgage
  - Market interest rate (4%), we assume no barriers (LTV, LTI, etc.)
- Renters in commercial market pay through rent increase: full cost pass-through
- Renters in social housing pay
  - (1) **no rent increase** for insulation (Nationale Prestatieafspraken)
  - (2) **rent increase** for heatpumps (full cost pass-through)
- Investments costs are made at ‘natural moment’; no additional construction costs

Income effects of Insulation Standard

- Median income effects are usually close to zero
- Spread is large, especially in low-income groups
- Home owners and renters in commercial markt on average lose
- Tenants in social housing benefit (due to ‘free’ insulation)



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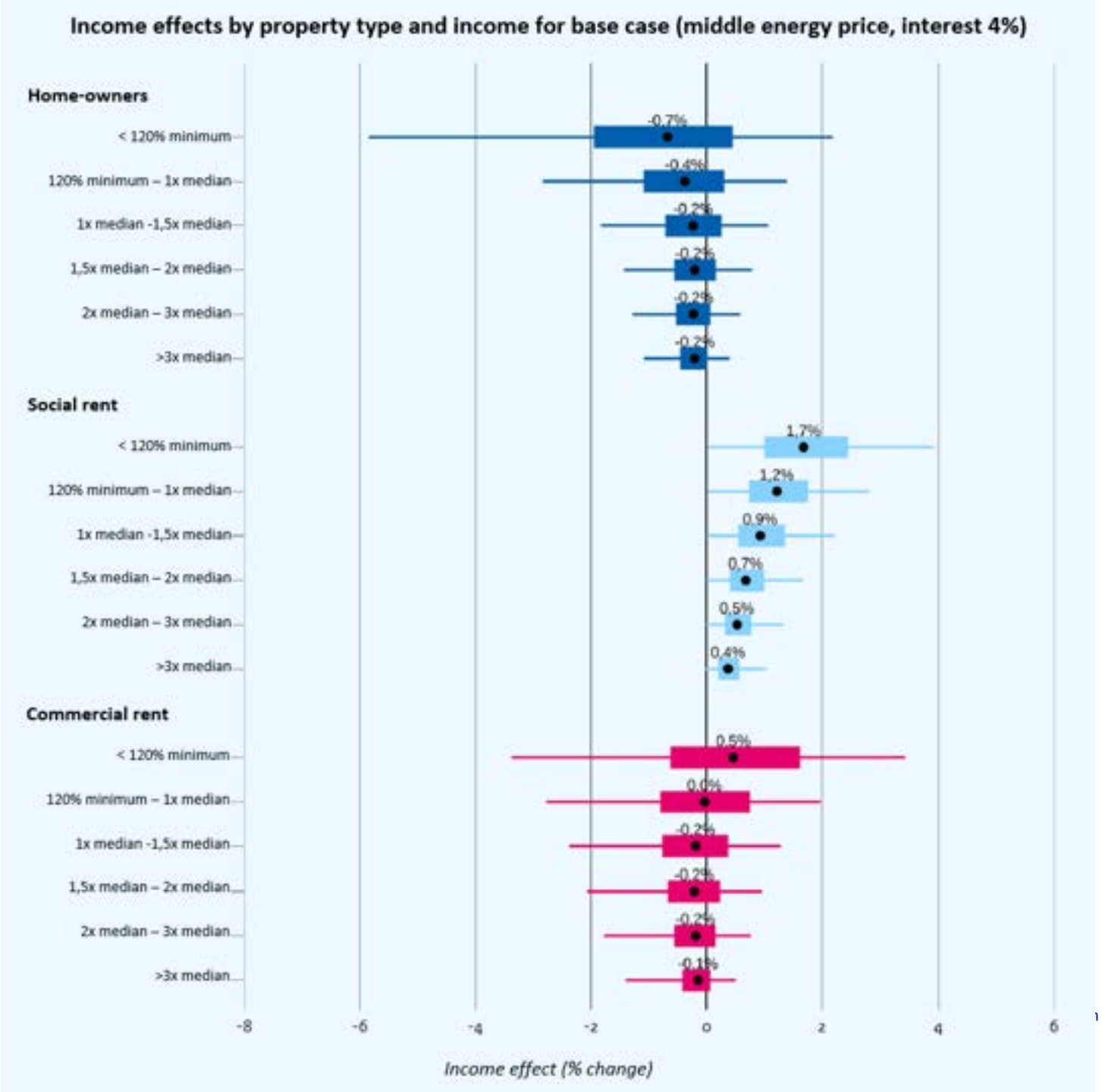


Income effects of Insulation Standard

- Households at high risk of a strongly negative income effect
  - Low-income
  - Older
  - Larger homes
  - Lower pre-insulation gas consumption

- Especially dwelling size matters:
  - **Diminishing returns of insulation in terms of floor space**

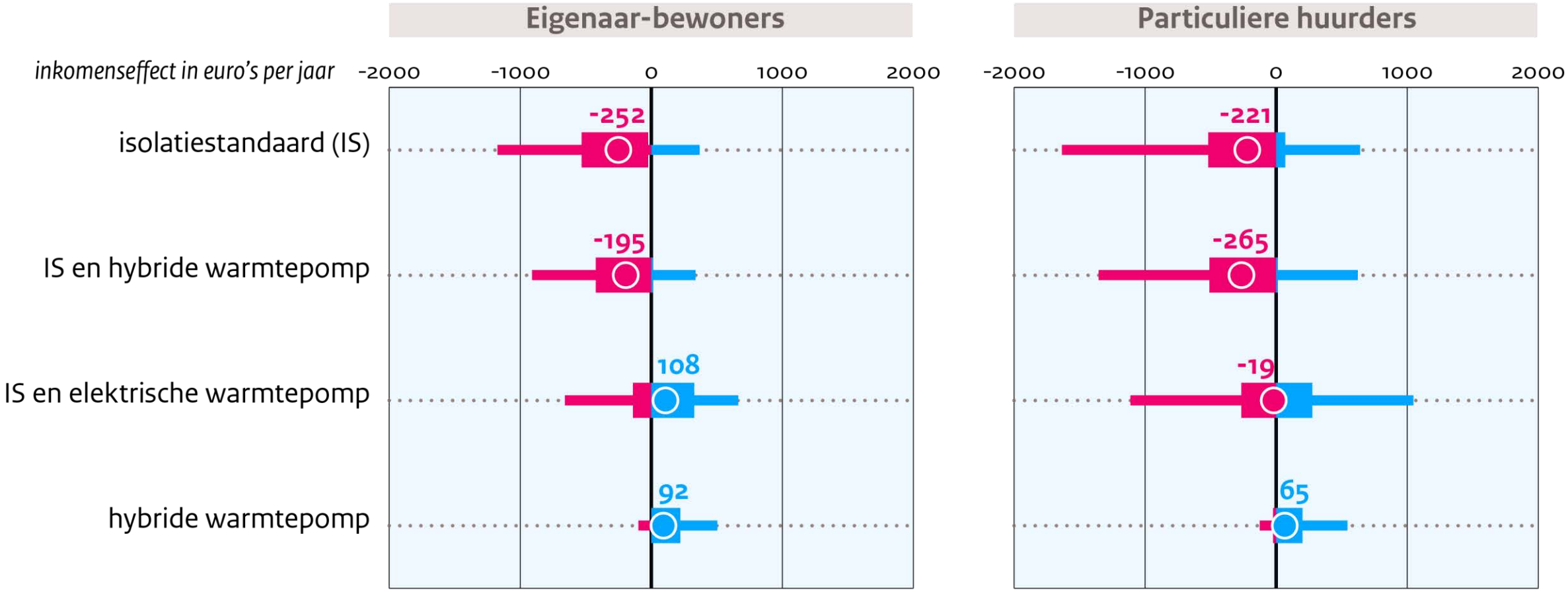
Extension: combination with heatpumps

• Insulation to the Insulation Standard (IS)	IS
• Only hybrid heatpump	hHP
• Insulating to the standard + hybrid heatpump	IS + hHP
• Insulating to the standard + all-electric heatpump	IS + eHP

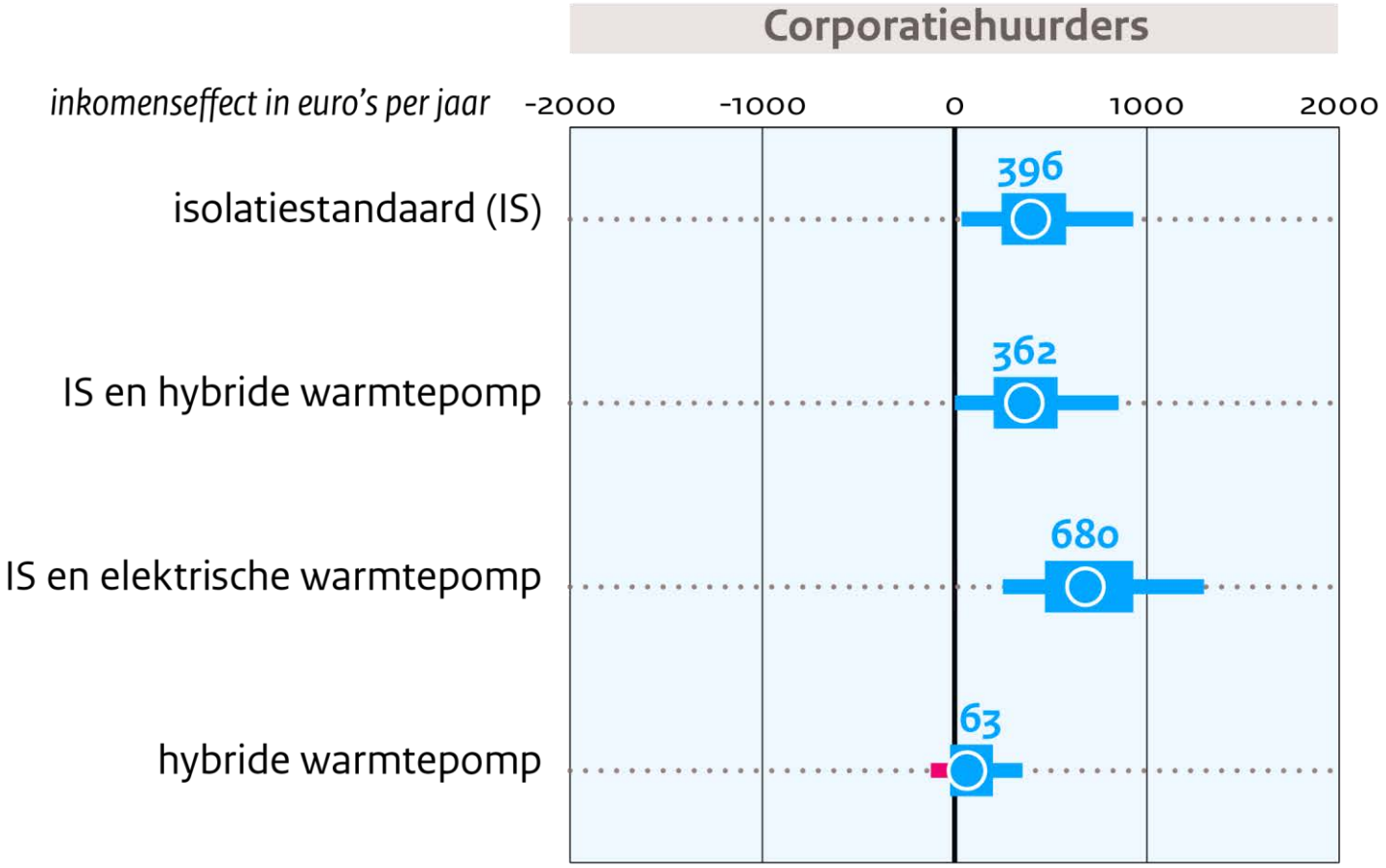
NB:

- Only for family homes (no apartments), all construction years
- Alternative is ‘doing nothing’: no home improvement, simply maintaining current gas heating
- No other options: insulation ‘light’, ACs, district heating, etc.

Income effects per option, by ownership type

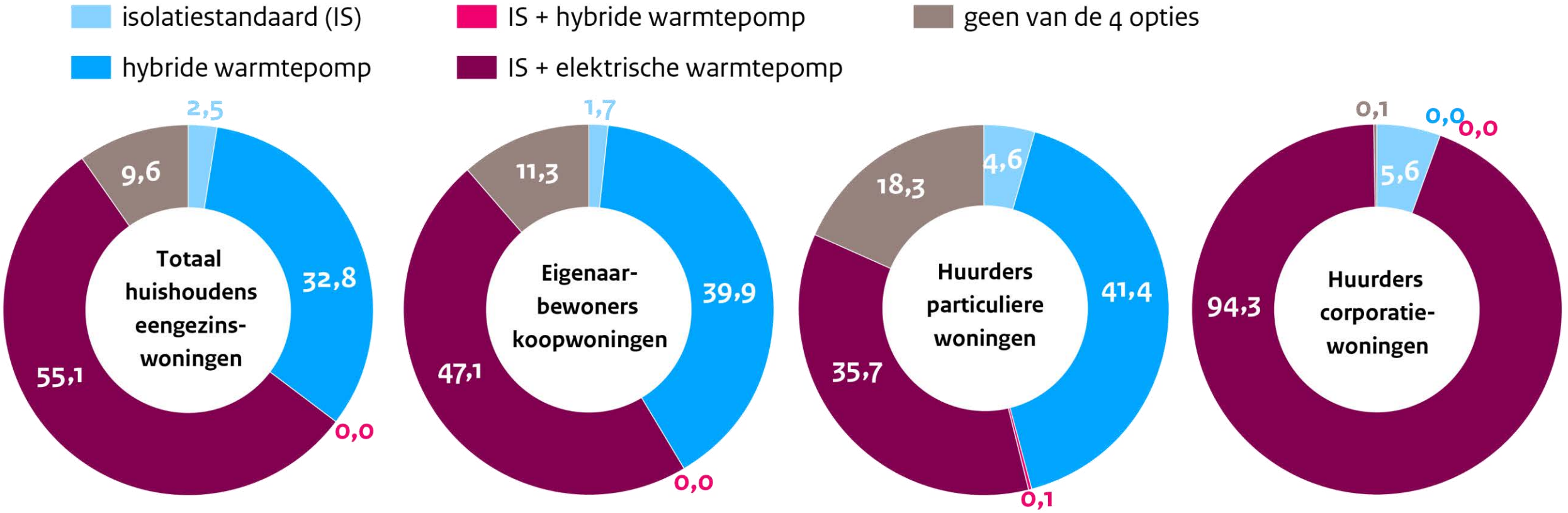


Income effects per option, by ownership type



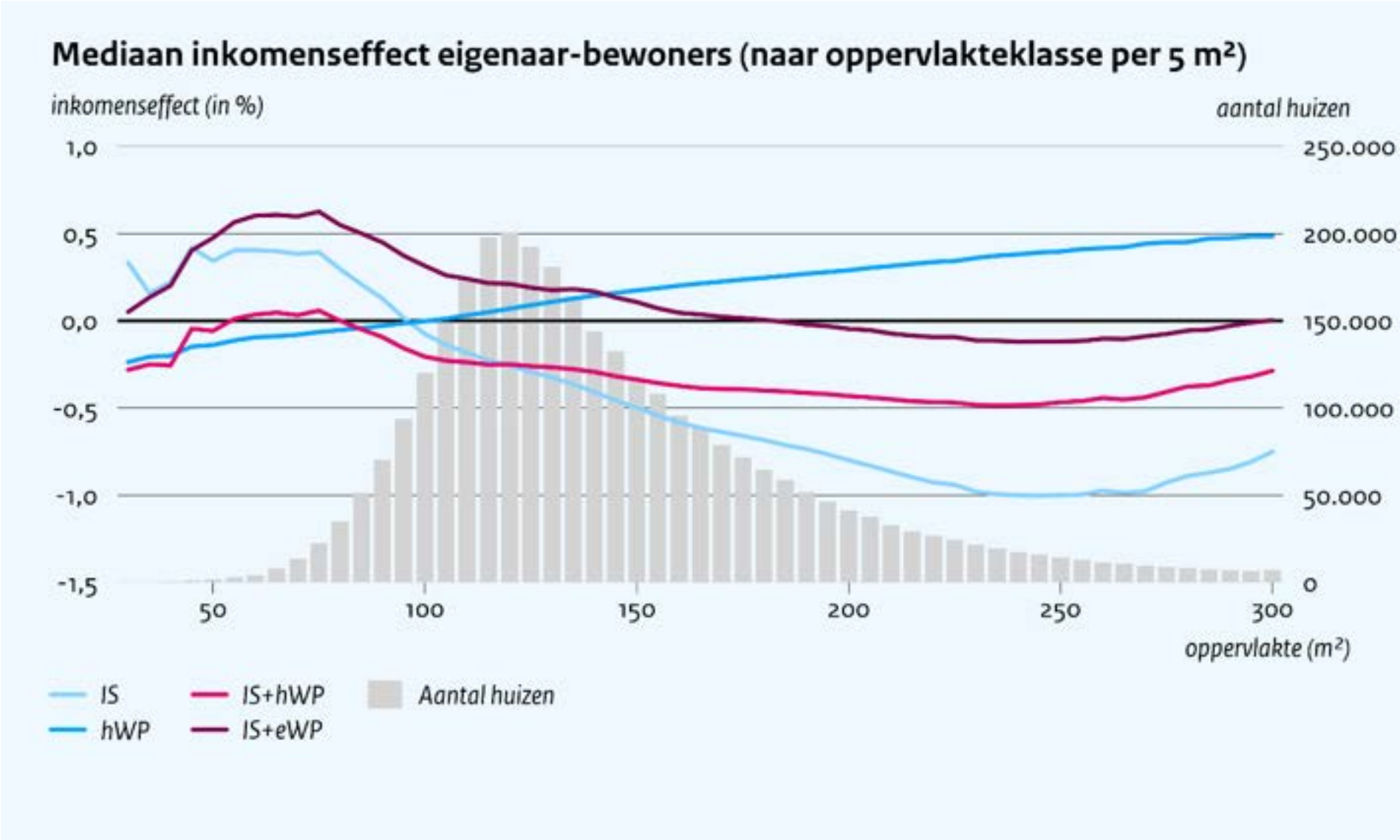
Take-away 1: >90% of households is better of doing *something*

in % van groep waarvoor betreffende optie financieel het gunstigst is

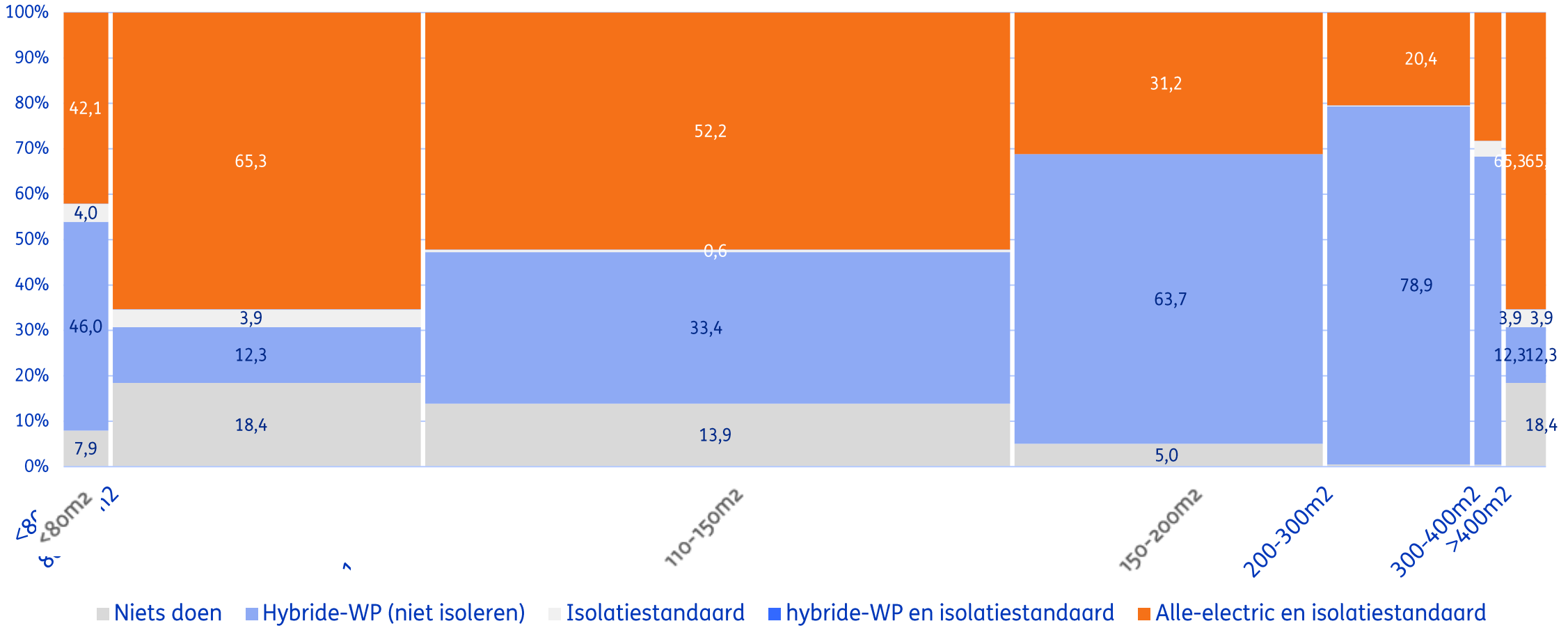


Take-away 2: The cost of extensive insulation determines whether an all-electric heatpump is financially attractive

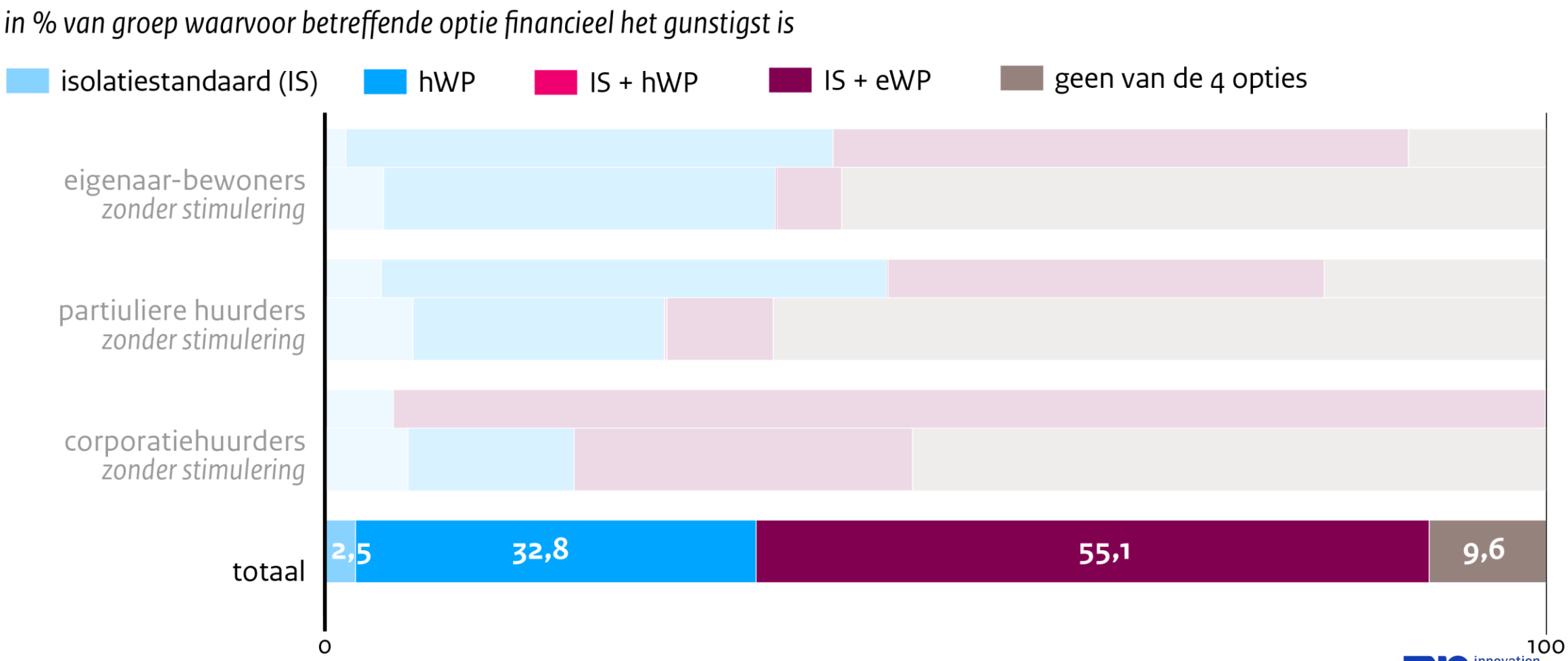
- Strongly determined by home size and type
- Insulation has diminishing returns on energy saving (and thus the energy bill)



Take-away 3: For homes in which extensive insulation is not financially feasible, a hybrid heatpump without insulation usually is

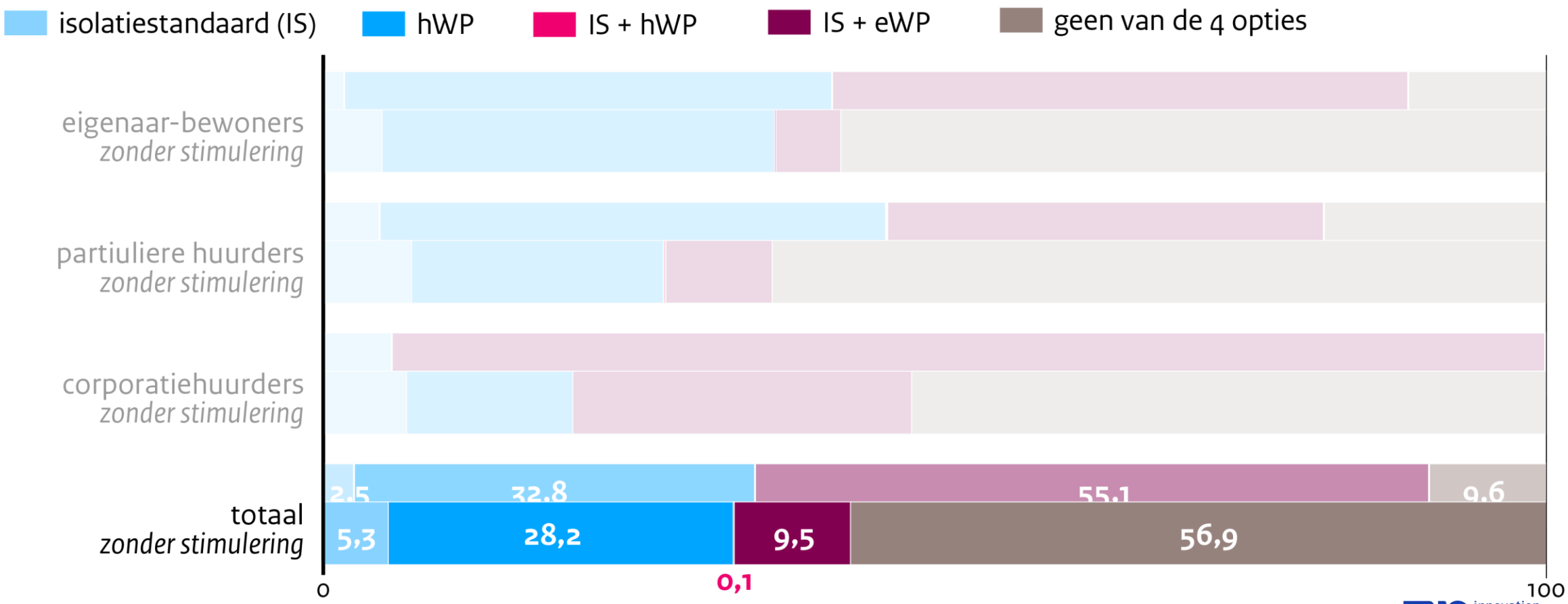


Does policy matter? Simulation without stimulating policies



Take-away 4: without stimulating policies, more than half of all households would therefore be better off *doing nothing*

in % van groep waarvoor betreffende optie financieel het gunstigst is



Not (yet) taken into account

Social benefits

- reduced CO2 emissions
- low-income households less vulnerable to energy price fluctuations

Private benefits

- Increased living comfort, health effects
- Possible increase in house value
- National perspective

District heating or other options may be more cost-efficient from societal point of view

Limited capacity in markets (materials, labour, grid congestion): dynamic problem

Agenda for future research

Main take-aways

1. **>90% of households are better off doing home improvements with current policies and price expectations**
   - Could be even higher when (cheaper) alternative home improvements are considered
   - Current policies have a major contribution to providing financial incentives to households for individual home improvement
   - Difficult to classify households in the ‘do nothing group’ of 10%
2. **Insulation + all-electric heatpumps are *already today* financially optimal for ~40% of home-owners and renters in the commercial market**
   - For renters in social housing, this option is optimal for almost all households
   - For renters in the commercial market, landlords experience different incentives than renters

Main take-aways

3. **The bigger the house, the more likely only a hybrid heatpump becomes the financially most attractive option**
   - Insulation is expensive and scales with size of the home, related to income but large heterogeneity
   - Hybrid heatpump is the financially optimal option for ~40% of home-owners and renters in commercial market
4. **We have identified individual financial incentives for individual home improvements: optimality per home may be different from national perspective (!)**
   - District heating or other options may be more cost-efficient from societal point of view
   - Whether a hybrid heatpump is a final destination or a transition towards sustainable home improvement, depends on the policy goal and availability of ‘green gas’ in the future
   - Limited capacity in markets (materials, labour, grid congestion): dynamic problem
   - Agenda for future research

Robustness

- Sensitivity of income effects to a range of energy prices is limited
  - Ranges from Klimaat en Energieverkenning 2024 PBL
- Interest rate matters for financing costs
  - Low-income households can benefit from Warmtefonds 0% interest loans
- Prices of all-electric heatpumps matter for share of households who go ‘all the way’
  - But the options hybrid heatpump and IS + all-electric are weak substitutes
- Overall baseline results are stable

TNO innovation for life

Spreiding inkomenseffecten In euro's

- Effect in euro's van vergelijkbare orde tussen inkomensgroepen
- Verschil in relatieve inkomenseffect is dus vooral gedreven voor verschillen in inkomen
- Alleen isoleren naar de standaard kost huishoudens zo'n 200-300 euro per jaar in de mediaan
- Alleen een hHP of 'alles doen' geeft positieve bedragen in de mediaan, die enkele tientjes tot een kleine 200 euro per jaar oplevert