Low energy dwellings: *Insights in actual energy use and occupants behaviour*

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EFL Topic Group Construction
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EFL EUROPEAN FEDERATION FOR LIVING

TU Delft

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Working at Delft University of Technology since 1991. Teaching and research interests: methods and instruments for asset and property management, supply chain integration and collaborative relationships, circular public procurement strategies, service-life-thinking and business models for sustainable transformation.

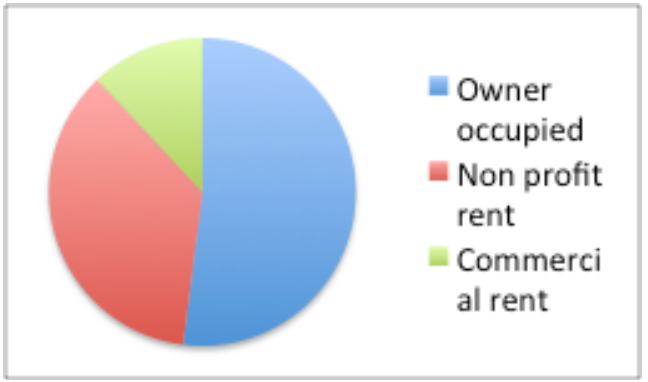
2018-2021 Technical Project Management CHARM

- Member Editorial Staff Dutch property management journal **Renda**
- Member Editorial Advisory Board of the International **Journal of Building Pathology and Adaptation**
- Ambassador Sustainable Housing Route Netherlands
- Member NEN 2767 Committee **Dutch Standard Condition assessment Built Environment**
- Member Program Advisory Board Platform Performance-Based Partnering Renovation and Maintenance (Platform RGS)
- Faculty Advisor Dream team MOR Solar Decathlon Europe 2019
- Member Circular Built Environment Hub

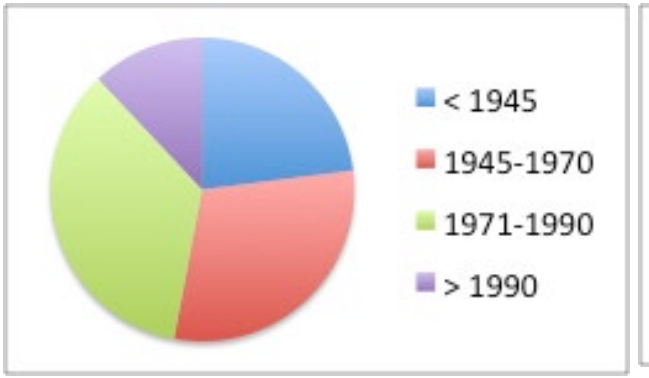
The Dutch Housing Stock

17 million people, 7 million dwellings

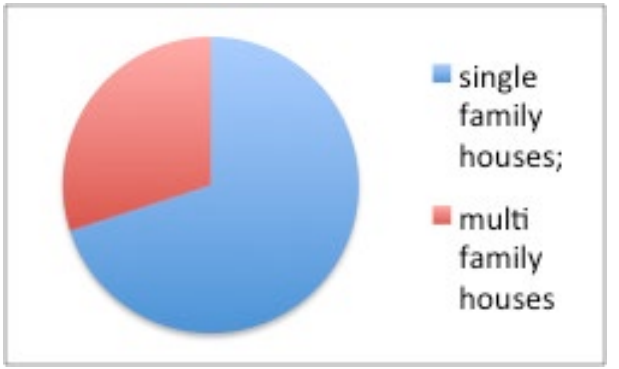
Tenure ship



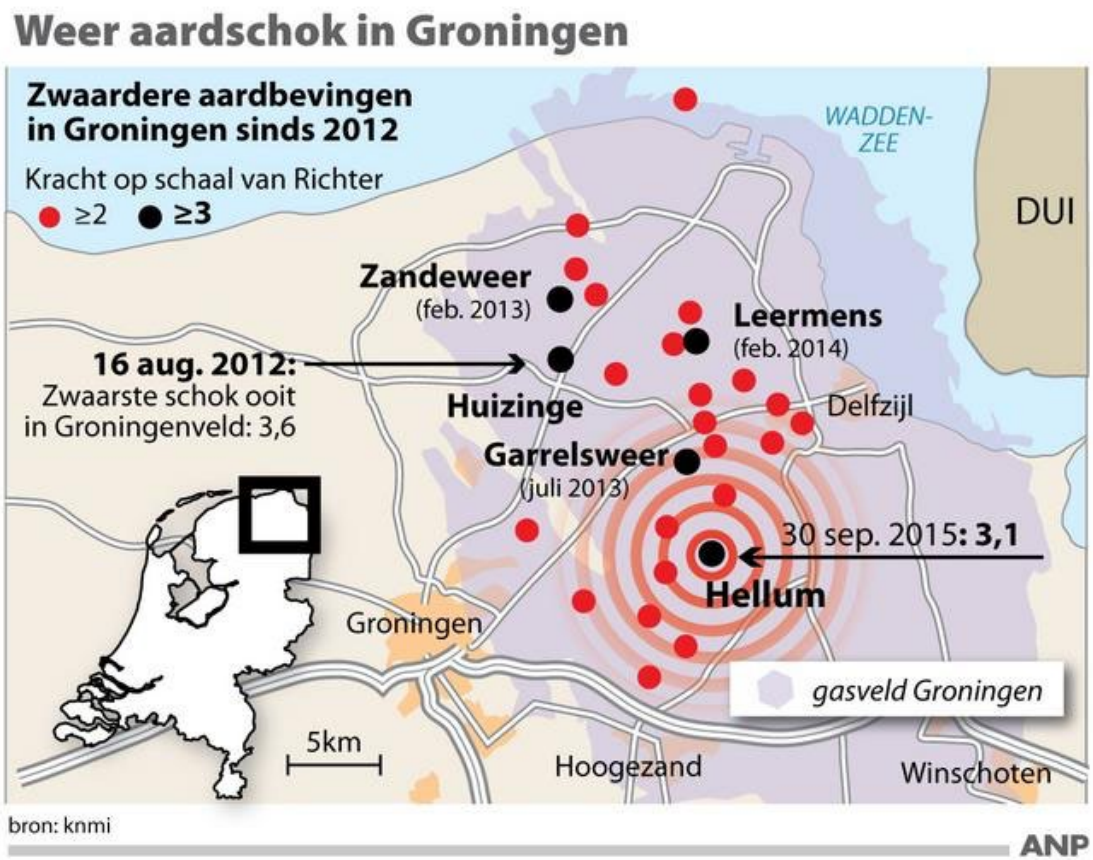
Year of construction



Type of dwelling



Game Changer in NL



2030 no more natural gas

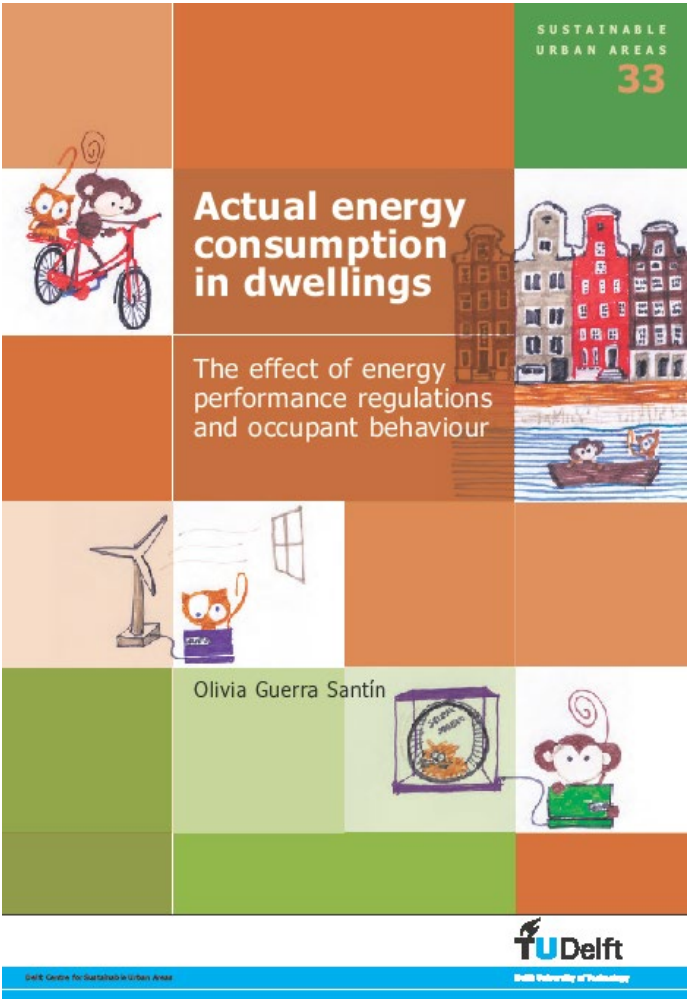
Gas free neighbourhoods

HOW?

Ambitions Dutch Housing Stock

- 1 million new homes before 2030
- 200.000 houses per year to be renovated: 50% district heating, 25% hybrid, 25% all electric
- Development of new district heat networks, e.g. use of geothermal sources
- Housing renovations: standardization, automation, prefabrication, robotization and performance optimization (monitoring, quality assurance)
- Cost reduction deep renovation through upscaling and innovation

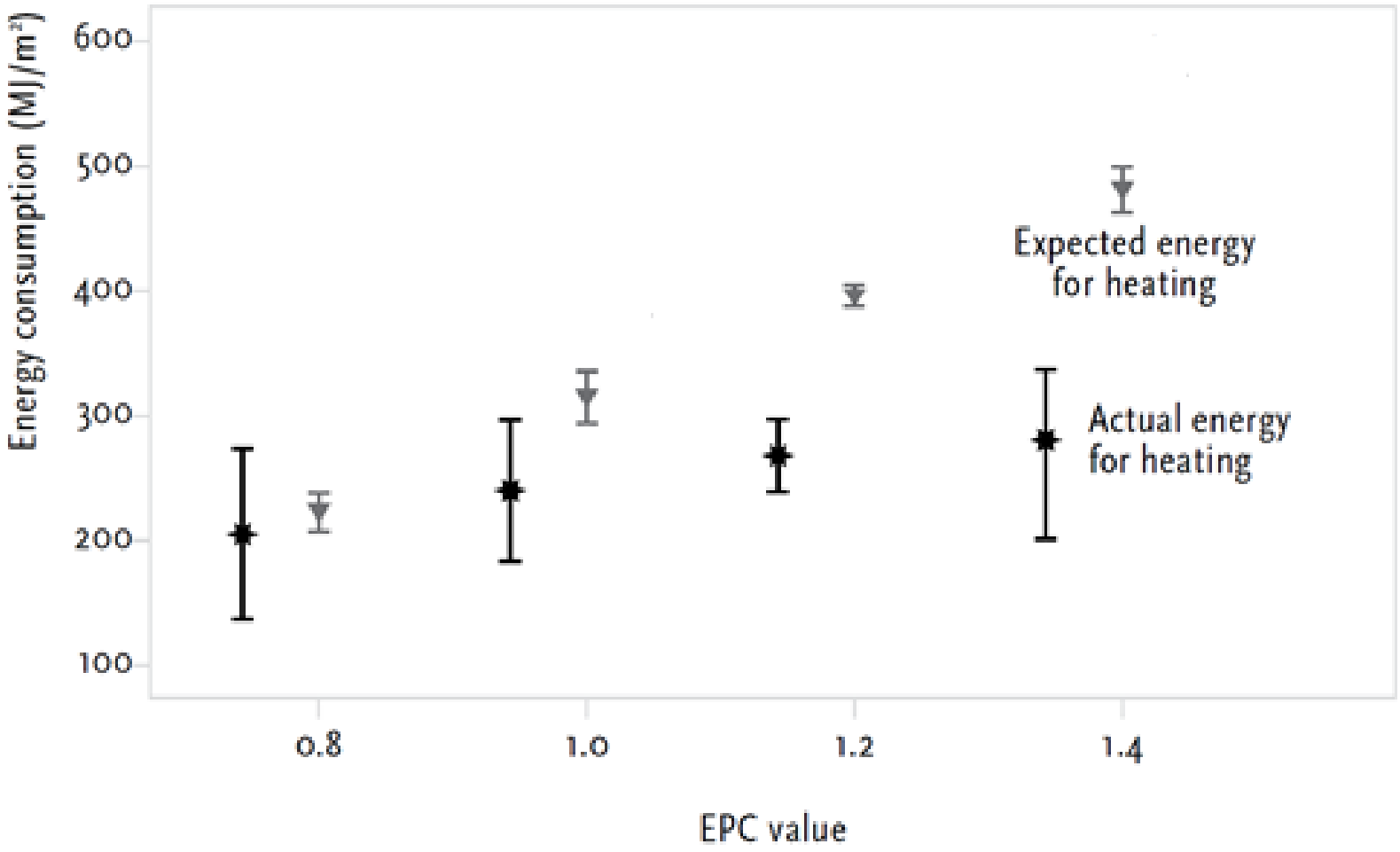
Energy performance of New Dwellings



- Energy Performance Regulations since 1995
- Level: non-dimensional digit: 1.4 (1995) – 1.2 – 1.0 – 0.8 – 0.6 – 0.4 (2015)

- PhD Olivia Guerra Santin (2010)
- Relation between dwellings built under various levels of EPC and final energy use
- 3 databases

Actual energy use in relation to level of Energy Performance Regulation (Survey n=330)



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Actual energy consumption in buildings

- Reducing the size of houses is the most effective way to reduce build-related energy consumption
- Obliging construction companies to monitor the quality of the construction would help to enhance the energy performance of dwellings

Effect occupant behaviour on energy consumption

Important factors (on housing stock level):

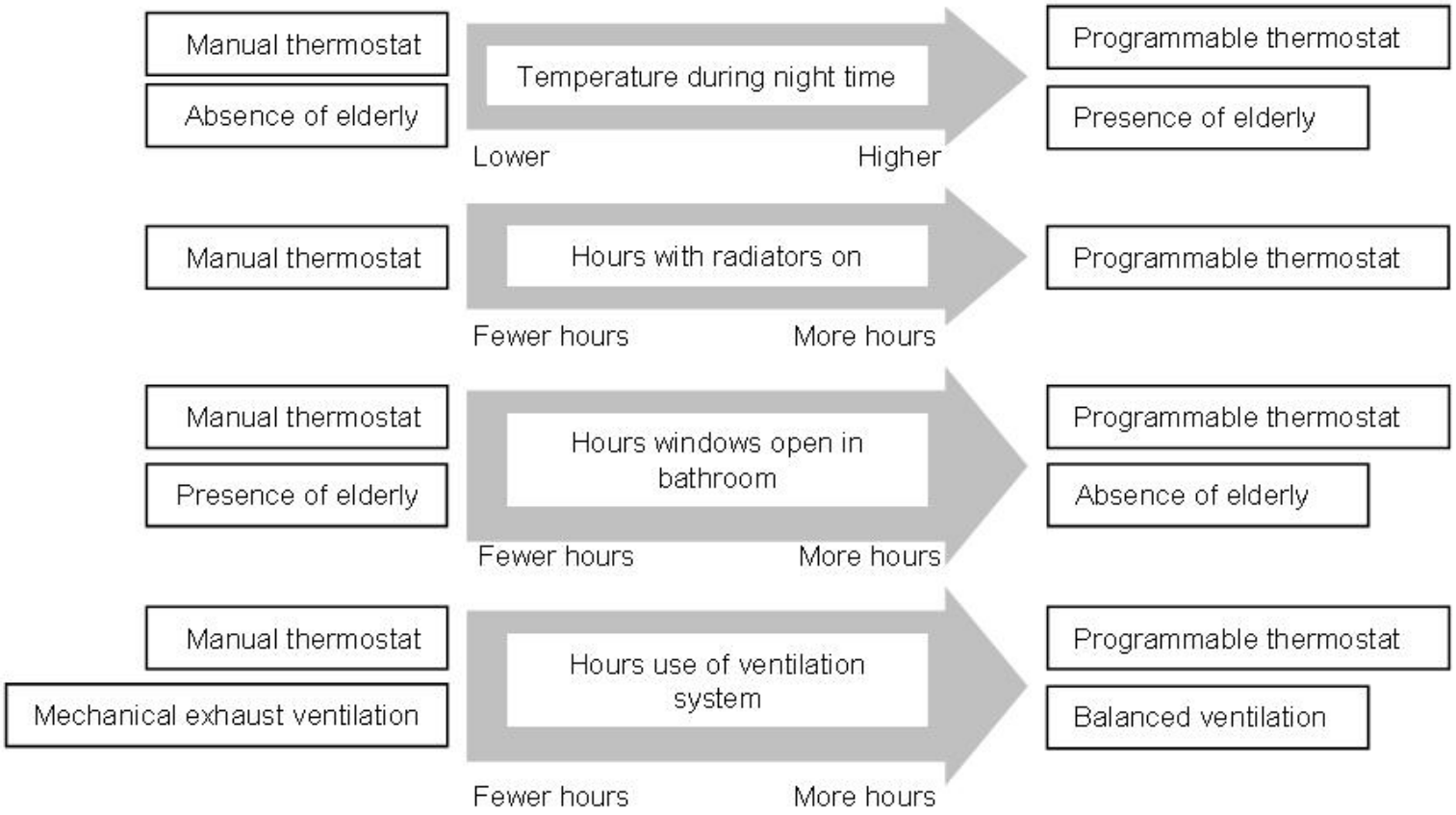
- Number of hours highest temperature setting
- Number of hours heated rooms in addition to the living room
- Opening of rooms in the living room (more than one hour a day)
- (Hours of showering)
- (Number of sleeping rooms used for other functions)

→ **Explains 12% of the variance in energy consumption**

Rebound effect (system level)

- Programmable thermostat:
  - More hours heating on, more radiators on
  - Mechanical ventilation: combination highest and lowest position
- Manual thermostat:
  - Mechanical ventilation: highest or lowest position a few hours, system off most of the time
- Well-insulated dwellings:
  - Higher temperature settings

Rebound effect (system level)



WoON steekproef

Thermal comfort and energy related occupancy behaviour in Dutch residential dwellings

PhD Anastasios Ioannou (2018)

- The effect of occupancy behaviour on the energy consumption of residential buildings cannot be statistically defined for large groups of population, due to the variance of people and types of dwellings

- The future in understanding the energy related occupancy behaviour lies in the advance of sensor technology, big data gathering, and machine learning

Energy Performance Certificates as tool for incentives policies

Covenant rental housing sector 2008-2020:

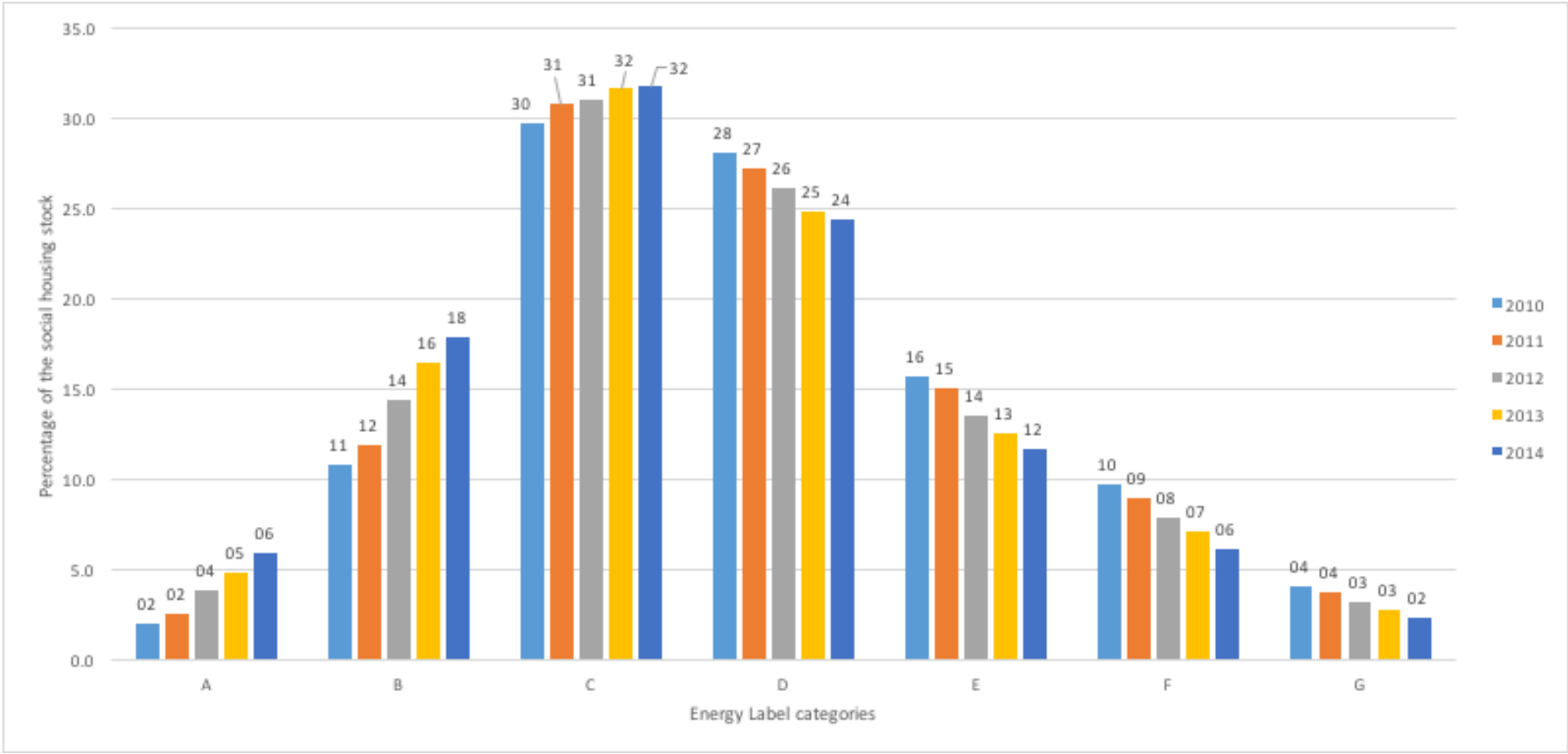
- Housing associations, tenants union, government
- Non-profit rented stock: 35 % - 2.3M dwellings
- 2020: average performance certificate (label) B

Monitoring:

- AEDES (national umbrella organisation of housing associations)
- SHAERE database: yearly updated EPC's
- Reliable for monitoring: 1.4M dwellings

Division energy performance certificates non-profit rented housing sector from 2010 to 2014

PhD Faidra Filippidou (2018) Energy performance progress of the Dutch non-profit housing stock: a longitudinal assessment (2018)



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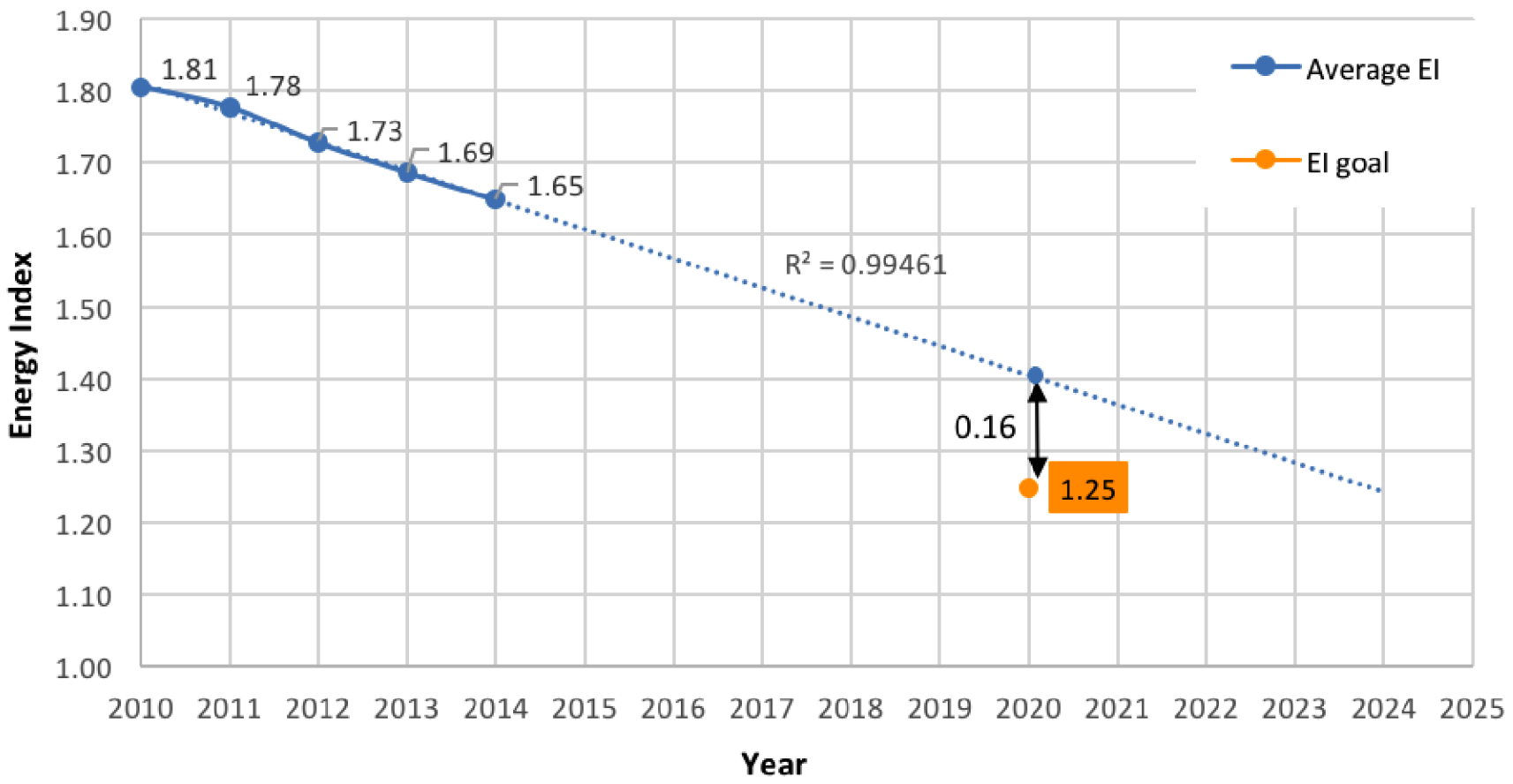
Development of Energy Index 2010 to 2014



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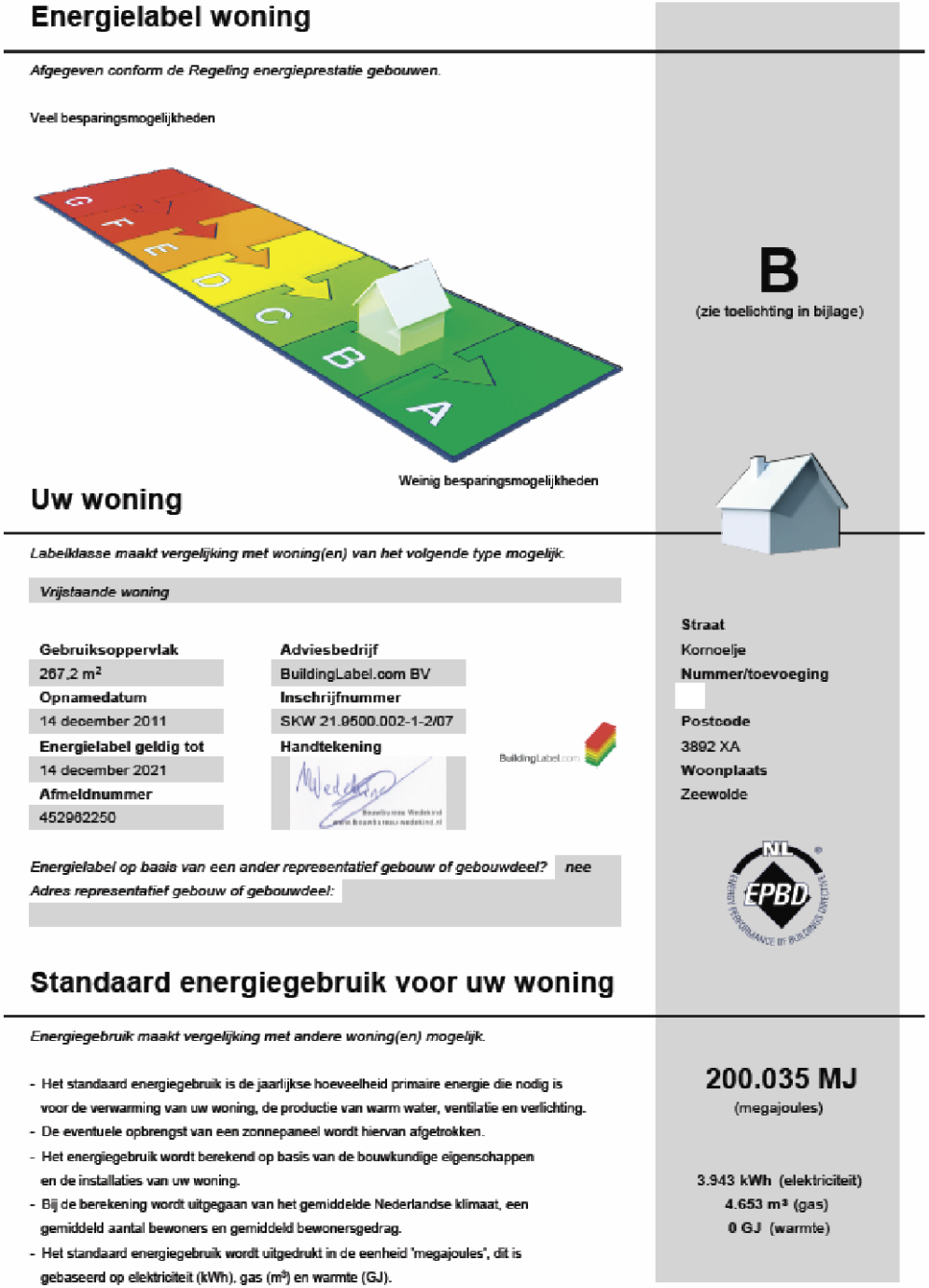
Energy Performance Certificate - actual energy use

PhD Dasa Majcen (2016)



Energielabel woning

Afgegeven conform de Regeling energieprestatie gebouwen.

Veel besparingsmogelijkheden

G F E D C B A

Weinig besparingsmogelijkheden

B

(zie toelichting in bijlage)

Uw woning

Labelklasse maakt vergelijking met woning(en) van het volgende type mogelijk.

Vrijstaande woning

Gebruiksoppervlak	**Adviesbedrijf**
267,2 m²	BuildingLabel.com BV
Opnamedatum	**Inschrijfnummer**
14 december 2011	SKW 21.9500.002-1-2/07
Energielabel geldig tot	**Handtekening**
14 december 2021	
Afmeldnummer	
452982250	

Straat
Kornoelje
Nummer/toevoeging
Postcode
3892 XA
Woonplaats
Zeewolde

Energielabel op baais van een ander representatief gebouw of gebouwdeel? nee
Adres representatief gebouw of gebouwdeel:

Standaard energiegebruik voor uw woning

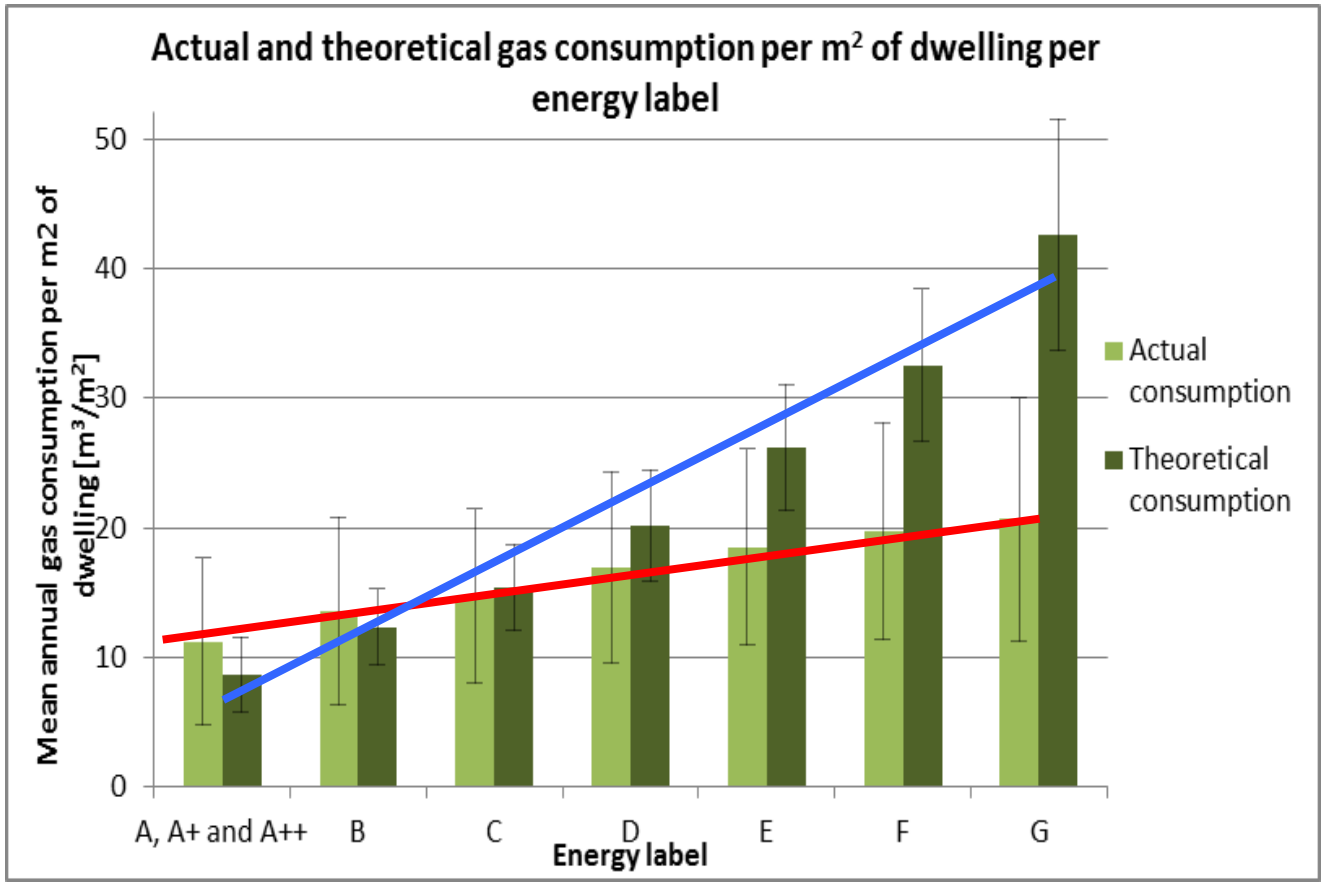
Energiegebruik maakt vergelijking met andere woning(en) mogelijk.

- Het standaard energiegebruik is de jaarlijkse hoeveelheid primaire energie die nodig is voor de verwarming van uw woning, de productie van warm water, ventilatie en verlichting.
- De eventuele opbrengst van een zonnepaneel wordt hiervan afgetrokken.
- Het energiegebruik wordt berekend op basis van de bouwkundige eigenschappen en de installaties van uw woning.
- Bij de berekening wordt uitgegaan van het gemiddelde Nederlandse klimaat, een gemiddeld aantal bewoners en gemiddeld bewonersgedrag.
- Het standaard energiegebruik wordt uitgedrukt in de eenheid 'megajoules', dit is gebaseerd op elektriciteit (kWh), gas (m³) en warmte (GJ).

200.035 MJ
(megajoules)

3.943 kWh (elektriciteit)
4.653 m³ (gas)
0 GJ (warmte)

Findings actual and theoretical gas use



Very little actual savings!

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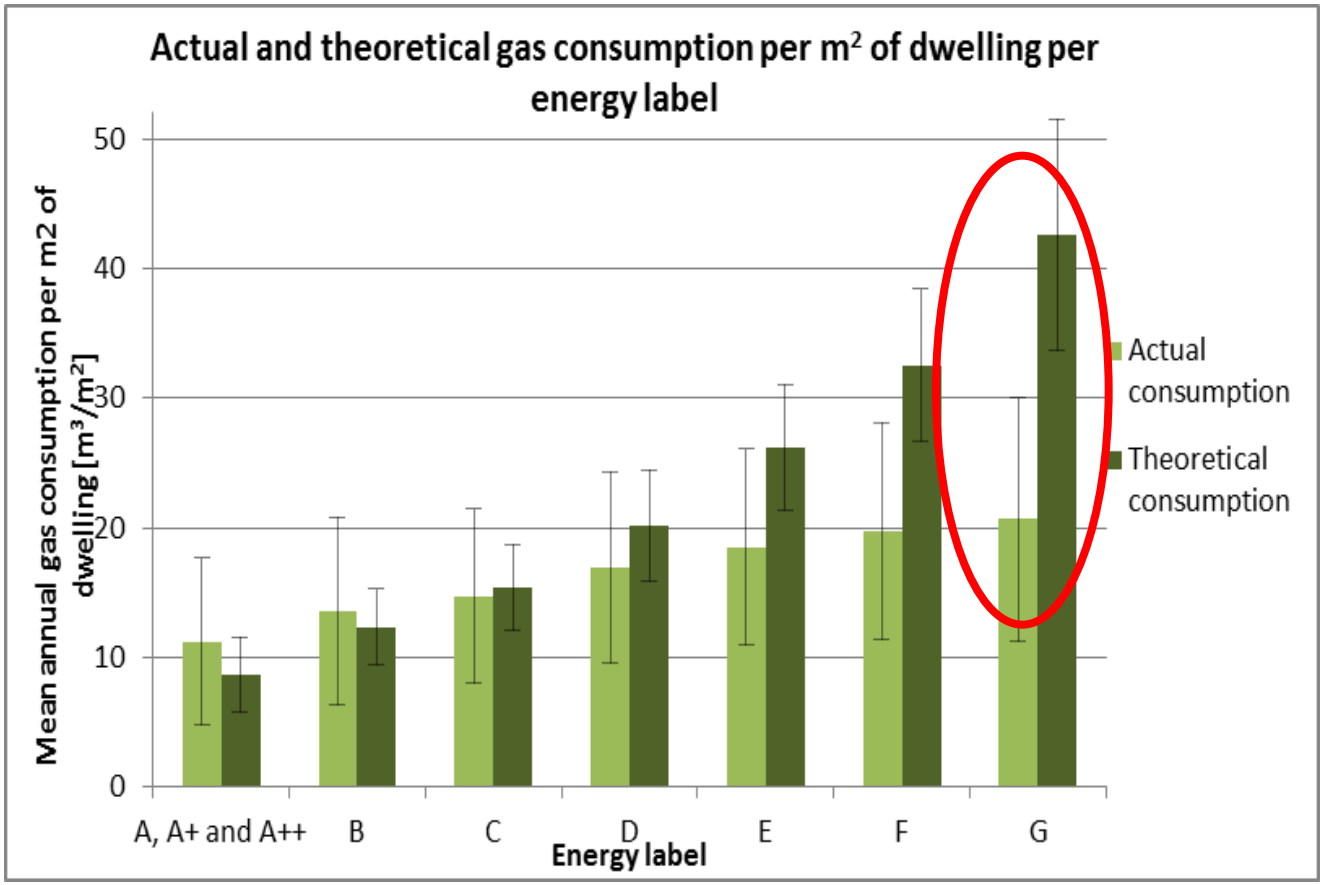
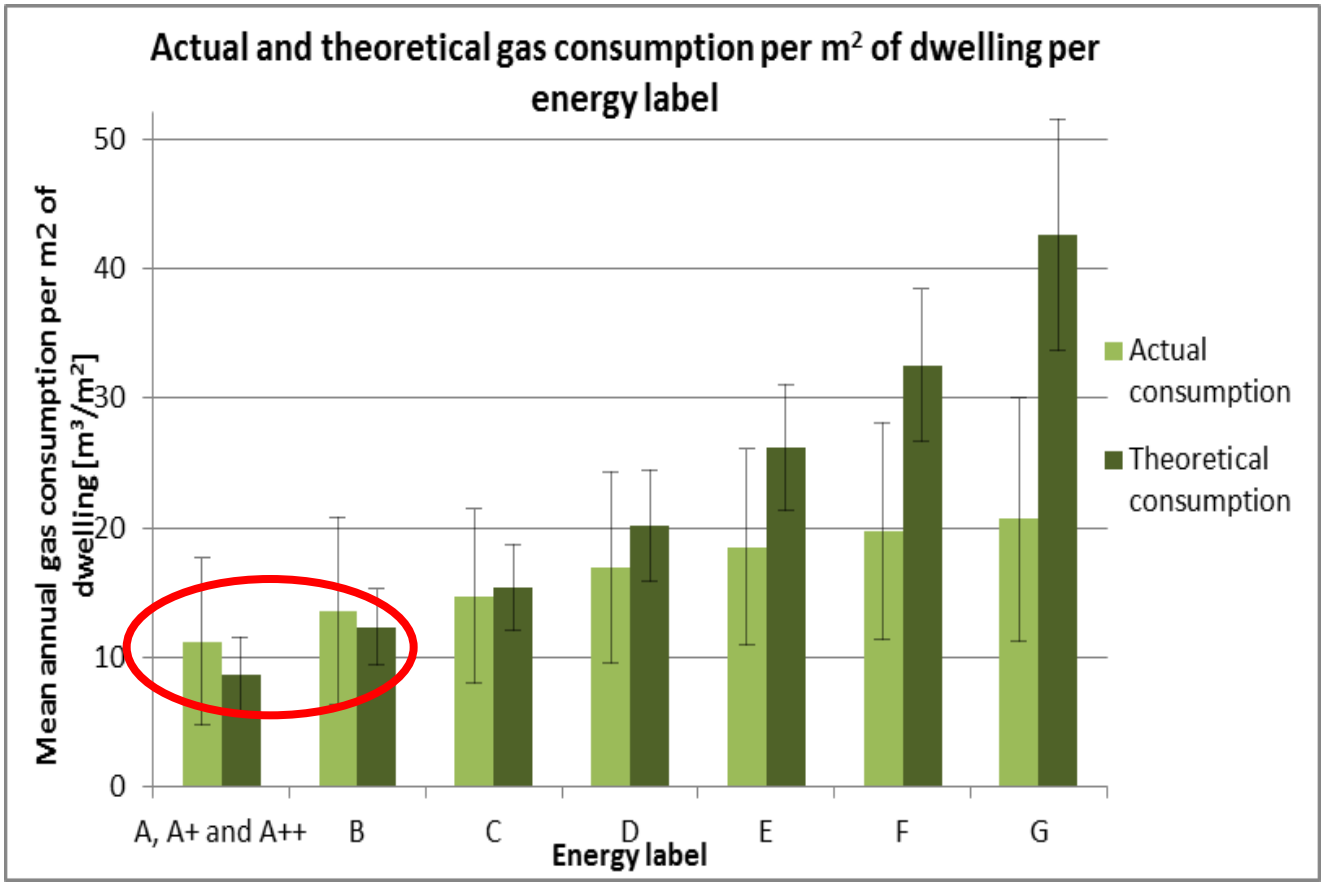
Actual energy use ‘bad’ houses



G label:

50% less use than expected

Actual energy use ‘good’ houses



A and B labels:

10-20% more use than expected

Explanations for the performance gap

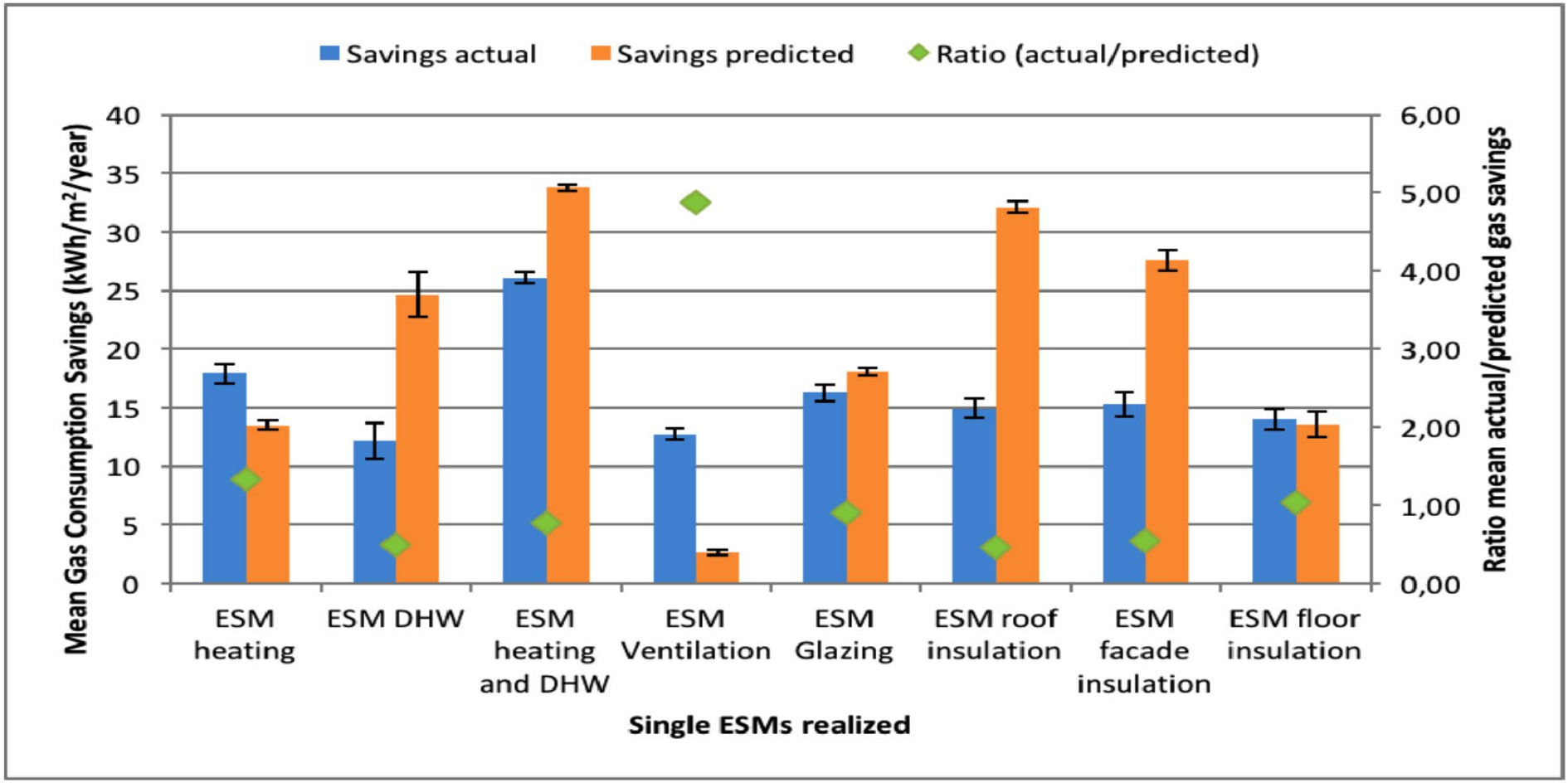
For high labels (A, B) dwellings:

- Underperformance of the buildings and installations
- Rebound effect – higher temps – sometimes due to the heating system

For low labels (E, F, G) dwellings:

- Better performances of buildings (U-values) and installations
- Lower heating in fewer rooms – sometimes due to the heating system

Effects of various energy saving measures: predicted versus actual savings



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Conclusions and implications

Actual energy use of dwellings deviates a lot from the theoretical models for new and renovated dwellings, reasons:

- Actual performance of the buildings
- Tuning and regulation of the heating installations
- High impact of the household characteristics and behaviour

Implications:

- Policies based on energy label steps will not have the intended effect in expected CO2 savings
- Communication to tenants about energy savings and reducing energy bills, should be done very carefully

Need:

- Need for better insights in the effect of occupant behaviour and desired and delivered comfort

Healthy homes are more important than just energy savings