

Energy consumption in dwellings: theory and practice

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Research line

Technology (Building, HVAC, control eng., data)



Building
Energy diagnosis

People

- Occupants
- Professionals

Environment

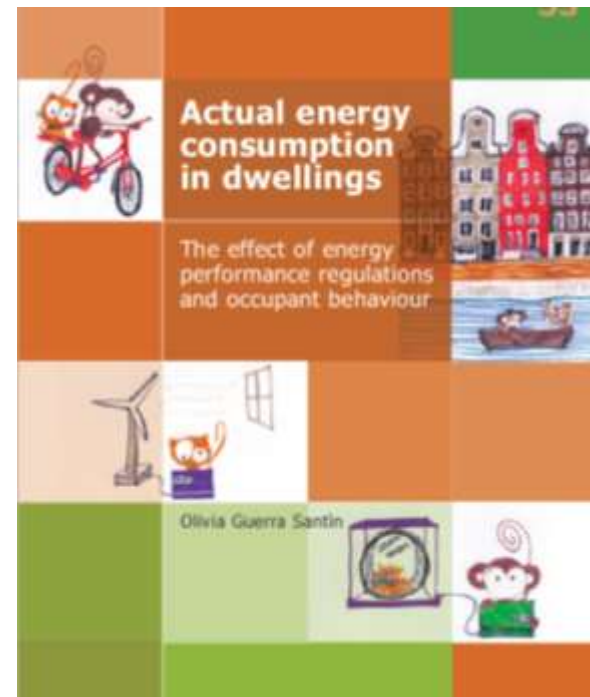
- Energy
- Indoor air quality
- Comfort
- Environmental impacts

Research line Energy Diagnosis

- Assessment of energy and indoor climate systems
 - At the levels of buildings, assets, cities, whole national building stock
 - By measurements in situ, National statistics, data from Energy Management systems etc...
 - Using statistics, pattern analysis and systems engineering/dynamics (e.g. presence patterns, comfort patterns)
- Development of diagnostic methods
 - What goes wrong in buildings, in HVAC?
 - What goes wrong in models and their inputs?
→ Calibration/training methods based on statistical approach
 - At building and building stock models

Building stock level

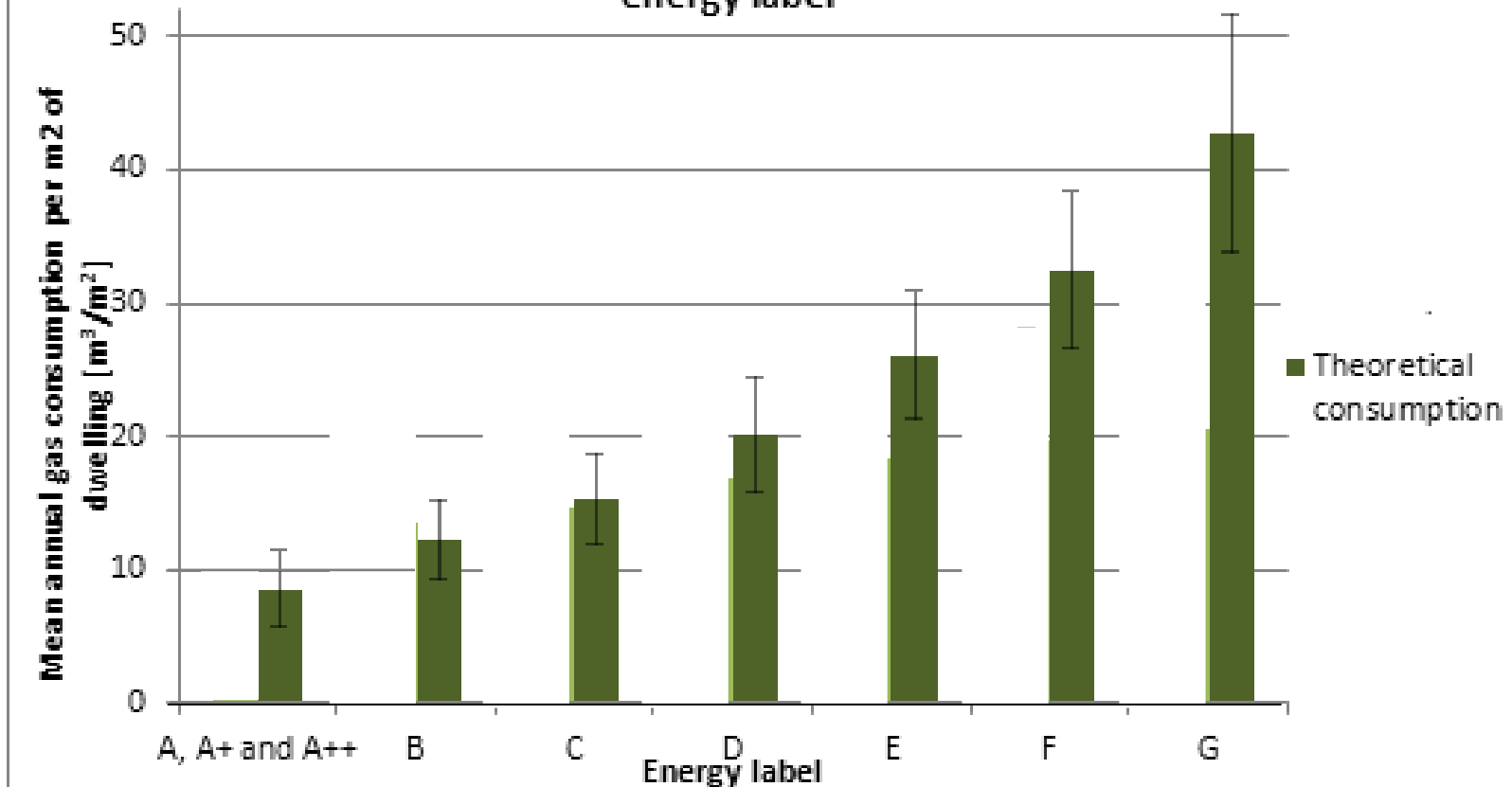
- PhD Faidra Filipidou, Paula van den Brom: follow up work Olivia Guerra Santin & Dasa Majcen (up to 2 million houses)



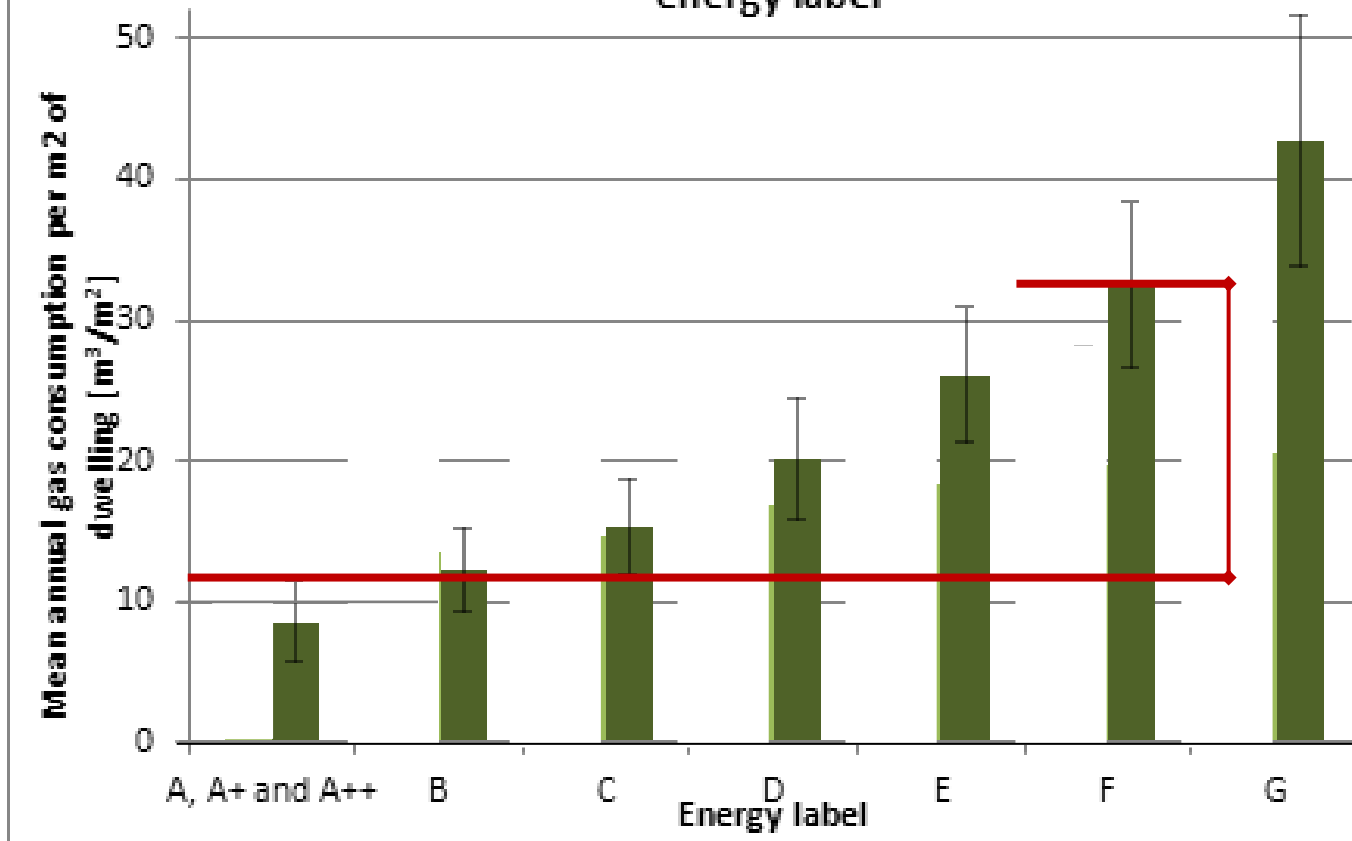
Theoretical Energy use

- Energy Label Model, based in EN ISO 13790
- Theoretical energy consumption is stored, together with inspection data, in:
 - National Energy label Database AND/OR
 - SHAERE data base (housing associations)

theoretical gas consumption per m² of dwelling per energy label

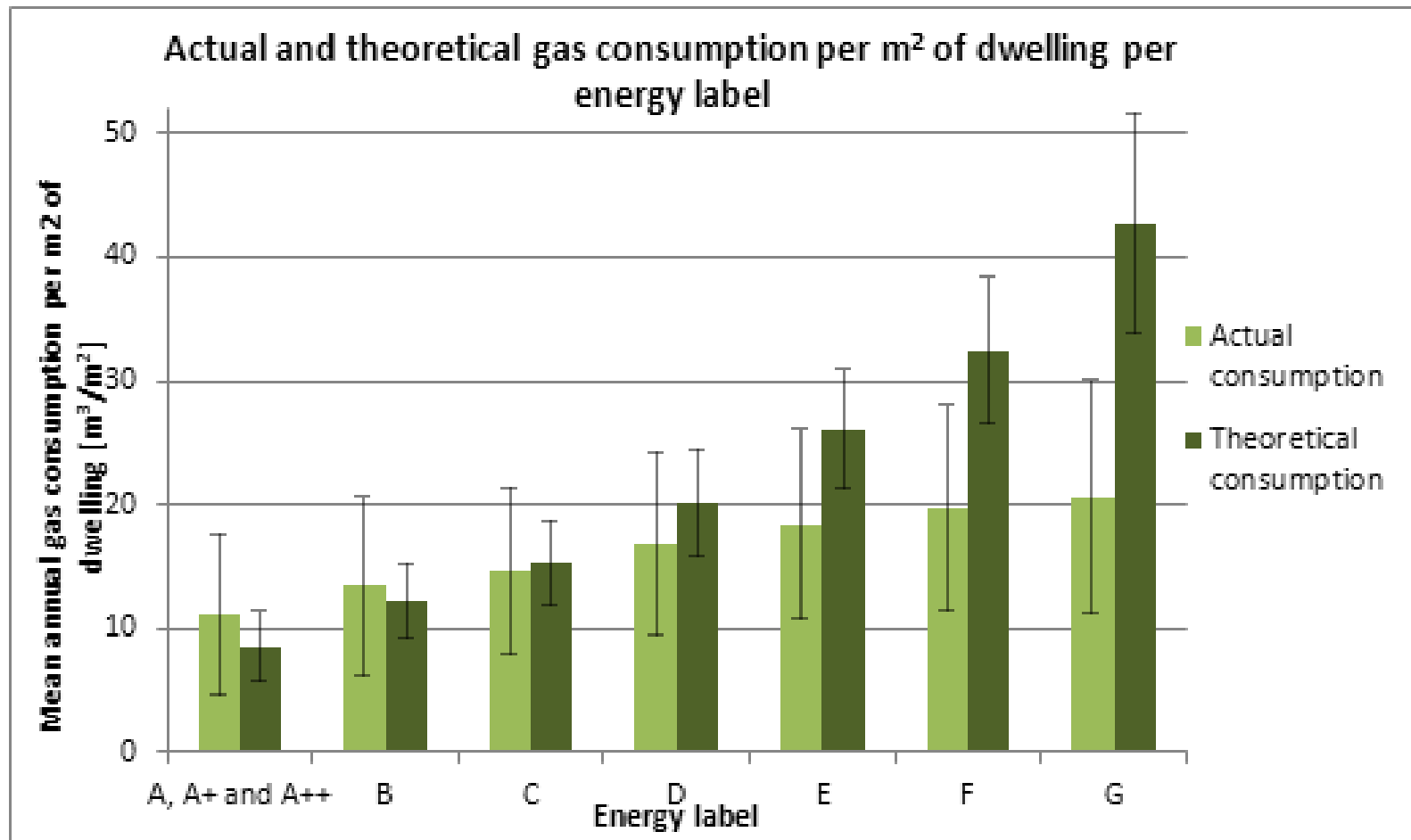


theoretical gas consumption per m² of dwelling per energy label

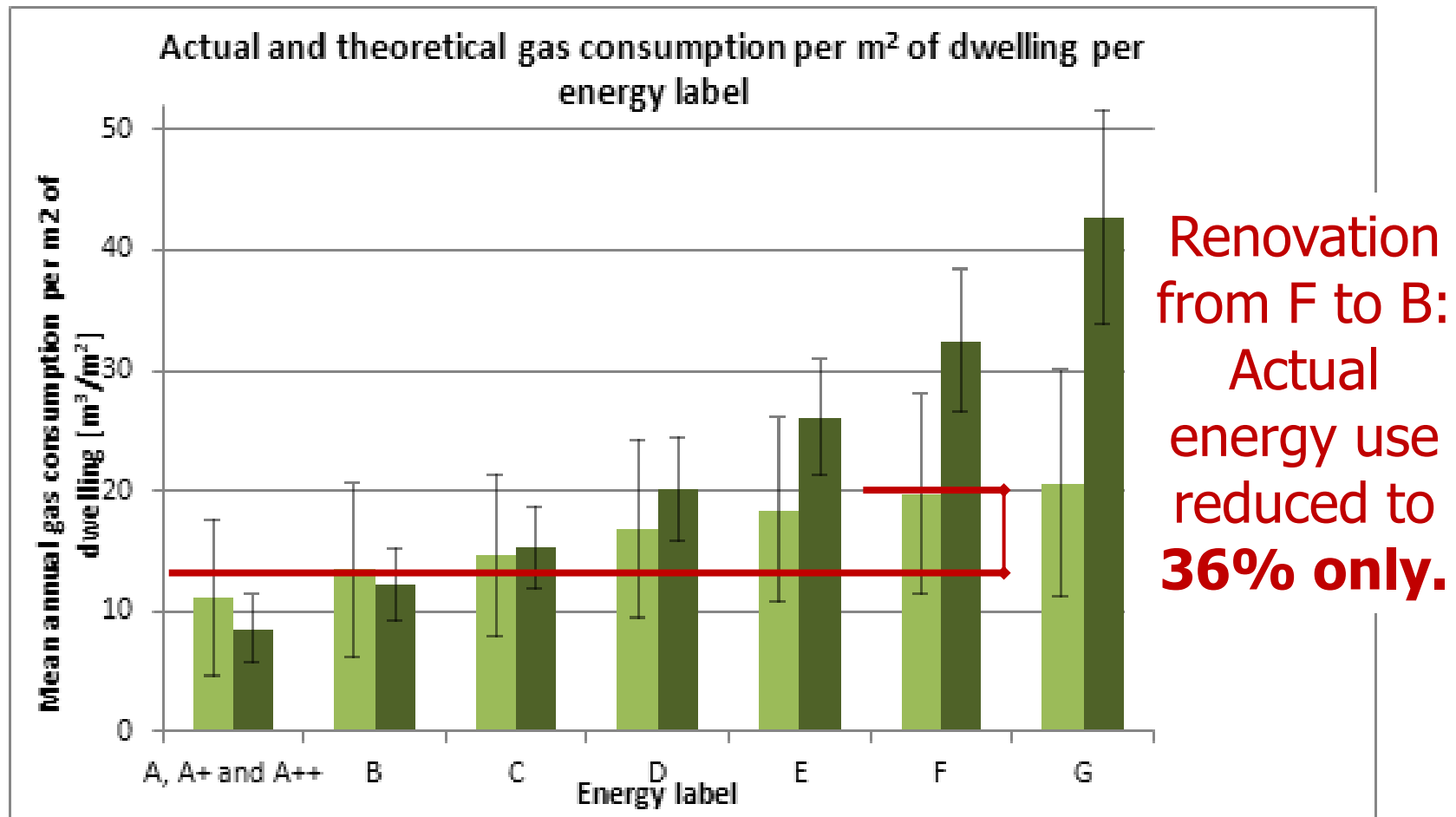


Renovation from F to B: energy use reduced by **66%**.

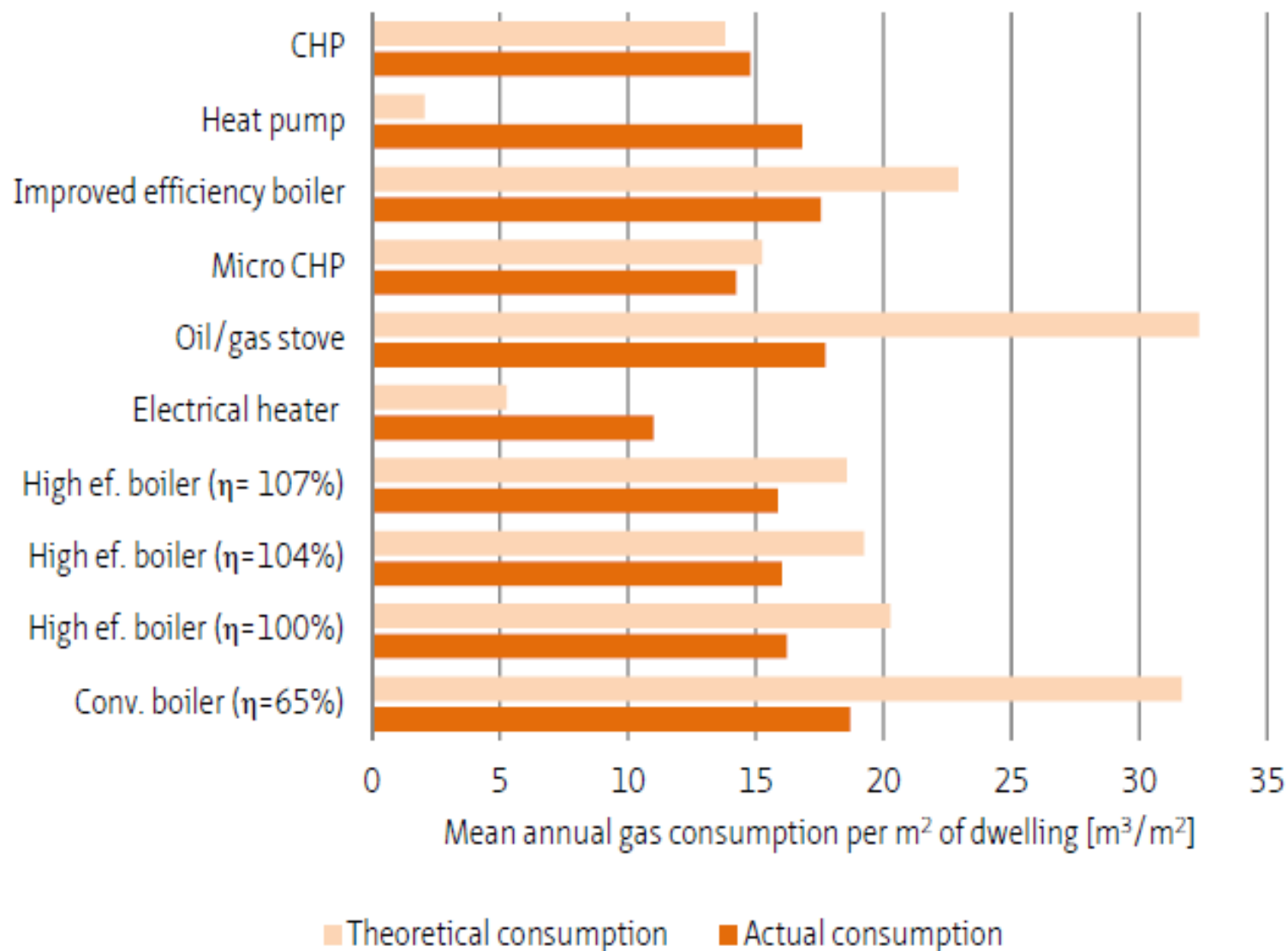
Measurements in 200.000 houses (also in 1 million houses)



Measurements in 200.000 houses (also in 1 million houses)



Gas consumption per m² of dwelling per installation type



Longitudinal studies: follow building upgrades since 2011

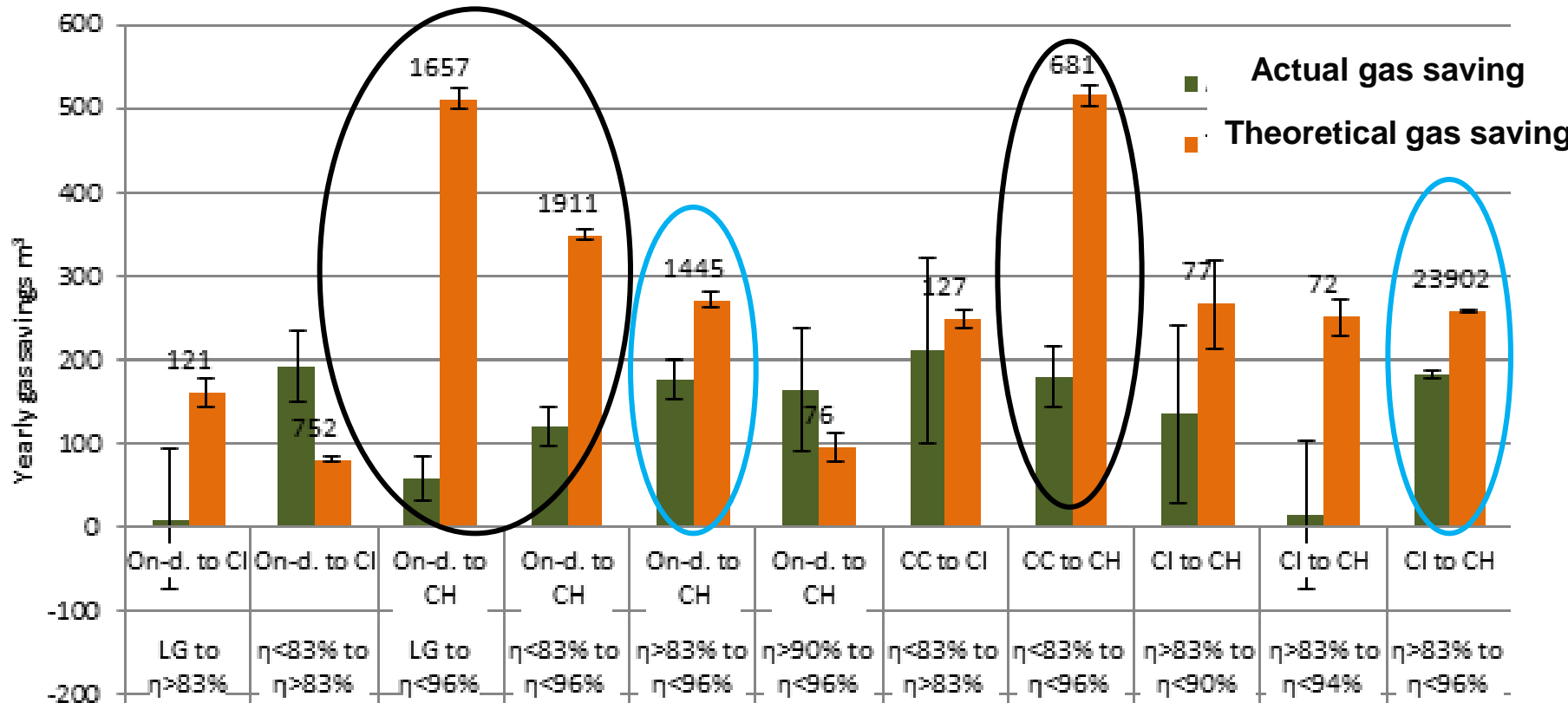
- 30.749 houses in which boilers (and only boilers) were replaced



- 15.744 houses in which glazing (and only glazing) was replaced



Prediction gap: boiler replacement

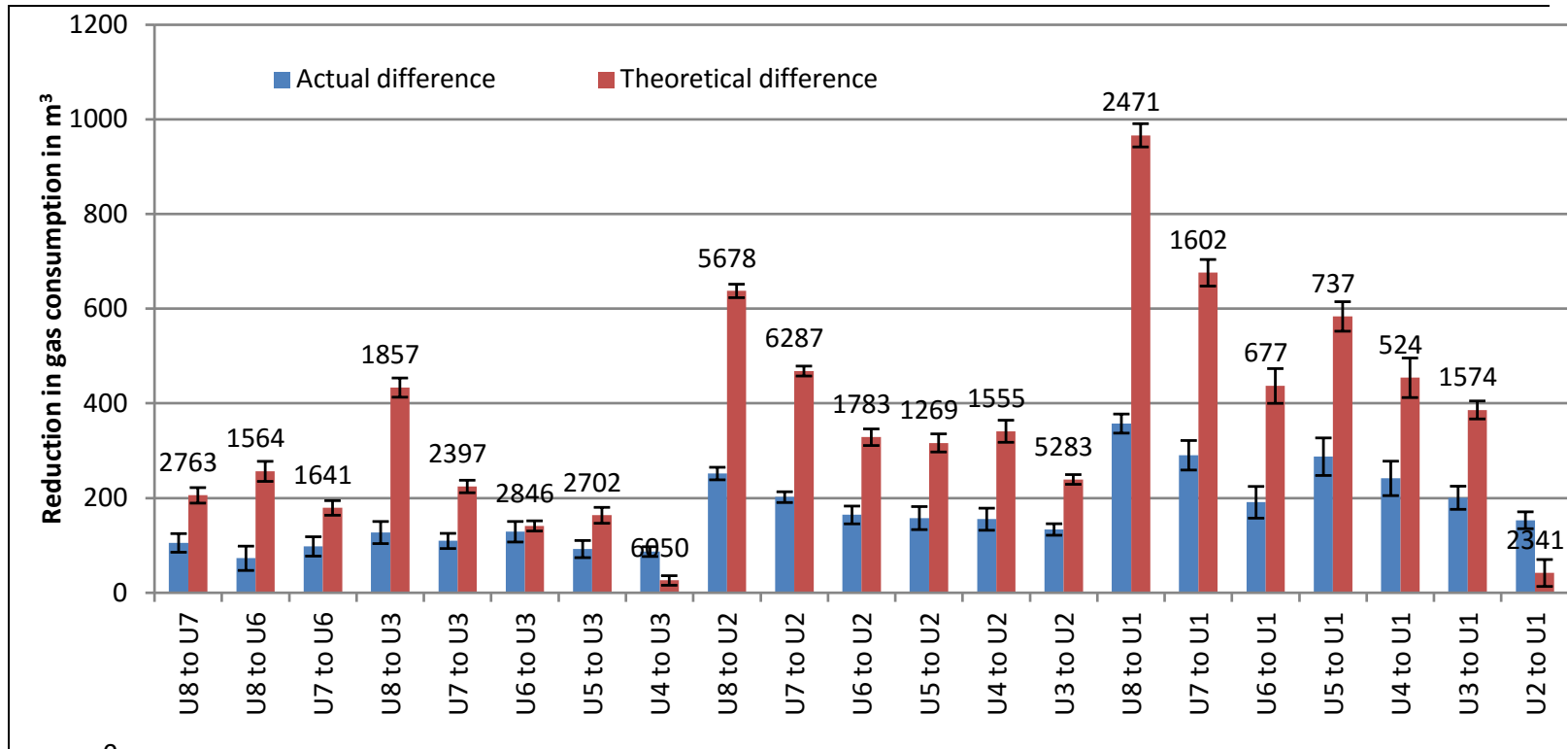


LG: Local gas heater (stove)

Non Condensing boilers: $\eta < 83\%$; $\eta > 83\%$

Condensing boilers: $\eta < 90\%$; $\eta < 94\%$; $\eta < 96\%$

Prediction gap: window replacement



What causes the gap?

- Small steps are better predicted than large steps
- The performances of **older systems** are generally much better than assumed
 - Efficiencies of HVAC seem to be higher
 - Rc values of walls seems to be higher

In-situ measurement of Rc values (EPM method)



Case Study	Construction Year	Rc-value: Assumed	Rc-value: Measured	Difference
1	1933	0.19 m ² KW ⁻¹	0.172 m ² KW ⁻¹	+5.6%
2	1964	0.19 m ² KW ⁻¹	0.78 m ² KW ⁻¹	-76%
3	1680	0.19 m ² KW ⁻¹	1.6 m ² KW ⁻¹	-88%

What causes the gap?

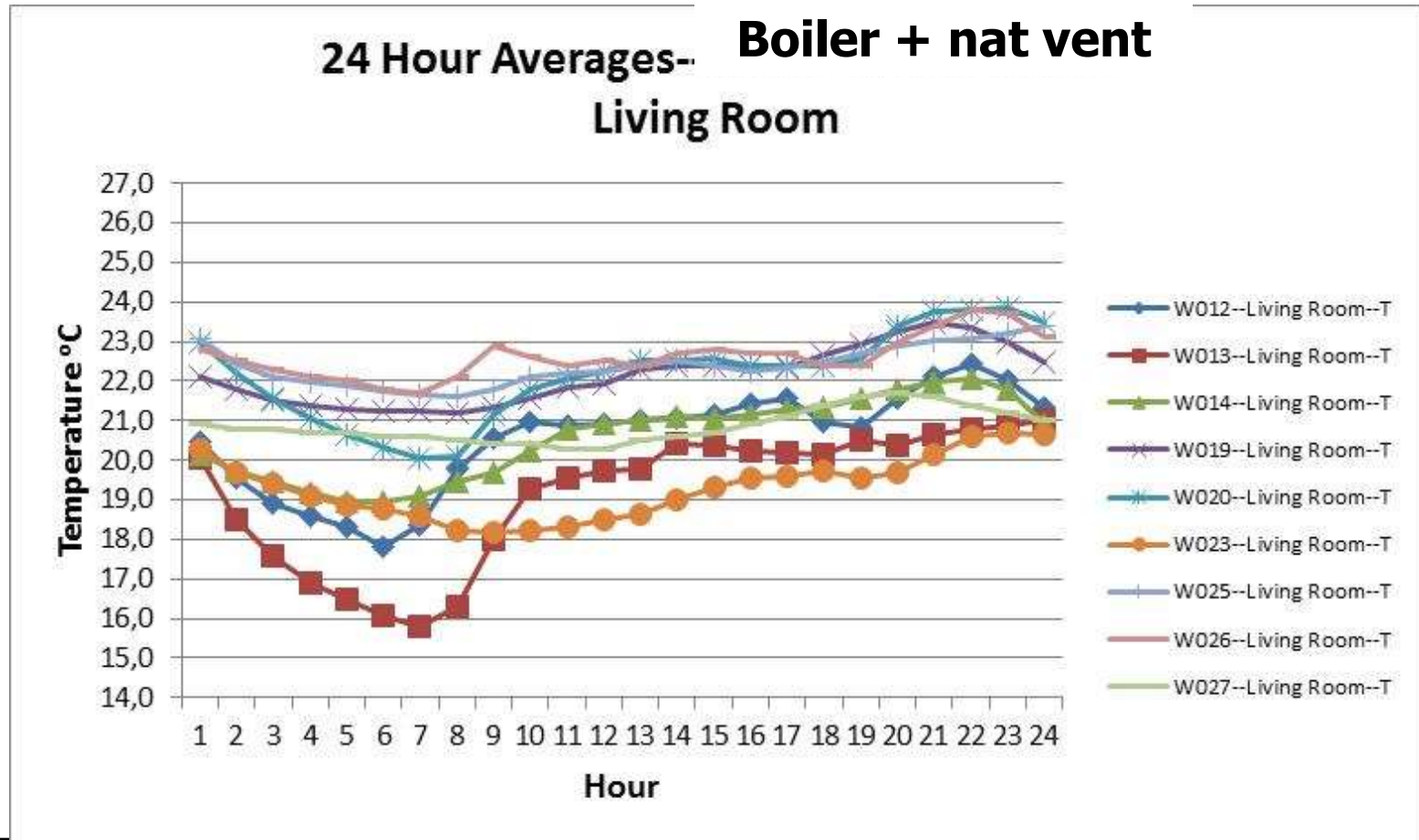
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What causes the gap?

- Small steps are better predicted than large steps
- The performances of **older systems** are generally much better than assumed
- Occupant behaviour
- Occupant behaviour **induced by technique**

In-situ measurements in 32 dwellings

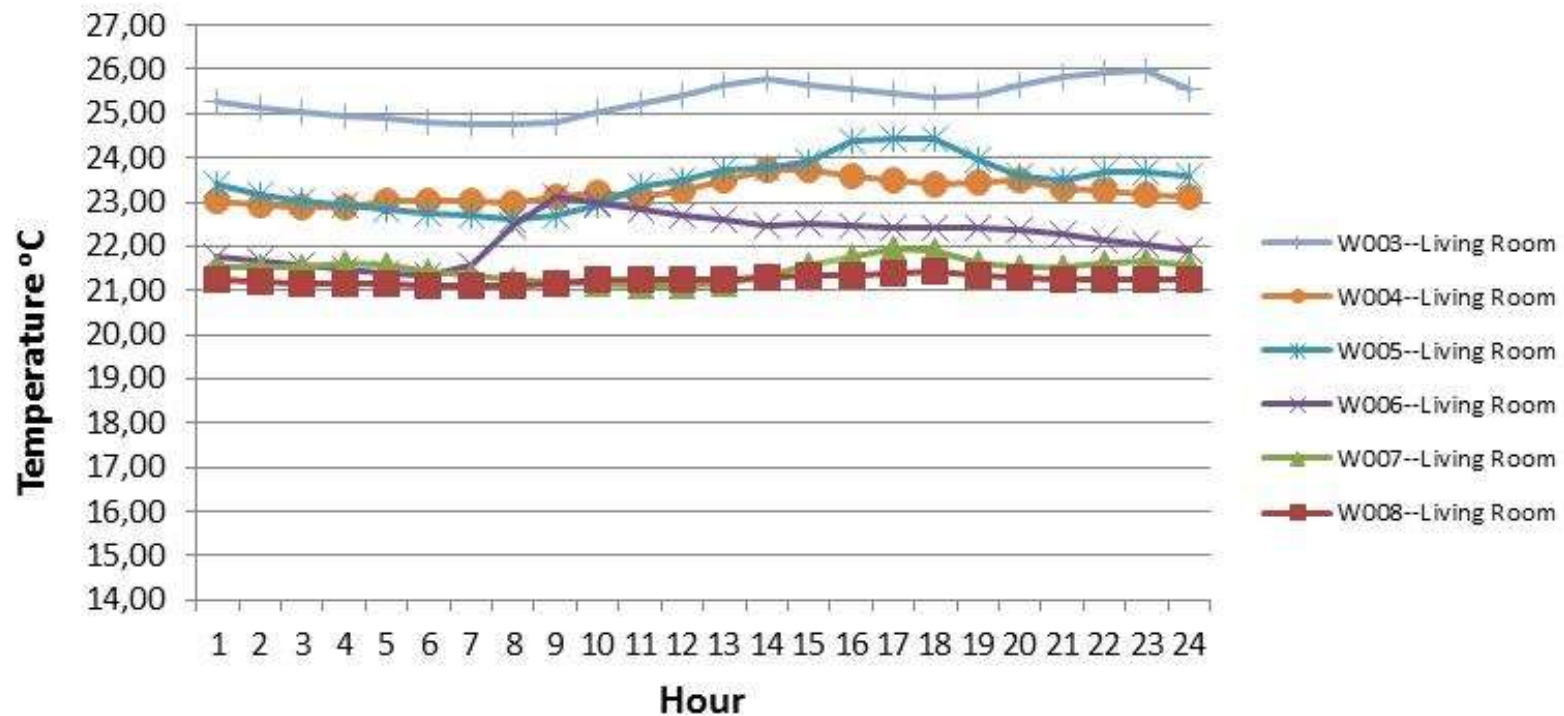
(MONICAIR/suslabnwe/Installaties2020)



In-situ measurements in 32 dwellings

(MONICAIR/suslabnwe/Installaties2020)

24 hour average profiles--| Heat pump + bal. vent Living Room



- Occupant behaviour or system characteristic?



Average Day T
~17 °C



Average Day T
~21 °C

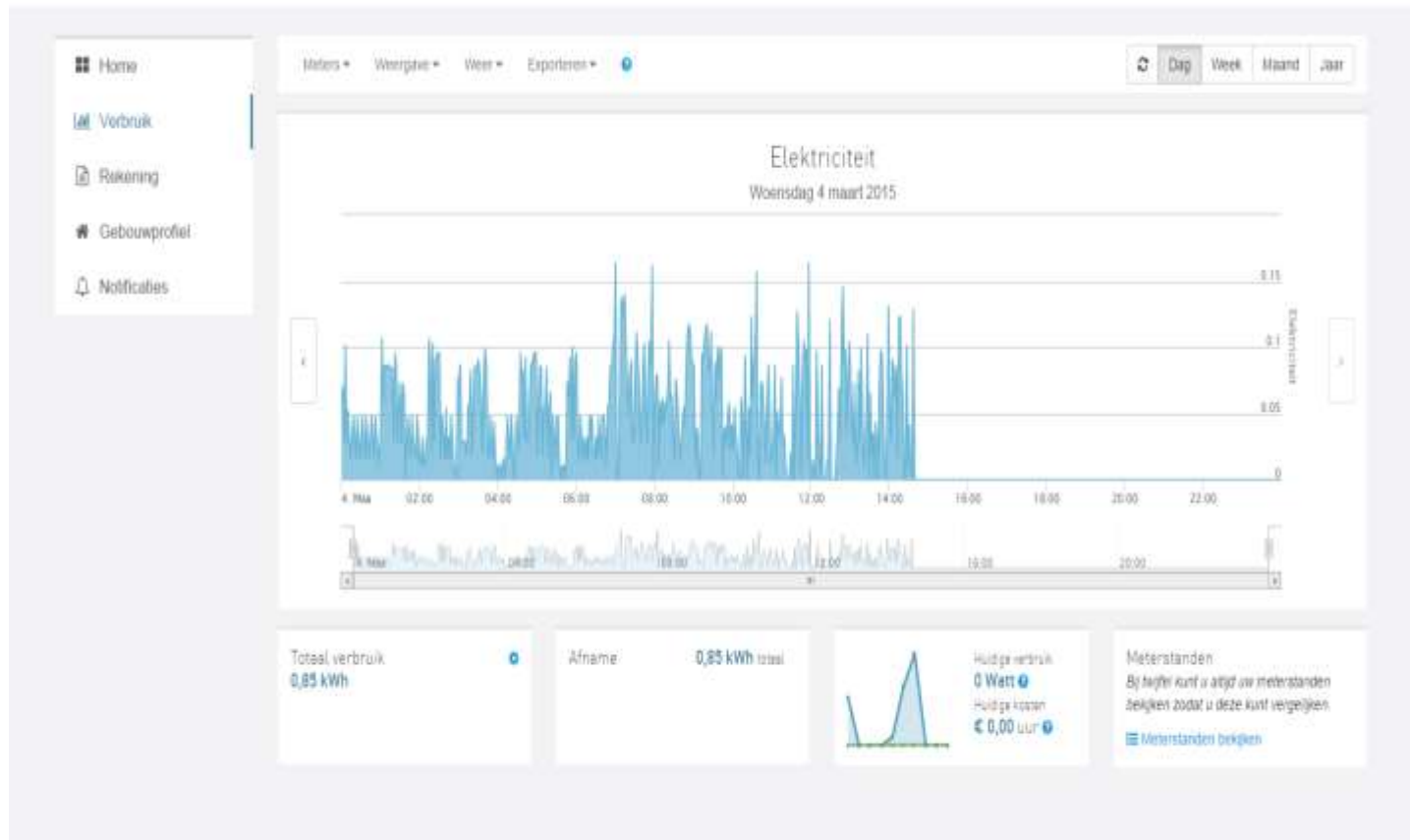
WHAT IS COMFORTABLE?

People seem to adapt to the temperature
they are given...

OPSCHALER

- Opschaler: Energy diagnose based on smart meter data
 - Monitoring in 200 houses
 - 2 PhDs (Tasos Ioannou, Arash Rasooli), 2 master students
 - With Enexis, Almende and several consultancies
 - www.otb.tudelft.nl/ecommon en www.opschaler.nl

Can continuous/aggregated reading of gas & electricity meters be used to estimate **accurately enough energy saving potentials** at house level and/or at block/district level?



Does it says something about

- The thermal quality of the house?
- The type/size of household?
- 'Energy behaviour' & comfort?