Evaluation into Practice to Achieve Targets for Energy Efficiency

EPATEE

Introduction to the project

Dario Di Santo, FIRE
Jean-Sébastien Broc, IEECP

Experience-sharing webinar EPATEE

5 March 2019

This project has received funding from the European Union’s Horizon 2020 Research and innovation programme under grant agreement No 746265.

The EPATEE project

OBJECTIVE: **creating favourable conditions** for improving the number, quality/performance and effective use of **ex-post impact evaluations** of energy efficiency policies.

CONCEPT: improving key stakeholders’ evaluation practices can lead to a better understanding and knowledge of impacts and how policies work, and thereby to increasing effectiveness of policies

Create the favourable conditions for ex-post impact evaluations

Building resources based on up-to-date knowledge and concrete experience feedback

Creating the conditions for an effective use of these resources

Knowledge Base
(user-oriented database of references)

Guidance and support

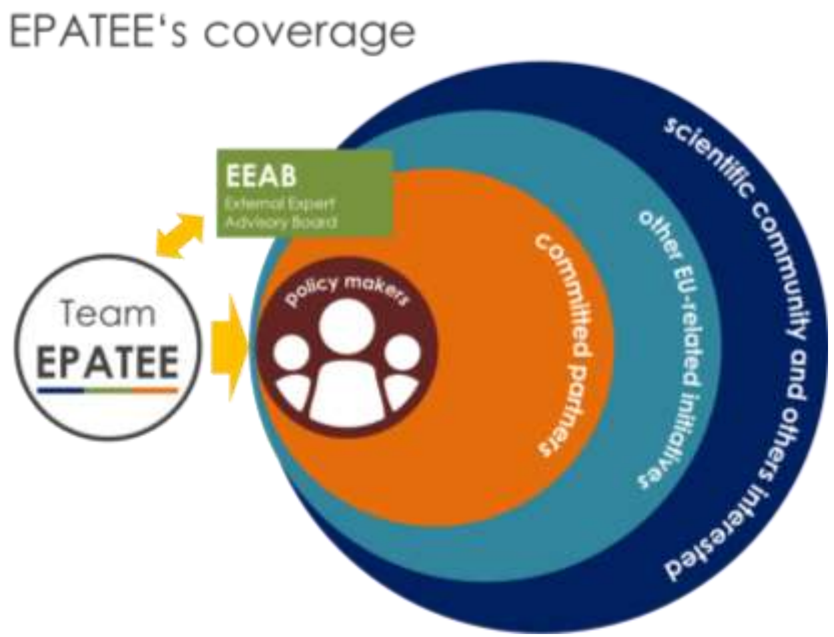
Case studies
(about ex-post evaluations)

Online toolbox
making resources easy to use

Experience sharing
targeted workshops, webinars, etc.

Dissemination
of results

Stakeholder involvement



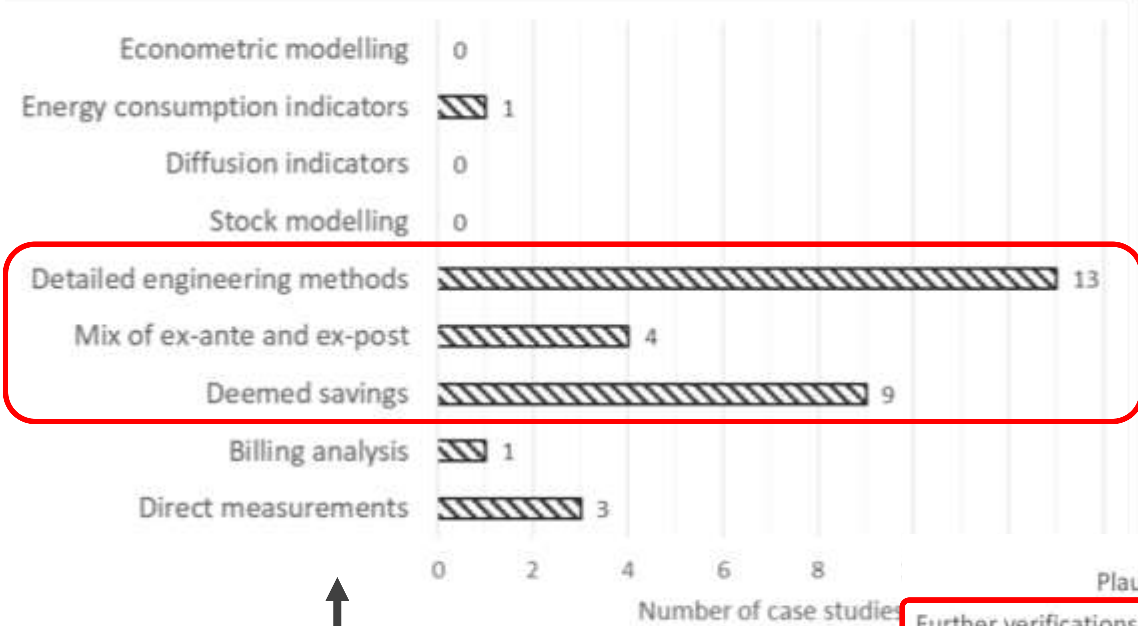
- Interviews with key stakeholders
- Surveys on evaluation practices
- EU peer-learning workshops
- National peer-learning workshops
- Webinars
- Direct support
- EPATEE newsletter

Previous experience sharing webinars about *How energy efficiency policy evaluation can produce **benefits and add value to policy makers**?* and *How and what can we learn from **verifying energy savings first estimated with engineering calculations**?*

Recordings available at:

https://epatee.eu/events-webinars

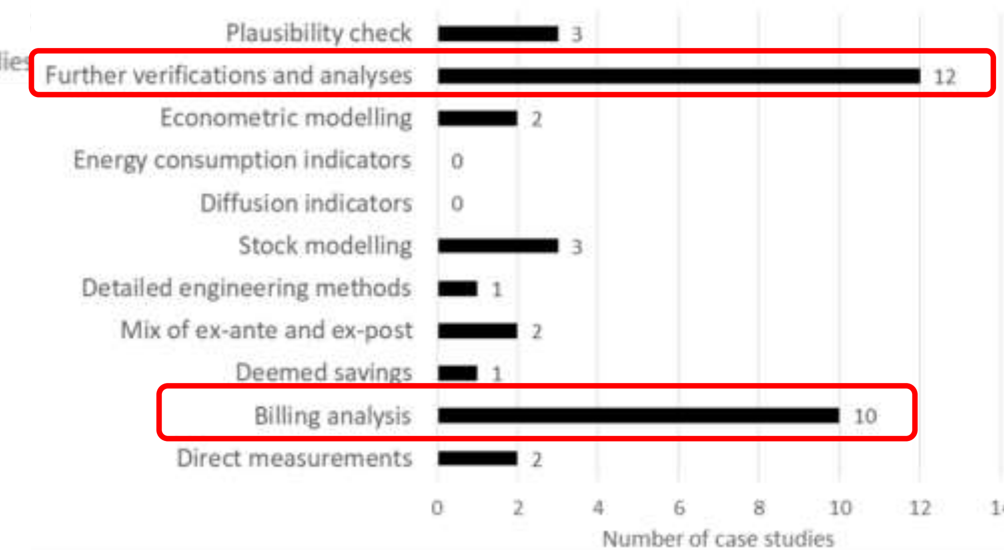
Comparing estimated and measured energy savings: why raising this topic?



Analysis of the 23 EPATEE case studies

Regular monitoring

Ex-post evaluations or studies



Comparing different methods: examples

Examples of use or comparison of different methods	Cases where these examples are mentioned
Plausibility check of the overall results (comparison with trends in energy consumption, and/or comparison with previous periods)	Environmental support scheme (AT), EE programmes of Vienna (AT), Primes Energie (BE)
Comparison of surveys and econometric analysis to assess additionality	EEO scheme (DK)
Comparison of different statistical methods	“Future investments” programme
Comparison of engineering calculations and billing data/analysis	Better Energy Homes (IE), Renovation programmes (LT), Subsidy scheme for housing corporations (NL), Supplier Obligation (UK), Warm Front (UK)
Comparison of monitoring of energy efficiency indicators (top-down approach) and monitoring based on engineering estimates at project level	Multi-year agreement (NL)
Comparison of standardised laboratory tests and field measurements	Purchase tax on new cars (NL)
Comparison of different methods to normalised energy consumption for weather conditions	WAP (US)

Looking for more references: EPATEE Knowledge Base

Search by Categories

Year of publication

1984 — 2017

Language

None selected

Study type	Type of policy instrument	Sector	Geographical scope
None selected	None selected	None selected	None selected

ADVANCED SEARCH

Evaluation type	Objective of evaluation	Data Collection	Calculation method
None selected	None selected	None selected	None selected

- Method 1
- Method 2
- Method 3
- Method 4
- Method 5
- Method 6
- Method 7
- Method 8
- Method 9
- Method 10

Baseline / counterfactual	Savings data presentation	Normalisation factors
None selected	None selected	None selected

Cost data	Uncertainty analysis	Other impacts
None selected	None selected	None selected

SEARCH

CLEAR ALL

Details about the type of methods

EPATEE

Check the previous webinars

https://epatee.eu/events-webinars

Webinar #5 - 2nd EPATEE dissemination webinar

Webinar #6 - March 28, 2019

Webinar #4 - How and what can we learn from verifying energy savings first estimated with engineering calculations? (Part 2)

Webinar #4 - March 5, 2019 - 11:00 to 12:15 am CET

Webinar #3 - How and what can we learn from verifying energy savings first estimated with engineering calculations?

Webinar #3 - December 14, 2018 - 11:00 to 12:15 am CET

Webinar #2 - First EPATEE dissemination webinar

Webinar #2 - May 30, 2018

This webinar presented the project, and more specifically the first online resources developed by EPATEE to make knowledge and experience more easily available about evaluating energy efficiency policies and programmes:

Webinar #1 (Part 2) - How energy efficiency policy evaluation can produce benefits and add value to policy makers?

Webinar #2 - March 20, 2018

What’s next?

- Two other examples to be presented today during this webinar!
- Topical case study about *[Comparing estimated and measured energy savings]* → published today !

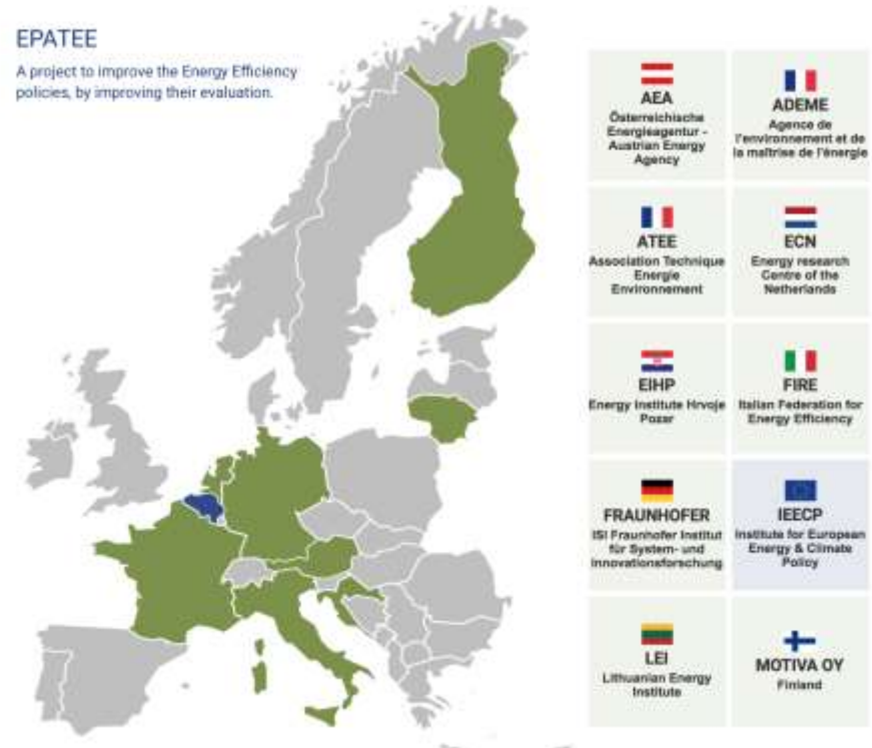
SAVE THE DATES

- **March 18th**, 2019: **[first national EPATEE workshop]** (France, Paris)
- **March 28th** , 2019: **[second dissemination webinar]** showcasing the EPATEE online toolbox
- **June 13th**, 2019: **fourth European peer-learning workshop** in Brussels

STAY TUNED!

Contacts

Thank you for your attention!



https://twitter.com/epatee_eu

https://epatee.eu/subscribe-our-newsletter

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STAKEHOLDERS ENGAGEMENT

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CASE STUDIES

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Metered data: what do they tell us we didn’t know?

(The Dutch case)

Prof. dr. L.C.M. Itard

EPATEE Webinar 5 March 2018

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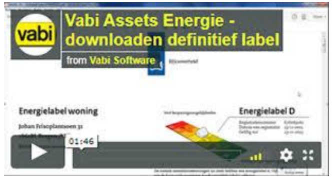
Building Energy Epidemiology

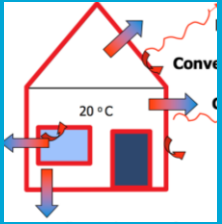
- Expertise in energy systems in buildings
- Coupled to statistical research on factors influencing operational energy use
- To prevent too high energy usage and understand energy systems in use

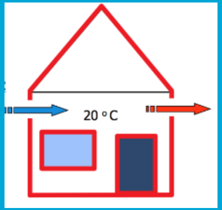
IEA Annex 70: https://energyepidemiology.org/

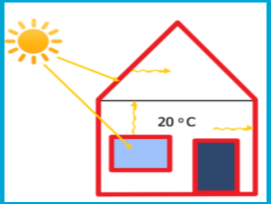
Energy policies for the building stock

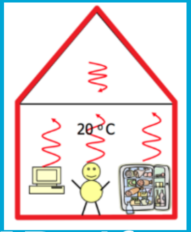
- Traditionally based on energy models of buildings (BES, Building Energy Simulation)
  - To assess the current situation
  - To assess efficiency of measures and scenario’s and steer











HEATING ENERGY IS SUM OF:

- Transmission (through the construction)
- Ventilation and infiltration
- Solar gains (through windows)
- Internal gains

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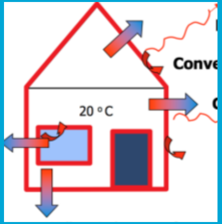

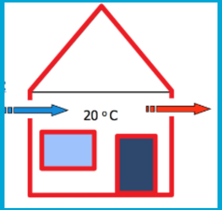

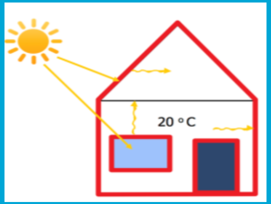

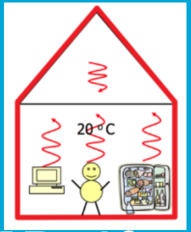

- Transmission (through the construction)
- Ventilation and infiltration
- Solar gains (through windows)
- Internal gains
- Accumulation of heat in construction

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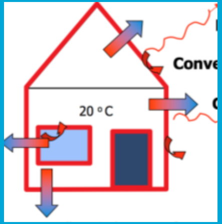
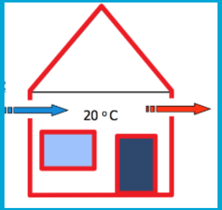
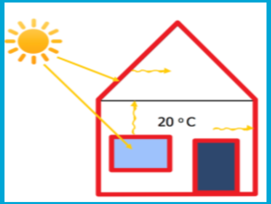
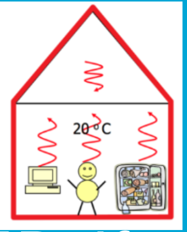








- Transmission (through the construction)
  Insulation, Rc, U-value, geometry
- Ventilation and infiltration
  Air flow rates, openings, air thightness
- Solar gains (through windows)
  Orientation, window size
- Internal gains
  Number of people, appliances
- Accumulation of heat in construction
  Materials

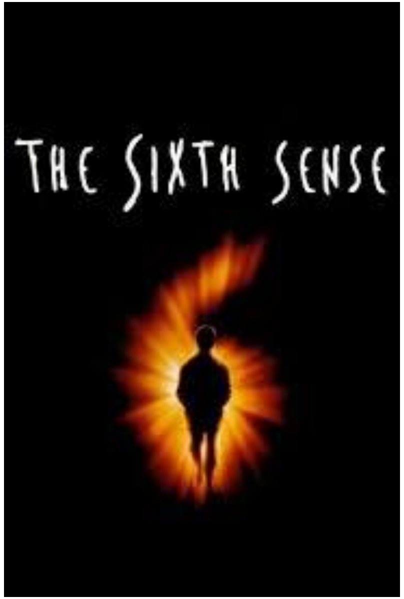
Energy policies for the building stock

- A few hundreds of input data per building archetype
- A few tens of building archetypes

(Episcope /Tabula)

Theoretical/ expected (actual and future energy use in building stock

Big data, digitization, smart meters & sensors



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IMAGINE THAT

- The yearly energy consumption of all houses would be recorded individually

- And we would have data on these individual houses

We could then

- Verify if the models are telling us the truth
- Calibrate models (have the right starting point)
- Check the efficiency of measures
- Learn: is it going as expected?

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IMAGINE THAT

- The yearly energy consumption of all houses would be recorded individually

  → National Statistics NL (~7 million yearly records)

- And we would have data on these individual houses

  → Energy label data records (~2 million houses)

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- Large samples (~ whole populations)
  - We can get rid of representativeness issues
  - Get rid of 95% confidence intervals
  - And know for sure what are the averages and the distribution

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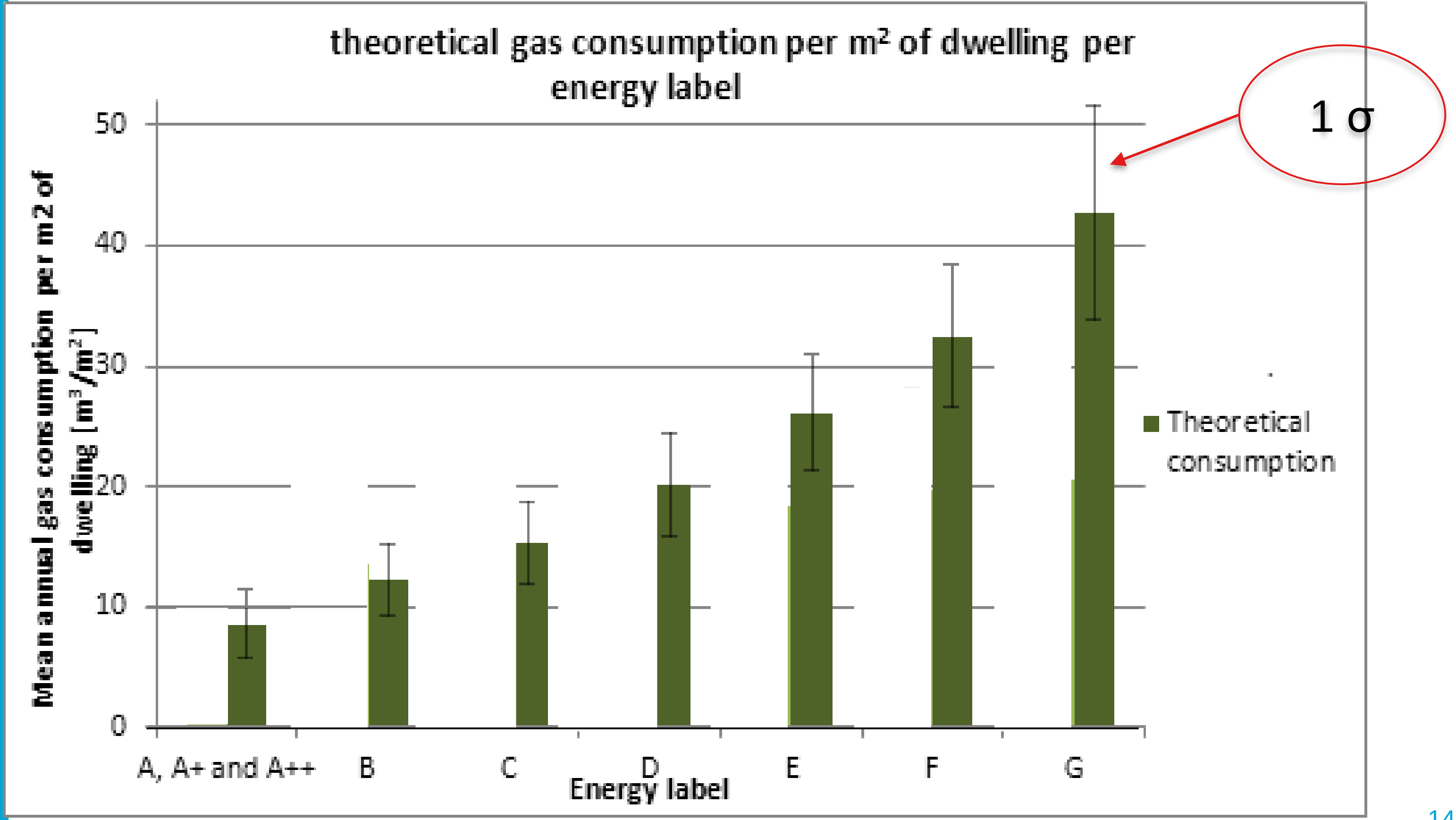
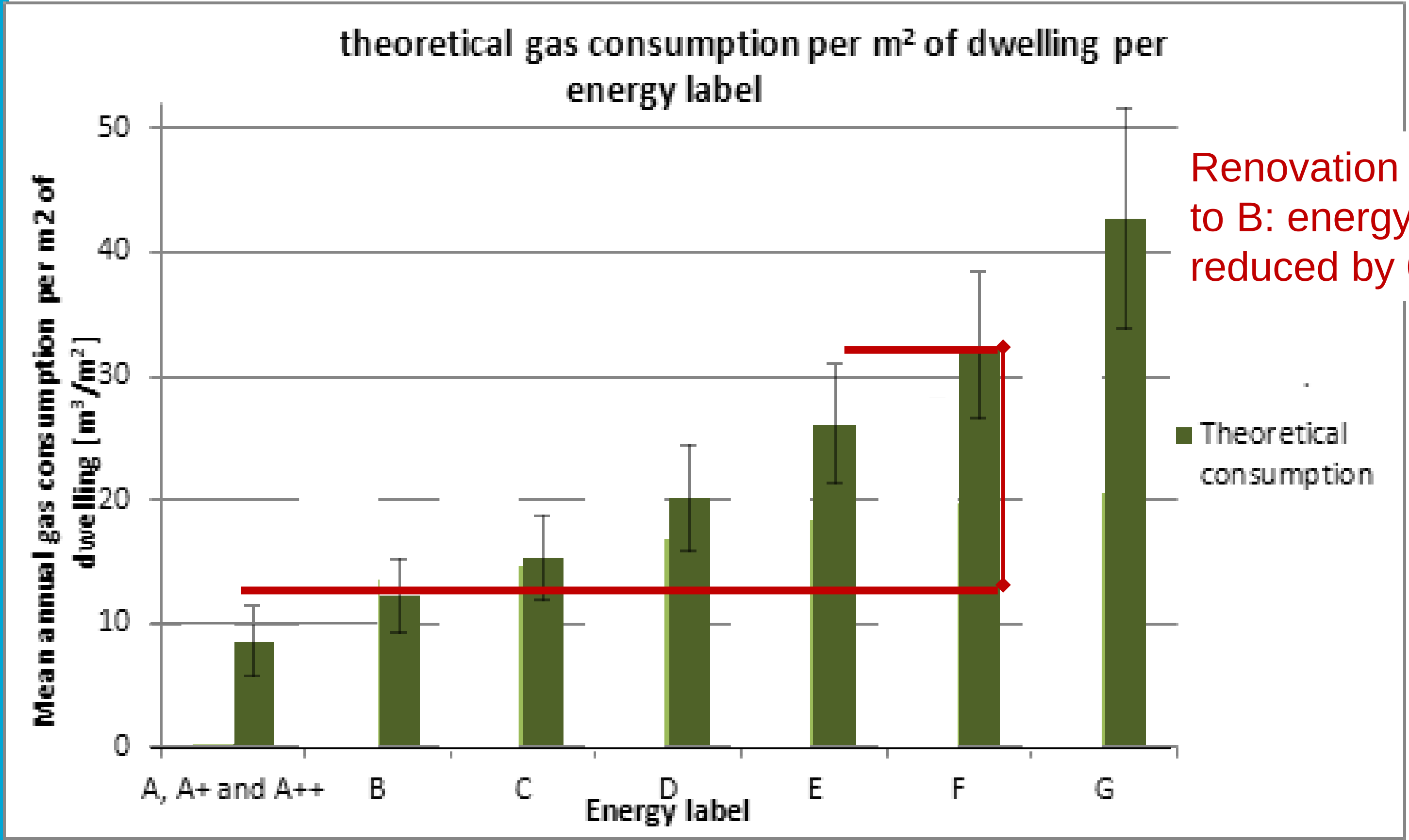
Shrinking databases

- large samples tend to reduce severely when you try to use them
  - Incomplete data, wring formats, labels without energy intensity etc…

~200.000 houses

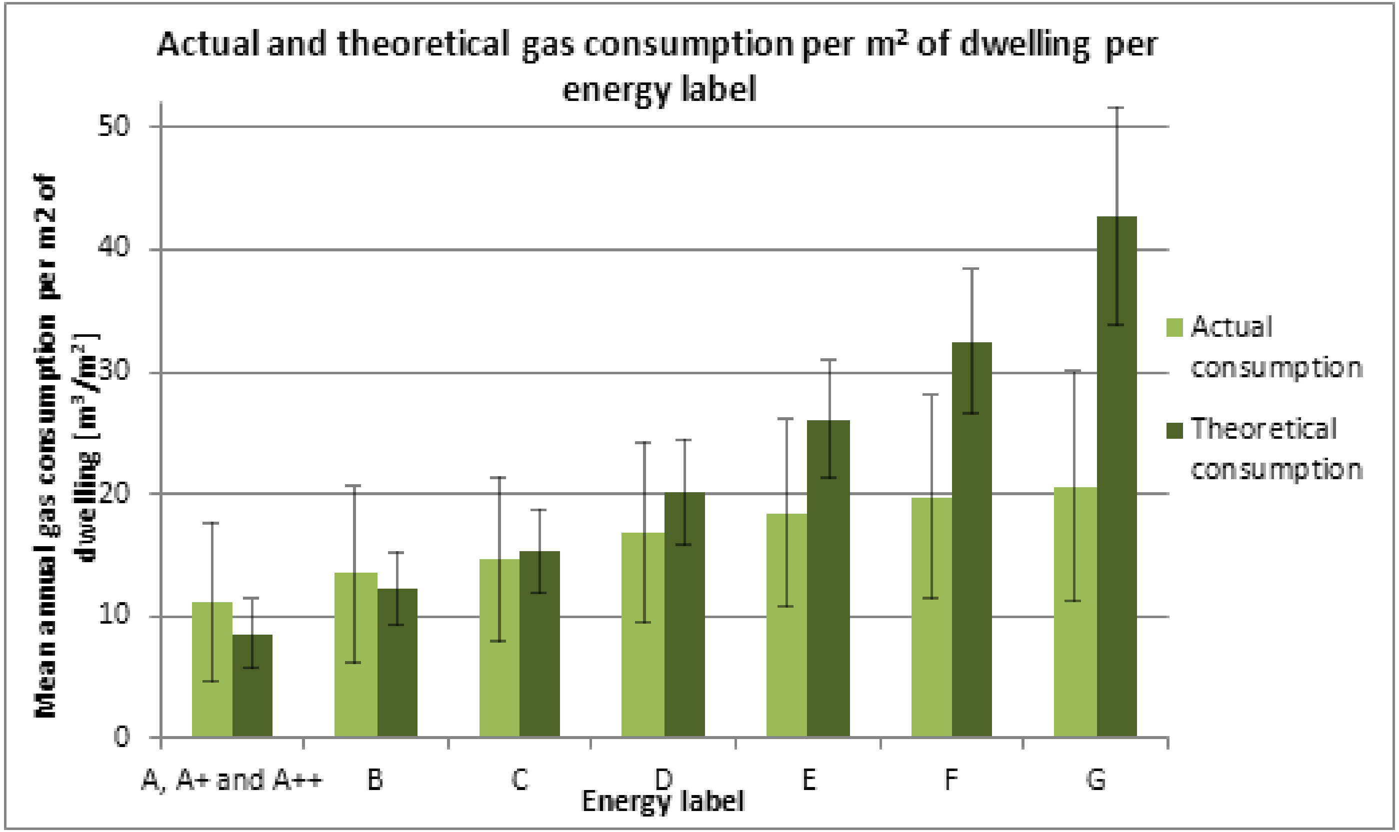
Y-axe:
heating
intensity
(1 m3 gas=
9 kWh





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

~200.000 houses



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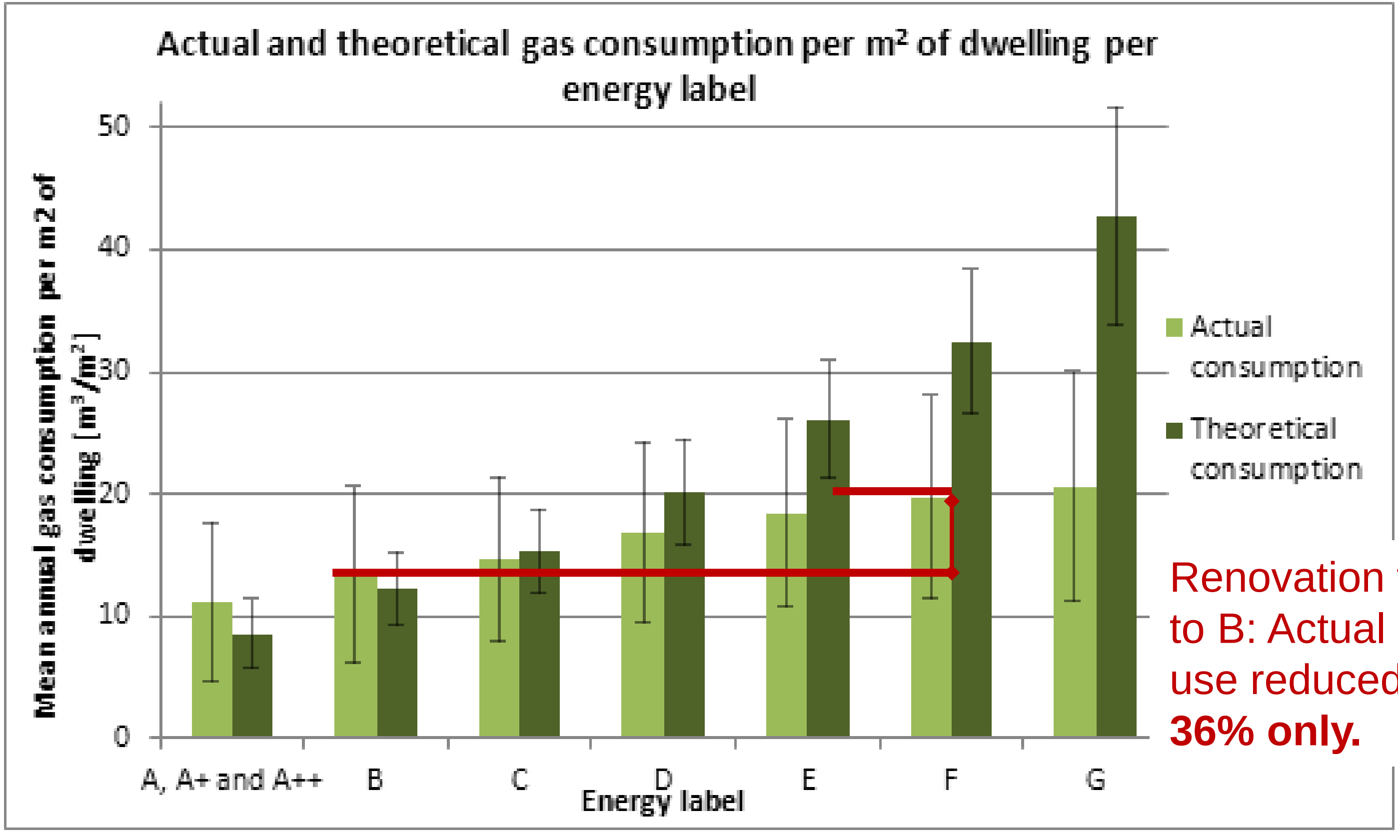

Renovation from F to B: Actual energy use reduced to **36% only.**

Why are the models inaccurate?

- Inaccurate/unknown inputs to models

→ lots of guesses

- Unknown interactions between HVAC/building/occupants

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What is needed to enrich the data?

- Large representative samples or whole population
- Energy data (and weather data)
- Building data
- Household data
- Possibilities to couple data at address level (cadastre linked data)

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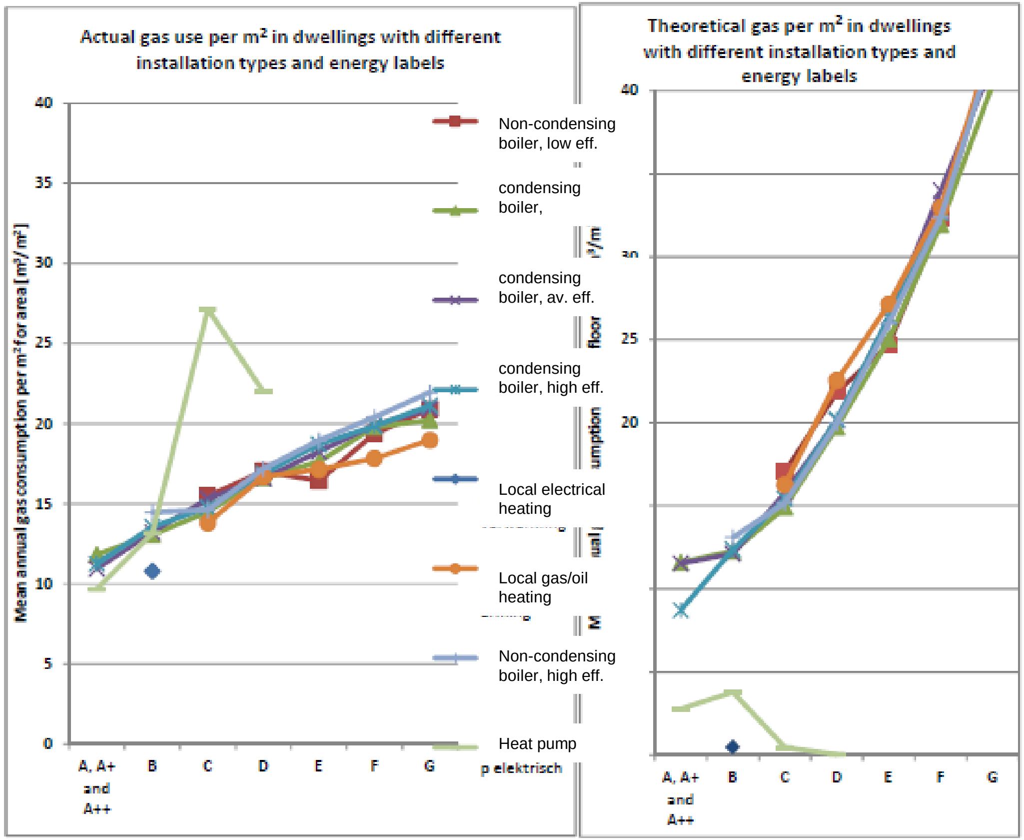
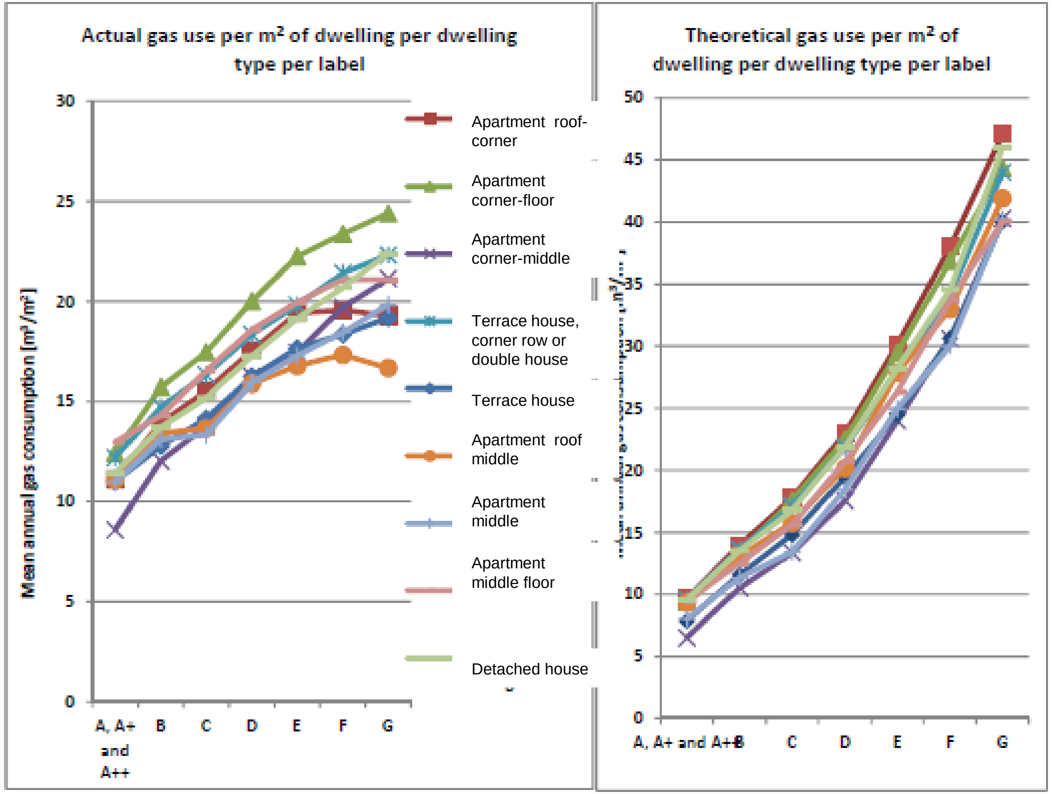
Adding information

- Energy label database
  - From government: contains limited information
  - From housing associations (30% of total stock) : all inspection data on building and HVAC are available
  - Micro data from Statistics NL: Demographics & Economics at household level

Per type HVAC



Per building archetype



With household data

- Multivariate regression models: which parameters are important to predict energy use?

- Building: floor area, construction year, type, heating type, ventilation type
- Household: number of occupants, composition, education, ability to pay the bills
- ‘Behaviour’: hours of presence, temperature, energy consciousness

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With household data

- What additional parameters explain the differences between modelled and actual use?

- Building: programmable thermostat, additional heating system
- Household: age, ownership type
- ‘Behaviour’: ventilation habits in weekend, thermal perception (hot/cold)

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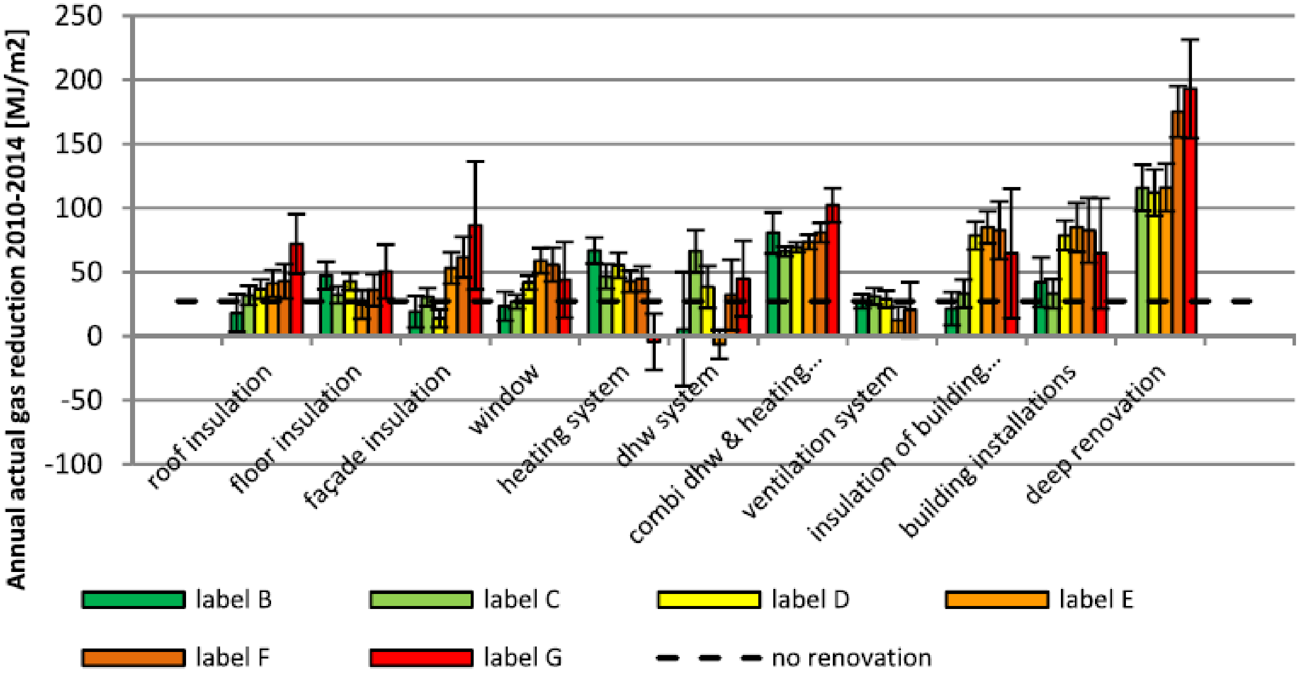
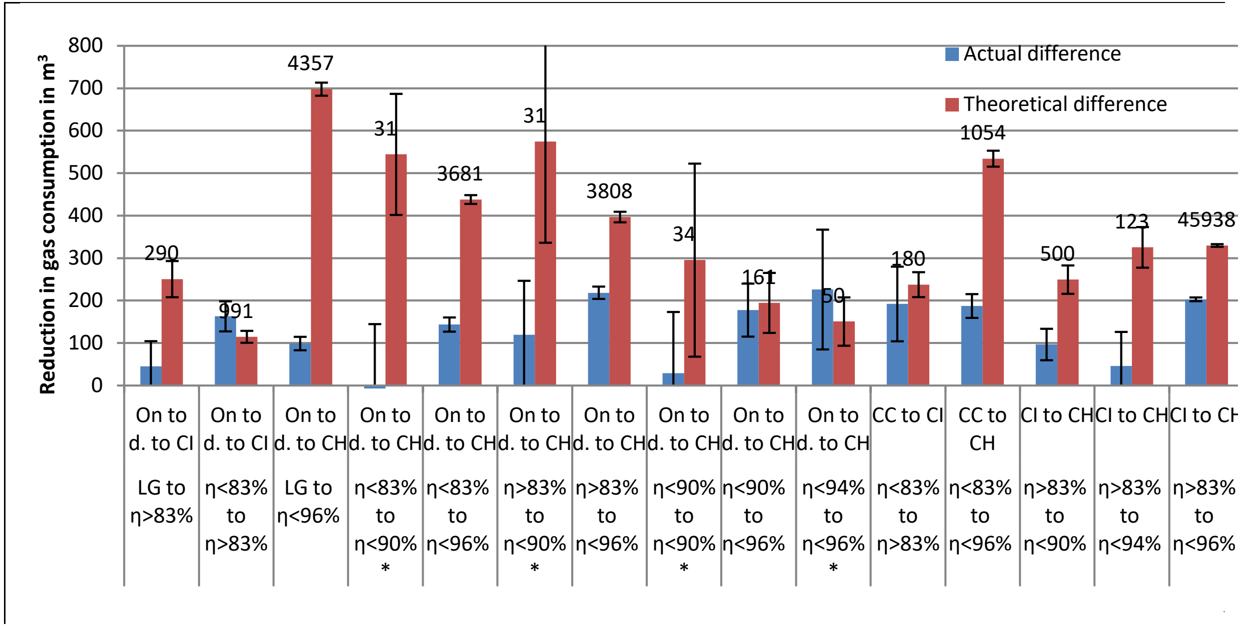
Databases with yearly energy data: Follow renovations the building stock

- ~90.000 cases (P. vd Brom, Energy & Buildings, Vol. 182, 2019)



Zoom in energy systems



Machine learning: the future

- Calibration of models in individual houses of groups of houses
  - E.g. finding Rc values at house levels
  - Finding ‘standard’ Rc-values per construction period
  - Determining indoor temperatures –without measuring them

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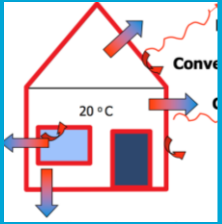

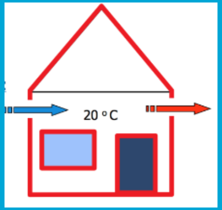

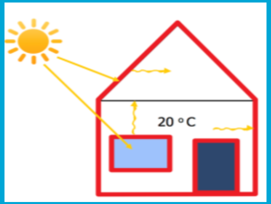

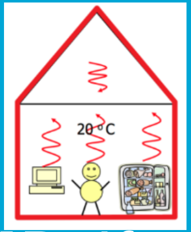

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Key-issues

- Availability of data
- How to cope with privacy
- Having an organization allowed to couple
- Quality of data (intrinsic & database)
- Continuity of data collection
- Changes in models
- TIME: data cleaning is very time costly

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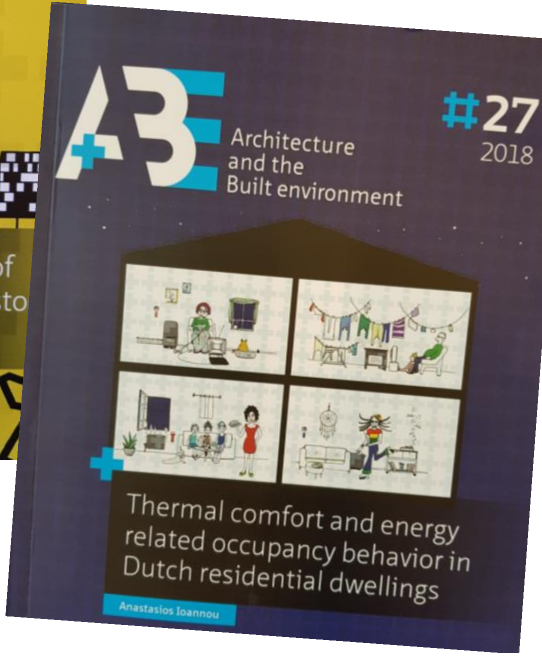
SUSTAINABLE URBAN AREAS 33
Actual energy consumption in dwellings
The effect of energy performance regulations and occupant behaviour
Olivia Guerra S
Architecture and the Built environment
#04
2016
Predicting energy consumption and savings in the housing stock
A performance gap analysis in the Netherlands
Daša Majcen


Architecture and the Built environment
#14
2018
Energy performance progress of the Dutch non-profit housing sto
a longitudinal assessment
Faidra Filippidou


Architecture and the Built environment
#27
2018
Thermal comfort and energy related occupancy behavior in Dutch residential dwellings
Anastasios Ioannou

Q&A

TU Delft

Contact:
L.C.M.Itard@TUDelft.nl

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UCL Energy Institute

UCL

Comparing Energy Ratings, Stock Models, and Empirical Data

Analysis of the differences between energy consumption from building energy stock models, Energy Performance Certificates, and the impact of efficiency measures using metered data from the UK National Energy Efficiency Data-framework

Alex Summerfield
UCL Energy Institute
Bartlett School of Environment Energy and Resources, UCL

TITLE STYLE
SUB STYLE

Context

- Researchers need a better understanding of policymaker perspectives to:
  - Do analysis that is relevant for policy development/initatives
  - Interpret and communicate findings in a way that is useful and clear, without going beyond their validity

- Help policymakers better understand the limitations of the tools and data they are relying on

- Learning process, an ongoing conversation…

Case study: 2017 UK Clean Growth Strategy (CGS)

- Responding to obligations under 2008 Climate Change Act
  - including submitting plans to the Committee on Climate Change so that they can evaluate progress on a road map to achieve the national carbon emissions objectives.
- CGS covers all sectors of the economy
- This work focuses on one chapter
  - the residential buildings sector.

Policy framework: CGS proposal for the residential sector

- *Shape or form*: what kind of programme?
  - *Energy efficiency retrofit programme based around EPC's*
- *Scale:* What size of intervention (energy savings, costs)?
  - *Aim for a minimum energy rating: EPC Band C across the stock*
- *Scope:* Which sub-sector/s targeted?
  - *All existing residential dwellings with EPC D or below, but especially fuel poor homes.*
- *Speed or urgency:* timeline and milestones and evaluation/ revisions possible within these constraints
  - *"As many as possible" by 2030, but all fuel poor homes*
  - *Acknowledge that some efficiency benefit will be taken as improved indoor conditions (and possibly improved health outcomes)*

Triangulation: energy policy development by combining outputs from various sources/tools as "evidence"

- SAP and Energy Performance Certificates to comply with the EU Building Performance Directive and subsequent legislation
  - Energy models i.e. SAP (Standard Assessment Procedure): simple building physics and conventional assumptions (e.g. "typical operation")

- National Housing Energy (Stock) models
  - Use national housing surveys for the composition to determine the numerous "categories" of dwellings
  - Calculations mainly based on SAP method for each category and weighted by prevalence

- National Energy Statistics
  - Large scale metered data for estimating economy wide energy consumption, carbon emissions
  - Also National Energy Efficiency Data Framework (NEED) tracking installations, such as condensing boilers or cavity wall insulation.

Energy Performance Certificates

- EPC ratings for dwellings calculated from SAP (standard assessment procedure)
  - as EPC bands (A to G) from SAP ratings (0-100) for individual dwellings
  - Intended to provide a “like with like” comparison.
  - Sets ‘typical” indoor conditions: 21˚C demand temperature for percentage of the floor area and the same duration of heating

Energy Performance Certificate

SAP

[redacted]

Dwelling type:	Ground-floor flat	**Reference number:**	[redacted]
Date of assessment:	19 May 2016	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	21 May 2016	**Total floor area:**	76 m²

Use this document to:

- Compare current ratings of properties to see which properties are more energy efficient
- Find out how you can save energy and money by installing improvement measures

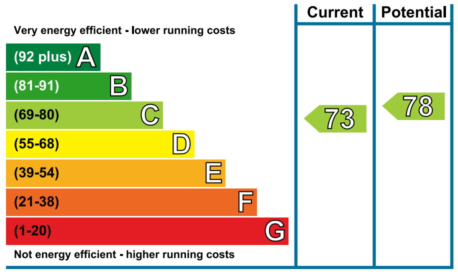
Estimated energy costs of dwelling for 3 years:	**£ 1,704**
Over 3 years you could save	**£ 312**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 333 over 3 years	£ 189 over 3 years	You could save £ 312 over 3 years
Heating	£ 918 over 3 years	£ 750 over 3 years	
Hot Water	£ 453 over 3 years	£ 453 over 3 years	
Totals	£ 1,704	£ 1,392	

These figures show how much the average household would spend in this property for heating, lighting and hot water. This excludes energy use for running appliances like TVs, computers and cookers, and any electricity generated by microgeneration.

Energy Efficiency Rating



The graph shows the current energy efficiency of your home.

The higher the rating the lower your fuel bills are likely to be.

The potential rating shows the effect of undertaking the recommendations on page 3.

The average energy efficiency rating for a dwelling in England and Wales is band D (rating 60).

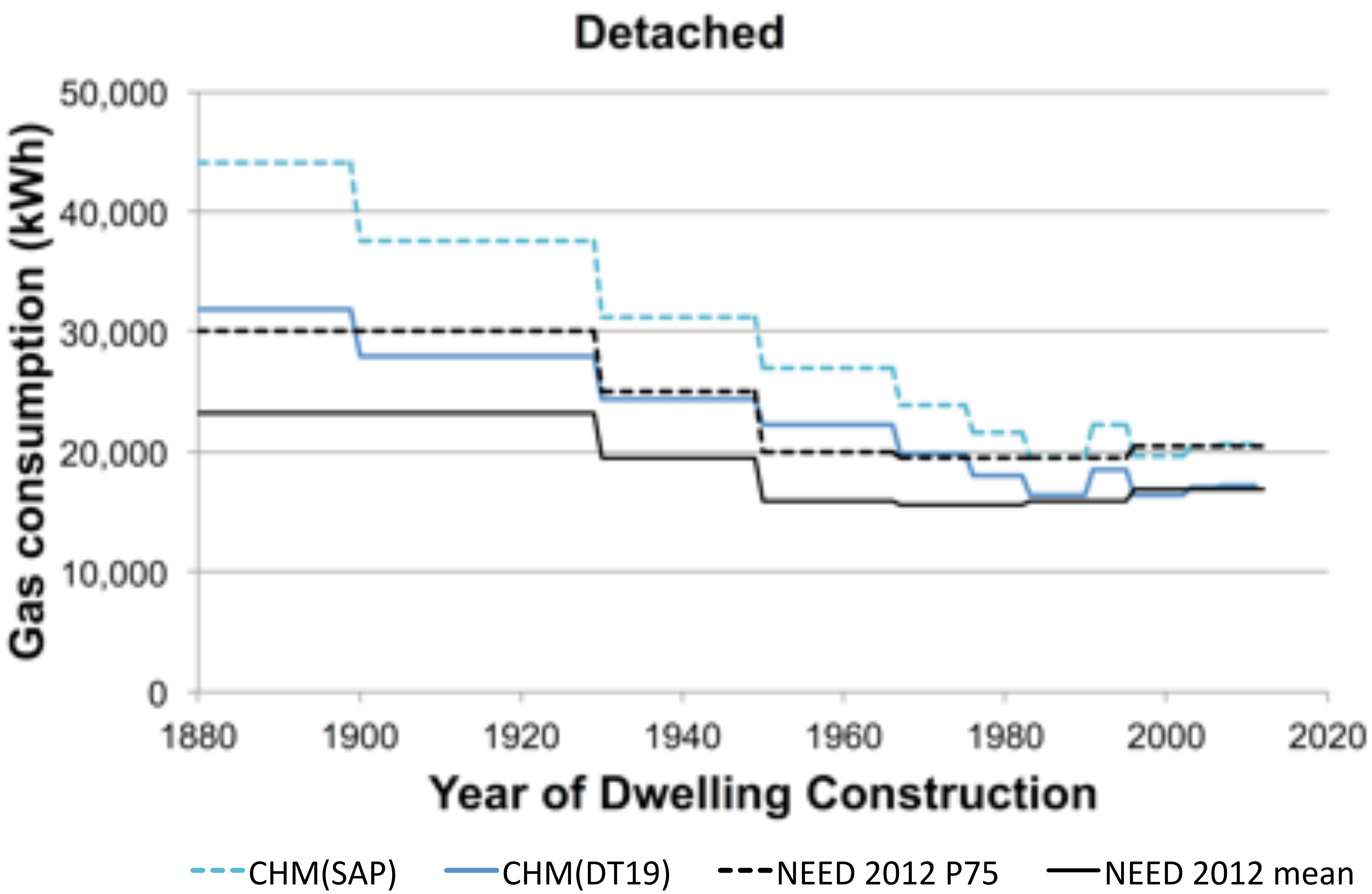
Supporting evidence for policy development

- Cambridge Housing Model (CHM)
  - **National** housing stock energy model
  - (Cambridge refers to where the software was developed)
  - Previously used in official reports on stock consumption
- CHM combines 14000's "sub-categories" of dwellings that emerge from the English Housing Survey
  - estimates energy demand of sub-sectors, whole stock in England
  - Based on a SAP type method, but with
  - Uses a uniform **19˚C demand temperature** (plus a few other adjustments)

Methods

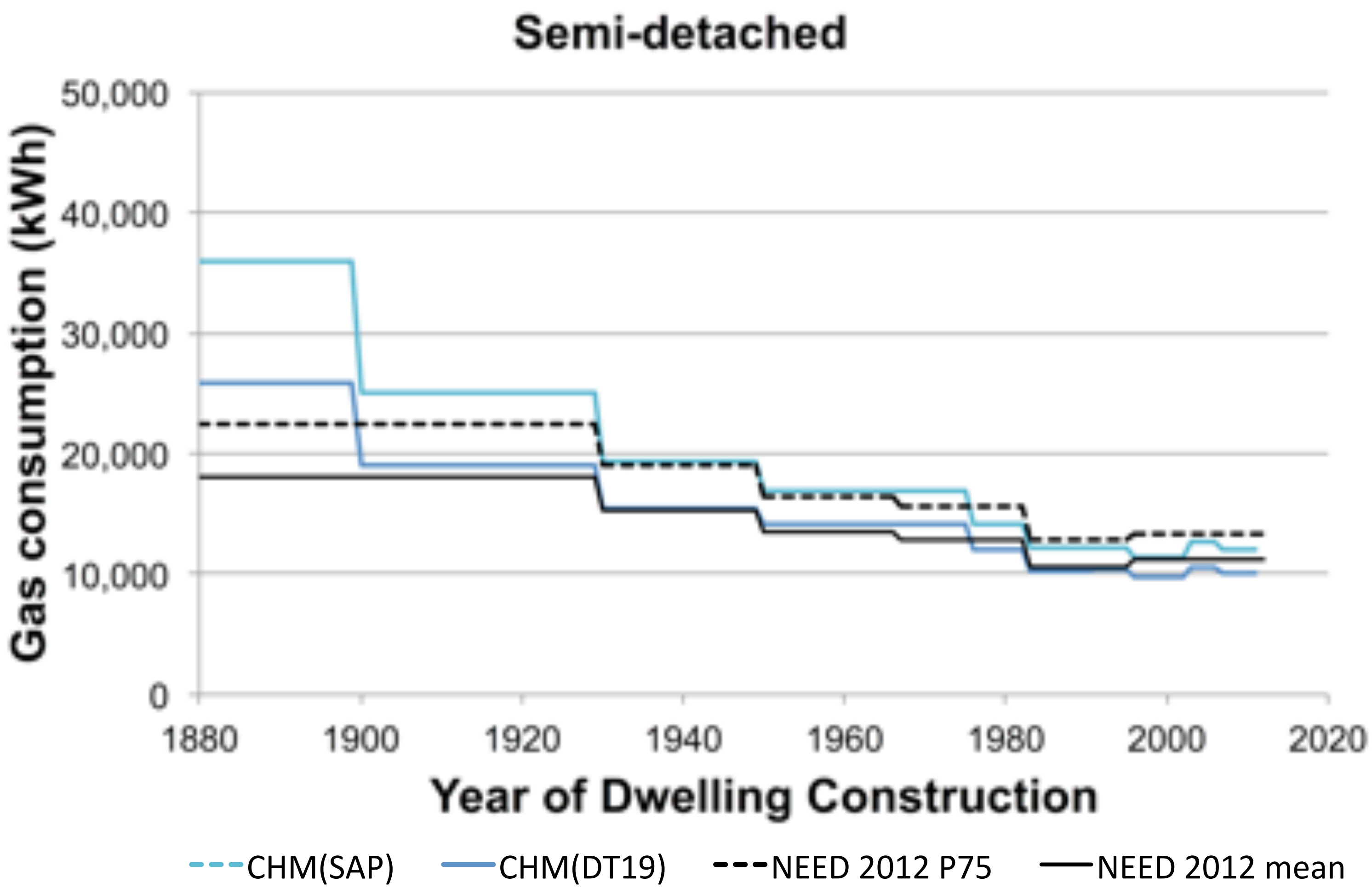
- Investigate systematic variations between modelled and empirical gas consumption data:
  - CHM(SAP) estimates using SAP 2009 (EPC) assumptions e.g. 21˚C
  - CHM(DT19) with the demand temperature reduced to 19˚C
  - NEED gas and electricity data for 2012 from ***> 2.5 million dwellings,*** *(all types except* flats/apartments)
  - EPC bands – converted to gas consumption ranges
- Focus on gas consumption for dwellings that record gas as being the primary heating fuel
  - Electricity data available (but no other fuels).
- Disaggregate by dwelling type, age band, and floor area category

Comparison of gas consumption across age bands



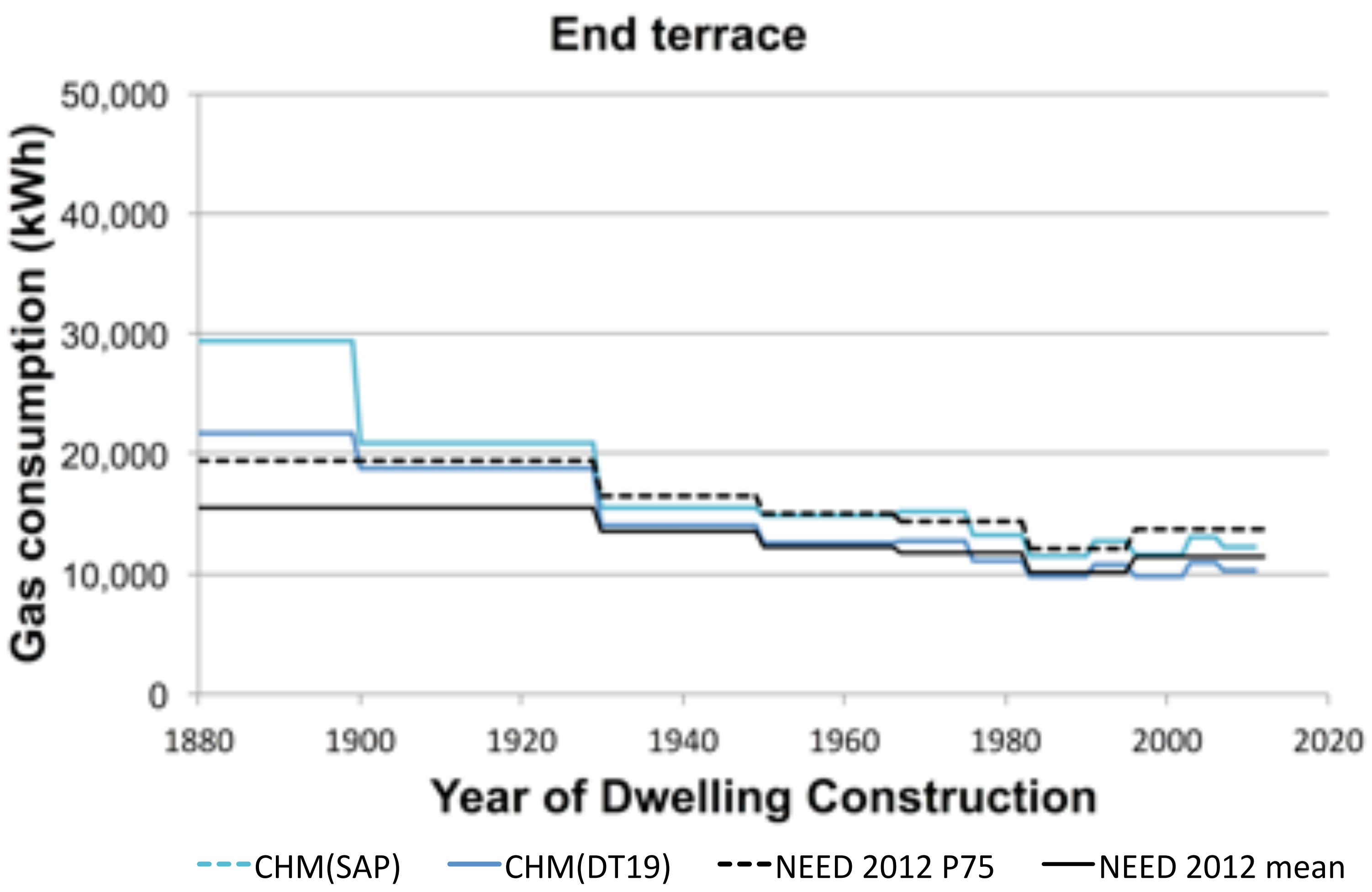
Estimates of gas consumption from CHM(SAP) and CHM(DT19) compared with mean (and 75th percentile) 2012 NEED gas consumption for detached dwellings by construction age bands.

Comparison of gas consumption across age bands



Estimates of gas consumption from CHM(SAP) and CHM(DT19) compared with mean (and 75th percentile) 2012 NEED gas consumption for detached dwellings by construction age bands.

Comparison of gas consumption across age bands



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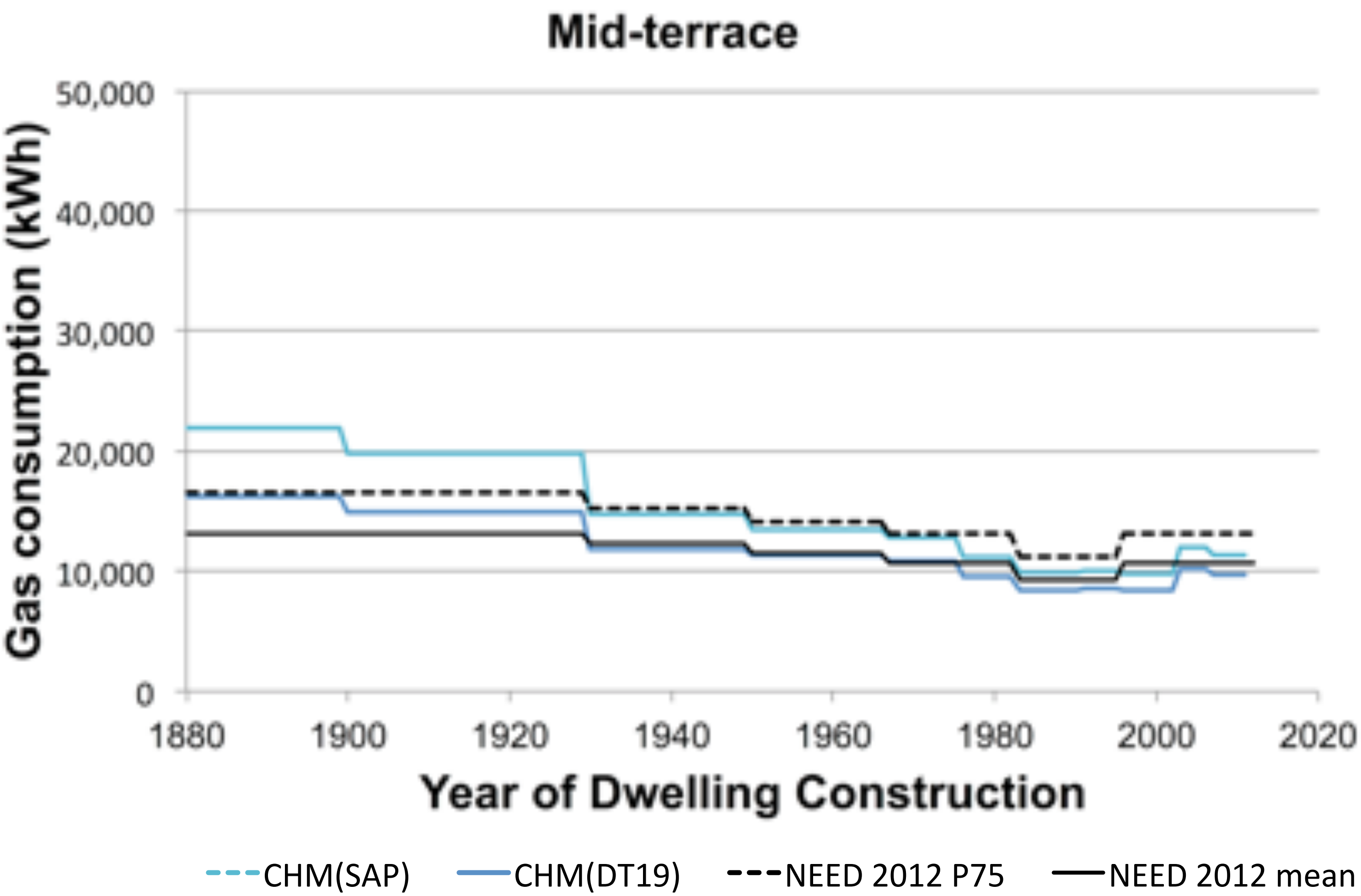
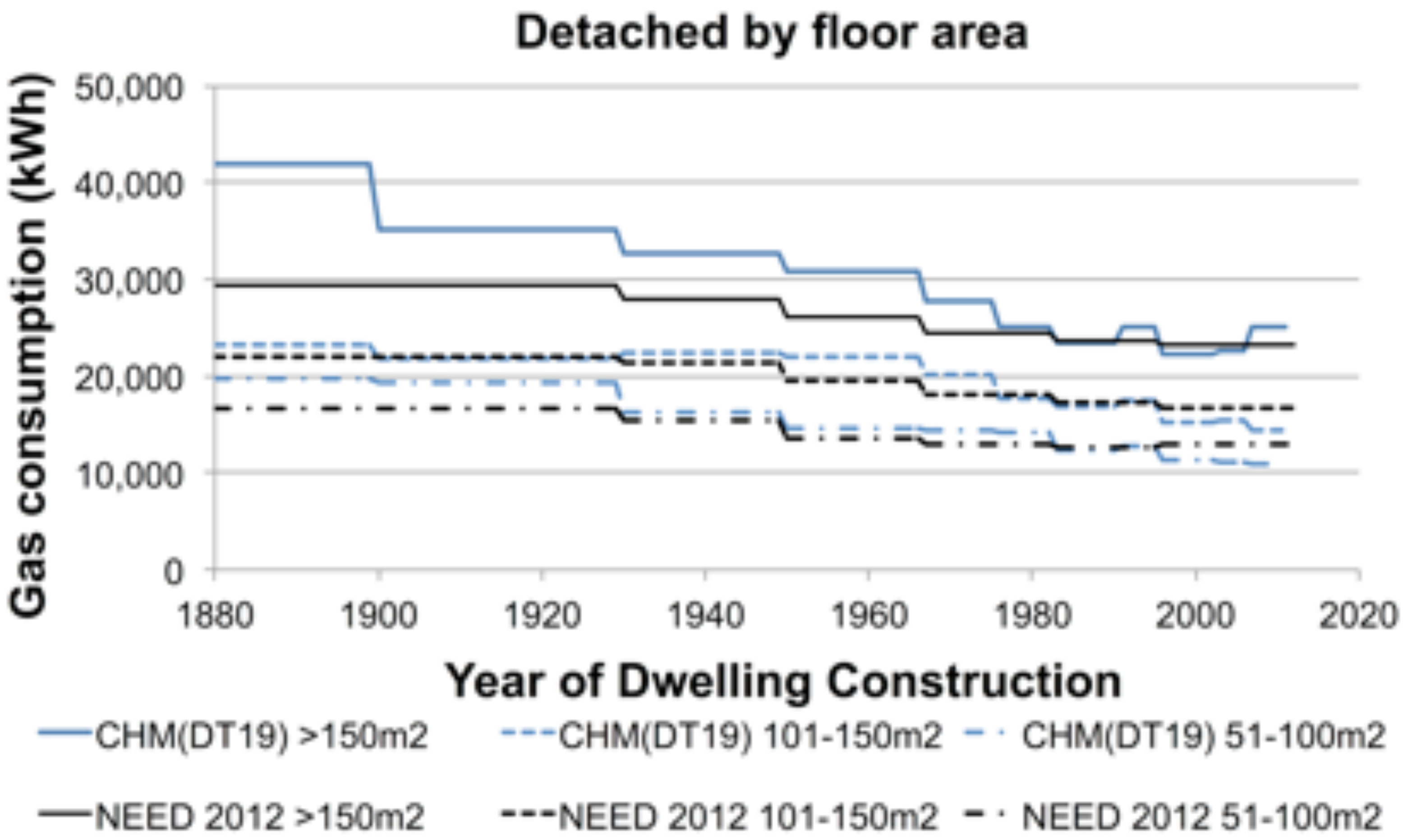


Estimates of gas consumption from CHM(SAP) and CHM(DT19) compared with mean (and 75th percentile) 2012 NEED gas consumption for detached dwellings by construction age bands.

Key points:

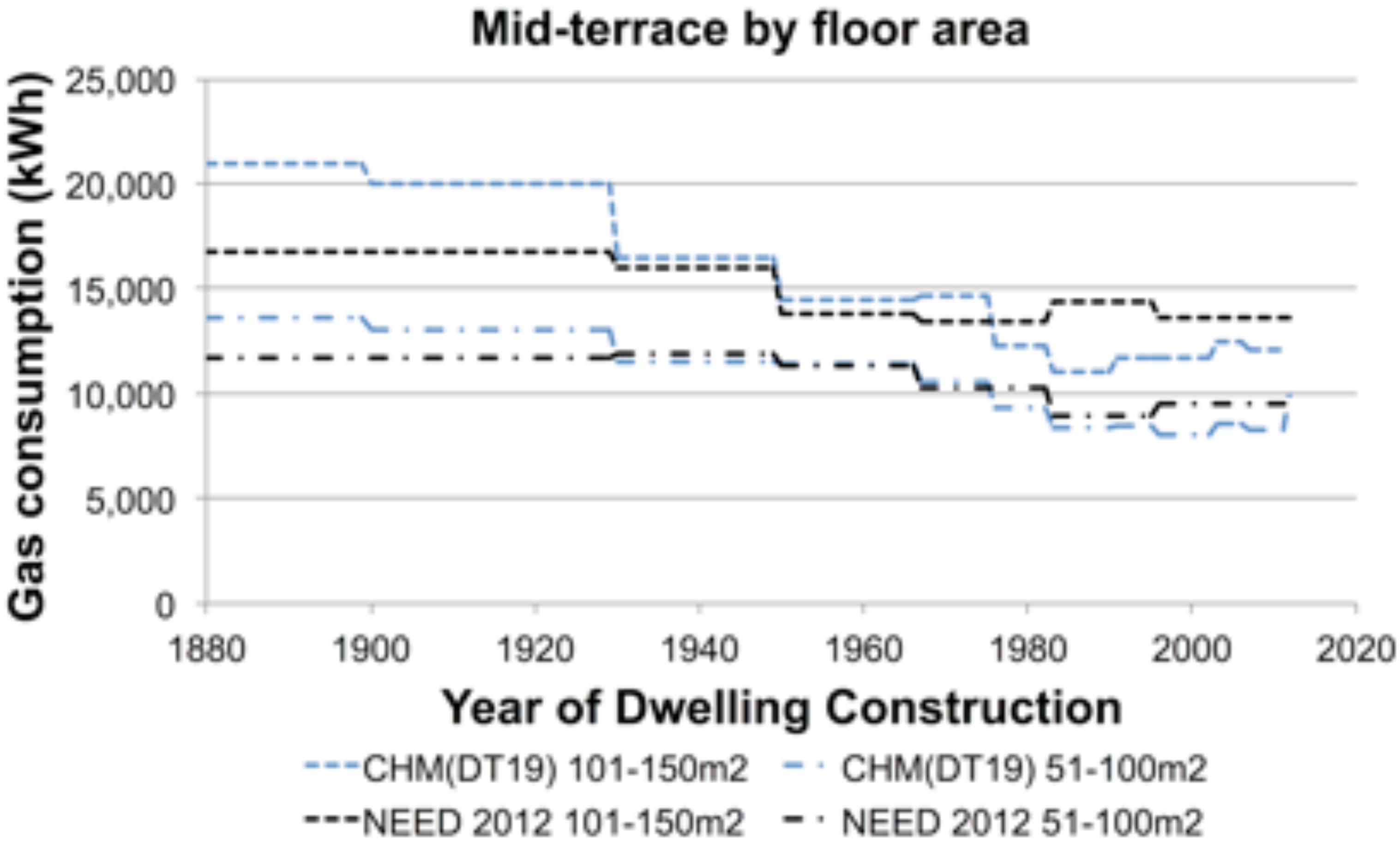
- CHM using SAP 2009 settings (e.g. demand temp 21˚C), *consistently overestimates* gas consumption:
  - Greatest variation seen for older detached dwellings
  - Large decline with age of construction up to newer dwellings
- CHM(DT19) shows a similar pattern for older dwellings
  - Still the greatest variation seen for older detached dwellings
  - Close match for post 1930 dwellings other than detached
  - Note: 19˚C setting is not based on empirical evidence for national average of indoor temps in the UK.
- The decline in gas consumption across age bands seen in NEED is much less than estimated from the models.

Comparison of gas consumption across age bands and by floor area category



Mean 2012 gas consumption from NEED data compared with estimates from CHM(DT19) for detached dwellings by floor area and age category.

Comparison of gas consumption across age bands and by floor area category

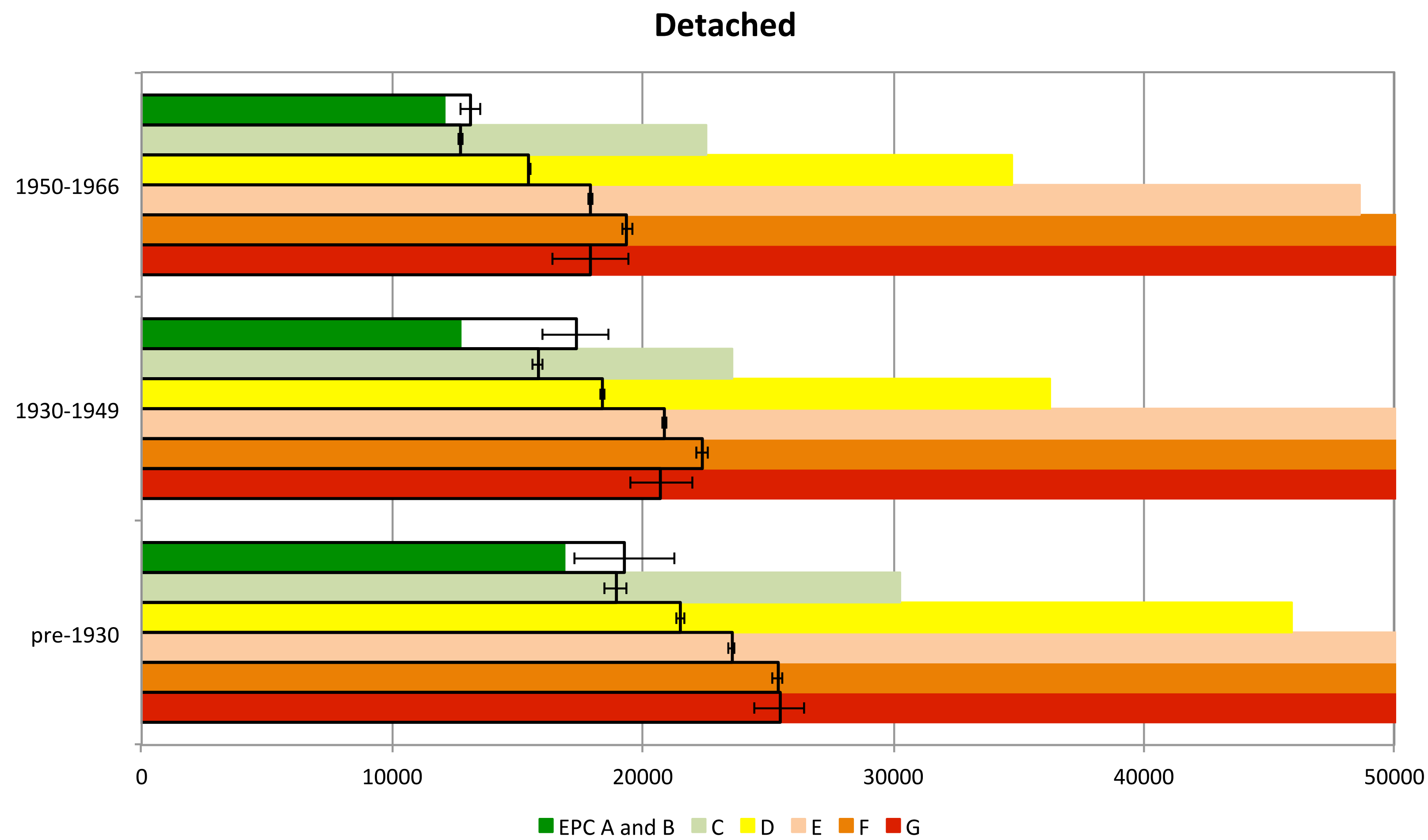


Mean 2012 gas consumption from NEED data compared with estimates from CHM(DT19) for mid-terrace dwellings (two party walls) by age category.

Key points:

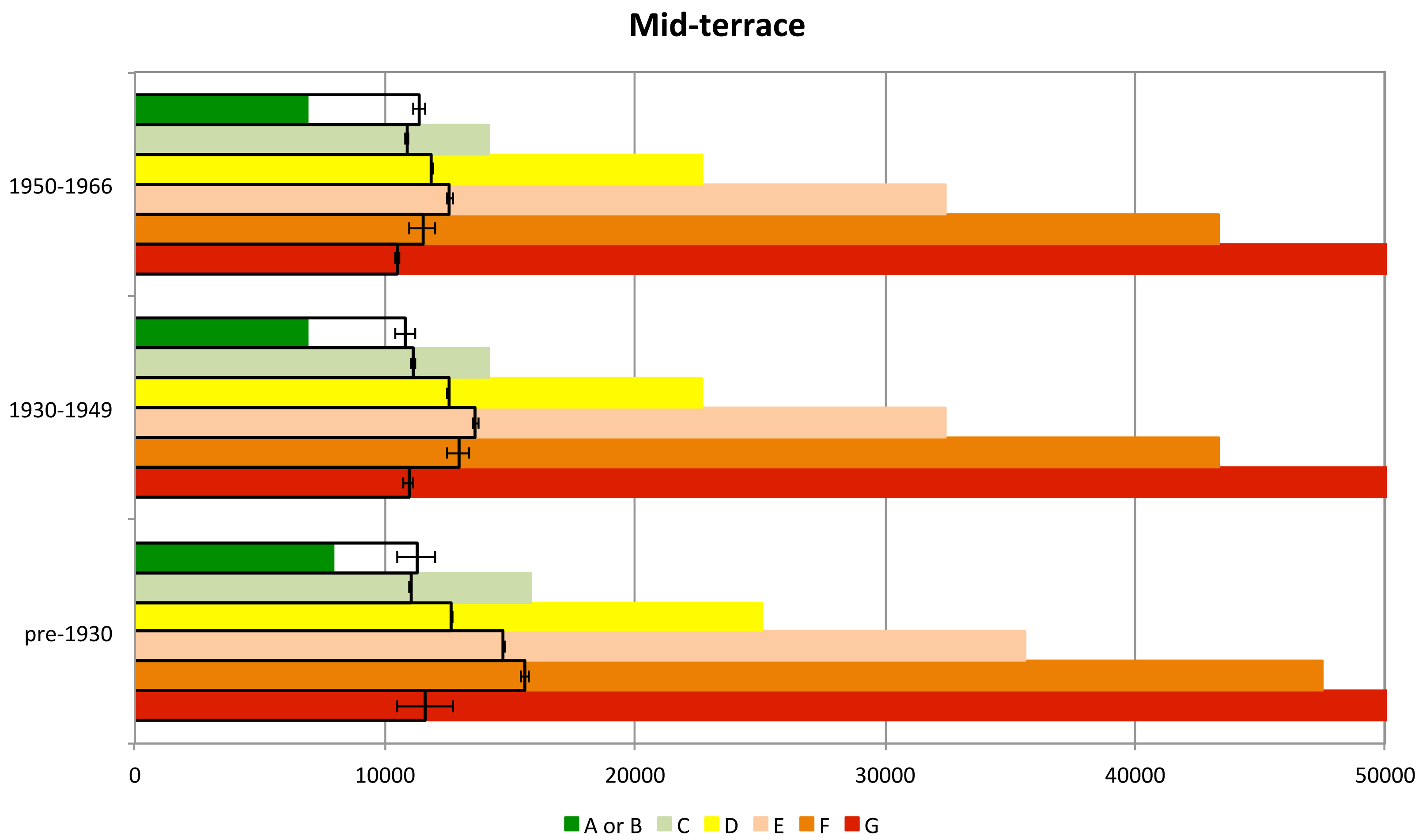
- CHM(DT19) and gas consumption of detached dwellings:
  - Greatest variation seen for older large (>150m^2) detached dwellings
  - Variations are reduced for newer detached dwellings ≤150m^2
- CHM(DT19) shows a similar pattern for terraces
  - Greatest variation seen for older large (>150m^2) detached dwellings
- Implies there is an issue with the SAP and CHM settings applied to larger energy inefficient dwellings
  - More apparent for detached as there are far more large dwellings of this type/form
- Tension between using uniform settings in models and ratings (like for like) and possible variations in heating operation across the stock, especially in relation to larger dwelling sizes

Gas consumption: EPC Bands compared with NEED



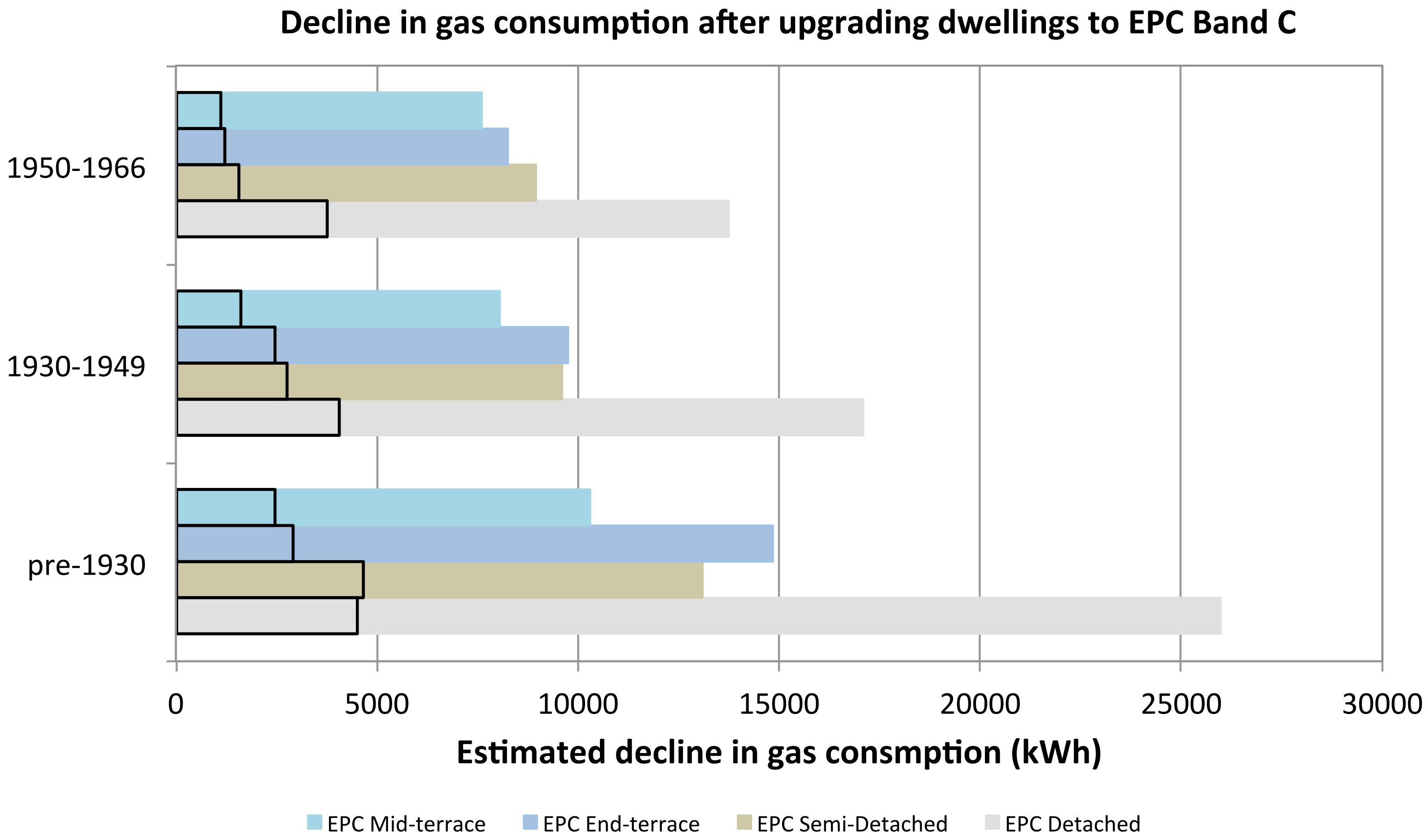
Comparison of empirical 2012 gas consumption for dwellings in NEED (black outline bars) for each EPC band compared with the expected gas consumption based on SAP/RdSAP calculated EPC bands (shown in their respective colours)

Gas consumption: EPC Bands compared with NEED



Comparison of empirical 2012 gas consumption for dwellings in NEED (black outline bars) for each EPC band compared with the expected gas consumption based on SAP/RdSAP calculated EPC bands (shown in their respective colours)

Savings from retrofit to EPC level C



Comparison of the expected mean decline in gas consumption from EPC ratings after retrofitting dwellings up to EPC Band C by age and dwelling type (shaded bars), with the equivalent estimate using changes in NEED gas consumption data (indicated by the black outline bars).

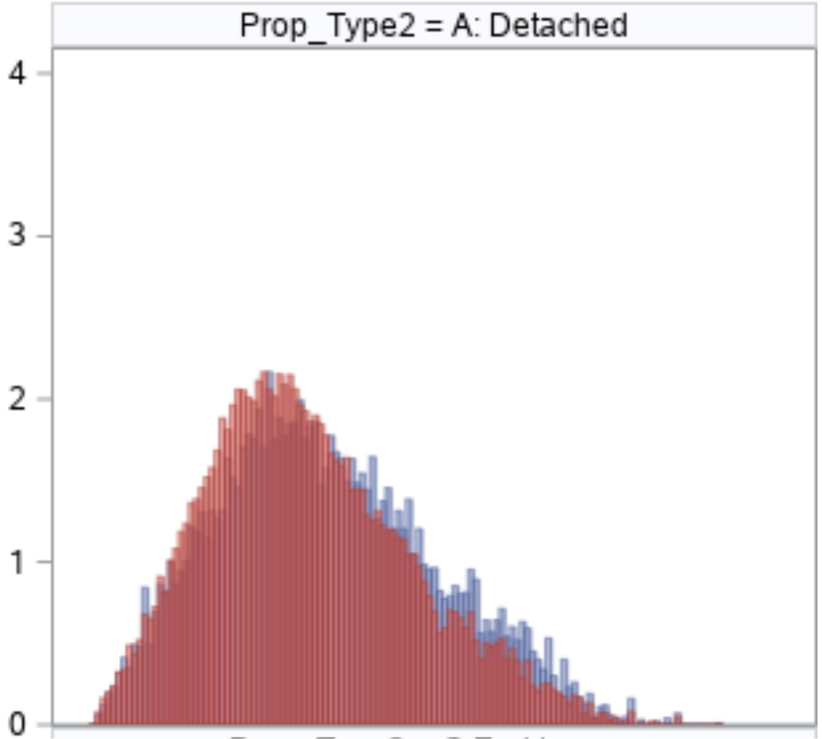
Summary

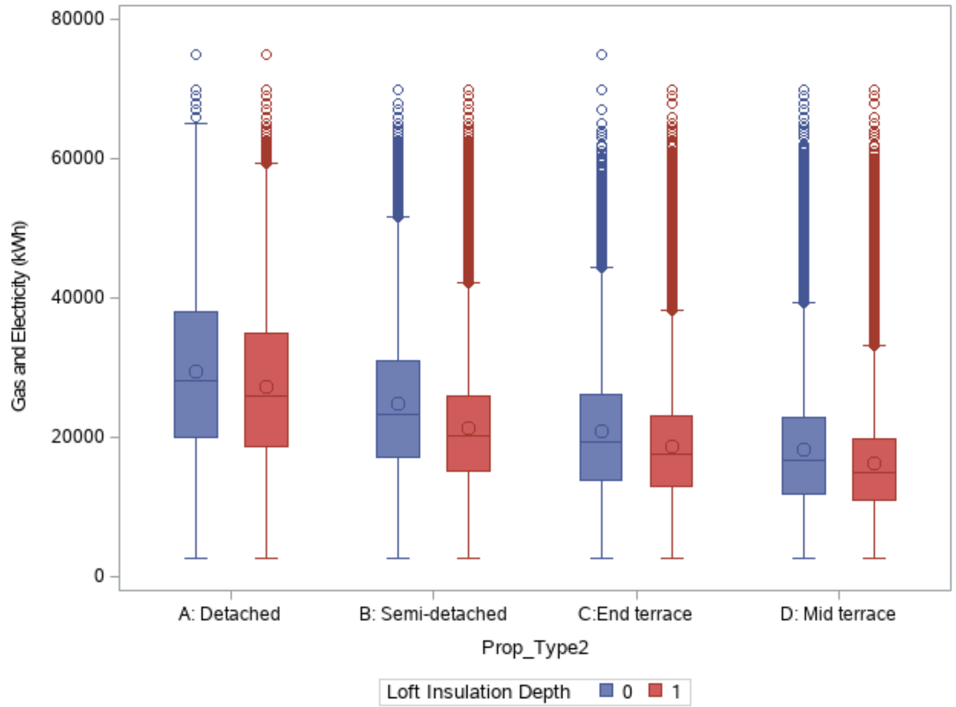
- The EPC (SAP) methodology that assumes uniform parameters for space heating across the stock – intended to provide a like for like comparison – is deeply embedded in models.
  - empirical energy consumption highlights the problem of using this approach in predicting changes due to efficiency
- Systematic overestimation in key target sub-sectors, especially older detached dwellings appears connected with floor area:
  - Larger dwellings of all types not heated (ventilated?) in the same way as smaller dwellings (may be related to the number of occupants).
- Savings based on improvements are likely far lower than expected from models – but is a systematic (predictable way).

New empirical work: can NEED unravel the impact of specific energy efficiency interventions?

- *Work in progress - unpublished*
- Similar to a case-control study
- Focus on detached dwellings
  - First solid wall construction (specified as not cavity wall)
  - Baseline has no insulation and no efficient boiler (not condensing)
  - Compare gas consumption with those that have efficiency measures (insulation and condensing boiler)

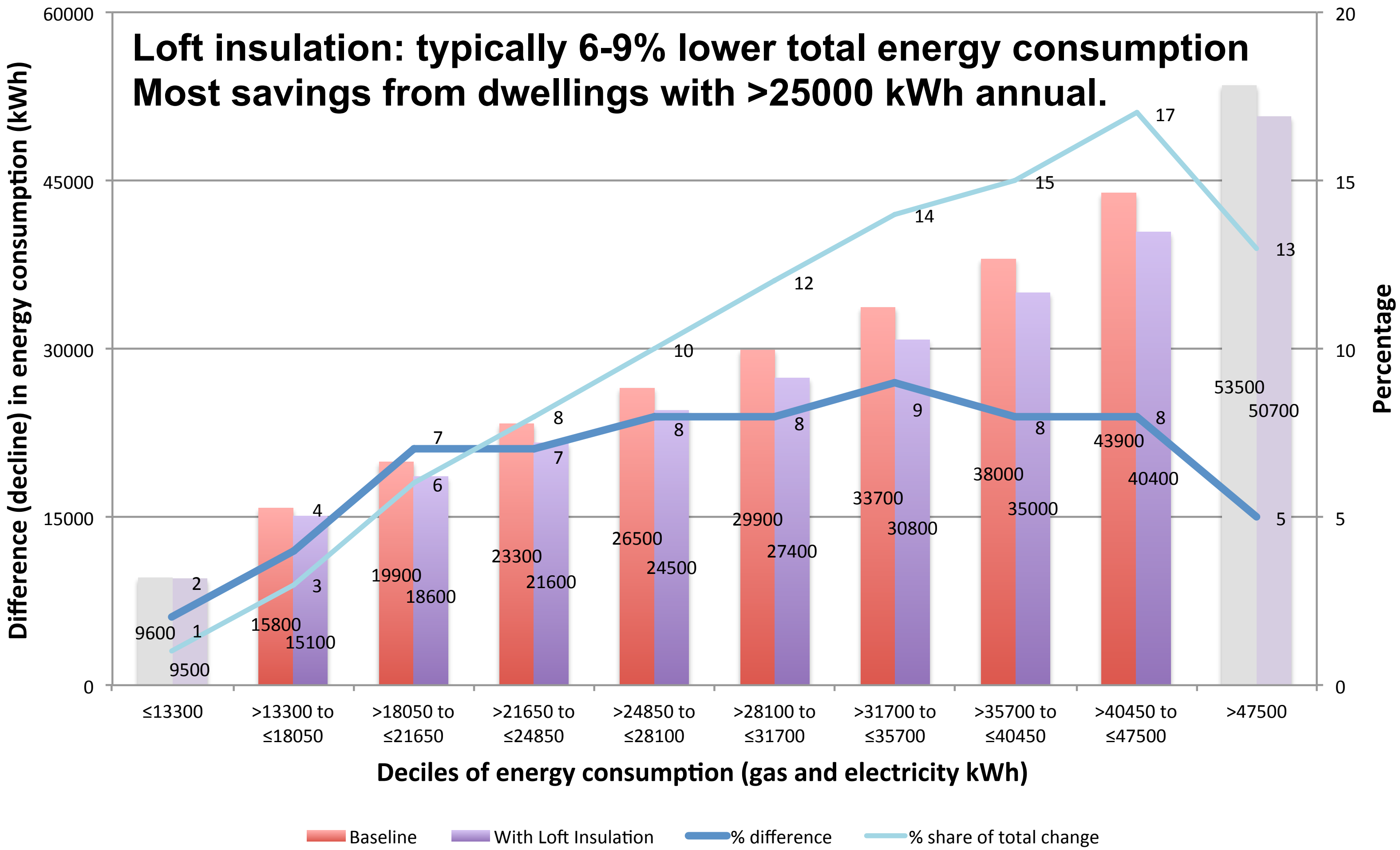
Solid wall detached dwellings with loft insulation: plotting change in energy (gas = electricity) consumption





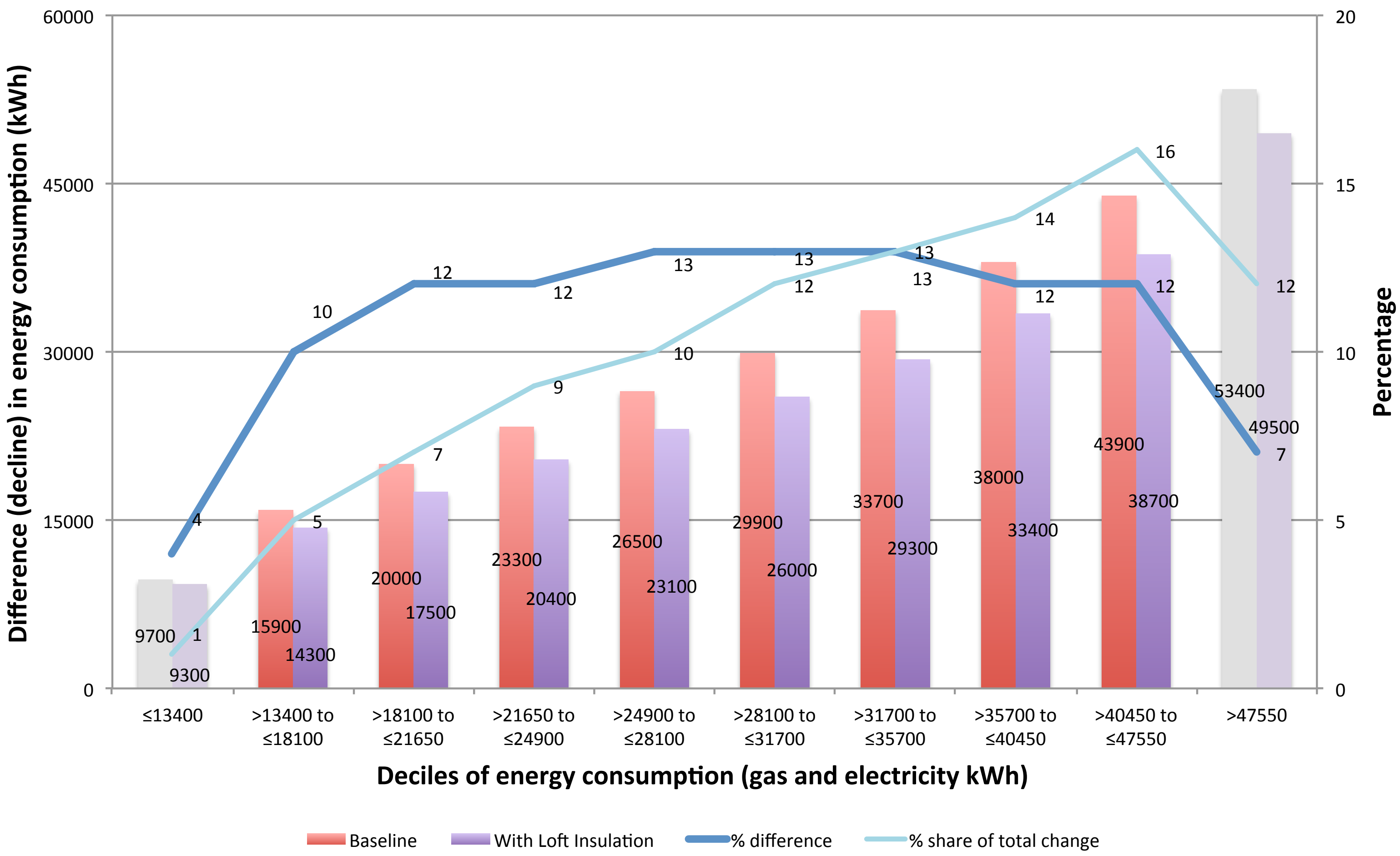
Gas and electricity consumption of solid wall dwellings with loft insulation compared with baseline (no efficiency measures, i.e. no condensing boilers).

Solid wall detached dwellings with loft insulation: alternative visualisation with deciles



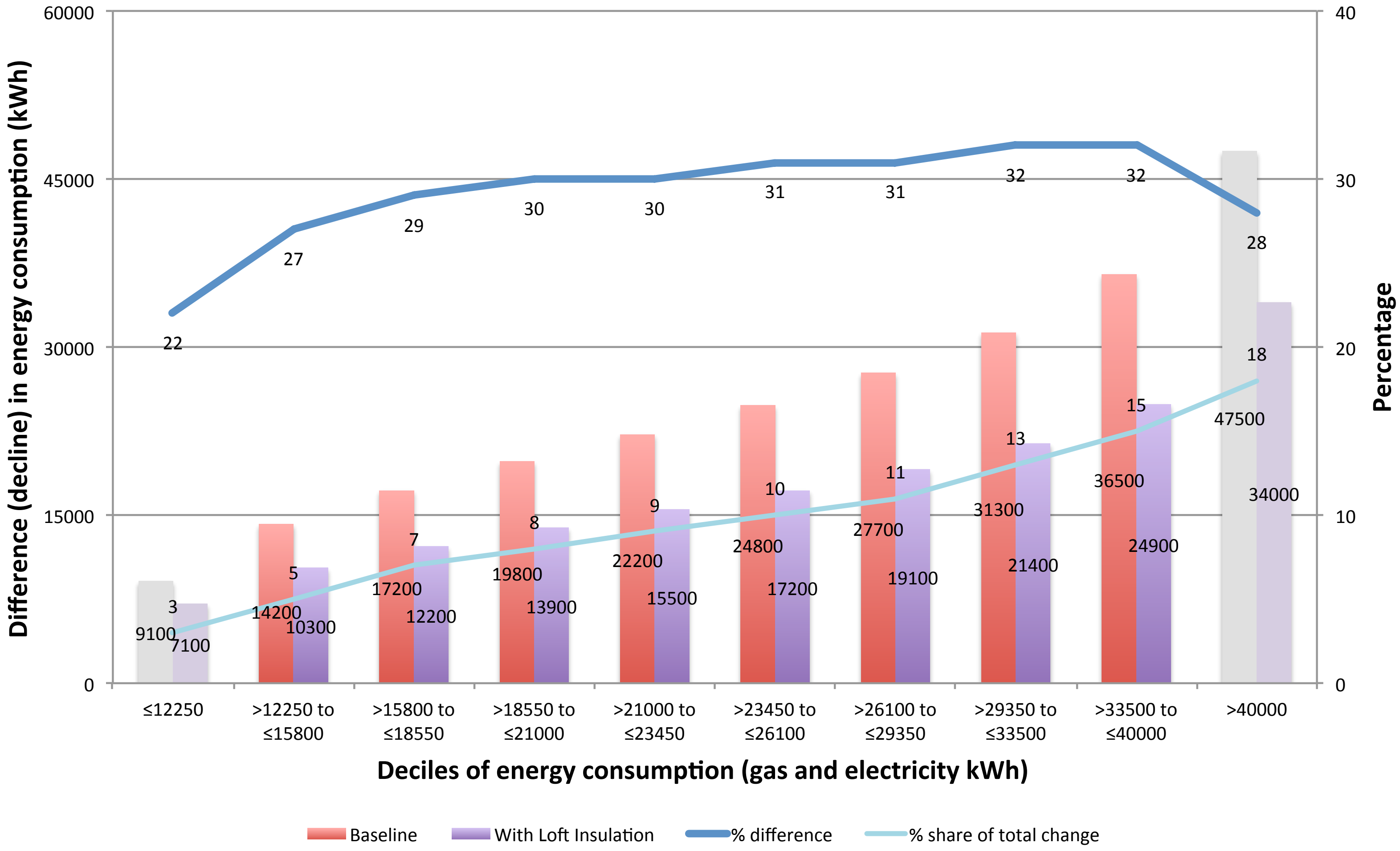
Gas and electricity consumption of solid wall detached dwellings with loft insulation compared with baseline solid wall detached dwellings (no efficiency measures).

Solid wall detached: loft insulation and Cnd Boilers compared with baseline



Gas and electricity consumption of solid wall detached dwellings with loft insulation and condensing boilers compared with baseline (no efficiency measures).

Cavity wall detached: loft insulation, cavity wall insulation and condensing boilers compared with baseline



Gas and electricity consumption of CW detached dwellings with loft and cavity wall insulation and condensing boilers compared with baseline (no efficiency measures).

Summary

- Can obtain clear empirical findings on energy savings from installing efficiency measures
  - Not average across dwelling type, but shift in the distribution
  - Condensing boiler only linked with substantial savings if dwelling already has insulation
  - Most savings obtained when all measures are done (more than adding average percentage of savings)
  - Most of the total share of savings from higher energy consumers, but may have social policy reasons to address low consumers.

- Suggests worthwhile to do as much as possible at once, rather than repeated cycling around the stock with incremental improvements.

- Extra (tentative result not shown): social gradient in savings evident for single efficiency measures, but as energy performance improves the social gradient reduces.

Summary

- Need to consider the process of scaling up to large numbers of 'deep' retrofits, but how deep?
  - How to progressively work through the residential stock, training the construction industry and ensuring delivery of efficiency improvements
- Need more detailed research on real-world operation to unravel before and after studies
  - now have the smart meters,
  - temperature sensors,
  - and data management to do this at scale.
- Transformation of the residential stock should be doable, if the research, evidence, and policy development work goes hand in hand.

Thanks!

- Contact: *a.summerfield@ucl.ac.uk*
- Full paper available soon in *Energy Policy*:

Contents lists available at ScienceDirect

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What do empirical findings reveal about modelled energy demand and energy ratings? Comparisons of gas consumption across the English residential sector

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