hothouse

Hot water provision in homes: consumption, storage and lifestyle

Hot water in the UK

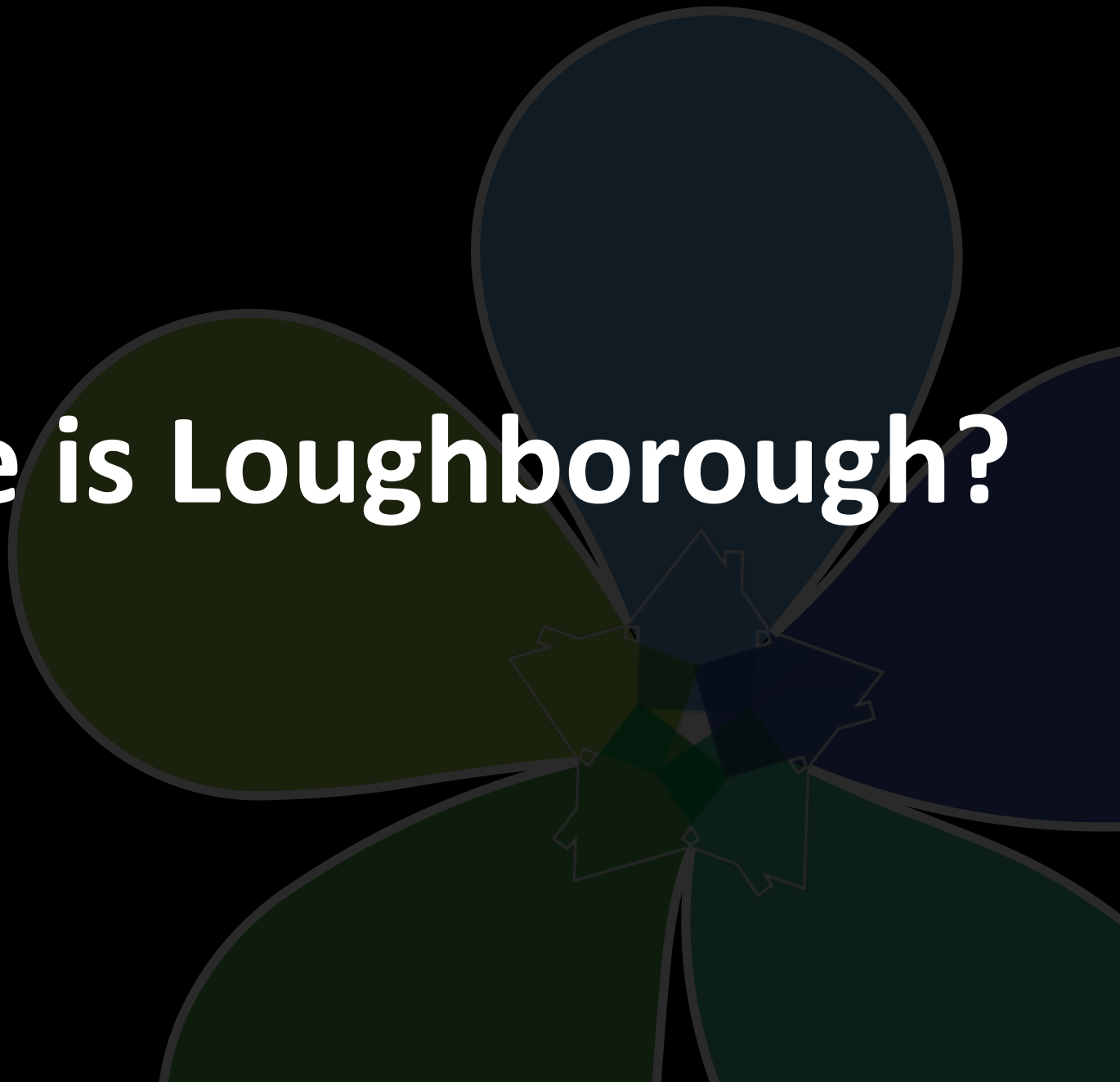
Loughborough University

Richard Buswell

ACEEE Hot Water Forum: Portland, Oregon

23rd February 2016

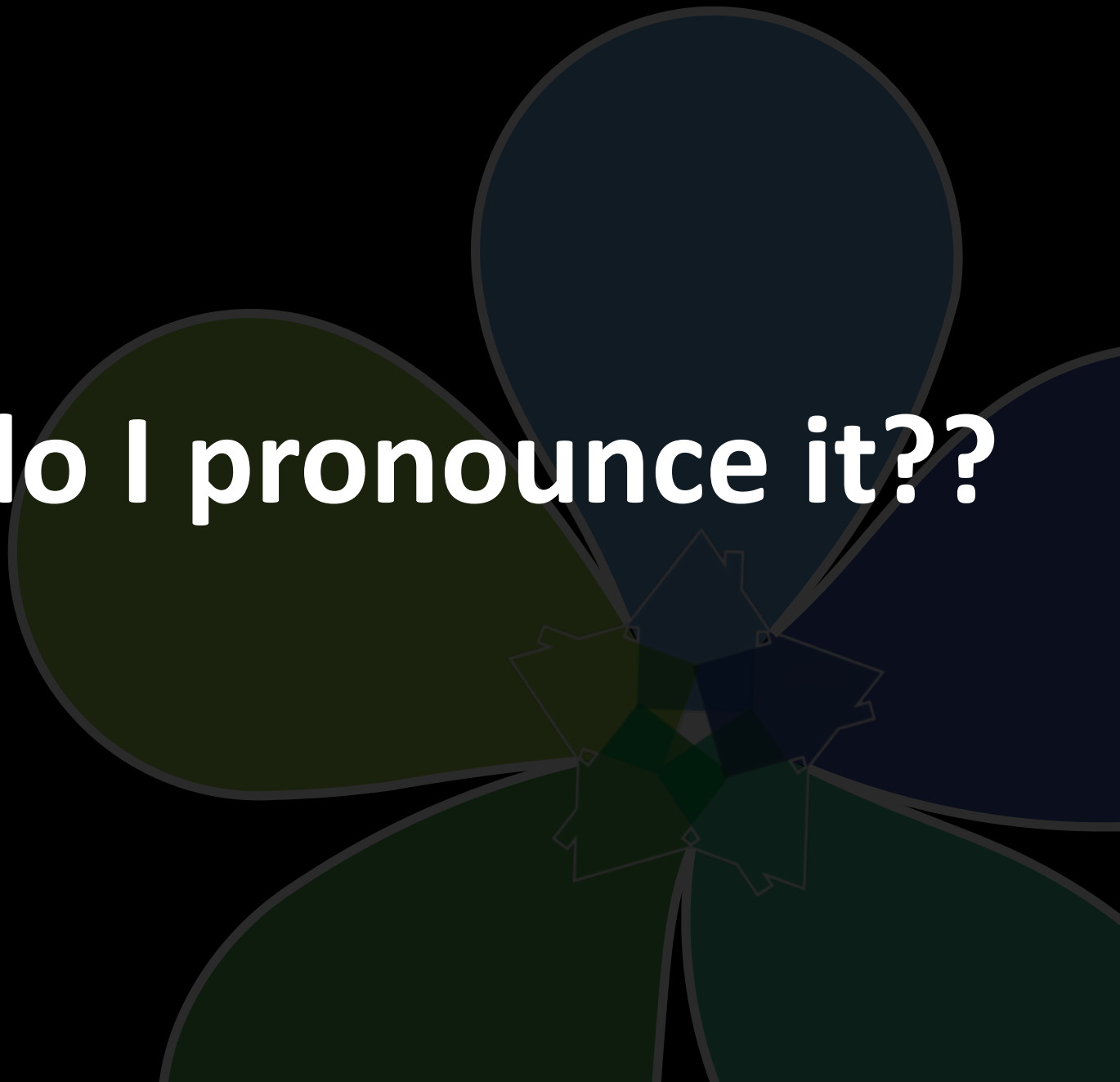
Where is Loughborough?



Regions of the UK

Loughborough

How do I pronounce it??



Building energy research Group

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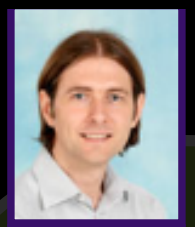
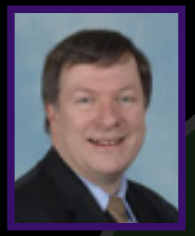
Mahroo Eftekrai



Steve Firth

Christina Hopfe

Kevin Lomas



Dennis Loveday

John Mardaljevic

Simon Taylor

Jon Wright

performance measurement and building physics

Modelling and optimistation

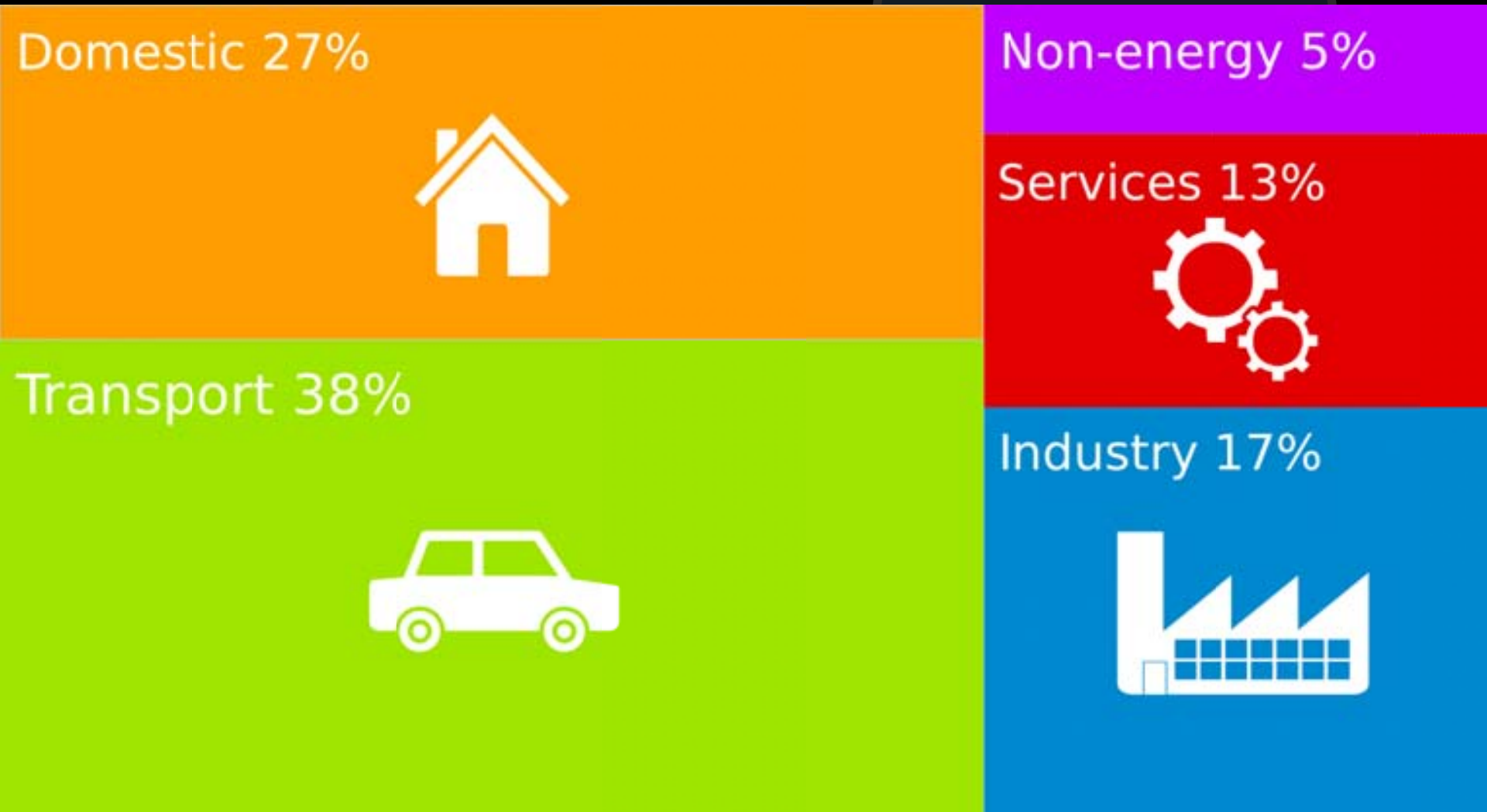
Overview

- Background to UK energy and DHW
- DHW monitoring in the UK
- UK vs North America
- HotHouse project
- Some early analysis

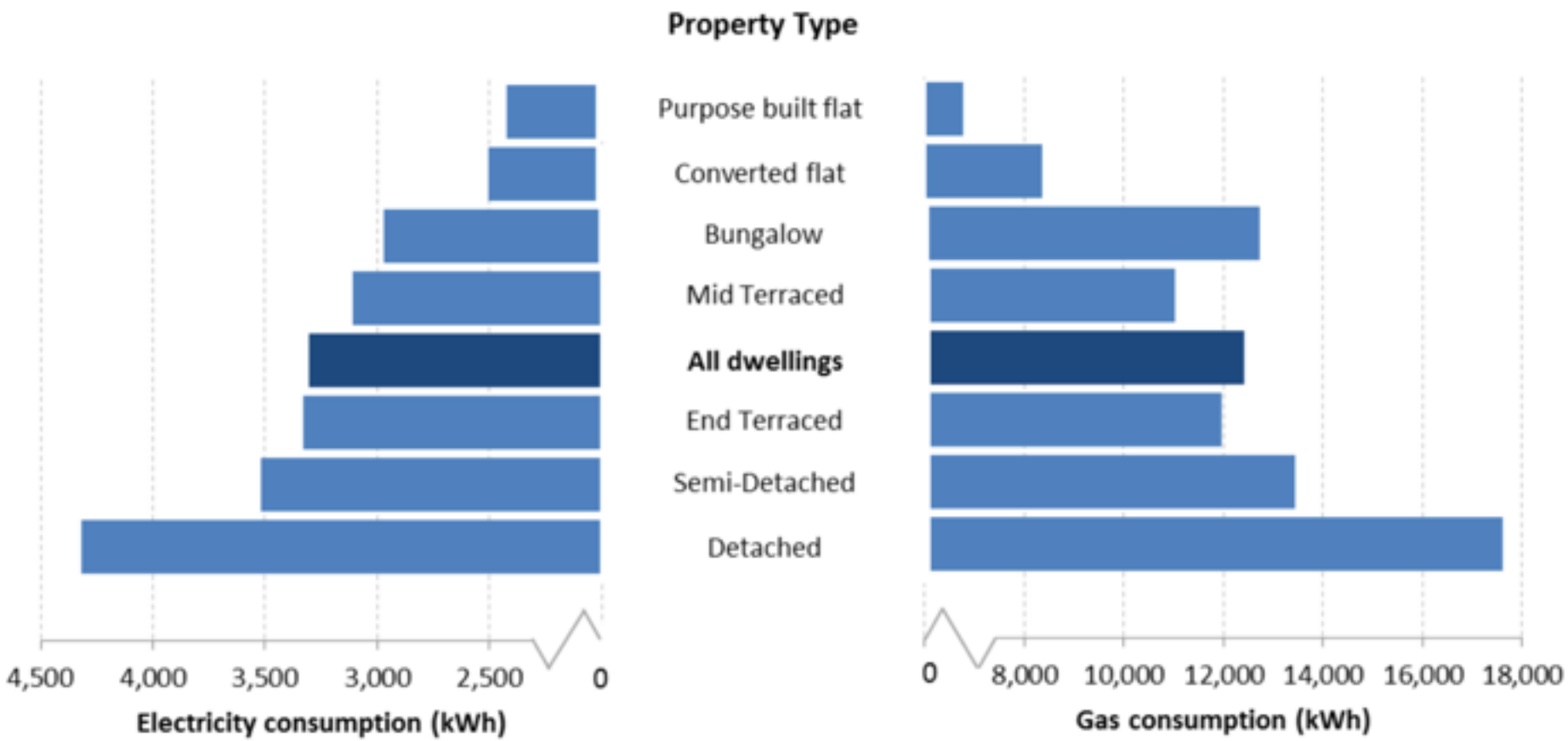
UK Home ownership

1980 to 2014 + 5.5m households

UK Energy consumption



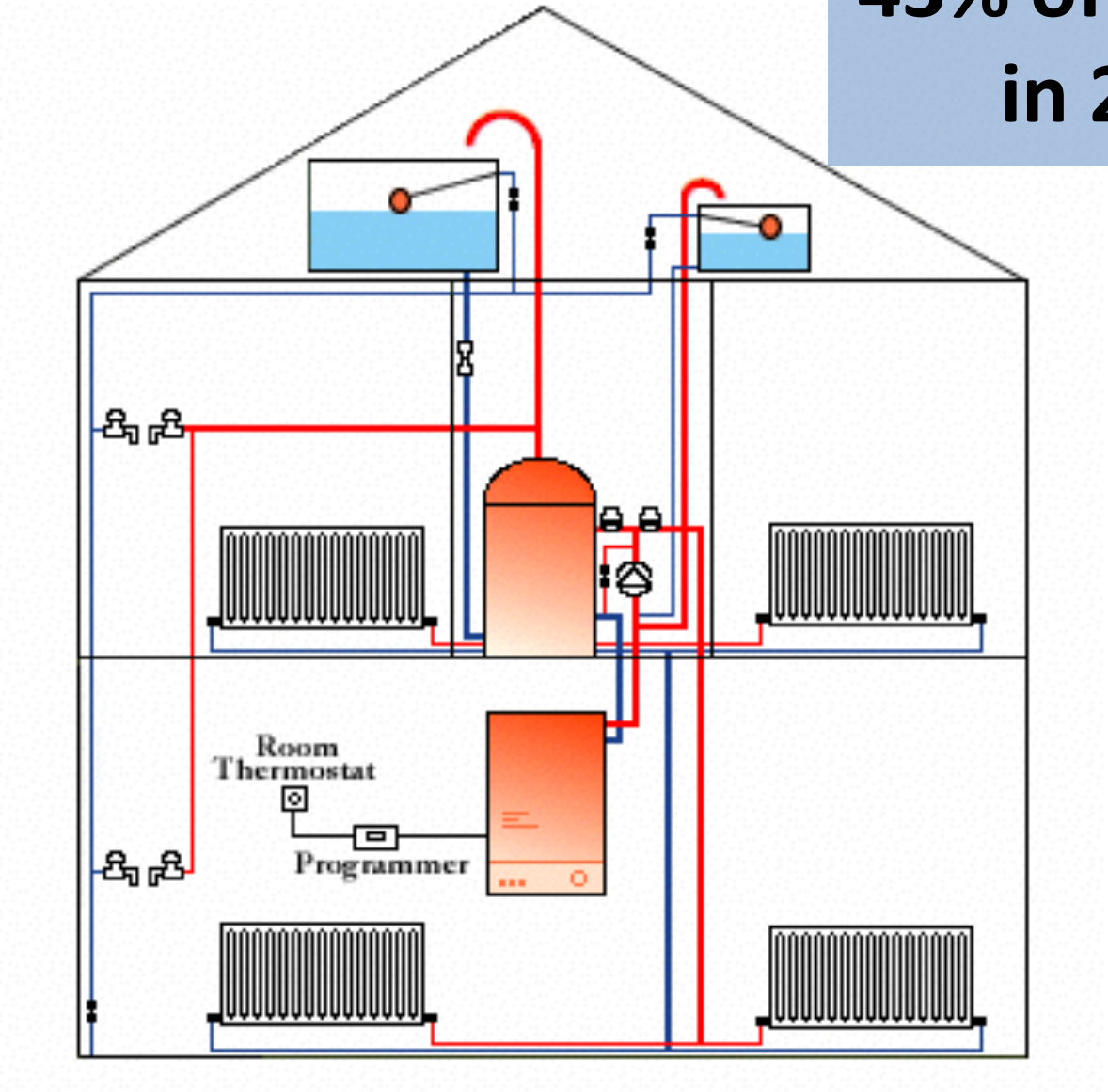
Median annual consumption



Open vent, storage and system Boiler

http://www.gasman.fsbusiness.co.uk/system_basics.htm

43% of systems in 2010

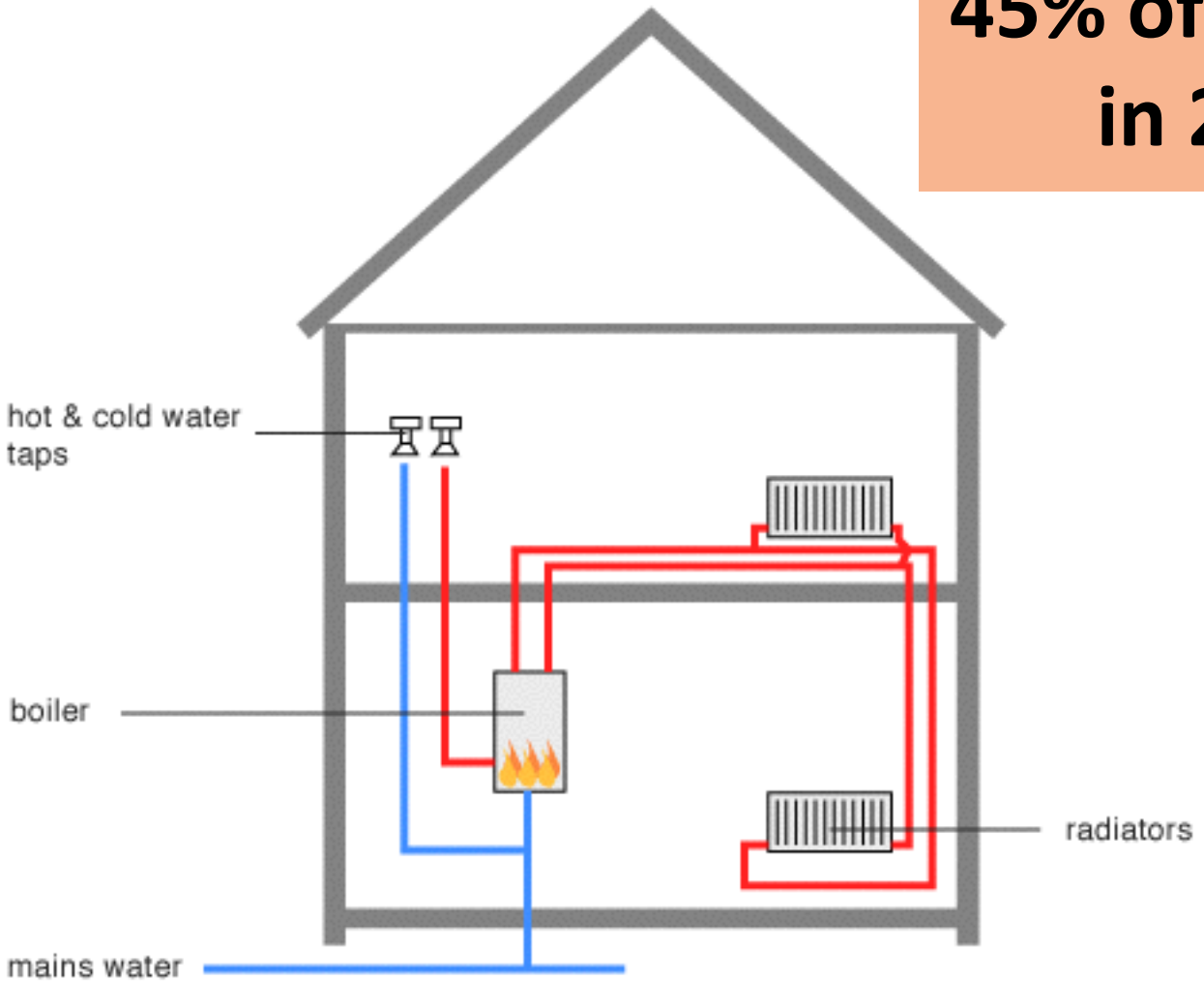


Typical cylinder installation

Combination Boiler

http://www.greenspec.co.uk/building-design/retrofit-gas-heating/

45% of systems in 2010



Energy Savings Trust

- +100 DHW in homes monitored (2008)
- Technology performance trials (2013)
- +100,000 self-report water use (2014)
- +60 monitoring to validate (2015)

Feature list	UK	US	CA
Volume consumed			
litres/day	122 **32G**	192 **51G**	172 **45G**
litres/person/day	46 + 26 N	38 + 52 N	17 + 39 N
litres/day v freq. occur.	left skew	left skew	left skew
Variation	considerable	considerable	-
Delivery			
Incoming water temp	10 - 20, varies	-	8 - 11
Hot water temp (℃)	52.9/49.2	50.3	51.8
Generation method	gas boiler	mix gas/elec.	mix gas/elec.
Storage	tank/combi	mixed	yes
Solar thermal	no	-	yes
Flow rate litres/sec	-	>0.19	-
Draw-offs/day	10 - >60	20 - 120	-
Characteristics			
Seasonal variation	Vacation dip	-	Vacation dip
Short draw offs	Effects performance	50% <1 min	-
Draw-off type			
Taps and showers	yes	yes	yes
Appliances	no	yes in some	unclear
Profiles			
Morning peak (litres)	9 - 11	-	12 - 14
Morning peak time	08:00 - 09:00	-	06:00 - 08:00
Evening peak (litres)	8 - 9	-	10 - 11
Evening peak time	19:00 - 20:00	-	18:00 - 19:00

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32G

51G

45G

127/121 F

123 F

125 F

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32G

51G

45G

127/121 F

123 F

125 F

48 - 52G

54 - 57G

46 - 48G

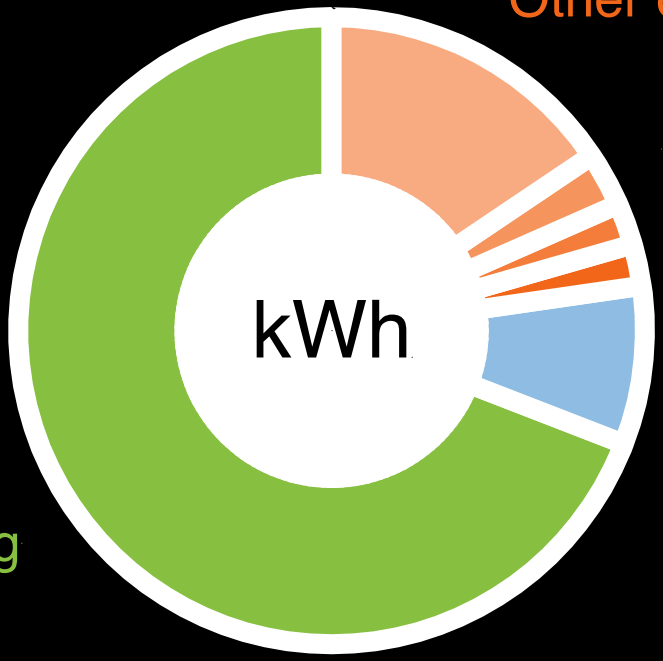
50 - 52G

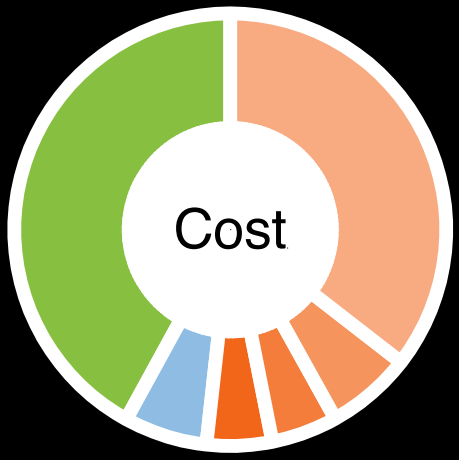
Hothouse: family homes

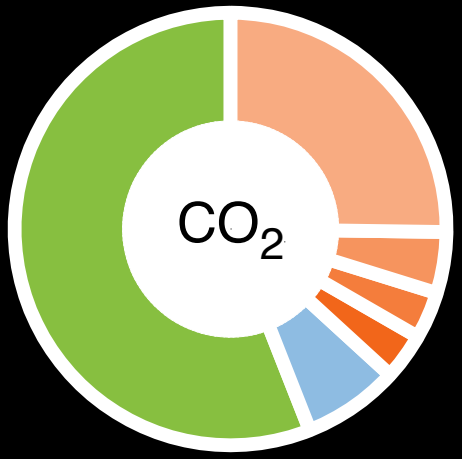
Timing DHW demand and load shifting with increasing levels of electrification of heat

The families

- 2-7 people : most were 4
- Children : babies to adults
- Most at home weekdays
- 1900 and 2000 : most 1940-60
- Mixture of systems

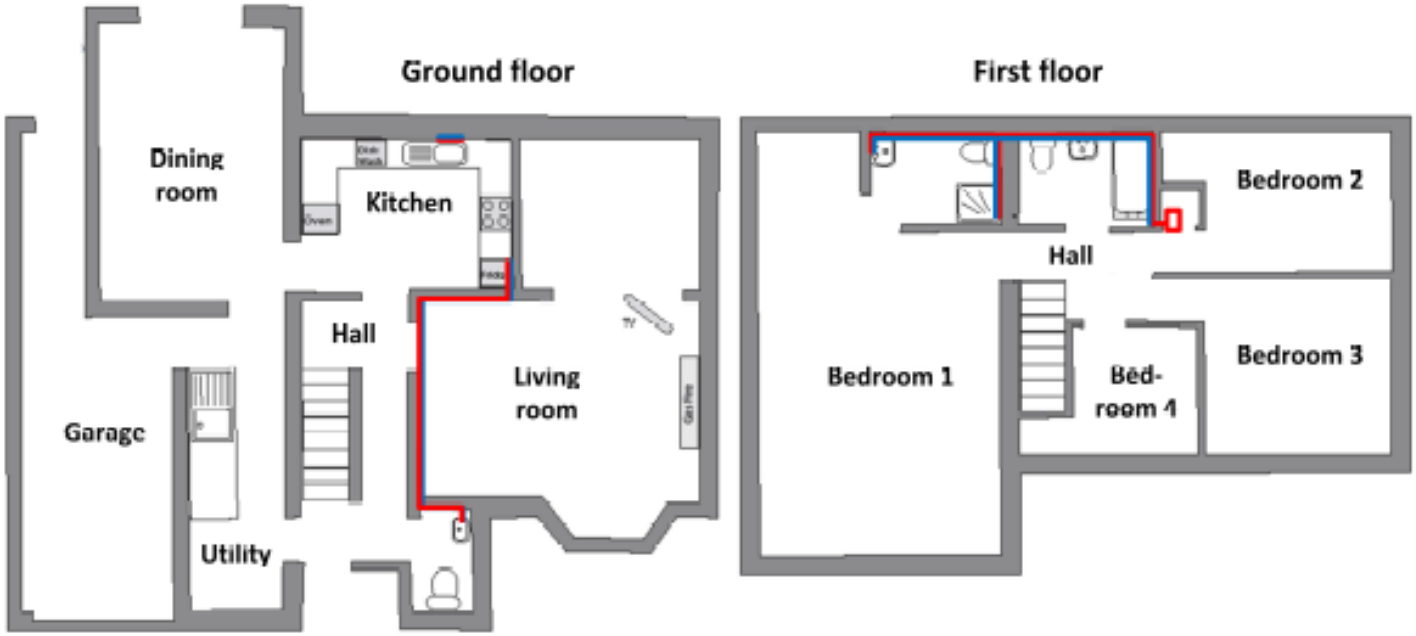

kWh
Other devices
Lighting
Digital media
Laundry/cold app
Hot water
Space heating


Cost


CO_2

Modelling assumptions

- Modelled one home
  - 2 dynamic simulation tools (1min)
  - 3 steady-state tools (1 month)
- Compared assumptions
- Looked at estimated losses with an analytical model


Ground floor
First floor
Dining room
Kitchen
Hall
Living room
Garage
Utility
Bedroom 1
Hall
Bedroom 2
Bedroom 3
Bed-room 4

Model vs measured

- **Hot water demand: -2% to + 40%**
- **Energy consumption: -7% to + 36%**
- **Boiler efficiency: +14% to +22%**
- **Temperature rise: +1.2°C to +14°C**
- **(+34°F to +57°F)**

Conclusions

- Complexity of systems is challenging
- Systems affect behaviour
- Predicting the future
- Should models just use measured profiles ?
- DHW and DSR dependent on demand

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Thank you

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www.hothouse-project.co.uk