Project Overview

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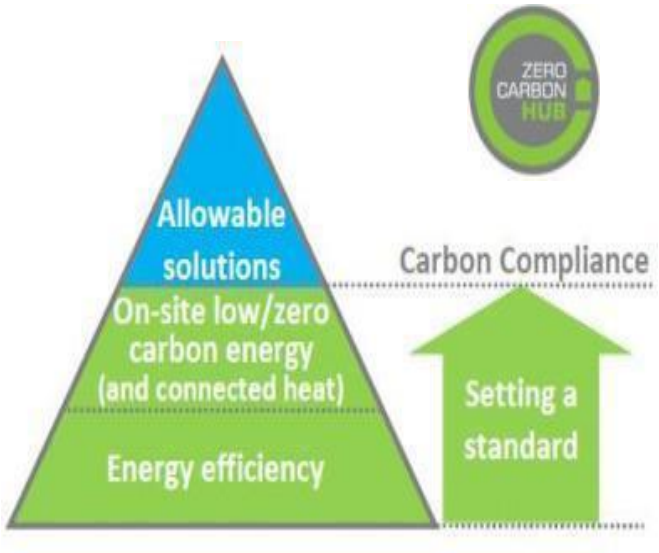
Background: Zero Carbon Policy



- Energy Efficiency
- Carbon Compliance
- Carbon Offsetting

- Forming a R&D consortium
- Common problem to solve
- Securing funding

AIMC4 Challenges

Technical: Level 4 (44% carbon emissions reduction over 2006 Regs)

- Fabric First Solution & Simple Services Solution

Commercial: Level 4 Home, for the cost of Level 3 (Energy)

- Best Starting Price, deliverable means to cost engineer, final price point

Market: Desirable Customer Focused Homes

- Easy to Use and Run, Efficient and Reliable

Phasing & Timeline (Nov 10 – Apr 14)

Quarter	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15-18
Scoping, research & supply chain development															
Design Development															
Planning															
Construction															
Building performance and Post-Occupancy Evaluation															
Customer Education and Care, post construction POE															
Internal Training															
External promotion															

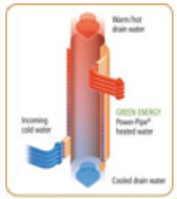
Supplier Sandpits

'There are three competing developers, and two manufacturers - but everyone has realised if it benefits one it benefits the other and that it's good for the construction industry as a whole.'

'I thought the sandpits were a fantastic process despite some initial doubts.

Having been through them, I can't see a better way to achieve the objectives'

Selecting Products for in-use Performance



New skills to install

Supervise, Fit & Forget

Supervise, Fit & Educate

Occupant unaware

Occupant interactive

Fit & Forget

Fit & Educate

Existing skills to install

Lean Workshops

- Collaboration between suppliers
- Elimination of waste in all forms
- Starts with design
- Goes through to construction (especially interfaces)
- Series of workshops
  - Timber frame
  - Masonry
  - Windows
  - Services & SIP's

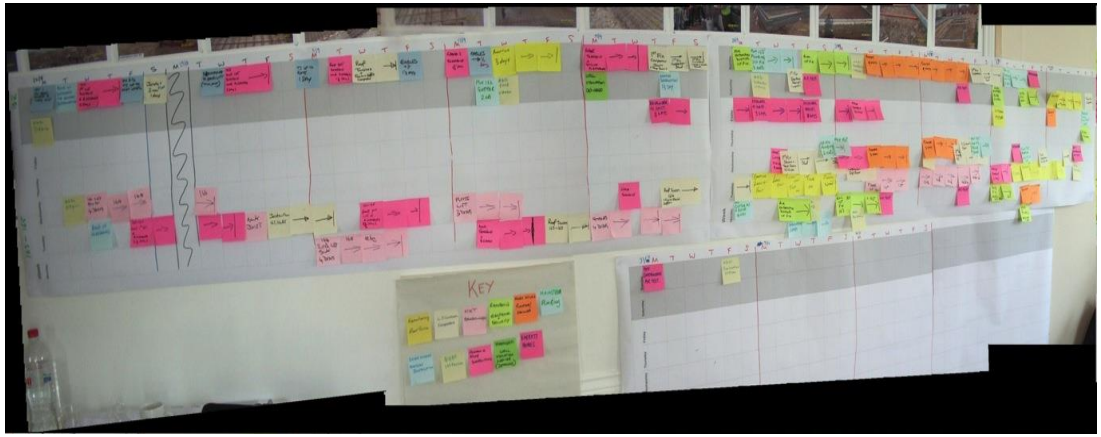
Design Interdependencies

	MEV1	MEV2	MEV3	MEV4	MEV5	MEV6C	MEV7C	DI1	DI2C
Construction	Thin - joint	Thin - joint	Thin - joint	Thin - joint	Closed panel	Closed panel	Thin - joint	Dynamic insulation	Dynamic insulation
Wall	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.16
Roof	0.10	0.10	0.1	0.10	0.10	0.10	0.09	0.10	0.08
Floor	0.12	0.12	0.12	0.12	0.10	0.14	0.13	0.10	0.12
Party Wall	N/A	0	0	0	0	N/A	N/A	N/A	N/A
Door	1.3	1.3	1.3	1.3	0.9	0.9	1.1	0.9	0.9
Windows	DG 1.2	TG 0.8	TG 0.8	DG 1.2	TG 0.8	TG 0.8	TG 0.83	TG 0.8	TG 0.8
French doors	DG 1.15	DG 1.15	DG 1.15	DG 1.15	TG 0.8	TG 0.8	DG 1.3	TG 0.8	TG 0.8
y-values	0.032	0.040	0.045	0.040	0.046	0.032	0.025	0.049	0.034
Airtightness	4	4	4	4	4	4	4	3	3
g-values	0.50	0.39	0.39	0.50	0.41	0.41	0.49	0.41	0.41
WWHR	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FGHR	Yes	In built	Yes	In built	Yes	No	No	Yes	No

	MVHR 1&4	MVHR 2&3	MVHR5	IEF1	IEF2	IEF3
Construction	SIPs	SIPs	Closed Panel	Timber frame	Timber frame	Timber frame
Wall	0.15	0.15	0.15	0.12	0.12	0.12
Roof	0.10,0.15	0.10,0.15	0.08	0.07	0.07	0.07
Floor	0.12	0.11	0.09	0.08	0.08	0.08
Party Wall	0	0	0	0	0	0
Door	1.1	1.1	0.9	1.0	0.8	1.0
Windows	TG 0.83	TG 0.83	TG 0.8	TG 0.8	TG 0.8	TG 0.8
French Doors	DG 1.3	DG 1.3	TG 0.8	N/A	N/A	N/A
y-values	0.039	0.045	0.066	0.060	0.070	0.060
Airtightness	3	3	2	3.5	4	4.4
g-values	0.49	0.49	0.41	0.41	0.41	0.41
WWHR	No	No	No	Yes	Yes	Yes
FGHR	No	Yes	Yes	Yes	Yes	Yes

Smart Construction and Delivery

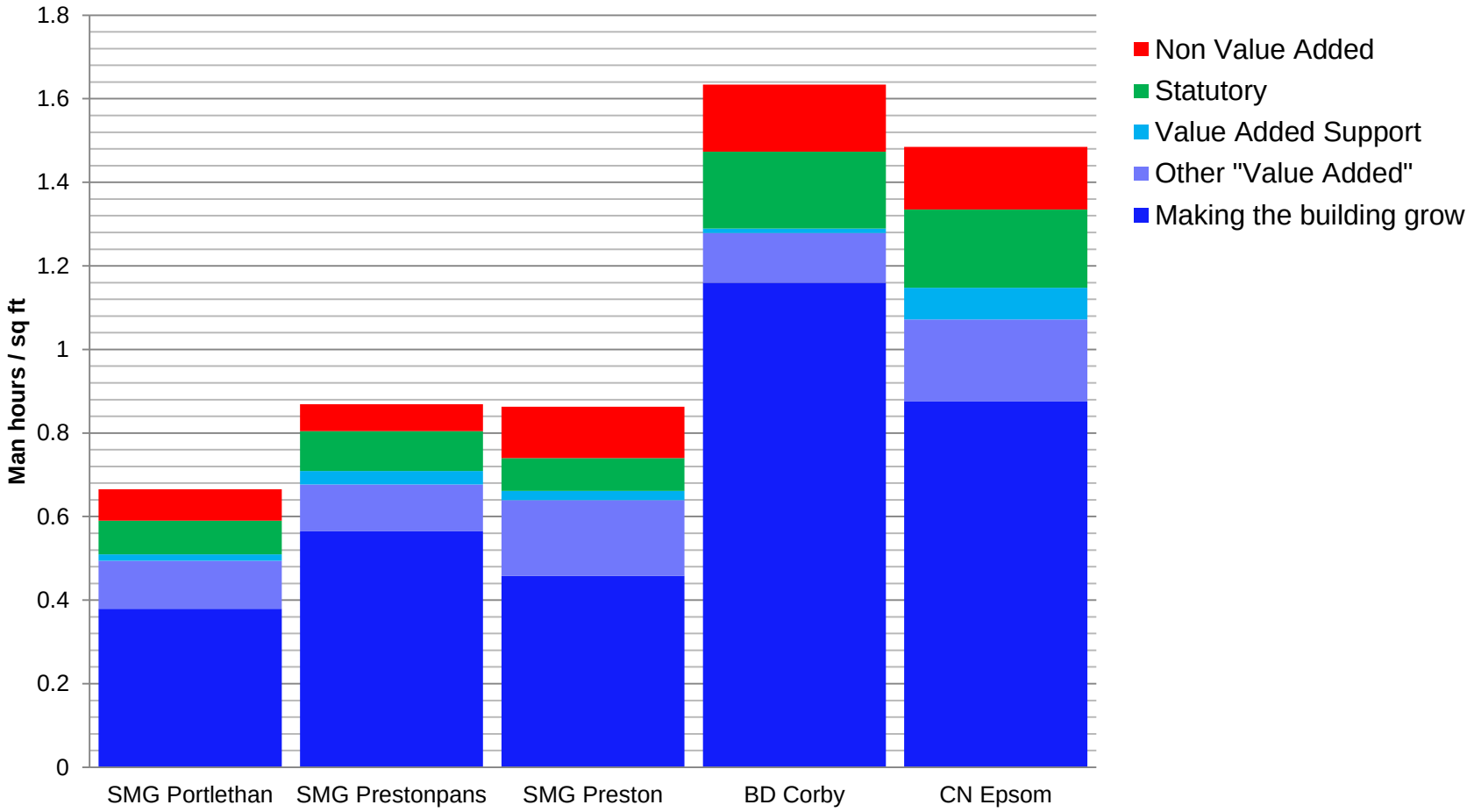
- Culture - working together
- Collaborative Planning - early workshop with trades
- Lean Principles
- CLIP – Process measurement : waste in material & Labour



AIMC4 Homes – 17 in total

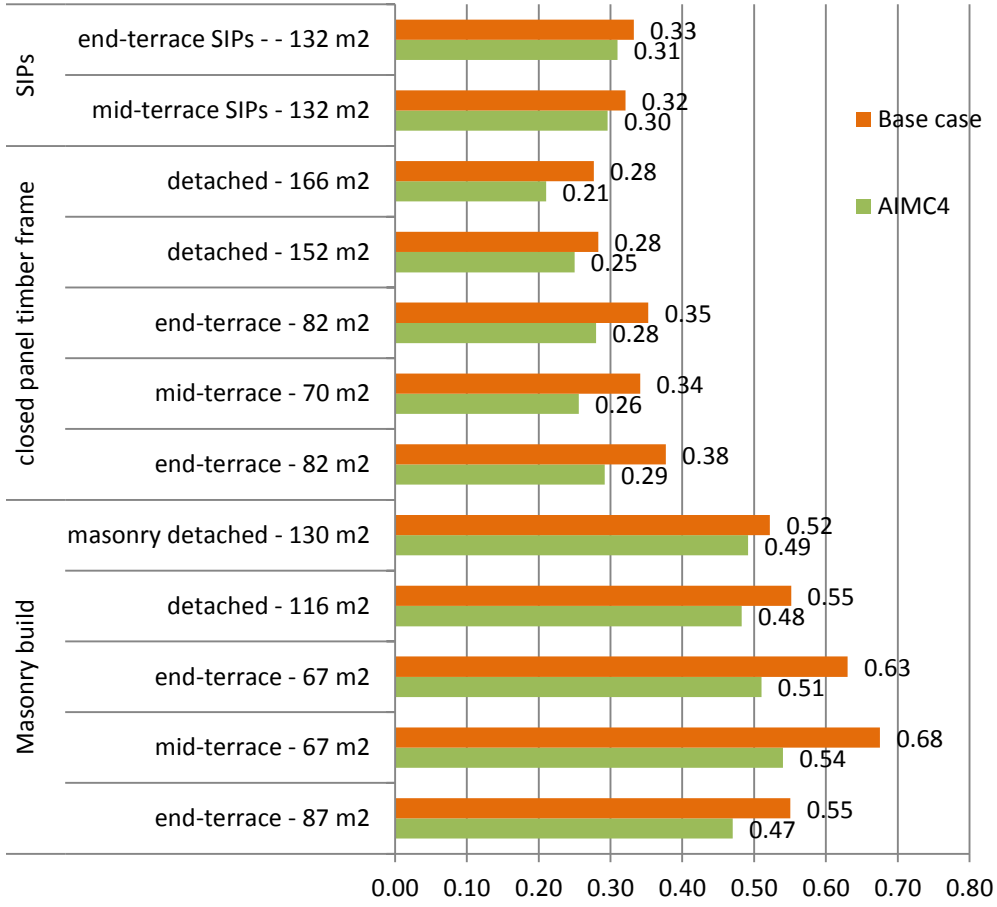
Open & Closed TF, SIPS &
Thin Joint Masonry

BRE site analysis – Process Efficiency



Embodied Carbon

Will fabric-first solutions have higher embodied carbon than PV solution?



The AIMC4 homes displayed around **6 % less** embodied carbon in comparison with the **base case**

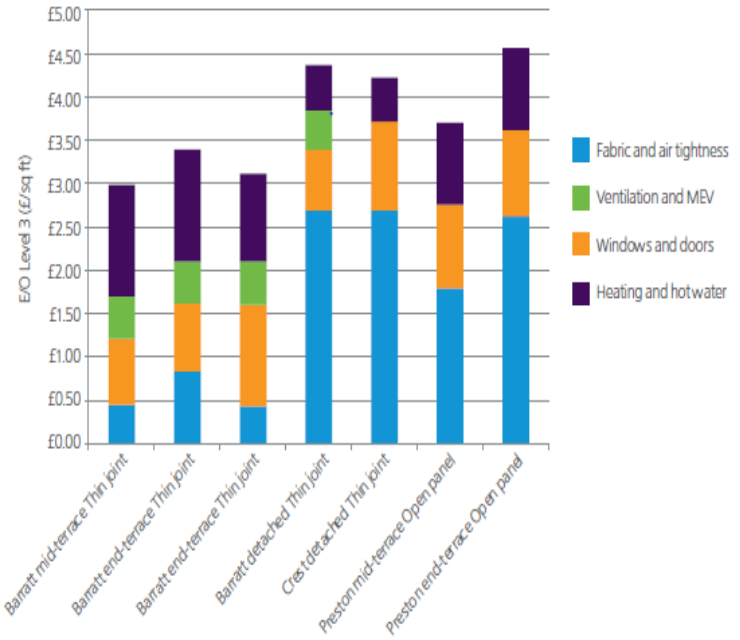
Timber Frame has **30-45%** less embodied carbon than masonry

The AIMC4 homes displayed **4tCO_2e** less embodied carbon in comparison with the **base case**

Costs & Future Considerations

- To pioneer the low cost, low carbon homes of the future
  - £2.98 - £4.57 ft² (**42% reduction**, since start)
  - Could come down further
- Speed savings & process improvements NOT considered
- Not skills dependant & simpler solution to build
- Low risk "green in perpetuity" solution
- Zero maintenance, offering lower whole life cost
- Volume delivery – should drive further savings
- Supply chain integration – opportunity to take out cost

Figure 2: Extra-over cost of the thin joint and open panel timber frame AIMC4 homes per square foot



Building Performance - What did we measure?

- Party walls for sound and heat flux
- Airtightness
- Co-heating tests (sample)
- Thermography
- Performance monitoring (16 out of 17)
  - Energy
  - Window opening
  - Relative humidity
  - Carbon Dioxide

Airtightness

Site	Corby				Portlethan		Prestonpans			Preston			Epsom				
Fabric	thin- joint masonry				closed panel timber frame					Sigma OP-4 open panel timber frame			thin-joint	SIPS			
					Sigma II	Sigma II Dynamic	Sigma II		Sigma II Dynamic								
	Detached	End-terrace	End-terrace	Attached	Detached	Detached dynamic	End terrace	Mid terrace	End terrace dynamic	End terrace	Mid terrace	End terrace	Detached	End terrace	Mid terrace	Mid terrace	End terrace
As-designed	4	4	4	4	4	3	4	2	3	4	3.1	4.2	4	3	3	3	3
Weather-tight					3.1	2.0	3.3	1.9	2.5				3.5	1.4	1.1	1.2	1.2
First Fix	6.0	4.2	6.2	8.2	3.7	2.5	3.8	2.6	3.6				2.7	2.1	2.5	2.1	2.1
Second Fix	5.3	5.6	6	6.8									2.6	2.0	1.9	1.8	2.1
As-built	3.5	3.7	3.3	3.6	4.2	3.8	3.2	2.7	3.2	3.3	3.0	4.1	3.2	1.7	1.9	1.5	2.3
After 1 year	4.1	4.1	4.6	4.2	3.7	3.2	3.9	3.0	3.3	6.4	4.9	5.6	2.6	2.3	1.7	1.3	1.9

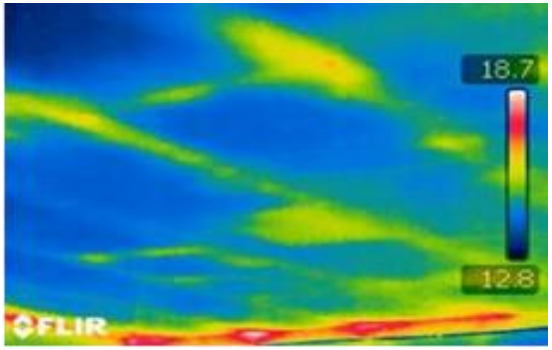
Party Walls – U-Values

- All party walls displayed heat loss, to varying degrees
- TF party walls performed very well
- Sample was small & with few sensors
- Further research needed
- SAP assumption may not reflect actual

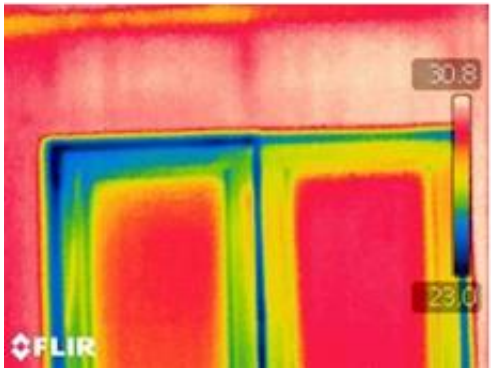
Table 2: Party Walls - As-Built performance, Heat Flux Testing

Site	Party Wall Construction Type	Thermal U-value ($W/K/m^2$)
Corby	Masonry	0.16 ± 26%
Epsom	Standard timber frame	0.05 ± 26%
Portlethan	Single skin timber frame	0.01 ± 26%

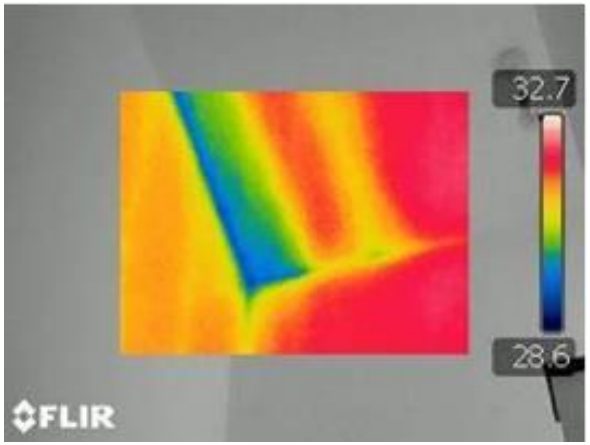
As built testing - thermography



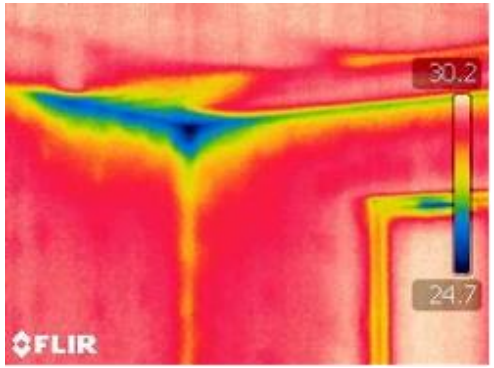
MEV6C: Integral garage ceiling



DI2C: Heat loss around Master bedroom window

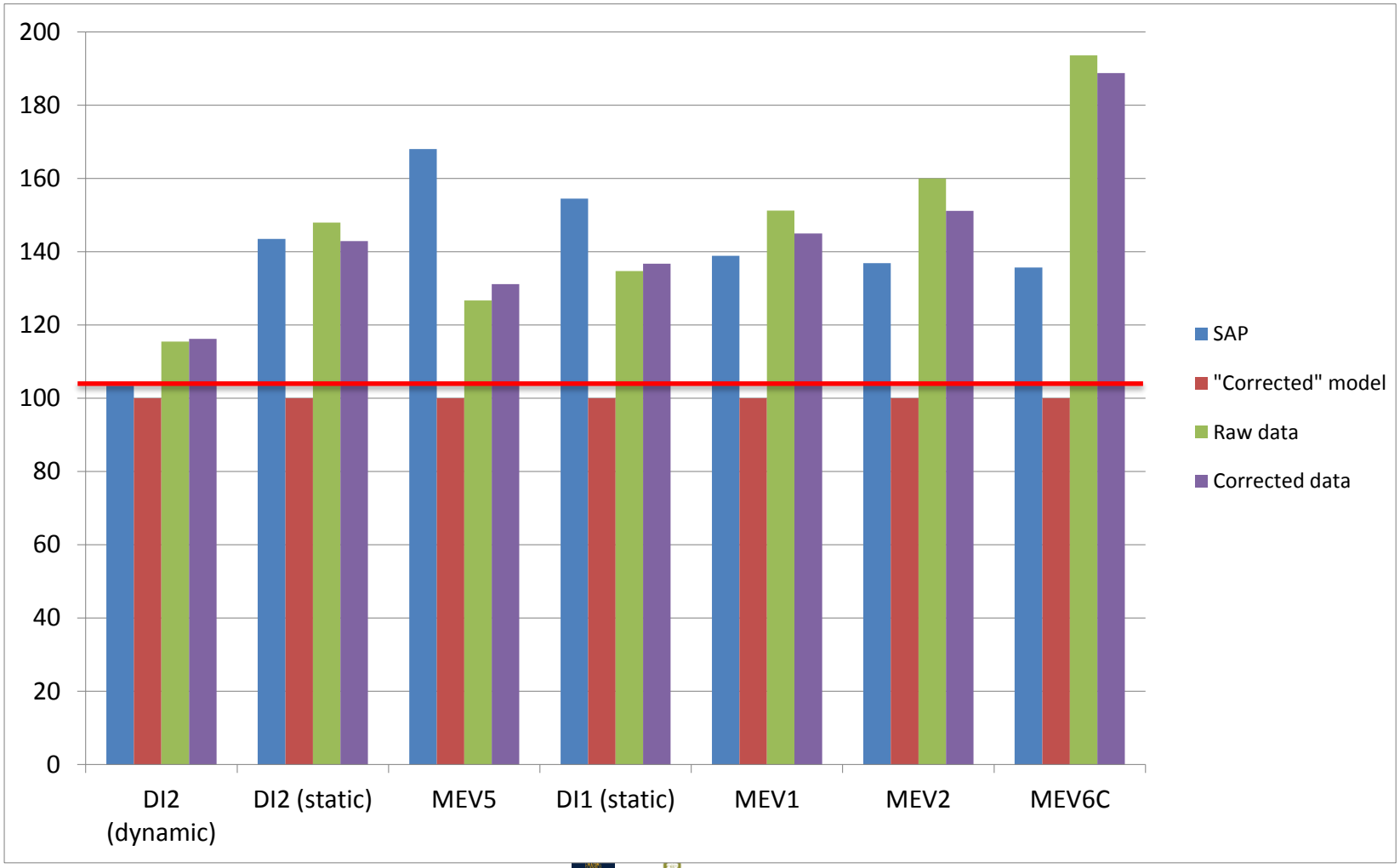


MVHR3: cold spot along the party-wall & ceiling junction (above stair)



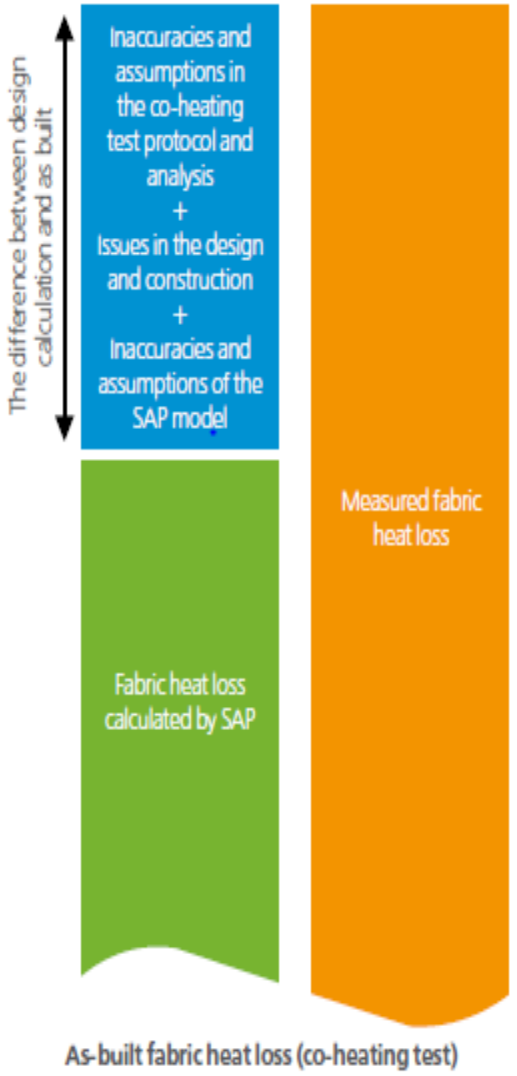
MEV7C: Bedroom 4 – cold spots along wall & ceiling junction.

As Built Fabric - Co-heating test results



Design v As Built: Performance Gap Summary

- No homes met there SAP design value
- All but one, generally performed well, against other comparable research
- Performance Gap – 3 Key Areas
  - Shortfalls in SAP
  - End of line testing (Co-heating test), is not robust
  - Design & Build practice



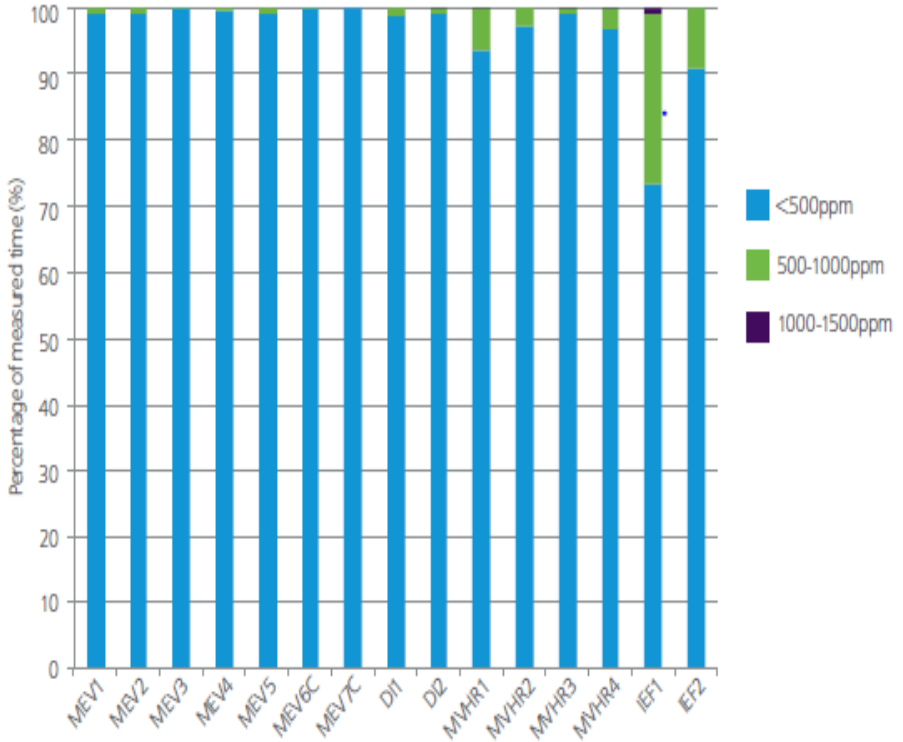
In Use Performance - What did we measure?

- Electrical circuits
  - Small Power
  - Fans
  - Lighting
- Space heating & Hot water
- Water & window usage
- WWHR
- Temperature & Relative Humidity
- Air quality

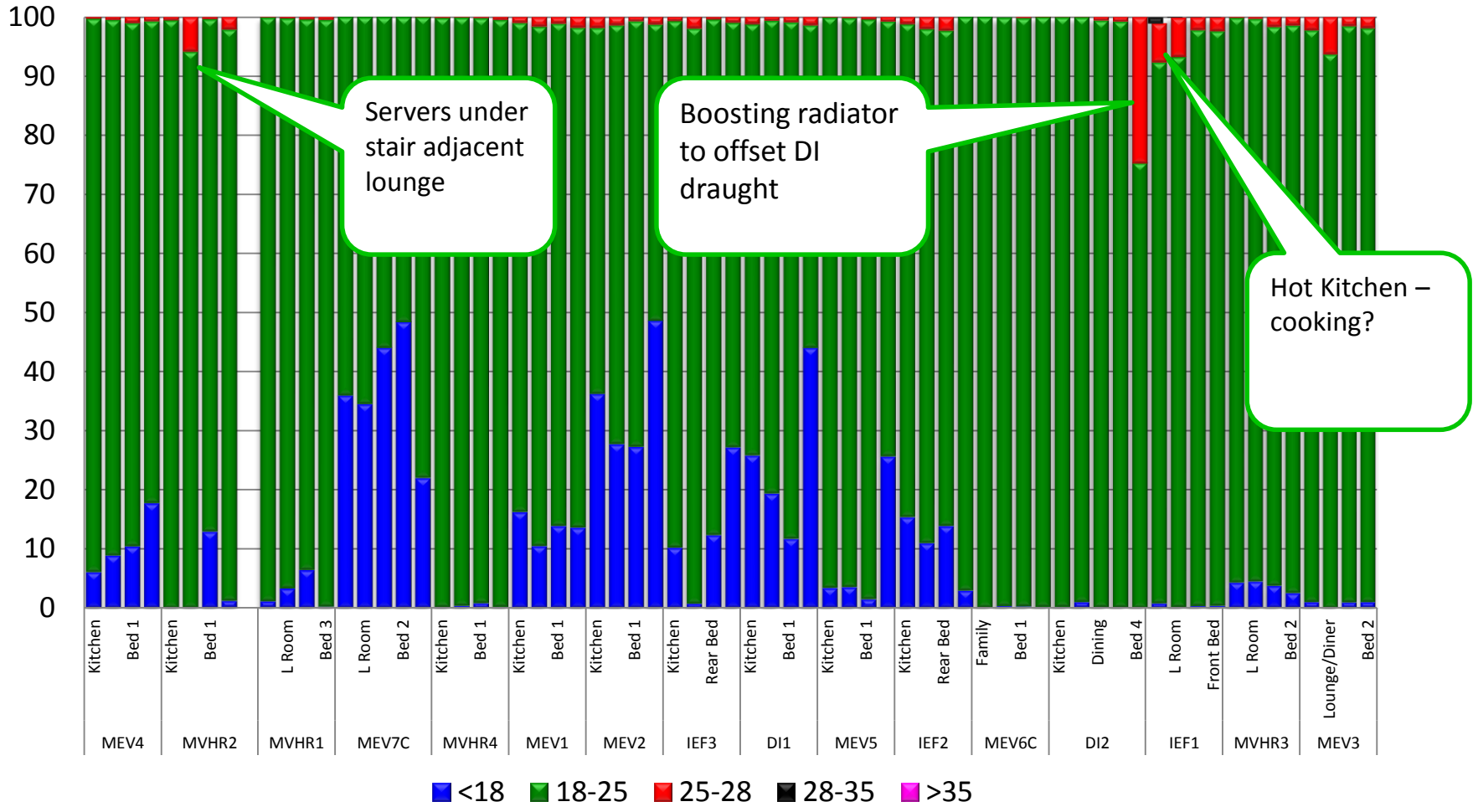
Air Quality

- Co2 good proxy for air quality
- ≥ 1500 : Schools learning threshold
- No issues
- Raised level in one home – but not concerning

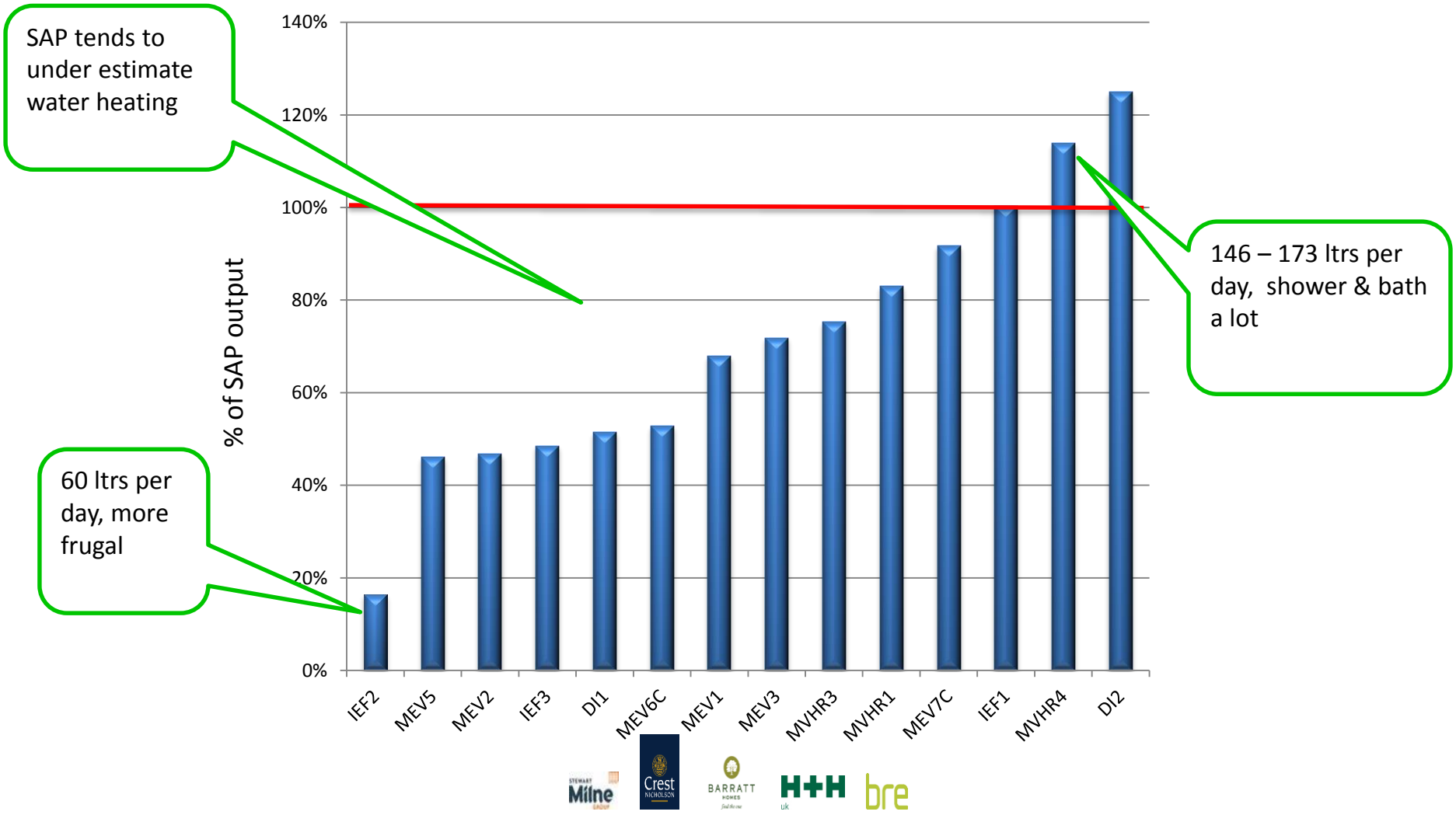
Figure 5: Carbon Dioxide concentrations[3]



Internal Temperature

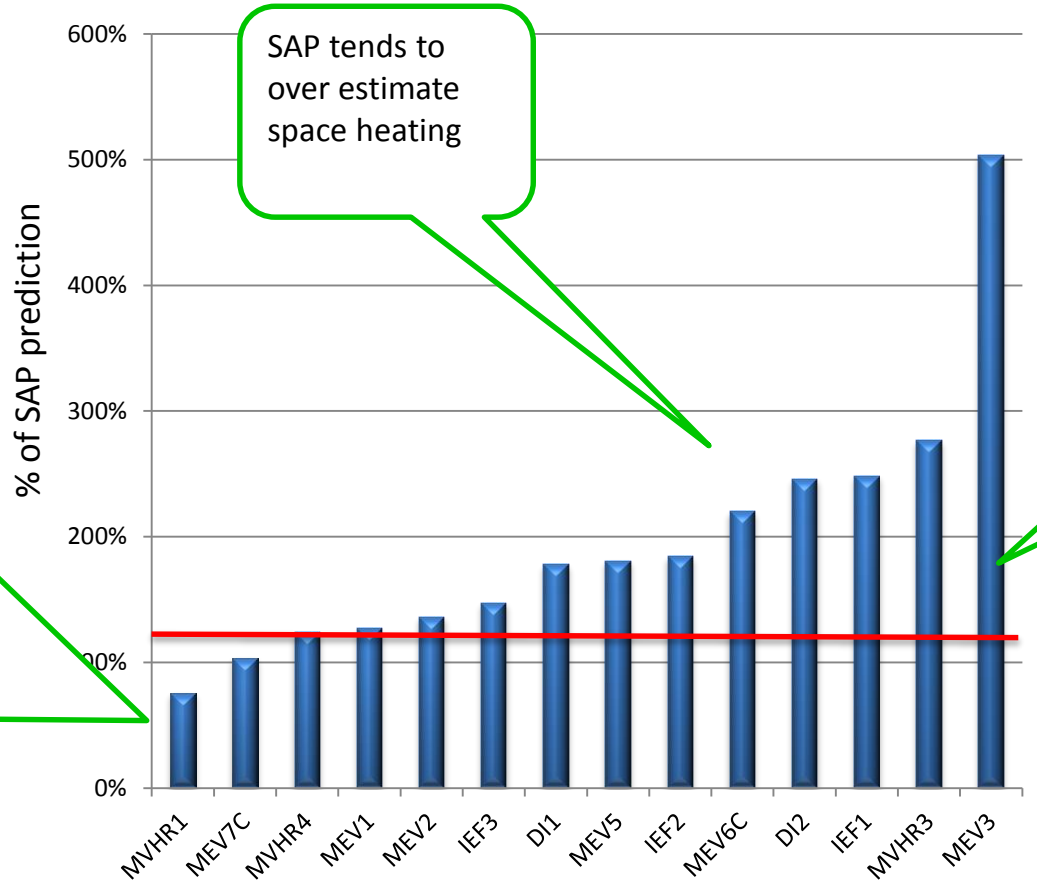


Water Heating & Usage



Space Heating

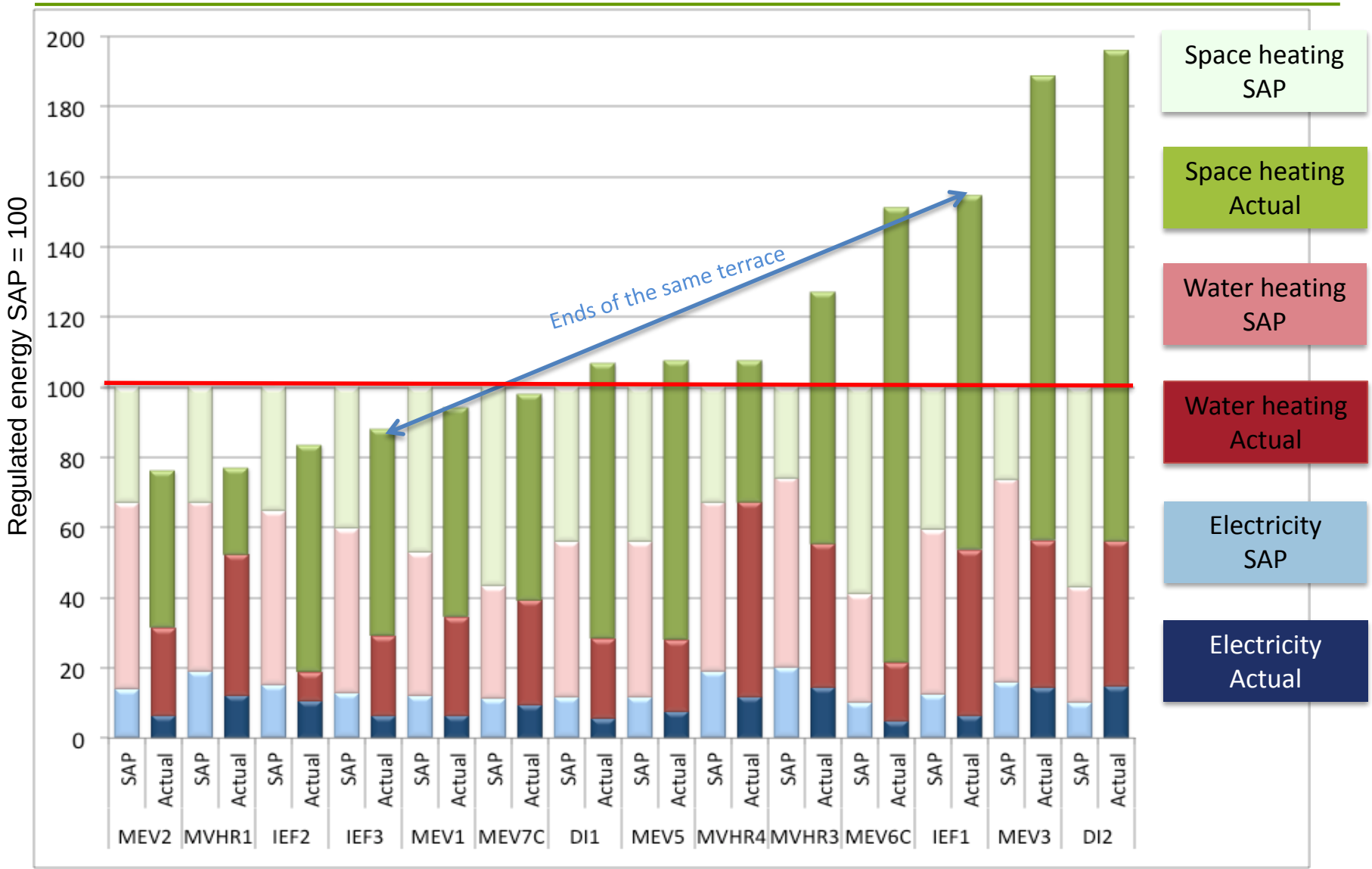
- Rooms 92-99% 18-25^{O}C
- Windows rarely open 0.28% (Nov-Apr)
- Only people who said environmental features were very important
- Only people who said would put jumper on when cold



SAP tends to over estimate space heating

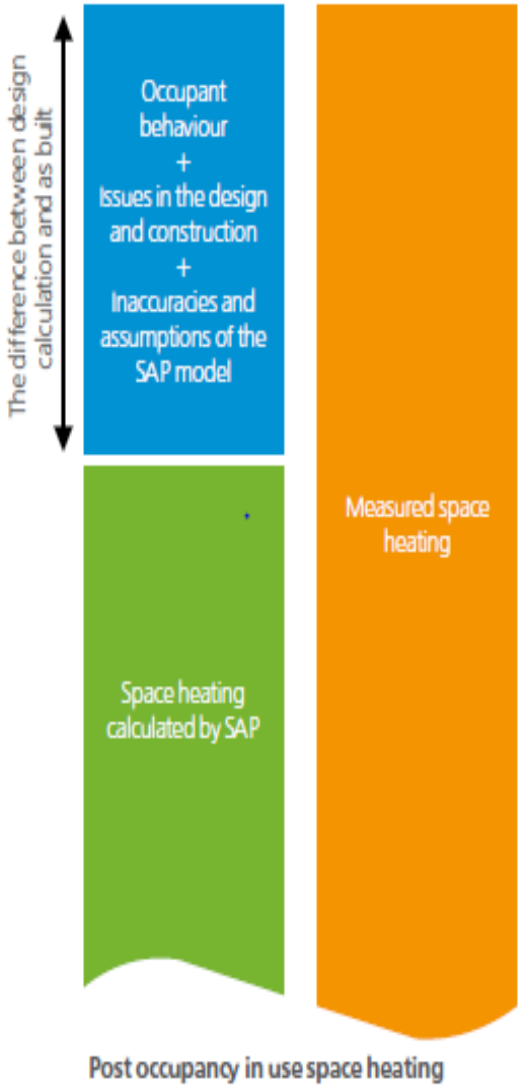
- Rooms rarely below 22^{O}C – more often above 25^{O}C
- Windows open 6.6% (Nov-Apr)
- Never used energy display or TRV's

Overall Energy Consumption

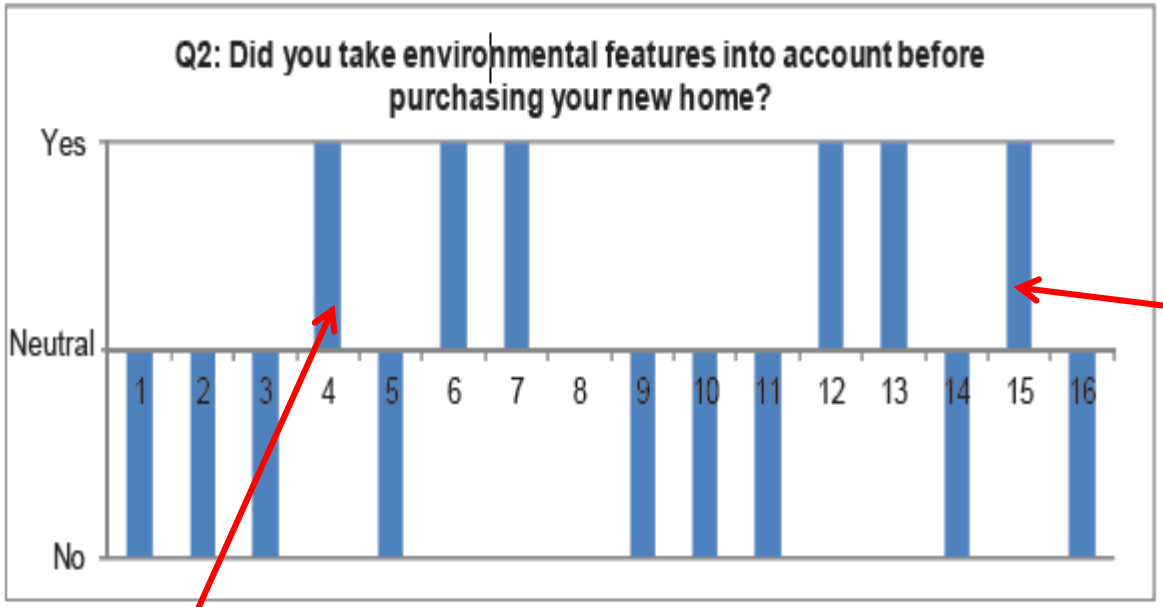


In Use: Performance Gap

- 9/14 Homes (+/-10%) or better than SAP
- Performance Gap – 3 Key Areas
  - Shortfalls in SAP assumptions
  - Occupant behavior
  - Design & Build practice



Sustainability as a buying factor



"An energy efficient house should mean a warmer house and lower energy bills"

"Energy efficiency is important"

We need to create a long term change in the perception by consumers, lenders and valuers of the **"VALUE"** of energy efficient/low carbon homes so that there is a premium on new build sustainable homes.

Overall Customer Perception

- All customers were either more satisfied (75%) or neutral (25%) with their AIMC4 home, than their previous home.
- All customers are satisfied or very satisfied with running costs
- Vast majority felt the POE process had been unobtrusive and did not impact on their behaviour
- 14/16 felt they were operating their home efficiently, in reality they may not i.e. opening windows rather than turning down heating controls

Thermal comfort – In General

- 12/16 were satisfied with the internal temperature, during all four seasons
  - Two homes in the SE responded negatively, in summer as they felt too hot, however two identical homes responded neutrally
  - 3/16 felt unable to cool their home in the summer
  - The two DI plots responded negatively , found it difficult to keep home warm, due to localised air movement
  - 13/16 are satisfied overall ventilation in their home
- Temperature is subjective and can be affected by many factors – ventilation strategy (e.g. opening windows), individual perception, location etc

" the house is warm but we open windows to ventilate."

"maintains good ambient temperature without heating."

"the house is very warm and retains heat well. We like it like that.

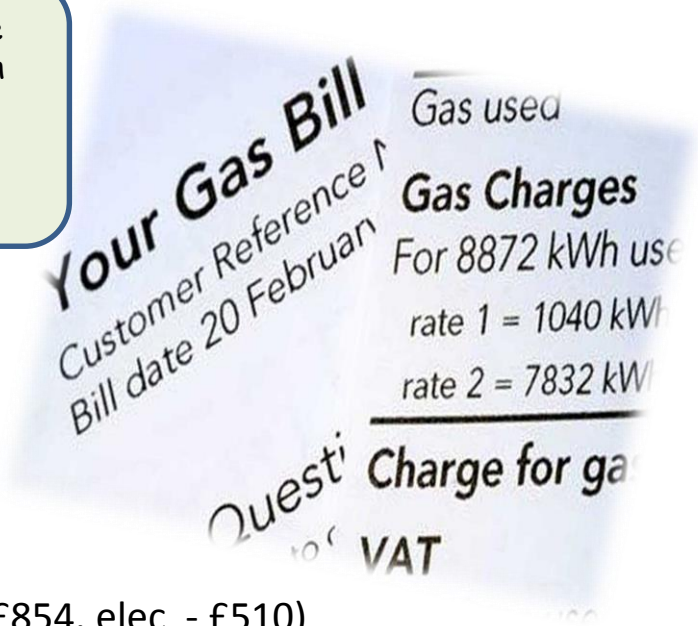
"the house heats up quickly and is comfortable and stable."

Running costs

Annual Energy Bills:

Mid Terrace	£408 - £995
End Terrace	£501 - £875
Detached	£576 - £1,250

" amazed; others are paying for one month what we paid for a quarter."



2013 UK National Average Annual Energy Bill = £1,364 (gas - £854, elec - £510)

AIMC4 Average £737 - 45% less than UK average

"very cheap, pleased, definitely compare to our previous property."

Conclusions

- Customers are satisfied overall
- They enjoy living there
- Pleased with their running costs
- Low energy features, are not part of, the decision to buy
- Occupant behaviour is the biggest influence, with little scope for developer to influence
- Evidence of a disconnect between what customers think they do/aspire to and their actions
- More needed to understand individual motivations/barriers to reducing energy consumption
- “Fit and forget – Fabric first” approach was a success

Information Papers – Free download

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