Feedback from Occupants in 'as Designed' Low-carbon Apartments, a Case Study in Swansea, UK

Energy Group – Community Housing Group: 11/11/15

Extract of Presentations to:
Coastal Housing Group 2013
Sustainability and Energy in Buildings International Conference 2011 & 2012
Mediterranean Green Energy Forum June 2013

Dr John Littlewood
jlittlewood@cardiffmet.ac.uk
Ecological Built Environment Research and Enterprise Group
Cardiff School of Art & Design

Cardiff Metropolitan University
Prifysgol Fetropolitan Caerdydd
UWIC

Acknowledgements

Much of the research documented in this presentation was part of Cardiff Metropolitan University's contribution to Work Package Six (monitoring low carbon buildings & products) of the Low Carbon Built Environment project undertaken in collaboration with the Welsh School of Architecture at Cardiff University, UK.

CMU's funding is from and in collaboration with Coastal Housing Group, Swansea and the European Research Development Fund's Convergence, Regional Competitiveness and Employment programmes; administered by the Low Carbon Research Institute for the Welsh Government.

Cardiff Metropolitan University & Schools (Departments)

Cardiff Metropolitan is based in the centre of Cardiff, Wales and has two campuses in the city: http://www.cardiffmet.ac.uk/Pages/home.aspx.

In 2014, Cardiff Metropolitan was rated the **Highest in UK Research Excellence** for post 1992 Universities – *Applied Research.* ***For impact, the proportion rated as 3* or 4* is 83%: http://www.cardiffmet.ac.uk/research/Pages/REF-2014.aspx.***

The University in 2015 celebrates 150 years, with five schools:

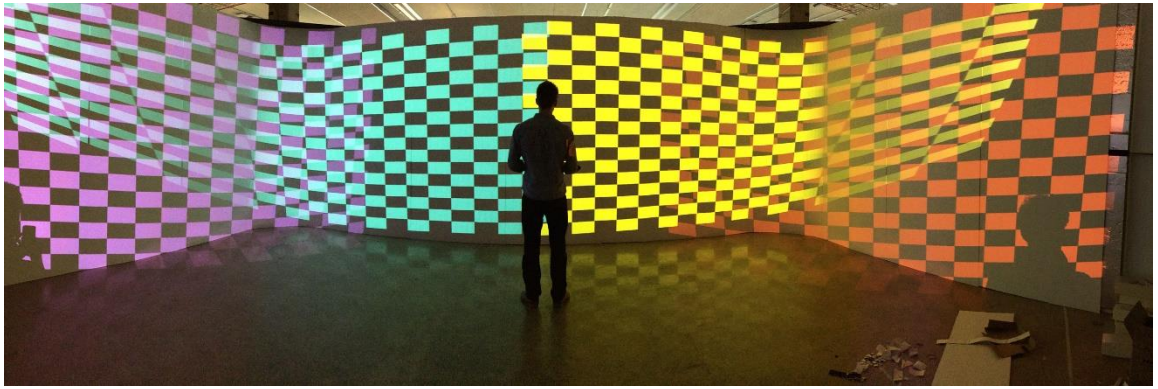
- Art & Design (CSAD);
- Sport;
- Education;
- Health Sciences;
- Management.

Plus, Product Design Research.

12,000 students, 5000 international students + many Erasmus+ students.

CSAD Research Expertise

Architectural Science, Building Engineering, Urban Ecological Food (EBERE);
MIT accredited Cardiff-FabLab
Product Design, Manufacturing & Engineering
Community Engagement
Fine Art & PEL



The Perceptual Experience Lab (PEL) is a synthetic reality facility that emulates human perceptual experience through immersion, directional sound, smell, temperature and vision. It generates realistic simulations of real world environmental and social settings, enabling rich empirical research at fine grain detail.

CREATE supports Research & Enterprise informed Teaching

http://cardiff-school-of-art-and-design.org/research-enterprise/

http://www.fablabcardiff.com/

FabLab
Cardiff Caerdydd

CSAD Research Groups

Every discipline in CSAD and Architecture, Energy & Environmental consultancy and research is conducted within the Ecological Built Environment (EBERE) group formed in by Dr John R Littlewood.

EBERE's focus is to undertake applied research & enterprise following ecological principles to reduce the use the impact of planetary resources and which interacts with industry in Wales and beyond to inform learning, teaching and scholarship & key foci:

- Assessment, benchmarking, recording & testing building design, construction,
- & systems performance through: design, construction, commissioning and
- Operation phases;
- Impacts upon building users' energy use, comfort and wellbeing;
- Recording and mapping cultural heritage;
- Professional change in ecological innovation
- Urban Ecological Food

http://cardiff-school-of-art-and-design.org/research-enterprise/research/

WHAT DOES SUSTAINABLE & ECOLOGICAL REALLY MEAN

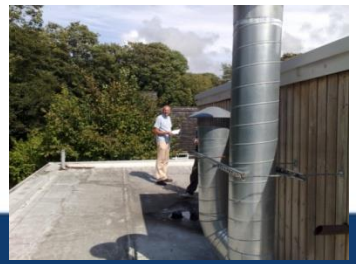
Definition of sustainable: ***'capable of being sustained';***
If resources are finite, how can mankind sustain the planet.

In 2010, Gordon Brown the Prime Minister of the UK stated that " the UK economy is one of the strongest in the world and is sustainable". How is this possible when the UK has been in the worst economic crisis since WWII ;

The problem with the word 'sustainable' is that it can be related to any profession and field of business.

Definition of ecological: ***'tending or intended to benefit or protect the environment or living organisms'.***

Ecological is routed in the protection of resources, both the environment and people i.e. community.



Dr John R Littlewood - What I do

Doctorate

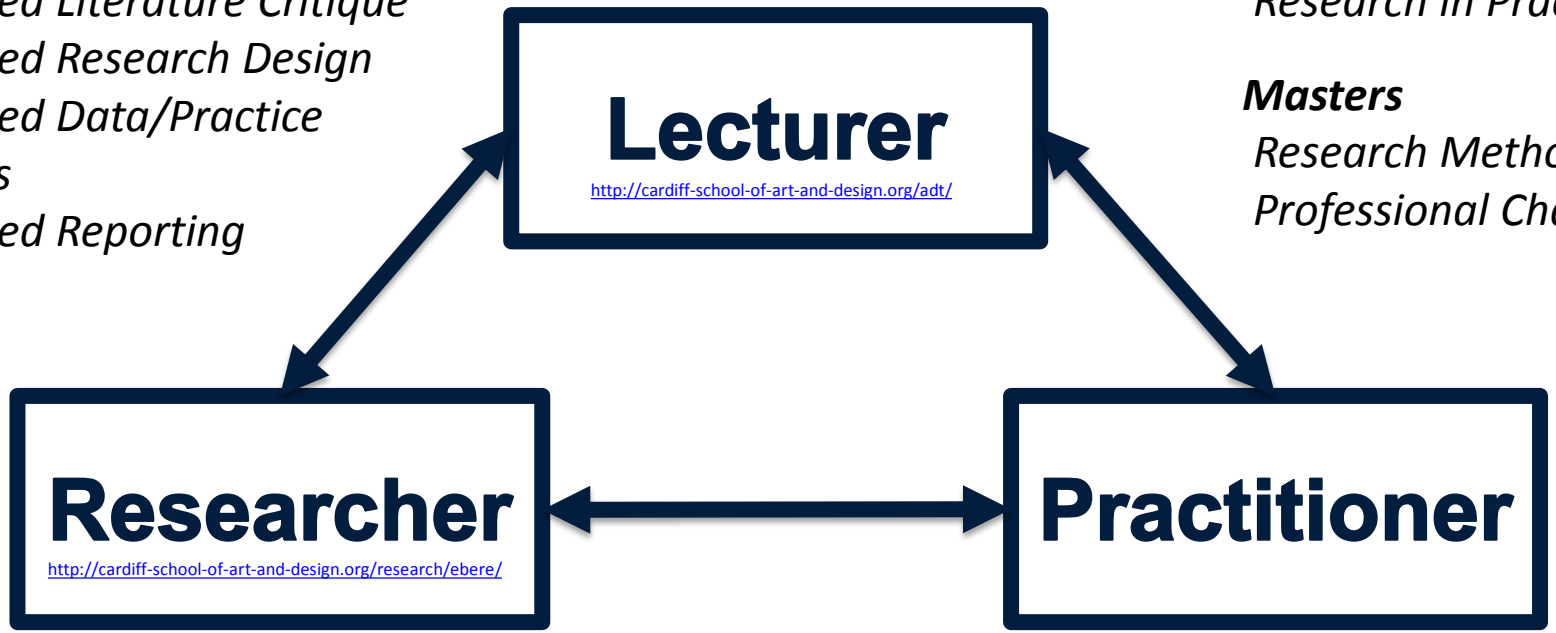
Advanced Literature Critique
Advanced Research Design
Advanced Data/Practice Analysis
Advanced Reporting

Bachelors

Research in Practice

Masters

Research Methods
Professional Change



Dwelling Performance
Occupant Behaviour & Comfort
Professional Change
Ecological Innovation & Resources

Performance Testing,
Building & Occupant Monitoring
Building Pathology
Project Management

Shakespeare - Hamlet

To quote one of the most famous lines from Shakespeare's (1623) Hamlet, but in the context of environmental performance monitoring:

"To be or not to be that is the question for quantitative and or qualitative holistic building performance assessment"

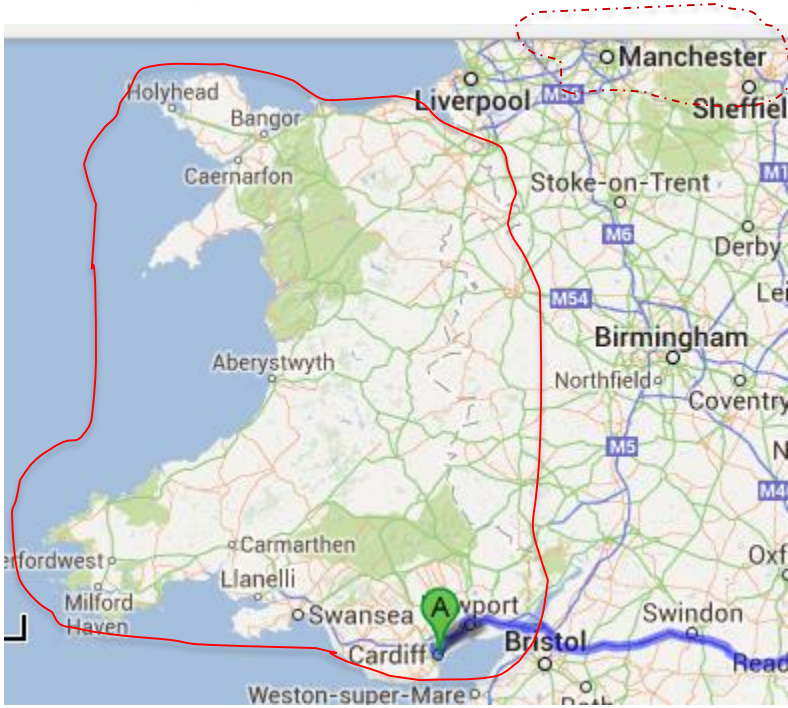
Or more simply:
why do we need to monitor buildings?
do we need to use both quantitative and qualitative methods?
when do we monitor, do we wait until the building is finished/in use (POE)?
or should we start during construction?

The results presented will hopefully answer these questions

Policy context – UK & more specifically in Wales

The UK government aims to achieve 80% reduction in carbon emissions, on 1990 levels by 2050; with 20% reductions by 2010, which were missed (HM Government. 2015).

In Wales, there are the highest carbon emissions per person in the UK and the 12th highest emissions in the world (Welsh Government, 2015).



28 years after Brundtland

Surely in 2015, 28 years after Brundtland's (1987) well known definition for sustainability we know what 'Sustainability' actually means let alone carbon neutral buildings; or do we?

Is the following statement true or false?

Like other mammals, mankind has learnt to live in harmony with the planet and the environment?

Low Carbon Built Environment

Reduce CO2 emissions associated with the built environment by bringing Welsh academics & industry together.

Targeting the built environment sector at all scales, from component to building to region.
Including all stages of the built environment process, from planning to design to construction to operation.

Work Package 6 AIM:

to develop guidance on how to assess performance of low carbon buildings & products

Work Package 6 TARGETS:

•To assist ten enterprises (so far at CMU – Pennant, Melin Homes, Greenhill, W Griffiths, Jehu) -;

•To develop one collaborative R&D relationship (possibly with

•To develop & trial new process for monitoring, such as i). in-construction (iCT) test methods – combining thermography (iCT:Th, air tightness tests (iCT:Ap) & smoke tests (iCT:Ap-s) (example one and two);
ii). post occupancy evaluation through physical and social monitoring (example three and four)

Example 1&2: in-construction testing (iCT) - before occupancy

•Traditionally building performance is assessed and monitored once a building is completed and occupied as part of post occupancy evaluation studies.

•Cardiff Metropolitan University have developed a three stage modus operandi for assessing the performance of buildings during the construction process (Littlewood et al, 2011 and Littlewood, 2013), entitled:

• ***in-Construction Testing (iCT)***

•A series of tests for iCT have been developed using thermography: ***iCT:Th,*** and air permeability ***iCT:Ap*** testing adapted and combined with smoke tests for in-construction testing ***iCT:Aps***:

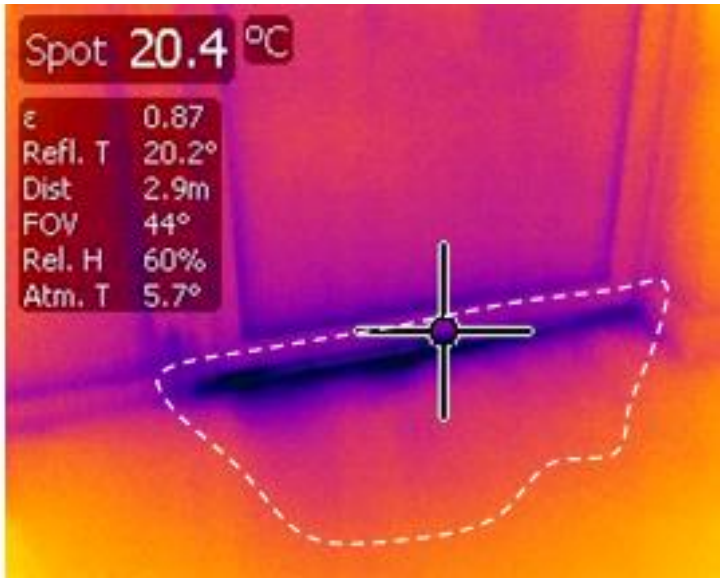
•The aim of the iCT procedures is to assess whether design (predicted) strategies are translated into construction quality & performance standards in low carbon buildings.

•For the *iCT:Th* the modus operandi is in three stages:

- pre-test procedures,
- On-test procedures,
- Post test procedures.

Littlewood, 2013.

Observations : qualitative methods – air leakage



•Two problems of air leakage: i. cold air entry visible underneath exterior door facing onto balcony and ii. also underneath the skirting board, in the corner of the room.

•What causes the issues: is it design, construction, or the technology – or all?
•How will the problems affect: thermal & acoustic performance & the transmission of fire?
•How resilient is this ‘as designed resource efficient building’?

Littlewood, 2011, 2013

Thermogram on the left reproduced by permission Steve Goodhew., University of Plymouth

So, predicted performance not being realised

Growing evidence of a potential large gap between the 'as designed' and the 'predicted' performance and 'actual' performances of buildings in use and operation in the UK, particularly dwellings (Zero Carbon Hub, 2010, Bell et al, 2010, Littlewood, 2013).

This gap in performance can be caused by many issues (Nooraei et al, 2012 and 2013).

So, comprehensive building performance evaluation and assessment of occupant behaviour and attitudes is an essential method to check whether the actual building performance meets the design expectations (Bordass, 2008 and 2011).

CASE STUDIES: INTERACTING WITH COASTAL HOUSING

Design Critique – design stage
Construction quality assessment & impact on thermal performance
POE – occupant impacts - overheating

Littlewood, 2013

Semi structured interviews/Walkthroughs

	Flats interviewed	Percentage
Summer	25	36%
Winter	36	52%
Both Summer and Winter	21	30%

Summer

Age	Quantity	Percentage
Under 5	0	0%
5 to 17	1	3%
18 to 24	1	3%
25 to 34	2	6%
35 to 44	3	9%
45 to 54	6	18%
55 to 64	12	35%
Over 65	9	26%
Total	34	

Time	Quantity	Percentage
08:00 to 12:00	15	60%
12:00 to 16:00	15	60%
16:00 to 20:00	20	80%
20:00 to midnight	25	100%
midnight to 08:00	25	100%

Winter

Age	Quantity	Percentage
Under 5	0	0%
5 to 17	0	0%
18 to 24	2	4%
25 to 34	1	2%
35 to 44	4	8%
45 to 54	10	19%
55 to 64	20	38%
Over 65	15	29%
Total	52	

Time	Quantity	Percentage
08:00 to 12:00	21	58%
12:00 to 16:00	18	50%
16:00 to 20:00	29	81%
20:00 to midnight	35	97%
midnight to 08:00	35	97%

Nooraei, et al. 2013

Semi structured interviews/Walkthroughs

Summer		
Radiator Setting at start	Quantity	Percentage
1	1	4%
2	1	4%
3	2	8%
4	3	12%
5	15	60%
OFF	3	12%
Total	25	

Winter		
Radiator Setting at start	Quantity	Percentage
1	0	0%
2	0	0%
3	3	8%
4	1	3%
5	29	81%
OFF	3	8%
Total	36	

- Radiators not set according to summer conditions

Summer

SUMMER	Living/dining		Bedroom 1		Bedroom 2	
	Quantity	Percentage	Quantity	Percentage	Quantity	Percentage
Open	17	68%	22	88%	13	52%
Closed	8	32%	3	12%	12	48%
Total	25		25		25	

Winter

WINTER	Living/dining		Bedroom 1		Bedroom 2	
	Quantity	Percentage	Quantity	Percentage	Quantity	Percentage
Open	16	44%	17	47%	11	31%
Closed	20	56%	19	53%	25	69%
Total	36		36		36	

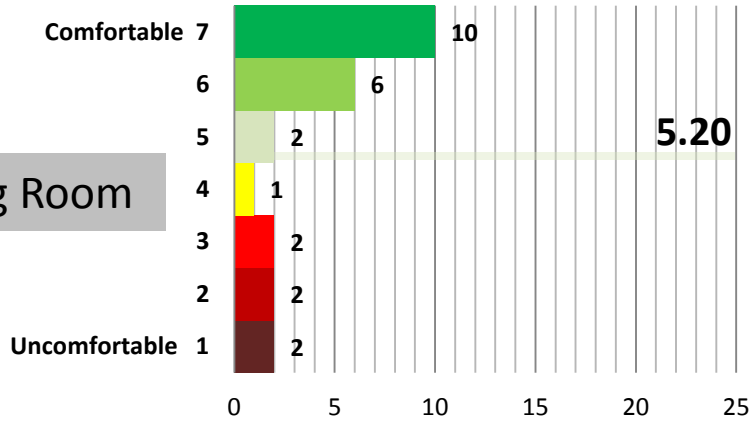
Nooraei, et al. 2013

Semi structured interviews/Walkthroughs

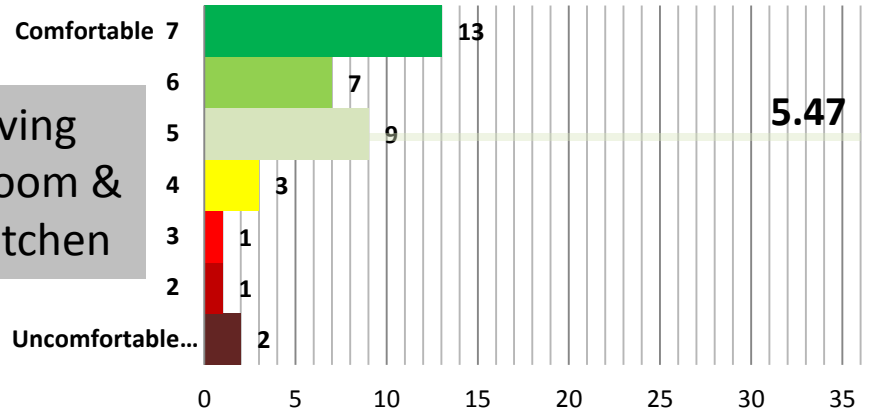
Summer Temperature

Winter Temperature

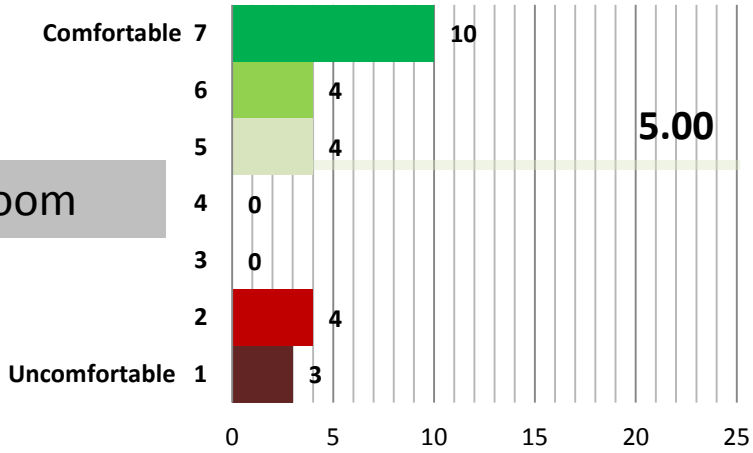
Living Room

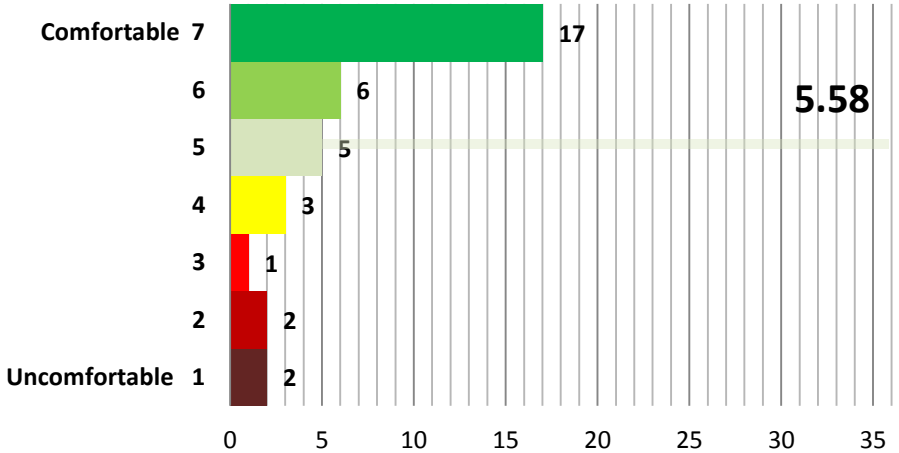


Living Room & Kitchen



Bedroom





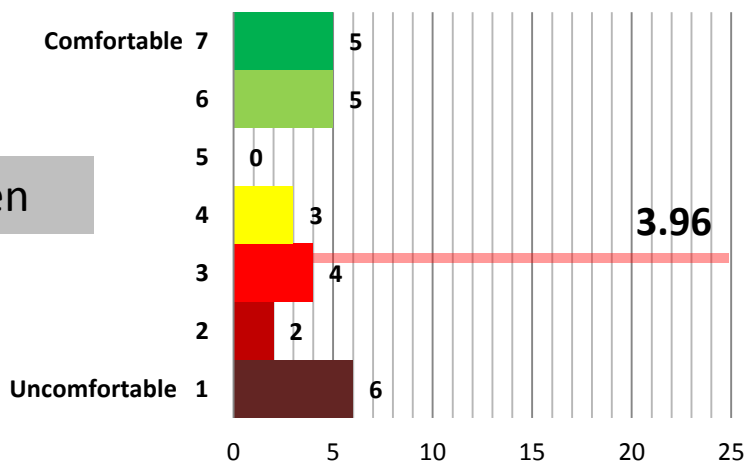
Nooraei, et al. 2013

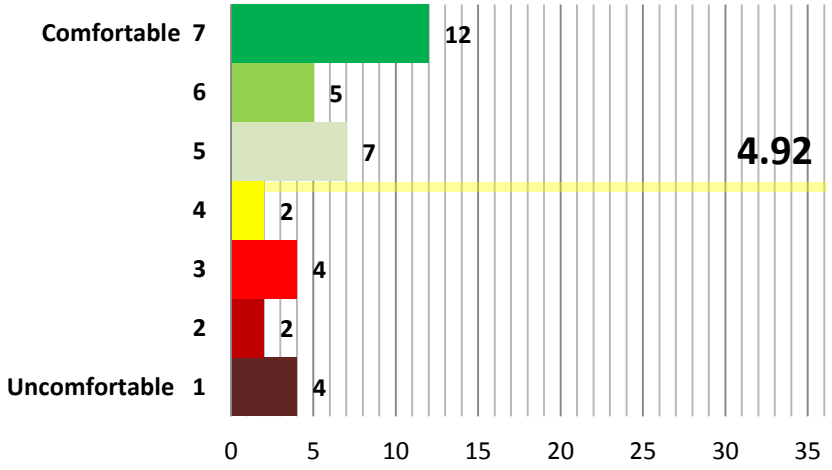
Semi structured interviews/Walkthroughs

Summer Ventilation

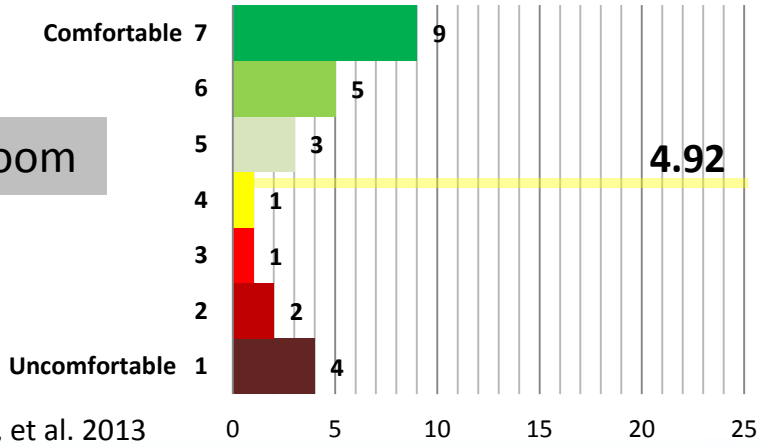
Winter Ventilation

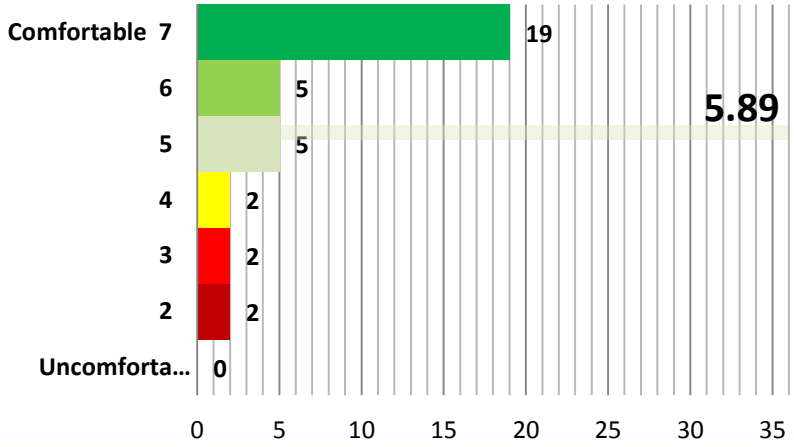
Kitchen





Bedroom





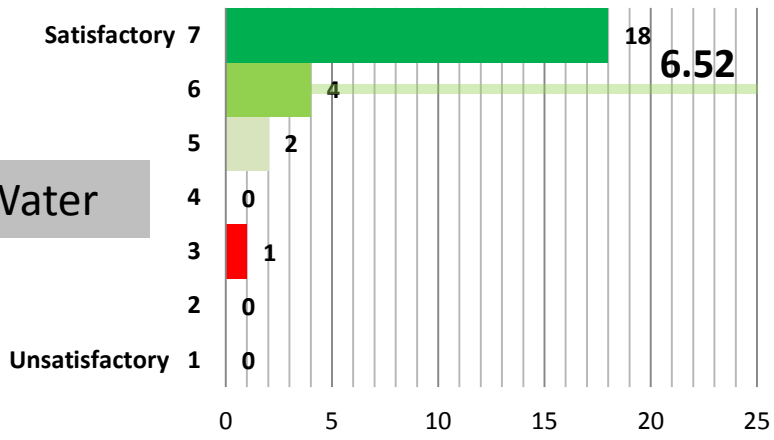
Nooraei, et al. 2013

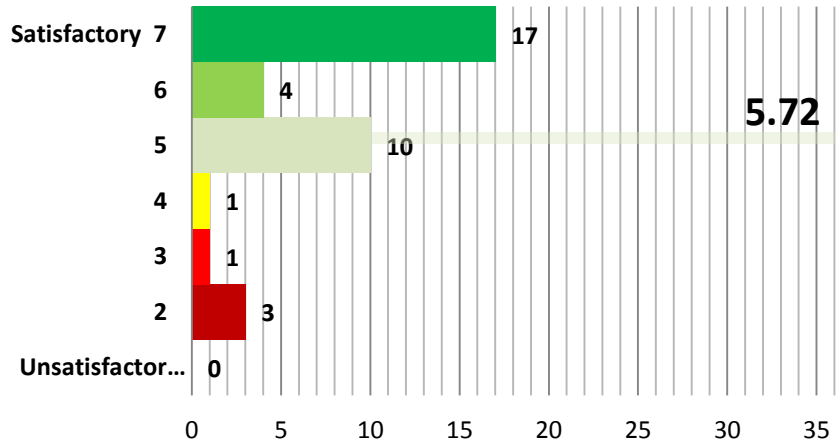
Semi structured interviews/Walkthroughs

Summer Water Provision

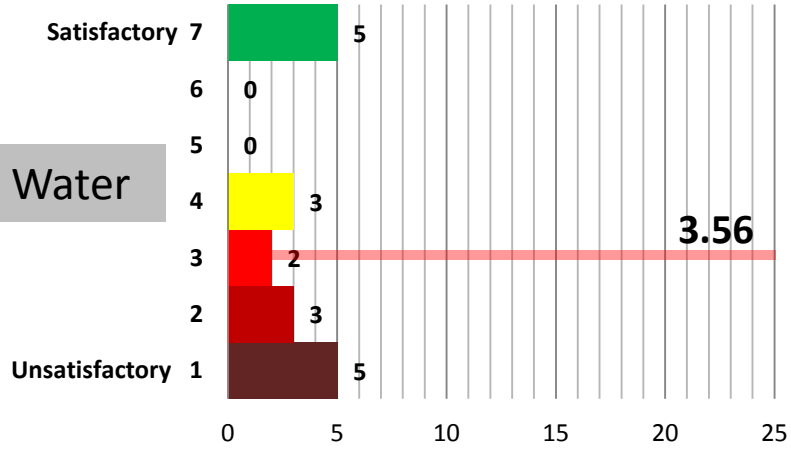
Winter Water Provision

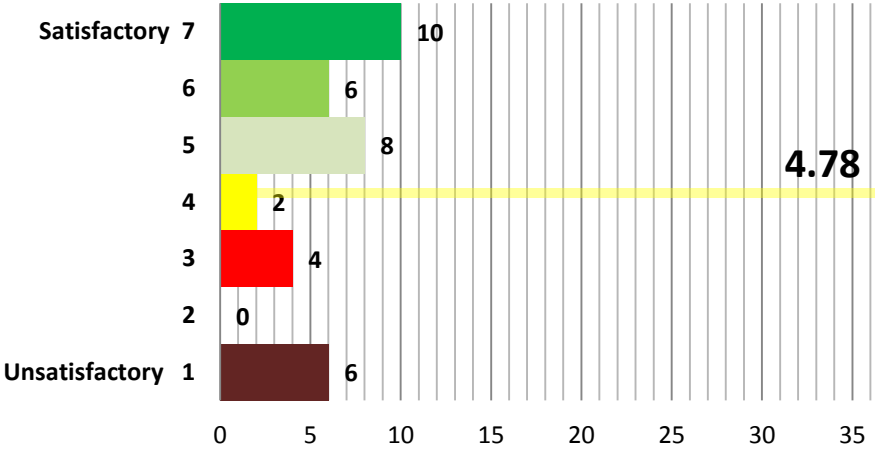
Hot Water





Cold Water





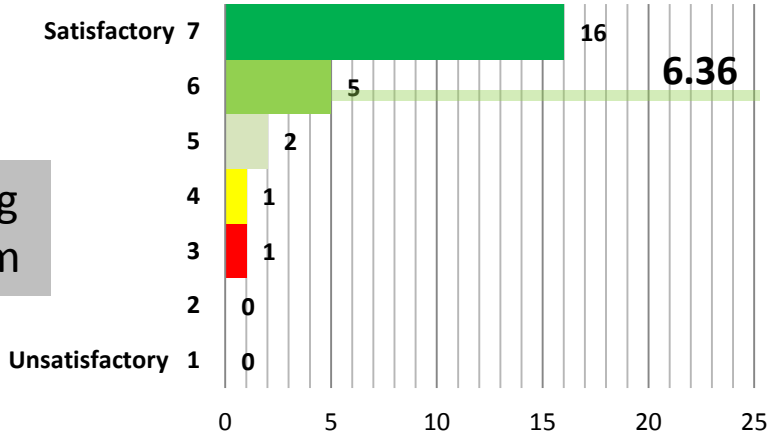
Nooraei, et al. 2013

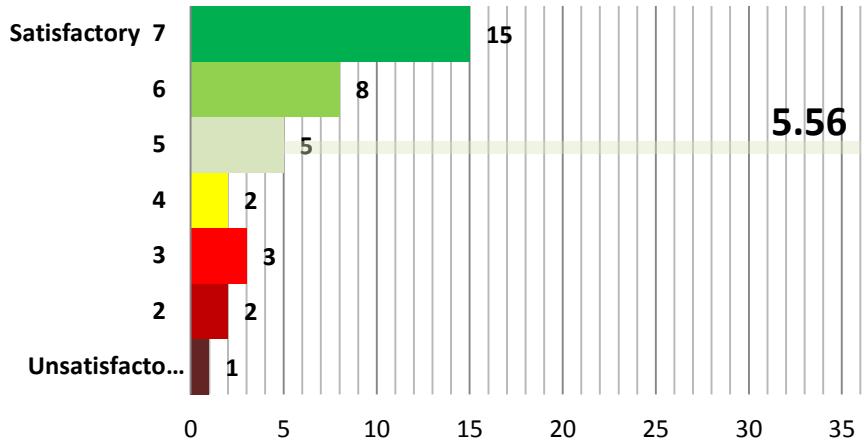
Semi structured interviews/Walkthroughs

Summer Daylight Level

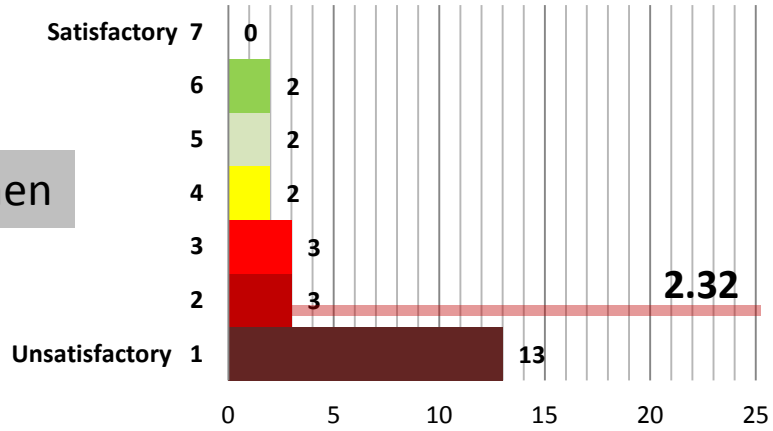
Winter Daylight Level

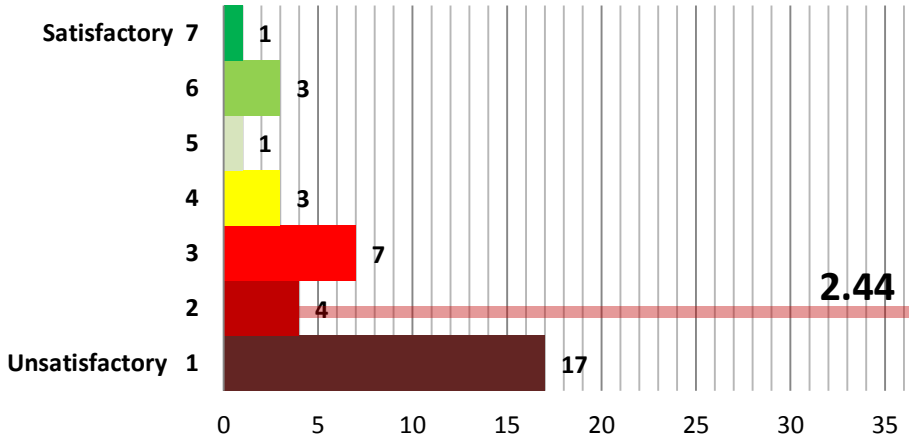
Living Room





Kitchen





Nooraei, et al. 2013

Semi structured interviews/Walkthroughs

Summer Gas Payment & Usage

	Quantity	Percentage
Much less expensive	**7**	**32%**
Less expensive	5	23%
Similar	2	9%
More expensive	3	14%
Much more expensive	2	9%
Don't know	3	14%
Do not apply	0	0%
Total	22	

Winter Gas Payment & Usage

	Quantity	Percentage
Much less expensive	**8**	**23%**
Less expensive	**8**	**23%**
Similar	5	14%
More expensive	5	14%
Much more expensive	3	9%
Don't know	3	9%
Do not apply	4	11%
Total	36	

	Quantity	Percentage
Much less	**12**	**60%**
Less	1	5%
Similar	3	15%
More	0	0%
Much more	0	0%
Don't know	4	20%
Do not apply	0	0%
Total	20	

	Quantity	Percentage
Much less	**14**	**40%**
Less	12	34%
Similar	2	6%
More	1	3%
Much more	0	0%
Don't know	2	6%
Do not apply	5	14%
Total	36	

Nooraei, et al. 2013

LONG TERM MONITORING – INTERNAL COMFORT, CLIMATE & ENERGY

•18 month duration, three apartments (one ground floor (south), one second floor (west)
•and one last floor (north). Commenced December 2012

Climatic condition monitoring:

air temperature; barometric pressure; relative humidity;

wind speed and direction;

high and low temperature in each 24 hour period;

precipitation, with seasonal total; solar radiation;

resultant temperature – factoring in affect of wind and precipitation which lower or raise the temperature;

date, time and carbon dioxide.

Link to live weather data:

LONG TERM MONITORING – INTERNAL CONDITIONS & ENERGY USE

Internal conditions monitoring in each room: air temperature, relative humidity, exterior fenestration/door opening period; carbon dioxide in the hall.

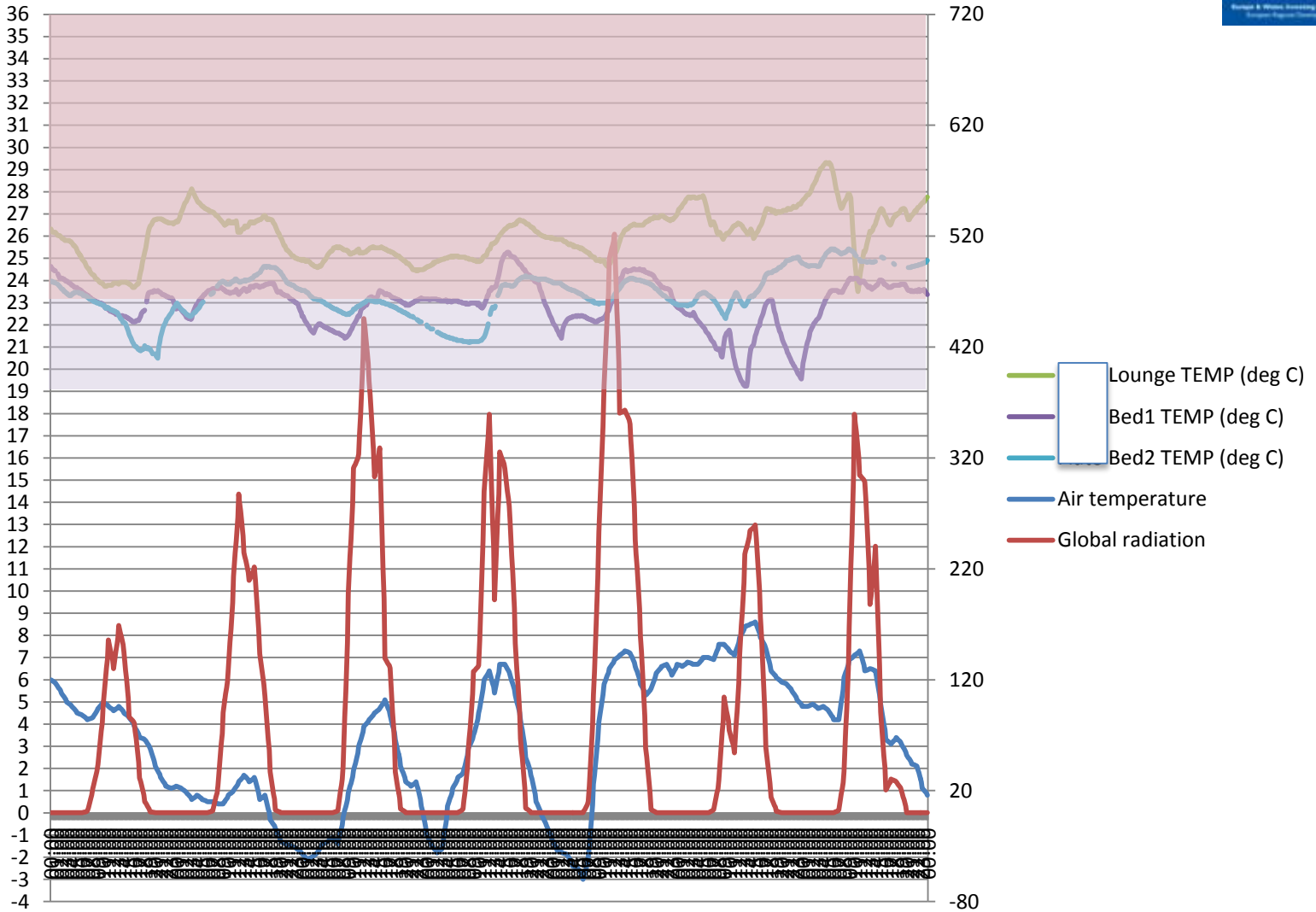
Electrical circuits (energy use): lighting, sockets, cooker, & total Electricity use.

Heating (energy use): space and water heating energy Consumption.

Recommended temperatures & overheating

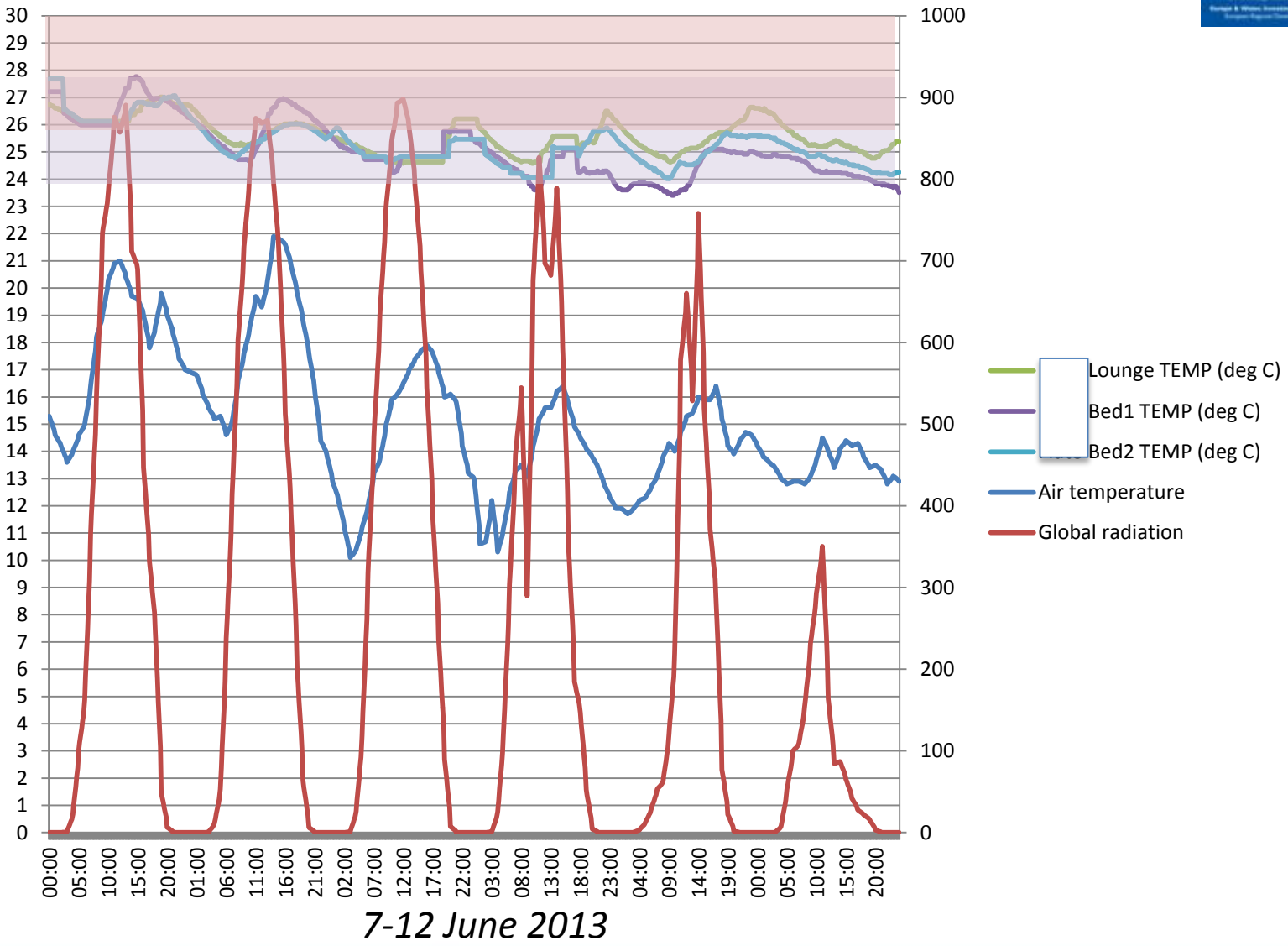
	Winter	Summer
CIBSE recommended temperatures		
Living room	**22-23ºC**	**23-25 ºC**
Bedroom	**17-19 ºC**	**23-25 ºC**
CIBSE overheating threshold		
Living room	**-**	**28 ºC**
Bedroom	**-**	**24 & 26 ºC**

Quantitative results



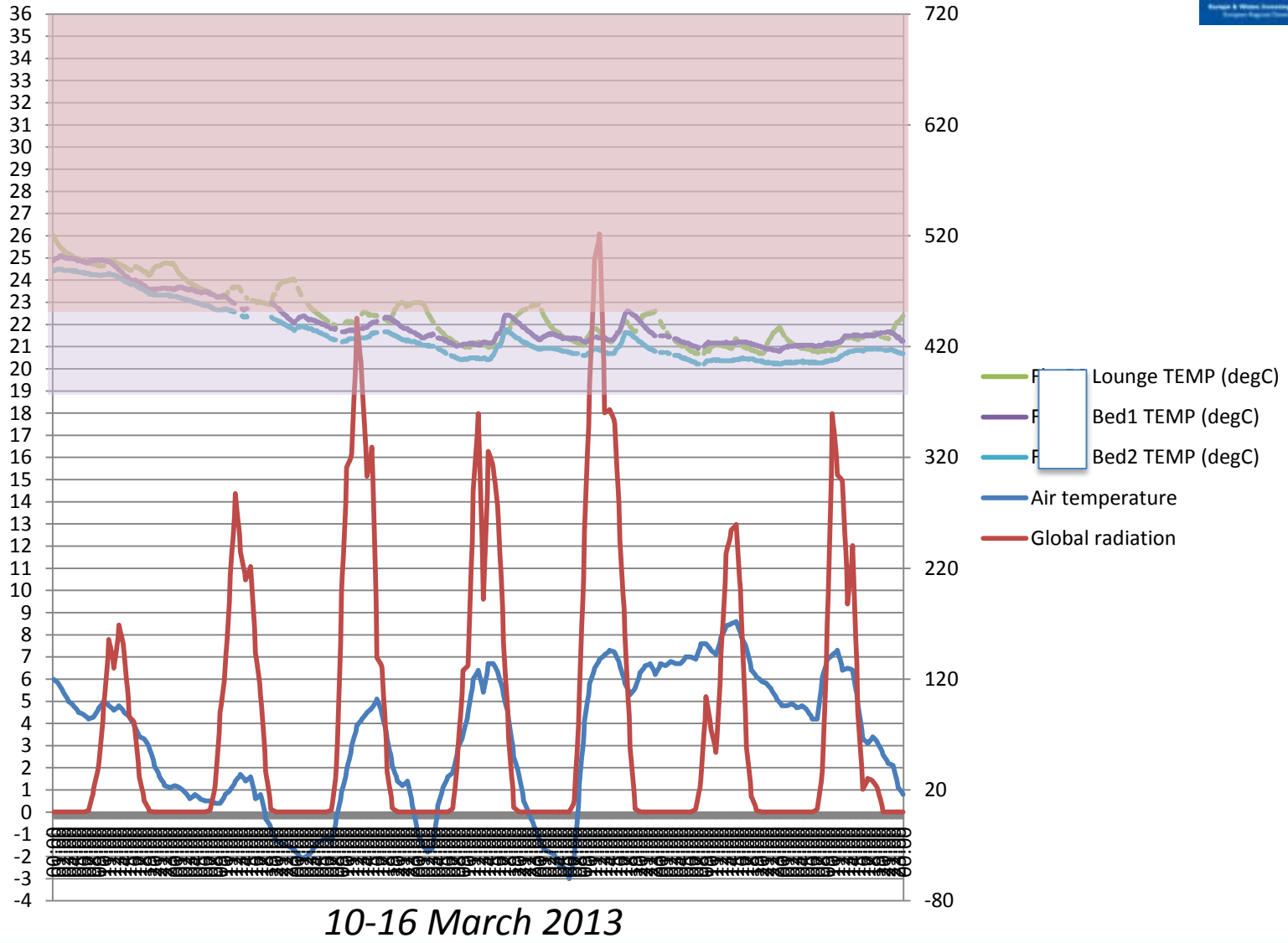
10-16 March 2013

Quantitative results



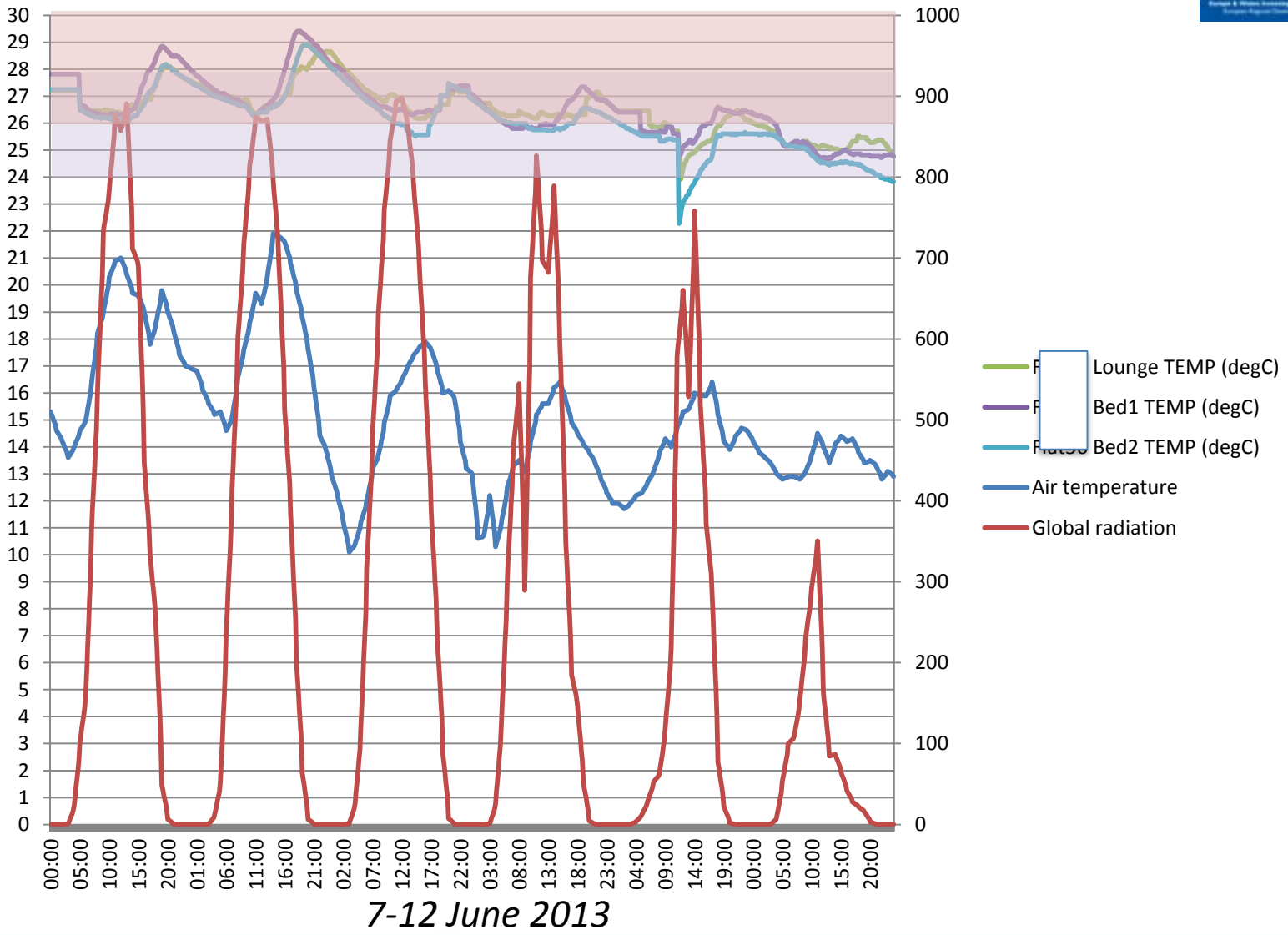
7-12 June 2013

Quantitative results



10-16 March 2013

Quantitative results



Quantitative results

- Lack of knowledge about heating controls ⟶ Importance of handover, hands-on training, and simplified User Guide
- Oversimplified controls;
- Location of controls; TRVs behind furniture and not accessible

To be or not to be, a simple method for building performance monitoring

Does as built performance in use meet as designed and predicted performance? **NOT IN MOST CASES**
Can we get away with a simplified method for monitoring? **Possibly if iCT is also used, but design, construction, commissioning and education of users needs to be improved**
Can we choose one monitoring method over another? **NO**
Can we wait until a building is finished to monitor performance? **NO**
Can we rely on honesty from testers appointed by contractors? **NO**

The answer:
In-construction testing, spot checks, through commissioning and into occupancy; mixed methods approaches; appropriate contract.....

Any questions

References

1. LITTLEWOOD, J. R. 2011. *Mechanisms for assessing the environmental performance of dwellings through the interaction of Universities and SMEs. Keynote address at the 3rd International Conference on Sustainability in Energy and Buildings (SEB'11), June, Marseille, France.* Editors: Nacer M'Sirdi, Aziz Namaane, Robert J. Howlett, and Lakhmi C. Jain. Springer, Heidelberg, Germany. pp. 13-14.

2. LITTLEWOOD, J, R. 2013. Assessing and monitoring the thermal performance of dwellings, Chapter Four. In: *Architectural Technology: Research & Practice*. Editor: EMMITT, S. Wiley Blackwell, Oxford, UK. Due for publication May 2013.

3. LITTLEWOOD, J. R. TAYLOR. T. GOODHEW. S. EVANS. N. I. COUNSELL. J. A. M. WHYMAN. A. WILGEROTH. P. 2011. *Development of a thermography protocol for the in-construction testing of the thermal performance of low carbon dwellings*. Paper accepted to be presented as a poster and published in the proceedings of the Chartered Institute of Building Services Engineers Technical Symposium, 6-7 September 2011, Demontford University, Leicester, UK.

4. NOORAEI, M. LITTLEWOOD, J. R. EVANS, N. I. 2013. 2013. Passive cooling strategies for apartment buildings in Tehran, Iran and Swansea, UK. Chapter TBC. In: *Sustainability in Energy and Buildings - Proceedings of the 4th International Conference on Sustainability in Energy and Buildings (SEB'12).* Editors: Anne Hakansson and Robert J. Howlett. Vol. 13. Springer, Heidelberg, Germany. pp.TBC. ISBN: TBC.