

Warm house, Cold house:

a review of measures of thermal comfort used in Get Bill Smart's energy efficiency assessments

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Other project consortia:



Original project funded by:



Improving Residential Energy Efficiency International Conference (IREE)
Wollongong, Australia, 16-17 February 2017

Outline

Reviewing measures of household thermal comfort as they relate to energy efficiency assessment in a project, Get Bill Smart (GBS).

- Get Bill Smart (GBS) project background
- The GBS Detailed study
- Comfort
- GBS temperature and energy logging methods
- Comfort and energy measures
- Example project results
- The future

Get Bill Smart (GBS) project

*As part of Low Income Energy
Efficiency Program (LIEEP).*

GBS investigated how to best support energy efficiency and thermal comfort in low-income households in Tasmania, Australia.

GBS Detailed Study

Detail (51 houses, 49 household gps)

- Billing data
- Householder surveys
- House condition observations
- Monitoring
(Temperature, humidity, electricity)
- Household interviews

GBS Bulk group (500 households)

- Billing data
- Householder surveys

		Community capacity building approach	
		Off (Greater Hobart)	On (Clarendon Vale / Rokeby)
In-home education and upgrades approach	Off (Representative)	153	76
	On	157	63

		12	12
		12	13

Comfort

a physiological need

a parameter for healthy housing

*an energy efficiency building
standard*

a cultural construct

BUT little detailed data into relationships between thermal comfort and energy efficiency performance in existing housing stock;

AND little data on the impact of support programs on energy use /comfort relationships.

GBS temperature and energy logging

Temperature/relative humidity :

3 to 4 in-situ, stand-alone USB loggers in each house (one of these external).

Recording at 30-minute intervals.

Electricity:

Wireless, plug-in electricity sensors on every heating device.

Current clamp sensor on each circuit in the electrical meter board.

Accumulating, minute-interval electricity consumption data to cloud based storage service.

Comfort and energy measures

- *difference between inside and outside temperatures (ΔT)*
- *time spent in thermally comfortable temperatures inside the house, comfort zone (%CZ)*
- *change in the time spent in the 'comfort zone'*
- *average daily winter heating power consumption (kWh/day)*

Comfort zone was between 18 and 24 degrees Celsius

Indicators developed for GBS

Household Heating Efficiency (HHE):

- expressed as $^{\circ}\text{C}/\text{kWh}/\text{day}$
- the ratio of average ΔT (expressed in $^{\circ}\text{C}$) to average daily heating energy consumption (kWh/day).

Comfort Zone Efficiency (CZE)

- expressed as $\%cz/\text{kWh}/\text{day}$
- the ratio of the percentage of time spent in the 'comfort zone' ($\%cz$) to average daily heating power consumption (kWh/day).

Example project result #1

Before Living Temp vs Before Heating Electricity vs Before Total Electricity vs % time in CZ				
Living Temp Quintile	Before Living Temp Average	Before Heating Electricity Average	Before Total Electricity Average	Before % time in CZ
	(°C)	(kWh/day)	(kWh/day)	(%)
Q1	23.00	33.50	59.76	65.6%
Q2	20.01	19.57	33.18	58.3%
Q3	18.17	13.37	28.63	29.4%
Q4	17.16	12.13	34.69	21.5%
Q5	14.62	11.76	26.29	11.1%

Table 1: Average living room temperatures compared with heating electricity, electricity consumption and time spent in the defined comfort zone. A comparison of detailed participant households. Table from Rooney et al.

Kara (case 43)

(after interview 1/9/15)

'I can't put the heater down any more in the winter when it's cold. I can't just keep putting jumpers on and on'

Example project result #2

Houses grouped by heating types	Heating electricity			% time in the comfort zone (CZ)		
	Before (kWh/day)	After (kWh/day)	Change (kWh/day (%))	Before (%)	After (%)	Change(%)
Houses with Heat Pumps	14.52	16.07	1.54 (10.6%)	41.6%	43.2%	1.6%
Houses with Hardwire resistive heaters	22.07	25.57	3.50 (15.8%)	31.8%	34.5%	2.6%
Houses with Only Heat pumps	14.55	16.01	1.46 (10.1%)	44.4%	42.7%	-1.7%
Houses with Only Resistive Heaters	23.59	28.71	5.12 (21.7%)	26.0%	29.6%	3.6%

Table 2: Main heater types compared with heating electricity and time in the comfort zone. Table from Rooney et al. (Change in kWh/day affected by colder 'after' winter in 2015.)

Teri – 30% saving with heat pump

Teri a retired, single occupant avoided the heat pump in her rental because she didn't understand how to make it 'blow' (hot air) comfortably. Instead she used an old, inefficient electric resistive, plug-in heater.

Education from family supported Teri to start using the heat pump. She then saw around a 30% drop in her electricity bill.

Ingrid – project result example #3

'too scared to put the heaters on...because there is too many [sic] costs involved' (after interview 1/9/15).

Ingrid only used \$1.50 of electricity a day and thought that was 'the lowest that anyone can' (before interview 19/5/14).

Ingrid – project result example #3

	Living Temp (°C)	Bedroom Temp (°C)	Kitchen Temp (°C)	Outdoor Temp (°C)	Avg out/in temp diff (°C)	% time in comfort zone (18°C - 24°C)
Before winter	11.1	10.9	9.7	9.7	1.3	0.8%
After winter	10.5	10.1	8.8	8.8	1.5	0.9%
Difference	-0.6	-0.8	-0.9	-0.9	0.1	0.1%

Table: Ingrid's average daily temperatures and time in comfort zone during winter conditions. Case 33 from Rooney et al.

Ingrid – project result example #3

	Before (kWh/day)	After (kWh/day)	Change (%)
T ₃₁ Heating (plug in heating)	0.79	0.81	2.7%
T ₄₁ Heating (hard wired heating)	0.00	0.00	0.00
Total Heating	0.79	0.81	2.7%
Other Light and Power (T ₃₁)	2.51	3.59	43.1%
Hot Water	2.30	2.16	-6.1%
Total Household Electricity	5.61	6.57	17.1%

Table: Ingrid's average daily energy use and heating efficiency during winter conditions Case 33 from Rooney et al.

Project result example #4

Household		Cassie and Partner (Case 34)	Deirdre and child (Case 13)	Troy (Case 12)	Ingrid (Case 33)
Total heating (kWh/day)	Before	10.73	53.47	12.67	0.79
	After	12.45	54.05	8.84	0.81
Household Heating Efficiency (°C hours/kWh/day)	Before	0.91	0.19	0.16	1.67
	After	0.84	0.20	0.28	1.78
% time in comfort zone (18°C-24°C)	Before	68.8	74.4	1.4	0.8
	After	72.9	83.5	0.7	0.9
Comfort Zone Efficiency (%CZ/kWh/day)	Before	6.41	1.39	0.11	1.06
	After	5.86	1.55	0.08	1.15

Table: Selected participant households heating efficiency compared with total heating energy and time in comfort zone during winter conditions. Data from Rooney et al.

Future of the measures

Policy actions supported in findings but also need to further develop and refine HHE, CZE and time spent in comfort zone and their relationship with qualitative data.

What further work can be done?

- Comfort zone as individual rooms, not averaged for house
- Work with existing tools, eg NatHERS
- Different applications (compare new houses to existing)
- Different climates and heating/cooling needs
- More systematically linked with householder responses, for example through a time of use diary, or linked answers from interviews and surveys
- Household typologies for policy

Foundations

Rooney M, Watson P, Watson S. Get

Bill Smart: Detailed Study Report

Prepared by Mission Australia,

Sustainable Living Tasmania,

University of Tasmania, RED

Sustainability Consultants for the

Australian Government: 2016; can

be accessed at

http://www.slt.org.au/get_bill_smart.

This presentation builds on GBS research and contributions made by participants.

Thank you to Mission Australia, SLT and UTAS teams GBS community champions and householders for taking part in the trial.

In particular thank you: Dr Millie Rooney and Dr Michelle Gabriel (for GBS research); Anton Vikstrom (for GBS project management); Todd Houstein (for the early GBS proposal and early development of the HHE concept).

Thank you also to the scholars who reviewed this paper, your critiques were greatly appreciated.

Funding for the GBS project was provided by the Commonwealth Government.