HEEP & BEES – How energy is used in N.Z. houses & commercial offices

Nigel Isaacs

Nigel.Isaacs@branz.co.nz Phone (04) 238 1366

Overview

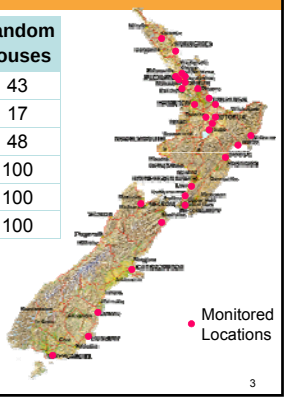
- **Household Energy End-use Project (HEEP)**
  - Residential sector energy use
  - Meaning of Statistics - Space heating
  - Domestic Hot Water (DHW)
- **Building Energy End-use Study (BEES)**
  - Questions & Issues
  - Research Plan
  - Early Results

2

HEEP numbers

~400 random houses
62 non-random houses
1,200 'temperature' locations
850 dataloggers
255 solid fuel fires & burners
14,000 power measurements
440 hot water systems
175 LPG heaters

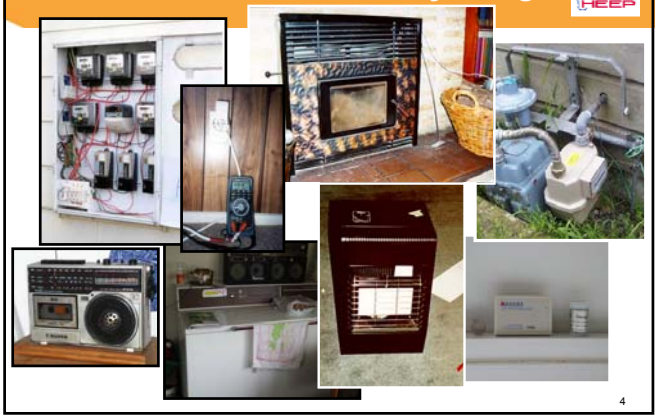
Year	Random Houses
1999	43
2000	17
2001	48
2002	100
2003	100
2004	100



Year 9

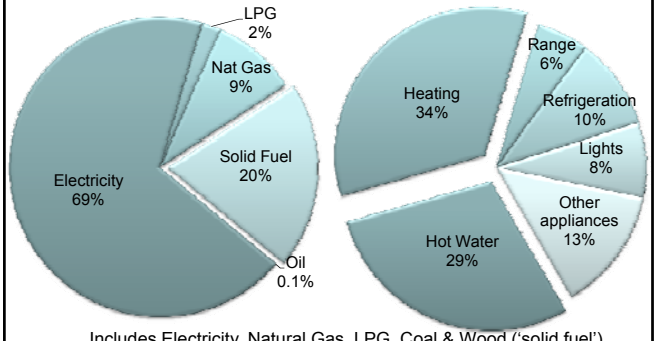
3

HEEP Monitored "everything"



4

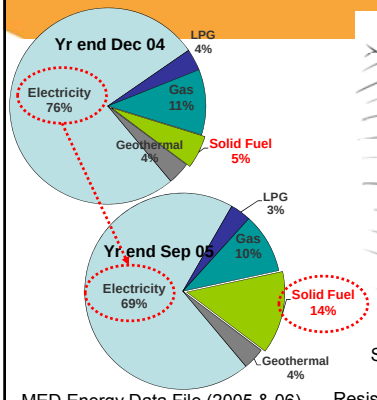
NZ Housing Fuels & End-uses



Includes Electricity, Natural Gas, LPG, Coal & Wood ('solid fuel')
Source: HEEP Year 10

5

Residential Fuels



MED Energy Data File (2005 & 06)

Something was hiding in the wood shed !
Resistance heaters = 530 MW station

6

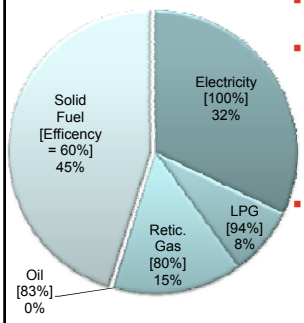
Meaning of Statistics?

Main Heater Fuel used	2006 Census Fuels	HEEP Main Fuel	
		% Count	% Energy
Solid Fuel	46%	44%	45%
Electric	71%	30%	32%
LPG	26%	15%	8%
Retic. Gas	13%	10%	15%
Other & No fuel	9%	1%	
Total	**166%**	**100%**	**100%**

- **Census reports EVERY FUEL**
  - NZ houses average 1.7 heating fuels
  - Census – an unreliable basis for energy planning!

7

Space heating energy



- **HEEP gave NEW knowledge**
  - Wood & gas (55%) Electric (45%)
- **Heat pumps**
  - BIG change since HEEP finished
  - 2007 in 40% Christchurch houses
  - New electric load = new generation
  - Opportunity to heat & cool
  - Change grid load
  - Capital and running costs
- **New houses warmer – why?**

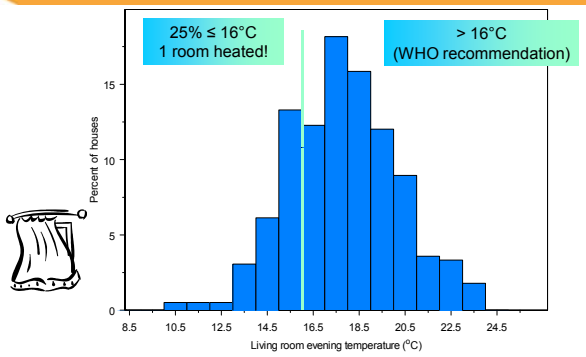
Winter:
- Insulation = warmer & less energy

Summer:
- Design, operation, materials, insulation

HEEP Year 10 report

8

Winter living room temperatures



Winter = June to August; 5 pm to 11 pm

9

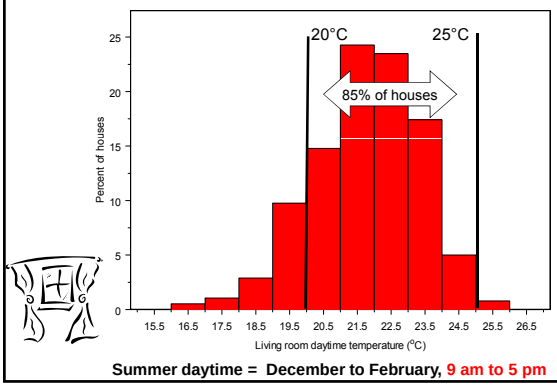
Thermal Insulation Does Work

Insulation	Overnight Bedroom	Evening Living Room
No requirement Pre-1978	13.2°C ± 0.1	17.6°C ± 0.1
Mandatory Post-1978	14.5°C ± 0.2	18.6°C ± 0.2

- **Post-1978 houses have**
  - larger floor areas **and**
  - warmer temperatures
  - AND use less heating energy

10

Summer Temperatures



Summer daytime = December to February, 9 am to 5 pm

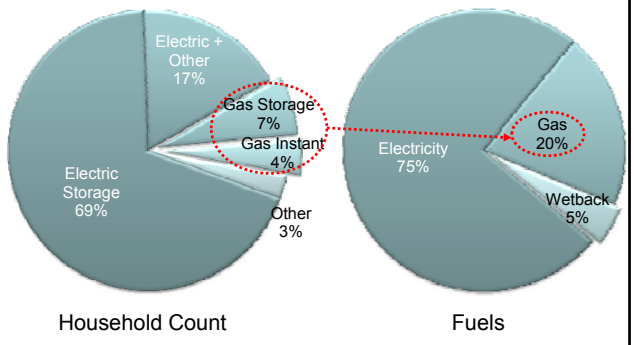
11

Hot water cylinders

Electric Storage A Grade | Electric Storage C Grade | Electric Storage D Grade

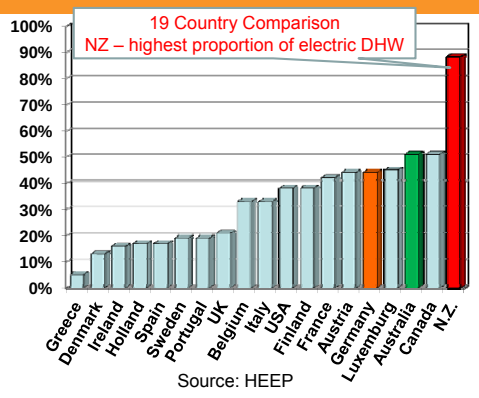
12

Domestic Water Heating (DHW) Fuels



13

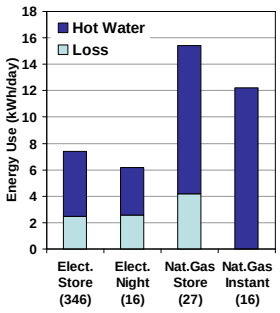
Use of Electric DHW



Source: HEEP

14

Domestic Hot Water



- **Total = Water + Standing Losses**
  - Social
  - Technical
- **Reduce standing losses:**
  - About 1/3 (range 27% - 42%)
  - Cylinder insulation
- **Reduce energy use:**
  - Changed behaviour bath to shower:
  - 1971/2: 74%; HEEP: 6% Bath
  - Reduce water use (shower head)
- **Does gas = more hot water?**
  - Graph is HEEP average
  - Electric low pressure, copper cylinder
  - Gas mains pressure, steel cylinder
  - Gas DHW = +20% water
  - Self select – inadequate electric HW?

Year 11

15

Search for NZ oldest cylinder

(Thanks to Radio NZ National, 'Sounds Historical')

Date	Type	Location	In use
1920s	Wetback	Stewart Island	☑
1930s	Electric dairy	Rahotu	☑
1934	Wetback	Taranaki	☑
1938	Electric storage	Christchurch	☑
1930s	Gas califont	Otaki	

- **Copper, low pressure cylinders**
  - LONG life (depend on water quality)
- **Modern mains pressure, steel cylinders**
  - Likely to have shorter life

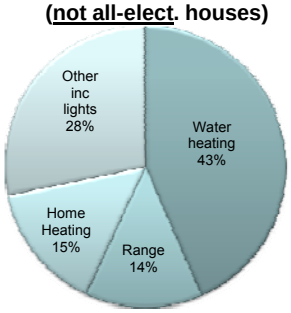
16

Electric People use many appliances

17

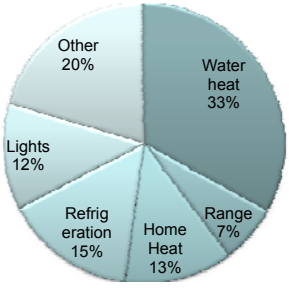
What was/is electricity used for?

1971/72 Electricity Study (not all-elect. houses)



Average per house = 8,400 kWh/yr
(Statistics NZ & NZ Electricity Dept)

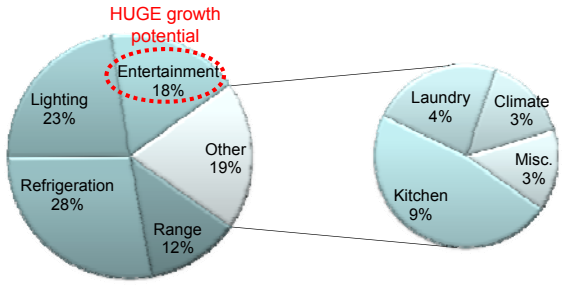
HEEP NZ Average 2004



Average per house = 7,750 kWh/yr
(HEEP Yr 10)

18

Non-heating Electricity



(~37% household energy, 460 W average)

Note: Excludes Domestic Hot Water & Space heating

Year 10 19

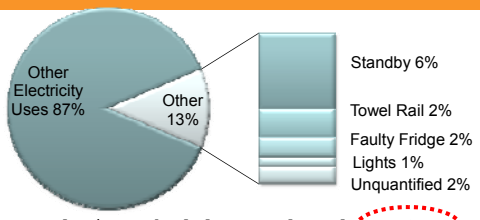
Entertainment

- **Includes TV, video, DVD, computers etc**
- **Lots of new types – e.g. DVD recorders**
- **Fast uptake of large LCD and Plasma**
- **Most appliances not covered by MEPS**
  - **M**inimum **E**nergy **P**erformance **S**tandard
- **Satellite decoders – HEEP raised issue in 2001**

  12 W per box x 2 per house x 1.4 million houses
  = new power station (~70 MW)
  (lowest 2 W ~ 10 MW)
  (highest 20 W ~ 110 MW)

20

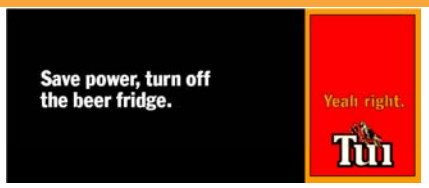
Standby Vampires & Baseload



- **Average (~ $150/yr) (13% elect.)** **112 W**
  - Standby – common appliances 57 W
  - Baseload – heated towel rails 21 W
  - Faulty refrigeration (~1 in 6) 15 W
- **NZ Electric heating** (8,670 hr yr) **105 W**

Year 10 21

Ultimate research outputs ?



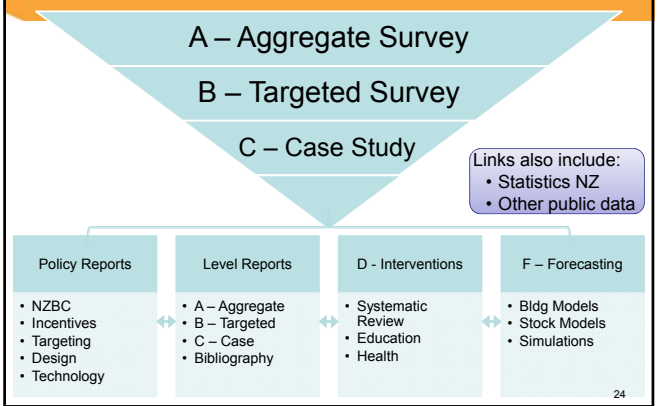
22

BEES Research Objectives

1. Quantify & characterise **non-residential** water & energy use;
2. Understand how water & energy is used today;
3. Improve the basis for policy development & implementation
4. Improve models of non-residential building energy use;
5. Guidance to create more productive work environments;
6. Reduction of GHG emissions & adaptation to climate change;
7. Design & operation guidance to reduce energy use & GHG;
8. Improve the development of NZBC, Standards & rating tools;
9. Make data & analysis publicly available & readily accessible;
10. Identify & prioritise greatest potential energy savings;
11. Co-ordinate with FRST, other NZ & international research; and
12. Make best possible use of the Participant & FRST funding

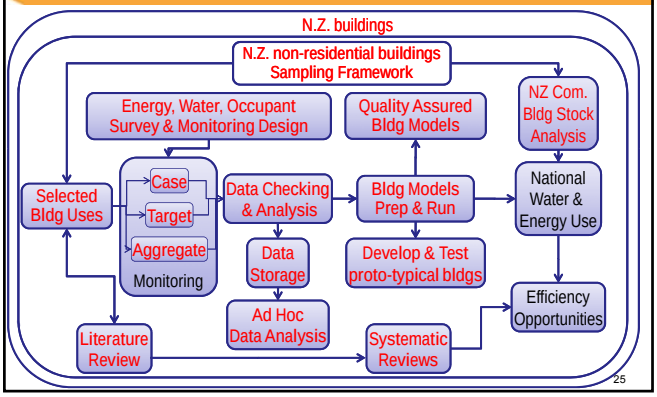
23

BEES Research Method



24

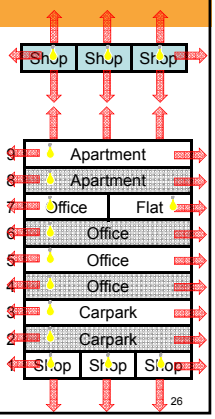
BEES Project Design



25

KEY ISSUE – Building Complexity

- **Simplest building**
  - Single use (e.g. shop)
  - 1 or more 'premises'
  - Single storey
  - Distributed energy
- **Complex building**
  - Multiple uses
    - e.g. shop, carpark, office, apartment
  - Multiple 'premises'
  - Multiple storeys
  - Distributed & central energy
    - e.g. tenant meter, central air conditioning
- **Need to deal with complexity**
  - 1 premise data = limited utility



26

Estimate – Height & Floor Area

Size Stratum (m²)	Building Count	No. Storeys	Area (10^6 m²)	% strata	% total
1 (0-649 m²)	24,868	1-2	7.4	99%	25%
		3+	0.1	1%	0%
2 (650-1,499 m²)	5,887	1-2	5.3	96%	18%
		3+	0.2	4%	1%
3 (1,500-3,499 m²)	2,300	1-2	4.4	85%	15%
		3+	0.8	15%	3%
4 (3,500-8,999 m²)	1,048	1-2	3.6	65%	12%
		3+	1.9	35%	6%
5 (9,000 + m²)	370	1-2	4.0	66%	14%
		3+	2.1	34%	7%

1-2 storeys = 83% of Total Floor Area

Web-search Preliminary estimate – subject to revision

Year 3

27

Estimate - Main Building Fabric

Main Building Fabric	Count	%
Brick	50	5.1
Concrete	676	68.8
Fibre Cement	42	4.3
Glass	23	2.3
Metal Profile	49	5.0
Other	2	0.2
Roughcast / Render	11	1.1
Stone	11	1.1
Timber	118	12.0
Total	**982**	**100.0**

Web-search Preliminary estimate – subject to revision
Based on floor area (m²) not count of building

Year 3

28

Estimate - Roof Composition

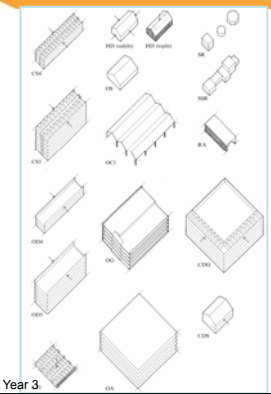
Roof Composition	Count	%
Flat Roof (non-trafficable)	101	10.1
Flat Roof (trafficable)	128	12.8
Metal Profile	687	68.6
Other	3	0.3
Glazed	3	0.3
Shingle Roof	13	1.3
Tiled	67	6.7
Total	**1,002**	**100.0**

Web-search Preliminary estimate – subject to revision
Based on floor area (m²) not count of building

Year 3

29

Built Form Classification



Built Form
CDO4: Sidelit Cellular strip, Open Plan 1-4 storeys
CDO5: Sidelit Cellular strip, Open Plan 5 storeys +
CS4: Sidelit cellular strip, 1 to 4 storeys
CS5: Sidelit cellular strip, 5 storeys or more
CT1: Toplit cellular, single-storey
HA: Artificially lit hall
HD: Daylit hall, either sidelit or toplit (or both)
OA : Artificially lit open-plan multi-storey space
OC1: Open-plan continuous single-storey space
OD4: Sidelit open-plan strip, 1 to 4 storeys
OD5: Sidelit open-plan strip, 5 storeys or more
OG: Open-plan car parking or trucking deck
OS: Open-plan space in a single shed
SR: Single-room form
SSR: String of single-room forms

16 basic typologies
Steadman, Bruhns, Holtier, et al. 2000

Year 3

30

Estimate - Built Form

Built Form [% floor area (m²) not count of building]	Count	%
Sidelit cellular strip, Open Plan Space 1-4 storeys	28	3
Sidelit cellular strip, Open Plan Space 5 storeys +	12	1
Sidelit cellular strip, 1 to 4 storeys	108	11
Sidelit cellular strip, 5 storeys or more	67	7
Toplit cellular, single-storey	1	0
Artificially lit hall	56	6
Daylit hall, either sidelit or toplit (or both)	20	2
Artificially lit open-plan multi-storey space	75	8
Open-plan continuous single-storey space	17	2
Sidelit open-plan strip, 1 to 4 storeys	254	26
Sidelit open-plan strip, 5 storeys or more	42	4
Open-plan car parking or trucking deck	8	1
Open-plan space in a single shed	134	14
Single-room form	62	6
String of single-room forms	86	9
Total	**970**	**100**

Year 3 31

Occupancy & Fuels - Preliminary

Duration of Occupation	Premises	% Premises
1 year or less	24	10%
2-6 years	107	43%
7-11 years	48	19%
12-16 years	29	12%
17-21 years	12	5%
22 years or more	27	11%
Total (14 missing)	**247**	**100%**

Energy Type	Premises	% of Premises
Reticulated electricity	260	99.6%
Natural gas	28	10.7%
Diesel or fuel oil	9	3.4%
Wood, waste or biomass	5	1.9%
Self-generated electricity	5	1.9%
Coal	1	0.4%

Year 3 32

Equipment - Preliminary

Equipment (261 premises)	Total Number	Mode	Mean	Median	Present in
Computers	3074	2	11.8	5	92%
Refrigerators/freezers	564	1	2.2	1	92%
Printers	812	1	3.1	2	85%
Microwaves	326	1	1.2	1	85%
Photocopier	383	1	1.5	1	71%
Computer server	315	1	1.2	1	69%
Stand-alone fax machine	259	0	1.0	1	52%
Water cooler	226	0	0.9	1	50%
Dishwasher	154	0	0.6	0	38%
Cooktop/oven	141	0	0.5	0	30%
Projector	128	0	0.5	0	29%
Electronic whiteboard	155	0	0.6	0	12%

Equipment for business and for staff

Year 3 33

Component B - Monitoring

- **50 buildings completed**
  - Internationally resourced equipment
  - Throughout NZ
  - 1-2-3 'businesses' or 'premises' in a building
- **Analysis underway**
  - Data cleaned & in database
  - Goal: Understand end-use(s) by building type(s)

Temperature & Humidity

CO_2

Electricity

Time lapse Photo (gas, water)

Year 3 34

HEEP Lessons for BEES

- **Just counting is not good enough**
  - no existing 'Census' for non-domestic buildings
  - no 'list' of non-domestic buildings
  - Number of appliances IS NOT = energy use
- **Expect wide variations:**
  - Occupants
  - Equipment
  - Activities, etc
- **Expect the unexpected**
  - Monitoring & survey everything!
  - e.g. poorly performing refrigerators
  - need good size sample to be certain

Year 3 35

Household Energy End-Use Project Buiding Energy End-use Study

- **HEEP & BEES – an experienced team**
  - BRANZ
  - CRESA
  - John Jowett, statistician
- **BEES – now joined by**
  - Energy Solutions Ltd
  - Centre for Building Performance Research, Victoria University of Wellington
  - Other sub-contractors & field staff
- **International Energy Agency 'Near Zero Energy Building'**
  - www.iea-shc.org/task40
- **Funders**

EECA | Research Science & Technology | Department of Building and Housing | BRANZ Funded by BRANZ from the Building Research Levy

36