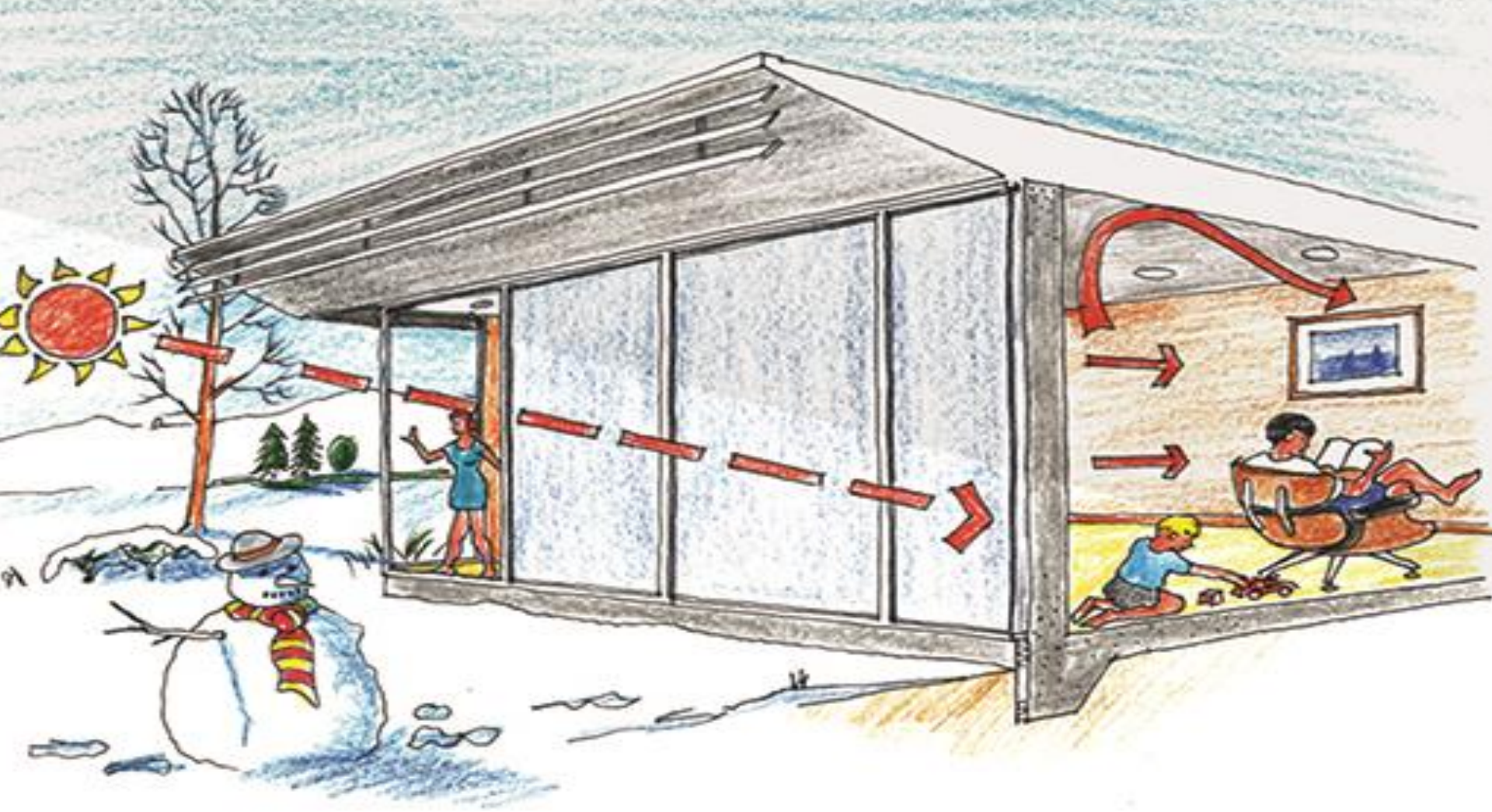

BUILDING ENERGY EFFICIENCY

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Focus of this talk

Challenge your thoughts on energy efficiency…

- People are more important than energy
- Consumers need to demand comfortable & healthy homes

Structure of the talk

- Overview of the performance of our building stock
- Key design/science topics behind comfortable & energy efficient homes

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About Me

- **Building Environmental Scientist**
- **Masters of Building Science from the Victoria University of Wellington**
- **Key Research Areas:**
  - Building Simulation
  - Building Information Modelling (BIM)
  - Whole Building Life Cycle Assessment (LCA)
- **Current Research Projects Include:**
  - The Quantifiable Evidence of Building Beyond Code
  - Development of a Best Practice Thermal/Energy Simulation Guide for Building Designers

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The Building Research Association of New Zealand (BRANZ)

Better Buildings Through Research-Driven Leadership

Our objective is to support industry through provision of robust analysis, modelling, forecasting, evidence and advice so we are building better for New Zealand.

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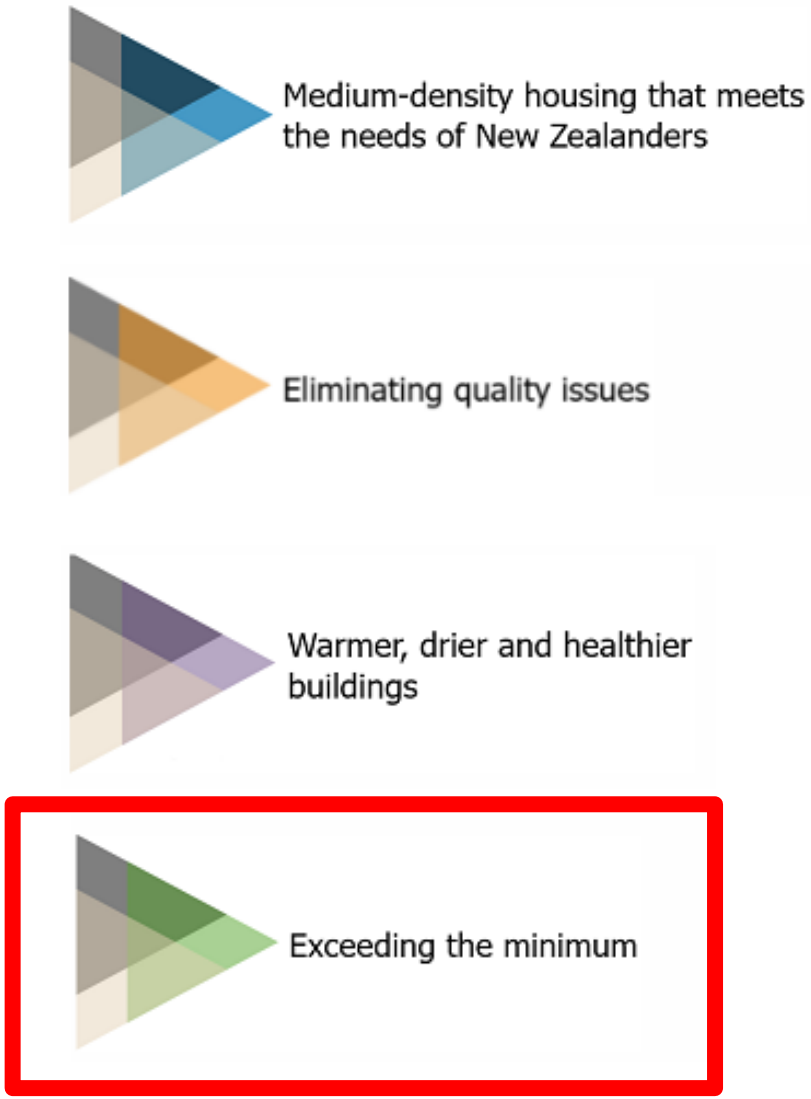
Current BRANZ Research



People Focus

- **The choice to exceed building code**
- **Who benefits from exceeding the minimum?**

Science Focus

- **The quantifiable evidence of building beyond code**

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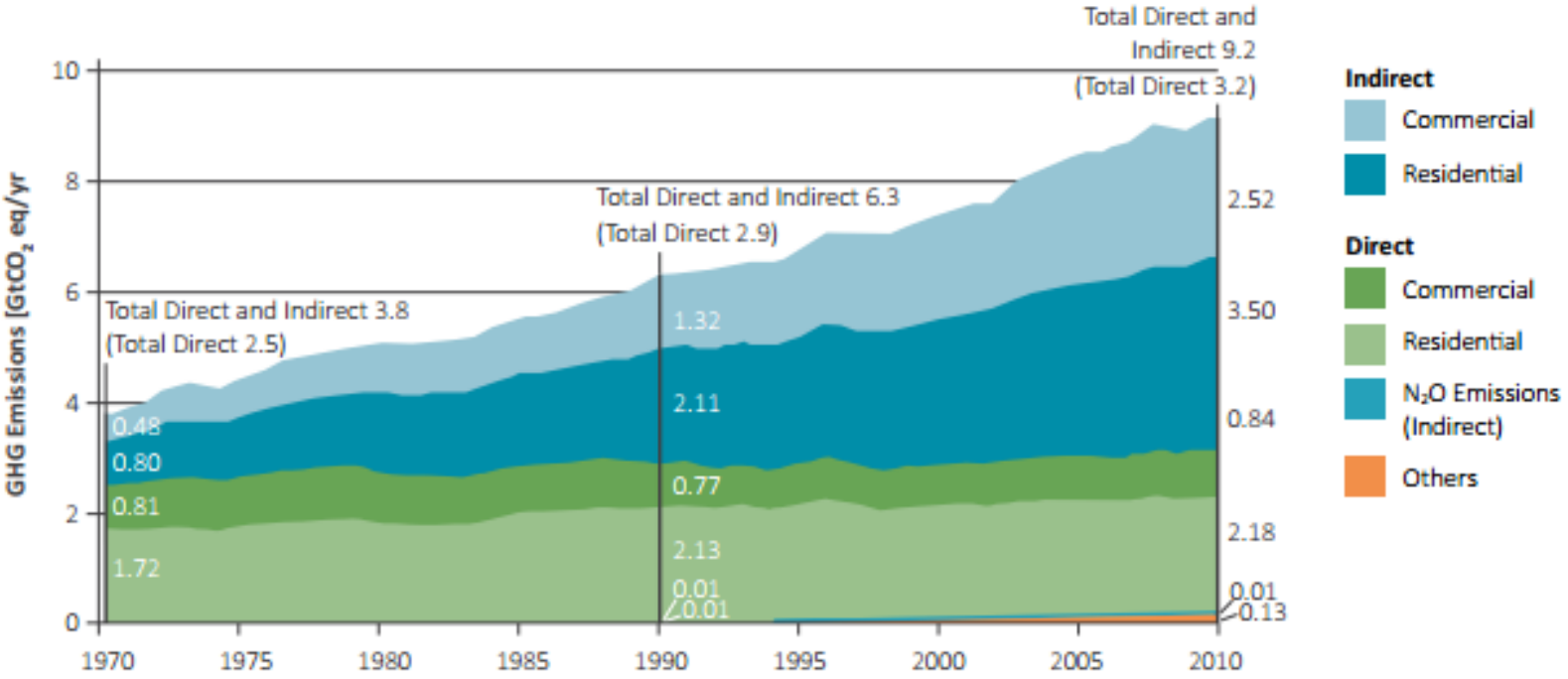
The Need For Building Energy Efficiency

- **Building sector is responsible for ~20% of NZ's energy-related Green House Gas emissions**
- **Majority of buildings that will be in existence in 2050 have already been built.**



Source: Transition to a low-carbon economy for New Zealand April 2016 The Royal Society of New Zealand

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How Energy Is Used In Buildings

Electricity End Uses

Commercial Office Buildings

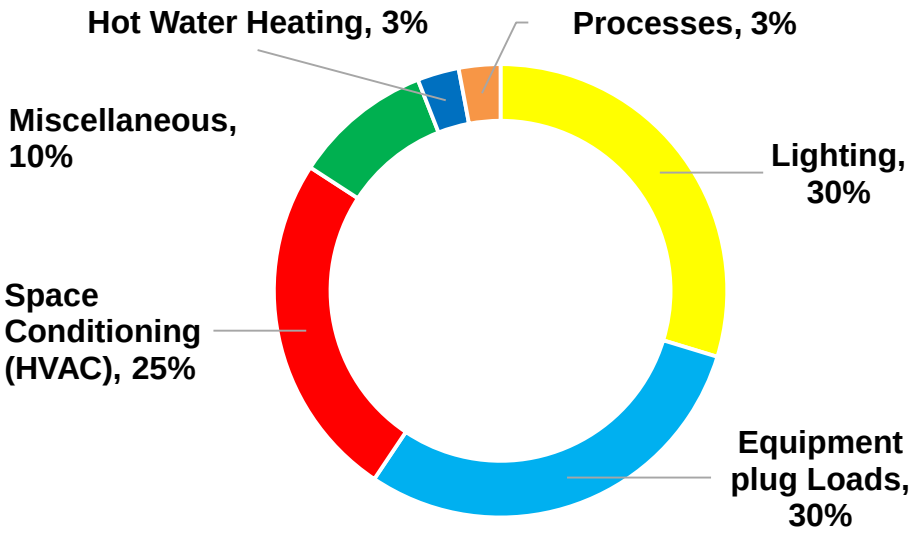

Figure 63 Page 51
Building Energy End-use Study (BEES) Part 1: Final Report (Building Energy End-use Study (BEES) No. BRANZ Study Report 297/1)

Residential Buildings

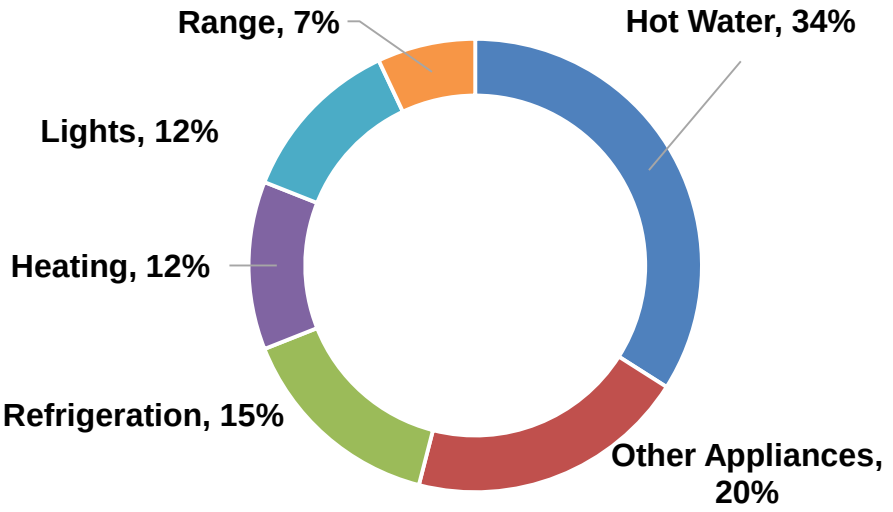

Figure 6 Page 9
Energy use in New Zealand households: final report on the household energy end-use project (HEEP)'. BRANZ Study Report 221. Building Research Association of NZ Ltd, Judgeford, New Zealand.

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An Energy Efficient Home Is…

Passive House Standards:

- Annual heating and cooling <15 kWh/m² per year
- Total energy consumption for heating, hot water and electricity <120 kWh/m² per year

HEEP House = NZ :

- Heating ~20kWh/m²

…But It Is Not Necessarily A Comfortable Or Healthy One

Room	Mean temperatures (°C) Morning	Day	Evening	Night
Living room	13.5	15.8	17.8	14.8
Bedroom	12.6	14.2	15.0	13.6
Ambient	7.8	12.0	9.4	7.6

Table 34
Energy use in New Zealand households: final report on the household energy end-use project (HEEP)'. BRANZ Study Report 221. Building Research Association of NZ Ltd, Judgeford, New Zealand.

Performance of New NZ Homes

Auckland House's Annual Space Heating Energy Use kWh/m²

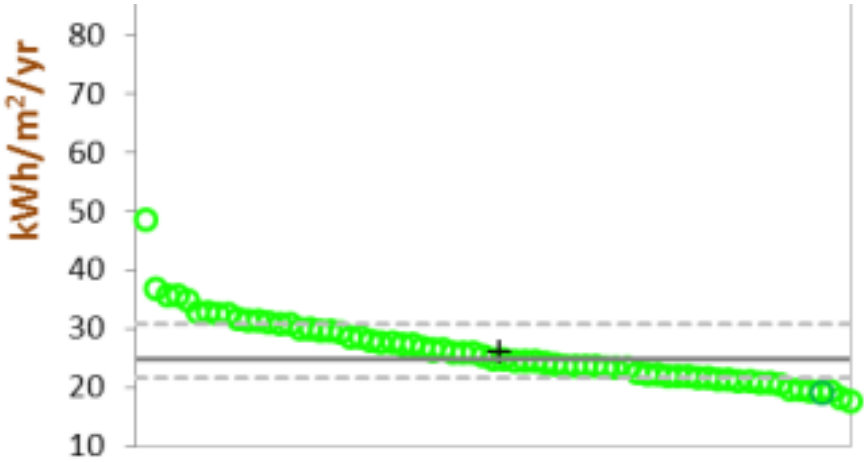

Figure 5 Page 17 BRANZ Study 2015 - Measuring our sustainability progress: Benchmarking New Zealand's new detached residential housing stock

Amount of Time per Year Living Room Spaces are within Comfortable temperatures (from 7am-11pm 18-25°C) with no mechanical heating/cooling

Location	NOW Home®		Random mean	
	hrs/yr	% of daytime	hrs/yr	% of daytime
Auckland	5652	97%	4877	84%
Hamilton	5299	91%	4099	70%
Christchurch	4419	76%	3248	56%

Table 10 Page 25 BRANZ Study 2015 - Measuring our sustainability progress: Benchmarking New Zealand's new detached residential housing stock

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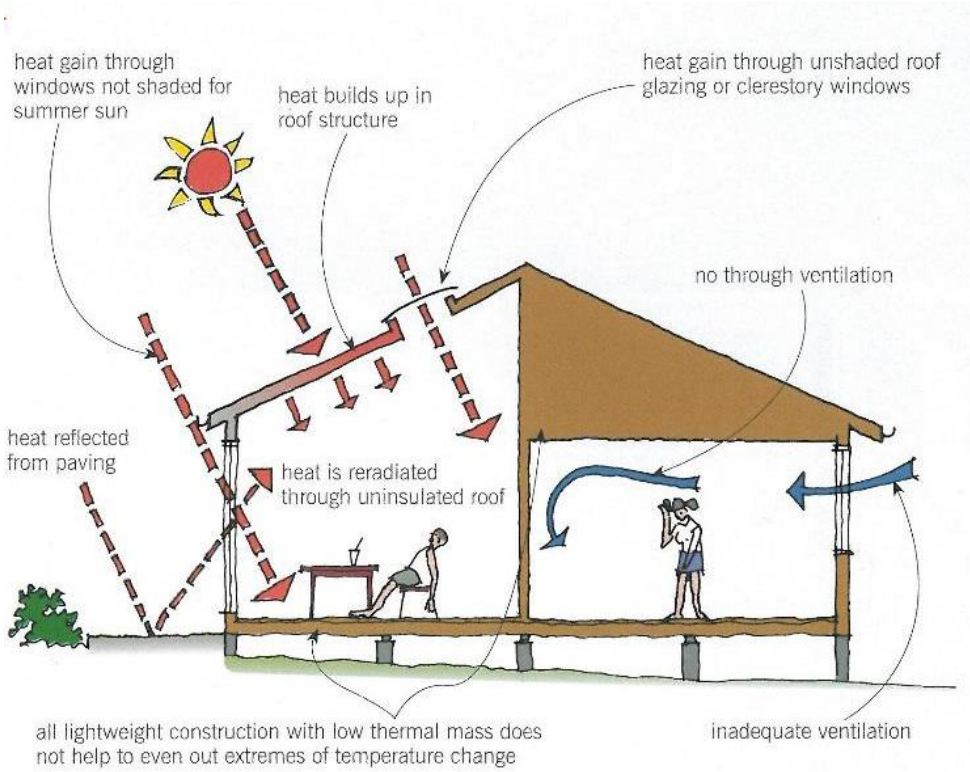
Future Performance of New NZ Homes

YEAR	OVERHEATING # hours/day for Summer Months
2012	1 hour 20 mins
2030	2 hours 9 mins
2080	4 hours 43 mins

Why Spaces Overheat?

- Lack of cross ventilation
- Lack of insulation
- No or poor location of summer north and west shading
- Too much unshaded glazing



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An Energy Efficient Home: Performance Criteria

Reticulated Energy Use

Climate Zone 1: Auckland

- New homes 5800 kWh/yr
- Existing homes: 6200 kWh/yr

Climate Zone 2: Wellington

- New homes 6300 kWh/yr
- Existing homes: 7300 kWh/yr

Climate Zone 3: South Island

- New homes 7300 kWh/yr
- Existing homes: 8400 kWh/yr

Indoor Environmental Quality

Average Temperature

- Living room 5-11pm >18˚C
- Bedroom 11pm – 7am >16˚C

Average Relative Humidity

- Living room 5-11pm in winter 40-70%
- Bedroom 11pm – 7am in winter 40-70%
- Surface relative humidity <80% year round

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Source:
http://www.beaconpathway.co.nz/further-research/article/hss_benchmarks

An Energy Efficient Home

The building code is a minimum standard…

…we can build better

New Zealand Building Code:

- **H1 Energy Efficiency**
  - Sets Minimum Insulation levels e.g. Thermal Resistance (R-value m^2 °C/W) for Auckland Climate:
    - Roof R2.9
    - Walls R1.9
    - Floor R1.3
    - Windows R0.26
- **E3 Internal Moisture**
- **G4 Ventilation**
  - Net Openable Window Area >= 5% of the Floor Area

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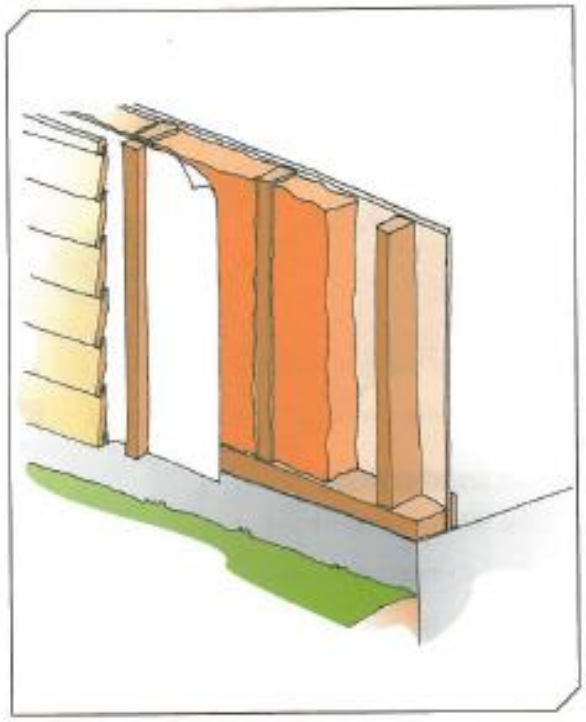
An Energy Efficient Home: Thermal Envelope

Thermal Resistance (R-values): A measure of resistance to the flow of heat. $m^2 \cdot °C/W$. **The higher the R-value the better.**

Construction R-value: The R-value of a typical area of a building element.



Framing timber	Insulation material R-value					
	1.8	2.0	2.2	2.4	2.6	2.8
	Construction R-value					
studs 600, dwangs 800 (14%)	1.9	2.0	2.1	2.2	2.3	2.4
studs 600, dwangs 600 (16%)	1.8	1.9	2.0	2.1	2.2	2.3
studs 400, dwangs 800 (18%)	1.8	1.9	2.0	2.1	2.2	2.2
studs 400, dwangs 600 (20%)	1.8	1.9	1.9	2.0	2.1	2.2
(22%) framing ratio	1.7	1.8	1.9	2.0	2.0	2.1
(24%) framing ratio	1.7	1.8[2]	1.9	1.9	2.0	2.0

Notes

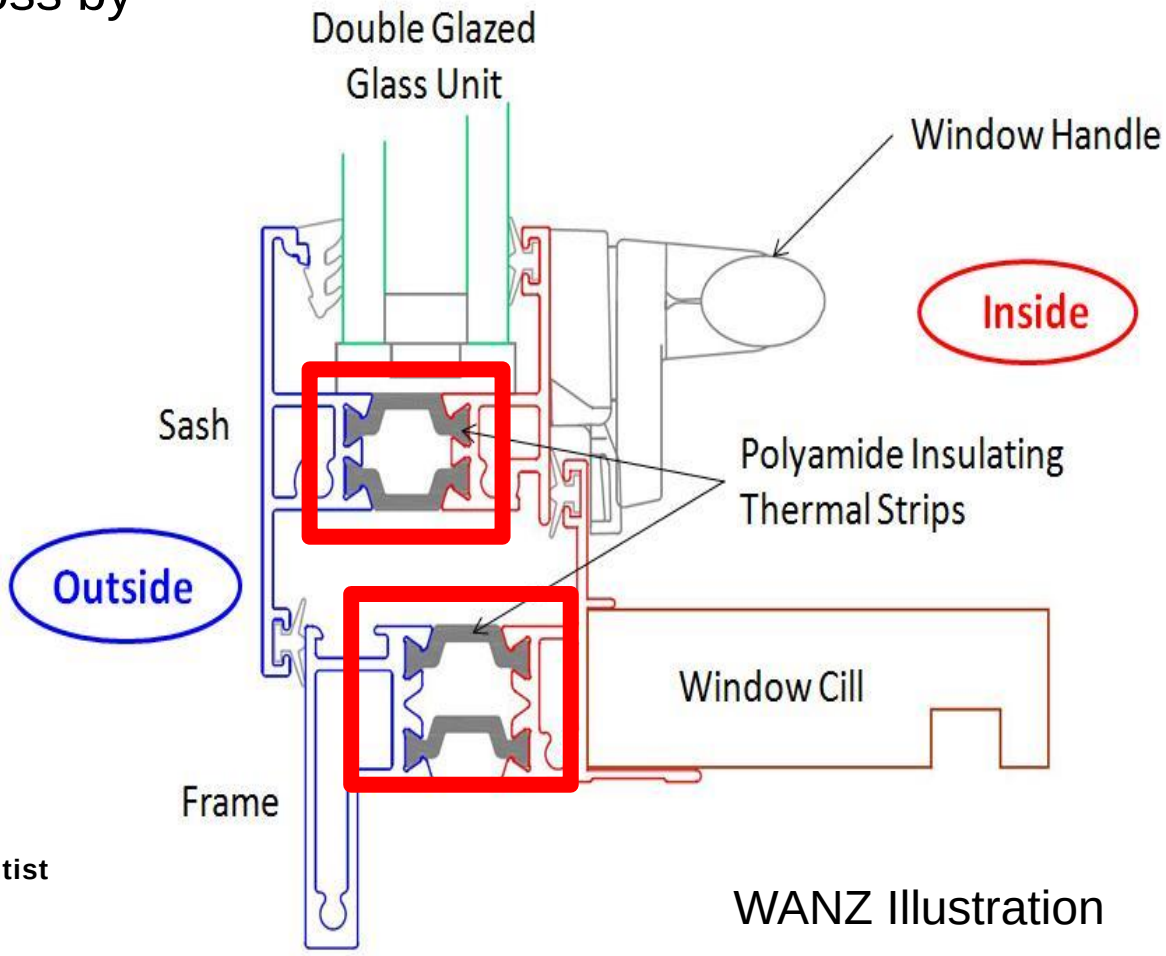
1. All insulants should be placed against wall underlay without pushing the underlay into the cavity
2. R3.0 is the highest practicable R-value of common insulation materials that can be used with 90 mm studs

An Energy Efficient Home: Thermal Envelope

BRANZ modelling shows:

Thermally broken aluminium window frames with Low E IGU's adds **~$4000** to a standard 'spec' house (at 20°C indoors) and reduces heat loss by

- 15-20% in Christchurch
- 22-30% in Wellington
- 27-36% in Auckland



WANZ Illustration

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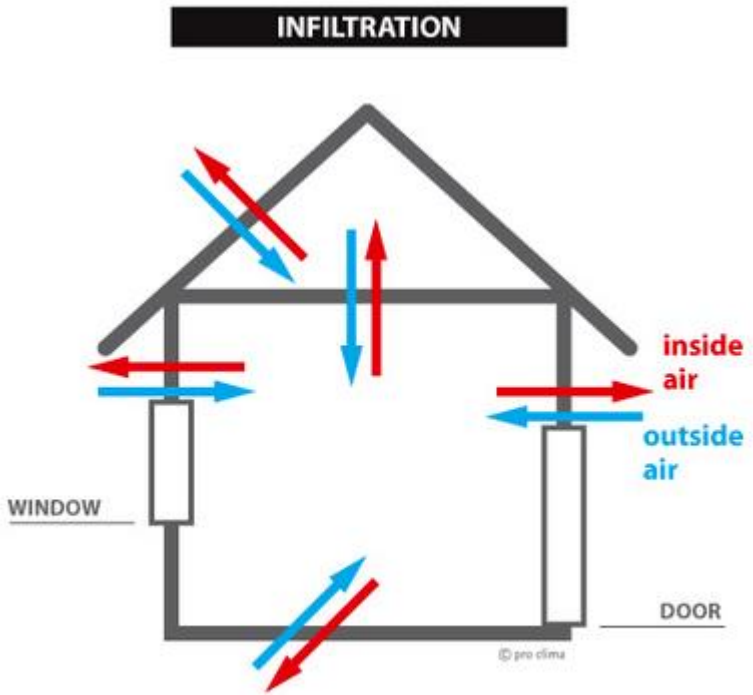
An Energy Efficient Home: Airtightness

Infiltration rates (air changes per hour) for various airtightness categories

- **Draughty** (pre-1960s house) = 0.9 ac/h
- **Leaky** (post-1960 house with some strip lining) = 0.7 ac/h
- **New Houses 0.1-0.5 ac/h**



Uncontrolled air movement through the building envelope.

Source: http://proclima.co.nz/air-movement-infiltration

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An Energy Efficient Home: Internal Moisture

Moisture Sources:

- 3 bedroom House 4 Occupants = **14L/day** (ASHRAE Standard 160-2009)

Moisture Sources by Activity (BRANZ, 2005):

- Dishes 1.0L/day
- Cooking Gas 3.0L/day
- Clothes Washing 0.5L/day
- Clothes Drying Unvented Drier 5.0L/load
- Showers/Baths 1.5L/day
- **People Breathing:**
  - Sleeping 7hrs 0.14L/person
  - Active 0.2L per hour per person

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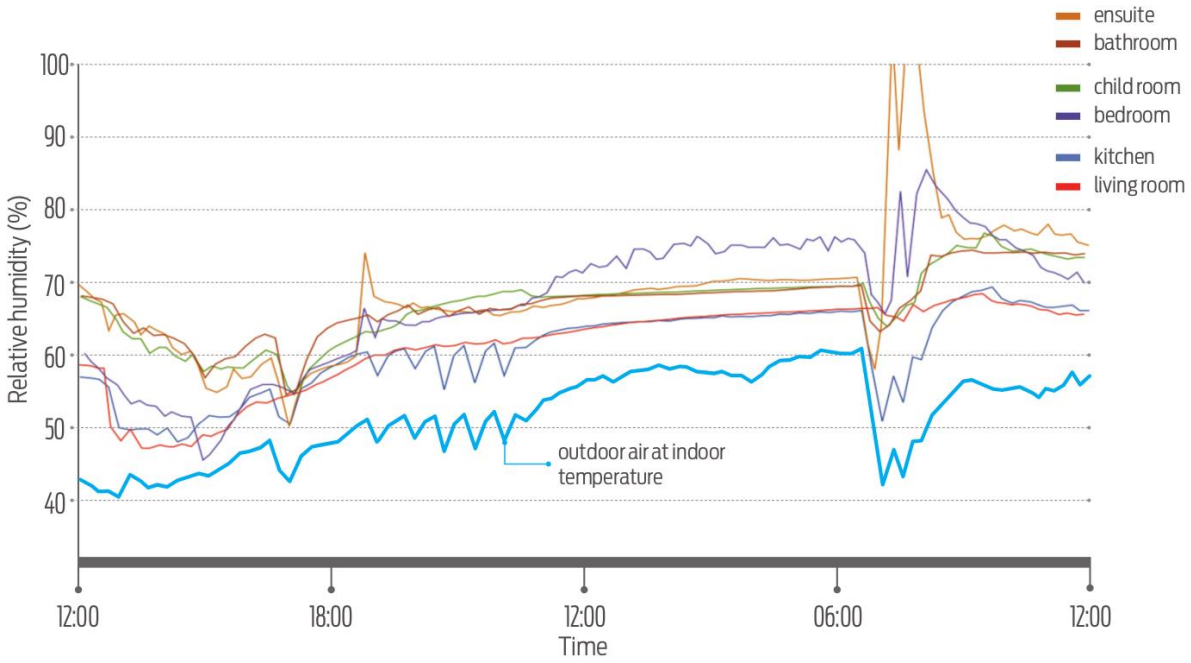
Table 4.3.2: ASHRAE Standard 160-2009 Criteria for Moisture-Control Design Analysis in Buildings

BRANZ Bulletin 460 2005

An Energy Efficient Home: Ventilation



How and when to ventilate to manage moisture levels?

- Heat the house
- Flush ventilation and achieve a near full air exchange of the house in about 10–15 minutes
- Morning is the best time

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BRANZ Build Magazine Issue 156 October 2016
New home, old habits

Tools for Building Energy Efficient Buildings

Design Tools

Whole Building Simulation

EnergyPlus - **FREE**

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Alf v3.2 — ALF 3.2: ANNUAL LOSS FACTOR

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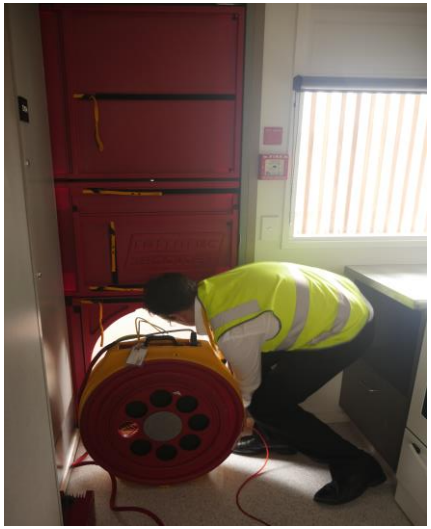
Actual Performance Tools

Post Occupancy Evaluation (POE) – Building Occupant Survey

Energy Auditing

Temperature & RH% Sensors

Blower Door Test – Air Tightness



Thermal Imagery

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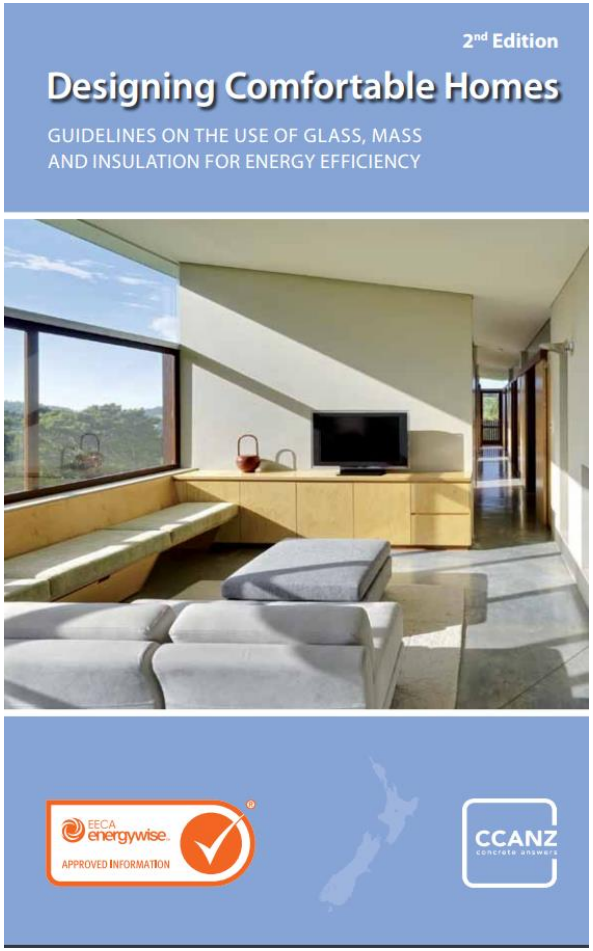

http://www.cominghometoconcrete.co.nz/portals/170/files/Designing_Comfortable_Homes.pdf

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The Take Home Message

Comfortable homes don't have to be just for grand designs

Beacon Pathway's NOW Home®
New Lynn 146m² ~$214,000 Build Cost (2008)

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Page 16 New Zealand Business Council for Sustainable Development. (2008). Better Performing Houses for New Zealanders: Making it Happen. Author, Wellington.