Retrofitting NZ houses for energy efficiency and comfort

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Funded by
FRST

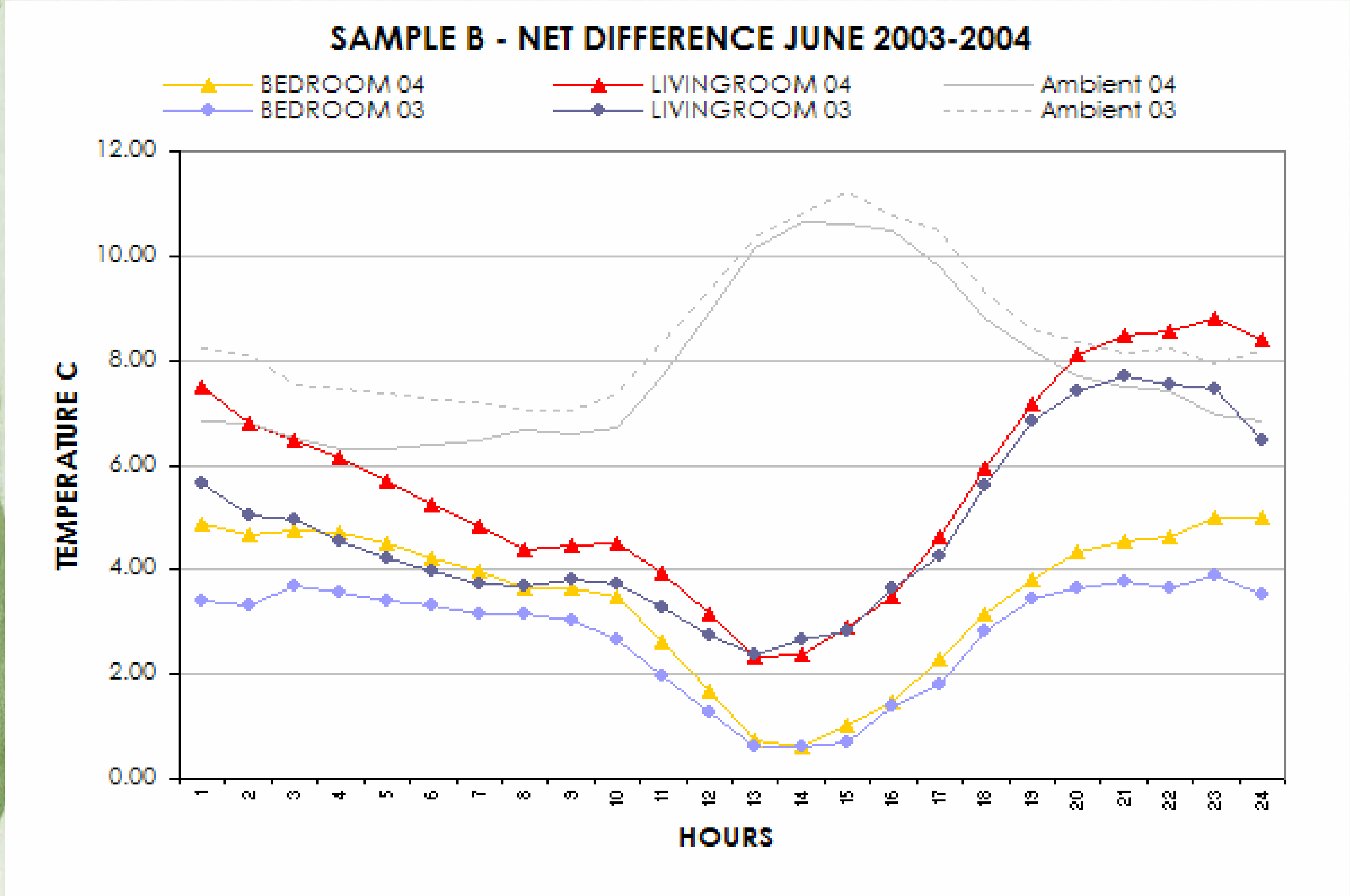
UNIVERSITY of OTAGO
SAPERE AUDE
Te Whare Wānanga o Otāgo

A research project by
the Energy Management Group
Physics Department - University of Otago
Dunedin

Process

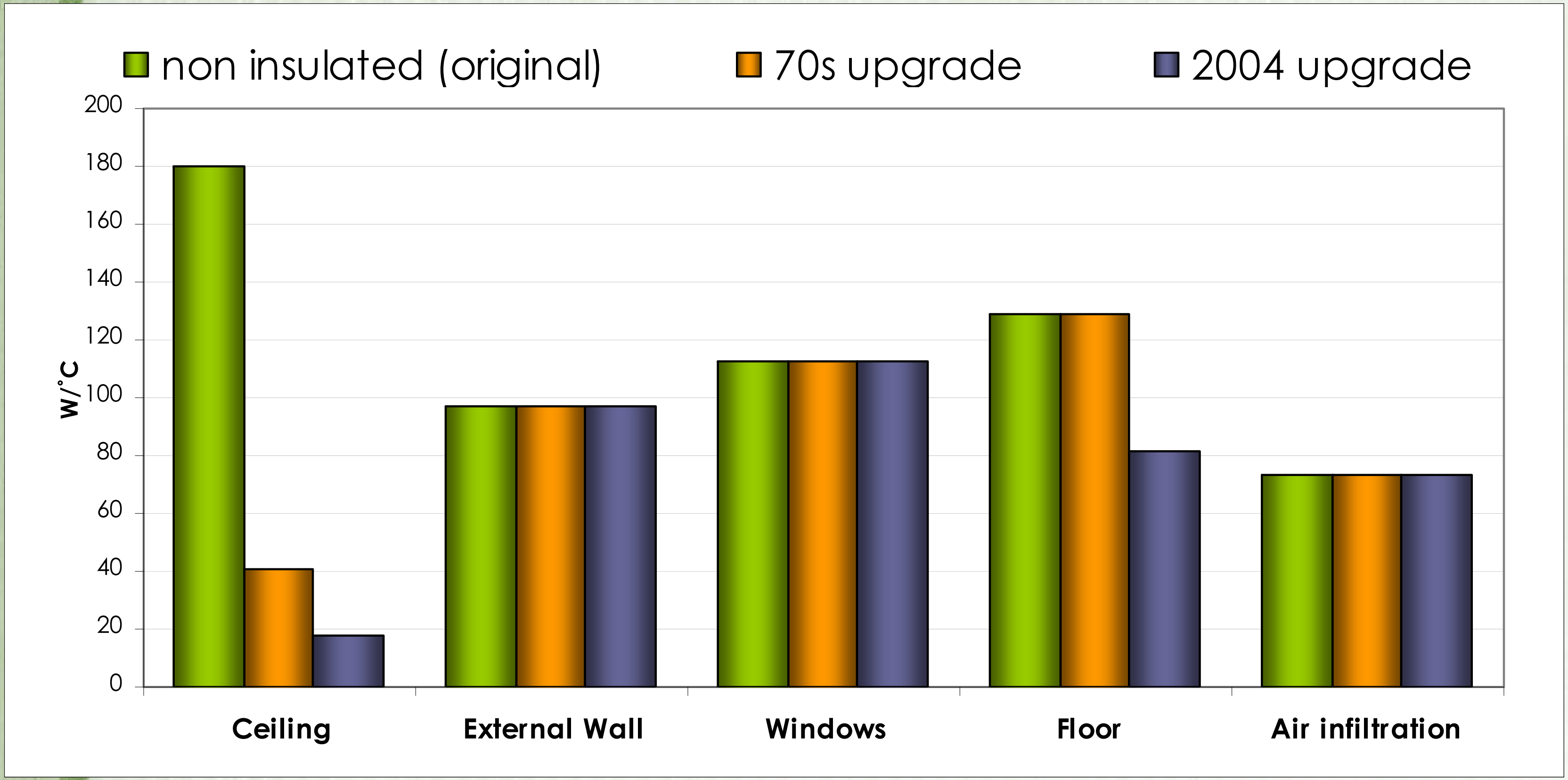
- **Objective**
  - To identify improvements in houses participating in the Energy Efficient Upgrade Programme in southern New Zealand regions.
- **Upgrade Programme**
  - Started in 2002 /Ongoing for 7 years
  - 400 pre 1978 houses per year in southland
  - Focus on the weatherization of the building envelope:
    - FLOOR and CEILING insulation
    - Draughts stopping
    - Insulating the hot water cylinders
  - All houses had been retrofitted with ceiling insulation during’70s (Macerated Paper)
- **Two Samples of 50 houses each were monitored over 2 years period while the programme was being implemented.**

Net Temp Differences - June



- **Higher net differences were achieved in living areas after heating was applied to this houses after upgraded**
- **5% improvement in the number of hours above 12°C in June**

Heat losses through the building envelope



- Small reduction in % Ceiling losses after last upgrade

Findings

- **Temperatures**
  - Low indoor temperatures predominated in winter… <12 °C for 48% of the time during winter
  - Minimum temperatures between 5 and 5.4 ° C (sample averages)
  - Some improvement was found in net temperature difference after heating is applied (0.4 °C whole year & 0.6 °C over winter months).

Findings

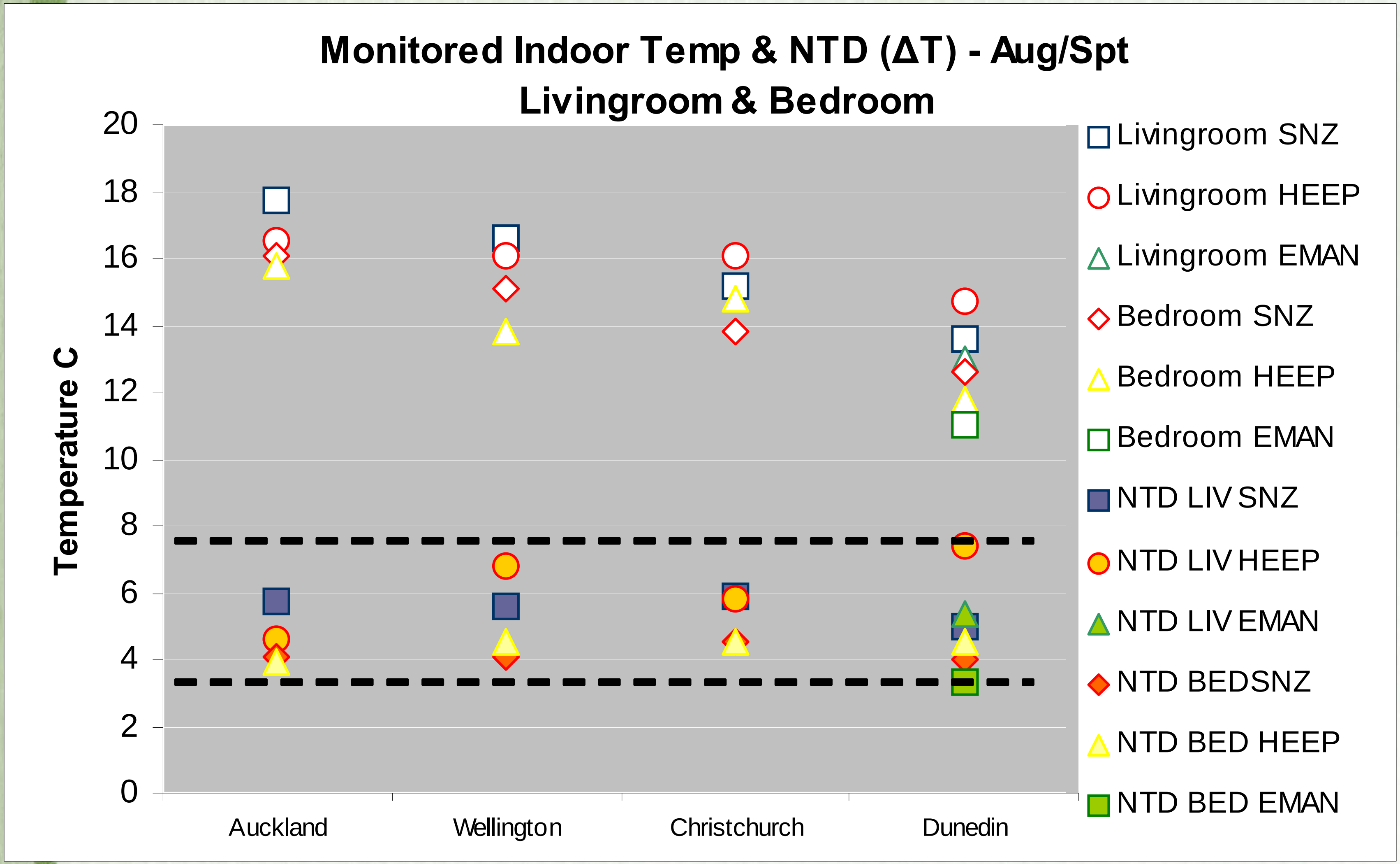
- **Energy Use for Space Heating**
  - Little energy was applied for space heating
  - The occupants tended not to heat the entire house
  - A small reduction in energy consumption was apparent after the upgrade (7%)
  - High losses occurred through uninsulated walls and single glazed windows

The HNZC upgrade programme in Dunedin failed to make houses sufficiently warm to satisfy WHO recommendations

Findings

- **Reasons were found to be:**
  - The impact of an earlier 70's retrofit did not seem to be taken into account
  - High losses occur through uninsulated walls and single glazing windows.
  - People don't heat enough

Results


Monitored Indoor Temp & NTD (ΔT) - Aug/Spt
Livingroom & Bedroom
Temperature C
20
18
16
14
12
10
8
6
4
2
0
Auckland
Wellington
Christchurch
Dunedin
Livingroom SNZ
Livingroom HEEP
Livingroom EMAN
Bedroom SNZ
Bedroom HEEP
Bedroom EMAN
NTD LIV SNZ
NTD LIV HEEP
NTD LIV EMAN
NTD BEDSNZ
NTD BED HEEP
NTD BED EMAN

Comparison of Stats NZ, BRANZ HEEP, Philippa's "Healthy HousesStudy"and our results

- **Standard upgrade packages give between 0.4 °C and 0.8 °C improvement in annual average temperatures**
- **Code compared to un-insulated gives around double this increase**
- **Net temperature differences are around 4 °C for bedrooms and 6 °C for living areas**
- **This means by the time you get to the South Island the times when indoor temperatures are lower than 16 °C are appreciable, lower than 18 °C often and lower than 20 °C mostly.**

Thus we need to go to the next step

- We “borrowed” 2 houses from HNZC.
- To further improve both houses, we have installed different insulation materials, available in the market, to insulate the building envelope.
- Houses were monitored to identify the increase in the thermal resistance of the building envelope at each stage.
- Houses located in Brockville

House 1

- Masonry veneer house:
  - concrete block
  - single glazed wooden frame
  - tiled roof
- Multi fuel burner in th living area
- **upgraded with the HNZC standard upgrade package**

Underfloor & Windows

- Aluminium foil was replaced by EPS

- Double glazed aluminum framed windows
- Drapes with pelmets


The Walls

- EPS & GIB on top of existing exterior walls.
- Window sill was done with new thickness required.



Whole house calorimetry

- **Specific thermal losses determined through the building envelope**
- **Houses were heated to achieve steady state then ΔT and P were recorded.**
- **Monitoring was done under the following conditions:**
  - Night time (no solar gains)
  - Unoccupied (no internal gains / no evaporative gains)
  - ACH was known using a “blower door” test
  - Energy input was monitored
  - Envelope area was known
  - ΔT was monitored

U & R values were found

Monitoring: The equipment

- Indoor temperature and RH was monitored by placing data loggers in each room.
- A local weather station was installed in the roof.
- Data collected was downloaded to computer.
- Electric heaters were used to rise indoor temperatures.
- Fans were installed to generate internal air movement.
- A Blower door test was used to quantify the amount of ACH after each test.

Results

Calculated lumped R value for house 1 (including infiltration)

• Uninsulated	0.40
• Standard package	0.66
• Our package	1.15

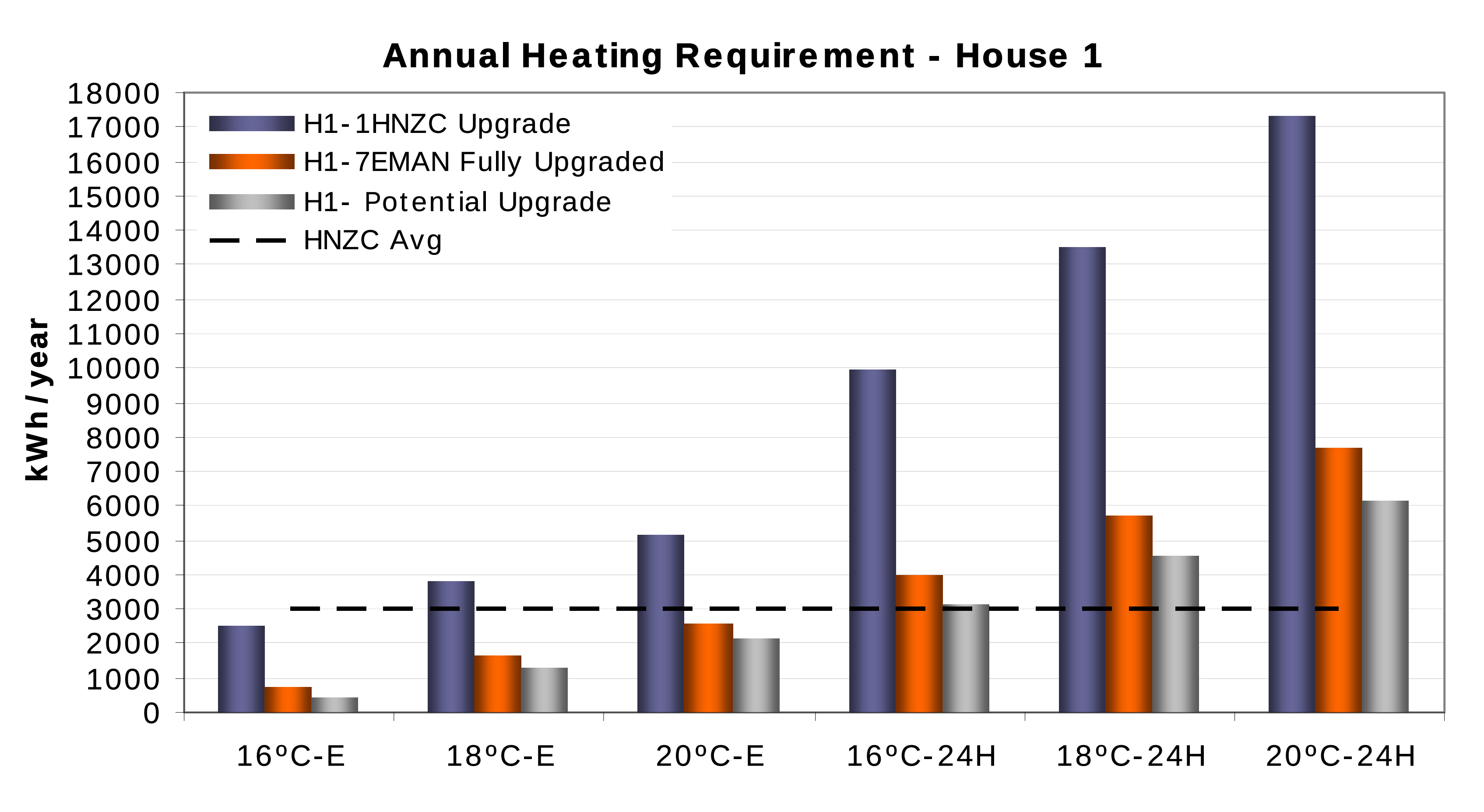
Measured lumped R value for house 1 improved from

• Uninsulated	Not known
• Standard package	0.67
• Our package	0.99

Regulation/Calculated 0.80

Cost of the upgrades came to around \$120 /m^2 of envelope area

What does this mean in terms of energy consumption ?



Acknowledgments

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- **BRANZ for support and advice**
- **BRYAN SMAIL for upgrading the houses**

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