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Achieving transition to sustainability: Lessons from human factors and ergonomics

Craig Brown and Professor Stephen Legg

Unsustainability results from human activity (is anthropogenic):

Transition to sustainability will require either the cessation, or preferably change, of human activity.

Behaviour change is hard to achieve for many reasons:

Norms, values, social comparisons, free-loaders, instincts, addictions, habits, needs, wants, abilities, limitations, desires, capabilities, capacities, personality, attitudes, skill, knowledge, trust, decision-making ability, use of heuristics, biases, conflict, community engagement, locus of control, coping, information processing/overload, attention, awareness, lack of salient/timely feedback, denial, conflicting goals, equity, risk perception, motivation, maintenance…

Many of the above reduce to *lack of 'fit'* between individual/group and wider system

Attempts to change individuals:

Tend to fail due to incongruence with system

Workers will perform unsafe acts if work culture, peers, management, incentives, etc. are not congruent with safety policy

System change required, not 'blame the worker'

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When trying to change an addict's behaviour, one prefers not to have the addict continue to associate with other addicts…

How about when the whole system promotes and normalises an addiction?

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anthropocentric design of sociotechnical systems

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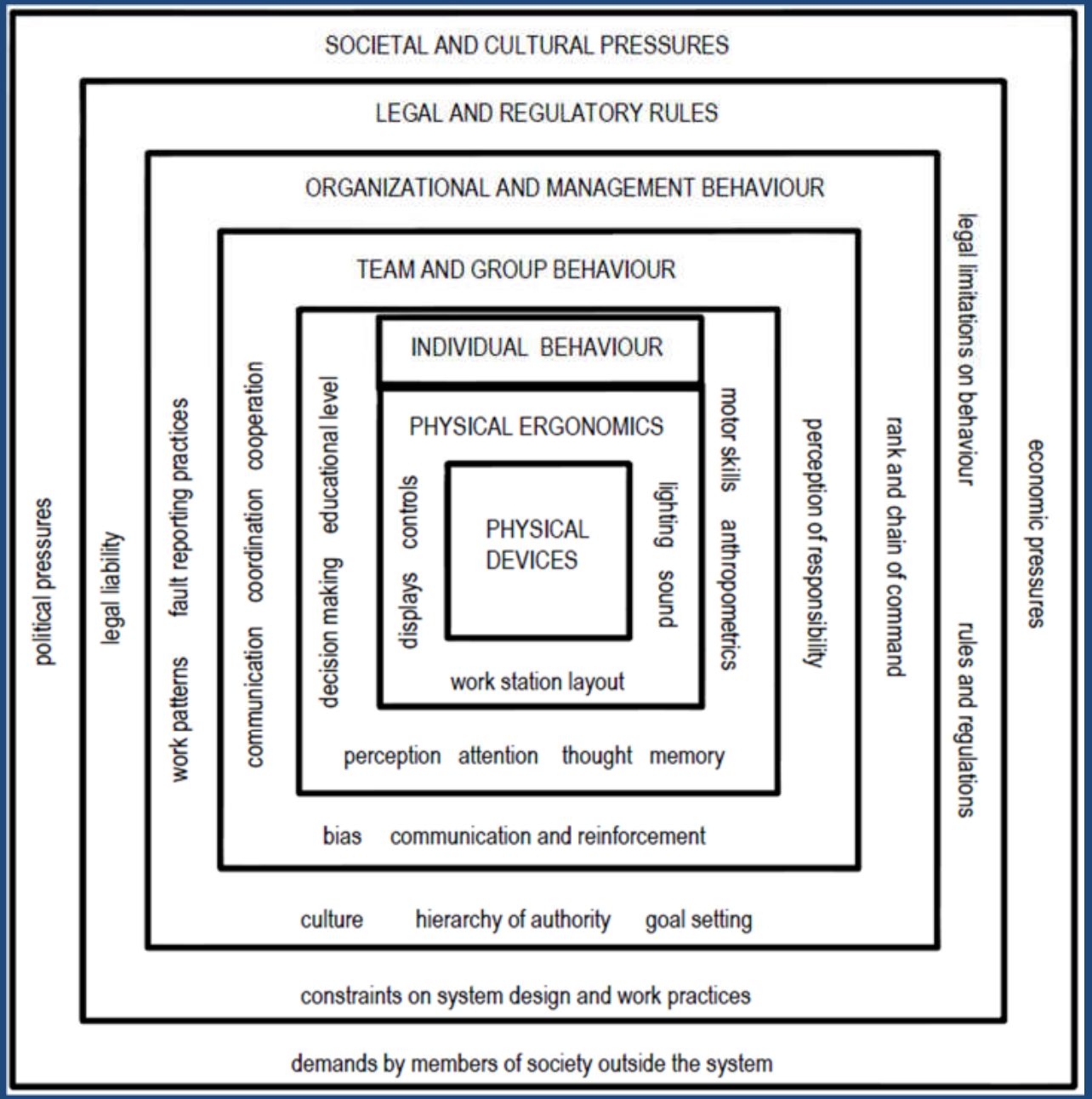
Ergonomics IS:

Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to **optimize human well-being and overall system performance**…

Organizational ergonomics is concerned with the optimization of sociotechnical systems, including their organizational structures, policies, and processes

(IEA Council, 2000)



anthropocentric design of sociotechnical systems

Ergonomics IS NOT:

- 'Ergonomic' products
- Sitting up straight
- Health and Safety

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Behaviour change: Encouraging people to put on an extra jumper and catch the bus

System change: Improving home insulation and heating systems and public transport options

HF/E: Contributes methods for analysis, design, implementation, evaluation, engagement…

…in the design of sociotechnical systems
…particularly in terms of the interface between the user and the wider system
…with due attention paid to people's abilities, needs, limitations, motivations, etc.

KEY POINT: Designing systems around users will improve system performance.
Quality of design for 'the human factor' is usually the limiting factor.

anthropocentric
design of
sociotechnical systems

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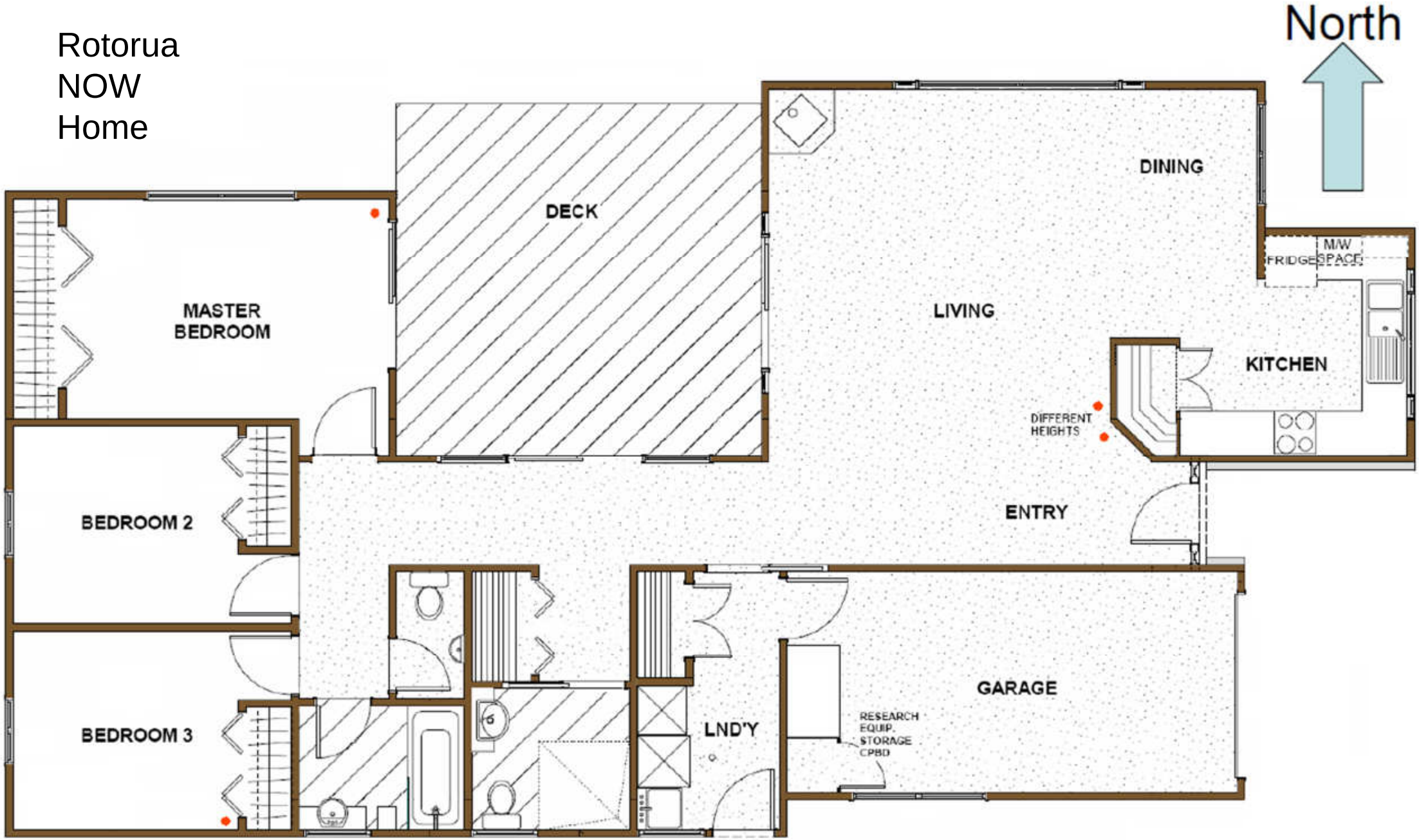
Case Studies

- Rotorua NOW Home
  - Lessons learned
  - cf. Waitakere NOW Home
- Self-Explaining Roads
  - Roads shouldn’t need an operating manual

Rotorua NOW Home

- Beacon Pathway initiative in conjunction with Housing New Zealand Corporation
- Second project to build a more sustainable house (in conventional form)
  - First project was Waitakere NOW Home
  - Project has developed to become Home*Smart* Homes
- Monitoring of heating/temp, water, IAQ…

Rotorua
NOW
Home



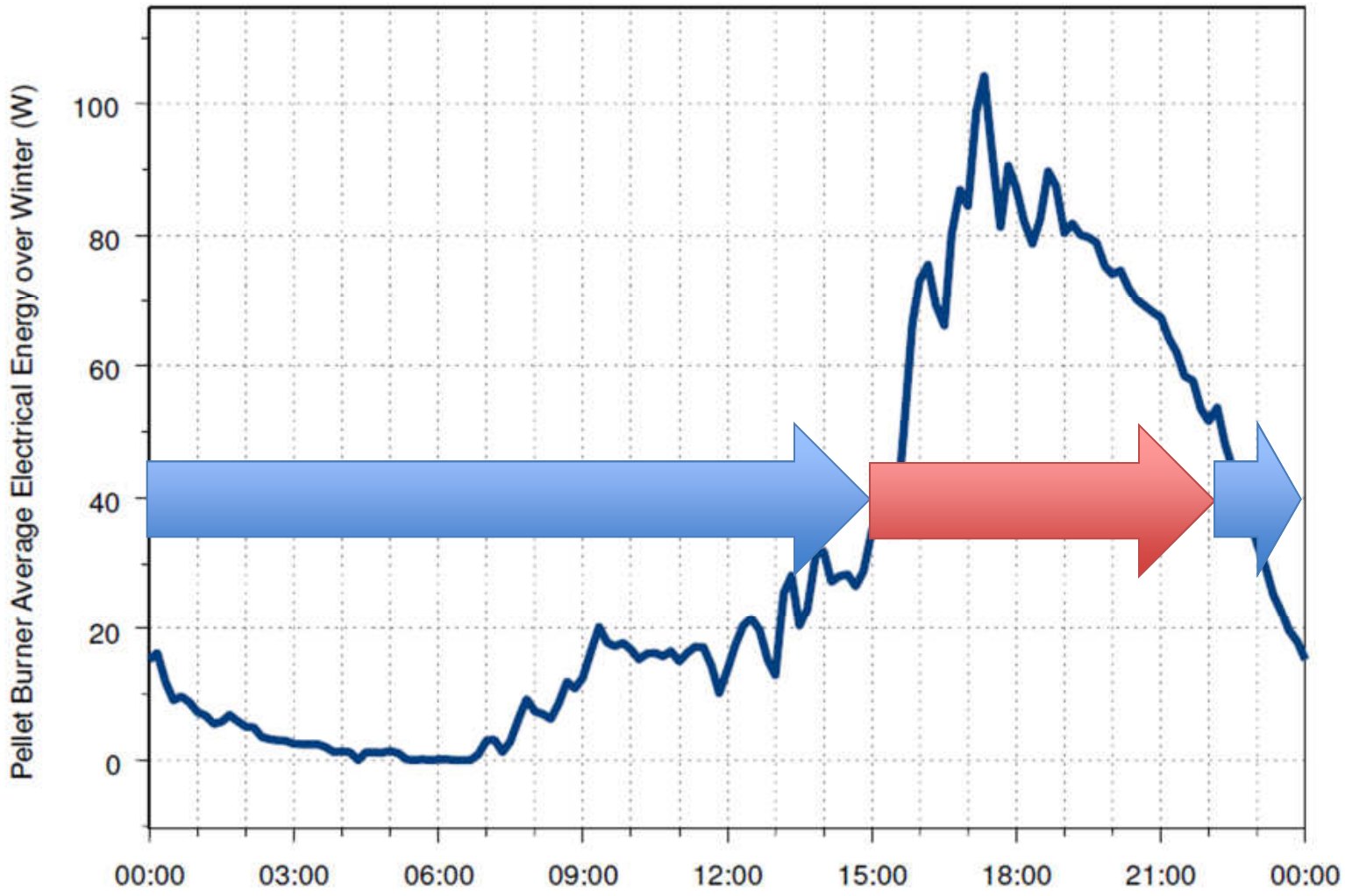
Solar water heater

- Performance
  - Achieved 36% of water heating needs
  - 42% of total electricity use was supplementary water heating

- Commentary
  - “The control unit for the SWH system was a basic thermostat inside the storage cylinder set to 60ºC.
  - There were **no timer controls** used within the system and **no system displays** used.
  - Controlling the cylinder therefore requires manually turning the element off from the fuse board.
  - Not unexpectedly, this does not appear to have happened.
  - Had the performance of the Rotorua NOW Home® SWH system achieved 50% of water heating needs, then an additional 600kWh of reticulated energy would have been saved.
  - This shows how important integrated system design (especially in terms of control design) is in a more involved setup such as SWH heating and how important the control feedback is in determining ongoing performance and costs”.

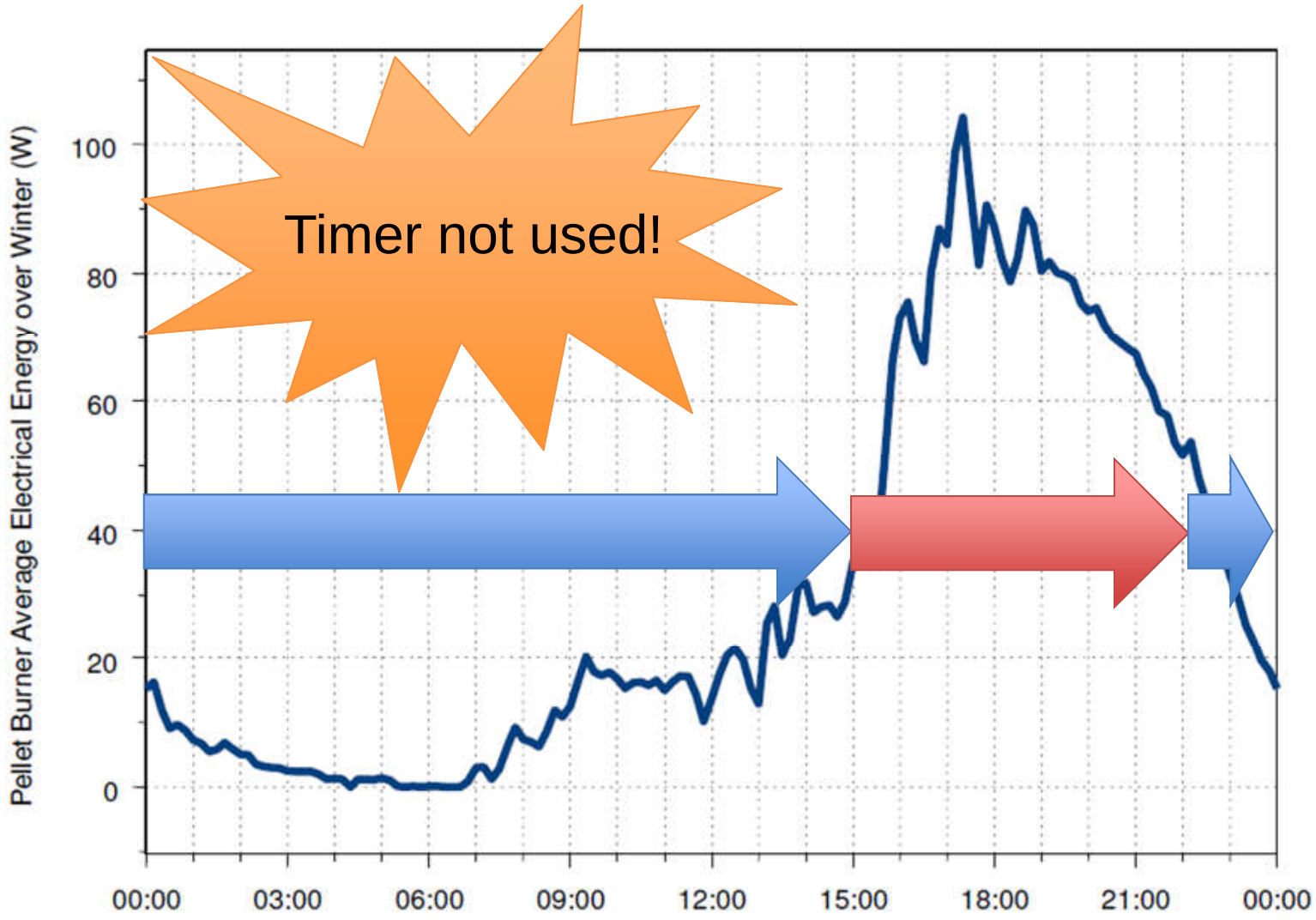
(Figures and text from final performance monitoring report)

Pellet burner use



NB Free fuel was supplied to tenants

Pellet burner use



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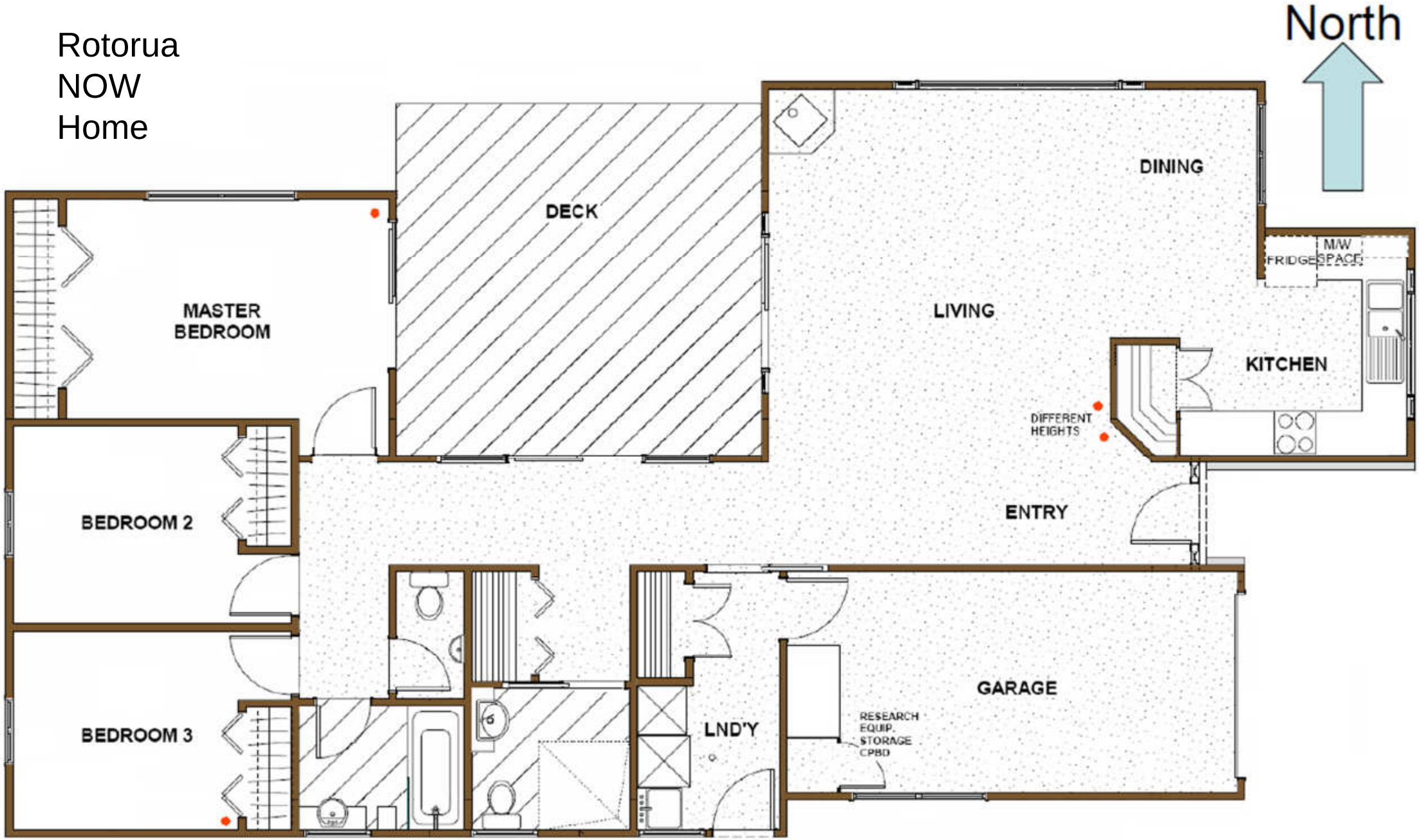
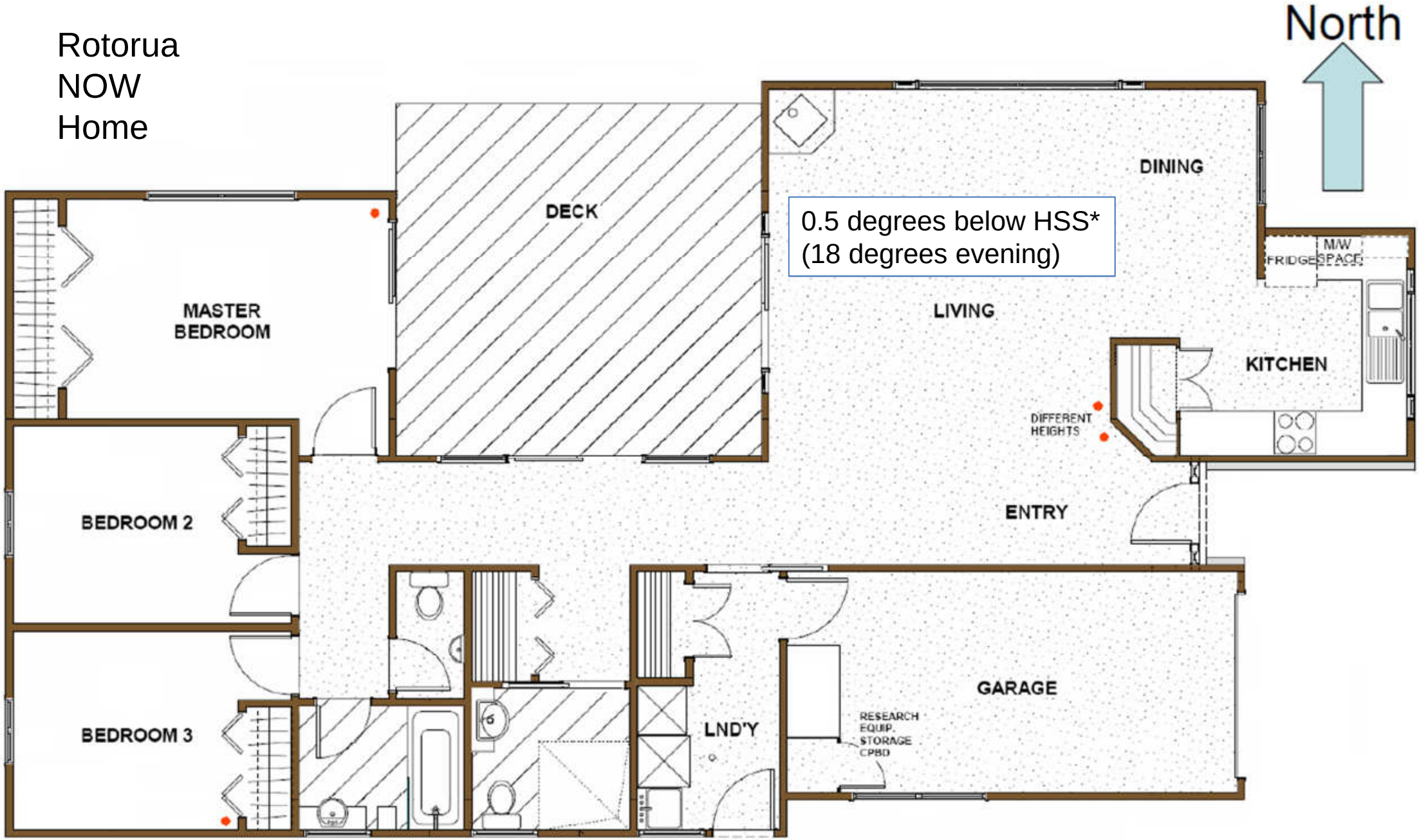
Rotorua
NOW
Home



• Temperature sensors

*HSS = “High Standard of Sustainability”

Rotorua
NOW
Home



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Rotorua
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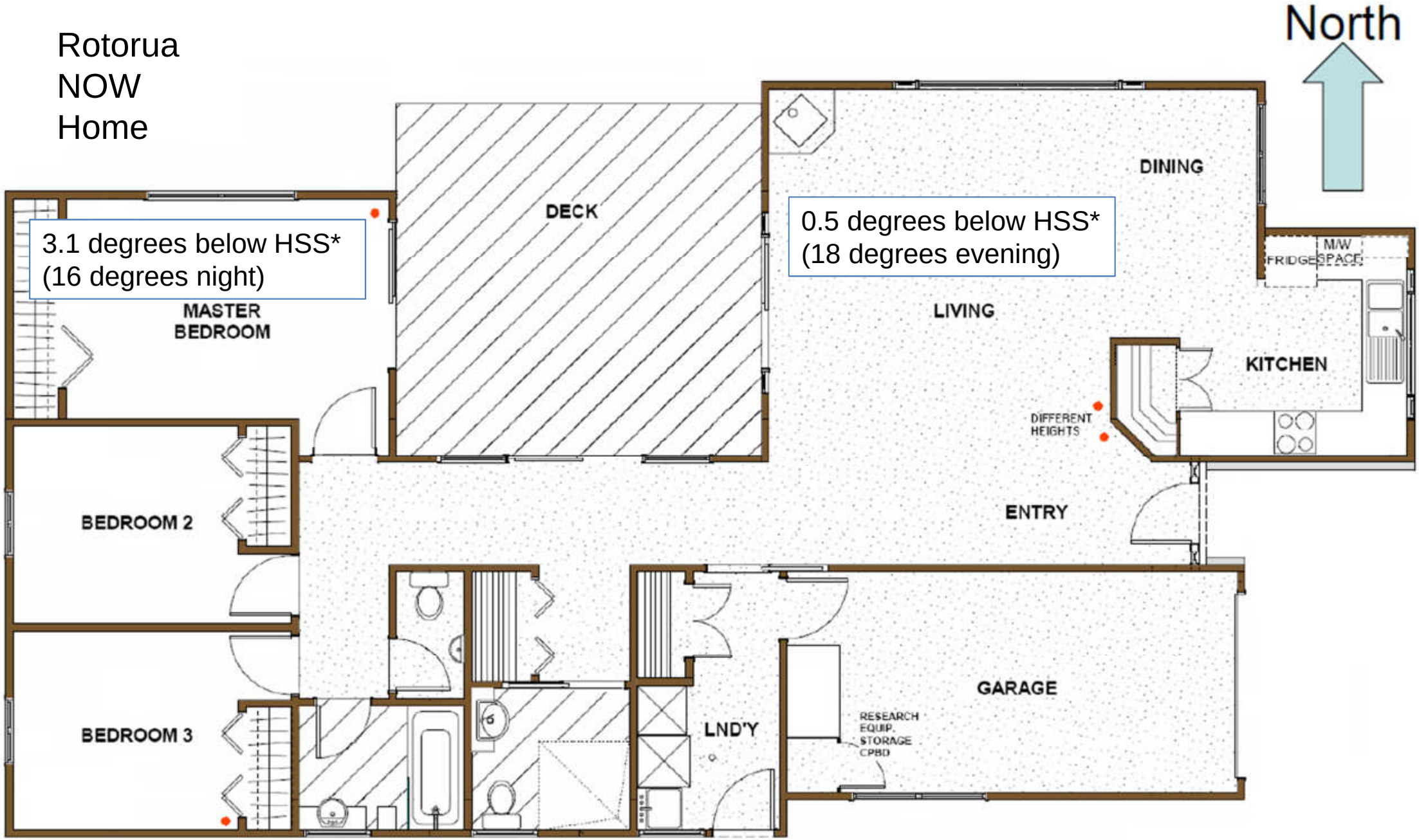

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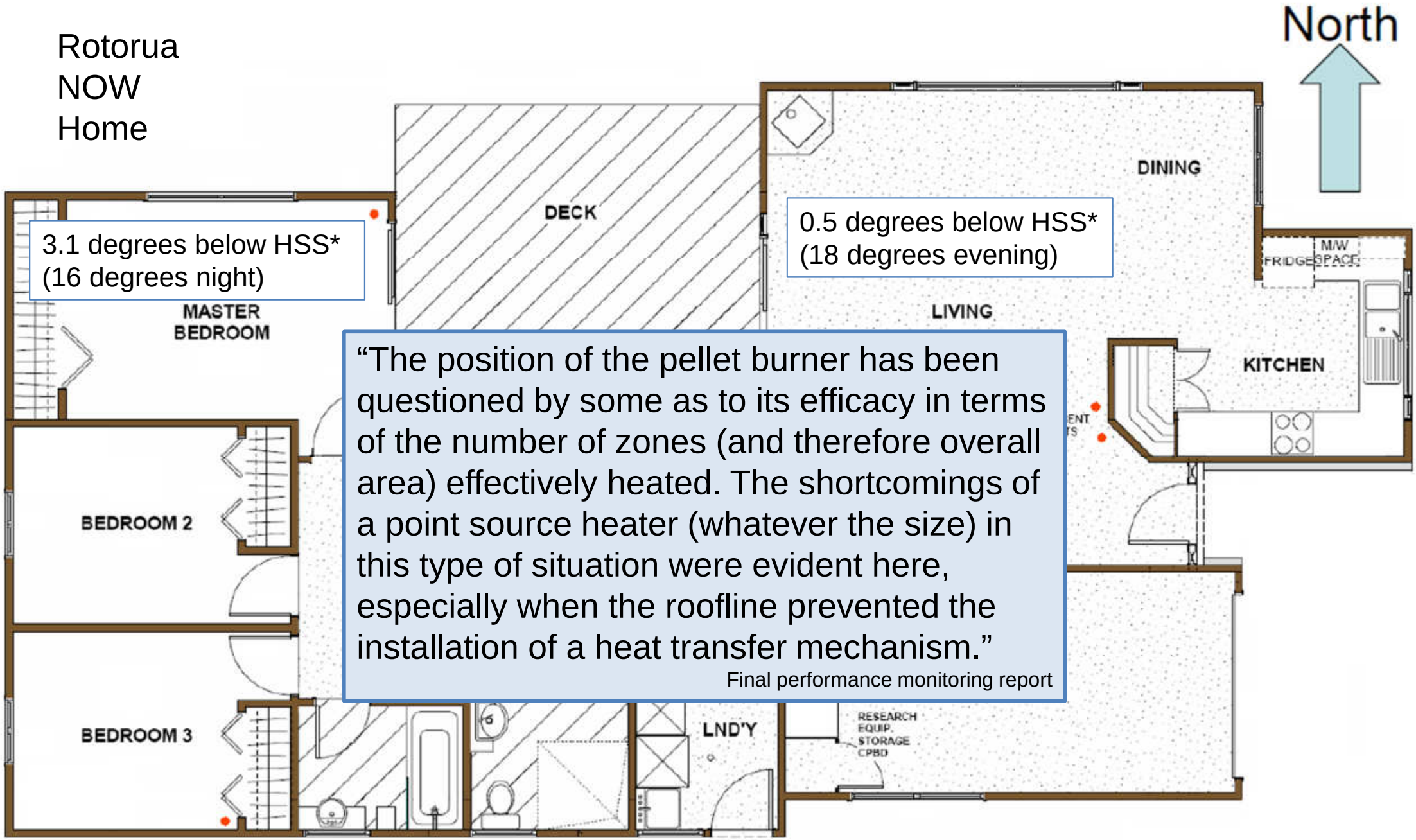


"The position of the pellet burner has been questioned by some as to its efficacy in terms of the number of zones (and therefore overall area) effectively heated. The shortcomings of a point source heater (whatever the size) in this type of situation were evident here, especially when the roofline prevented the installation of a heat transfer mechanism."

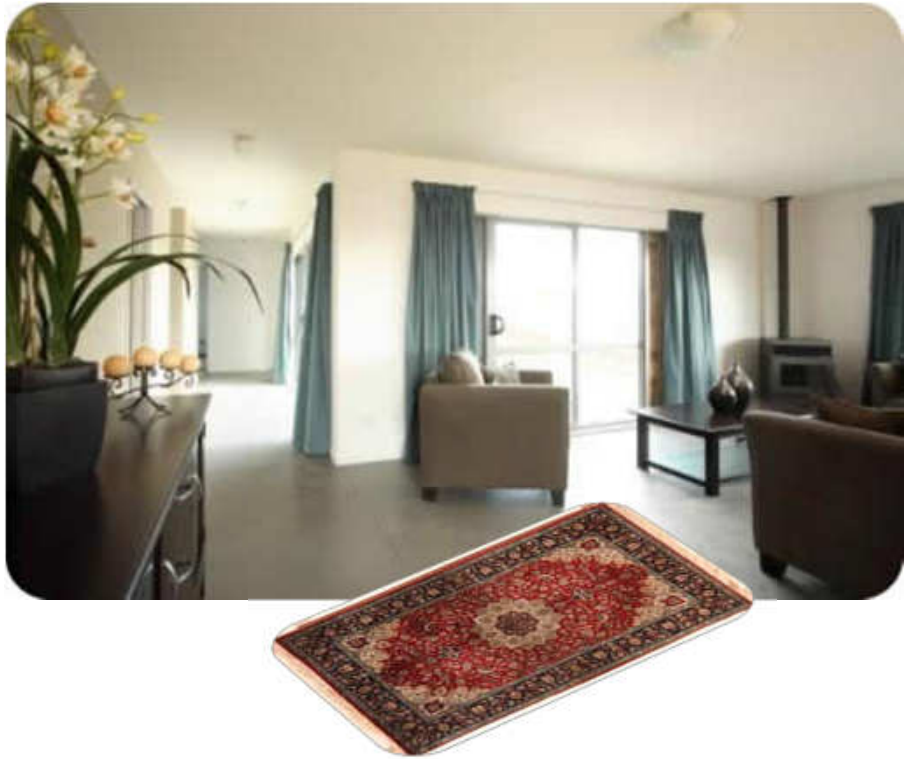
Final performance monitoring report

• Temperature sensors

*HSS = "High Standard of Sustainability"

Thermal mass

- "There was detailed design consideration to ensure the floor was well insulated and included an exposed concrete slab ground floor with a 40mm layer of polystyrene insulation beneath it. The floor included a foundation wall constructed from insulated concrete framework blocks."
- "However, the occupants did not like the exposed concrete floor (they were concerned about falls onto the hard surface and the perceived coldness of the surface) and placed rugs and mats over most of it thereby limiting its ability to moderate room temperatures."



- The ergonomist involved in the *Waitakere* NOW Home argued against the use of concrete floors for this reason (though budgetary constraints meant that they were used)

Michael Kohn (Slider Studio)…

comments on **Council House 2** topic in…

People in Buildings blog

As an architect I have designed some very clever buildings with complex Building Management systems automatically opening and closing windows to save energy. But **in practice the users preferred to open the windows themselves!**

So for me its not so much about the combination of kit and technology that one can integrate into a building as there will always be a fabulous array of technology out there - but **it's more the acceptance and operation of the building technology by end users that leads to real productivity gains and happy building users…**

The building end user is often the missing design team member that could take a valuable part in the collaborative design process.

Who turned out the lights?

- Tenants: too many lights on too few circuits

- Data: “The lights were also a high energy user in the first year using 800kWh or 12% of the total electricity use. The second year saw a large reduction in the lighting energy use with a 28% (230kWh) reduction resulting in a lighting use of 570kWh for the second year. It is unknown why this is the case.”

Physical construction issues

- Internal guttering
  - Leaked
- Ceiling insulation R4.0
  - Specified as R5.0
  - Still much higher than code
- Poor level of finish
  - Typical stuff: door handles falling off, patchy paint, extractor not connected
  - Polyurethane finish on floor scuffed quickly
- Solar hot water system installed at suboptimal angle
  - 30º roof angle plus frame
  - 38º ideal
- Low pressure water system combined with water restriction devices for high pressure
  - Very long time to fill jug
  - 2 litres per hour shower
  - "…noted by the occupants"
  - (but not by installers??)

Design/specification/project management issues

- Internal guttering
  - Prevented installation of heat transfer kit (was this specified in the design?)
  - Used to achieve ‘modern look’ (get away from existing state house appearance)
  - Preferred by one development partner, not by the other

- Solar water heater system
  - No timer on the supplementary heating element
  - Small collector area
  - High heat losses from having an externally mounted cylinder with relatively low levels of insulation
  - Inadequate controls and feedback
  - Fixed frame
  - Was this a specification issue (who chose it and on what basis)?

- Wrong insulation, wrong water restrictors, poor finish, wrong angle on SWH
  - Selection and oversight of builders (budget, tendering process, timeframe…?)

Other feedback from tenants

- Low perception of privacy and security
- Clothes line
  - Couldn't reach without a ladder
  - Unsafe to use with a ladder
  - Indicative of general level of thought given to usability?
- Lack of space
  - Maybe inefficient use of space?

- "Due to difficulties in contacting the occupants to arrange interviews, a decision was made to interview only the principal adult resident for the four quarterly surveys"
- "The primary occupant of the Rotorua NOW Home® was more circumspect than the occupants of the Waitakere NOW Home®, rating the house perfect or near perfect (9 or 10) in only four of the 35 categories, whereas the Waitakere NOW Home® residents gave these ratings to 19 of the 35 categories"

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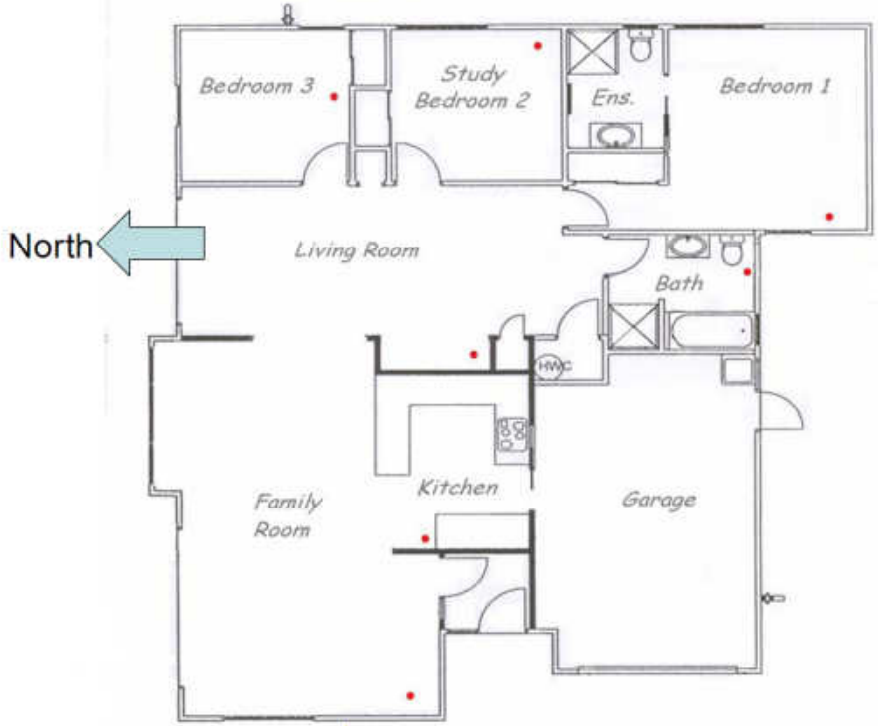
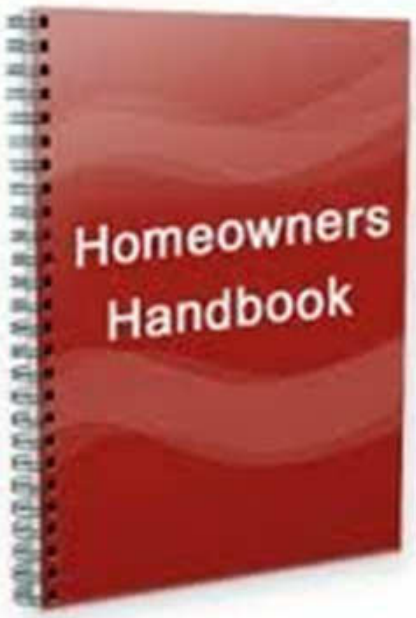


More from monitoring report

- Heating required every day over winter – and pellet burner even used a couple of days in December
- Plans to develop homeowner manual
  - Do people read manuals?
  - Should basic household systems need manuals?
  - What will happen over time/when tenants change?
  - Potential for errors and inefficiencies greater when unintuitive operating procedures required
- Design criteria and specifications being developed for future Home*Smart* Homes (what the NOW Home project has become)
- "The biggest issues seem to have arisen as a result of the more **complex design**, insufficient regard for the colder climate, **and occupancy behaviour**"
- "Additional design criteria and specifications are required to ensure these issues don't occur in future homes. These include, for example:
  - Alternative methods to achieve thermal mass
  - Better specification around heating and the need for heat transfer"
- And we need to interview *all* the occupants about the specific behaviours identified
  - Change in lighting use – why? What is wrong with the lighting provided? What would be better?
  - Why was the heater not used overnight or the timer set to come on in afternoon before return from school/work?
  - Floor coverings
  - (Would some be cold and others hot? Would some be in charge of heating and others not?)



Lighting

Space heating

Water heating

Wrong insulation

Position of clothes line

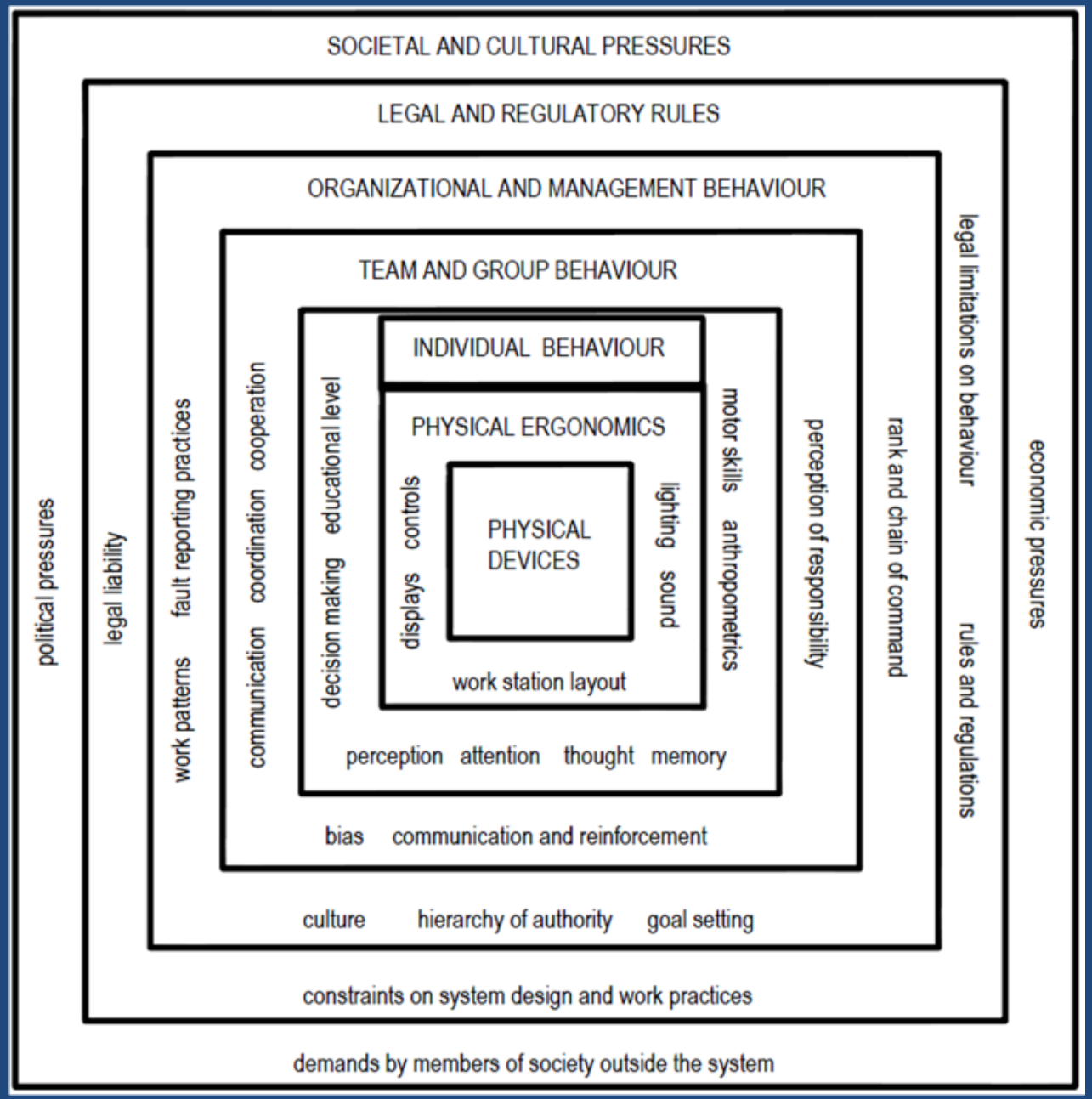
Lack of space / layout

Privacy/security

Flooring

Comfort

Individual differences



Roof design

Water pressure

Build quality

Positioning (clothes line, SWH)

Monitoring of construction

Feedback

Contractual issues

Accounting for users in design

anthropocentric design of sociotechnical systems

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The Ergonomist and the Eco House: the experimental application of a Collective Design Process for residential construction

Design Team members

COHFE
Centre for Human Factors and Ergonomics

CDP strengths

- Overall system performance becomes the focus instead of the building alone
- Integration between built space, technical systems and the organisation of tasks .. more naturally achieved

(Granath, 2001)

Ergonomist - functions in NowHome

1. Initial project scoping and planning
2. Site selection
3. Brief template design
4. Research and performance specification development
5. Wrote system descriptions for all elements
6. Iterative design draughting and testing against the performance specifications in the brief

Slides from NZ Ergonomics Society presentation by Dave Moore (2007)

Case Studies

- Rotorua NOW Home
  - Lessons learned
  - cf. Waitakere NOW Home
- Self-Explaining Roads
  - Roads shouldn’t need an operating manual

Non Self-Explaining Roads

Non Self-Explaining Roads

Self-Explaining Roads

Self-Explaining Roads

Charlton, Mackie, Bass, Hay, Menezes & Dixon (2010) Using endemic road features to create self-explaining roads and reduce vehicle speeds. *Accident Analysis and Prevention* (42) 1989-1998.

Pre-treatment

Local roads

Collector roads

Post-treatment

Local roads

Collector roads

Benefits are

increased rates of cycling and walking and slower vehicle speeds

Which lead to

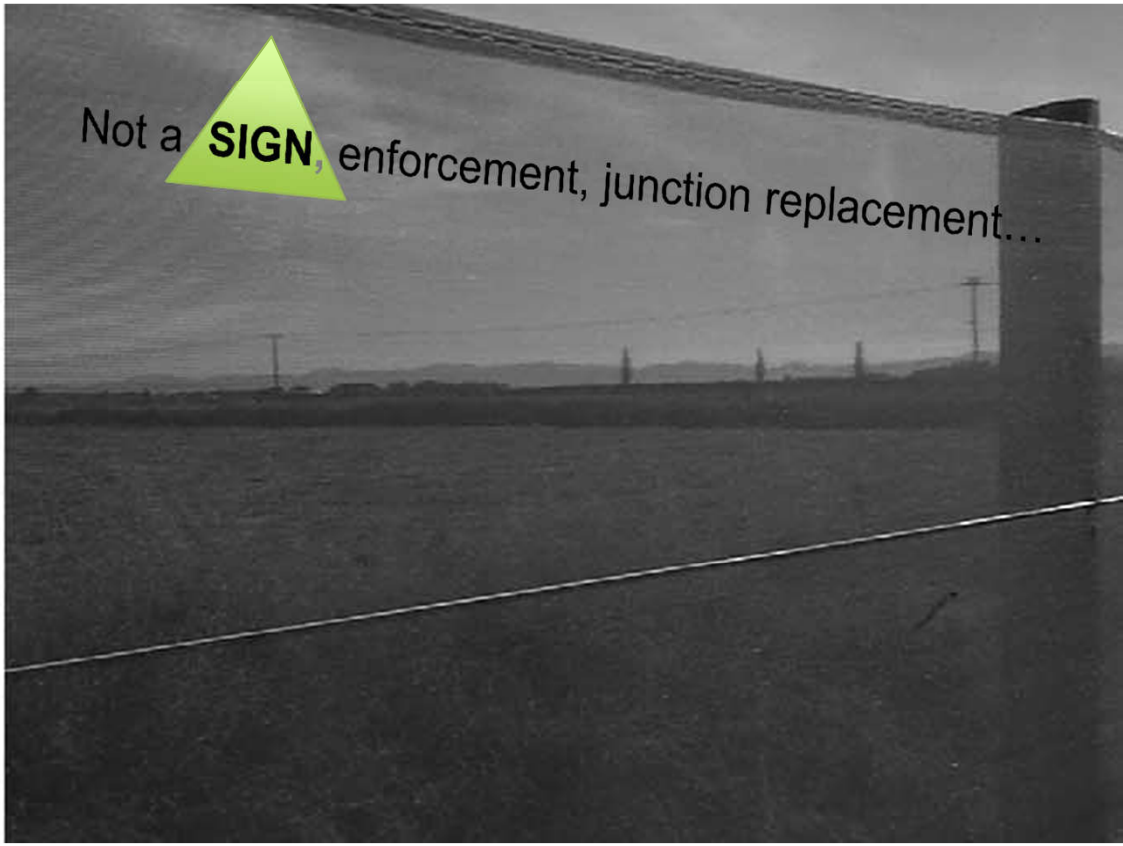
lower vehicle emissions, reduced accidents, and potentially lower rates of vehicle ownership

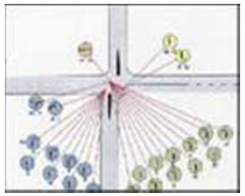
Further benefits include

more walkable neighbourhoods, improved social interaction, reduced healthcare costs and less expenditure on (and use of) fuels


STOP

How a bit of shadecloth fixed NZ's worst junction for accidents:





Charlton, S. (2003) Restricting intersection visibility to reduce approach speeds. *Accident Analysis and Prevention*, 35, 817-823.

Lessons from HF/E

- Don’t blame the ‘consumer’
  - Behaviour change is required…
  - But substantial behaviour change will only accompany system change…
  - But system change needs to optimise the ‘human factor’ (in conjunction with technology)

  - Focus on optimising the interface between people and technology
    (don’t waste time trying to change people when the system is broken)
    (see also: latent failures vs active failures in accident analysis)

  - Take a sociotechnical systems approach
    (jointly optimise technological and social systems)
    (better ‘fit’ between people and environment)

- Commonly used products shouldn’t need an operating manual
  - Roads shouldn’t need an operating manual
  - Heaters shouldn’t need an operating manual
    (If a commonly used product needs a manual then it likely won’t get used optimally)

- Rebound effect
  - Behaviour change again – how to maintain
  - Energy saving / road safety
    (No, that’s right, we didn’t cover this, but see our paper for this and some other ‘lessons from HF/E’...)

Design for Sustainable Behaviour

Dan Lockton
David Harrison
Neville Stanton

Brunel UNIVERSITY WEST LONDON | cleaner electronics

Improving the **use efficiency** of consumer products by **understanding** user behaviour & **influencing** it through design

As technological advances make consumer products more efficient, it's often **human behaviour** that's the weak link in the chain. We buy 'energy-saving' lights and then leave them on all night. We boil a kettle-full of water even though we only need a mug-full. We stick with the default setting on the washing machine, afraid of investigating the others.

Behavioural decisions (or the lack of them) are responsible for **a third of household energy use**—this is a big issue, and while governments have favoured social marketing campaigns to 'solve' it, in many ways it's worth thinking about this as a design problem. It's about people interacting with technology: how and why they do it, and how that interaction might be influenced (if indeed it should), by helping people do things better.

We have developed **Design with Intent**, a design toolkit for designers and strategists working on products, services and systems where influencing user behaviour could lead to improved performance, both environmentally and in other areas of social benefit. The toolkit encompasses more than 50 design patterns for influencing people's behaviour from different disciplines, and has been refined via a series of workshop sessions with designers and design students. We've demonstrated it to a diverse range of design teams from companies including Engine Service Design, Learndirect and QinetiQ, and have more trials and demos lined up.

A further stage of our research involves building functional prototypes of concepts suggested by the method in response to a particular energy use brief on kettles and running comparative user trials to find out which techniques have the most significant effects on behaviour in practice: **enabling, motivating** or **constraining**? Results—which patterns work best, in what situations, and why (both technologically and in human factors terms)—will be fed back into the toolkit to refine it further and produce a useful innovation tool.

More information: www.danlockton.co.uk

If you'd like more information, to download the latest version of the toolkit, or have any feedback, please visit www.danlockton.co.uk or email Daniel.Lockton@brunel.ac.uk

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