



**CREATIVE ARTS
AND INDUSTRIES**
SCHOOL OF ARCHITECTURE
AND PLANNING

FUTURE CITIES
RESEARCH HUB

RESHAPING BUILDING RETROFIT

BRIDGING THE GAP BETWEEN HOUSEHOLDERS AND RETROFIT
PROGRAMMES IN AOTEAROA NEW ZEALAND

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WHO WE ARE

We investigate the complexities of built environments and their interfaces with natural ecosystems to expand knowledge, instrumentalities and find innovative and effective design approaches and solutions at all scales – from individual buildings to entire neighbourhoods, cities and regions.

OUR VISION

We co-create a more equitable, regenerative and healthier built environment for the future generations of Aotearoa New Zealand, through evidence-based research focused on strategic innovation in policy-making, planning and design to combat climate change, affirming equality, and enhancing urban well-being.



Paola Boarin
Co-Founder &
Director



Alessandro Premier
RD leader

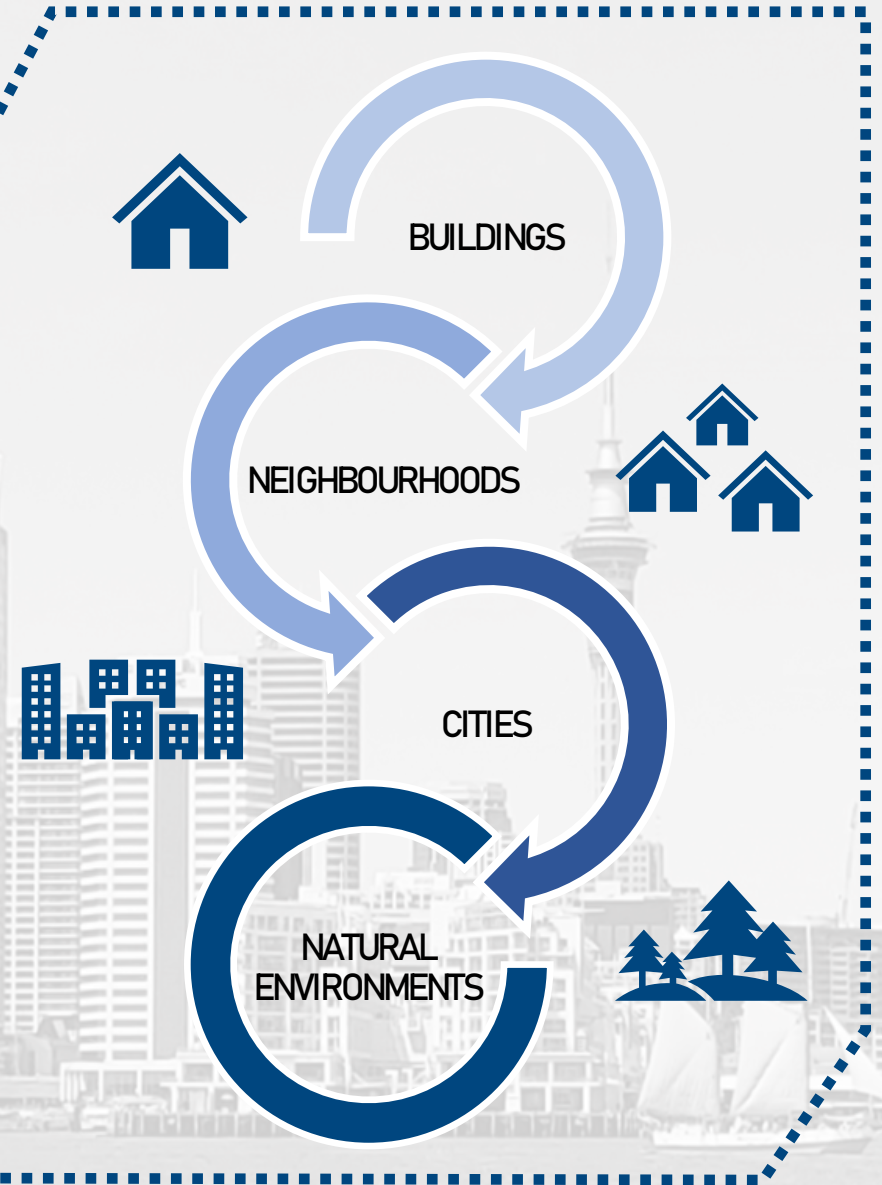


Timothy Welch
RD Leader



Manfredo
Manfredini
RD leader

CLIMATE CHANGE, URBAN WELLBEING & SPATIAL JUSTICE



SUSTAINABLE, RESILIENT & REGENERATIVE APPROACHES

- Creating a balance between people, nature and the built environment
- Responding to climate change at the different scales
- Improving the sustainability and resilience of cities and buildings
- Enhancing the health of ecosystems during and after urbanisation



LOW-CARBON SOLUTIONS & ZERO-EMISSION ECONOMY

- New or upgraded low-carbon materials
 - New recycling and re-use approaches
- Solutions to achieve net-positive homes and buildings
- Clean and affordable energy implementation
- Manufacturing and construction methods and processes to improve building quality



URBAN INNOVATIONS

- Developing smart cities
- Using big data to inform planning and design
- Assessing the impacts of transportation on urban life
- Using better transport systems and data to help improving our cities



URBAN WELLBEING, SPATIAL JUSTICE & COMMUNITY DEVELOPMENT

- Improving fairness, well-being, and community growth
- Spatial quality and quality design in cities
- User-centred design and designing with communities
- Creating affordable and equitable cities



OVERVIEW

- The climate crisis and the role of buildings
- Building retrofit and retrofit programmes
- Performance gaps and POE
- The role of occupants in performance
- Research on the Otago Home Upgrade Programme

THE CLIMATE CRISIS...



Image source: Reuters - A view of flood damage in the aftermath of cyclone Gabrielle in Hawke's Bay, New Zealand
<https://www.reuters.com/world/asia-pacific/new-zealand-police-still-looking-8-people-missing-after-cyclone-gabrielle-2023-02-25/>

- Climate change: weather extremes, natural disasters, food and water insecurity, rising sea levels, economic disruption – **the crisis of our time.**
- Today, the global average surface temperature is around **1.2 °C above pre-industrial levels**, prompting heatwaves and other extreme weather events.
- IEA recently concluded, in its updated Net Zero Roadmap, that a pathway to limiting global warming to **1.5 °C is very difficult – but remains open.**

Information from the World Energy Outlook 2023 (<https://www.iea.org/reports/world-energy-outlook-2023>)

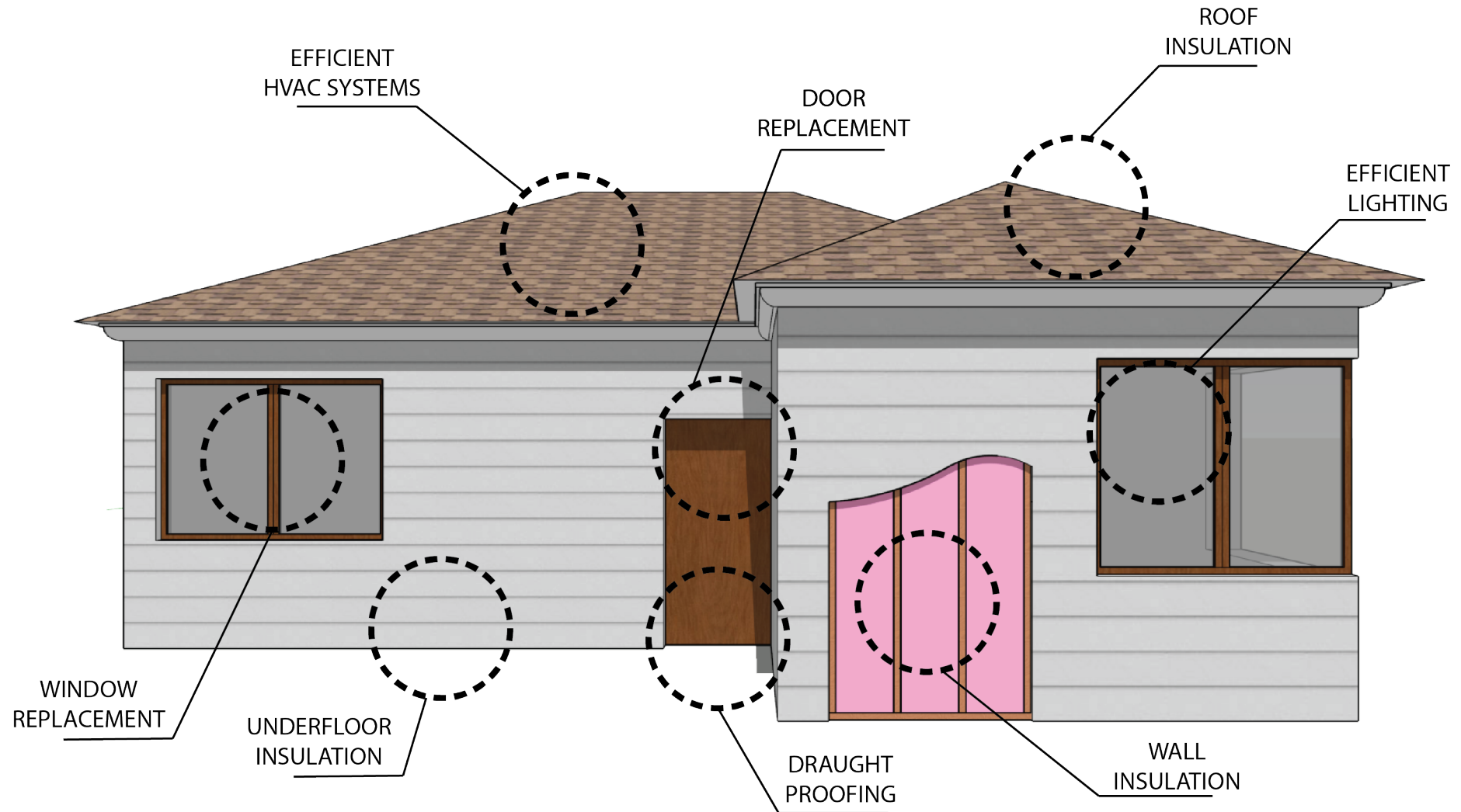
THE CLIMATE CRISIS... AND THE IMPACT OF BUILDINGS



- The operations of buildings account for **30% of global final energy consumption** and close to **40% of total direct and indirect CO² emissions**.
- Buildings sector energy use increased by around **1% in 2022**.
- Strategies - Performance **standards** and building energy **codes** are increasing across countries.
- The use and efficiency of **renewable** building technologies are **accelerating**.
- Goal by 2030 - All new buildings and **20% of existing building stock** zero-carbon-ready – **Building retrofit rate**.

Image source: <https://www.gatesnotes.com/Buildings-are-good-for-people-and-bad-for-the-climate>

WHAT IS BUILDING RETROFIT?



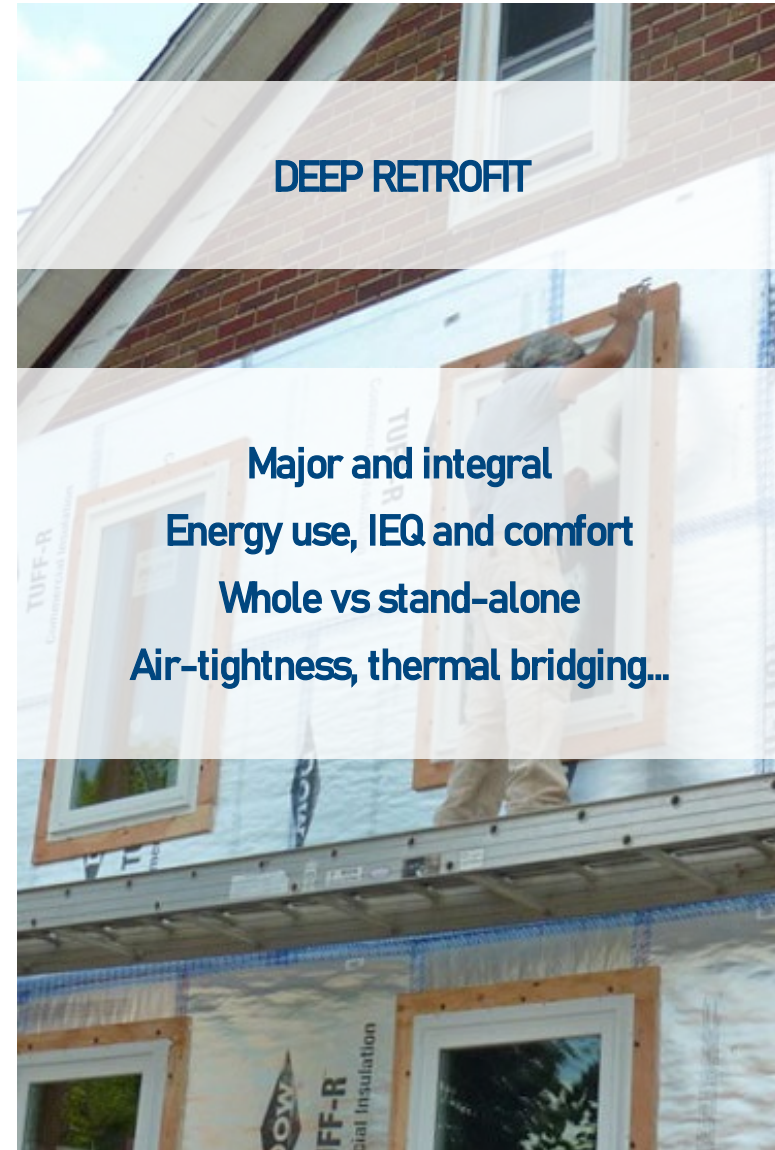
WHAT IS BUILDING RETROFIT?



SHALLOW RETROFIT

Single measures / partial refurbishment
Low risk and short payback
Aotearoa
Eg. heat pump & windows

Image source: <https://www.aucklandhomeshow.co.nz>



DEEP RETROFIT

Major and integral
Energy use, IEQ and comfort
Whole vs stand-alone
Air-tightness, thermal bridging...

Image source: <https://www.greenbuildingadvisor.com/collection/deep-energy-retrofits>

RETROFIT IN THE RESIDENTIAL SECTOR

- **Challenging** – cost, privacy, inconvenience, motivation.
- **Critical** – over **70%** of the European residential buildings stock in **2050** already stands today
- **Householders' role** in shaping the clean energy transition – **challenging to fund** clean energy technologies and retrofits
- Deep retrofits can **cost 4-9 months** of income for poorer households in **China and the US** – barrier resulting in limited retrofits
- **Governments' role** ensuring change is accessible for vulnerable communities – financial **incentives and subsidised retrofit programmes**



Image source: <https://www.safeguardeurope.com/applications/energy-saving-retrofit>

RETROFIT IN THE RESIDENTIAL SECTOR... AOTEAROA NEW ZEALAND



Image source: Paola Leardini

- Homes in Aotearoa New Zealand are not meeting heating and energy **needs of occupants** – Energy hardship/fuel poverty, respiratory illnesses, leaky buildings.
- Up to **460,000** homes in the country require retrofitting.
- **Benefits:** reducing cost of heating, increased comfort, better health and mental well-being.
- Shallow retrofit programmes – a **deep retrofit** programme is needed in the country.

RETROFIT IN THE RESIDENTIAL SECTOR... AOTEAROA NEW ZEALAND



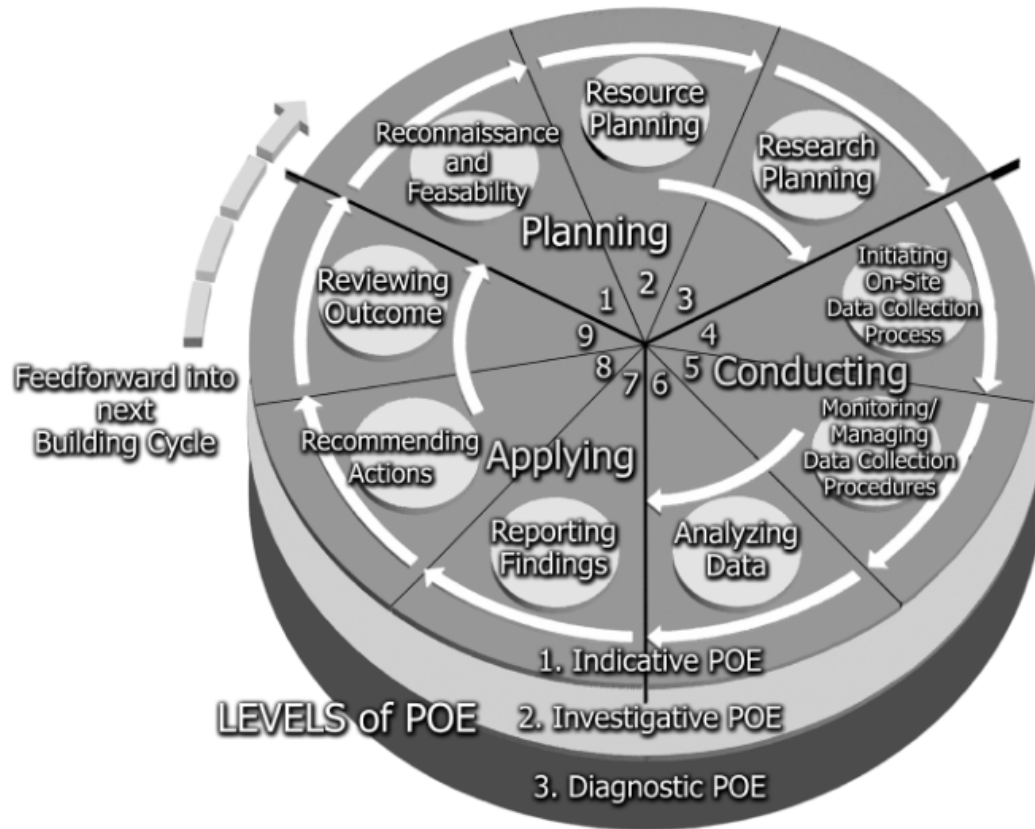
GAPS IN AOTEAROA NEW ZEALAND – WHAT NEEDS OUR ATTENTION?



Image source: <https://perkinswill.com/insights/sustainable-efficient-affordable-residential-retrofit/>

- **Expand** energy efficiency programmes to benefit the wider stock of existing buildings, especially to promote **deep retrofits** that yield greater performance improvements.
- **Align** funding schemes, retrofit programmes, and government strategies with **emissions targets**.
- Continuous **monitoring and evaluation** of the outcomes.
- Understand the **needs of vulnerable households** at a closer level – **Post-Occupancy Evaluation (POE)**.

POST-OCCUPANCY EVALUATION (POE)



Post-occupancy evaluation process (Preiser et al., 2001)

- **Systematic assessment** of buildings' performance once it is occupied
- **Quantitative** (physical variables) and **qualitative** (occupants' **satisfaction**)
- Ability to **compare** estimates against actual **performance**
- **Potential** to assess energy-related behaviours and operation efficiency.
- Most projects **focus on quantitative** neglecting links with occupant-related parameters like driving factors and comfort.

PERFORMANCE GAPS AND UNDERLYING CAUSES

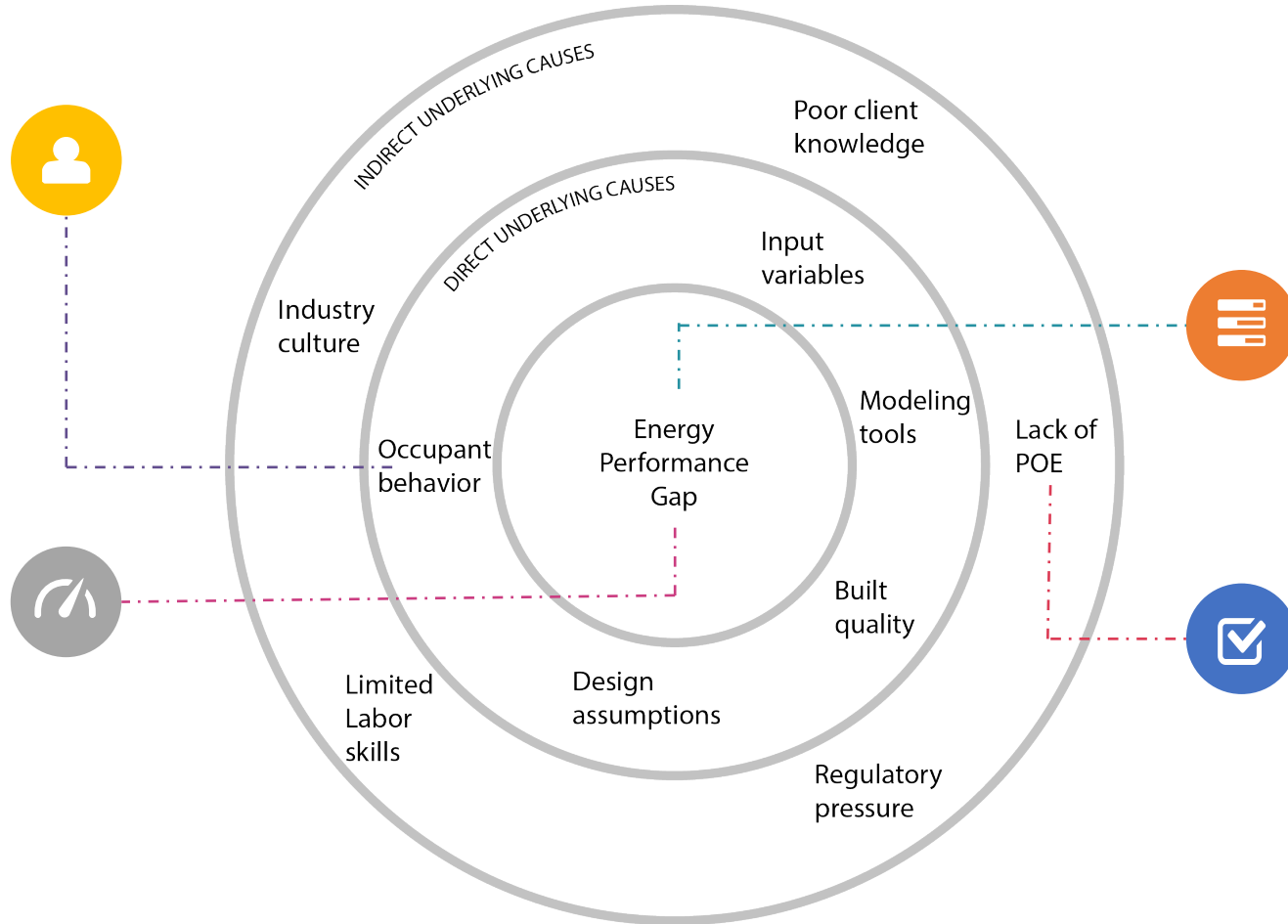
Occupant behaviour

One of the main reasons for the EPG – increase in studies



Boundaries

A margin of error is inevitable (10%), but it can be up to 2.5x higher



Performance Gaps

Discrepancy between estimated and actual energy/thermal performance – Risk in tackling climate change challenges



Lack of POE

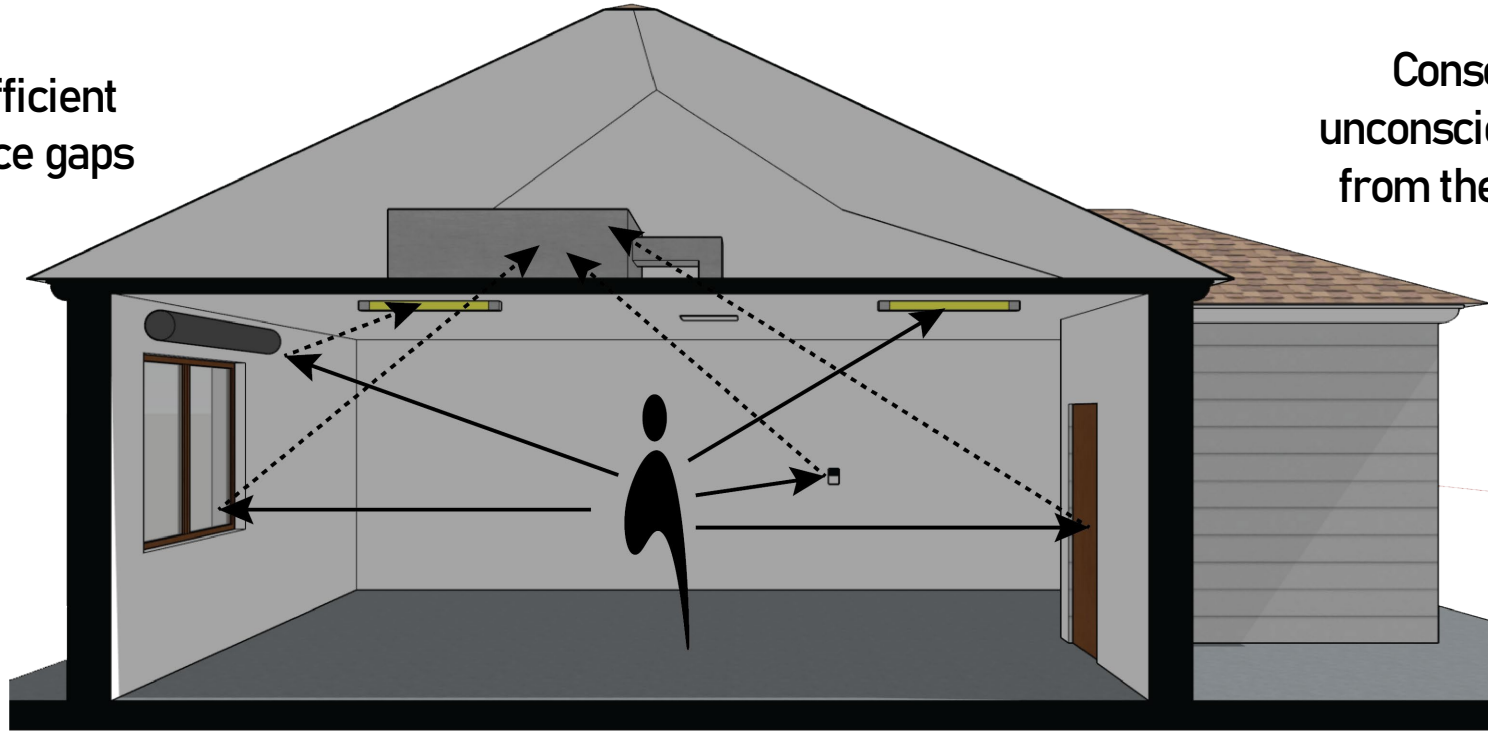
Lack of data to learn from previous experiences and improve our design



OCCUPANT-BUILDING INTERACTION

Technology ≠ building efficient
Behaviours ≠ performance gaps

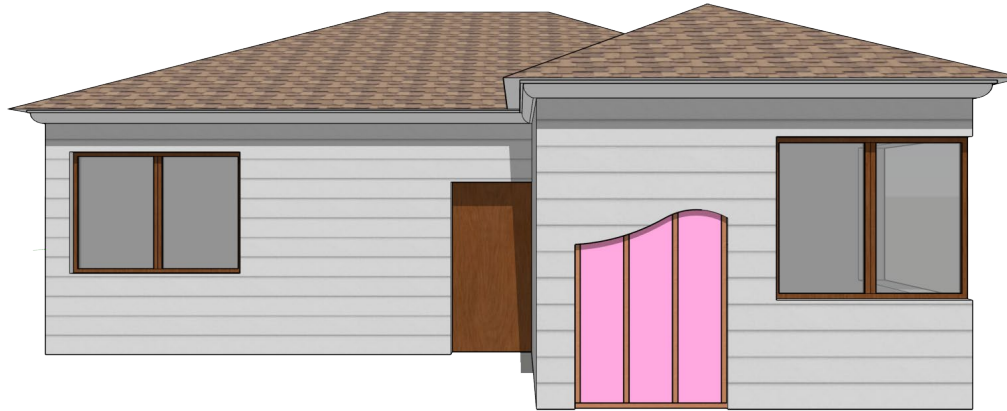
Conscious and
unconscious practices
from the interaction



Complex and hard
to predict

Effective human
behaviours and efficient
building systems

SO, WHAT IS HAPPENING TODAY...?

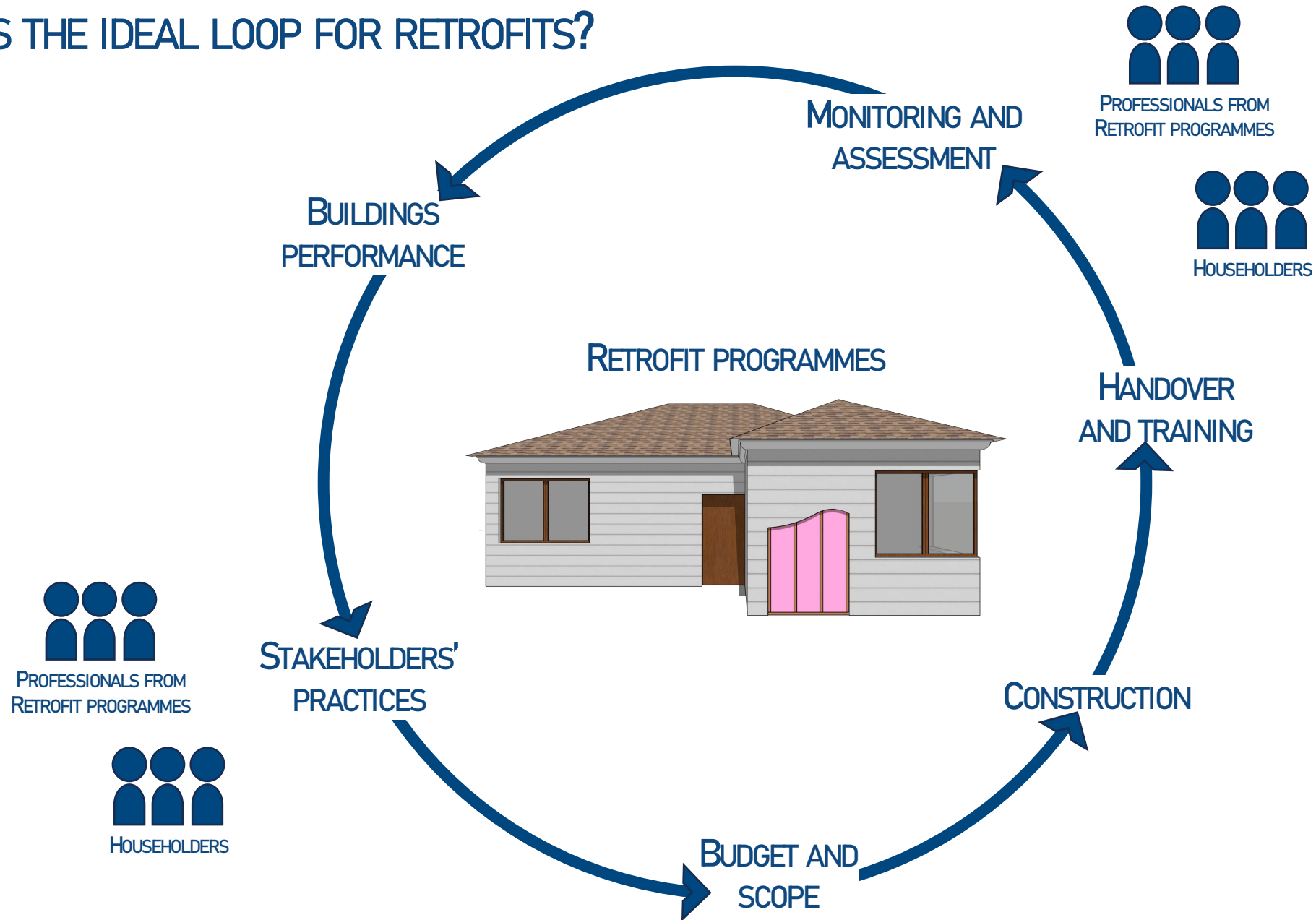


What are the rules guiding their practice?
What is motivating their retrofit choices?
Do they have the tools they need?

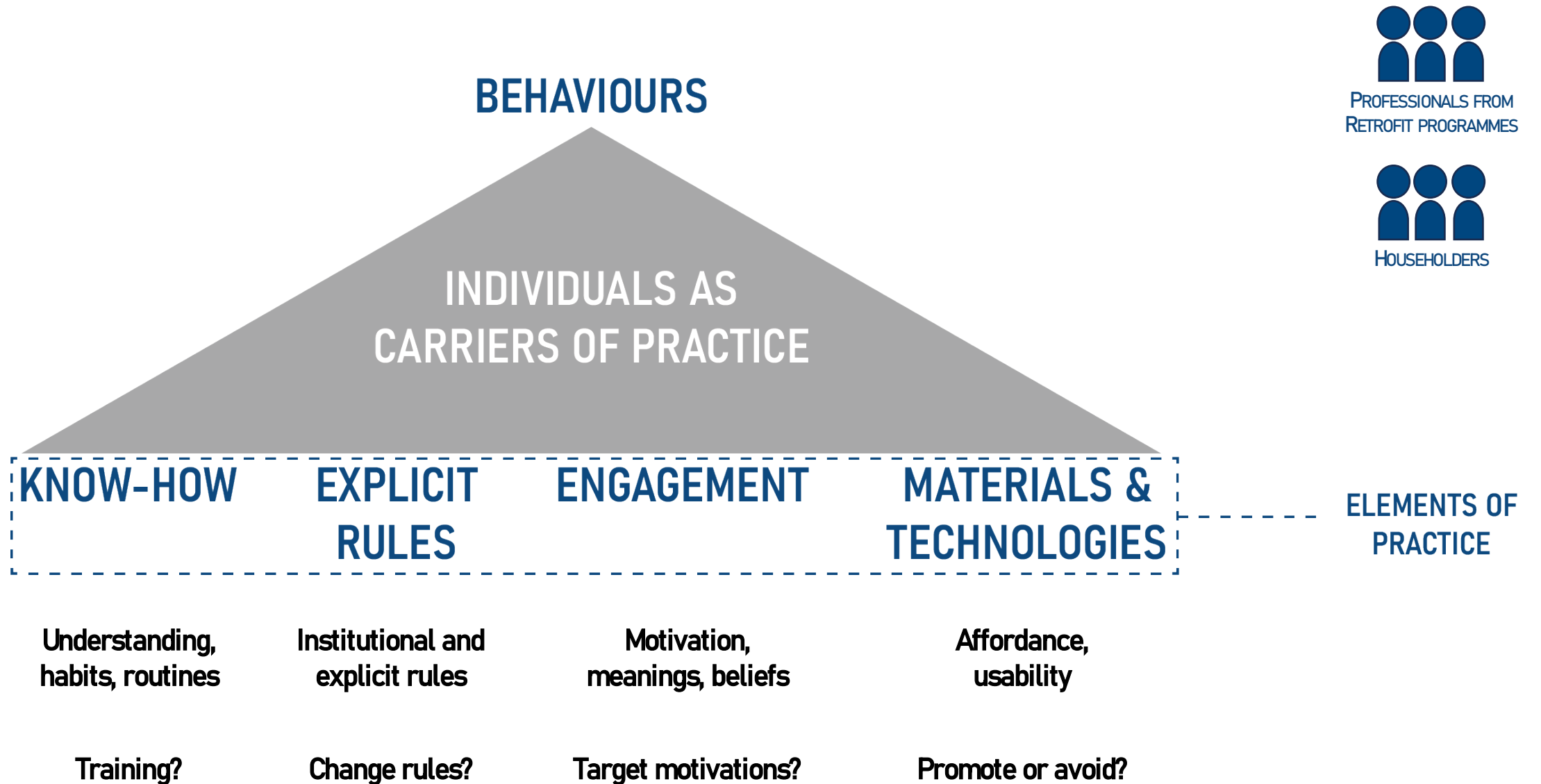
What is the baseline thermal and energy performance?
What is the thermal and energy performance after the retrofit is completed?

Are measures aligned with their practices?
Are they easy to understand and operate?
Do occupants know how to use them and why?

WHAT IS THE IDEAL LOOP FOR RETROFITS?



PRACTICE THEORY – BEYOND BEHAVIOURS



RESEARCH - THE OTAGO HOME UPGRADE PROGRAMME



Collaboration with Aukaha -
the Otago Home Upgrade programme

Case Studies located in Dunedin

66 homes for data analysis

3 semi-structured interviews with professionals

9 semi-structured interviews with householders

Semi-structured interviews
with retrofit programmes

Document review of case
study reports

Statistical analysis
of IEQ data

Semi-structured interviews
householders

Focus Group
With householders

Data triangulation and Best
practice analysis

Elements of practice
guiding programme

Pre-retrofit **building
survey**

Pre- and Post-retrofit IEQ
performance

Elements of practice
guiding behaviours /
householder needs

Co-develop **improvement
strategies** aligned with
householder needs

Recommendations to
retrofit programme /
definition of
sociotechnical POE

CONCLUDING REMARKS

There is still a lot of **room for growth** in the residential retrofit practice in Aotearoa New Zealand. We have an **old and inefficient existing building stock** that is not performing well for our whānau. However, many talented people and institutions are working towards improving the quality of homes and the energy well-being in the country.

Let's make sure that soon we have **deep retrofit programmes** responding to the householders' needs and **practices**, with measurable **performance objectives** and continuous **monitoring** and assessment.





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THANK YOU

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