Research Project: Measuring the Performance of Ultra-efficient Dwellings in New Zealand

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Requesting permission from High st co-housing home owners to install environmental sensors and electricity loggers in their homes.

Summary of project

International findings suggest that large-scale uptake of houses built to state-of-the-art ultra-efficient standards could provide significant health, financial, and climate benefits. Given New Zealand's poor housing stock and the consequences of this for energy poverty, health and the cost of decarbonizing the energy system, adopting ultra-high efficiency standards could be particularly beneficial. However, due to the small number (<50) of these buildings currently in New Zealand, there remains uncertainty about their performance in comparison to other building types. This project will collect and analyze indoor-air quality and energy use data from a first-of-its-kind medium density cluster of 20 ultra-efficient houses in the cold-climate zone of Dunedin. This third-party analysis will enable a definitive evaluation of the performance of affordable ultra-high efficiency housing in New Zealand and provide a critical evidence base for future building regulations.

Background

State-of-the-art ultra-high efficiency buildings (such as that specified via the Passive-House Standard[1]) are characterized by specialized designs with very high levels of insulation, extreme airtightness, mechanical heat-recovery ventilation and optimized solar management. International studies have shown that large-scale uptake of these buildings can reduce annual space heating demand and associated greenhouse gas emissions (up to 90%) in almost any climate[2]. They can also lead to a reduction in winter heating demand that currently constrains countries ability to achieve 100% renewable electricity[3]. Further, high-performance buildings can both reduce energy poverty (through removing the need for costly energy inputs for heating/cooling) and improve associated health outcomes by providing a high-quality indoor environment[2,4,5,6,7]. This a particularly relevant in New Zealand where widespread poor housing conditions[8] have been shown to have significant negative health impacts especially on lower socio-economic households[4,9].

New Zealand's current Building Code significantly lags these state-of-the-art standards. The current standards do not specifying sufficiently high insulation values in colder areas of the country[10] and modern complex houses[11], and have inadequate specifications regarding ventilation and air tightness[12] leading to moisture problems in modern houses. These deficiencies have been recognized and improvements to the New Zealand building code are currently being considered.

Given the long-term impacts of building choices (the average lifetime >90 years) these decisions have important long-term ramifications for the health and climate impacts of these buildings. There is an opportunity for New Zealand leap frog over incremental improvements to current standards and move directly to the ultra-high efficiency building standards being considered internationally[3].

Despite the potential benefits, due to the small number (<50) of ultra-high efficiency buildings currently, one of the key barriers to these buildings in New Zealand is the uncertainty about their real-world performance in comparison to other building types and whether they offer a solution that can be scaled nationally. To inform these critical decisions, evidence of the real-world performance of ultra-high efficiency dwellings is desperately need.

Housing research in New Zealand to date has predominantly focused on the energy poverty[4,7,9] and existing buildings[14]. While there have been some studies of Passive Houses in New Zealand these are predominantly single dwelling studies[13] or modelling[3]. In this project we aim to evaluate the real-world performance of ~20 residential buildings, built to the Passive House standard.

Overall Aim of the Research

This project aims to exploit a unique opportunity to provide an evidence base for ultra-efficient buildings in New Zealand. Recently a medium density housing project consisting of 20 houses built to the Passive house standard has been completed in Dunedin - approximately doubling the number of ultra-efficient houses in New Zealand. These houses represent an affordable model of modern housing for New Zealand. This project aims to collect and analyze energy use and indoor air quality data from this housing cluster. This third-party analysis will enable a definitive evaluation of the performance of affordable ultra-high efficiency housing in one of New Zealand's coldest climates and provide a critical evidence base for future building regulations.

Proposed Research

In this research we will monitor the indoor air quality and energy inputs of up to 24 ultra-low energy houses (from the Dunedin co-housing project[20]) over a 2 year period. We will then analyze this data to extract key performance metrics for these houses. These results will be compared with similar results from a nationally representative sample of houses being collected as part of the parallel-running HEEP 2 study led by BRANZ[14].

Indoor air quality monitoring will be carried our using Tether wireless monitoring devices in bedrooms and living areas. These devices measure internal temperature, CO_2 concentration and relative humidity at 10 minute intervals. These devices will be placed in bedrooms and living areas to establish a whole house picture of indoor air quality. An outdoor monitor will provide outdoor reference values.

We will also monitor electricity usage of the whole house and key heating devices including the mechanical ventilation system and hot water systems on a 30 min time resolution. 24 of these monitors have already been purchased. From this electricity consumption data we will determine total annual space heating energy use, seasonal and daily variations and compare them with typical houses. Between house variation will also be investigated. Season and daily variations are important for understanding the impact of widespread uptake on electricity grids.

The indoor air quality data will be used to explore annual and seasonal averages of all indoor air quality metrics and maximum and minimum values. These will be compared to similar results from the HEEP 2 data. Data analysis will commence as soon as one year data is available but the availability of data from a second year will enable a comparison between seasons.

Methodology is aligned with that developed for the HEEP 2 study and the comparability of the data collected in this project will be maximized through continuing interactions with the members of Energy Hardship Consortium who have a number of similar studies on low-income households.

With the consent of the homeowners, the anonymized results of this work will be widely disseminated via the Energy Hardship Consortium (Kianga Ora, EECA, MBIE, BRANZ) and will be used to inform MBIE building strategies. This work is extremely topical. There are significant discussions currently under way across NZ about home heating and building standards. For example, MBIE is currently consulting on a document focusing on operational efficiency for buildings[16] and researchers monitoring indoor temperatures in a number of new build Auckland hoses have found that Homestar 6 (a building certification scheme) is not performing as promised[19]. This work will also feed in the Climate Change Commissions advice to government.

With the consent of the homeowners, the rich dataset collected in this project will be made open to other researchers so that it is available for future projects, similar to data collected in previous research[18]. The findings of the study will also be written up for publication in scientific journals.

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