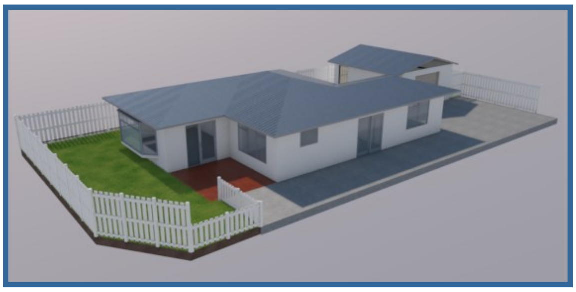
U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND



University of Canterbury

Residential Retro-fit Housing | 04/06/2021

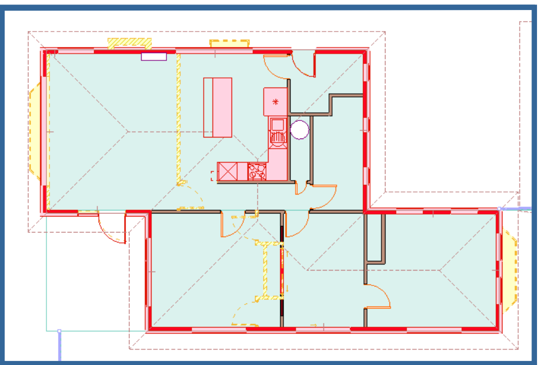
Energy Conscious Ōtautahi

Project Summary

Energy Conscious Ōtautahi (ECŌ) is a project that aims to address systemic housing issues within New Zealand through the development of a retrofit building design providing an affordable option to transition to net zero. Christchurch City has seen significant instability since the major earthquakes having occurred in the last decade. Since, the Christchurch rebuild has seen extensive development projects, with many new builds and renovations appearing across the city. However this growth isn't reflected in the suburbs where the majority of lower income homeowners are situated. These suburbs are predominantly filled with cheaper, outdated housing constructed in the mid 20th century throughout New Zealand. These homes feature flawed building design and were often constructed poorly, leading to very inefficient buildings with harsh living conditions. The ECŌ project team is made up of a group of multi-disciplinary students and faculty from the University of Canterbury, with a range of experience levels in energy systems and sustainable building design.

Design Strategy

The proposed retrofit aims to lower the cost of living and improve the occupant's quality of life whilst reducing the pre-existing home's impact on the environment. This will be done by considering a variety of factors that determine the building's embodied carbon cost across its life span. Through collaboration with local industry experts common issues with residential buildings within this demographic will be identified. Local innovations will be combined with modern technical tools to provide affordable and effective solutions for these issues, creating a package that can be applied to a large portion of NZ houses. The goal is to create a cohesive system that works alongside the occupants and reacts to external conditions to be as energy efficient as possible while still providing a comfortable space to live in. This serves our target market by providing a way for them to improve the their lifestyle and reduce the annual costs of their homes in a way that is financially achievable. This hopes to bridge the gap between the cheap, sub-standard homes and the unaffordable, passive homes of the future.



Project Data

Location: Christchurch/Ōtautahi, New Zealand
Climate Zone: 3/4, Temperate Oceanic
Lot Size: 159.5m^2 = 0.0394 acres
Building Size: 93.3m^2 = 1004.3 ft2, 1 story
Occupancy: 2 adults, 1 child, 1 toddler (251 ft2/person)
Market Value: $540,000 NZD ~ $367,000 USD
Energy Performance: EUI = 22.11 kBtu/ft2/yr
Average Utility Cost: $156 NZD = $105USD
Annual Carbon Costs: 10 kg CO_2 eq/m^2/yr

Technical Specifications*

R-Values (ft^2°Fhr/Btu)
- Wall: 25.5 (RSI4.5)
- Roof: 46.6 (RSI8.2)
- Windows: 4.5 (RSI0.77)
- Floor: 18.6 (RSI1.3)

Mechanical Systems
- Heat Pump
- Hot Water Heat Pump
- Heat Recovery Unit

On-Site PV
- 10200 Btu (3kWh)

Prospective Partners

-Eco Design Advisory
-MCD Architects
-Meta Architects
-FanTech
- Chatterton Builders
- Terra Lana
-BECA Consulting
-Christchurch Council
-NZ Government

U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Project Highlights

Architecture

Changing the distribution of the windows around the external walls of the home provides both improved thermal performance and better living conditions. The home was designed in the Northern hemisphere where the South-facing wall is the one which receives the most sun. This is addressed in the design by having the main windows facing North. The stucco cladding on the outside of the house was outdated and poor performance, so this was replaced with wooden board cladding. The large brick chimney should be removed due to old-fashioned design and potential earthquake danger. The rearrangement of the kitchen allows for more modern, open plan living.

Engineering

Thermal analysis revealed the weak spots in the example property to be the external walls and large bay windows. SIPS panels were put between the external cladding and the wooden framing as they provide an efficient continuous layer of insulation. For insulation between the framing, Terra Lana Wool Blanket was used for environmental reasons. Double glazed windows with UPVC framing was chosen to replace windows due to the balance of cost and thermal effectiveness that they provide. A lowered ceiling and an HRU system was sized for the house to provide ventilation. The existing gas hot water cylinder was replaced with a hot water heat pump to increase energy efficiency.

Market Analysis

The ECO modular retrofit stands as a versatile solution to the stagnating outdated housing sector in Ōtautahi. The package is flexible as to fit with the varying financial capacity of homeowners on a case by case basis, and could be rolled out on a mass scale with governmental assistance. Not only does the package increase the property value, but it also will reduce operational cost and provide a pathway to the eco-friendly lifestyle many New Zealanders desire to live.

Durability and Resilience

Climate change projections were analysed and the worst possible forecasts for extreme weather conditions were considered during the design process. The four building science control layers were each addressed. Thermal performance was increased by eliminating thermal bridges and increasing insulation, air exfiltration was reduced by improving window and door seals, bulk and vapour moisture infiltration was reduced by the use of membrane systems which cause water to run down an outer layer of the wall before penetrating further into the house.

Embodied Environmental Impact

Life cycle analysis was utilized to predict the embodied carbon in the retrofit process and compare this to the impacts of a new build. Results from this were favourable for our scenario. Carbon efficiency was also heavily considered when considering choices of appliances and building materials for the home.

Integrated Performance

Smart plugs and connected devices will be installed in tandem with OpenHAB software to automatically control the operation of many household appliances. Operating at the switch will reduce vampire loads and routines for when occupants are in the home can be used to automate this process, requiring minimal user input. Quality of life can also be improved by these systems by turning on interior heating before the occupants are home so they come home to warm rooms.

Occupant Experience

While work is being done on the home, the opportunity can be taken to improve the quality of living by creating a more open plan layout. Careful project planning should be utilized to minimize the amount of time spent by the occupants in temporary accommodation. The residents were surveyed about problems in the existing house and in the retrofit design since they are the most knowledgeable about the living conditions in their home.

Comfort and Environmental Quality

The air quality in the home was improved by increasing the air changes per hour and installing high grade filters in the HRU. Acoustic testing was done on the current house and it was determined that there would be only improvements in regard to a very small problem with the new design.

Energy Performance

The Homestar guideline was used to assess the energy performance of the current home and the new design and compare these to model New Zealand homes. Energy usage of existing appliances were measured and improved but economic replacements for poorly performing appliances were found and listed. Renewable energy sources were researched and it was discovered that solar power was the best suited for the job. Grid connection was considered and it is possible for energy generated during off-peak hours which is not needed by the household can be returned to the grid for carbon credits.