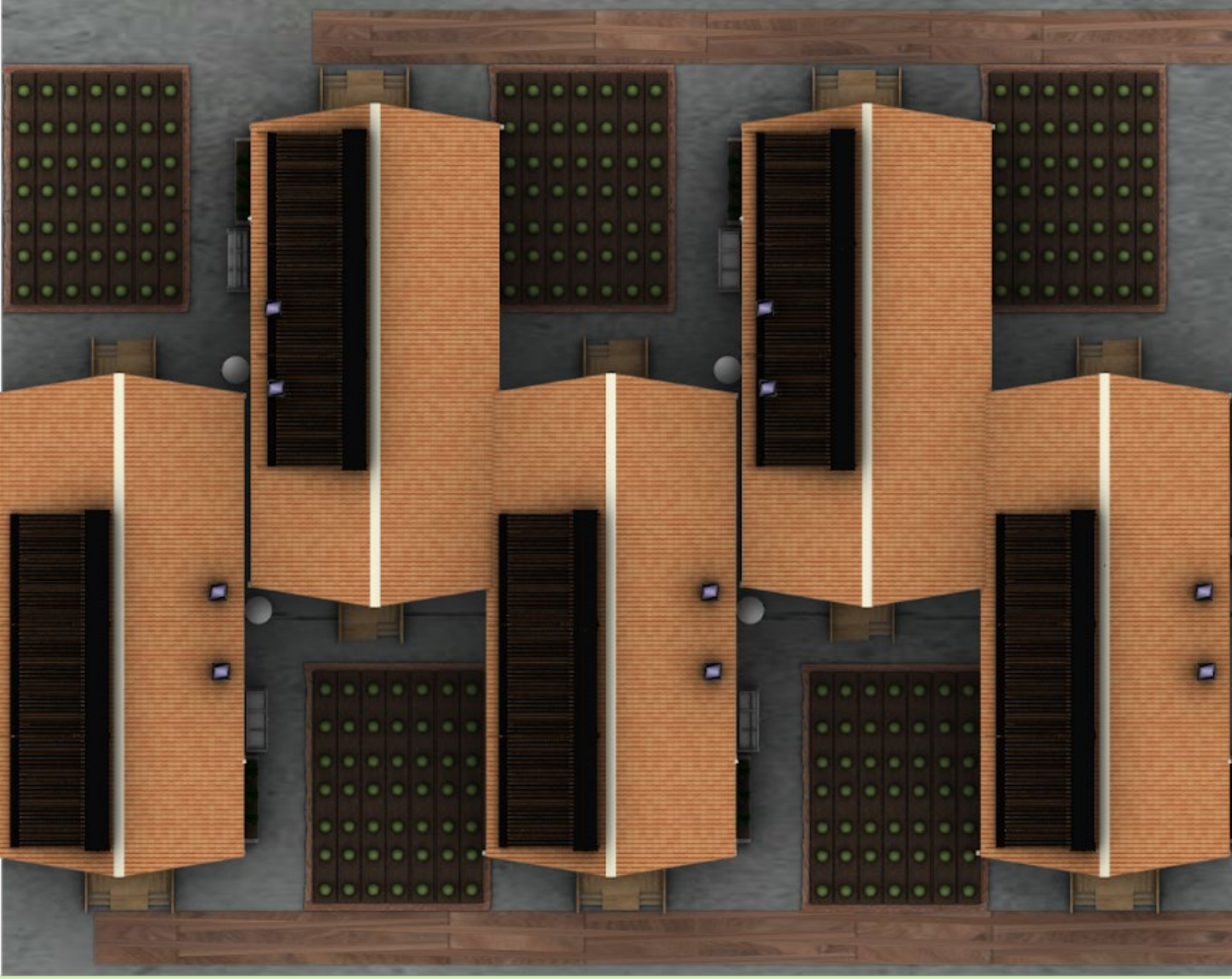


Connected Homes

Sustainable Public Tenant Housing (SPTH)

Solar Decathlon Design Challenge 2020

Attached Housing Division

Project Report

U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON

CONNECTED HOMES

MONASH University

1.1. Project Introduction

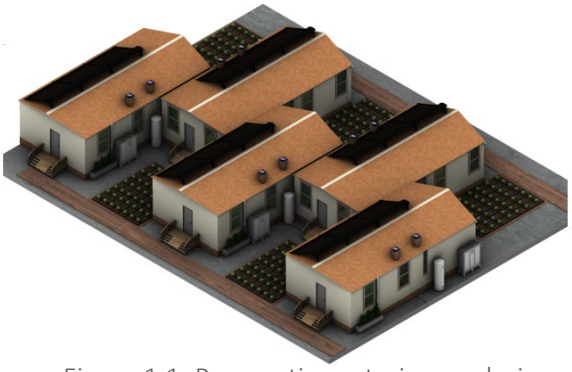


Figure 1.1: Perspective exterior rendering

1.1.1. Project Summary

Sustainable Public Tenant Housing (SPTH) aims to bring community-focused attached housing to public tenants while also being a proof of concept of net-zero energy housing. Our design is an environmentally conscious and cost-effective housing solution for public tenants. It is a step towards building economically and environmentally sustainable housing in a sector where supply is not meeting the demand. The attached housing division was chosen for SPTH as it aligns well with the nature of public tenants' needs for low-maintenance, medium-high density housing in the built-up suburb of Box Hill.

1.1.1.1. Design Strategy

Centralising utilities, recycling rainwater and adopting passive lighting/ventilation strategies were considered as priorities of the design, which provides ample space for 2-3 occupants per dwelling, keeping accessibility needs in mind. Since the project is aimed at the government providing housing for public tenants on tight budgets, the project's overall building and operation costs need to be minimised through off-site construction as well as the use of efficient building systems and energy saving equipment within the dwellings.

1.1.1.2. Project Data

- **Location:** 43&45 Albion Road, Box Hill, VICTORIA, AUSTRALIA
- **Australian Climate Zone:** 6, **Closest Equivalent US Climate Zone:** 3 (San Francisco)
- **Building Area:** 490m^2 (5274 ft^2) total or 107m^2 (1147 ft^2) per dwelling
- **Lot Size:** 1386 m^2 (14919 ft^2) total or 231m^2 (2486 ft^2) per dwelling
  - Single Story **5 Dwelling** Attached Housing Complex
  - Communal front and back gardens area
- **HERS index:** 45 w/o PV, -3 w/ PV (San Francisco climate setting)
- **DOE Zero Energy Home Ready**

Figure 1.2: Details and expected occupancy per dwelling

1.1.1.3. Technical Specifications

- **Roof:** R-50, Foundation: R-24, **Wall:** R-36, **Floor:** R-36 (ft2·°F·h/BTU)
- **Windows:** SHGC: 0.25, U-Value: 0.240
- **HVAC:** Hydronic ASHP + HRV
- **PV:** 10 x 330W panel array with a dedicated 5kW inverter and battery per dwelling (50 panels total)
- **Estimated Total Costs:** $3.3 million AUD ($2.01 million USD)

1.1.1.4. Project Highlights

Energy Performance

Our HERS score of -3 with PV was achieved using passive house design, utilising natural ventilation and lighting through north facing windows allowing passive heating and lighting from the winter sun, as practised in the Southern hemisphere.

Each dwelling has an LG PV array, known for its durability, PV-inverter and battery system reducing complexity and dependency on other systems.

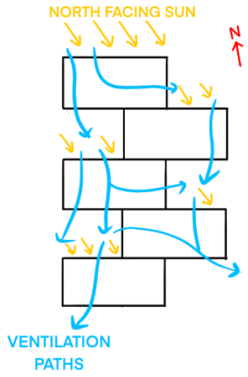


Figure 1.3: Demonstration of passive design strategies

Engineering

SPTH utilises a custom rain-to-hot water system by South East Water (SEW), a Victorian government water utility. The system treats harvested rainwater using heat and ultraviolet disinfection to provide non-potable domestic hot water (e.g., for bathing and showering).

Walls and ceiling consist of high performance Earthwool insulation for thermal insulation. Rigid insulation, a membrane to control against water, air and vapour are used for the walls, ceiling and floor. Roofs utilise a durable COLORBOND® steel roofing and walls have a fibre cement cladding.

Financial Feasibility and Affordability

To ensure feasibility for the government in construction, off-site construction is integrated into the design. Utility costs will be minimised for the affordability of SPTH occupants through rainwater recycling, PV generation and energy saving appliances.

The total estimated cost for the project is $3.3 million AUD ($2.01 million USD) and preliminary estimates show a return period for construction costs of 14 years from rent alone, assuming all dwellings are occupied and rent will be constant ($1472 AUD/$992 USD per month).

Resilience

SPTH is geared to protect against the effects of natural disasters possible in Box Hill such as smoke from bushfires, storms, heatwaves and also other man-made disruptions such as grid losses and internal fires. Various materials such as fireproof fibre cement and systems such as the solar battery are set in place to prevent the effects of these possibilities.

Architecture

SPTH takes advantage of the attached nature of the dwellings, by centralising utilities and adopts passive design strategies to decrease energy requirements for heating and cooling, which are major energy consumers. The streamlined design allows for a tight, yet spacious horizontally placed set of dwellings that cover the land size. The configuration in which the dwellings were placed is used to maximum capacity to reduce heat gain. Additionally, accessibility was considered when designing the sizing for the interior.

Operations

Energy efficient electric appliances were selected to decrease utility costs and to comply with DOE Zero Home Ready guidelines. SPTH is also designed for easy occupant and government maintenance with automatic systems such as an automatic irrigation system. Additionally, a 1 m (3.3 ft) crawl space and 0.55 m (1.8 ft) dropped ceiling is incorporated to allow for easy maintenance access.

Market Potential

Box Hill which is near Victoria's capital, Melbourne and was chosen due to the high demand for public housing in the area in the past (1724 applicants as of December 2014 in Box Hill). With the convenience of being a residential area with easy access via public transport to the central business district (CBD) of Melbourne, the location suits public tenants well allowing them the possibility to engage in multiple lifestyles.

Comfort and Environmental Quality

Our design provides lighting using north-facing windows and warm-color LED lights. Dwellings were designed to be narrow with clear ventilation paths, to increase efficiency of passive cross ventilation and natural daylighting. Additionally, earthwool insulation is used providing sound deadening between dwellings. Hydronic underfloor heating and cooling is provided along with a HRV to keep temperatures comfortable. HEPA filters are integrated throughout the ventilation system to ensure the air is clean.

Innovation

The project also focuses on utilising off-site construction by building the dwellings out of only 2 modules that are common to all dwellings in SPTH, allowing for a simpler prefabrication process. This reduces construction costs, time and community interferences usually common with large projects.

1.1.2. Team Information

The Connected Homes team is one of three in the larger Monash Solar Decathlon Team in Monash University consisting of seven undergraduate students who are passionate about sustainability and minimising the future impact on the Earth using engineering and design. Although we are a new team, we started with the

enthusiasm to learn and utilise useful programs such as REM/Rate, SketchUp, Sefaira, Revit, Rhino and ArchiCAD with the help of our faculty lead and technical advisors and were excited to explore the fundamentals of building science.

Faculty Lead and Technical Advisors:

Faculty Lead: Brandon Winfrey
Lecturer in Water Engineering
Department of Civil Engineering

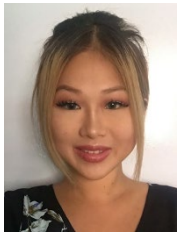
Technical Advisor: Victor Bunster
Postdoctoral Research Fellow
Faculty of Art, Design and Architecture

Technical Advisor: Elizabeth Sironic
Senior Lecturer
Department of Civil Engineering

Team Members:

Team Leader: Savith Suraweera
Mechanical Engineering/ Materials Science, 2nd Year

Jessica Li
Civil Engineering, 4th Year



Cyndy Li
Architecture, 3rd Year

Zeyue Wu
Civil Engineering, 3rd Year

Thomas Veitch
Mechanical Engineering/ Finance, 2nd Year

Krishan Fernando
Civil Engineering/ Architecture, 2nd Year

Shiyen Perera
Chemical Engineering/ Biomedical Science, 2nd Year

1.1.3. Industry Partners and Acknowledgements

We would like to thank Stiebel Eltron for partnering with us on this project and giving us great insight into the way their high efficiency equipment can help build net-zero homes. Jacobs Engineering Group provided advice to us in the building science principles. Also, we acknowledge the inspiration and fundamental design approach to our water systems from South East Water's Aquarevo project.

JACOBS® STIEBEL ELTRON AQUAREVO LYNDHURST

1.1.4. Additional Information

Figure 1.4: Detailed interior layout with floor plans

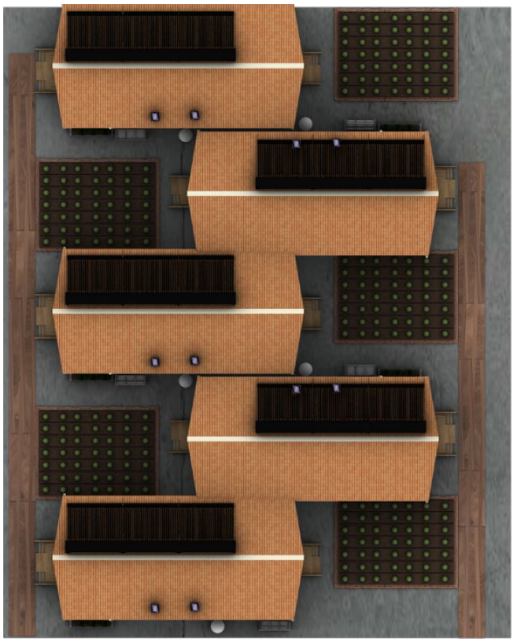


Figure 1.5: Staggered exterior rendering

Figure 1.6: Detailed interior rendering