U.S. DEPARTMENT OF ENERGY
Solar Decathlon
Design Challenge

MSB
MONASH SUSTAINABLE BUILDINGS
MONASH University

Flame Robin Farm

Project Data

Location	Lot 2, 557 Munro - Stockdale Road, Munro VIC 3862, Australia
Climate Zone	6
Lot Size	44ha (0.17 sq miles)
Land Cost	$392,700 USD
Building size	3121.5 sqft
Occupancy	1-5 people + non-human
Construction Cost	$398,378 USD
Average utility cost	$848 USD/year
Average maintenance cost	$3,403 USD/year

Technical Specifications

R-Values	Wall	28.96 ft²-h-F/Btu
	Floor	21.6 ft²-h-F/Btu
	Roof	48.3 ft²-h-F/Btu
U-Values	Glazing	0.159 Btu/h-ft²-F
	Frame	0.264 Btu/h-ft²-F
Embodied carbon	6723 kgCO2e	
HVAC	5.2kW ducted air-sourced heat pump with Stiebel-Eltron LWZ 170 E PLUS	
On-site PV	440W peak power	
Total source EUI	543 kBtu/ft²/year	
Net source EUI	-11 kBtu/ft²/year	
HERS (before PV)	41	

Project Summary

Australia is recognised for its biodiversity and unique natural landscapes. However, many residents, notably those living in rural regions and townships, consistently face the devastating impacts of natural disasters such as bushfires and floods. Such events have adversely affected Australian communities for decades and often result in irrevocable damage to homes and infrastructure. During the 2020 Australian Bushfires, approximately 19 million hectares of land was affected. This included the destruction of over 3,000 homes and the displacement of a great number of residents.

As a viable solution to these issues, MSB is proposing a bushfire and flood resistant single family farmstead, located in the East Gippsland region in Victoria. This area was selected due to its historical susceptibility to disaster events such as bushfires and floods. Gippsland's unique topography and climate also renders it very suitable for farming, with more than 6000 farms currently operating in the region. The farmstead will incorporate passive house strategies in order to achieve net-zero targets, whist maximising the safety of occupants in the event of a bushfire or flood.

Design Strategy

MSB's key design goals for the house include resilient shelter from extreme bushfire and flash flooding events, minimizing ecological impacts, improved living conditions, modularity, and sustainability. With a focus on passive design strategies involving orientation, elevation and natural materiality, the house aims to be integrated within its Australian ecosystem. In addition to these features, operable components accommodate flexible use and occupant control, whilst ensuring replicability of the design across other regional sites requiring extreme weather resistance.

ARCHITECTURE

Integrated with the site's terrain and ecology, the design ensures bushfire and flash flooding resistance, whilst prioritising the use of sustainable materials and passive house techniques to achieve a zero-energy building. The exterior envelope is in harmony with its surroundings while thermally insulating the home. The design process considers materials, form, and efficient program arrangement to accommodate human and non-human occupants' needs, ranging from livestock to native and endangered species. This provides families a home that is accessible, comfortable and safe from extreme weather events whilst reclaiming habitats for the existing ecosystem to thrive.

ENGINEERING

An efficient air sourced heat pump will power the ducted, reverse-cycle 5.2kW HVAC system with EER/COP of 12.62/3.70; and a Heat Recovery Ventilator (HRV) will recover 90% of the sensible heat from exfiltration. An indoor 315L storage tank will contain hot water heated by an air sourced heat pump with COP of 5.08, prioritising versatility and efficiency. Greywater will be reused to irrigate the green roof keeping it saturated and effective against bushfire attack. Coupled with rainwater, both will be naturally filtrated via reed beds and stored for toilet flushing and garden watering. Water from the on-site dams will be pumped for fire sprinklers in emergencies.

ENVELOPE

The structure's exterior consists of fibre cement cladding, external doors, sliding doors and triple glazed windows fitted with shutters; all of which are non-flammable with a Bushfire Attack Level (BAL) of 40. Hemp insulation for walls and roofs, along with Cleva Pods and insulation for flooring, provides thermal and sound insulation. Vapour barriers with airtight construction and careful sealing prevent moisture build-up and achieve a low airtightness value. Considering all of these factors, the wall system attains an optimal R-Value of 5.1 while the roof achieves 8.5 and flooring reaches 3.8. This ensures the envelope will be able to handle extreme weather events.

EFFICIENCY

The building prioritises energy efficiency by integrating both active and passive systems. Active systems include an Air Source Heat Pump, smart tunable lighting system, and on-site renewable electricity generation. Passive strategies include optimal building orientation, shading, high-quality thermal insulation, and triple-glazed windows. DesignBuilder has been employed for EnergyPlus modelling to evaluate the annual energy demand. Annual energy consumption has been compared with an IECC (2018) reference building to determine potential energy cost savings. Operational carbon reduction has been evaluated during the life cycle analysis. Additionally, operational water use is minimised by adopting appliances with a minimum water efficiency rating of 4 WELS stars.

GRID-INTERACTIVITY

Operational carbon is minimised by employing 16 x 440W SunPower Maxeon 6 Panels with individually attached Enphase microinverters, chosen for their flexibility and suitability for our three phase system, creating a 7kW system. This is paired with a Tesla Powerwall 2 (13.5kWh) smart battery. The Tesla Powerwall is able to connect to Home Assistant via Flame Robin's Google Nest hub. This allows automation of the battery's charging and discharging based on grid conditions, and energy consumptions/generation. The Powerwall also has built-in user friendly operating modes, & comes with a backup gateway system, allowing Flame Robin to disconnect from the grid and remain operational through our PV system during power outages and grid disruptions.

LIFE-CYCLE

To improve the life-cycle analysis (LCA) score, materials with low embodied carbon such as Durra Panel and Hemp insulation, are selected. These materials, sourced locally, minimise transportation emissions and bolster regional economies. The analysis encompasses stages starting from Materials (A1), Waste disposal (C4), excluding repair (B3), transporting locally sourced materials via trailer combinations excluding concrete. Wood-based materials are considered for their negative embodied carbon and carbon emitted potential, while stone and recycled plastic are for their lowered embodied carbon. Timber products also contribute to carbon withdrawal, with flora impact considered for CO2 reduction, ensuring a comprehensive assessment for sustainable decision-making throughout the life cycle.

HEALTH

Clean indoor air quality will be guaranteed by passive design strategies, Heat Recovery Ventilator (HRV), high air tightness and portable air purifiers with HEPA filters. All appliances are low-noise and tuneable LED's will be programmed to provide circadian rhythm lighting, aiding the occupant's mental wellbeing. Installation of CCTV, outdoor lighting and wrap installation (anti-mould and rot) will promote occupant health and safety. With proper disposal of construction waste and careful material selection, nearby water sources and soil will not be contaminated.

MARKET

Flame Robin Farm will target each affected area and provide a holistic solution that safeguards all farm infrastructure and inhabitants from the affects of a natural disaster, including the often neglected and defenceless farm animals. While the project designed for the Gippsland site will aim to achieve both fire and flood resilience, our design will also create the potential for scalability across different states in Australia and may be altered based on the needs of individual farms.

COMMUNITY

MSB engaged with local farming communities located in bushfire and flood prone areas to better understand the challenges they faced. Careful consideration of access to necessary amenities, an on-site dam and adequate land to accommodate a recreational farm, led to the selection of the for the project in the Gippsland region of Victoria. The site is located within a highly bushfire prone region that will heavily benefit from fire resilient farm infrastructure.