



# Hawai'i Natural Energy Institute Research Highlights

## Energy Efficiency & Transportation

### Project FROG Net Zero, Mixed Mode Buildings

**OBJECTIVE AND SIGNIFICANCE:** The objective of this multi-year project is to understand energy performance and operation of net zero energy, mixed mode buildings in tropical climate and to use the buildings as real-world research facilities for the study of energy efficient building features and control strategies. The specific objectives of the current work are to measure and evaluate indoor air quality, particularly CO<sub>2</sub>, in manually operated mixed mode buildings. High levels of CO<sub>2</sub> can cause drowsiness, absenteeism, and poorer student performance.

**BACKGROUND:** Two unique energy efficient, net zero energy buildings constructed on the University of Hawai'i at Mānoa campus serve as platforms for energy, comfort, and controls strategy research. Since 2016, HNEI has been extensively monitoring these mixed-mode Project FROG structures to gain insight into their performance.

The buildings were designed to be naturally ventilated with openable windows that allows air to flow through the room. On-Demand HVAC control prevents the room from being air conditioned continuously at night or when classroom capacity factor is below 60% during the day. With the adjustable ceiling fans, the mixed mode buildings are comfortable for most of the year without the air conditioning running. The buildings are also outfitted with photovoltaic systems that generate more power than they consume.

The current research focuses on observing and characterizing CO<sub>2</sub> levels in the mixed mode buildings and understanding the influence of window operation. As part of this project, HNEI developed a sensor providing the building occupants real-time feedback on CO<sub>2</sub> levels, including a cue to take action to increase fresh air.

From an energy perspective, these buildings serve as models for energy efficient construction with highly insulated roof and walls, high performance low E glazing, ceiling fans, LED lighting with daylight controls, and orientation to prevent solar heat gain through the windows.

In addition, the research platforms serve as beta test sites for innovative controls and sensor research experiments including:

- Real time CO<sub>2</sub> indicators
- Automated ceiling fan controls
- Innovative occupancy sensing device
- Unique hi-res energy monitoring system
- Unique power quality monitoring system
- Deployed a thermal comfort perception kiosk

**PROJECT STATUS/RESULTS:** The Project FROG buildings continue to serve as functioning classrooms for both high school and university classes. In this ongoing project, we observed that CO<sub>2</sub> levels can exceed recommended levels, occasionally by a factor of two. User awareness and training are imperative to properly operate in the mixed mode. Building decisions are made every day by the instructors that impact the indoor air quality of a mixed mode building. Operation of windows, ceiling fans, and air conditioning are judiciously used to create healthy indoor air quality.

This project will be completed in December 2020.



Figure 1. UH Mānoa Project FROG buildings.

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## **ADDITIONAL PROJECT RELATED LINKS**

### **TECHNICAL REPORTS:**

1. [Net Zero Energy Test Platform Performance Comprehensive Analysis](#), MKThink, March 2016

### **PAPERS AND PROCEEDINGS:**

1. 2020, S. Cerri, A. Maskrey, E. Peppard, [Retaining a healthy indoor environment in on-demand mixed-mode classrooms](#), Developments in the Built Environment, Vol. 4, Paper 100031. (Open Access: [PDF](#))
2. 2018, A.J. Maskrey, S. Cerri, E. Peppard, [Second Generation ZNE: Inheriting the Good Genes](#), Proceeding of ACEEE Summer Study on Energy Efficiency in Buildings Conference, Panel 10: Net Zero: Moving Beyond 1%, Article 10.
3. 2016, A.J. Maskrey, S. Cerri, E. Peppard, M. Miller, S. Uddenberg, [Positively net zero: case study of performance simulation and hitting the targets](#), Proceeding of the ACEEE Summer Study on Energy Efficiency in Buildings Conference, Panel 10: Net Zero, Net Positive, Article 10-1001.

### **PRESENTATIONS:**

1. 2018, A.J. Maskrey, S. Cerri, E. Peppard, [Next Generation ZNE: Inheriting the Good Genes](#), Presented at the ACEEE Summer Study on Energy Efficiency in Buildings, Panel 10: Net Zero: Moving Beyond 1%, Pacific Grove, California, August 12-17.