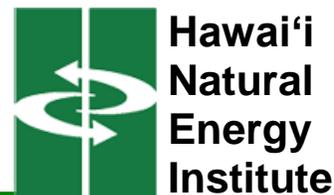


# Project Frog: Net Zero Energy Comparative Analysis



With the goal of demonstrating the feasibility of energy neutral institutional facilities in different microclimates, the Hawai'i Natural Energy Institute contracted Project Frog of San Francisco, CA, to install 3 high efficiency, energy neutral research platforms in two schools in Hawai'i. The platforms are designed to maximize natural ventilation, minimize heat gain, utilize natural daylighting while providing a comfortable interior environment. A 5 kW solar photovoltaic (PV) system generates more energy than the building uses. Two Project Frog platforms are installed on the Kawaikini New Century Charter School in Lihue, Kauai, and one is on the 'Ilima Intermediate School campus in Ewa Beach, Oahu.



Figure 1: Project Frog Kawaikini NCPS, Kauai

## Challenge & Significance

In most settings, buildings may have thermostats, and little else, to precisely understand how they perform. The net zero energy (NZE) platforms were installed as research prototypes to study in detail indoor comfort and energy disaggregation in direct relation to the external environment. Interior sensors capture temperature, humidity, lighting, CO<sub>2</sub> levels, and energy consumption of lights, fans, AC and plug loads. Weather stations capture local conditions.

In addition to comparisons of the same structure in different microclimates, this project is monitoring and comparing other classroom typologies found in Hawai'i schools, including another NZE structure. The data collected will be useful for informing the design of institutional structures in Hawai'i and other tropical climates.

## Status & Accomplishments

- 'Ilima Frog platforms were completed, Sept. 2011.
- Two Kawaikini Frog platforms completed, May 2013.
- All platforms exceeded projections and are net energy producers.

Research Platform	Annual Energy Consumption (kWh)	Annual Energy PV Generation (kWh)	Net Energy Margin (kWh)
Kawaikini East	3,084	7,629	4,545
Kawaikini West	3,448	7,662	4,214
Ilima Intermediate	7,600	9,050	1,450

- Monitoring equipment installed at Kawaikini and 'Ilima, January 2013.
- Assessment and selection of comparative classrooms, began January 2013.
- Draft Final Performance Report delivered, October 2014.
- Monitoring will continue on these structures through 2015, with time extensions likely.

### Contact(s):

Jim Maskrey  
808-956-3645  
[maskrey2@hawaii.edu](mailto:maskrey2@hawaii.edu)

Richard Rocheleau  
808-956-8346  
[rochelea@hawaii.edu](mailto:rochelea@hawaii.edu)

### Period of Performance:

2011-2016

### Partner(s):

- [Project Frog](#)
- [MKThink](#)
- [roundhouseOne](#)

### Funding:

- [Office of Naval Research](#)

Hawai'i Natural Energy Institute | School of Ocean & Earth Science & Technology

University of Hawai'i, 1680 East West Road, POST 109 • Honolulu, HI 96822

[www.hnei.hawaii.edu](http://www.hnei.hawaii.edu) • Ph: (808) 956-8890 • Fax: (808) 956-2336

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## Project Detail

Twenty five sensors are deployed in each of the Project Frog research platforms. Eight sensors measure energy consumption while 17 sensors gather detailed temperature, humidity, illuminance, air speed and CO<sub>2</sub> levels. The analyses explores relationships between external factors and internal factors, helping to identify drivers of energy consumption as well as user patterns that may impact consumption or comfort. Figure 2 illustrates the energy efficiency strategies being measured.

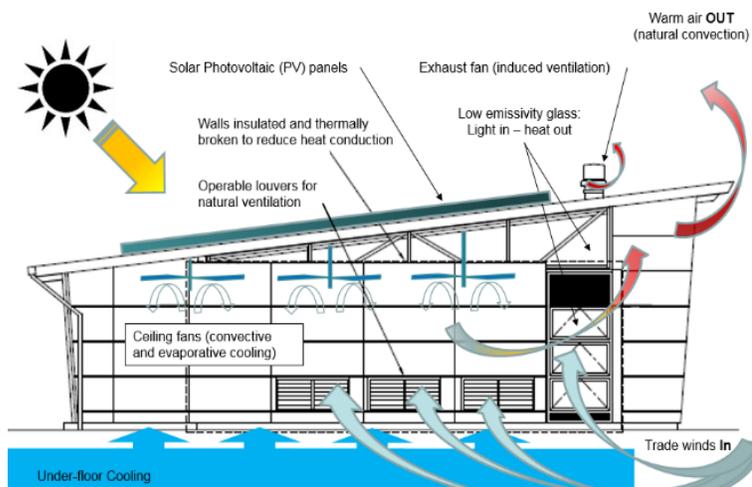


Figure 2: Energy Efficiency Strategies

For the first year studied, the building performance of the two Kawaikini platforms exceeded the projections (Figure 3). The project plan projected 3 levels of energy usage, High, Anticipated, and Optimal. The actual results show that the buildings (and occupants) used 14% less energy than predicted under the Optimum scenario. Complementing the efficiency of energy usage, the 2 solar PV systems generated an average of 7,645 kWh each totaling 15,291 kWh over the year. Combined they generated 8,759 kWh more than they consumed with the excess electricity absorbed by other end-uses at the school.

Preliminary findings for the comparative Ewa Beach platform at 'Ilima Intermediate indicate a higher energy consumption of 7,600 kWh. This was anticipated because the microclimate is generally warmer and sunnier than the Kaua'i site. Solar production at the 'Ilima site is also higher with 9,600 kWh generated on the identically sized PV array.

The data analysis for the other comparable classrooms will be available late 2015. Two additional Project Frog platforms of a different design are in the process of being installed at UH Manoa campus, and are anticipated to be complete in spring 2016.

Energy usage Analysis Kawaikini Charter School		High Estimate	Anticipated Performance	Optimal Performance
Load Description		kWh/yr	kWh/yr	kWh/yr
Projected	<b>Systems</b>			
	Mechanical Cooling	3,838	3,458	500
	Fans	1,000	220	1,000
	Lighting	2,008	1,028	1,028
	Plug Loads	1,278	1,278	1,278
	<b>Total</b>	<b>8,124</b>	<b>5,984</b>	<b>3,806</b>
	Energy Per Building	8,124	5,984	3,806
	<b>Total Energy (combined)</b>	<b>16,249</b>	<b>11,968</b>	<b>7,612</b>
Actual	Actual Annual Energy Consumption (combined)			6,532

Figure 3. Estimates Compared to Actual (Kawaikini)