Next Generation NZE: Inheriting the Good Genes

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Objectives for today

• Compare the performance of two generations of NZE structures: **10 to 47% improvement**

• Compare the performance of **innovative energy saving control strategies**

• Demonstrate **user preference & behavior on energy consumption**
Project FROG: “Flexible Response to Ongoing Growth”

Buildings area: 1,280 sf

1st generation - Frog


Ilima Intermediate School, Ewa Beach, Oahu (2010)

Buildings area: 1,440 sf

2nd generation - Frog

University of Hawaii at Manoa Campus, Oahu (2015-2016)

Designed to actively engage users while utilizing partially automated controls

Middle and high school classrooms

K-12 and university classrooms
Features to manage energy and comfort

**Energy Efficient Design**
- Orientation, insulation, high performance glazing

**Lighting**
- Daylight harvesting LED fixtures w/ O.S.
- Optional during day

**Windows and daylighting**
- Operable windows north and south. High clerestory windows

**Ceiling Fans**
- Air movement across skin
- Standalone or augments the HVAC

**Air Conditioning**
- Designed for mixed mode, higher delivery temp; 1 hour *ON-DEMAND* timer/thermostat
- AC will cycle to OFF between classes and not run unless activated
Comparative results

<table>
<thead>
<tr>
<th>Location</th>
<th>Average EUI (kBtu/sf-yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st generation</td>
<td>17.46</td>
</tr>
<tr>
<td>2nd generation</td>
<td>9.24</td>
</tr>
</tbody>
</table>

Overall Savings: 47.8%

- Ilima: 31.83 kBtu/sf
- Kawaiwiki East: 14.79 kBtu/sf
- Kawaiwiki West: 5.77 kBtu/sf
- UHM Frog 1: 10.37 kBtu/sf
- UHM Frog 2: 8.11 kBtu/sf
2nd generation Frogs

Designed to actively engage users integrating partially automated controls:

- **Lighting** – daylight harvesting sensors
- **HVAC** – On-Demand control
- **Ceiling fans** – 100% manual
Daylight harvesting & lighting controls

• Occupancy Sensors

• Daylight harvesting system
  • Energi Savr Node™ lighting management system by Lutron
  • 2 sensors per classroom

• Manual override for 100% daylighting
Energy Savings: Lighting
Actual energy used & percentage of savings

**FINDINGS**

- 457 kWh with no controls & lights at full brightness from 7:00am to 7:00pm

- The most effective intervention is manual
HVAC Controls

• Mixed Mode
• On-Demand HVAC control
  • ON: Manual override only
  • OFF: Auto-off in 1 hour

• Temperate climate
• Natural ventilation often sufficient
• Class schedules vary
• Ceiling fans augment ventilation to bring into comfort zone
Decisions: To cool or not to cool?

Ex. 1

**FROG 1**

Mon, Aug 28

Occupancy hours:
7.30am-12.30pm;
1:45pm-4:15pm

**FROG 2**

Mon, Aug 28

Occupancy hours:
7.30am-12.30pm;
1:45pm-4:15pm;
4:30pm-7:00pm
Decisions: To cool or not to cool?

Ex. 2

The “Awareness” Premium
Conventional vs On-Demand HVAC control

FINDINGS

- 84% savings over conventional thermostat
- Usage floats with existing class schedules and outdoor conditions
Tragedy of the commons

“Individual users, acting independently and rationally according to their own self-interest, behave contrary to the common good of all users.”

- Garrett Hardin -
Training Users:

“What the heck is *Mixed Mode* anyway?”

- Familiarize with controls
- Provide real time feedback
- Embed NZE as a “culture”
**Decision:**
Do we need the lights?

**Weekly average lighting power for afternoon class session for occupied hours**
Weekly average of HVAC power for morning class for occupied hours
Ex. 2.1 Air conditioning

Decision:
Do we need the A/C?

Ave. Weekly HVAC energy (kWh) for single class period
Conclusions and Recommendations

• Balance user engagement and sense of control with automation
  • Training, education and awareness

• Keep it Simple...
  • Offer cues and *clarity*

• Predictive modeling is useful during design ...
  • But for that pesky behavior

Lessons Learned:
Complex Interactions Impact Performance
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Engagement

Tragedy of the commons

Individual users, acting independently and rationally according to their own self-interest, behave contrary to the common good of all users.

-Garrett Hardin

Thank you

• Automated or manual controls?
• Should performance be dependent upon user awareness?