University of Hawaii at Manoa’s School of Architecture

ADVANCED BUILDING SIMULATIONS AND SUSTAINABLE PRACTICES
FOR HAWAII’S TROPICAL CLIMATE
Today’s Brown Bag program:

• A series of 5 minute presentations by ERDL affiliated researchers followed with opportunities to network and discuss (We have 5 presenters)

• Opportunity to: VISIT ERDL FACILITY AT 12:45PM AND Q&A
What is ERDL?

A growing research center for innovative energy technology applications and advanced simulations for buildings in tropical climate.

A place for students to grow in their understanding and application skills for advanced numerical methods and technologies to improve building performance.
DEVELOPING STUDENT SKILLS FOR FUTURE SUSTAINABLE DESIGN AT ERDL

Manfred J. Zapka, Ph.D., P.E., ENV SP, LEED AP, CEM, CEA
Adjunct Professor for Sustainable System Design
Architectural & Energy Engineering Advisor
UHM’s School of Architecture
Implications of New Design Parameters to the Built Environment:

Increased cost and scarcity of key resources:
- Petroleum, Freshwater, Key minerals

Changes to the operating environment
- Rise in ambient temperature
- Extreme weather events: Storm intensity
- Extended heat waves & Droughts
- Sea level rise, erosion and flooding

Future Trends Important for the New generation of Building Professionals:
Paradigm Shifts in Designing and Operating the Built Environment
Change in Our Understanding of Sustainable Design:

**Today:** Are We Doing Our Project Right?

**In Future:** Are We Doing the Right Project?

Future Trends Important for the New generation of Building Professionals:
Change of How We Perceive Sustainable Buildings & Infrastructure

Balance project benefits against risks & gain to the community, planet and Triple Bottom Line
Nexus of Sustainable Buildings and Infrastructure:

Buildings are small elements of the Built Environment

Need Systems Thinking and Design

We cannot design our buildings on an “island”

Future Trends Important for the New generation of Building Professionals:
Nexus of Sustainable Buildings and Infrastructure – Integrated Design
Future Trends Important for the New generation of Building Professionals: Nexus of Sustainable Buildings and Infrastructure – Integrated Design

**Systems (building level)**
- Energy efficiency and adapted comfort in buildings

**Systems (infrastructure level)**

**Data Base Applicants - BIM**
- “Static” building information systems

**Dynamic Bldg. performance optimization:**
- Energy simulation
- CFD simulation
GROW HONOLULU’S BUILDING PERFORMANCE SIMULATION COMMUNITY

Wendy Meguro
Assistant Professor
Sustainable Buildings & Community Design
UHM’s School of Architecture and UH Sea Grant College Program
Where does the energy go?

US Energy Use by Sector

- Building Operations: 41.7%
- Industry: 24.4%
- Building Construction and Materials: 5.9%
- Transportation - Other (rail, air, bus, truck, ship): 11.8%
- Transportation - Light Duty (auto, SUV, pickup, minivan): 16.3%

Image: Architecture 2030
Data Source: US Energy Information Administration 2012
Hawaii’s electricity is expensive!

Source: http://www.hawaienergyreportcard.org/economics.html
What can architects do?

Hawaii Clean Energy Initiative

The Hawai‘i Clean Energy Initiative is leading the way in relieving our dependence on oil by setting goals and a roadmap to achieve **70% clean energy by 2030** with **30% from efficiency** measures, and **40% coming from locally generated renewable** sources.

![Equation](http://www.hawaiicleanenergyinitiative.org/)

http://www.hawaiicleanenergyinitiative.org/
Goal: Grow Honolulu’s Building Performance Simulation Community
Use simulation as a design tool. Address daylight, glare, solar heat gain, whole-building energy use.
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Current Work from Graduate Architecture Systems Class: Environmental Technology, Sustainability & Simulation

Next steps … help inform tropical energy standards
HNEI – ERDL COLLABORATION TO HIGH PERFORMANCE BUILDINGS AND ENVIRONMENTAL SUSTAINABILITY

Jim Maskrey
Associate Specialist
University of Hawaii, Hawaii Natural Energy Institute (HNEI)
Hawaii Natural Energy Institute

Organized Research Unit in the School of Ocean and Earth Science and Technology, University of Hawaii at Manoa

- Basic and applied research (R&D) across many energy technologies
- Testing and evaluating (T&E) of renewable generation and energy efficiency technologies
- Supporting State of Hawaii energy assessments and policy development
- Managing public-private partnerships to demonstrate energy solutions in real world (on-grid) settings
- Contributing to STEM and workforce development

HNEI programs are multi-disciplinary with significant cost share from industry
HNEI Alternative Energy Research

Organized Research Unit in the School of Ocean and Earth Science and Technology, University of Hawaii at Manoa

• Alternative Fuels
  • Biomass and biofuels; Hydrogen; Methane hydrates

• Electrochemical Power Systems
  • FC for unmanned vehicles, FC contaminant mitigation
  • Battery testing, Electric vehicles

• Renewable Power Generation
  • Ocean Energy (OTEC, Wave); Photovoltaics

• Energy Efficiency
  • Building technology; Natural ventilation / comfort

• Systems Integration/Energy Security
  • Smart grid development
  • Microgrids
  • Grid-scale storage
High Performance Buildings

Objective: Validate performance and durability of High Performance (HP) modular, readily deployed building platforms.

High Performance Buildings Designed to optimize human performance using:

- Efficient lighting and daylighting
- Natural cooling and ventilation
- Advanced energy controls
- HP designs facilitates net-zero energy for on-grid or off-grid uses with rooftop PV.

- Hawaii prototypes instrumented, monitored and simulated for performance prediction.
- Performance modeling tools to be validated with local buildings for application in hot-humid environments.
ENERGY AUDITS AND VERIFICATION

Eileen Peppard
Sustainability Specialist
Environmental Research and Design Laboratory (ERDL)
Center for Smart Building and Community Design
University of Hawaii Sea Grant College Program
ENERGY AUDIT AND ENERGY MONITORING

Methods:
- Observations, measurements, and monitoring
- Data management and analysis
- Energy disaggregation
- Evaluation of existing energy performance
- Input data into energy simulation models
- Provide hypothesis for a solution
- Monitor and verify results of solution

ERDL Team:
- Instructors, faculty
- Researchers
- Students
- (undergrad + Grad.)
- Post-Doctoral Fellows

Students in building science class at ERDL in 2012

Student getting hands-on experience with a real-world project
ENERGY AUDIT AND ENERGY MONITORING – OBSERVATIONS

- Attic Insulation
- Air conditioner condenser
- Air conditioner register

ERDL team works with military housing managed by Forest City

Using thermal gun to see thermal bridging

Observe leaks in air duct
ENERGY AUDIT AND ENERGY MONITORING – MEASUREMENTS

- Blower door testing
- Duct testing
- Air handler observations
Energy audit and energy monitoring – **Monitoring + Verification**

Commercial Building Example: Kuykendall Hall

- 80 sensors on wireless network:
  - 5 air velocity
  - 2 globe temperature
  - 26 temperature
  - 22 relative humidity
  - 25 energy

Weather station with internet:
- 8 measurements

Stand-alone loggers:
- 8 light & occupancy
- 8 energy loggers for window AC units
SHOWCASE OF THE UHM BUILDING OF THE FUTURE – KUYKENDALL HALL

Tuan Tran, D.Arch
Research Associate and Post-doctoral Fellow at Environmental Research and Design Laboratory (ERDL)
UHM’s School of Architecture
THE FUTURE.....

THE RENOVATION OF KUYKENDALL HALL AT THE UNIVERSITY OF HAWAII AT MĀNOA IS PART OF THE DEPARTMENT OF ENERGY'S (DOE) COMMERCIAL BUILDING PARTNERSHIPS PROGRAM. THIS PROGRAM IS PART OF DOE'S LARGER NET-ZERO ENERGY COMMERCIAL BUILDING INITIATIVE.

CURRENT CONDITION

KUYKENDALL HALL RENOVATION PROJECT

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GOALS
• 1st zero net energy retrofit in Hawaii
• Redesign from sealed a/c to natural ventilation
• Improve comfort and reduce energy demand (zero fossil balance)
• Set new standard for building design and performance for the University and State

PARTNERS AND CONSULTANTS
• Benjamin Woo Architects – Hawaii
• Loisos and Ubbelohde- California
• U.S. Dept. of Energy
  – Lawrence Berkeley National Lab (LBNL)
  – Commercial building Partners Program
  – Better Buildings Challenge (White House Initiative)
• UC Berkeley – Center For the Built Environment

Photo credit: Benjamin Woo Architects
Anemometer calibration

On-site weather station collecting data on Kuykendall building’s roof top

Real-time online weather data

KUYKENDALL HALL RENOVATION PROJECT – ENERGY AUDIT + MONITORING

Annual outdoor temperature at UHM campus

Annual outdoor wind velocity at UHM campus
Ventilation analysis from wind tunnel measurement at the Center Built Environment – U.C. Berkeley

KUYKENDALL HALL RENOVATION PROJECT – ENERGY AUDIT + MONITORING

Air flow visualization from wind tunnel testing

Cross ventilation strategy

Wind tunnel measurement allows for testing different louvers’ configurations and optimizing the airflow performance inside the building.
Annual thermal comfort results —
A visual tool used to assess hourly thermal comfort performance over the course of a year

Adaptive thermal comfort (ASHRAE 55-2010)

90% acceptability limit
80% acceptability limit
uncomfortable
borderline (within 1°C or 1.8°F of uncomfortable)
comfortable

Predicted Illuminance level false color map

Visualization of the performance of the Integrated electric lighting and daylighting design
PREDICTED COMPARATIVE SAVINGS FOR:
PRE-RETROFIT DESIGN AND PROPOSED DESIGNS FOR KUYKENDALL HALL

US Department of Energy (DOE) and
EERE – Building Technologies Program Case Study Report - Fall 2012
VISIT OF ERDL FACILITY AND Q&A

Our lab also welcomes visitors
during ARCC/EAAE 2014 International Conference

THANK YOU!