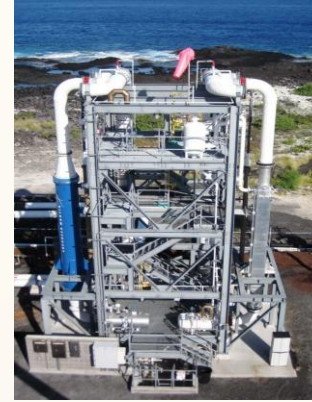




# Clean Energy Opportunities in Hawaii are Abundant



# *Rapid Development of Renewable Resources **Today***

## **Wind**



## **Solar**



# The Maui island Experience

## 72 MW of Wind Power

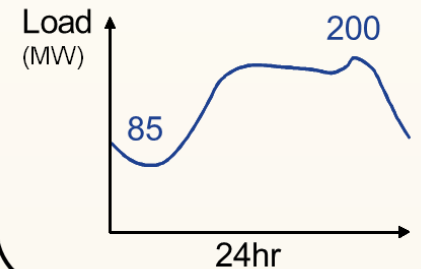
**KWP**  
**(30MW 2006)**

**KWP II**  
**(21MW 2012)**

**AWE**  
**(21MW 2013)**

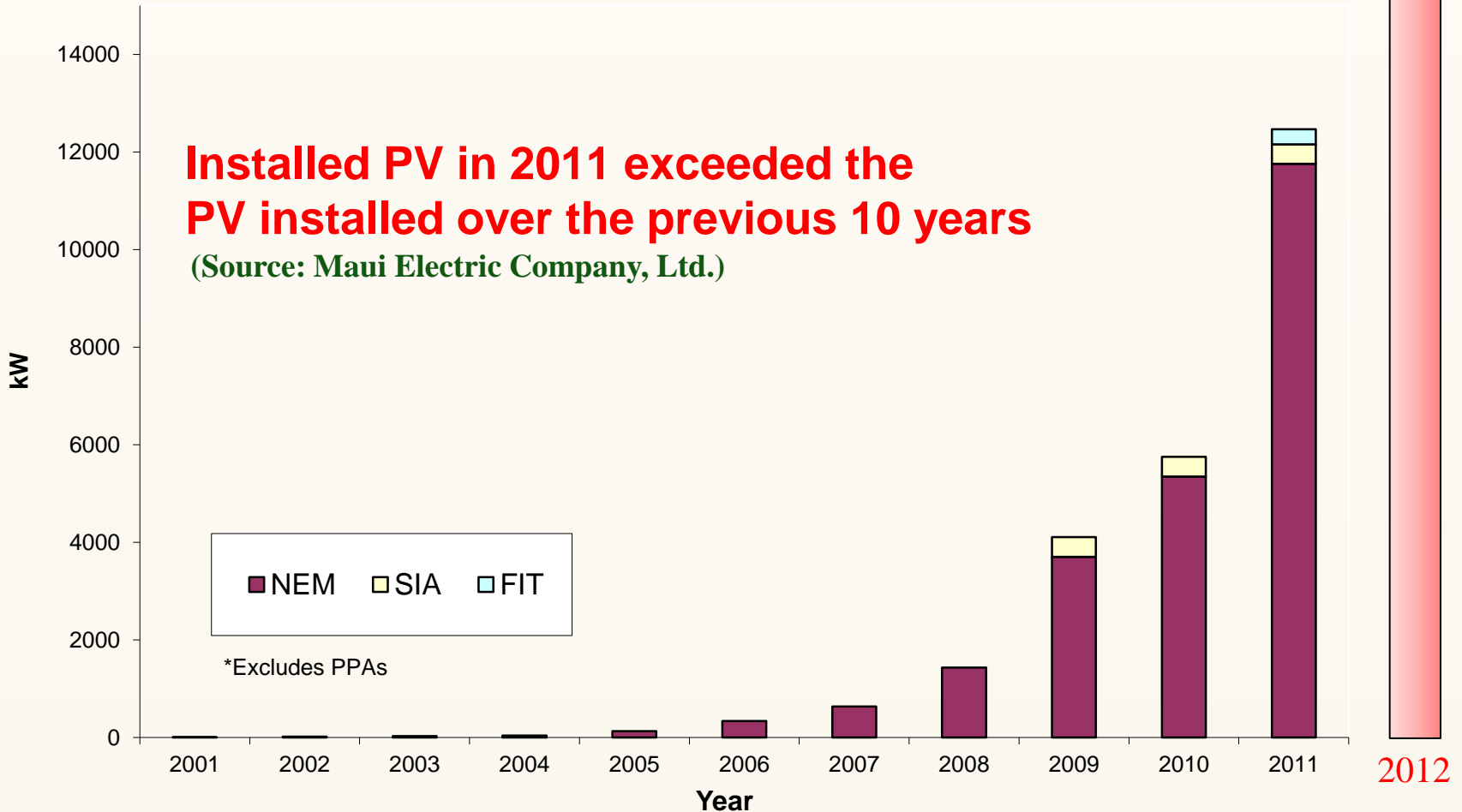
63,000 Customers

Daily Load Shape



# Exponential Growth in PV Market

## Island of Maui

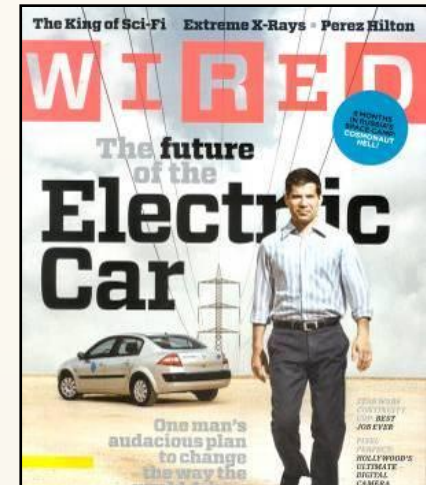


*Integrating High Penetrations of PV on Distribution Feeders is Today's Challenge in Hawaii*

# Electrifying Transportation

- 1/3 of oil imported for ground transportation
- Driving electric vehicles are ...
  - a good fit for Hawaii
  - cleaner (less CO2)
  - cheaper
    - Mitsubishi “i” @ 9 cents/mile (30 cents/KWh electricity)
    - Avg. Gas Car @ 20 cents/mile (\$4/gal gas; 20 mi/gal)

OKINAWA  
EV Charging Spot



# ***Making of the Maui Smart Grid***

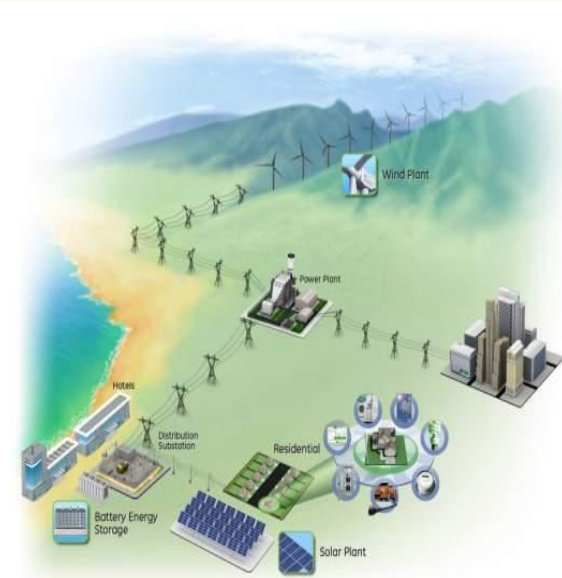
- Maui Smart Grid Demonstration Project (2009) **~\$12 M**
  - US DOE funded, HNEI led project to integrate smart grid technology to achieve reduced peak load on a distribution circuit and better management of intermittent renewable energy
- Japan-US Island Grid Project (2011) **~\$40 M**
  - NEDO funded, Hitachi led project to integrate high levels of PV, wind energy, and EV into an island wide smart grid environment
- Smart Grid-Enabled PV Inverters (2012) **~\$12 M**
  - US DOE funded, HNEI led project to develop and demonstrate advanced PV inverter functionality in a smart grid environment

***Three projects have partners in common and propose to share hardware, results, and lessons learned***

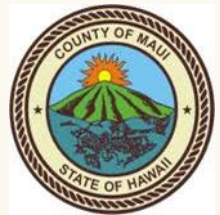


# Maui Smart Grid Demonstration Project (2009)

- Funded by US DOE with cost share from partners
- Implement advanced communications and control technologies to improve grid performance
- Demonstrate new “Smart Grid” technologies to:
  - Reduce peak demand by 15%
  - Better integrate wind and solar power
  - Improve grid reliability
  - **Inform consumer demand decisions**



Maui Electric Company, Ltd.



Hawaiian Electric Company

ALSTOM





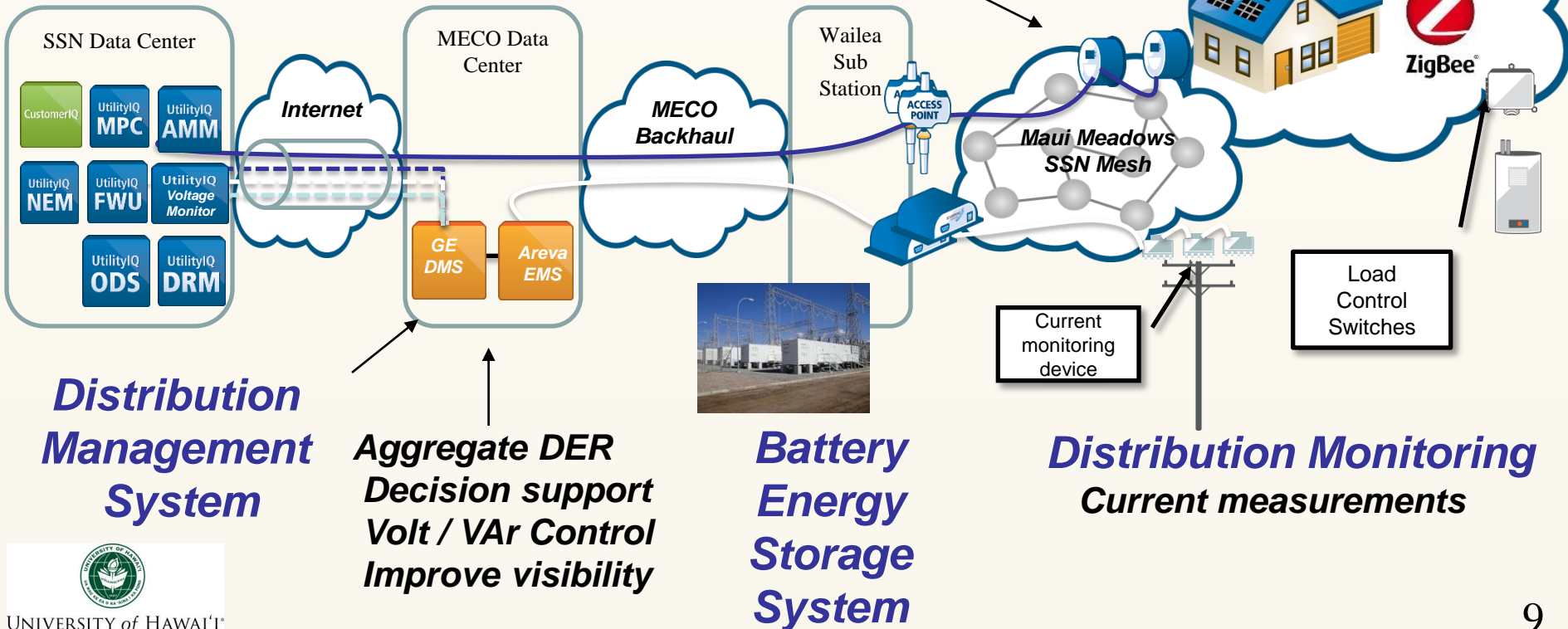
# Project will Manage Distributed Energy Resources (DER) to Support Grid Operations

## Advanced Metering Infrastructure

Two-way comms  
Voltage monitoring  
Outage detection

## Home Area Network

Demand response  
Monitor PV  
Customer feedback



Aggregate DER  
Decision support  
Volt / VAR Control  
Improve visibility

Battery Energy Storage System

Distribution Monitoring  
Current measurements

Distribution Management System

# Development and Demonstration of Smart Grid PV Inverters (2012)

- Enable high-penetration residential PV
- Lower grid integration costs
- Demonstrate benefits of inverter control in differing applications



**Principal Investigator** – Program management and analysis of benefits and impacts of intelligent inverter control capability



**Technology Lead** – Provide end-to-end, standards based, intelligent communications for inverter control



**Inverter Technology Lead** – Provide inverter with advanced grid functionality (AGF)



**Services Lead** – Provide system installation, training, and customer support

**Co-Utility Leads** – Assess capability of inverter AGF to mitigate PV variability impact on distribution feeder and provide other utility benefits



# Solution Architecture

## Utility Back Office Systems

### Inverter Management & Control Software

- Provision inverter on network
- Manage PV Production Data
- Send control signals to inverter
- Monitor status of inverter



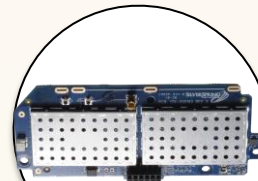
### Customer IQ

- Utility web portal
- Customer can see net bill impact & solar production

## Smart Grid Network

### Silver Spring Networks Network Interface Card

- SEP 2.0 over 2.4 GHz ZigBee
- 900 MHz utility smart grid network
- Retrieve PV production data
- Send inverter control signals through network



900 MHz



2.4 GHz

### Smart Meter

- Utility owned
- Home's primary meter

## Home



- ZigBee Communications Module
- SEP 2.0 DER

### Based on Fronius IG Plus V Inverter

Advanced Grid Functionality (examples)

- Remote generation curtailment
- Remote control of reactive power supply
- Low voltage ride through



# Japan – United States Smart Grid Demonstration Project (2011)



Other supporting partners  
Nissan Motor Co., Ltd.  
Advanced Energy Company  
U.S. Verizon Gr.  
Okinawa Electric Power Co.



Hawaiian Electric Company



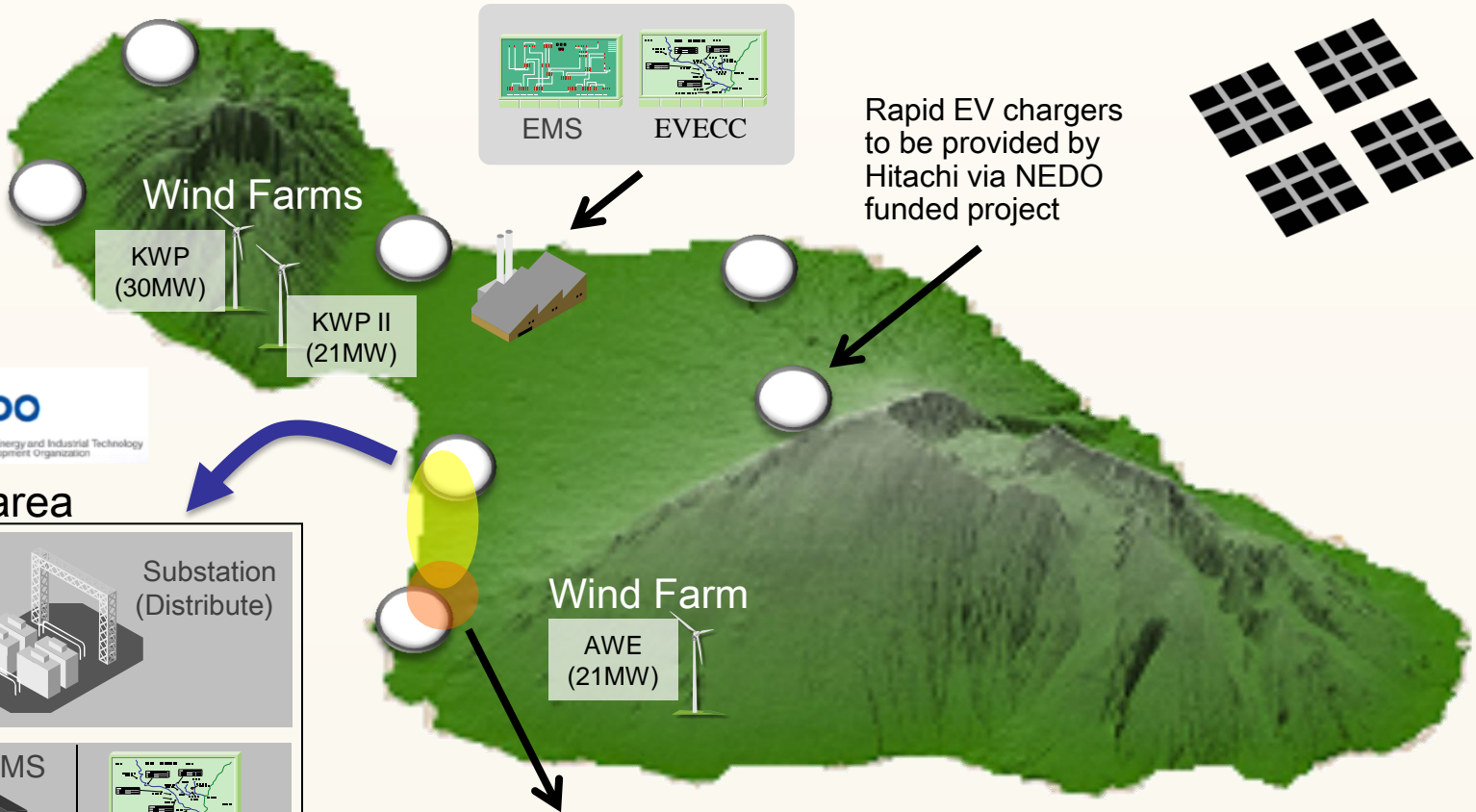
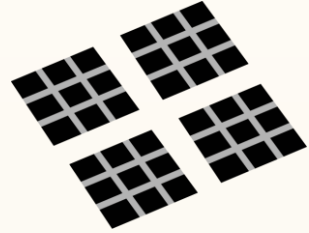
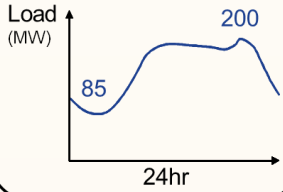
Maui Electric Company



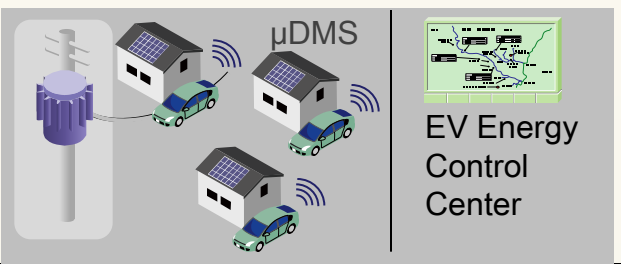
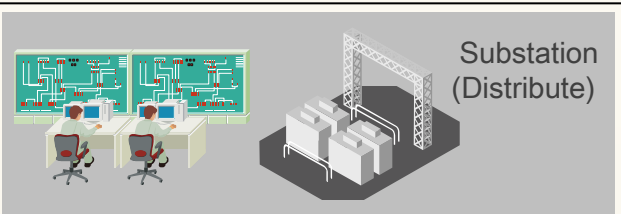
# Integrate Renewables and Transform the Maui Grid

63,000 Customers

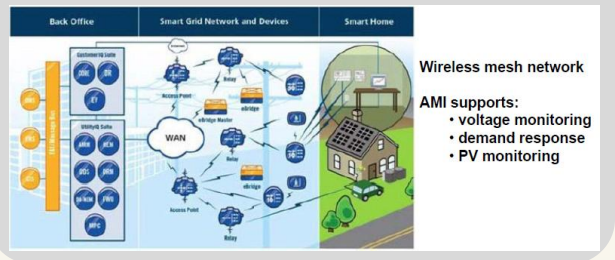
Daily Load Shape



Kihei area



Wailea area

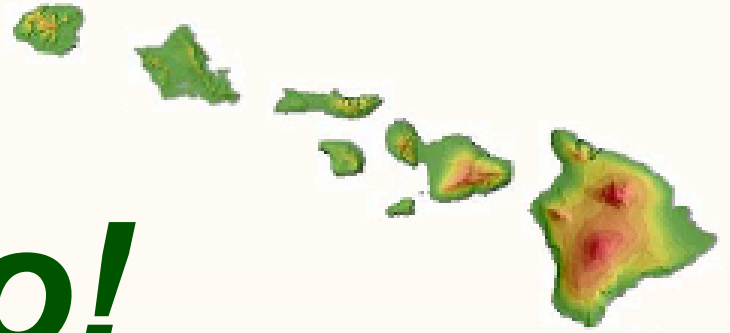


# Bottom Line

- Paradigm shift - energy insecurity → energy security
- Total energy cost (electricity & transportation) lowered and stabilized using renewable energy in place of oil
- **Hawaii** is an ideal working 'lab' to prove concepts and learn lessons about advanced energy technologies
- **Hawaii** as a national and international leader
  - Increasing energy independence
  - Reducing fossil-fuel use
  - Limiting greenhouse gases

## Opportunity for Hawaii to Establish a Clean Energy Economy





# ***Mahalo!***

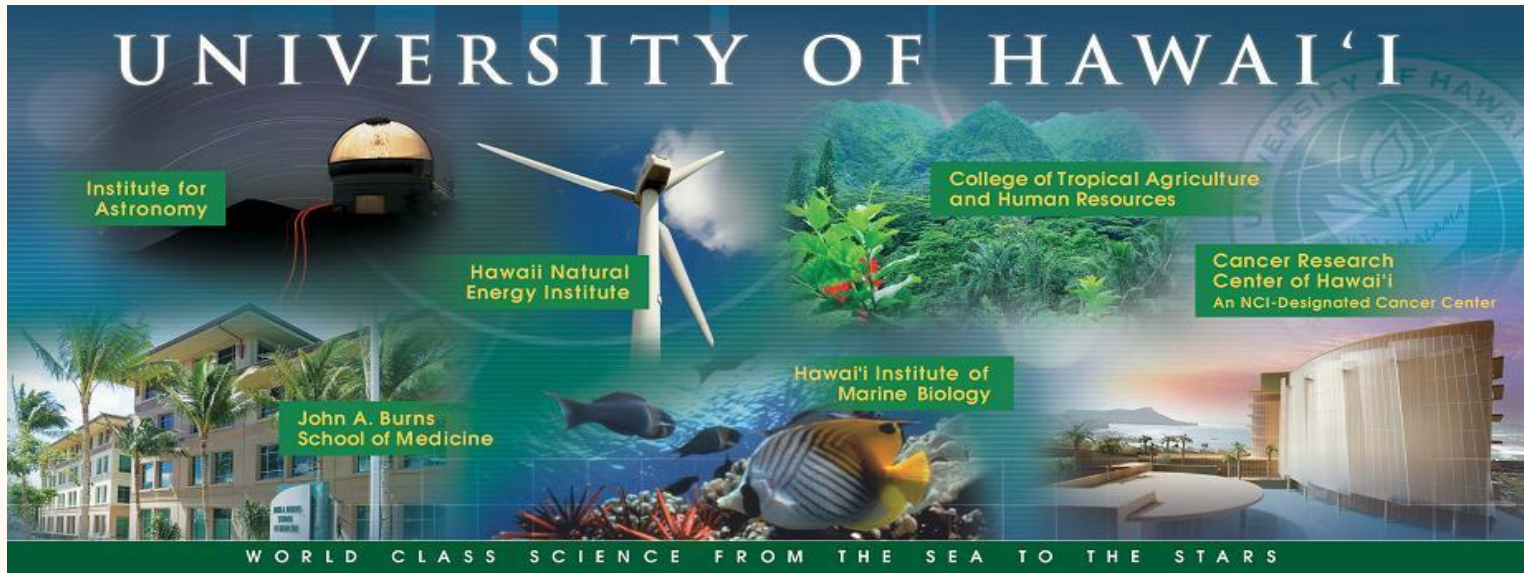
***(Thank you)***



For more information, contact:

Leon Roose  
Hawaii Natural Energy Institute  
School of Ocean & Earth Science & Technology  
University of Hawaii at Manoa  
1680 East-West Road, POST 109  
Honolulu, Hawaii 96822

Office: (808) 956-2331  
Mobile: (808) 554-9891  
E-mail: [lroose@hawaii.edu](mailto:lroose@hawaii.edu)  
Website: [www.hnei.hawaii.edu](http://www.hnei.hawaii.edu)



- Established in 1907
- 3 universities & 7 community colleges
- Over 53,000 students
- Manoa is the largest and main research campus
  - 14,000 undergraduate students
  - 6,000 graduate students



# Hawaii Natural Energy Institute (HNEI)

- **Organized research unit in School of Ocean and Earth Science and Technology, University of Hawaii at Manoa**
- **In existence since 1974. Established in statute in 2006 with mandate to develop renewable sources of energy and to demonstrate and deploy efficient energy end-use technologies**
- **Program Objectives**
  - **Research and development of new energy technologies**
  - **Testing and evaluation of emerging technologies**
  - **Research to support renewable energy deployment**
  - **Energy assessments and policy development**
  - **Develop and manage research partnerships to leverage investment in Hawaii**
  - **Contribute to STEM and workforce development**

*HNEI programs are multi-disciplinary efforts with strong collaboration and cost share from industry*

# HNEI Program Areas

- Hydrogen:
  - Hawaii Hydrogen Power Park
- Fuel Cells:
  - Testing and systems optimization
- Photovoltaics:
  - Thin film solar cells, deployment, testing, and analysis
- Electrochemical Power Systems:
  - Batteries and electric vehicles
- Ocean Resources:
  - Seabed methane hydrates, ocean thermal and wave energy
- Biofuels and biotechnology:
  - Biomass conversion - solid, liquid and gaseous fuels
  - Biofuels fit-for-use
- Grid Analysis and Smart Grids
- Technology Validation, Energy Assessment and Policy

