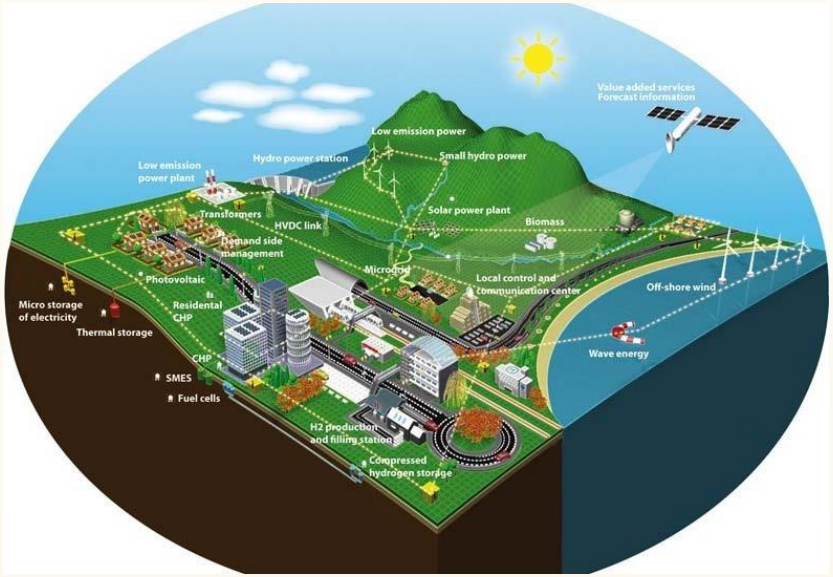
An Introduction to Smart Grids and Microgrids



Marc Matsuura

Sr. Smart Grid Program Manager

GridSTART
Hawai'i Natural Energy Institute | University of Hawai'i

Grid System Technologies Advanced Research Team

HNEI
Hawai'i Natural Energy Institute
School of Ocean and Earth Science and Technology
University of Hawai'i at Mānoa

UNIVERSITY of HAWAI'I
MĀNOA

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

APEC

Expert Group on New and Renewable Energy Technologies

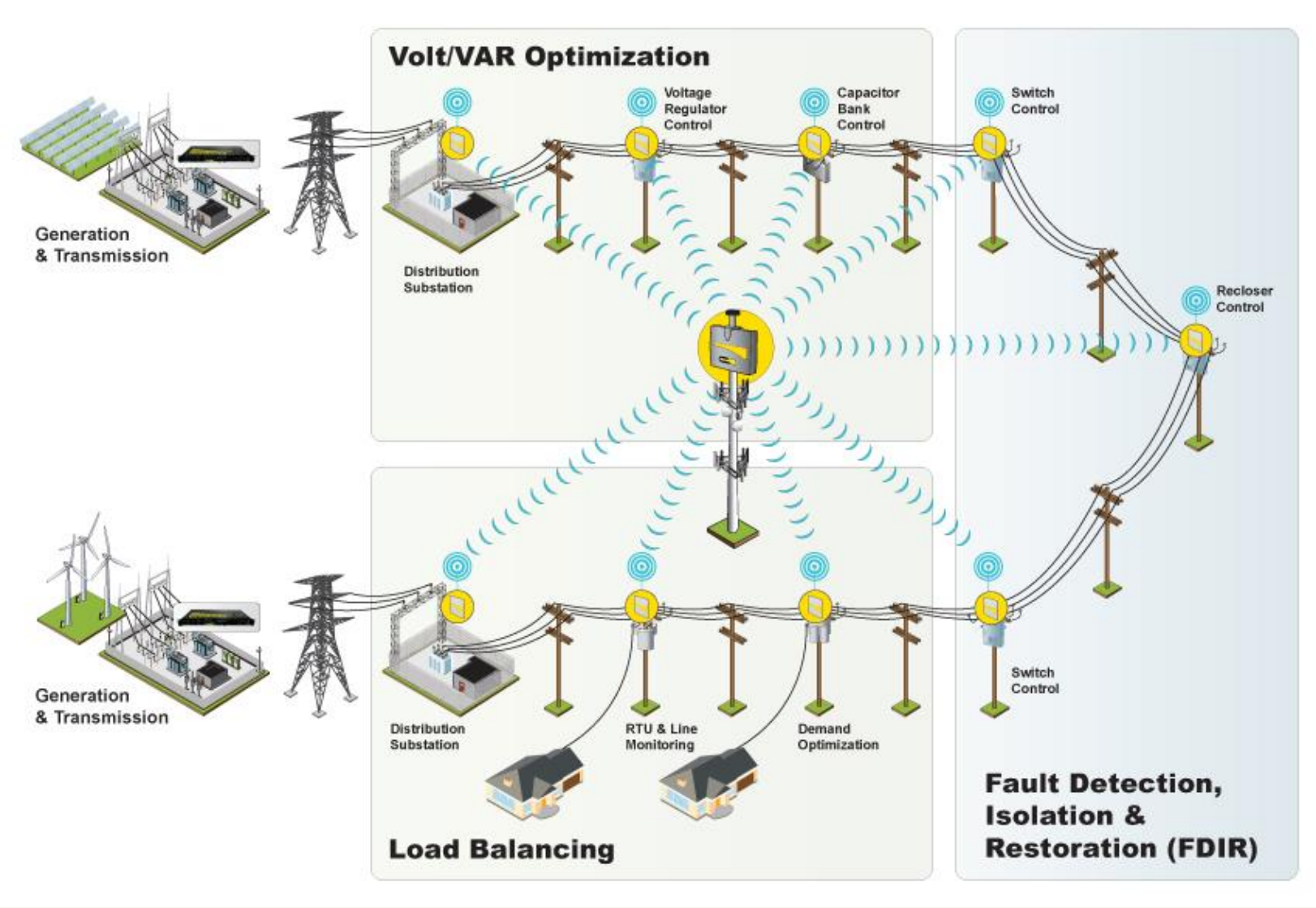
50th Meeting

Honolulu, HI
22 March, 2018

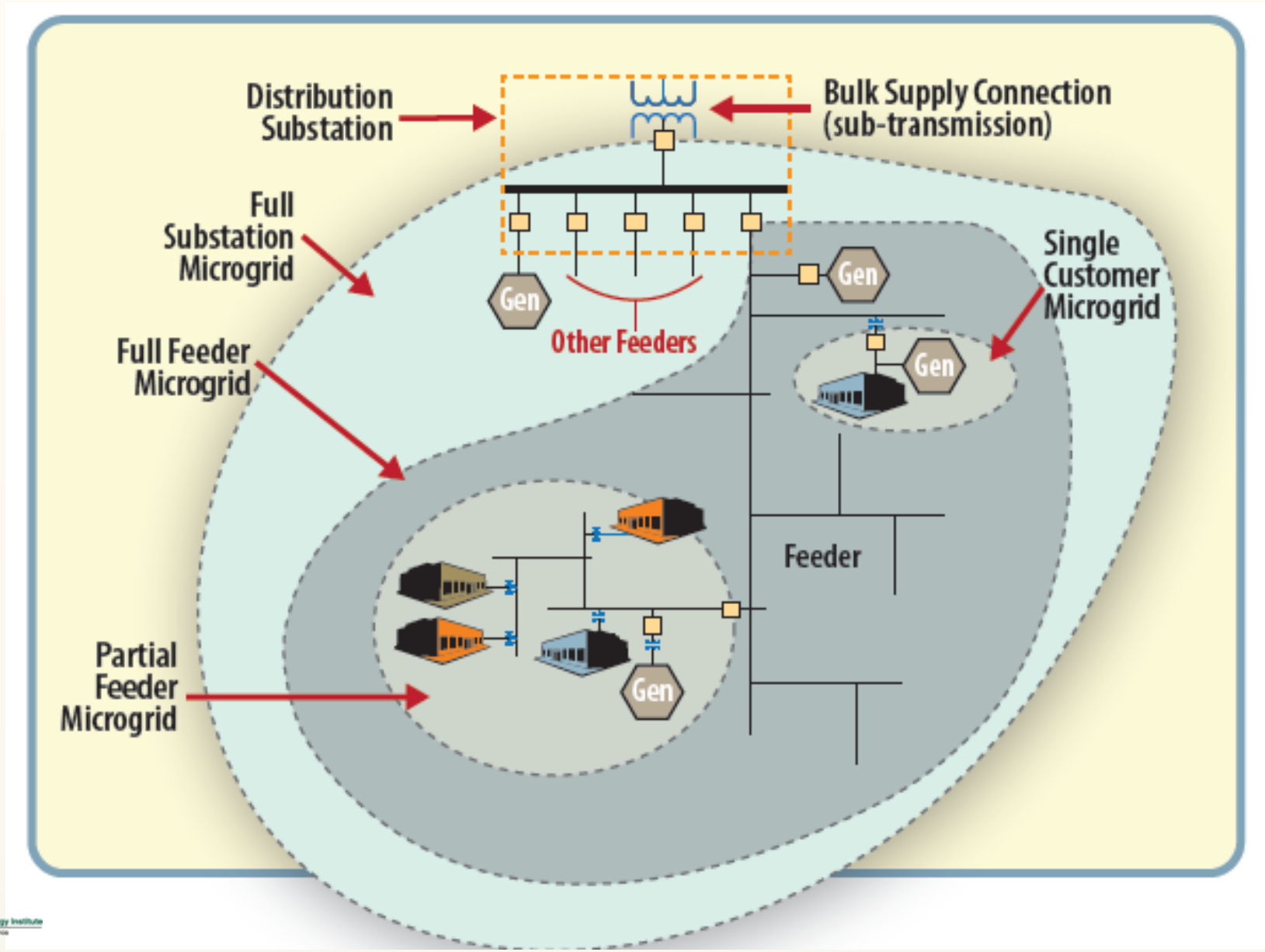
What is a smart grid?

Is it a smart meter?

Is it intelligent control of the power distribution system?

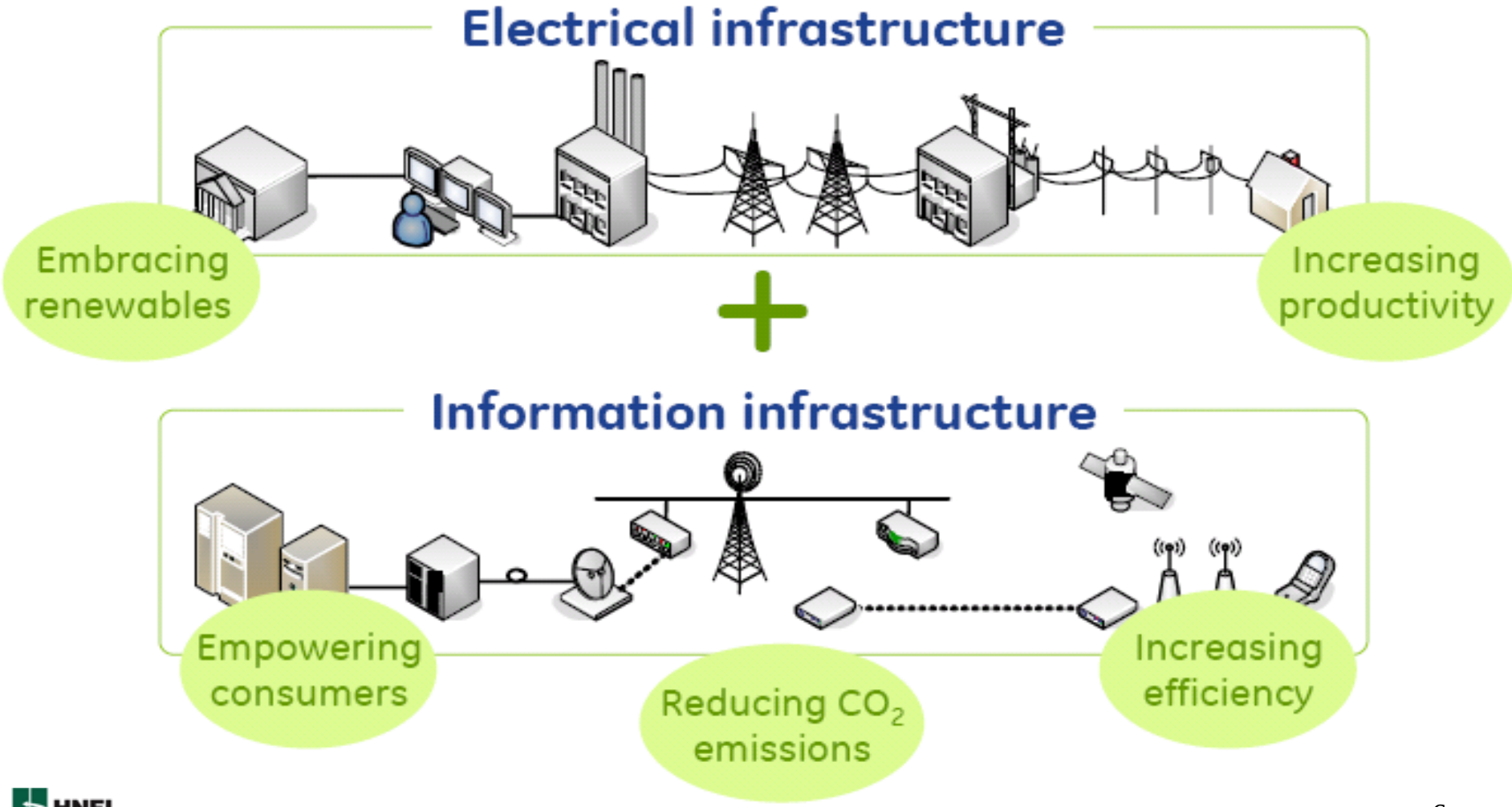


Is it intelligent microgrids?



EPRI Smart Grid

Secure Integration of Two Infrastructures



HNEI Hawai'i Natural Energy Institute University of Hawai'i at Mānoa

Sources: (1) UtilityPoint, by Ethan Cohen 7/18/0 (2) EPRI® Intelligrid

US DoE Smart Grid Characteristics

1. Enables active participation by consumers
2. Accommodates all generation and storage options
3. Enables new products, services and markets
4. Provides power quality for the digital economy
5. Optimizes assets & operates efficiently
6. Anticipates and responds to system disturbances (self-heals)
7. Operates resiliently against attack and natural disaster

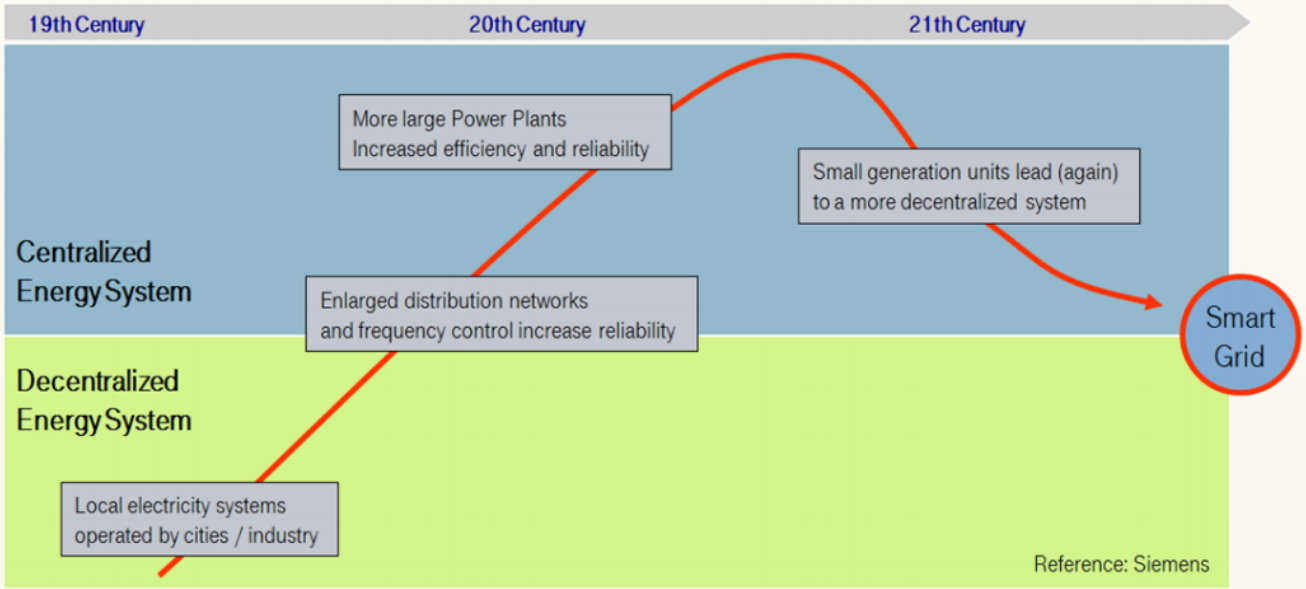
So, what is a smart grid?

It can be one or all of these, and more …

It should be *tailored* based on a *balance* of desired benefits (i.e., your issues to be solved and opportunities to realize) vs. cost to implement

Why do we need a smarter grid?

The Power Grid is Changing



Centralized extremity:
Centralized Energy System
(generation in large Power Plants)

Level of decentralization of a Smart Grid; respectively of several parts of the Smart Grid, that have to work together in one EU Smart Grid System

Decentralized extremity:
Decentralized Energy System
(generation in a very big number of distributed small and midsize generation units, all units are interconnected; large Power Plants did not exist)

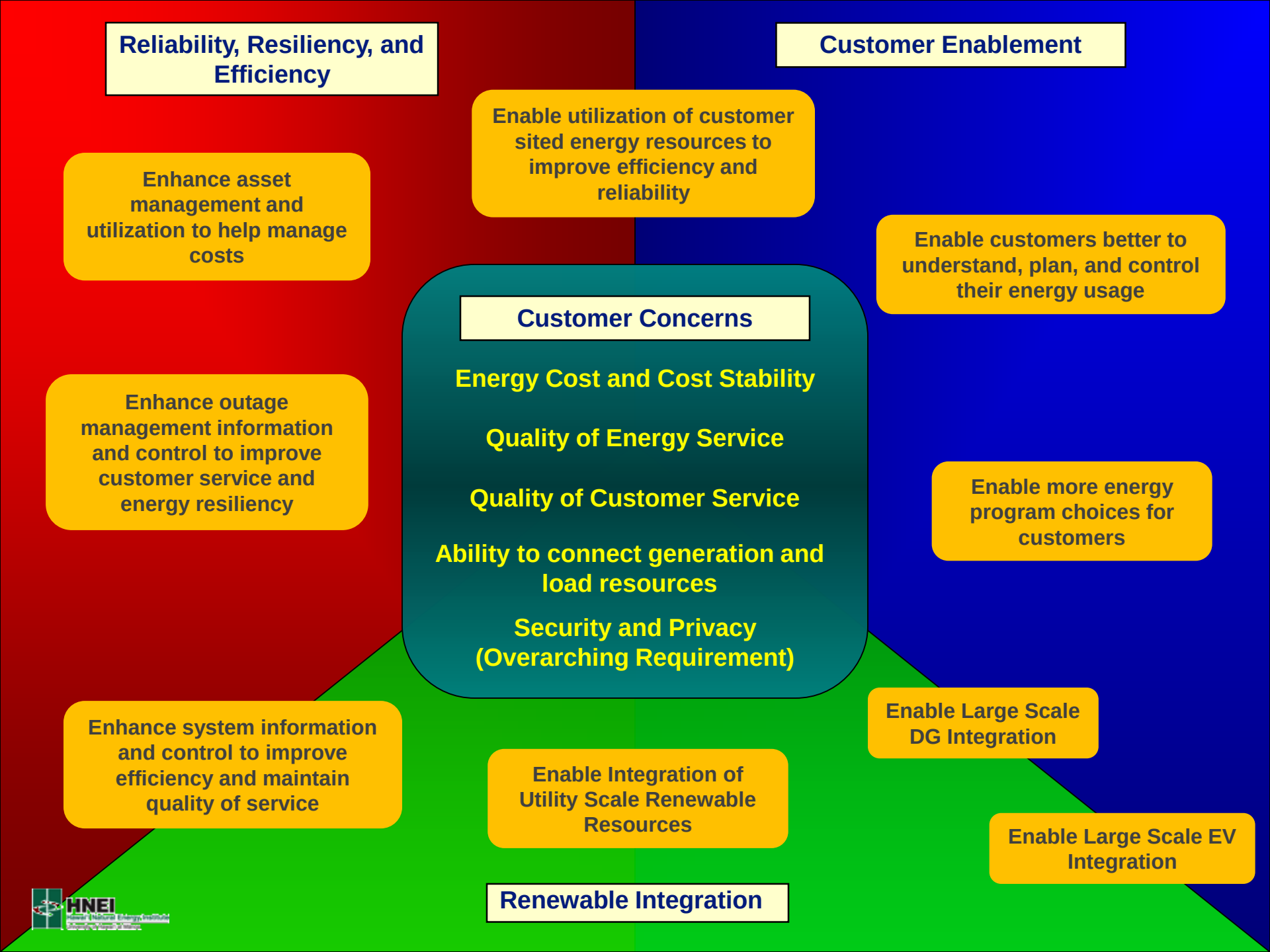
HNEI
Hawai'i Natural Energy Institute
University of Hawai'i at Mānoa

Typical SG Concepts

- Customer
  - More detailed energy usage information (AMI)
  - Faster connect/disconnect (incl. Prepay) (AMI)
  - Reduced outage times / timely outage information (AMI & DA)
  - Time of Use pricing options (AMI)
- Utility
  - Greater visibility and control (AMI & DA)
  - Remote and automated switching and restoration (AMI, DA, & FDIR)
  - Asset Management (AMI & DA)
  - More efficient use of manpower and the grid (AMI & DA)
  - Non-technical loss (energy theft) recovery (AMI)

Advanced SG Concepts

- Customer
  - Demand Response (DR) with two way communication and real-time aggregation
  - Smart PV Inverters
  - Customer Storage Systems
  - Smart EV Charging/Discharging
- Utility
  - Aggregated Distributed Energy Resource (DER) Control (VPP)
  - Volt/VAr Optimization / CVR with high PV penetration
  - Distributed Control Systems
  - Multifunction Central Storage Systems
  - Micro Grid / Hybrid Power Systems


Reliability, Resiliency, and Efficiency
Customer Enablement
Enable utilization of customer sited energy resources to improve efficiency and reliability
Enhance asset management and utilization to help manage costs
Enable customers better to understand, plan, and control their energy usage
Customer Concerns
Energy Cost and Cost Stability
Quality of Energy Service
Quality of Customer Service
Ability to connect generation and load resources
Security and Privacy (Overarching Requirement)
Enhance outage management information and control to improve customer service and energy resiliency
Enable more energy program choices for customers
Enhance system information and control to improve efficiency and maintain quality of service
Enable Integration of Utility Scale Renewable Resources
Enable Large Scale DG Integration
Enable Large Scale EV Integration
Renewable Integration
HNEI

Mapping Goals to Solutions

- Enable customers better to understand, plan, and control their energy usage
  - Smart Meter
  - Customer Information Portal
  - Customer Service Agent Information Portal
  - Customer-Site Energy Storage
- Enhance outage management information and control to improve customer service and energy resiliency
  - AMI outage information
  - Faulted Circuit Indicator information
  - Secondary Voltage Monitoring
  - Outage Management System
  - System outage portal
  - Remote switch operation

Identify Foundational Elements

TECHNOLOGY	HECO	HELCO	MECO
FOUNDATIONAL			
Operational Communications			
Wide Area Networks			
Field Area Networks			
Neighborhood Area Networks			
Sensing & Measurement			
Secondary Voltage Monitoring			
Faulted Circuit Indicators			
Operational Data Management			
Planning Tools			
Operational Systems			
Automated Field Reclosers			
APPLICATIONS			
Smart Meters			

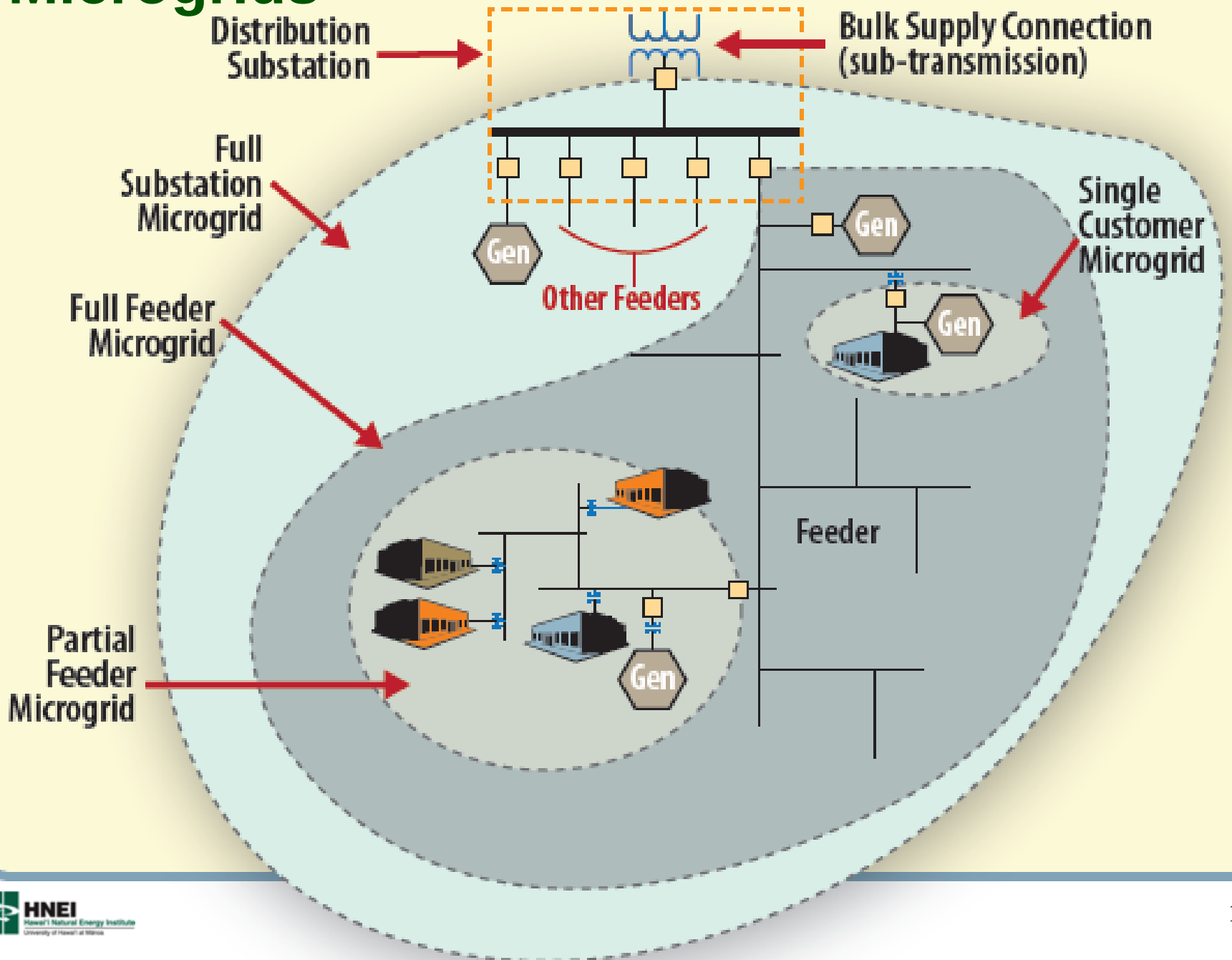
The blue-shaded area in each of the Harvey balls in the table represent the state of progress:
- A fully white Harvey ball means no technology has been deployed.
- A fully blue Harvey ball indicates the technology has been fully deployed.

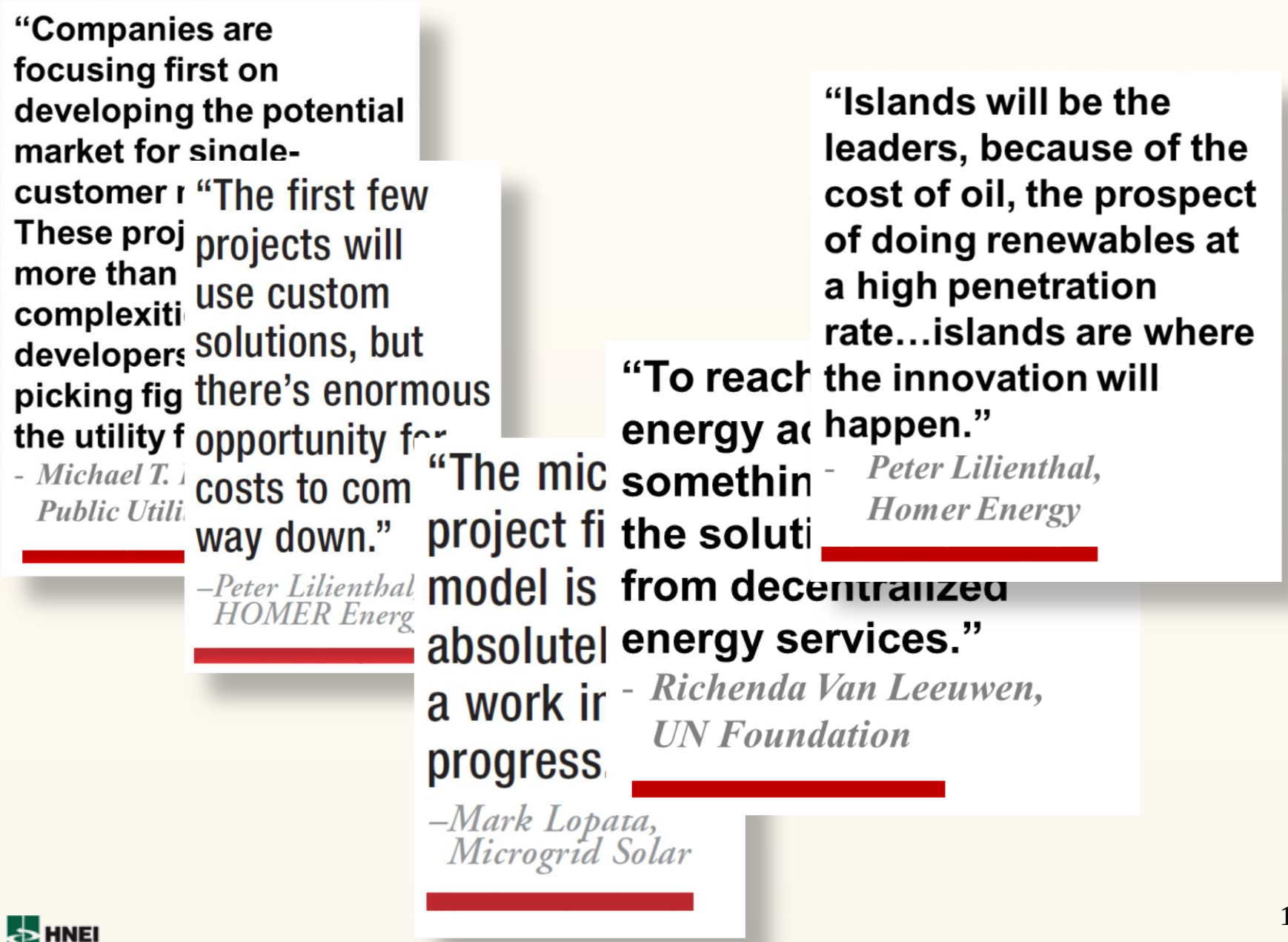
Develop a Deployment Strategy

Table 8 Conceptual Near-Term Deployment of Enterprise Systems and Field Deployments by Operating Company

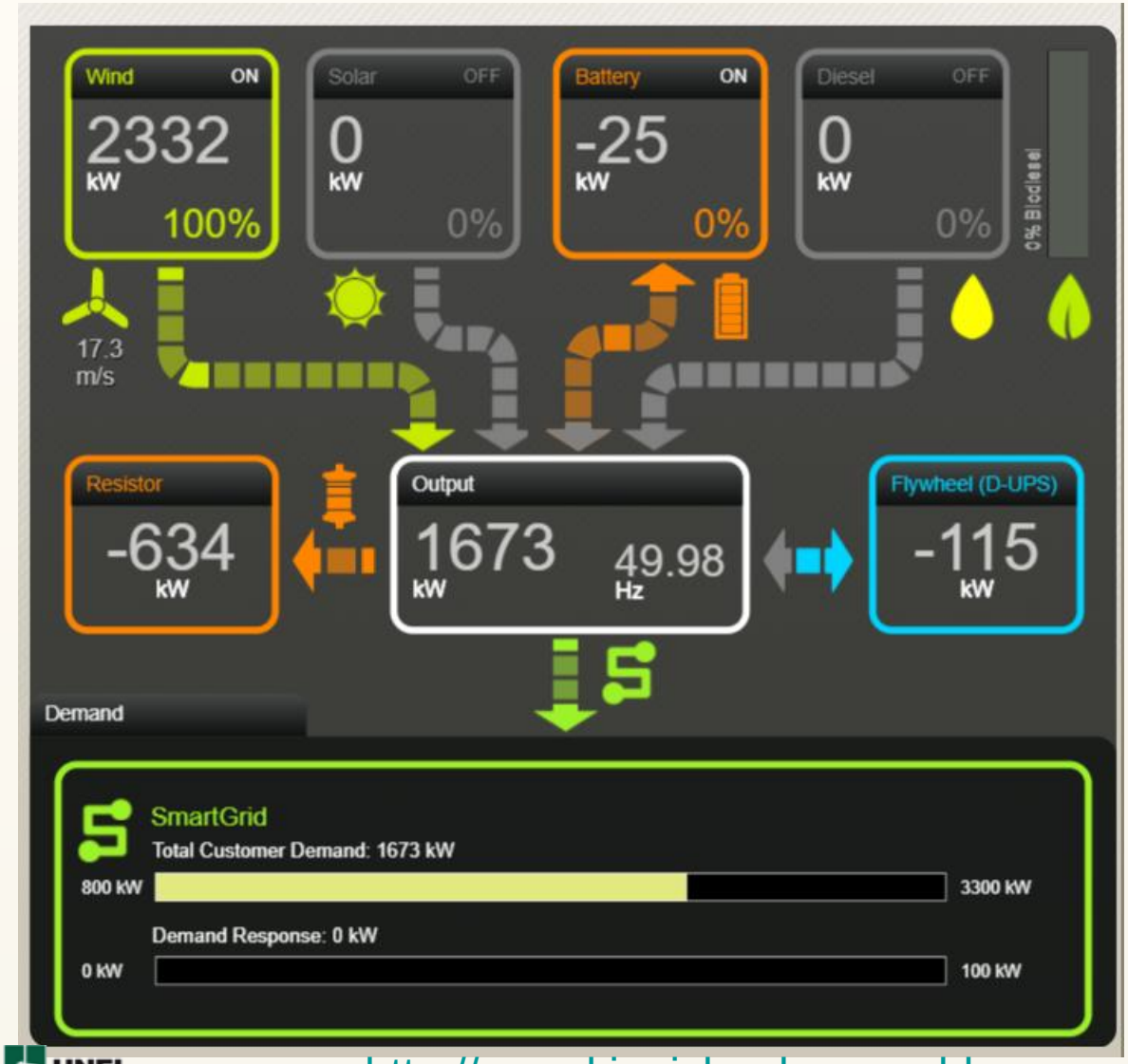
Technology	Enterprise System	Hawaiian Electric	Hawai'i Electric Light	Maui Electric	C-E Method
Advanced Meters		92,000	20,000	52,000	Policy
Head End & MDMS	1				Policy
FCI	1	1,300	500	400	SS&C
Grid 20/20		3,200	1,100	900	Policy
Intelligent Switches		220	75	60	SS&C
Telecom Mesh Devices		230	50	130	SS&C
Secondary Var Controllers		1600	600	400	Policy
Operational Analytics	1				SS&C
DMS	1				SS&C
OMS	1				SS&C
VVO	1				Policy
Data Management	1				Policy
NOC	1				SS&C
DOC		1	1	1	SS&C

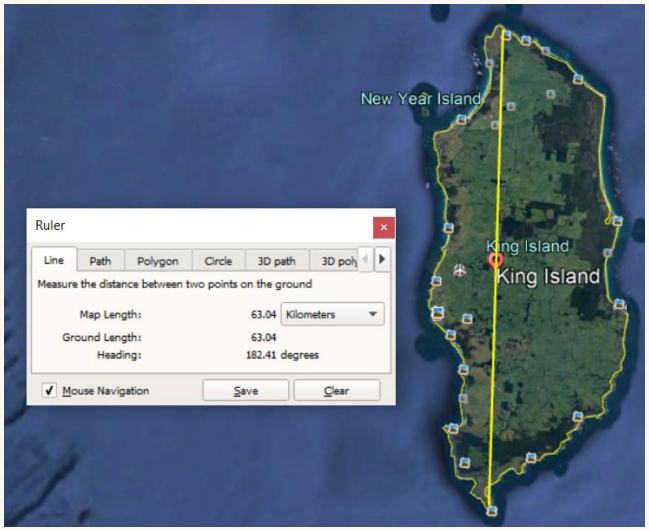
Microgrids


Distribution Substation
Bulk Supply Connection (sub-transmission)
Full Substation Microgrid
Full Feeder Microgrid
Partial Feeder Microgrid
Single Customer Microgrid
Gen
Gen
Other Feeders
Gen
Gen
Feeder


"Companies are focusing first on developing the potential market for single-
customer
These proj
more than
complexiti
developers
picking fig
the utility f
- Michael T.
Public Utili
"The first few projects will use custom solutions, but there's enormous opportunity for costs to com way down."
–Peter Lilienthal
HOMER Energ
"The mic project fi model is absolutel a work ir progress
–Mark Lopata,
Microgrid Solar
"To reach energy ac somethin the soluti from decentralized energy services."
- Richenda Van Leeuwen,
UN Foundation
"Islands will be the leaders, because of the cost of oil, the prospect of doing renewables at a high penetration rate…islands are where the innovation will happen."
- Peter Lilienthal,
Homer Energy

King Island Renewable Energy Integration Project





http://www.kingislandrenewableenergy.com.au/

Moloka‘i 100% by 2020

Year	April PSIP Moloka‘i Theme 1 Plan	April PSIP Moloka‘i Theme 3 Plan	100% Renewables by 2020	100% Renewables by 2030
2017				
2018	Install two 5 MVA Synchronous Condenser	Install two 5 MVA Synchronous Condenser		
2019			2.75 MW Contingency Battery Install 2.75 MVA Synchronous Condensers	2.75 MW Contingency Battery Install 2.75 MVA Synchronous Condensers
2020	Install 5 MW Wind	Install 5 MW Wind	Install 5 MW Wind Convert to biodiesel	Install 5 MW Wind
2021				
2022				
2023				
2024				

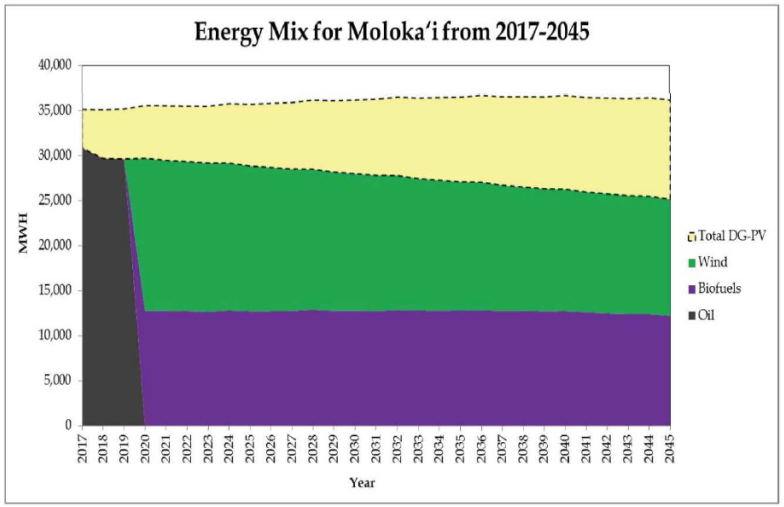


Figure K-62. Energy Mix for 100% Renewables by 2020 Plan on Moloka‘i

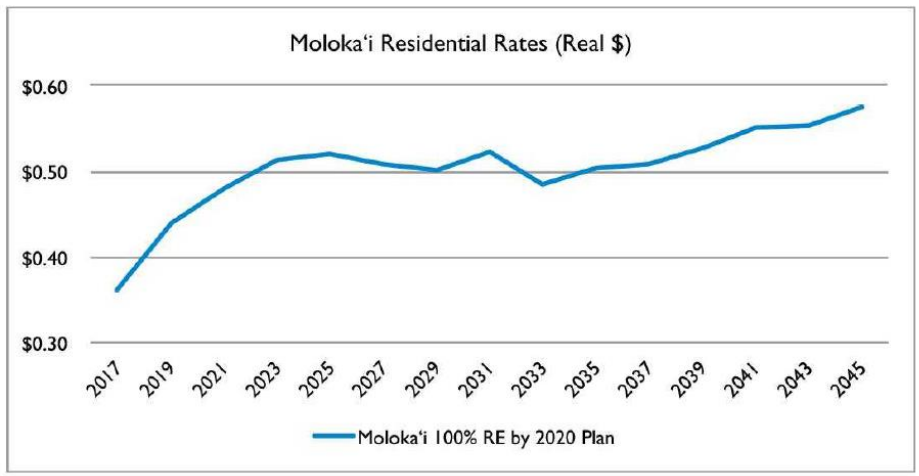
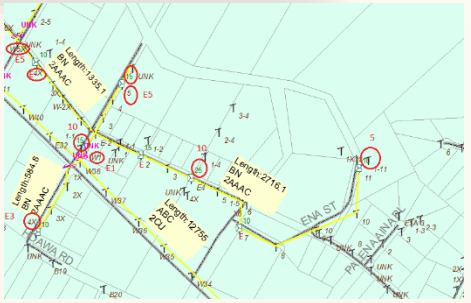
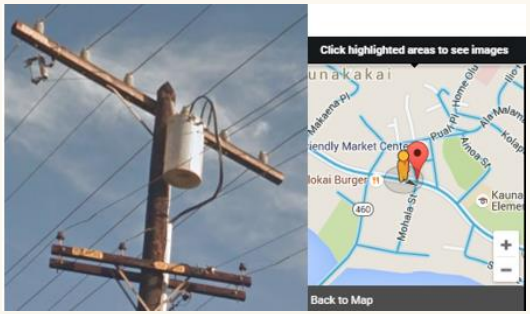


Figure 5-22. Residential Rates (Real $): Moloka‘i

Renewable Moloka'i Initiative

- **100% Renewable Goal by 2020**
- Battery Storage
  - 2MW, 333kW-hr, Li-ion Titanate; kW scale community BESS; chemistry (TBD)
- System Data Collection
- Production Modeling
- Load Flow & Midterm Dynamics Modeling
- Dynamic Load Bank
- PV Forecasting
- Island Grid Controller





Solar Power Forecasting for Hawai‘i

HNEI Cloud Monitoring and Solar Power Forecasting System

Regional numerical weather prediction model

- Every night, a multi-day forecast is generated
- Required for accurate predictions longer than ~6 hours ahead
- Creates a framework for shorter-term forecasts from satellites and sky cameras

Satellite images

- Every 15 minutes, images from a geostationary satellite (GOES-WEST) are used to generate 1-km resolution forecasts most accurate in the 30 minutes to 6 hours ahead forecasting range
- Provides boundary conditions for ground-based local forecasts

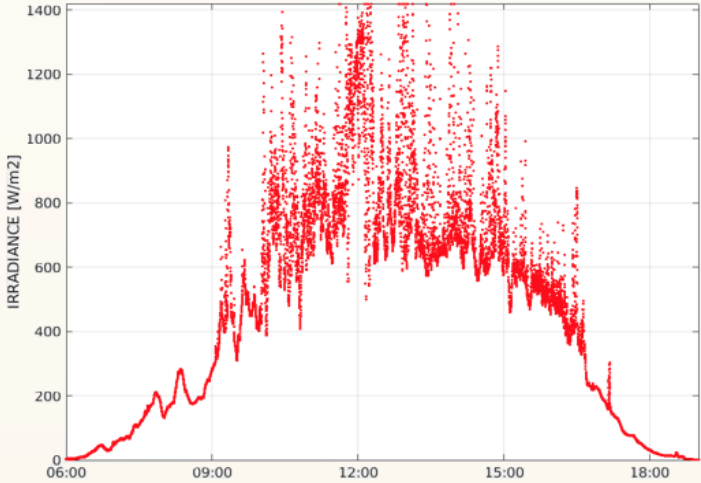
Ground-based instruments

- Every minute, images from a novel sky mapping system developed at HNEI, combined with irradiance observations from pyranometers, are used to generate high resolution, local irradiance conditions
- Every 2-4 minutes, short-term forecasts are generated from the ground-based data

HNEI Ground-based sky imaging and irradiance measuring system

From the data provided by this system:

- Determine cloud positions, velocities and attenuation levels
- Use that information with a clear sky solar model to generate high resolution irradiance nowcasts and forecasts maps
- From irradiance maps ⇨ PV power predictions

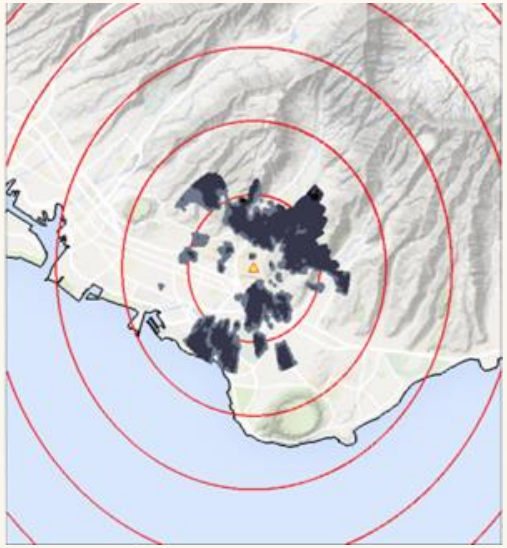


Goal:

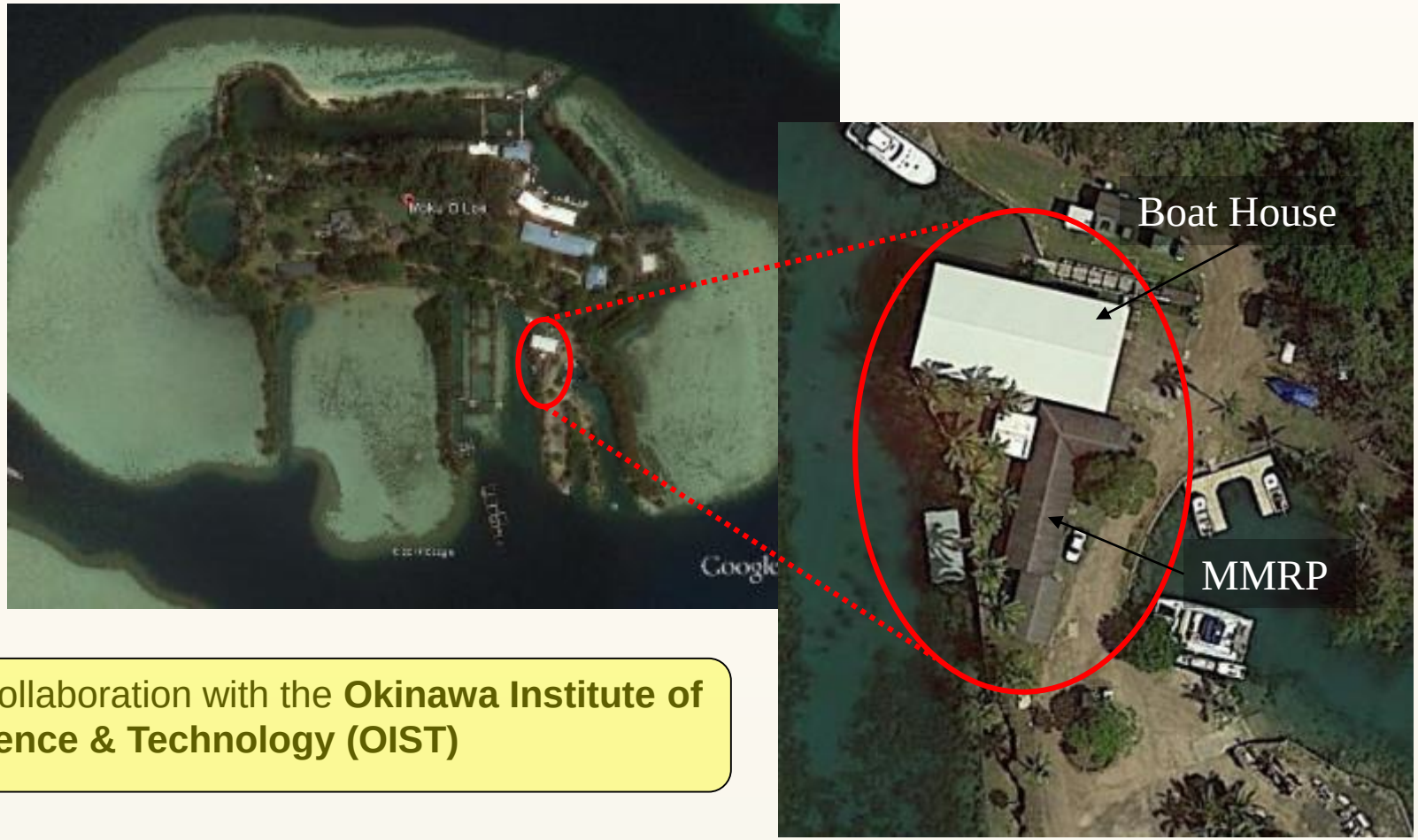
- To facilitate widespread, overlapping field deployment
- Low production cost using off-the-shelf instrumentation, open-source single-board computing hardware, and DIY technologies
- “Swarm” approach – low cost multiple camera system can remain resilient and functioning with individual camera failures.

Development Timeline:

- Completed – Software design and prototype testing
- 2018 – First operational deployment on the island of Moloka‘i

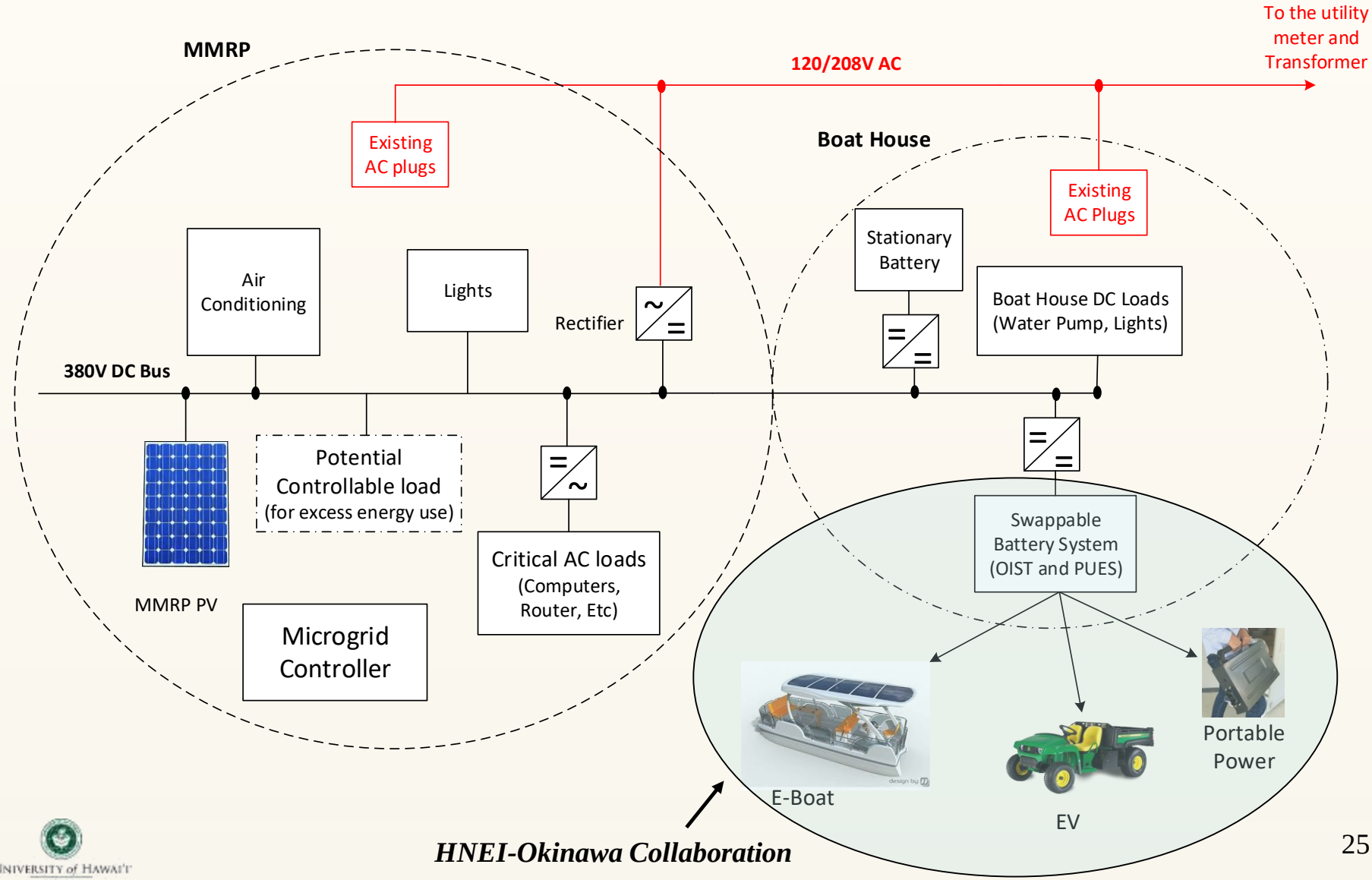


Moku o Lo'e DC Microgrid Project
("Coconut Island")



In collaboration with the **Okinawa Institute of Science & Technology (OIST)**

DC Microgrid Conceptual Design



HNEI-Okinawa Collaboration

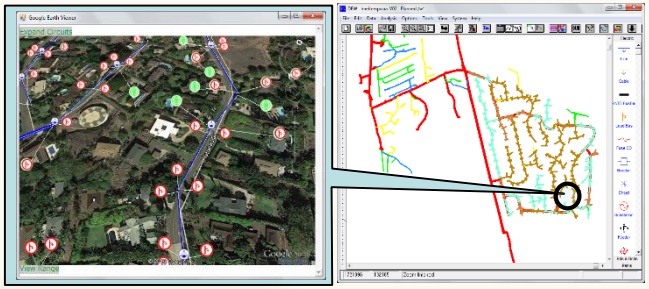
Smart Microgrid Projects

GridSTART
Hawai'i Natural Energy Institute | University of Hawai'i
Grid System Technologies Advanced Research Team

Smart/Microgrid Controls

HNEI develops algorithms and technologies to control and manage power to stabilize the power grid and to increase resiliency.

- ✓ Maui Smart Grid Demand Reduction Project
- ✓ Smart-Grid PV Inverter Project
- Palau high-speed BESS for contingency response
- High Resolution Solar Forecasting
- Advanced Conservation Voltage Reduction Technology Development Project
- Predictive Distribution Operator



Resilient Renewable Energy Microgrids

HNEI is developing, installing and testing smart and microgrid technologies in Hawaii and at US installations in the Pacific region

- Molokai Secure Microgrid Demonstration
- Coconut Island DC Hybrid Microgrid
- JBPHH Infrastructure Modernization and Renewable Integration Project
- Navy Marianas Infrastructure Modernization and Renewable Integration Project
- Navy Marianas Solar Integration Project
- USMC Okinawa Renewable Energy and Conservation Voltage Reduction Demonstration
- NAVFAC HI Advanced Inverter Demonstration

HNEI
Hawai'i Natural Energy Institute
University of Hawai'i at Mānoa

Mahalo!

(Thank you)

For more information, contact:

GridSTART
Hawai'i Natural Energy Institute | University of Hawai'i

Grid System Technologies Advanced Research Team

Marc Matsuura
Sr. Smart Grid Program Manager
GridSTART

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) 956-5070
Mobile: (808) 321-8928
E-mail: marc.matsuura@hawaii.edu
Website: www.hnei.hawaii.edu

HNEI
Hawai'i Natural Energy Institute
School of Ocean and Earth Science and Technology
University of Hawai'i at Mānoa

UNIVERSITY of HAWAI'I
MĀNOA