Unlocking a Renewable Energy and Clean Transportation Future in Hawaii

EV and PHV Okinawa Town Symposium

Sponsored by the Ministry of Economy, Trade and Industry,
Next Generation Vehicle Promotion Center (NEV)

Okinawa Convention Center, Conference Building A
4-3-1 Mashiki, Ginowan City
Okinawa 901-2224, Japan
February 7, 2014

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University of Hawaii at Manoa
Honolulu, Hawaii, USA

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

Hawaii is Paradise

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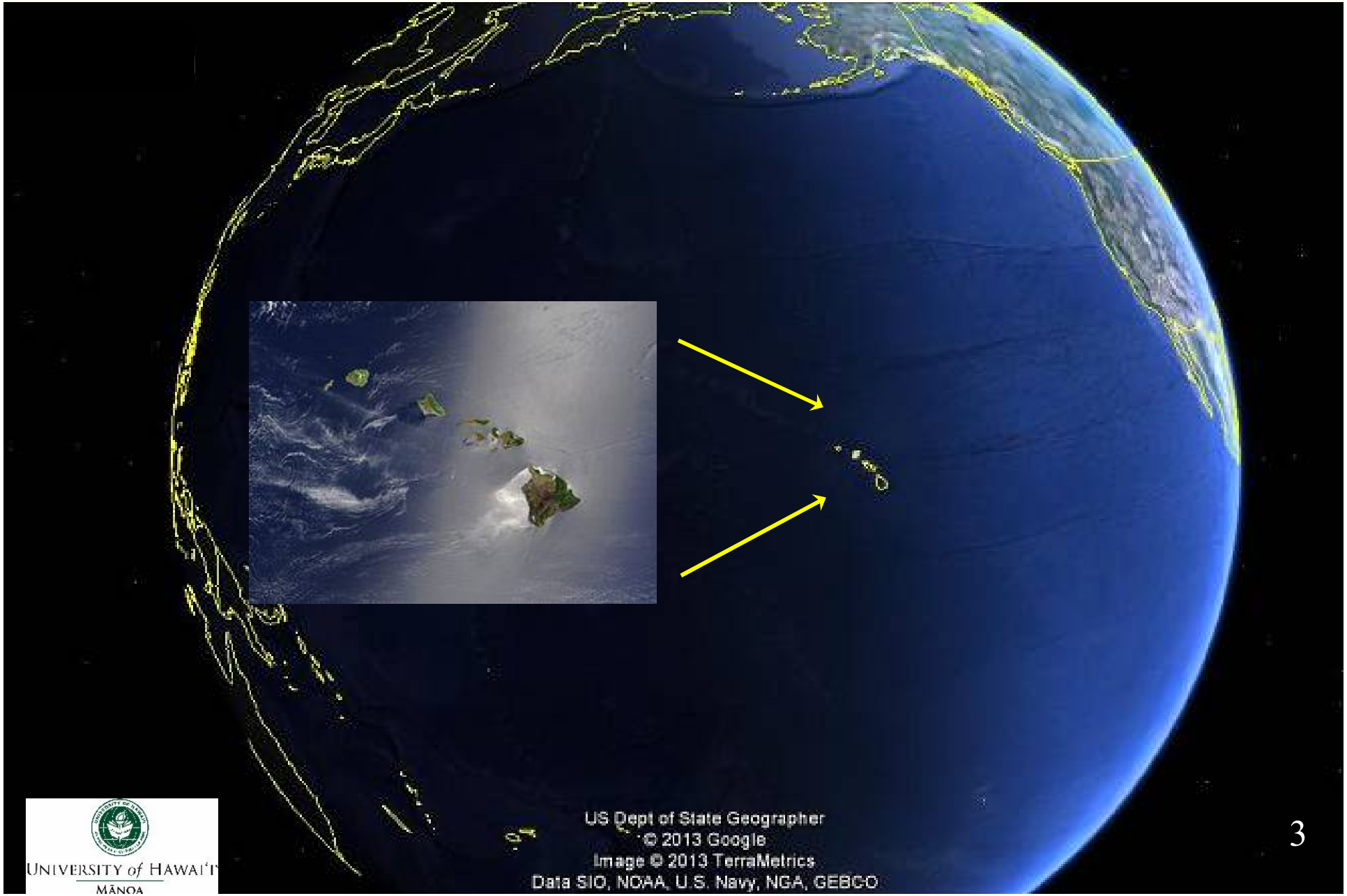
But, Hawaii is Very Geographically Isolated ….



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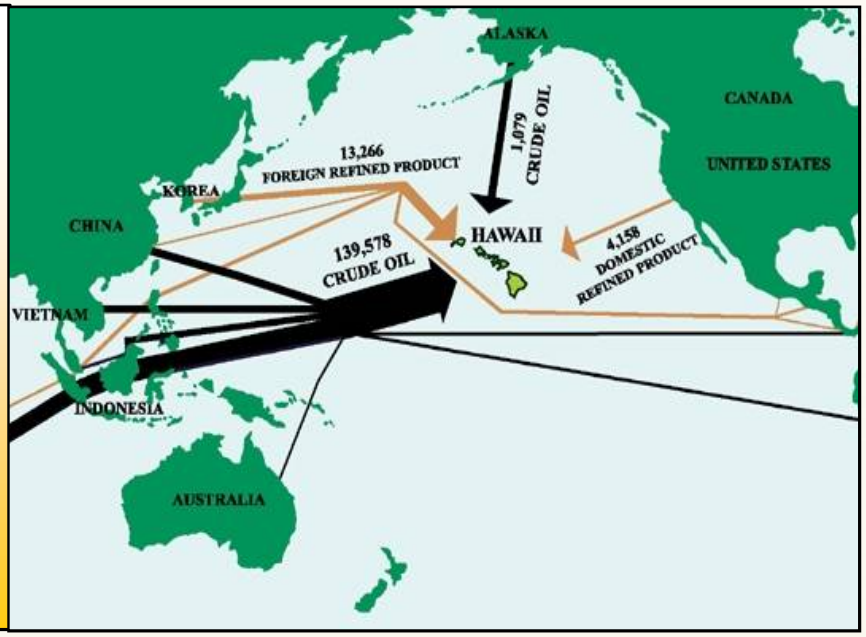
Energy Insecurity

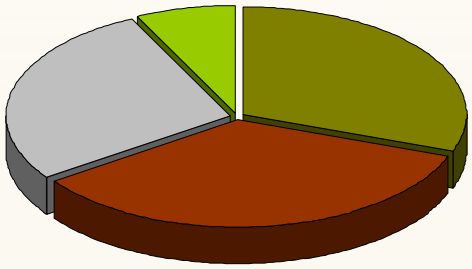
46.3 million barrels of petroleum were imported for Hawaii's total energy use in 2012

- **Primary energy:** **90%** fossil fuel, all imported, most of it is crude oil refined
- That's 36 barrels of petroleum for every man, woman and child living in Hawaii
- $5.09 billion left the state to pay for imported petroleum

- **100% of the crude oil for the State is *imported***

Hawaii Department of Business, Economic Development & Tourism





JET FUEL	34%
ELECTRICITY	32%
GASOLINE/ MARINE FUEL	27%
OTHER	7%

Crude Oil Supplies to Hawaii

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High Energy Cost Drains the Island Economy

High Cost of Service

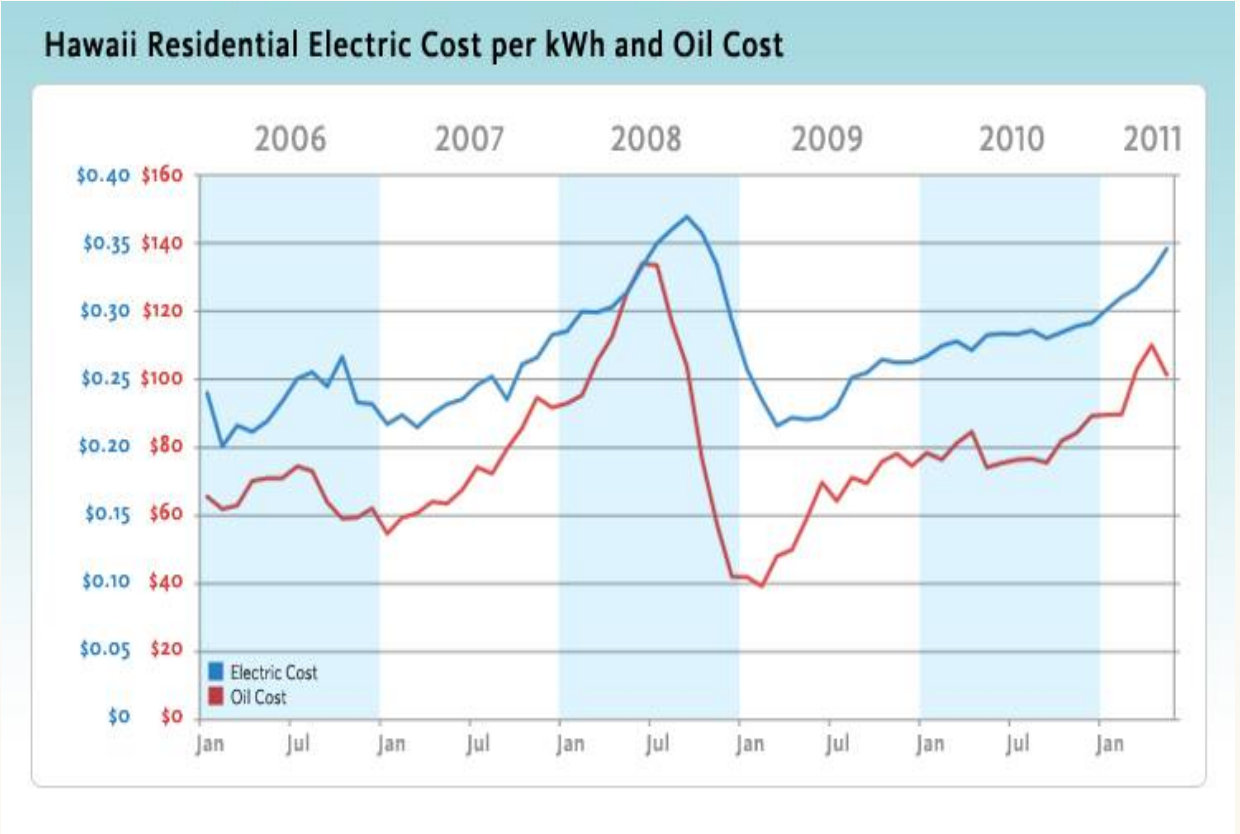
Hawaii ranks #1 in electric energy costs:

45.5 cents/kWh	Lanai
46.1 cents/kWh	Molokai
38.2 cents/kWh	Hawaii
36.2 cents/kWh	Maui
31.9 cents/kWh	Oahu

(Residential rates as of **April 1, 2013**)

11 - 12 cents/kWh U.S. avg.

Source: Hawaii Energy



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Clean Energy Opportunities in Hawaii are Abundant

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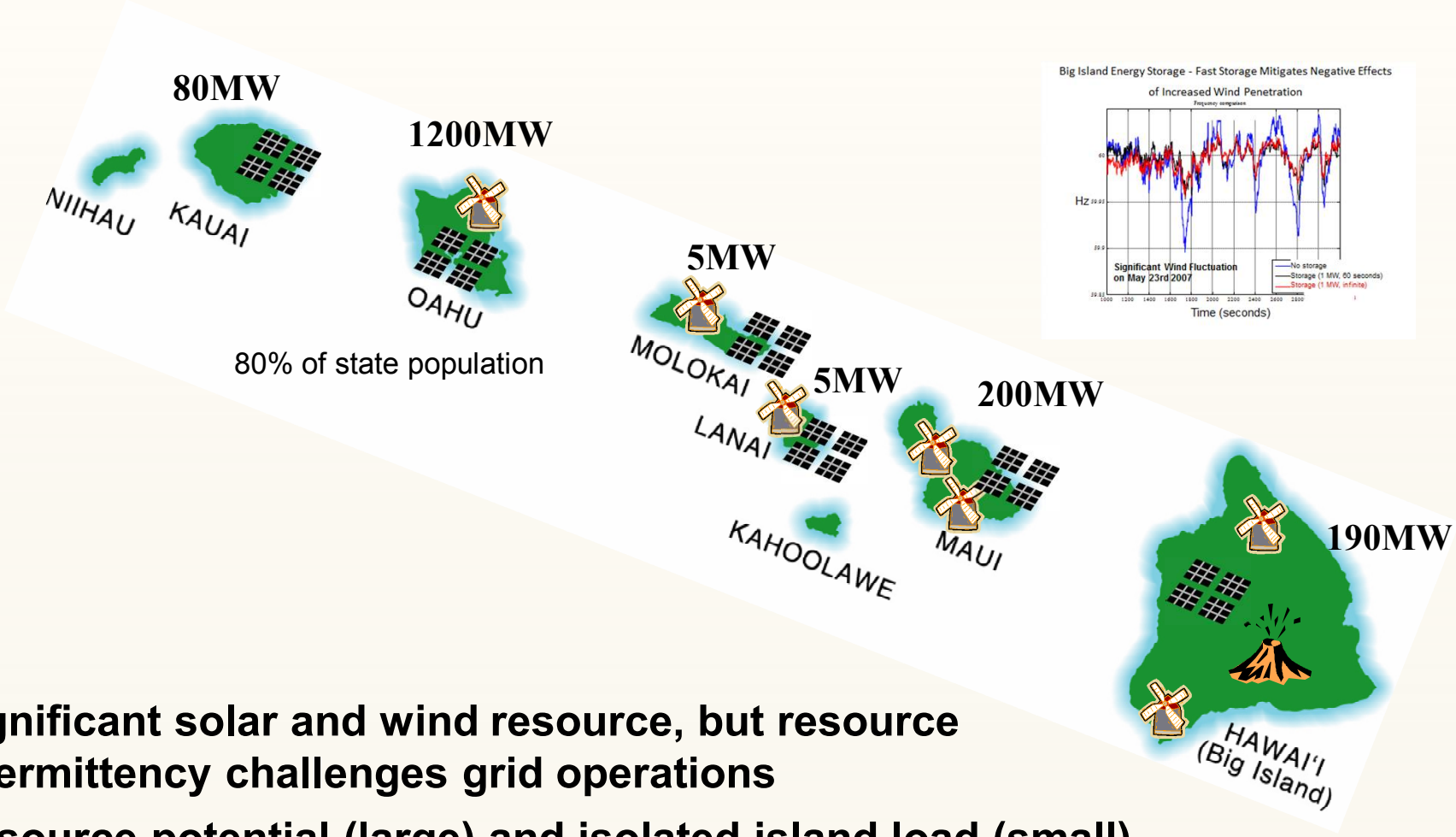
Isolated Island Grids with no Interconnection



- **Significant solar and wind resource, but resource intermittency challenges grid operations**
- **Resource potential (large) and isolated island load (small)**
- **Large gap between peak and minimum load (> 2:1)**

Opportunity to validate and deploy new technologies

Hawaii Clean Energy Initiative (HCEI)

Hawaii	The most petroleum-dependent state in the US is on track to increase its clean energy (efficiency and renewables) to **70% by 2030** and will have the greatest penetration of variable renewables on a grid in the US

Objectives

The State of Hawaii, US DOE, and local utility launched HCEI in January 2008 to transform Hawaii to a 70% clean energy economy by 2030:

- ***Increasing Hawaii's economic and energy security***
- ***Fostering and demonstrating Hawaii's innovation***
- ***Developing Hawaii's workforce of the future***
- ***Becoming a clean energy model for the U.S. and the world***

Editorials

TUESDAY | OCTOBER 21, 2008

Ambitious energy agreement charts right course

A promising new agreement between the state and Hawaiian Electric Co. is expected to make some significant progress in reducing Hawai'i's dependence on fossil fuels.

It calls for streamlining the regulatory process to achieve some worthy goals, including sending wind energy from Maui, Lāna'i and Moloka'i to O'ahu via state-of-the-art undersea cables, and developing a "smart grid" so customers can get lower rates during off-peak hours.

That's the good news. But

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the 50-page agreement also lacks some key details. Perhaps the most important one, given these tough economic times, is how much will it all cost, and how much of that cost will the consumer be asked to bear?

Admittedly, it's a difficult question to answer, given the scope and complexity of the plan. Still, looking out for ratepayers' and taxpayers' interests will be crucial. Part of that responsibility rests with one of the agreement's signatories, consumer advocate Catherine Awakuni, and the Public Utilities Commission.

Awakuni and the PUC have the obligation to ensure that the average ratepayer isn't unfairly burdened by the cost of developing the new, renewable-energy infrastructure.

There will be significant upfront investment costs. The undersea cable alone could run in the hundreds of millions of dollars, and the state should maximize opportunities for federal funding through the Department of Energy or similar sources.

And even with federal funding — U.S. Sen. Daniel K. Inouye attended the signing ceremony for the new agreement — ratepayers will likely be asked to pick up some of these costs as an investment in the state's renewable energy future.

Certainly, this future is the direction in which the state needs to be moving. Achieving the state's goal of 70 percent clean energy by 2030 is a laudable plan that sets us on the right path. Indeed, Hawai'i is uniquely positioned to be a leader in the area of wind, wave and solar energy efforts.

And in the long term, renewables offer an unlimited supply of environmentally friendly energy and reduces our over-reliance on fossil fuels — a more sensible and sustainable future.

It's an ambitious plan. If the agreement's goals are met, the result will be a fundamentally changed energy model. A more unified, more efficient grid will support different energy sources, primarily wind; HECO will move from a sales-based company to an energy services provider; and the consumer will have more control over energy costs with new ways to conserve using technology.

The Lingle administration hopes the agreement will be a win-win for everyone — the state, HECO and consumers. Refining these details will help ensure that success.

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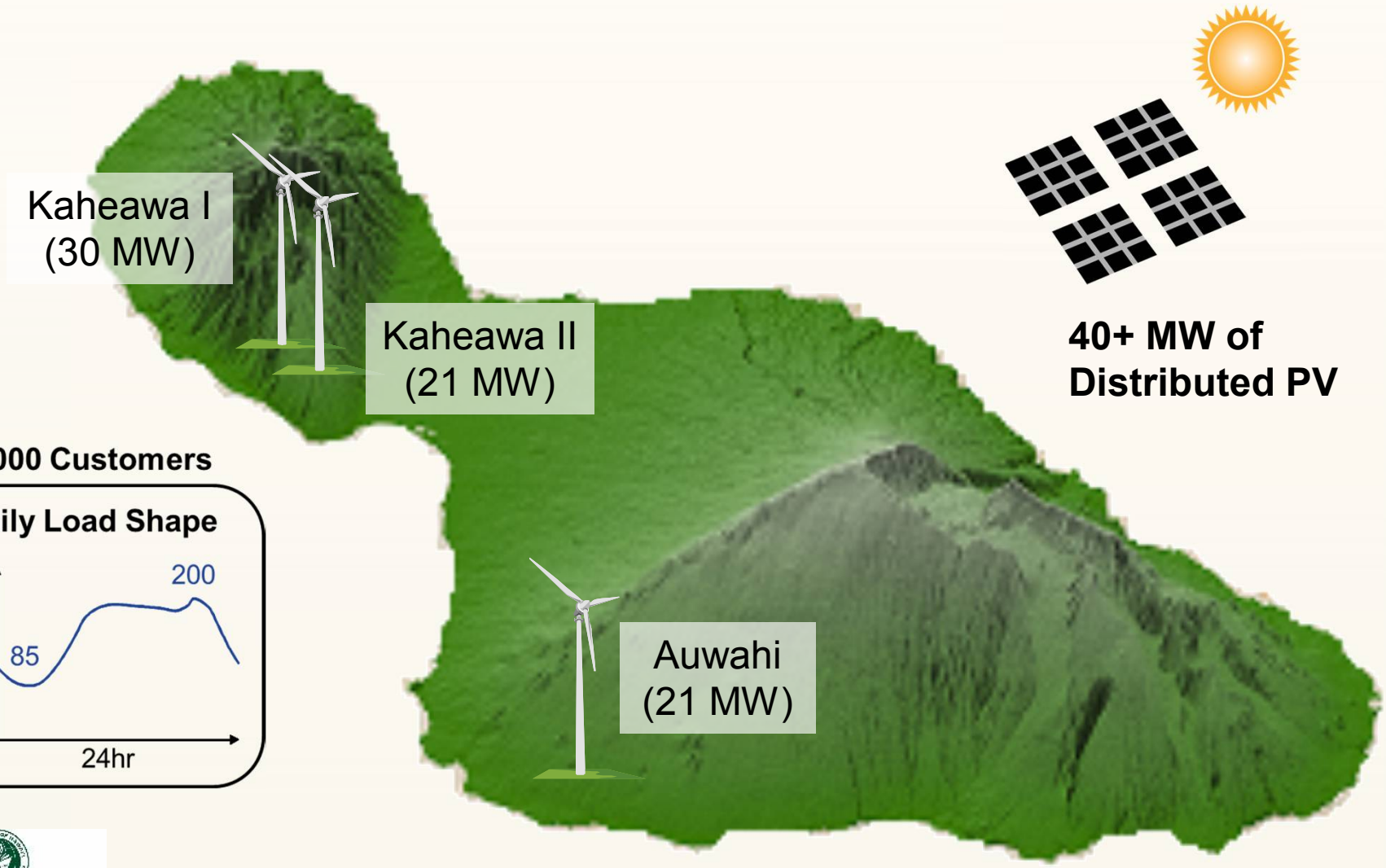
Integrating Large Amounts of Wind and Solar Power

Maui Island Case



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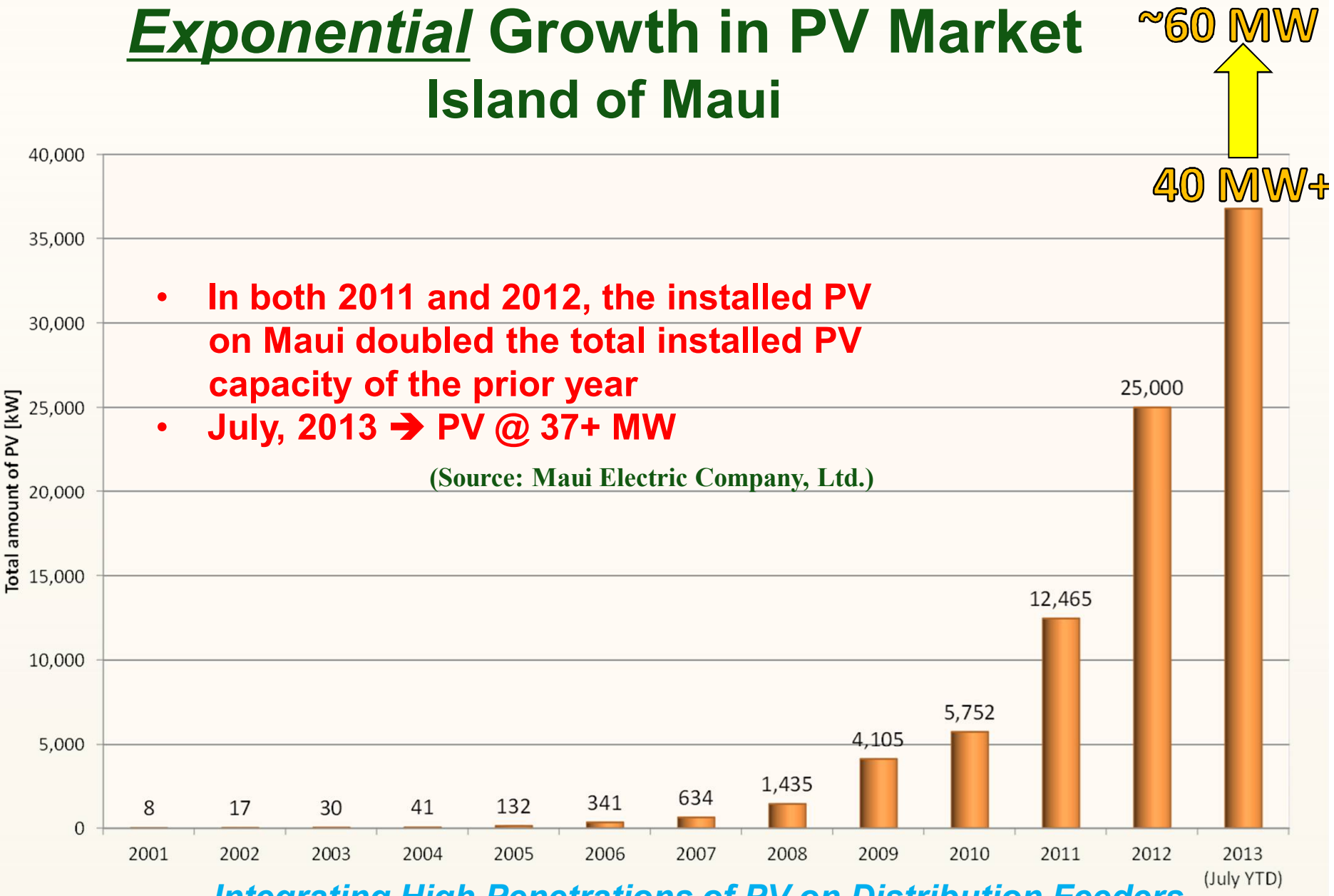
Exponential Growth in PV Market
Island of Maui



- **In both 2011 and 2012, the installed PV on Maui doubled the total installed PV capacity of the prior year**
- **July, 2013 ➔ PV @ 37+ MW**

(Source: Maui Electric Company, Ltd.)

Integrating High Penetrations of PV on Distribution Feeders Is a Challenge in Hawaii Today

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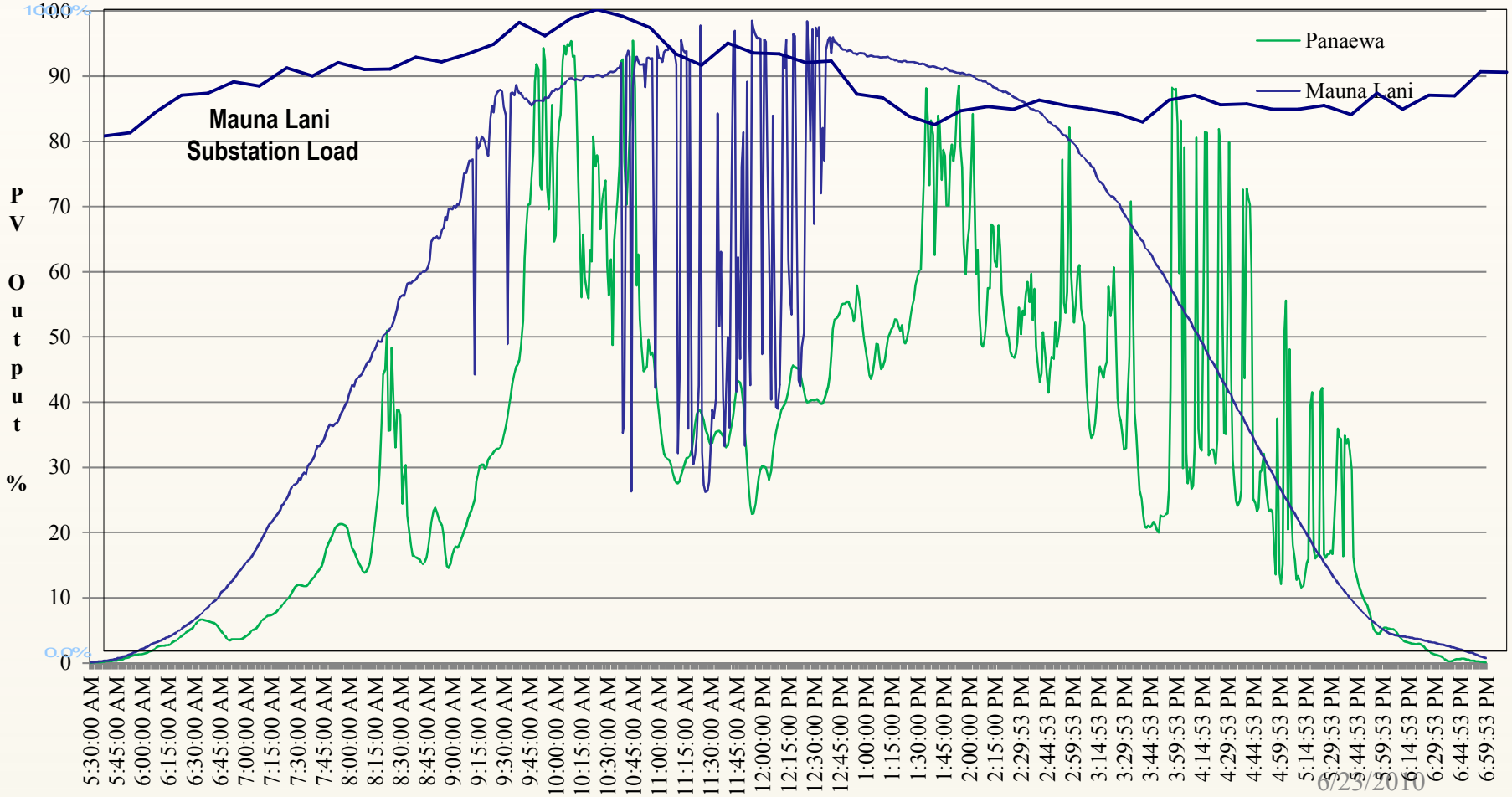
Solar Resource Intermittency and Variability



6/23/2010

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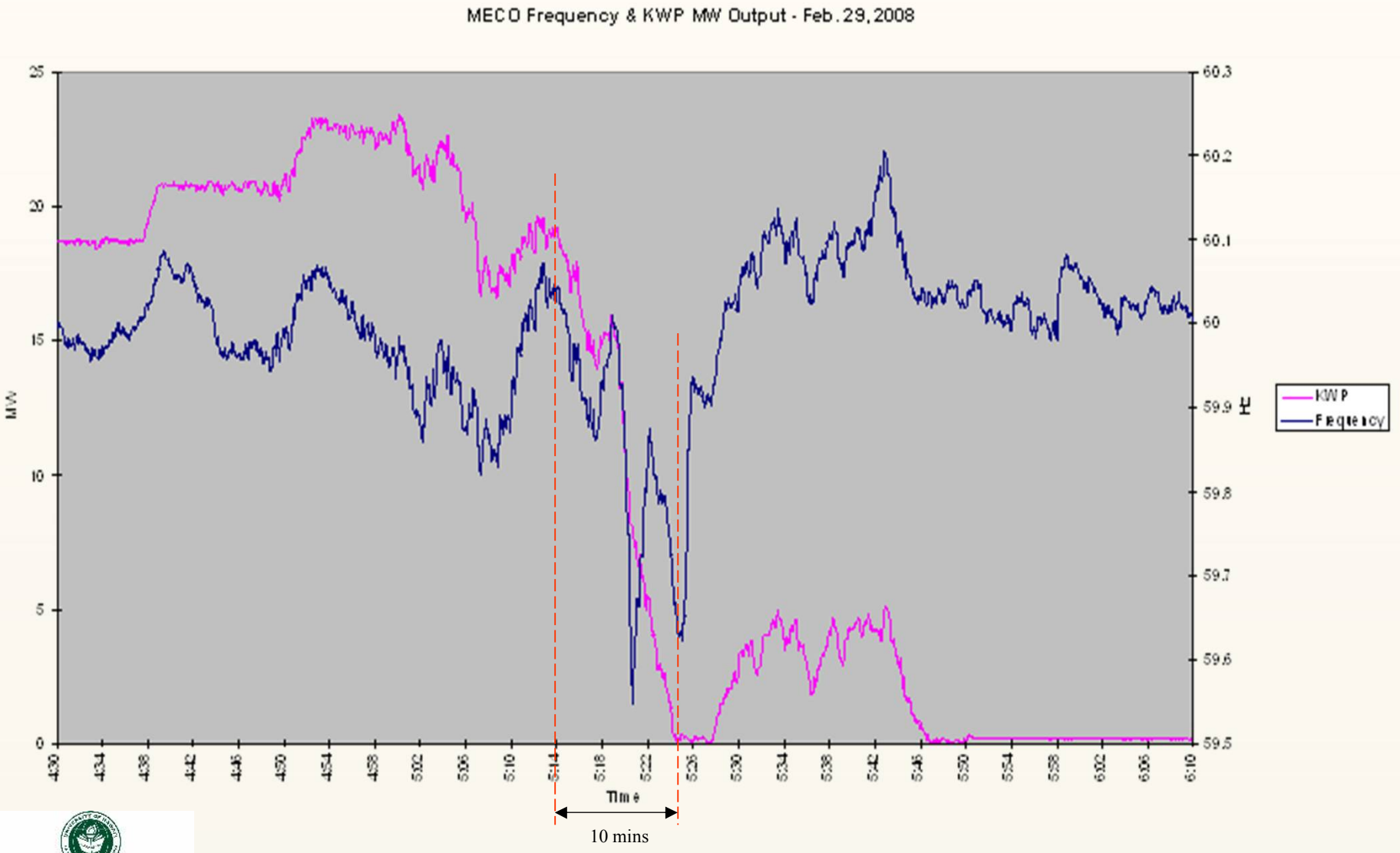
Wind Resource Intermittency and Variability



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Making of the Maui Smart Grid

- **Maui Smart Grid 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
- **Smart Grid-Enabled PV Inverters (2012) ~$11 M**
  - US DOE funded, HNEI led project to develop and demonstrate advanced PV inverter functionality in a smart grid environment
- **JUMP Smart Maui (2011) ~$30 M**
  - NEDO funded, Hitachi led project to integrate high levels of PV, wind energy, and EV into an island wide smart grid environment
- **Great Maui Project (2013) ~$20 M**
  - NEDO funded, Hitachi led phase 2 of JUMP Smart Maui project, to demonstrate *EV vehicle-grid and Virtual Power Plant* integration

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

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Japan – U.S. Collaboration

- President Obama and then Prime Minister Hatoyama met in November 2009 and agreed to cooperate on clean energy technology development.
- US Department of Energy (DOE) and Japan Ministry of Economy, Trade and Industry (METI) identified areas for joint activities that concluded in a "Clean Energy Technologies Action Plan“ that *included Okinawa-Hawaii collaboration*.
- DOE, METI, State of Hawaii and Okinawa prefecture signed a Memorandum of cooperation on the Okinawa-Hawaii Clean Energy Cooperation in June 2010.
- State of Hawaii and NEDO signed a MOU for implementation of a Smart Grid demonstration in Maui in November 2011.

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JUMP Smart Maui

A Japan – United States Smart Grid Demonstration Project

Maui Electric

Hawaiian Electric

maui economic DEVELOPMENT BOARD

DBEDT

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

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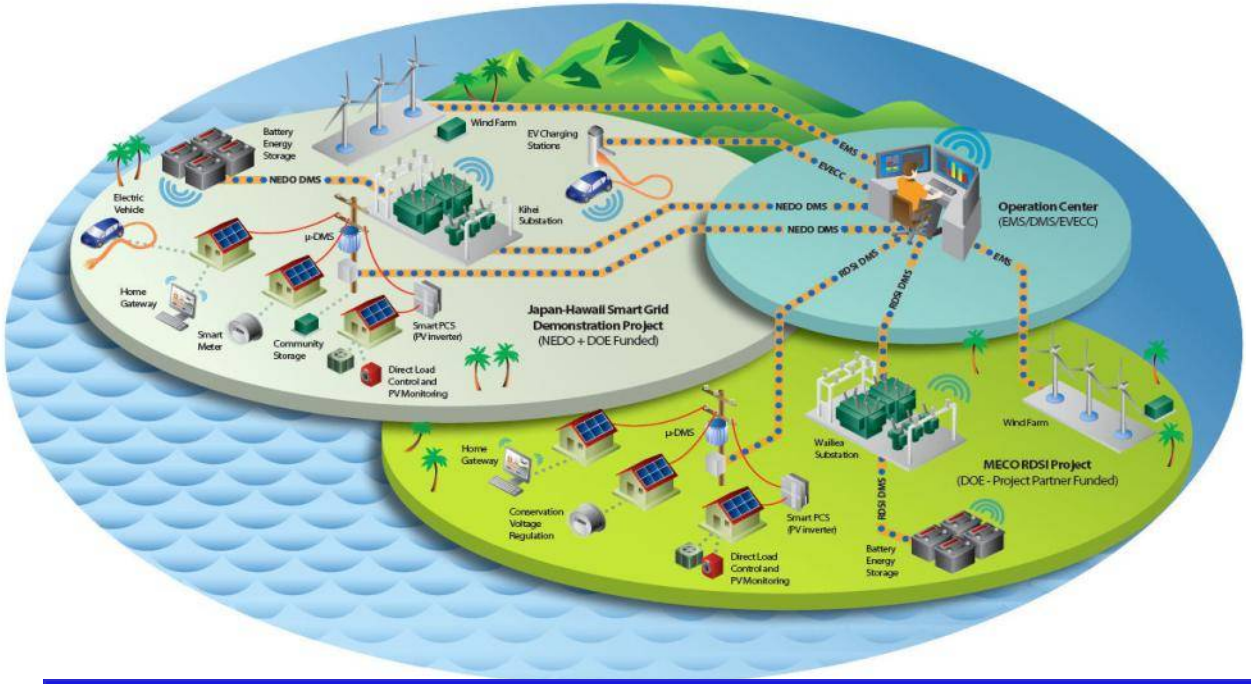
Outline of JUMPSmartMaui

JUMPsmartmaui
SMART ENERGY. SMART CARS. SMART GRID.

In Maui, large scale renewable energy (72MW of wind and 40+ MW of distributed PV) has been introduced. In addition, EV high penetrations are expected soon.



Issues

- Excess Energy
- System Frequency Impact
- Distribution Line Voltage Impact

Solutions

- Integrated DMS
- μDMS &Smart PCS
- EV charger control
- Battery system
- Direct Load Control
- ICT Platform

Basic Policy for Demonstration

Maximize Utilization of Renewable Energy (RE)

Stable Supply of Electric Power

Solution for Impact of EV & PV High Penetration

Geographical Locations of Devices in Maui

JUMPsmartmaui
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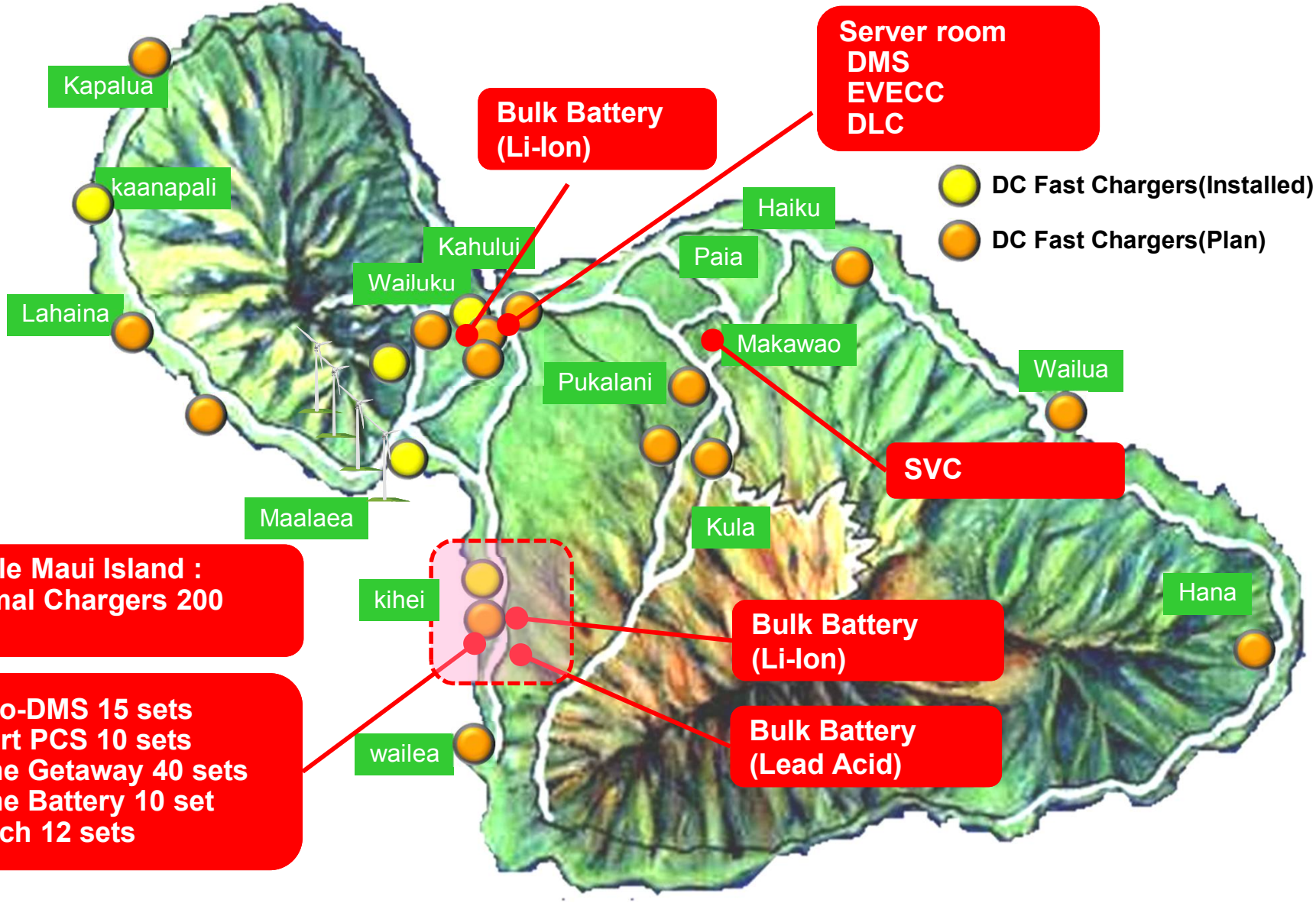
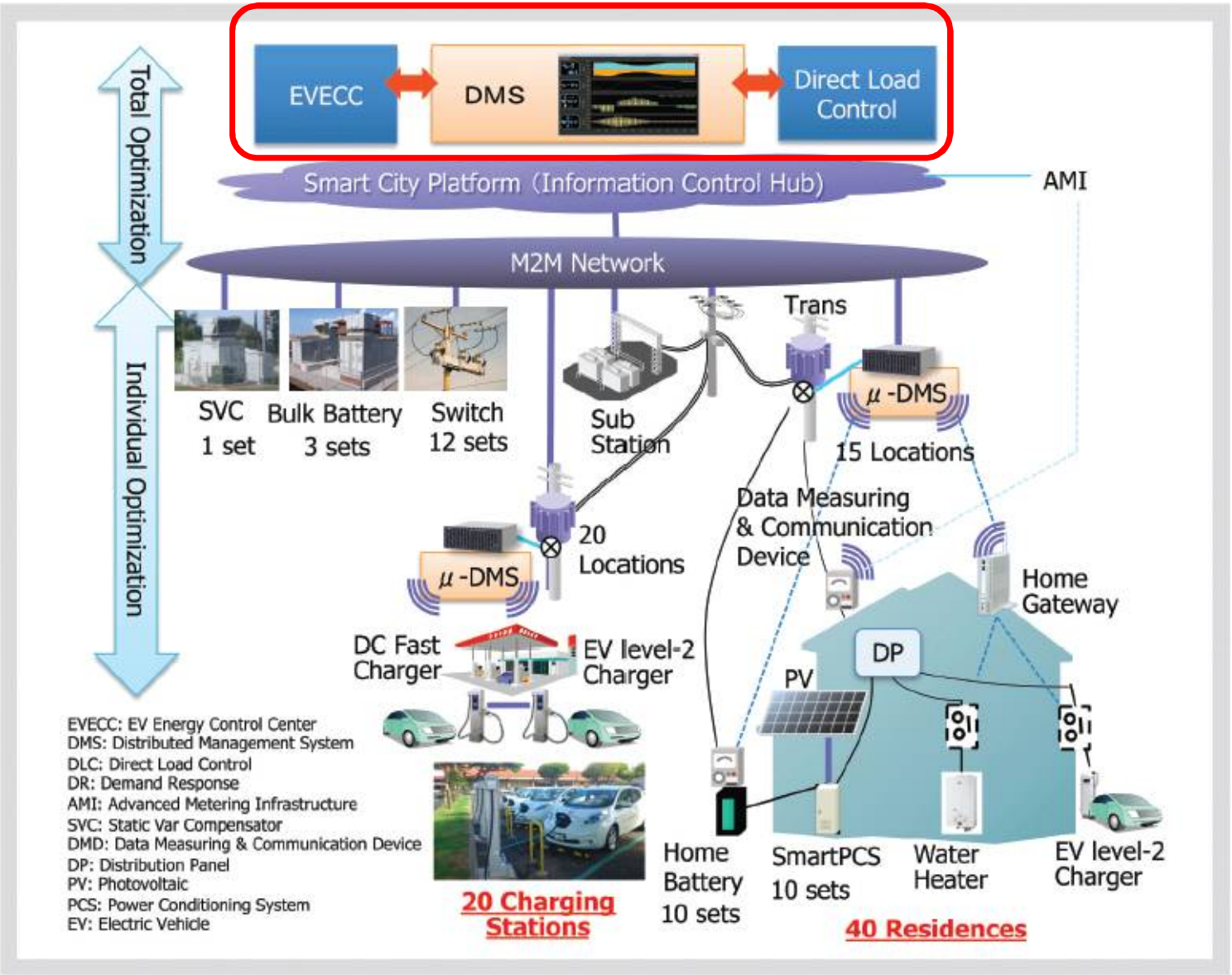


Overall View of System Configuration



JUMPsmartmaui
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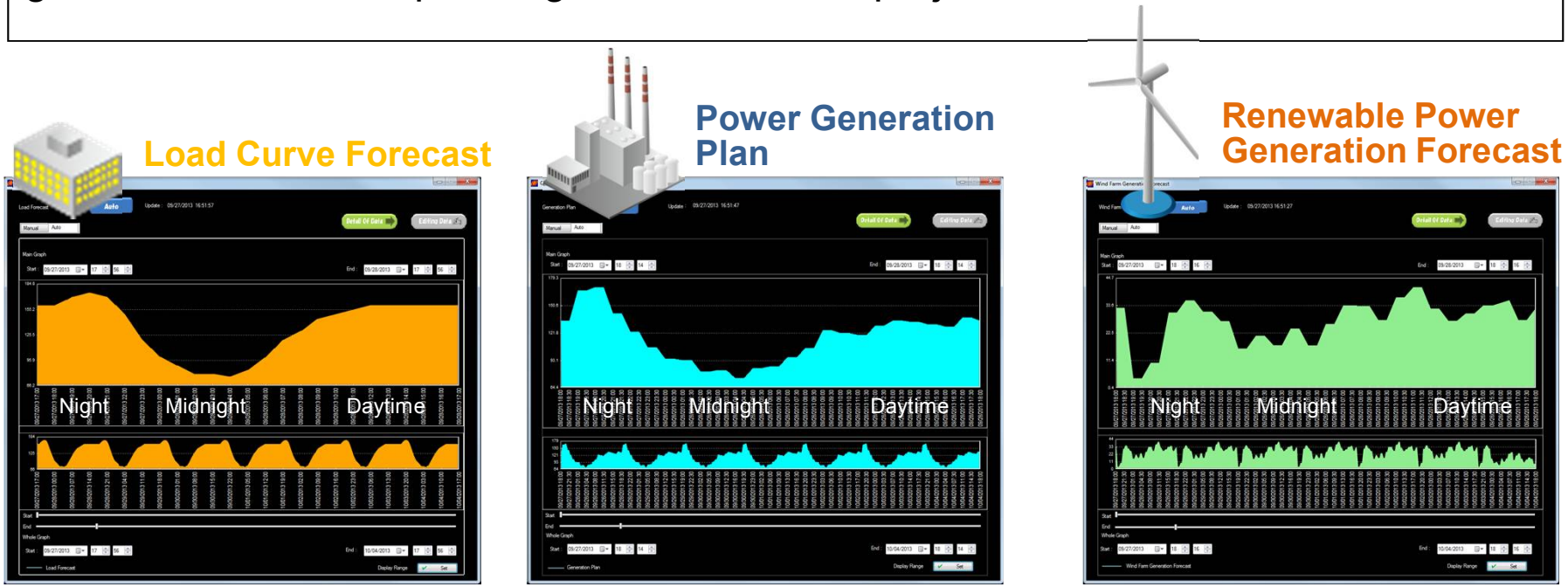
Maximum Utilization of Renewable Energy

Advanced load shift

Helps shift energy demand by integrating forecasts of renewable power generation with the operating schedule of the project's batteries.



The conventional load shift technology + **Advanced RE forecasts added**

JUMPsmartmaui
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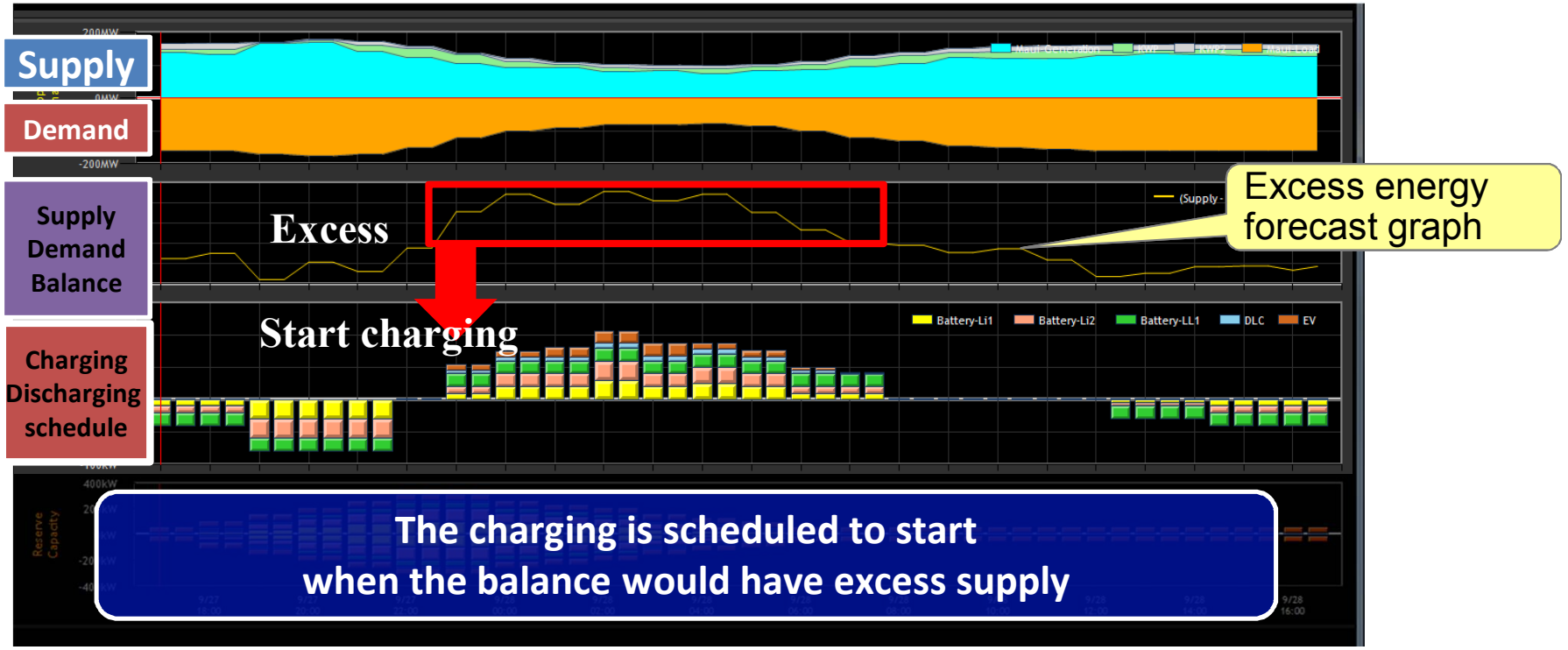
Maximum Utilization of Renewable Energy

Advanced load shift

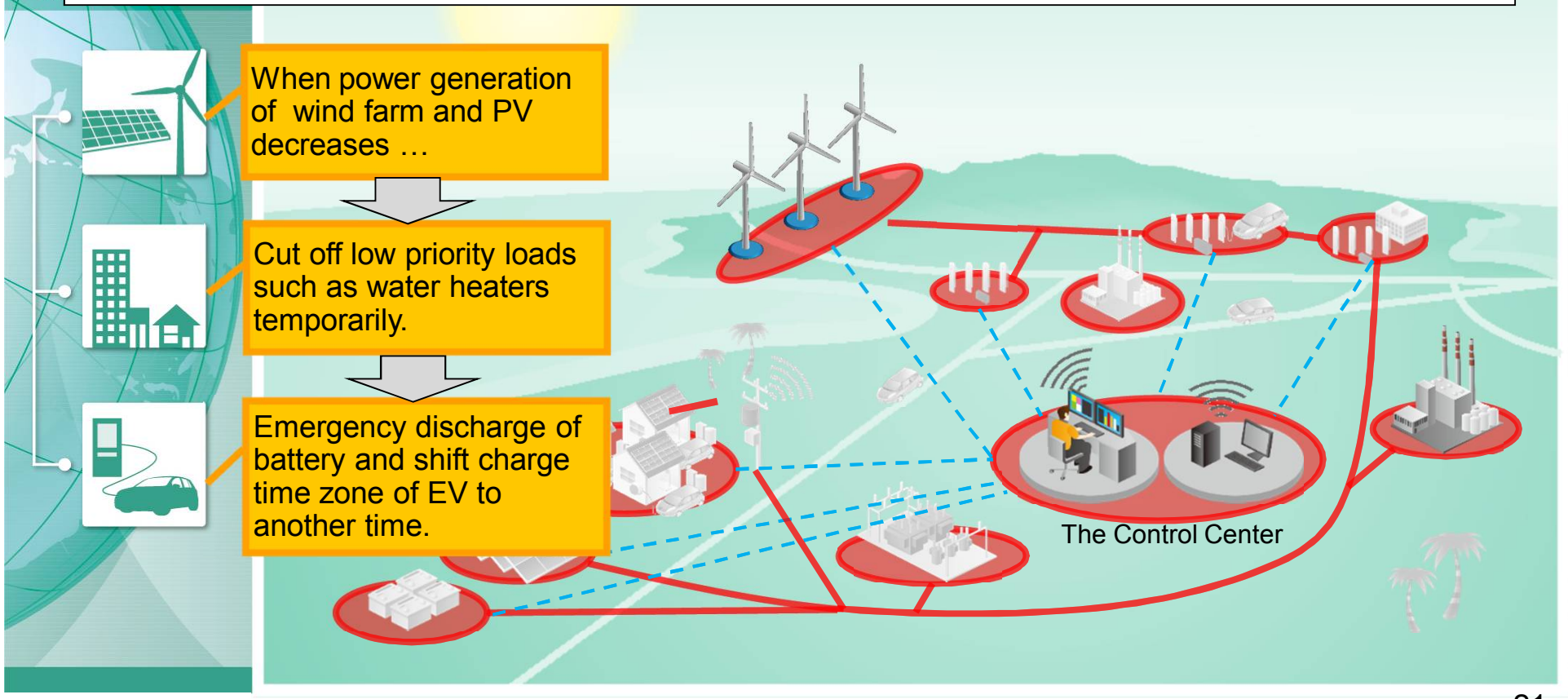
Helps shift energy demand by integrating forecasts of renewable power generation with the operating schedule of the project's batteries.



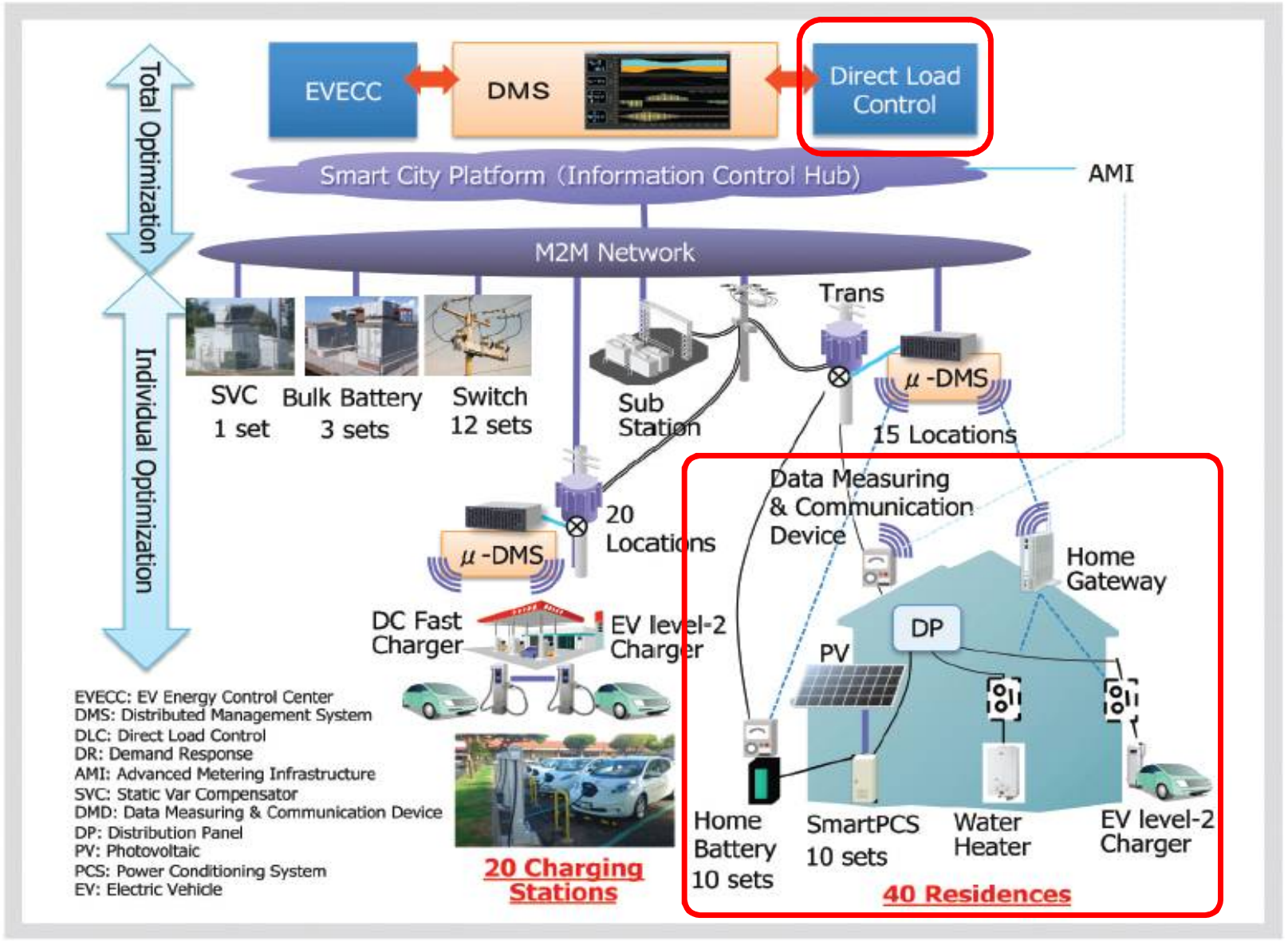
Stable Supply of Electric Power

Emergency demand and supply control

Keeps the electric power system stable by controlling and helping to restore loss of balance between power supply and demand.



Home Equipment



Home Equipment (cont.)

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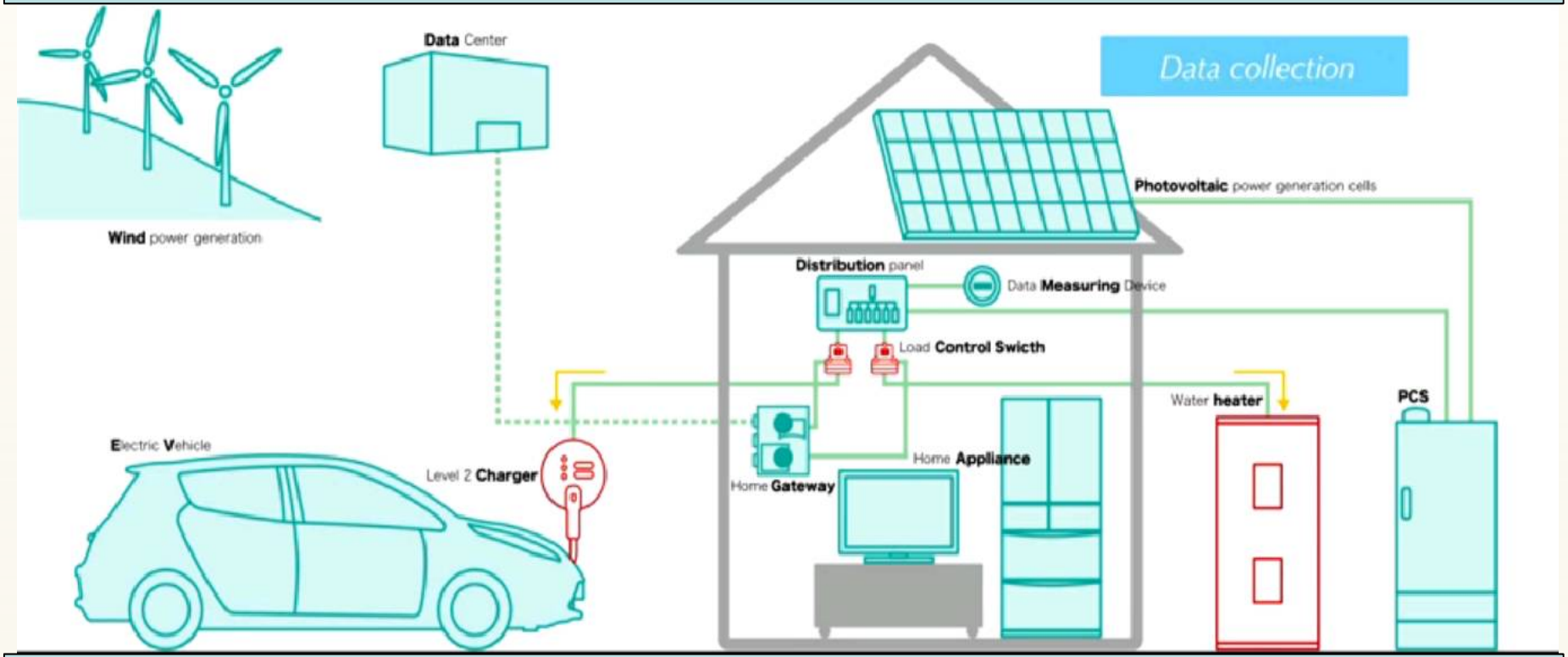
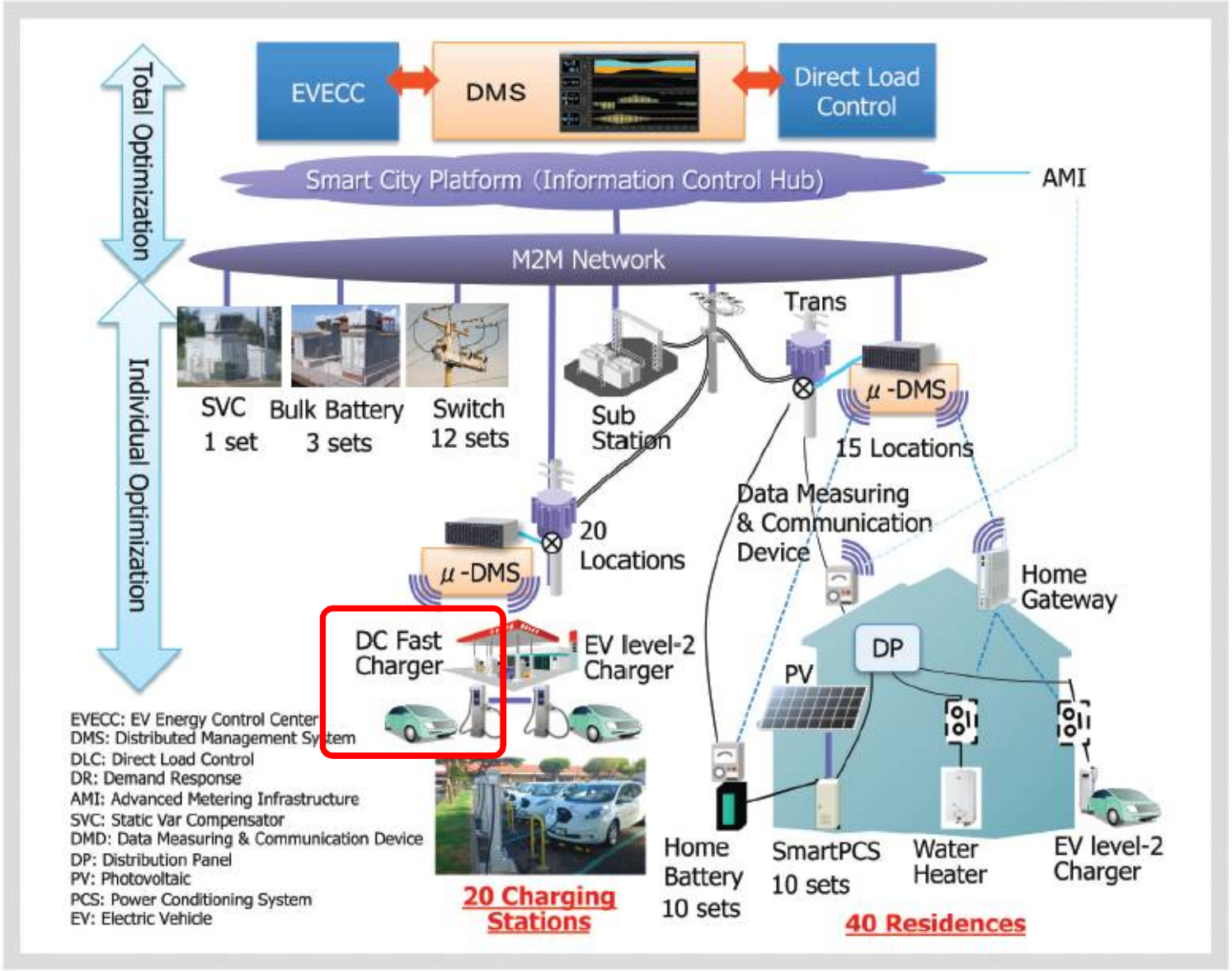
Direct Load Control to Enable More Renewable Energy



Smart EV Charge and Water Heater Control

DC Fast Charger



DC Fast Charger

JUMPsmartmaui
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Benefits

- Promote the use of electric vehicles and growing availability of fast charging stations.

What is the purpose?

To service the growing number of EVs on Maui roadways, the project's goal continues to be expansion of DC Fast Charger stations across the island. In terms of the Smart Grid, the goal is to develop an EV charging management system that is stable and will not affect the load and demand of the current electric system.

Features

- **Scalable EV charger system that can be adapted to different locations**
- **User-friendly JSM Web Portal for convenient status of current operation at various locations and maps**
- **DC Fast Charge Smart Card membership**
- **Location based traffic simulator**
- **Control of specific charging functions like Priority mode and Balanced mode based on location**

EV Fast Charging Stations on Maui

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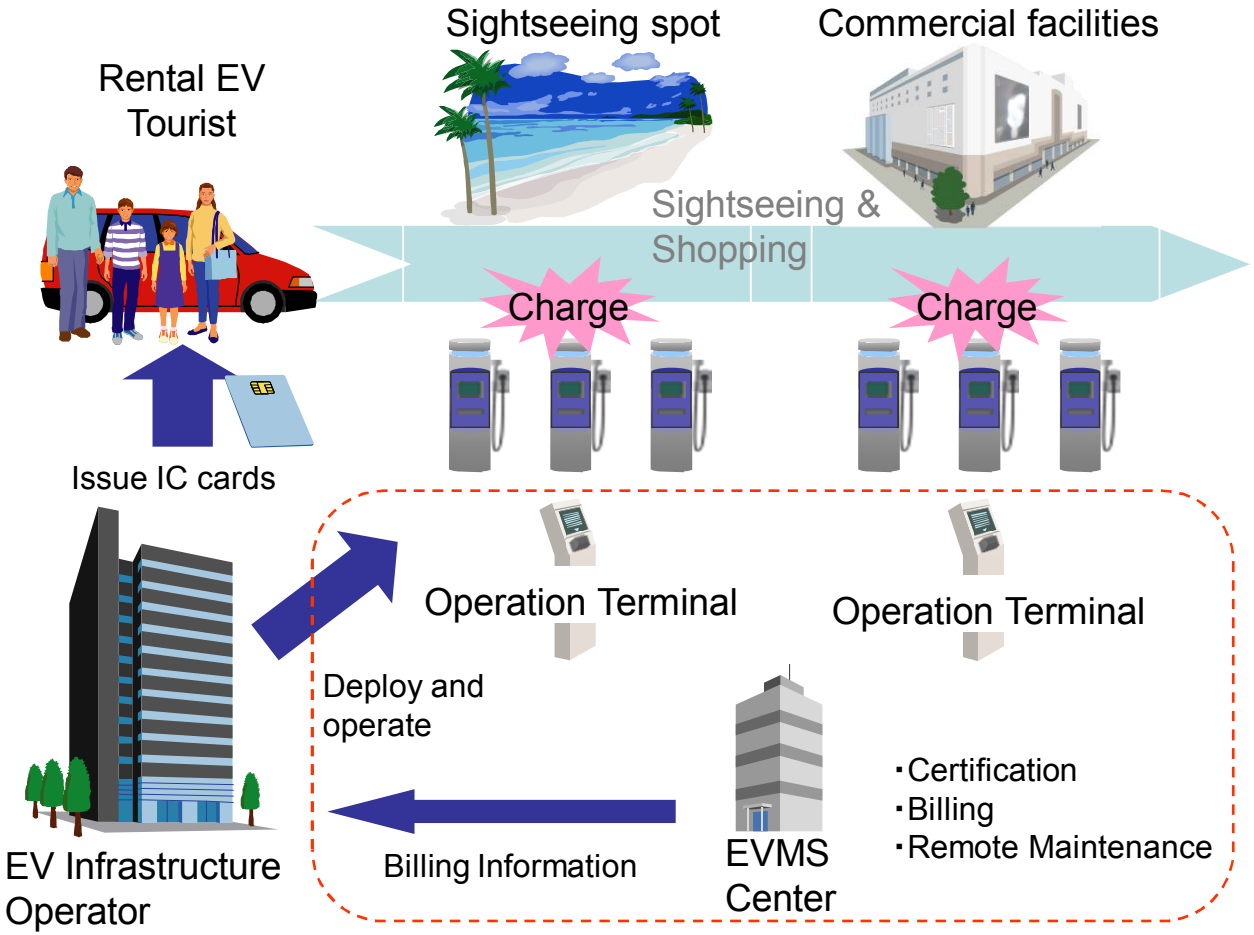
EV Business Case Model In Operation - Okinawa

- Rental EV Business model integrated with tourism



OKINAWA
EV Charging spot

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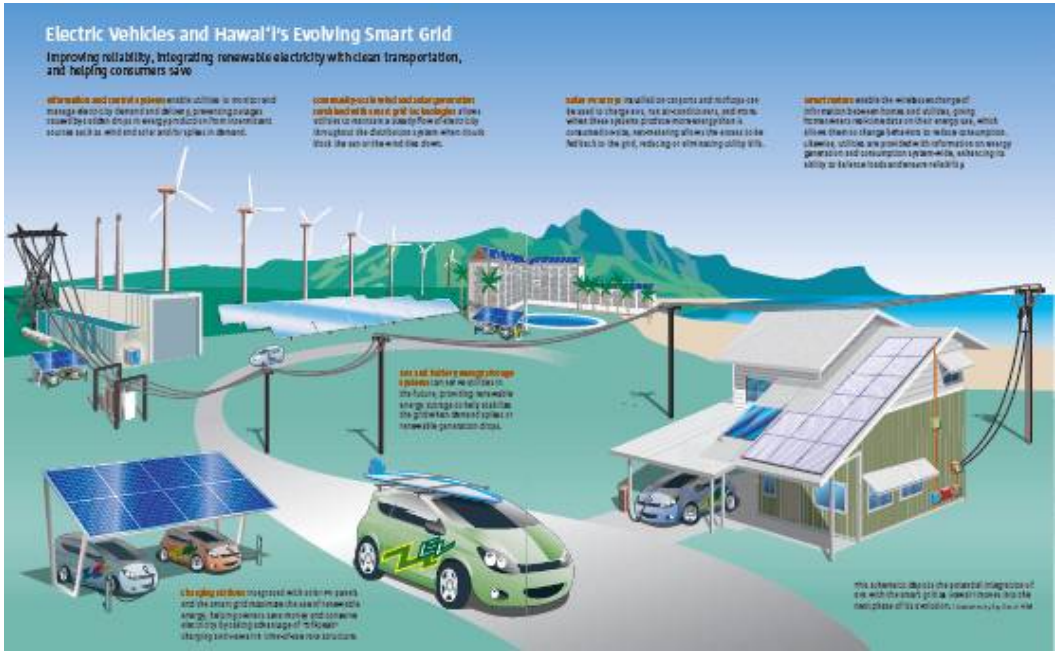
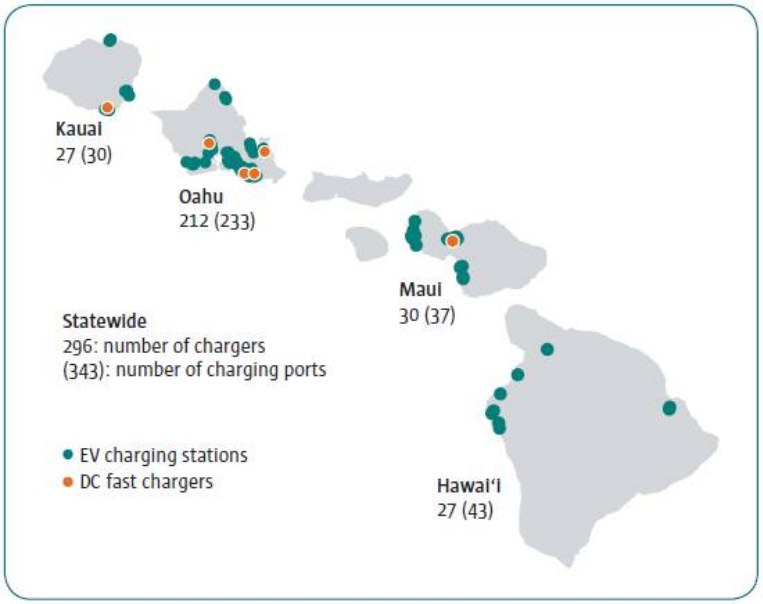
Hawaii State Energy Office EV Vision

State of Hawaii's Renewable Energy + EV + V2G concept





Locations of EV charging stations and DC fast chargers in Hawai'i as of February 2013.
Illustration by Stacy Buchanan, NREL

		Oahu	Maui	Hawaii	HI state total
Passenger car	Gasoline	647,150	170,270	179,017	1,077,697
	Hybrid	10,805	1,887	2,019	15,563
	EV	1,307	254	97	1,707
Commercial (Truck)	Gasoline	31,073	5,593	6,523	44,960
	Diesel	3,591	1,660	3,047	9,370
	Hybrid	73	2	1	77
	EV	5	0	0	5
Bus	Diesel	1,735	199	268	2,213
	EV	0	0	0	0

July 2013 registered vehicle data

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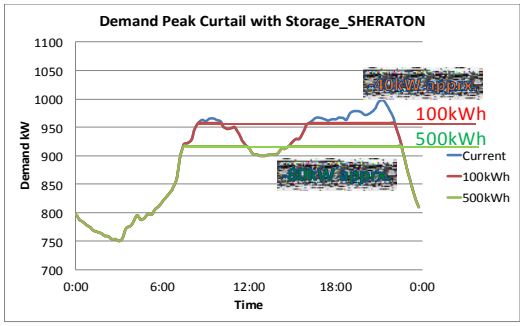
FY 2013 METI next generation automobile (EV/PHV/FCV) research in Hawaii

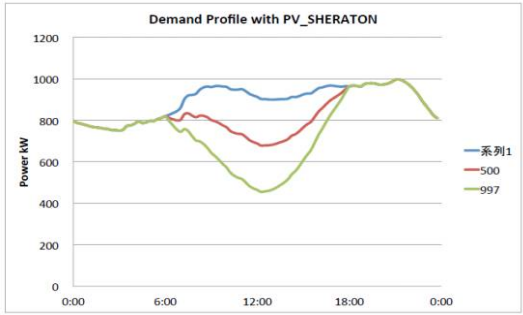
Flat Field Co., Ltd. (Atsugi-shi, Kanagawa 243-0021, Japan)

- Engaging Stakeholders
  - Hawaii State Energy Office (DBEDT), Maui County gov't.
  - Dept. of Transportation/HNL International Airport
  - Hawaiian Electric
  - JTB Hawaii Travel, TP Transportation
  - Oahu (Waikiki) Hotels
    - Hilton Hawaiian Village, Sheraton Waikiki, Royal Hawaiian Hotel, Trump Tower Waikiki, Kahala Hotel
  - Maui (Lahaina) Hotels
    - Westin Maui/Sheraton Maui, Hyatt Regency Maui

Learning

1. Eco-Tourism demand: EV bus is attractive for tourists
2. Short distance: good for busy road / circulating trolley
3. EV charging electricity: should be renewable base (not diesel, but solar and wind)
4. V2G discharge: more than mere saving electricity bill, building critical power back-up (e.g., tsunami & natural disaster, blackout)





V2B from EV

- Energy from 1 EV bus (~100 kWh) = 4 EV cars (~24 kWh)
- Bus operating schedule is fixed

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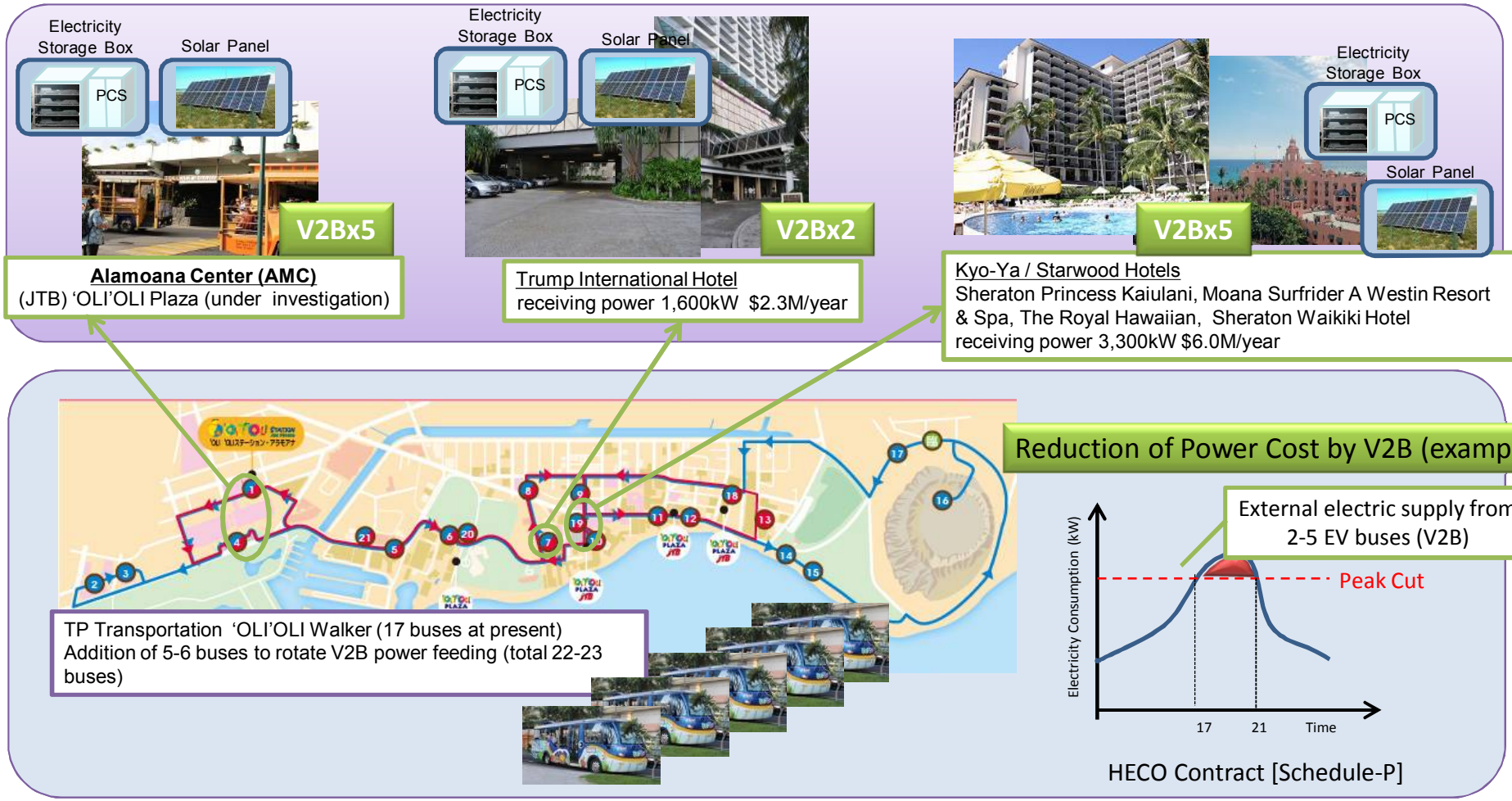
Flat Field's Progress Report: Waikiki (Nov 2013)



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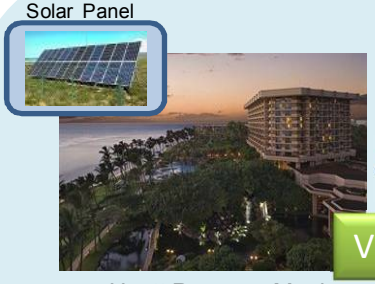
Flat Field's Progress Report: Maui (Nov 2013)

Solar Panel



V2B

Hyatt Regency Maui
500kW Solar Panel (from 2015)

Each Hotel

1-2 EV buses :
Kaanapali Islander#25 route
35 miles/day + electric supply from V2B

V2B

The Outlet of Maui (open in Dec 2013)

Solar Panel

Airport

Rent-a-car / Parking

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Research, Collaboration and Business Opportunities Abound

- **Hawaii and Okinawa are ideal working 'labs' to prove concepts and learn lessons about advanced energy technologies**
- **Hawaii can grow our successful collaboration with national and international partners like Japan and create a leading international showcase of smart energy solutions in action that will …**
  - √ **Increase energy independence**
  - √ **Reduce fossil-fuel use**
  - √ **Limit greenhouse gases**

A Key to Secure Paradise in Hawaii and Establish a Clean Energy Economy

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Mahalo!

(Thank you)

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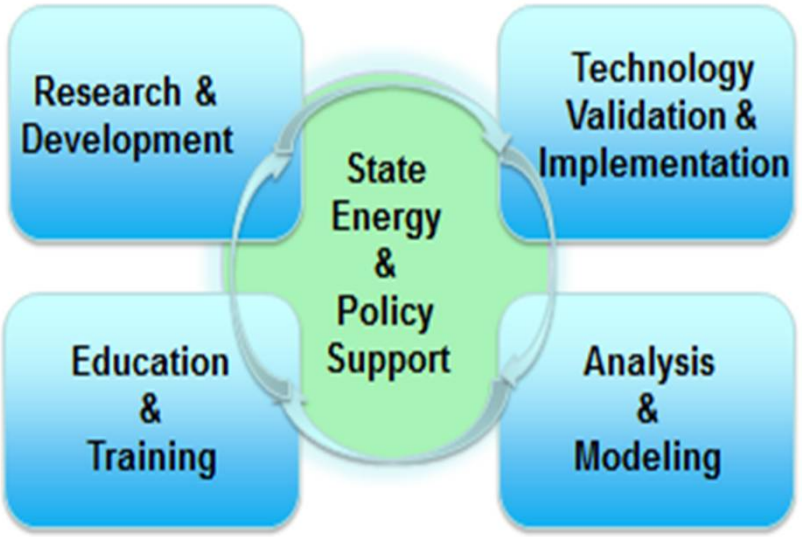
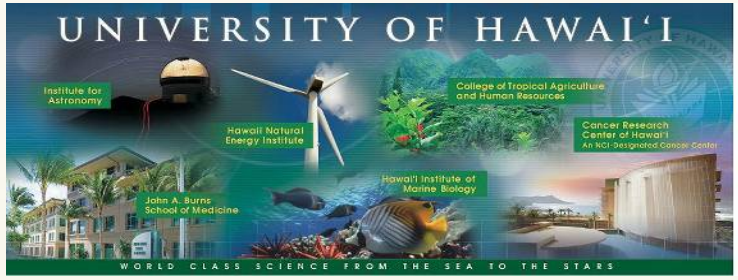
Supplemental Slides

Hawaii Natural Energy Institute

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

- ✓ **Alternative Fuels:**
  - Biomass, Biofuels, Hydrogen, Methane Hydrates
- ✓ **Electrochemical Power Systems**
  - Fuels Cells, Batteries
- ✓ **Renewable Power Generation**
  - Ocean Energy
  - Photovoltaics
- ✓ **Energy Efficiency**
  - Building Technology
  - Sea Water Air Conditioning
- ✓ **Systems Integration**
  - Grid modeling and analysis
  - Smart grid and microgrid development
  - Storage application on the grid





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MAUI SMART GRID PROJECT

- 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.

COUNTY OF MAUI
STATE OF HAWAII

Hawaii Natural Energy Institute
University of Hawaii at Manoa

Hawaiian Electric Company

ALSTOM

SILVERSPRING NETWORKS

medb
maui economic development board, inc.

Sentech, Inc.

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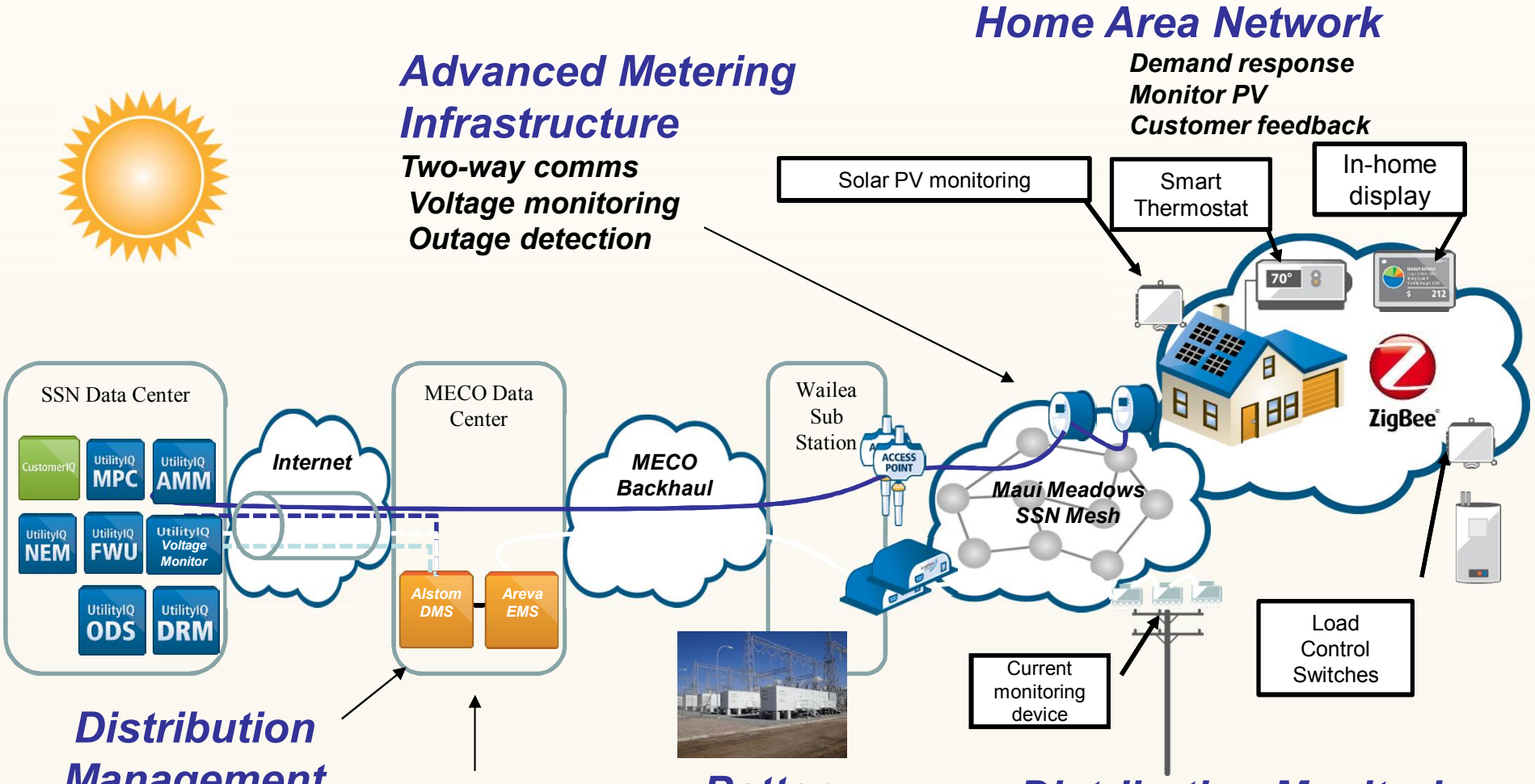
Project will Manage Distributed Energy Resources (DER) to Support Grid Operations



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Development and Demonstration of Smart Grid-Enabled PV Inverters

Research Project lead
- Project oversight, management and direction
- Smart Inverter application design; performance and data analytics

Communications and Customer Engagement technology lead
- Mesh com system; Inverter management & control system software
- Customer engagement via PV customer portal

Inverter technology leads
- Lead for communications integration into inverter, develop control functionality in inverter + control SW

Host utility in Hawaii
- Inverter operations for field pilot; performance evaluation

Co-Services lead – established PV provider in Maui
- Sales, marketing, installation, project management, customer service

Host utility in Washington DC, Maryland, New Jersey
- Inverter operations for field pilot; performance evaluation

Co-Services lead – established PV provider in PHI service territory
- Sales, marketing, installation, project management, customer service

Inverter Testing Laboratory Facility
- Site of functional requirements and inverter testing

Solution Architecture

Utility Back Office Systems

Inverter Management & Control Software

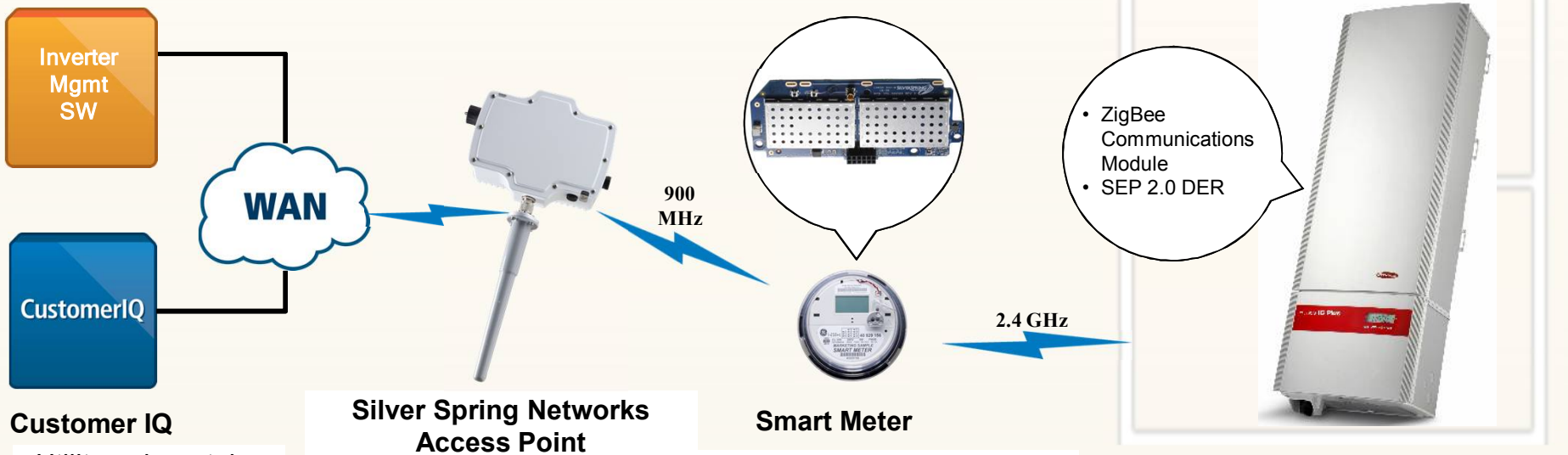
- Provision inverter on network
- Manage PV Production Data
- Send control signals to inverter
- Monitor status of inverter

Smart Grid Network

Silver Spring Networks Network Interface Card

- 900 MHz utility smart grid network
- Retrieve PV production data
- Send inverter control signals through network

Home



Customer IQ

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

Silver Spring Networks Access Point

Smart Meter

- Utility owned
- Home's primary meter
- SEP 2.0 over 2.4 GHz ZigBee

Based on Fronius IG Plus V Inverter

Advanced Grid Functions (Examples)

- Remote generation curtailment
- Volt-Var control curves
- Volt-Watt control curves

Silver Spring® NETWORKS

UNIVERSITY of HAWAI'I MĀNOA