2014 World Green Energy Forum

Gyeongju, Korea

Energy Storage: Game Changer for the Electric Industry

October 23, 2014

Lorraine H. Akiba, Commissioner
Hawaii Public Utilities Commission

Energy Storage in Hawaii Today

- Important resource to enable high levels of renewables on grids
  - Flexible tool to meet grid operating needs
  - Non-generation substitute for ancillary services vs. shifting energy
  - Kauai, Lanai, and Maui grids operating with significant levels of variable renewables supported by energy storage systems
- Promising tool to integrate distributed generation
  - Significant interest in customer-sited storage
  - Demonstrations looking at distribution-level applications
- Broad range of applications, siting, and ownership models
  - Ancillary services, peak load mgmt., customer-demand mgmt.
  - Mix of R&D, IPP, utility, and customer projects
  - Transmission, distribution, and customer-side applications

Hawaii Electric Systems

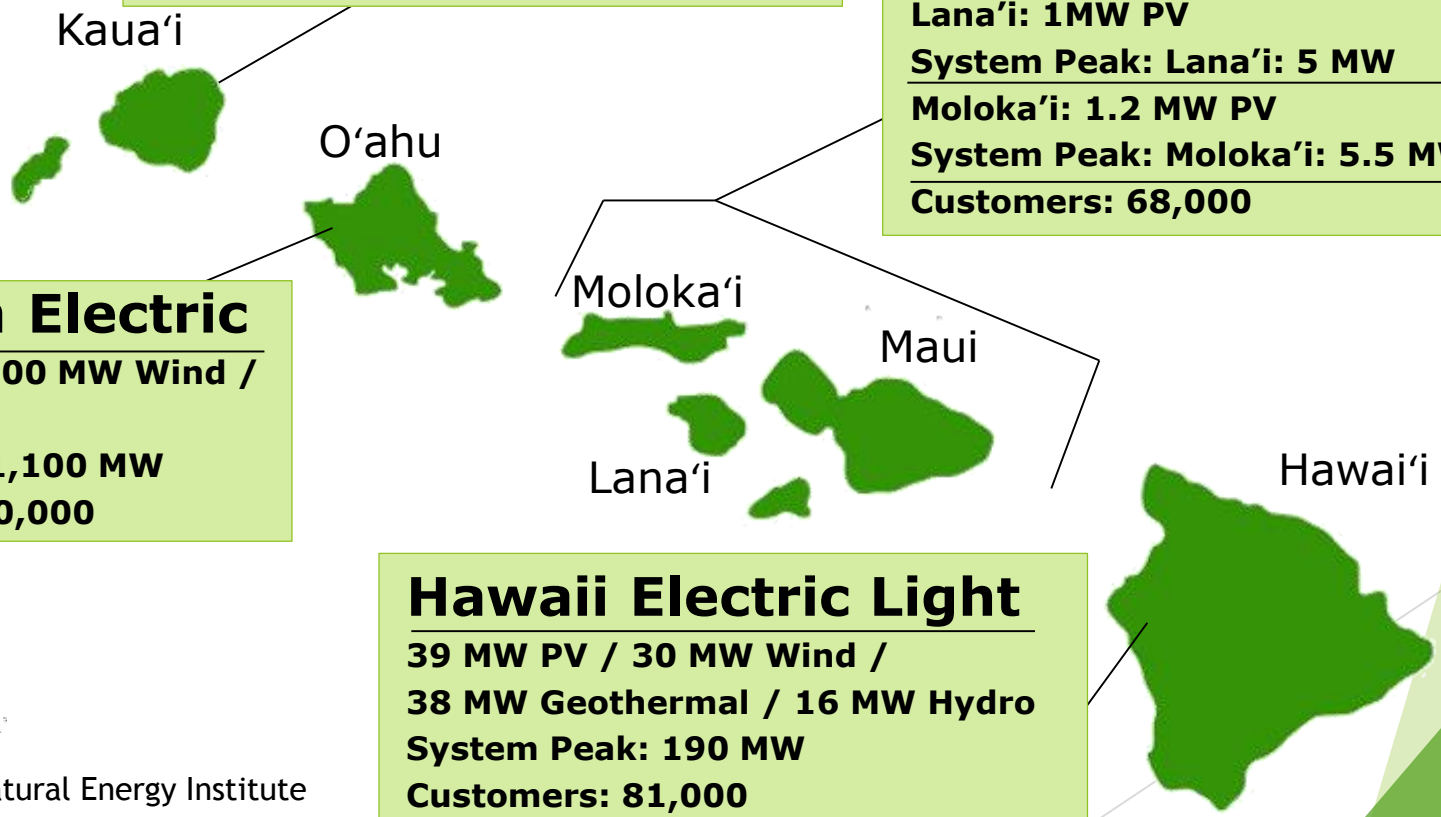
4 electric utilities; 6 separate grids

Kauai Island Utility Cooperative

27 MW PV (24 MW in development)
System Peak: 78 MW
Customers: 32,700

Maui Electric

Maui: 60MW PV / 72MW Wind
System Peak: Maui 200 MW
Lana'i: 1MW PV
System Peak: Lana'i: 5 MW
Moloka'i: 1.2 MW PV
System Peak: Moloka'i: 5.5 MW
Customers: 68,000



Hawaiian Electric

221 MW PV / 100 MW Wind / 69 MW WTE
System Peak: 1,100 MW
Customers: 300,000

Hawaii Electric Light

39 MW PV / 30 MW Wind / 38 MW Geothermal / 16 MW Hydro
System Peak: 190 MW
Customers: 81,000

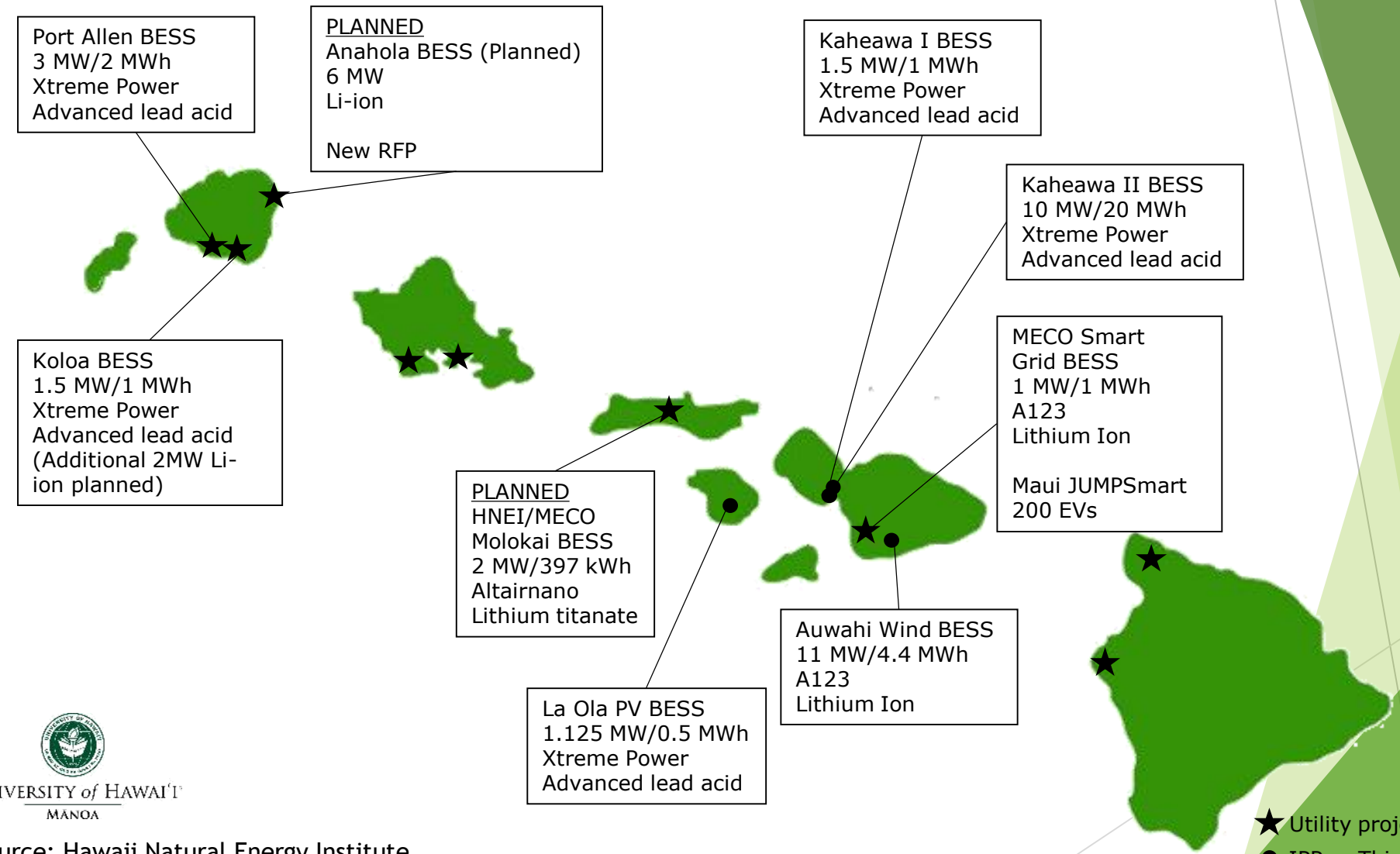
UNIVERSITY of HAWAI'I MANOA

Source: Hawaii Natural Energy Institute

Hawaii Battery Energy Storage System (BESS) Projects; RFPs

Title	MW	MWh	Date
Kauai Island Utility Cooperative Koloa BESS	1.5	1	2011
Kauai Island Utility Cooperative Port Allen BESS	3	2	2012
Lanai La Ola Solar … for 1.2 MW PV (solar) on 5 MW grid	1.125	0.5	2011
Kaheawa Wind I … 1st (30 MW) wind on 200 MW grid	1.5	1	2009
Auwahi Wind … 2nd (22 MW) wind on 200 MW grid	11	4.4	2012
Kaheawa Wind II … 3rd (22 MW) wind on 200 MW grid	10	20	2012
Maui Electric / USDOE Smart Grid BESS … Wailea	1	1	2013
Hawi Substation … for high wind penetration circuit	1	0.25	2012
HELCO Battery Energy Storage System … utility owned	(2) 0.1	(2) 0.25	2012
KIUC Energy Storage RFP … 45 project proposals received, for batteries / flywheels / pumped storage hydro / compressed air / water heaters.			
HECO Energy Storage RFP … 60 to 200 MW for Oahu. Proposals due 7/21/14.			

Kauai and Maui County Energy Storage Projects



UNIVERSITY of HAWAI'I MANOA

Source: Hawaii Natural Energy Institute

Storage Helping Integrate Wind and Solar Power Today

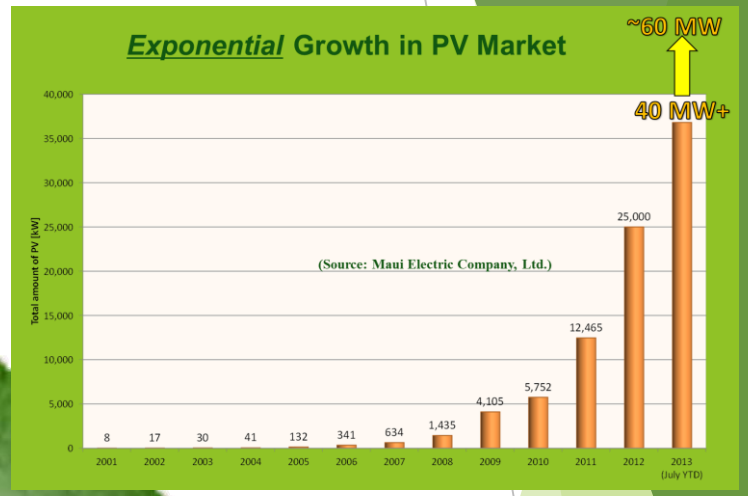
Maui Island Case

72 MW Wind
60 MW PV
132 MW Total

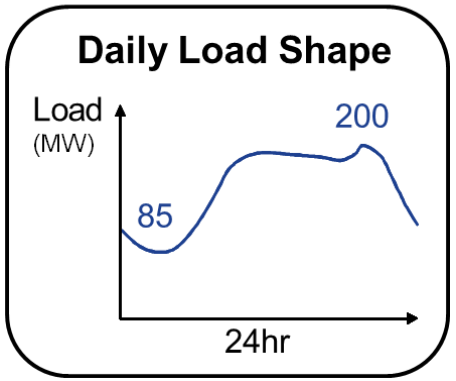
Kaheawa I
(30 MW)

Kaheawa II
(21 MW)

Auwahi
(21 MW)



63,000 Customers



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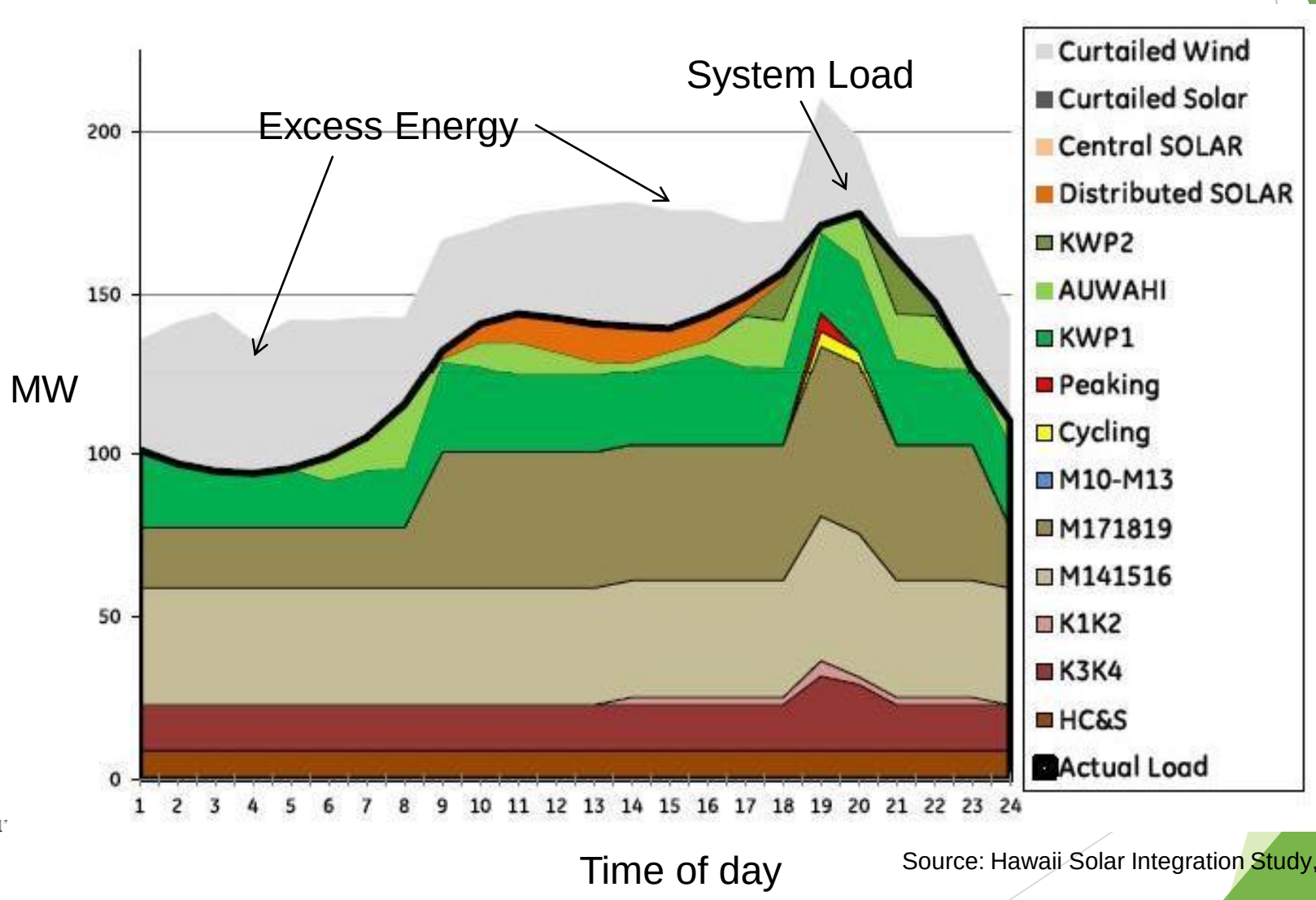
MANOA

Source: Hawaii Natural Energy Institute

Storage Installed at Wind Plants to Reduce Variability And Operate as "Virtual" Generation Unit



Source: Hawaii Solar Integration Study, 2012.

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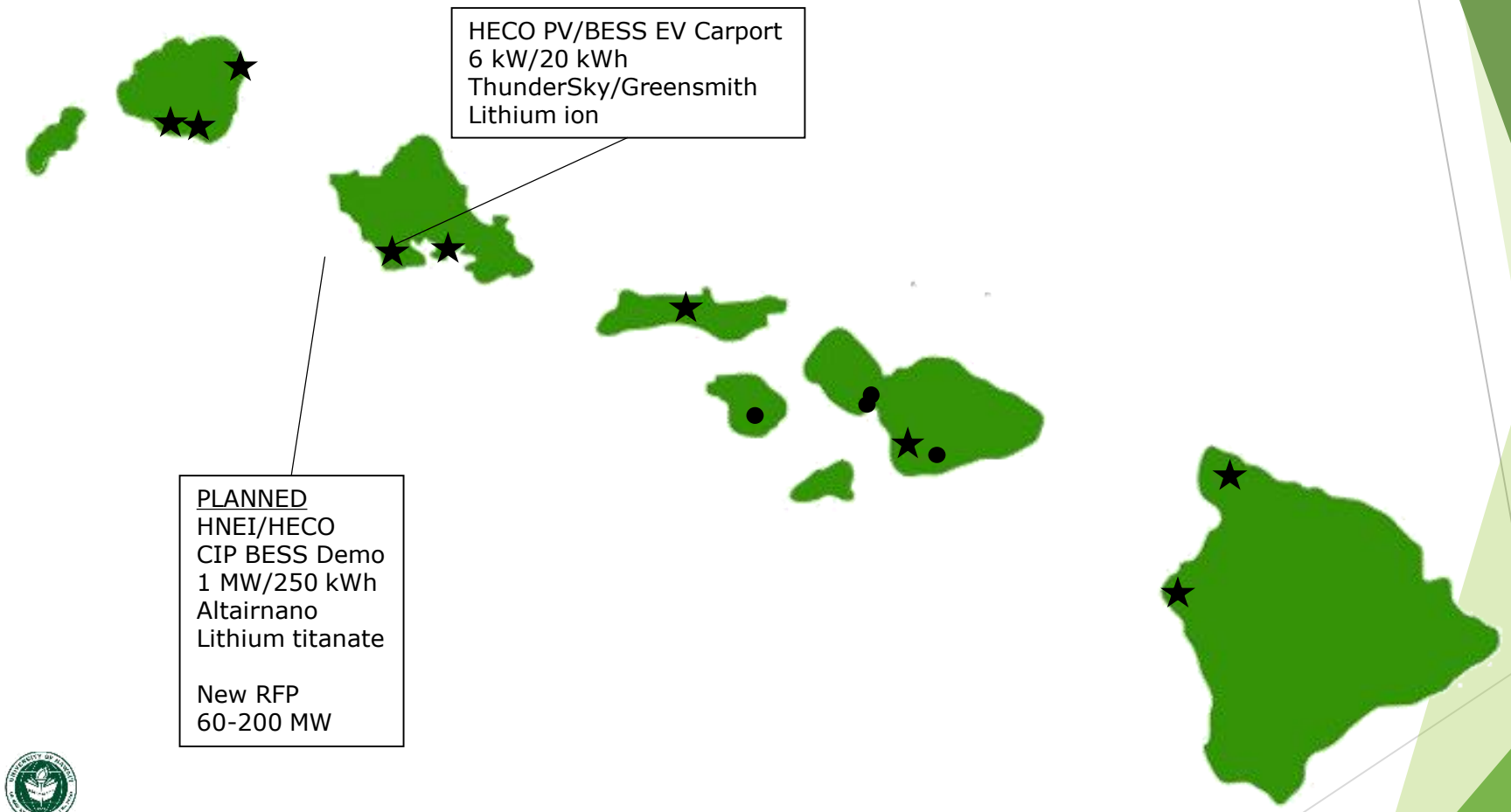
Oahu Energy Storage Projects



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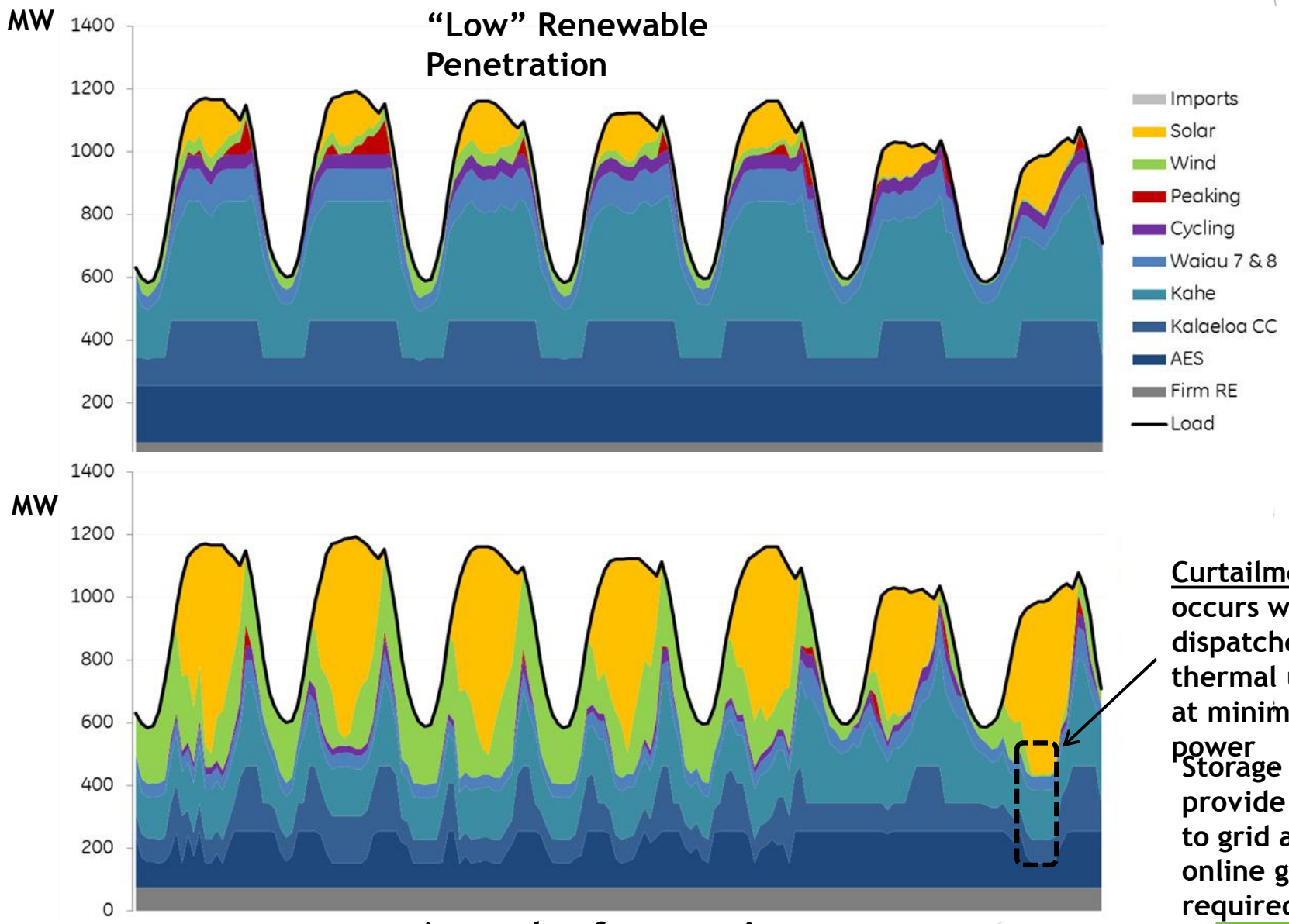
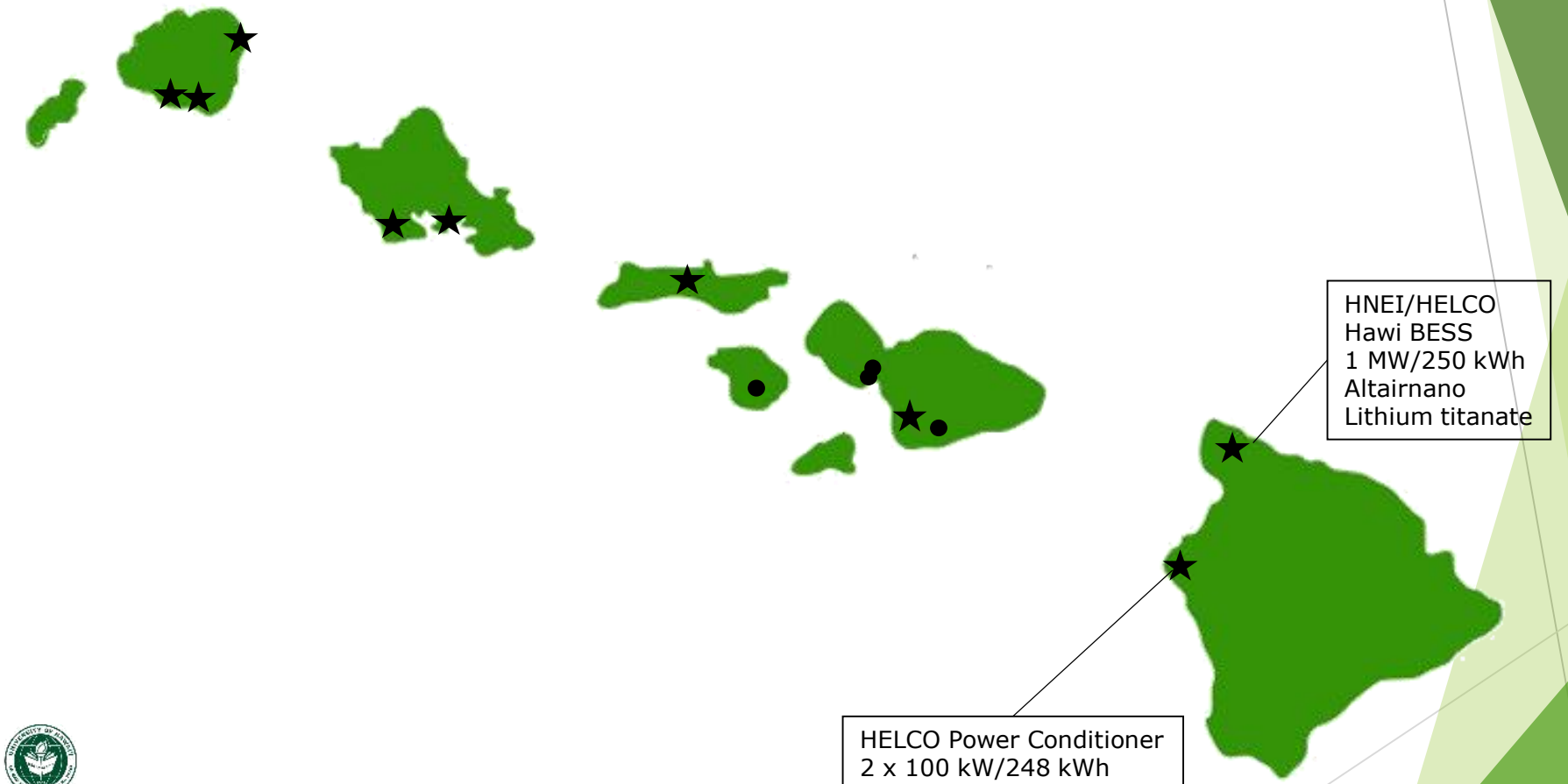
Source: Hawaii Natural Energy Institute

Oahu Storage Proposed to Increase Grid's Capacity to Integrate High Levels of Solar and Wind



Source: Hawaii RPS Study, forthcoming.

Big Island Energy Storage Projects



UNIVERSITY of HAWAI'I MANOA

Source: Hawaii Natural Energy Institute

BESS Demonstration Project Highlights

Haw'i 10 MW Wind farm at Upolu Point Hawaii Island

- 1MW, 250kW-hr at wind and utility interface; Li-ion Ti
- Control algorithms for frequency regulation and wind smoothing

Photo courtesy of HECO

NEDO Maui JUMPSmart Demonstration Project

- 200 Evs with charge management
- Control algorithms to match renewable energy supply and DR applications

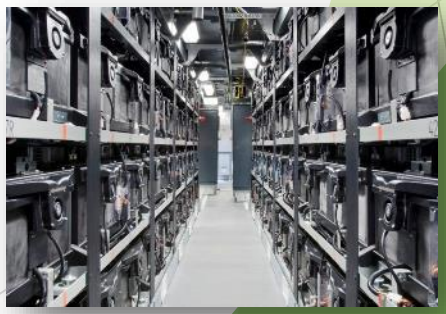
Molokai Secure Renewable Microgrid

- 2MW, 333kW-hr, Li-ion Titanate;
- Control algorithms for managing operating reserves, (fault management, frequency regulation)

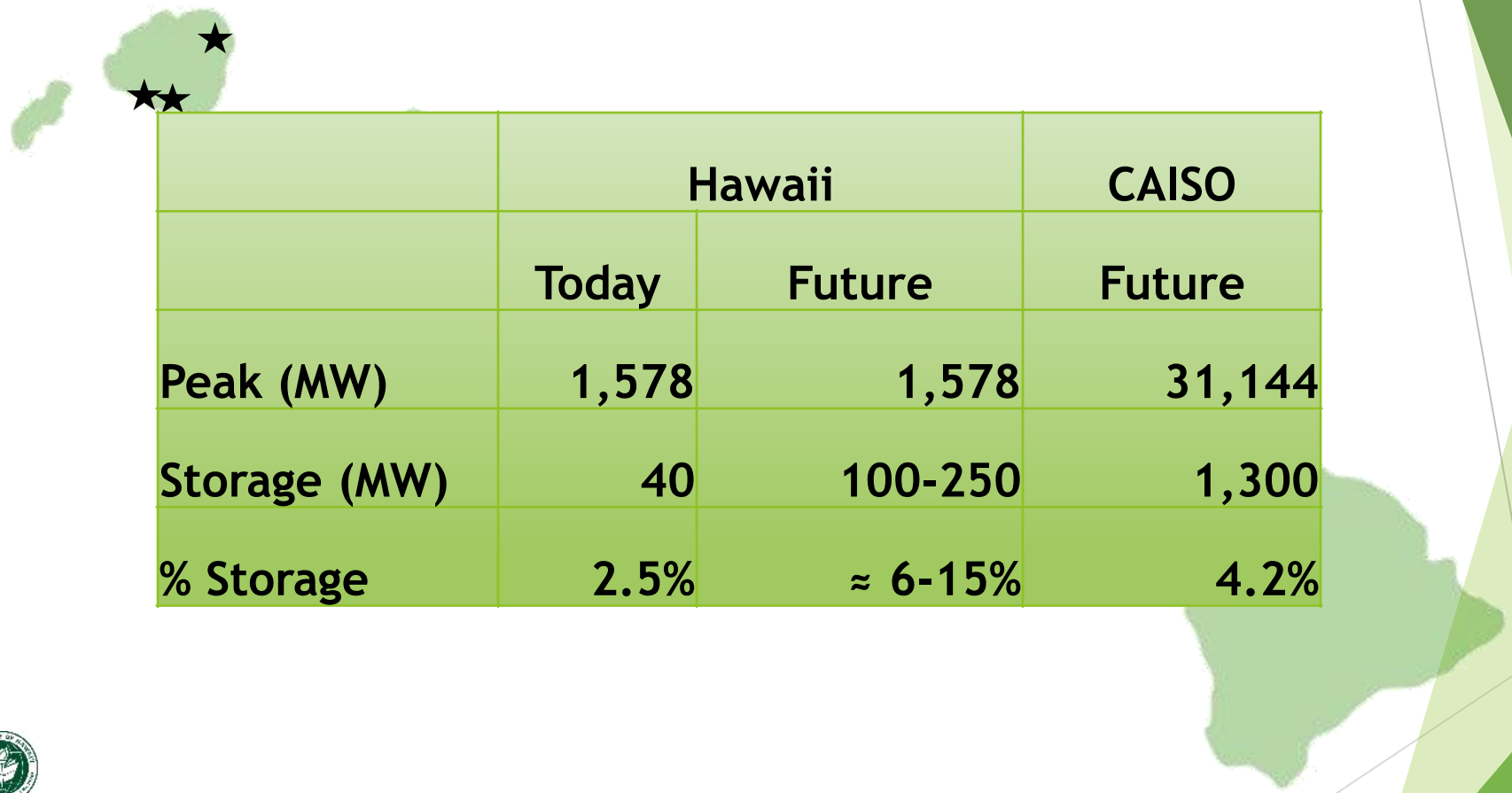
photos courtesy of Altairnano

CIP industrial feeder with high penetration (~3 MW of distributed PV)

- 1MW, 250 kW-hr at substation; Li-ion Ti
- Control algorithms for power smoothing, voltage and VAr support, and frequency regulation



Hawaii Energy Storage Project Summary



	Hawaii		CAISO
	Today	Future	Future
Peak (MW)	1,578	1,578	31,144
Storage (MW)	40	100-250	1,300
% Storage	2.5%	≈ 6-15%	4.2%

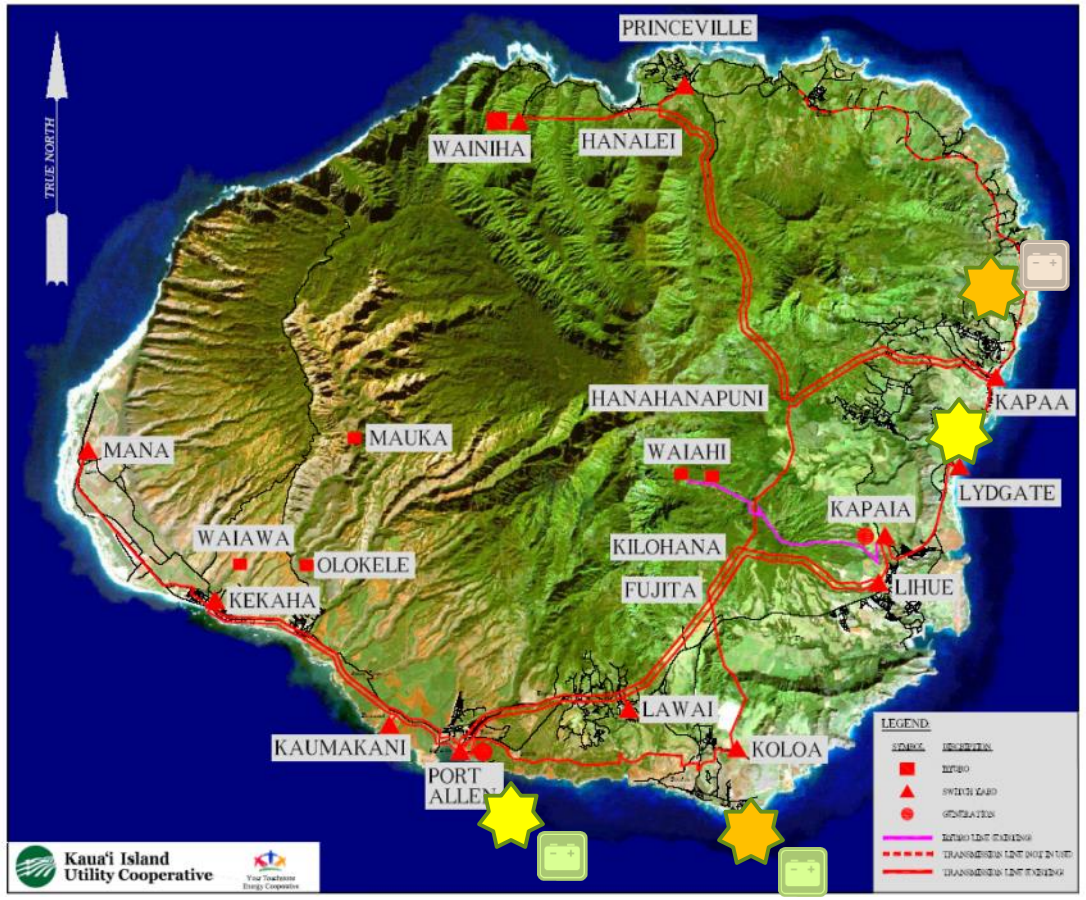
UNIVERSITY of HAWAI'I MĀNOA

Source: Hawaii Natural Energy Institute

★ Utility project

● IPP or Third-party project

KIUC Battery Energy Storage



Project Size(A.C. output)	Location	Grid Tie
6/4 MW/MWH	Anahola	Transmission Station
1.5/1 MW/MWH	Poipu	Dedicated Distribution Feeder
3/2 MW/MWH	Port Allen	Dedicated Distribution Feeder

Battery storage on Kauai

- Koloa BESS
- Rating: 1.5MW/1MW-hr
- Overload Rating: 2.25MW for < 10 seconds
- Commissioned: October 2011
- Type: Advanced lead acid

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- Port Allen BESS (2 units identical to Koloa)
- Rating: 3 MW/2MW-hr
- Overload Rating: 4.5MW for < 10 seconds
- Commissioned: December 2012
- Type: Advanced lead acid

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Future battery storage project: Anahola

6 MW lithium-ion BESS

Primary purpose: Smoothing 12 MW PV system scheduled for operation in 2014

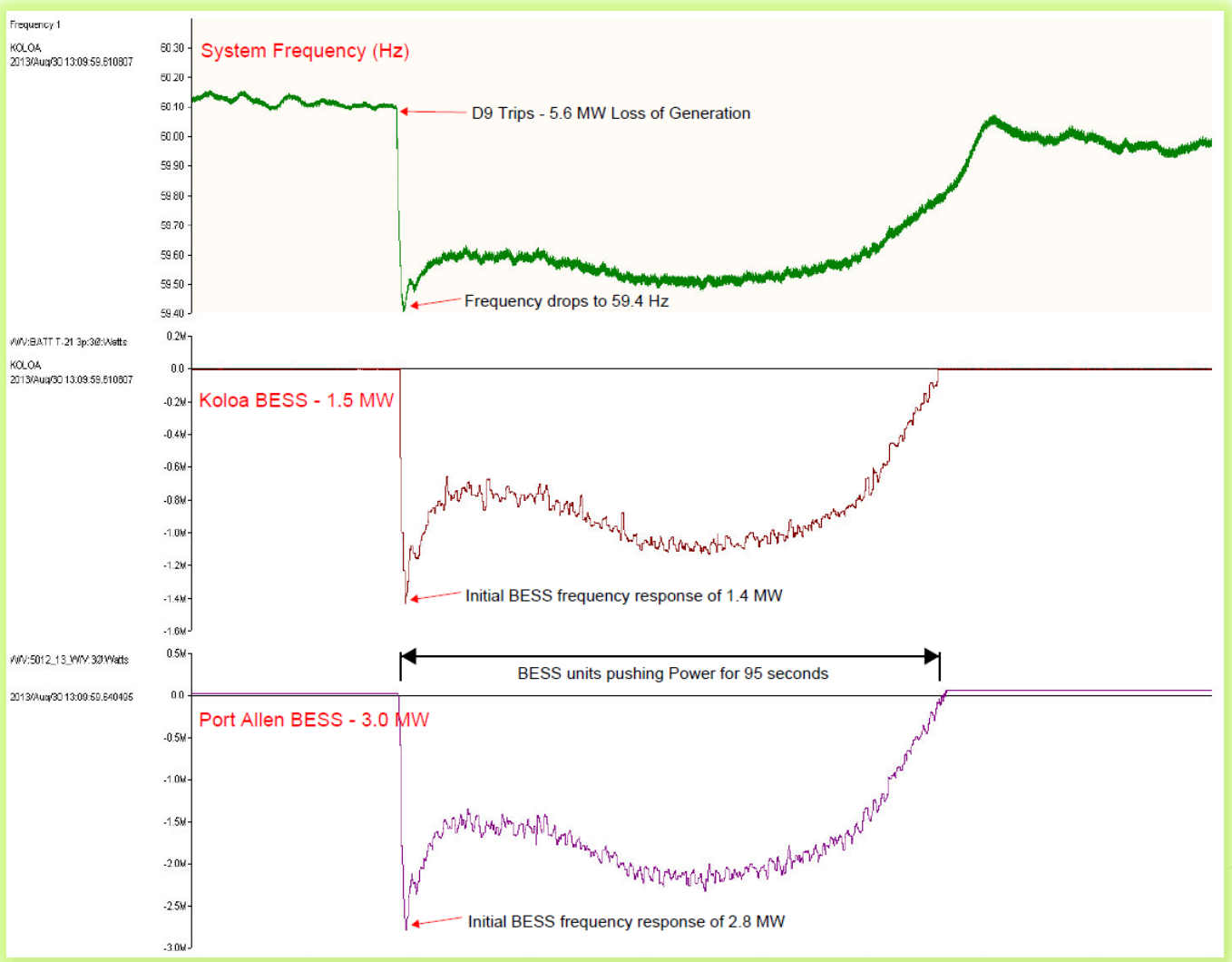
Kaua'i Island Utility Cooperative
Your Touchstone Energy® Cooperative

Battery storage: The Kauai experience

- Frequency response
- PV smoothing
- Covering for loss of generation

On at least a half-dozen occasions over the past 18 months, batteries have "stepped up" and prevented outages

Frequency response



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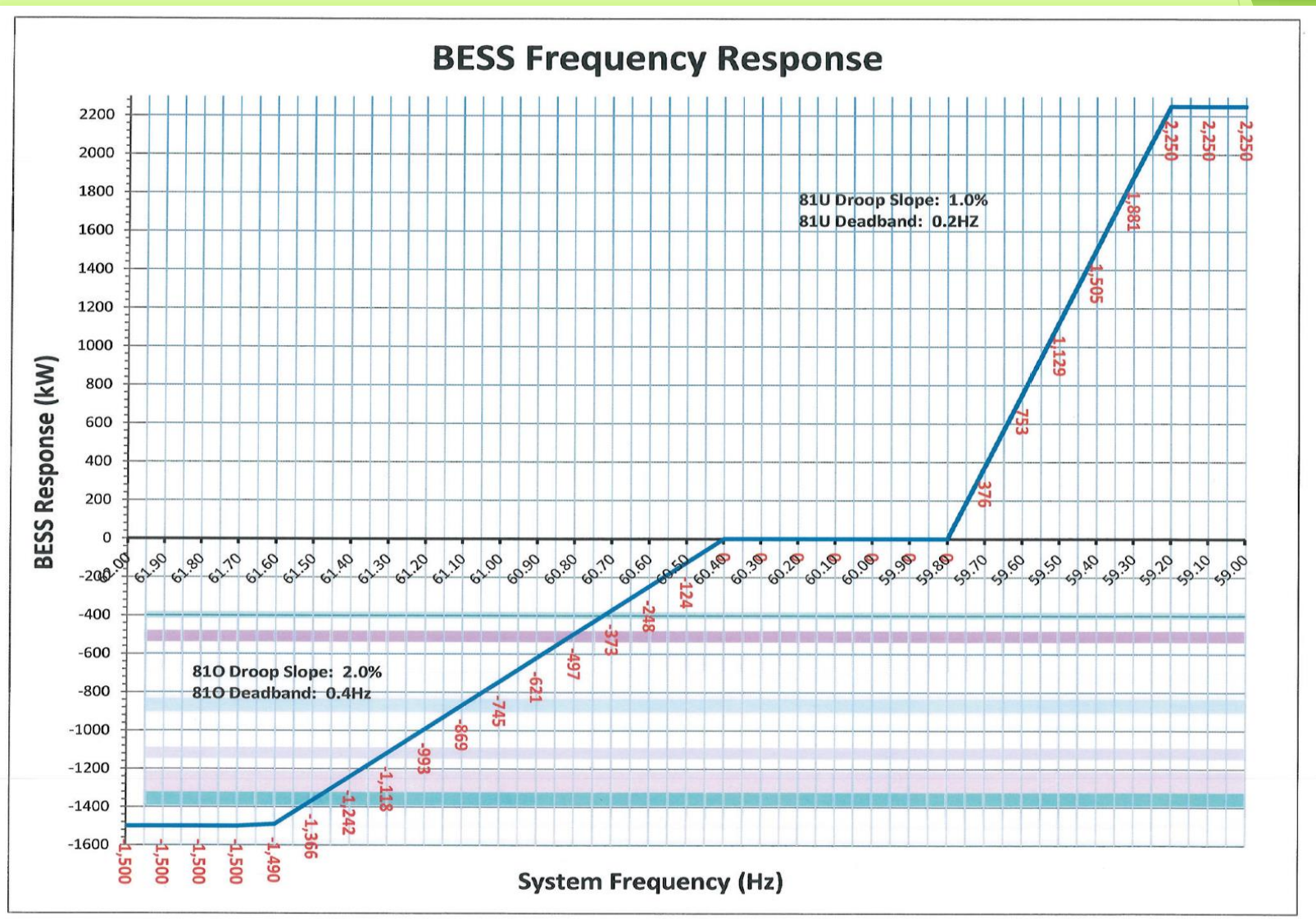
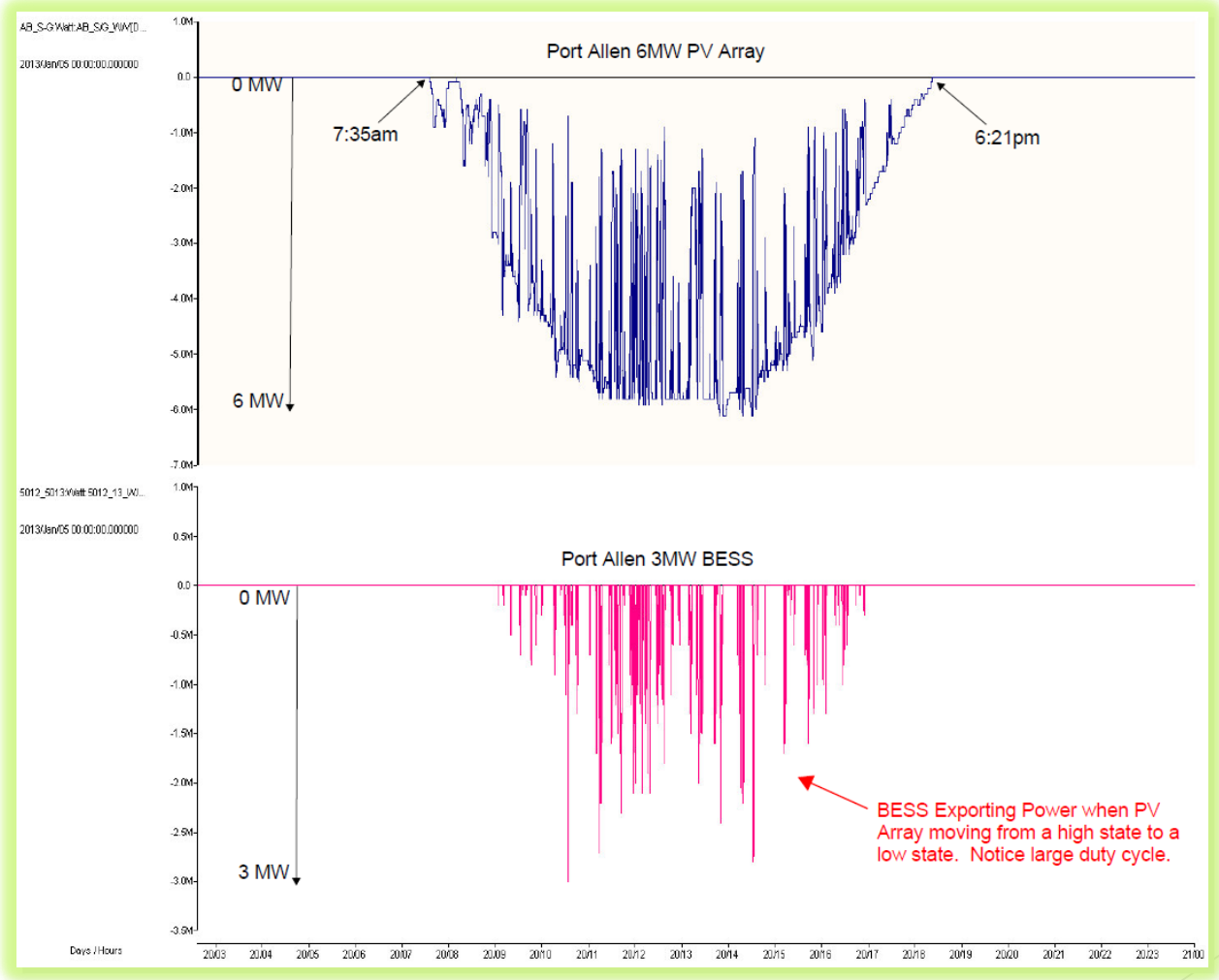

BESS Frequency Response
BESS Response (kW)
System Frequency (Hz)
81U Droop Slope: 1.0%
81U Deadband: 0.2HZ
81O Droop Slope: 2.0%
81O Deadband: 0.4Hz
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
-1200
-1400
-1600
62.00 61.90 61.80 61.70 61.60 61.50 61.40 61.30 61.20 61.10 61.00 60.90 60.80 60.70 60.60 60.50 60.40 60.30 60.20 60.10 60.00 59.90 59.80 59.70 59.60 59.50 59.40 59.30 59.20 59.10 59.00
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
-124 -248 -373 -497 -621 -745 -869 -993 -1,113 -1,242 -1,366 -1,490
-1,500 -1,500 -1,500 -1,500 -1,500
376 753 1,129 1,505 1,881 2,250 2,250 2,250

PV smoothing



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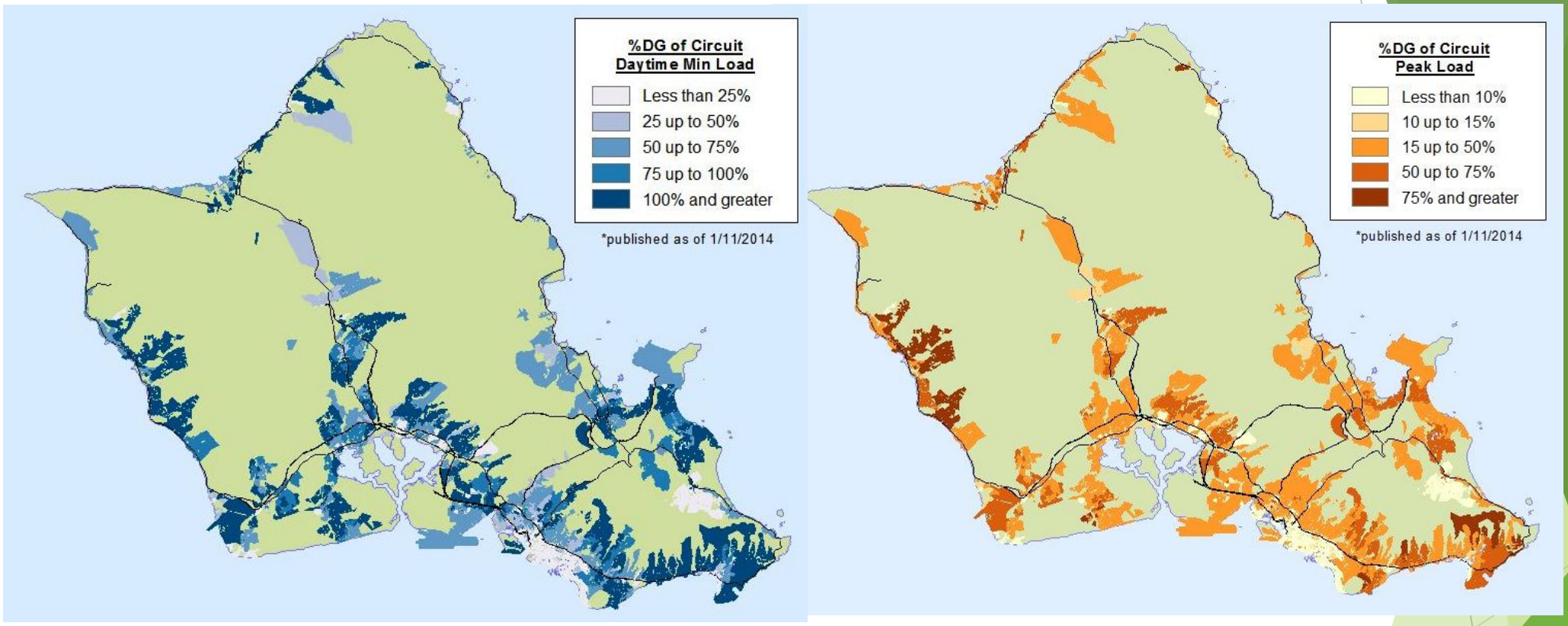
Next Frontier: Breaking through Distribution System Boundaries

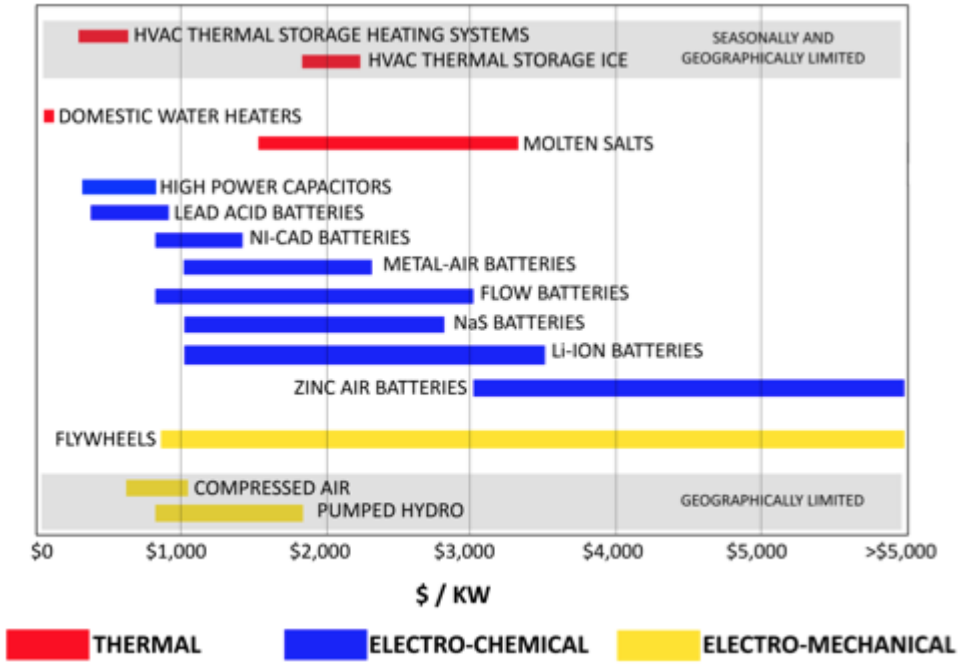


Source: Hawaiian Electric Co.

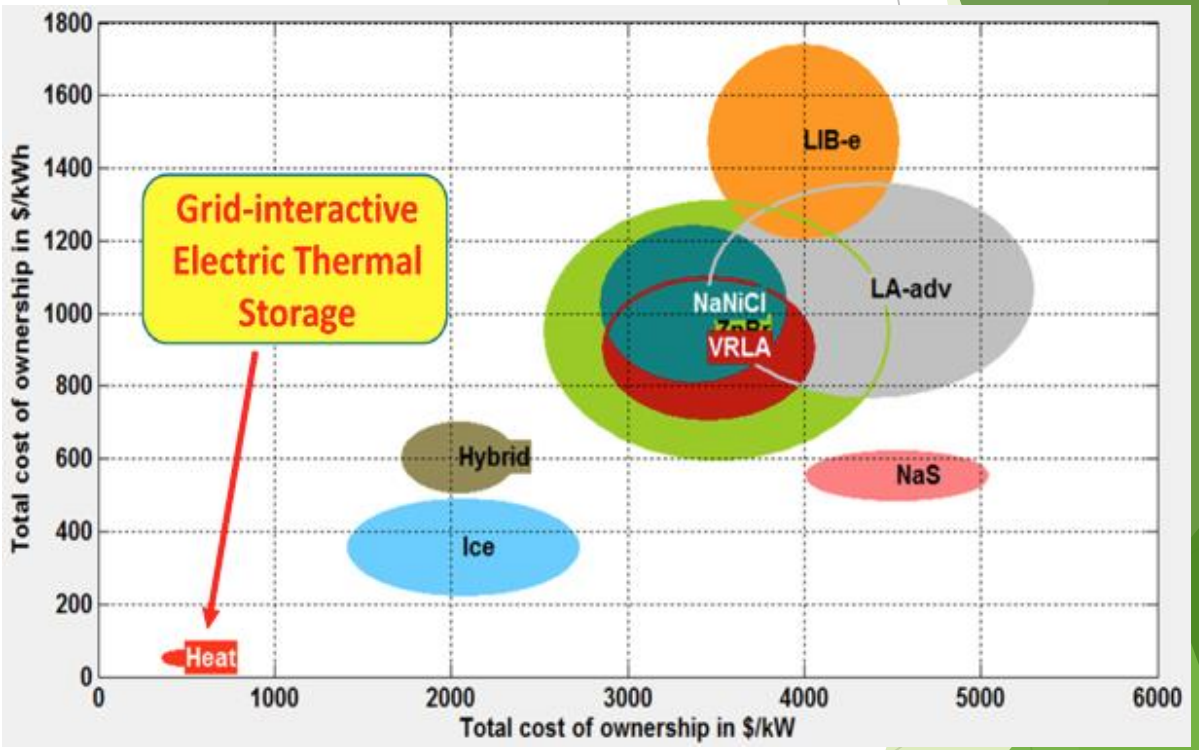
Current grid limits have slowed DG interconnection significantly

- Active demonstrations evaluating distribution-level storage applications
- Utilities and stakeholders drafting tariff language for customer-sited storage
- Commission white paper envisioned active market for distributed storage
- Aggregated distributed storage can help address system integration constraints

Storage Potential of Grid Interactive Water Heating ("Electric Thermal Storage")



The Electricity Storage Association



US Department of Energy Sandia Lab ES-Select – Energy Storage Valuation Software Tool

Acknowledgement: KANU Hawaii / Shifted Energy

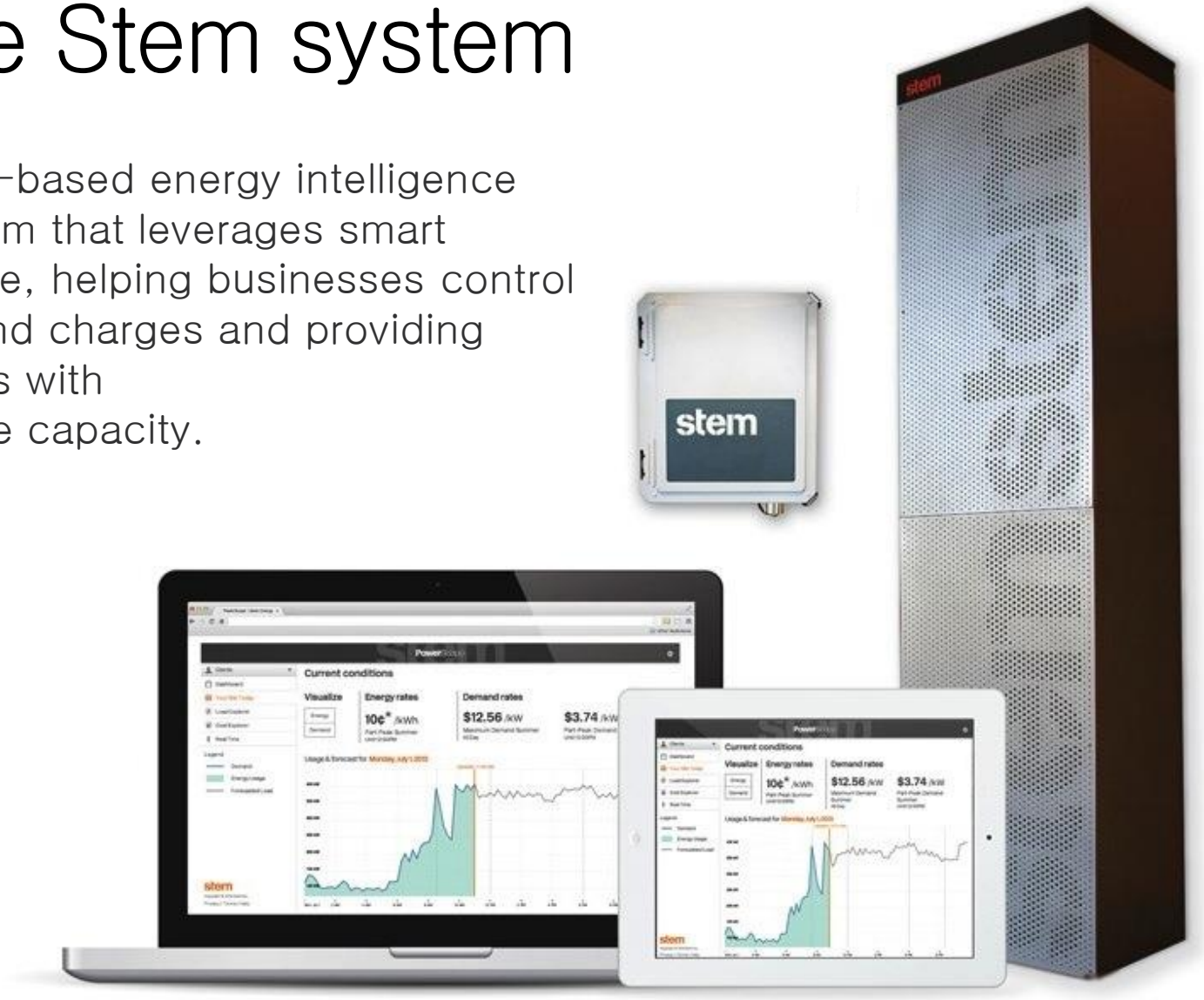
Stem energy storage

Dispatchable energy on the customer side

stem | Hawaiian Electric

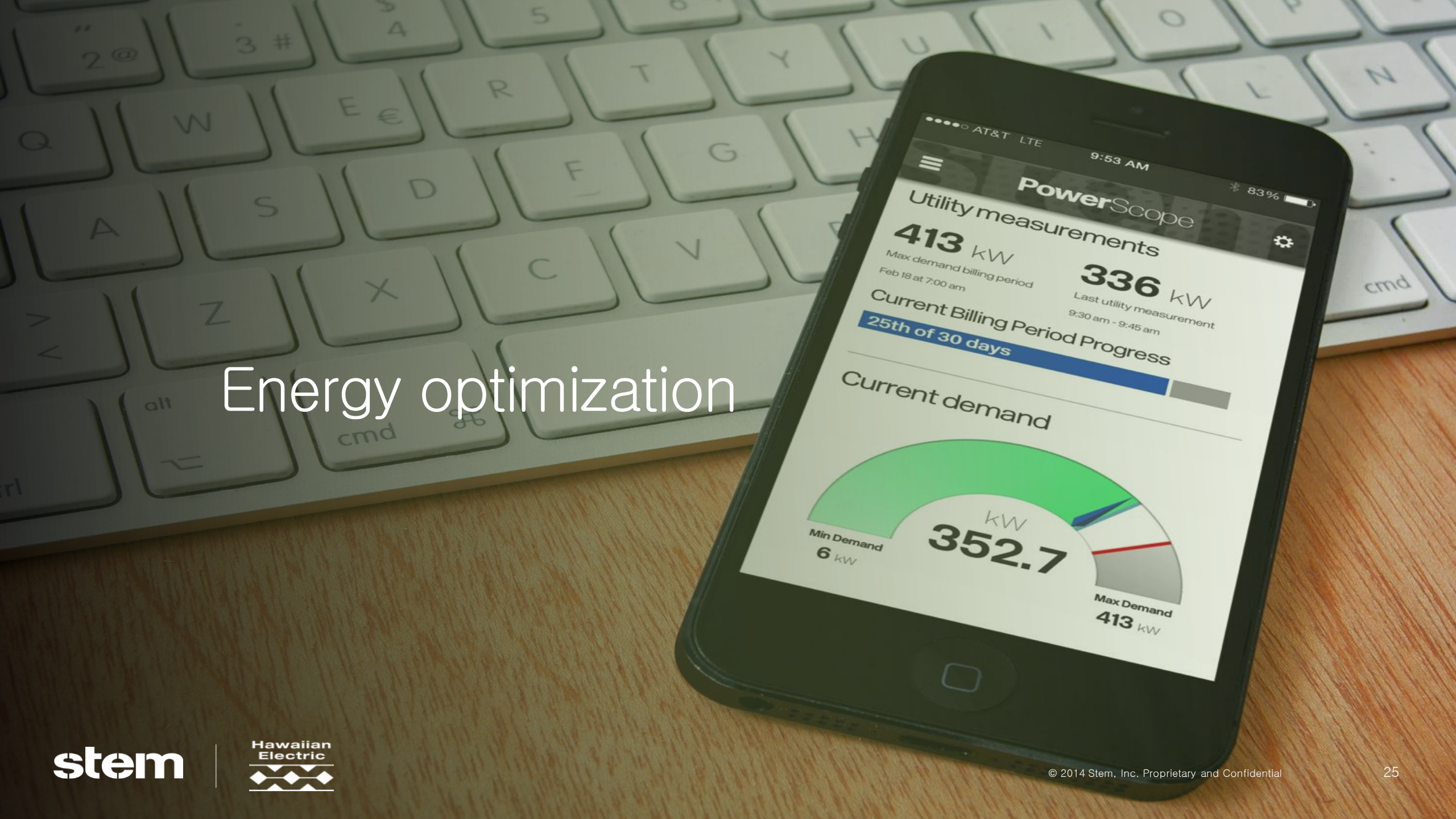
The Stem system

Cloud-based energy intelligence platform that leverages smart storage, helping businesses control demand charges and providing utilities with
flexible capacity.



stem | Hawaiian Electric

Energy optimization



stem | Hawaiian Electric

Energy

40.2 MWh

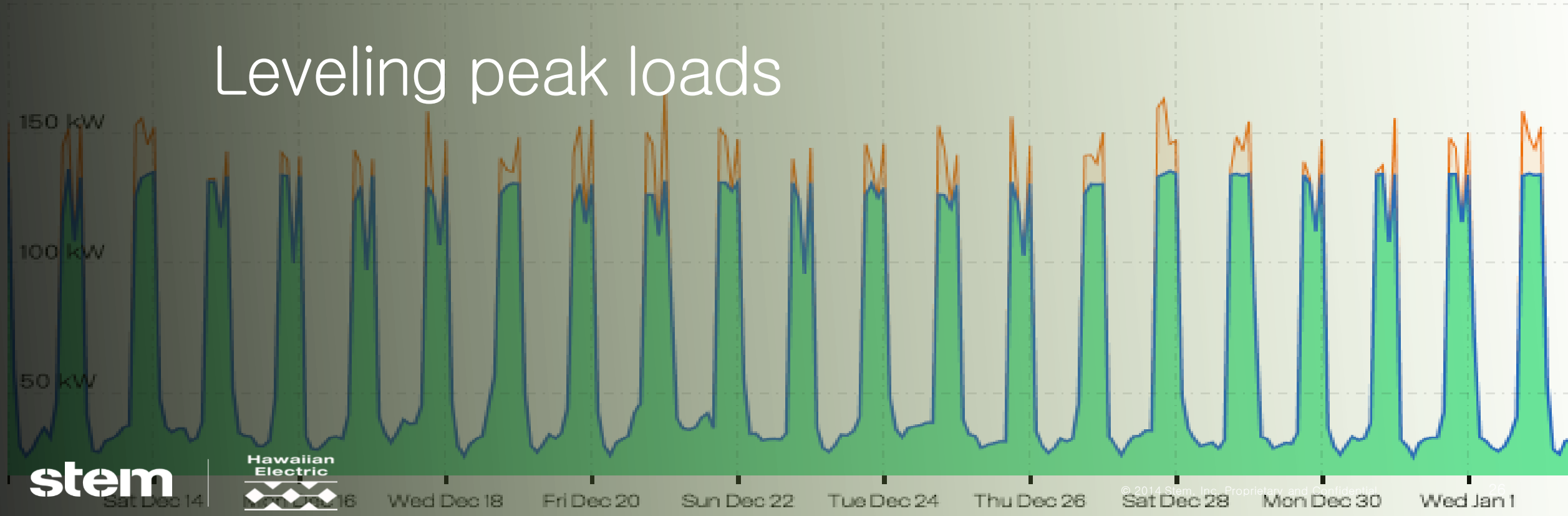
Demand

139 kW

Maximum Demand

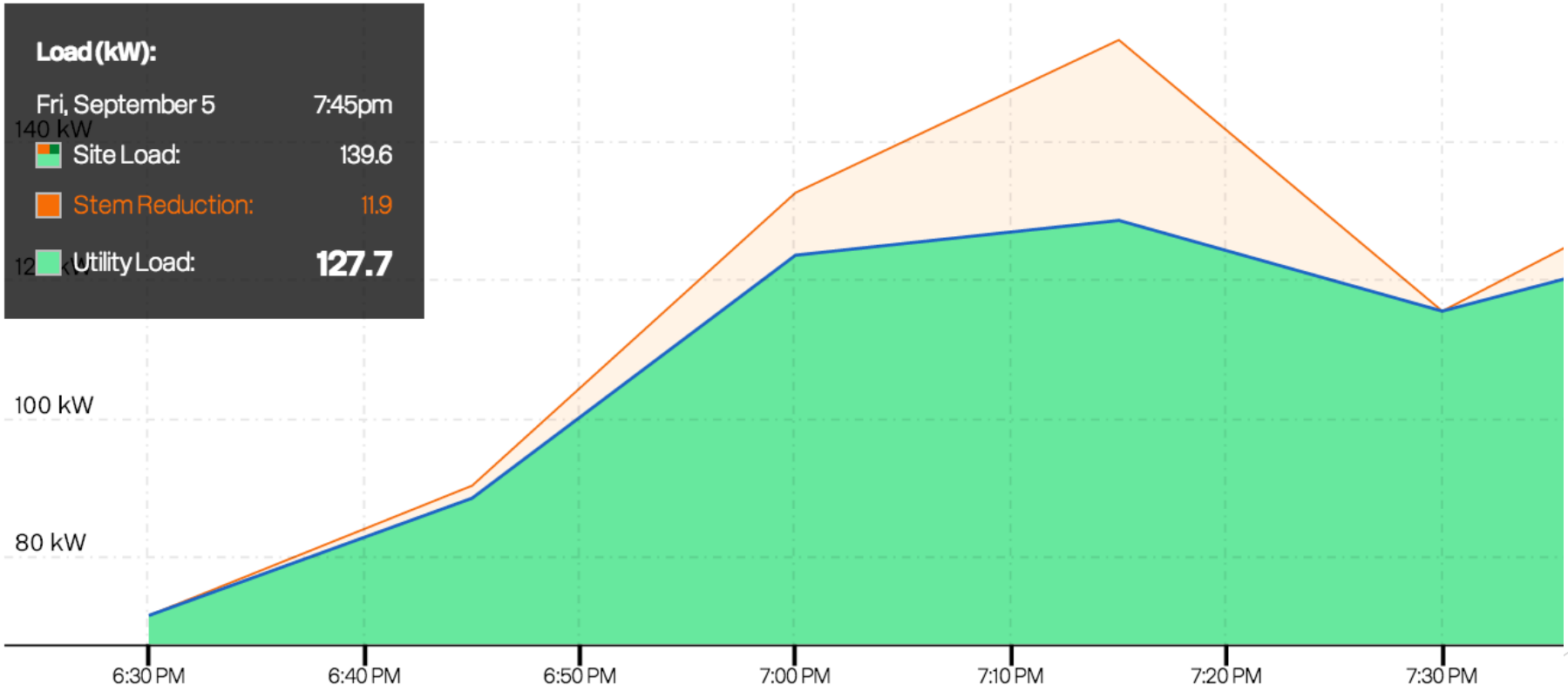
Show on graph

Leveling peak loads



stem | Hawaiian Electric

Peak reduction with Stem



stem | Hawaiian Electric

Distributed energy storage

stem | Hawaiian Electric

Policy and Regulatory Reforms to Achieve Hawaii's Clean Energy Future

- Recent directives and orders to Hawaii's utilities to implement new business models to become a world leading operator of a high renewable energy resource grid
- Regulatory policies and pricing also need to reflect these new business models with new incentives to achieve Hawaii's clean energy future
- Review and revision of pricing of energy services to reflect new business and technical demands

Recent Major Decisions and Orders to Implement the Integrated Grid

- Integrated Resource Planning Docket No. 2012-0036, Order No. 32052
  - White Paper entitled: “Commission’s Inclinations on the Future of Hawaii’s Utilities” which outlines the vision, strategies and regulatory policy changes required to align new utility business models with customer’s changing expectations and state energy policy
  - Provided specific guidance for future energy planning and review, including strategic direction for capital investments in the integrated grid of the future
  - With respect to energy storage specifically required the utilities to address grid support functionality through distributed energy storage sited on utility distribution infrastructure or behind the meter for customer sided energy storage to mitigate impacts of high solar PV penetration on circuits

- Reliability Standards Working Group Docket No. 2011-0206 Order No. 32053
  - Adopted recommendations from the RSWG working group final work product for integrating utility scale and renewable energy resources in reliable and economic manner
  - Specific directives for actions to lower energy costs, improve system reliability and addressing emerging challenges to integrate additional intermittent renewable energy
  - Directed the utilities to prepare energy storage utilization plans for all island grids to be included in Power Supply Improvement Plans requirements

- Policy Statement and Order Regarding Demand Response Programs Docket No. 2007-0341 Order No. 32054
  - Specific guidance concerning the objectives and goals for demand response programs as distributed energy resources to be used by the utilities as generation resources
  - Requires integrated demand response portfolio that will enhance system operations and reduce electricity costs to customers
  - Required utilities to address using distributed energy storage and customer sided storage including electric vehicles for demand response

Outline of JUMPSmart Maui

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

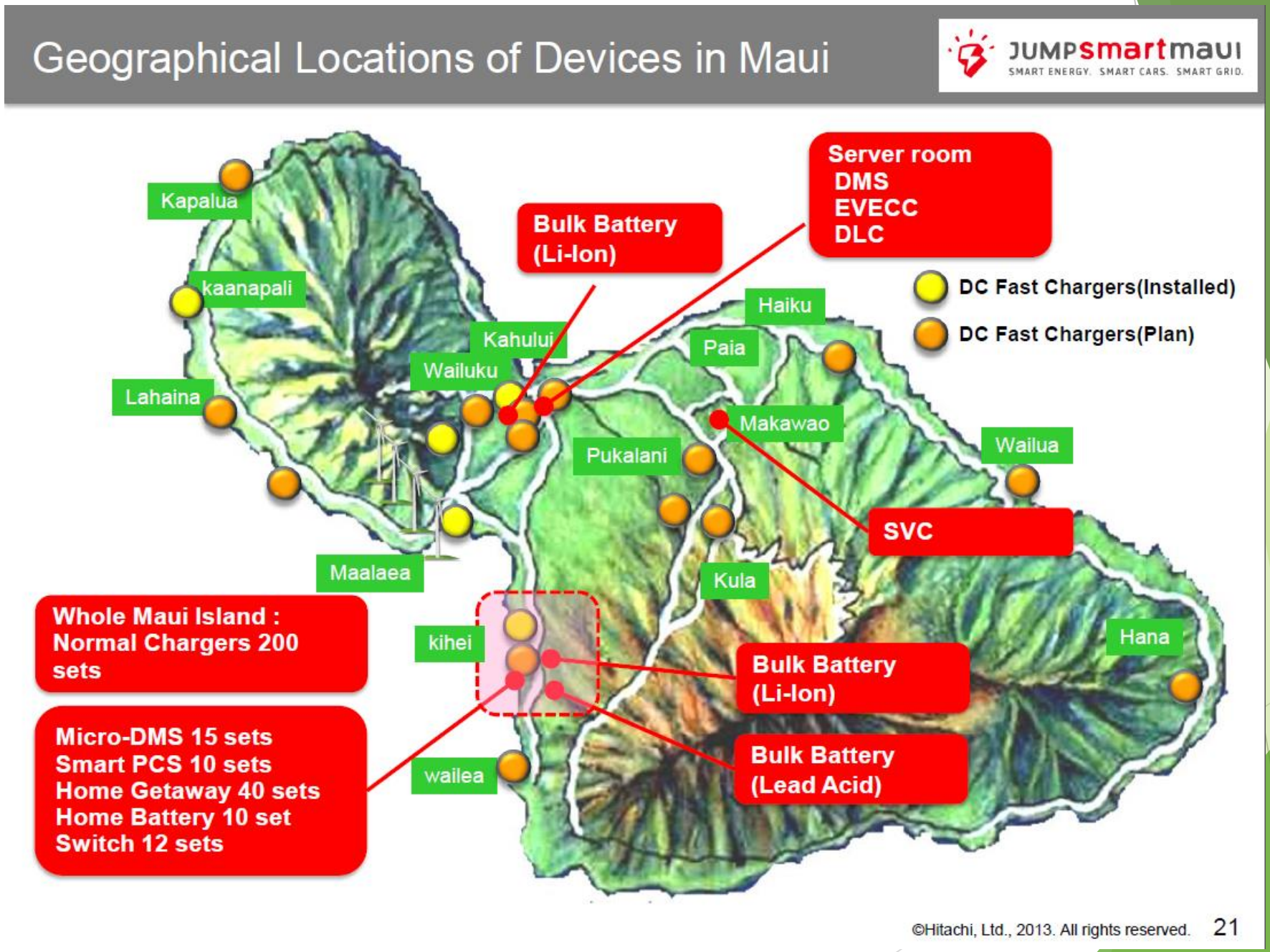
Basic Policy for Demonstration

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



Overall View of System Configuration

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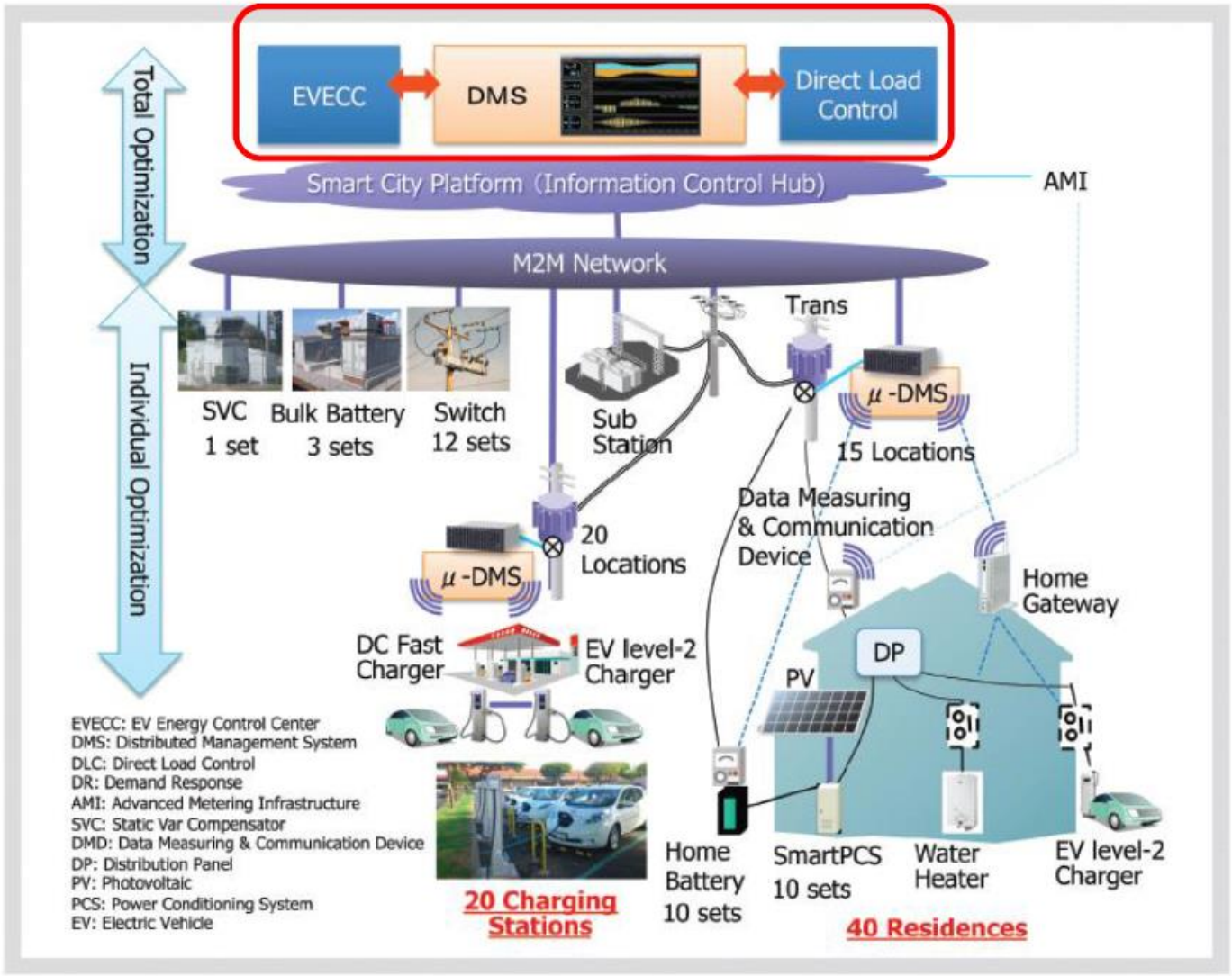

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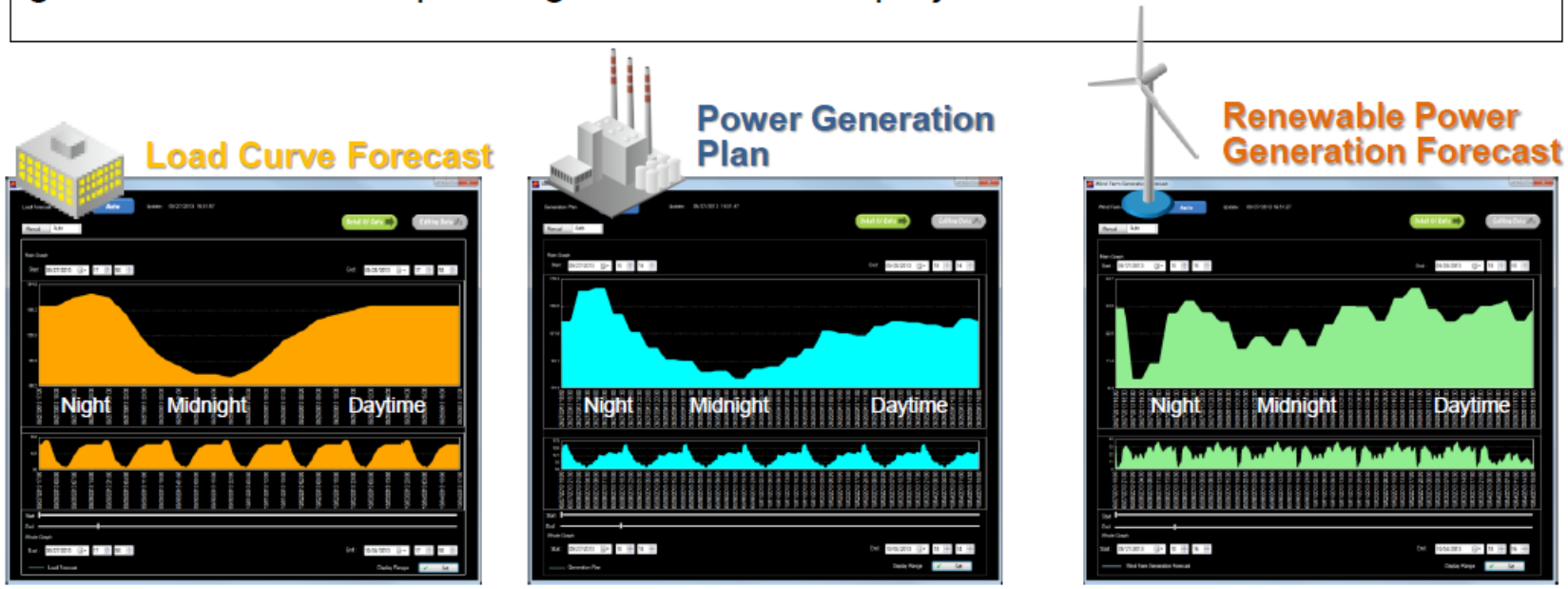
Maximum Utilization of Renewable Energy

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**

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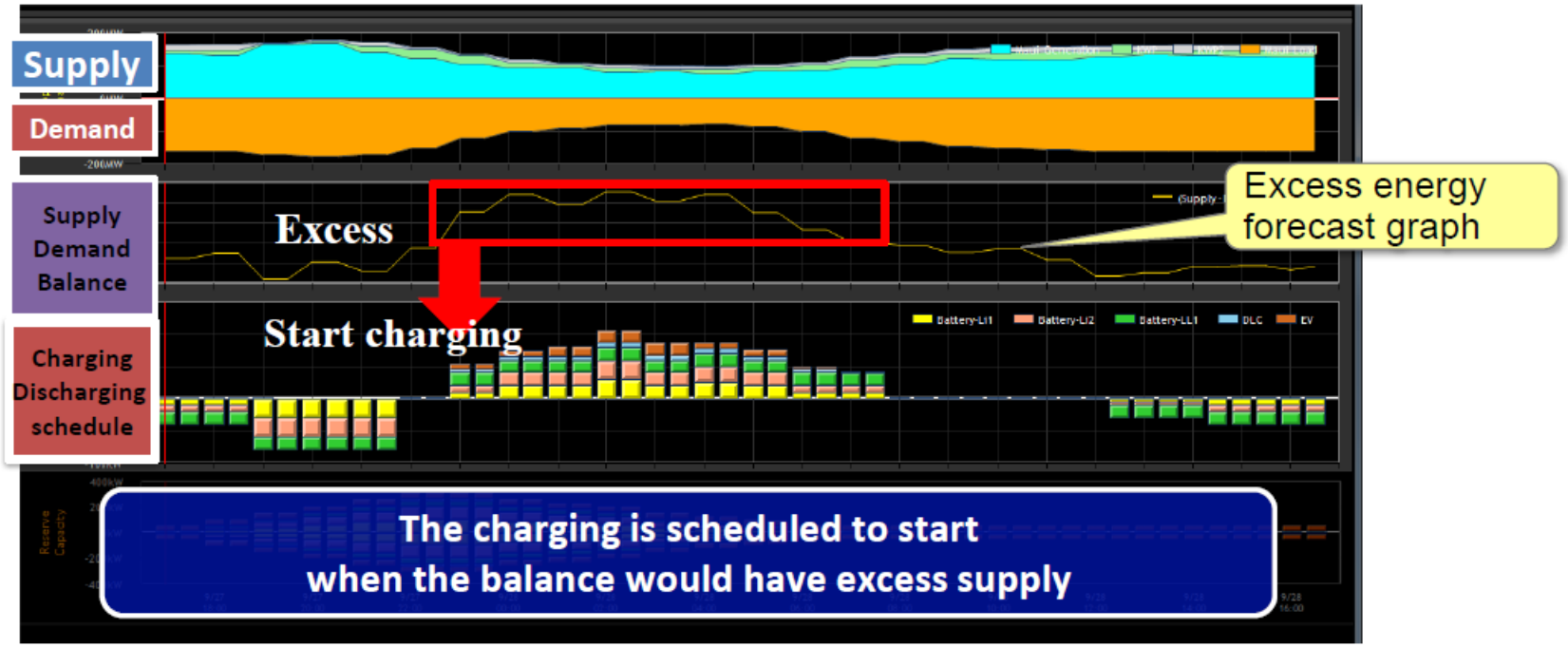
Maximum Utilization of Renewable Energy

Advanced load shift

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



System Operation – Integrated DMS (cont.)

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Stable Supply of Electric Power

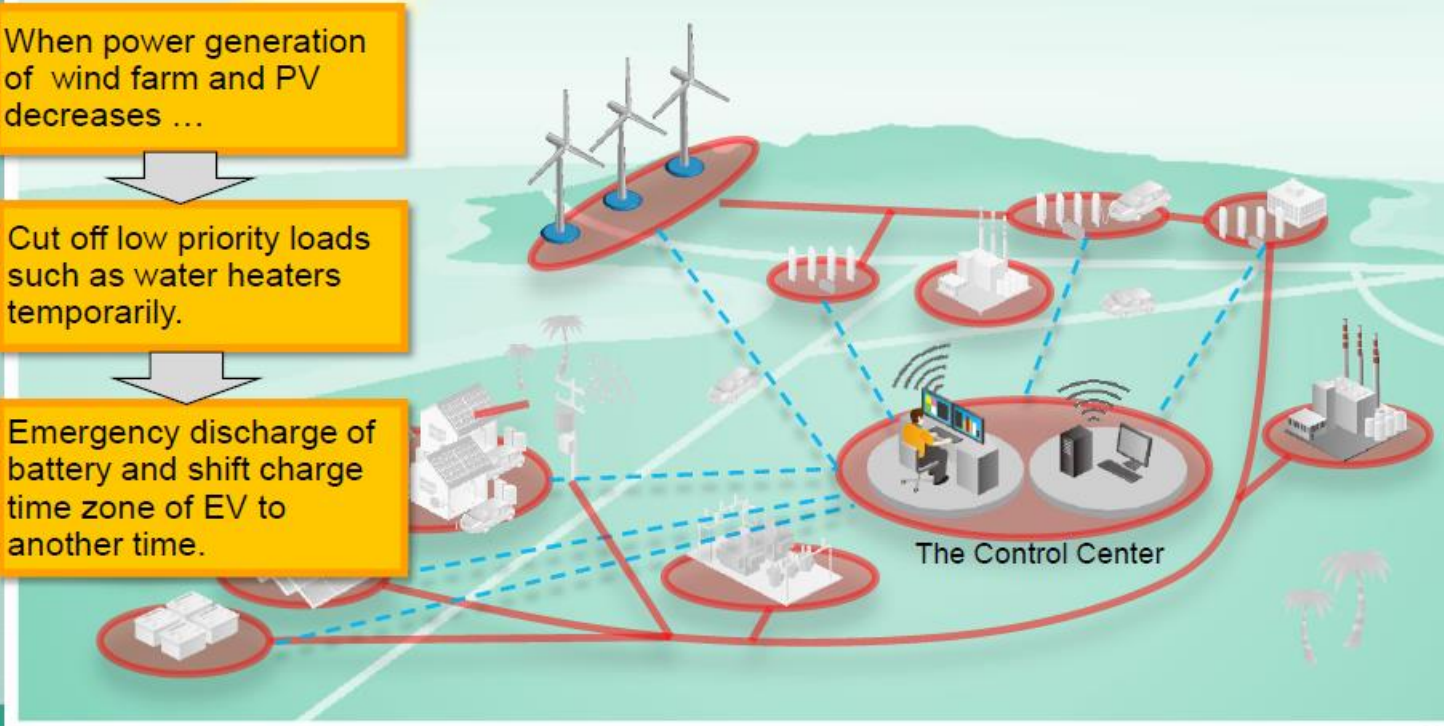
Emergency demand and supply control

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

When power generation of wind farm and PV decreases …

Cut off low priority loads such as water heaters temporarily.

Emergency discharge of battery and shift charge time zone of EV to another time.



Home Equipment

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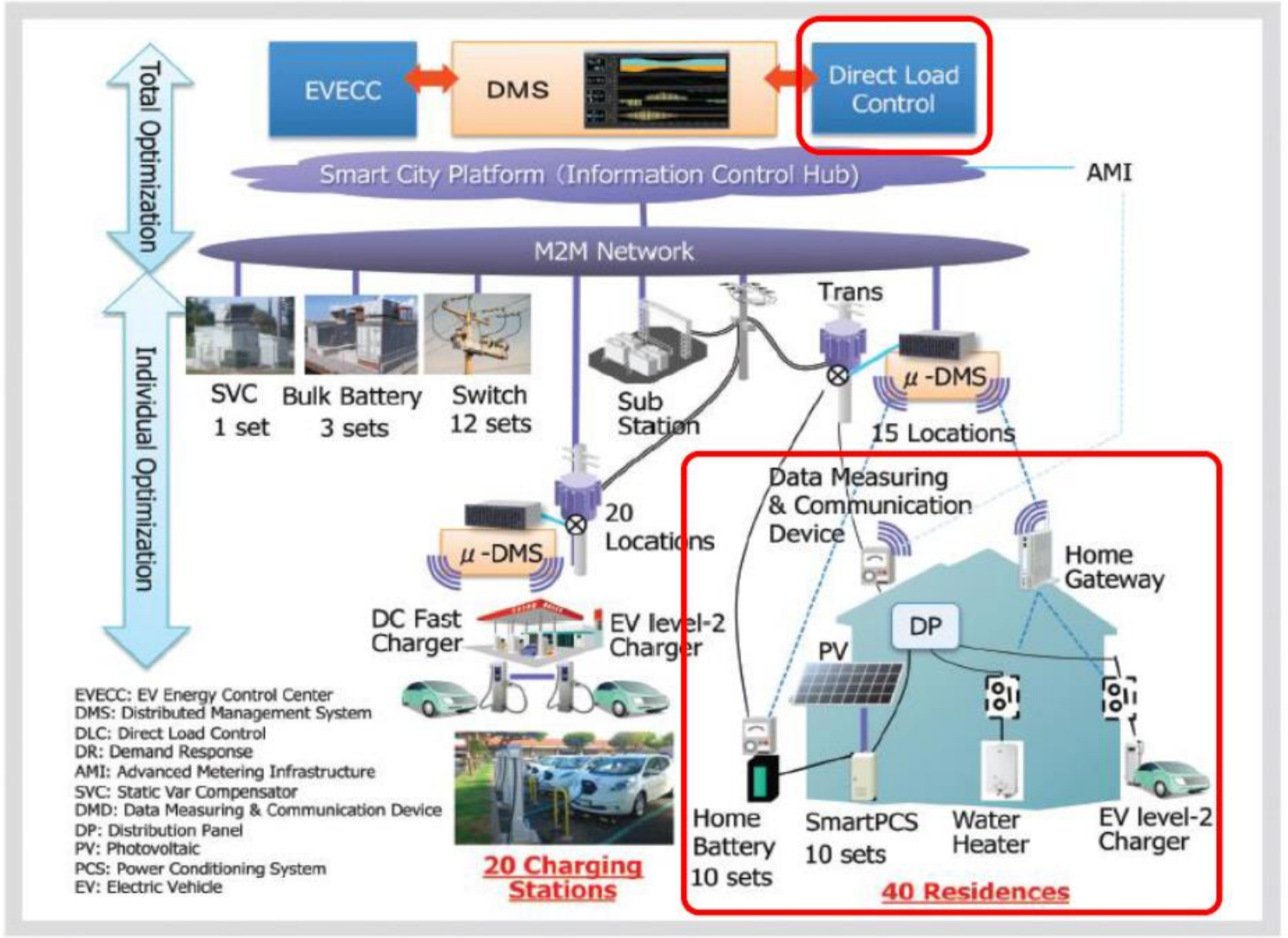

Home Equipment (cont.)

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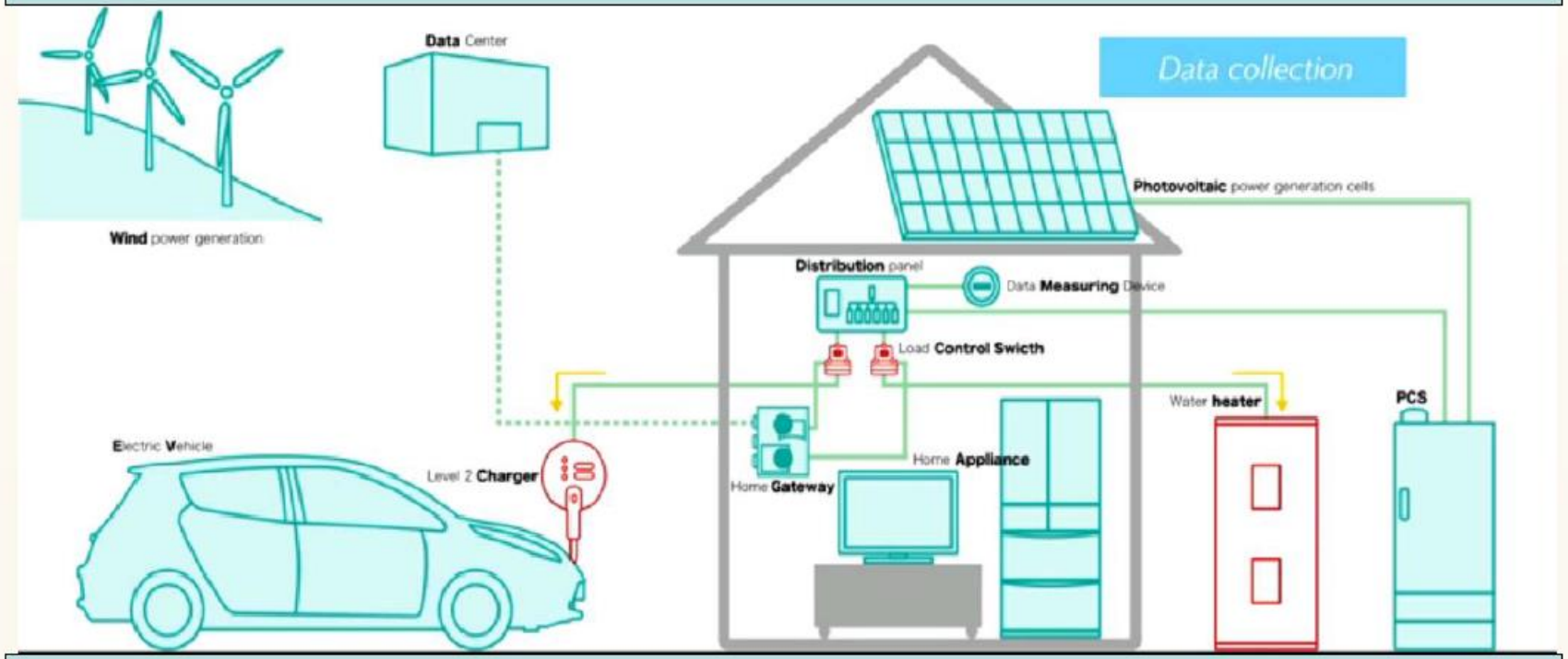
Direct Load Control to Enable More Renewable Energy



Smart EV Charge and Water Heater Control

Mahalo!

For any questions, please contact:
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