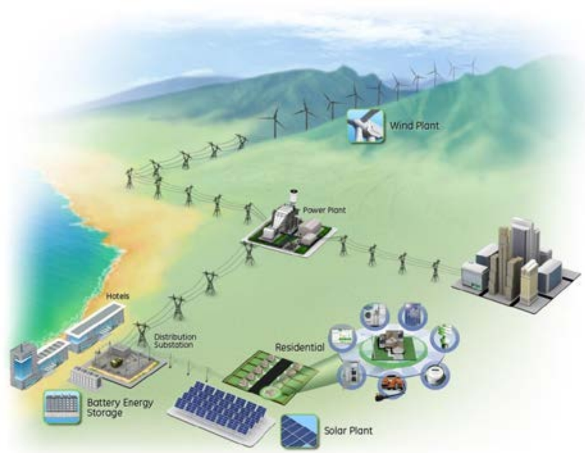
EV for Hawaii’s Clean Energy Future



Electricity Use in Rural and Islanded Communities:

QER Workshop

February 9, 2016

by

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School of Ocean and Earth Science and Technology

University of Hawaii at Manoa

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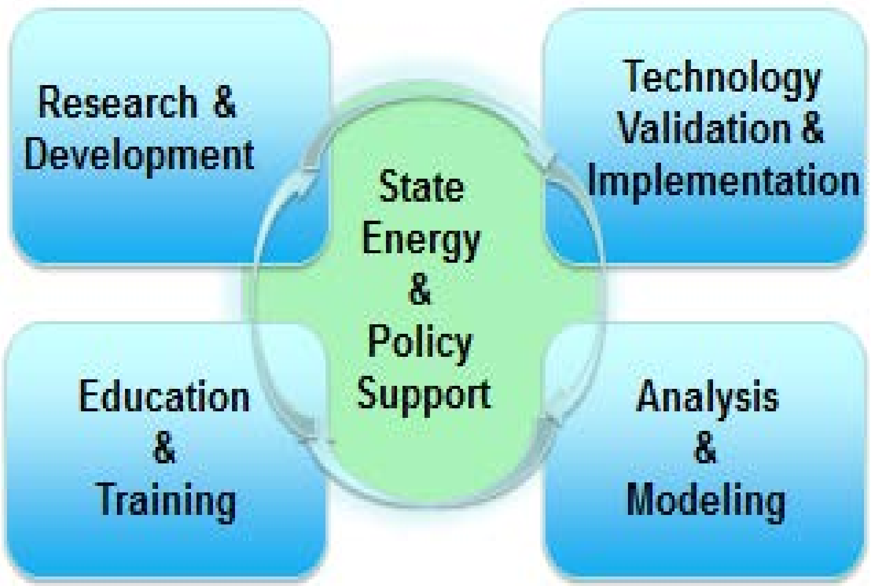
Maui Smart Grid Demonstration Projects

JUMPSmart Maui

Grid Operations under High Renewable Penetration

Hawaii Natural Energy Institute (HNEI)

- **Organized Research Unit in School of Ocean and Earth Science and Technology, largest graduate education and research organization at University of Hawaii**
- **2007 - Established in statute to work with state government organizations to reduce dependence of fossil fuels**
- **Diverse staff (90)- engineers, scientists, lawyers, postdocs, students**
- **Areas of Interest**
  - **Alternative Fuels**
  - **Electrochemical Power Systems**
  - **Renewable Power Generation**
  - **Building Efficiency**
  - **Transportation**
  - **Grid Integration**



Grid Systems Technologies Advanced Research Team

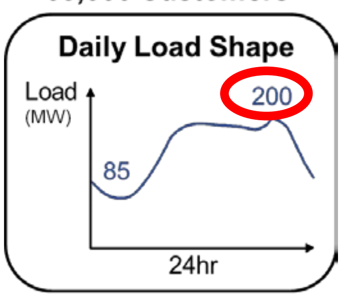
- Interdisciplinary team of faculty, professionals, post-doctoral fellows and students including over 100 years utility and regulatory experience.
- Grid modeling and analysis; smart grid and micro-grid R&D; application of grid storage; power system planning and operations; alternative transportation, and energy policy
- Sample Projects
  - ***Renewable Portfolio Assessment*** - Renewable integration, grid reliability studies supporting PUC, HCEI, and utility
  - ***US DOT Electric Vehicle Transportation Center*** - FSEC partnership to address EV integration and battery performance
  - ***Maui Smart Grid (RDSI) Project*** – Control of distributed resources and energy storage for peak demand reduction
  - ***Maui Advanced Solar Initiative***– Development and demonstration of advanced inverter functionality and communications for SG w high penetration PV
  - **JUMPSmartMaui** – Smart grid demonstration with focus on PV and EV technologies (NEDO-Hitachi)

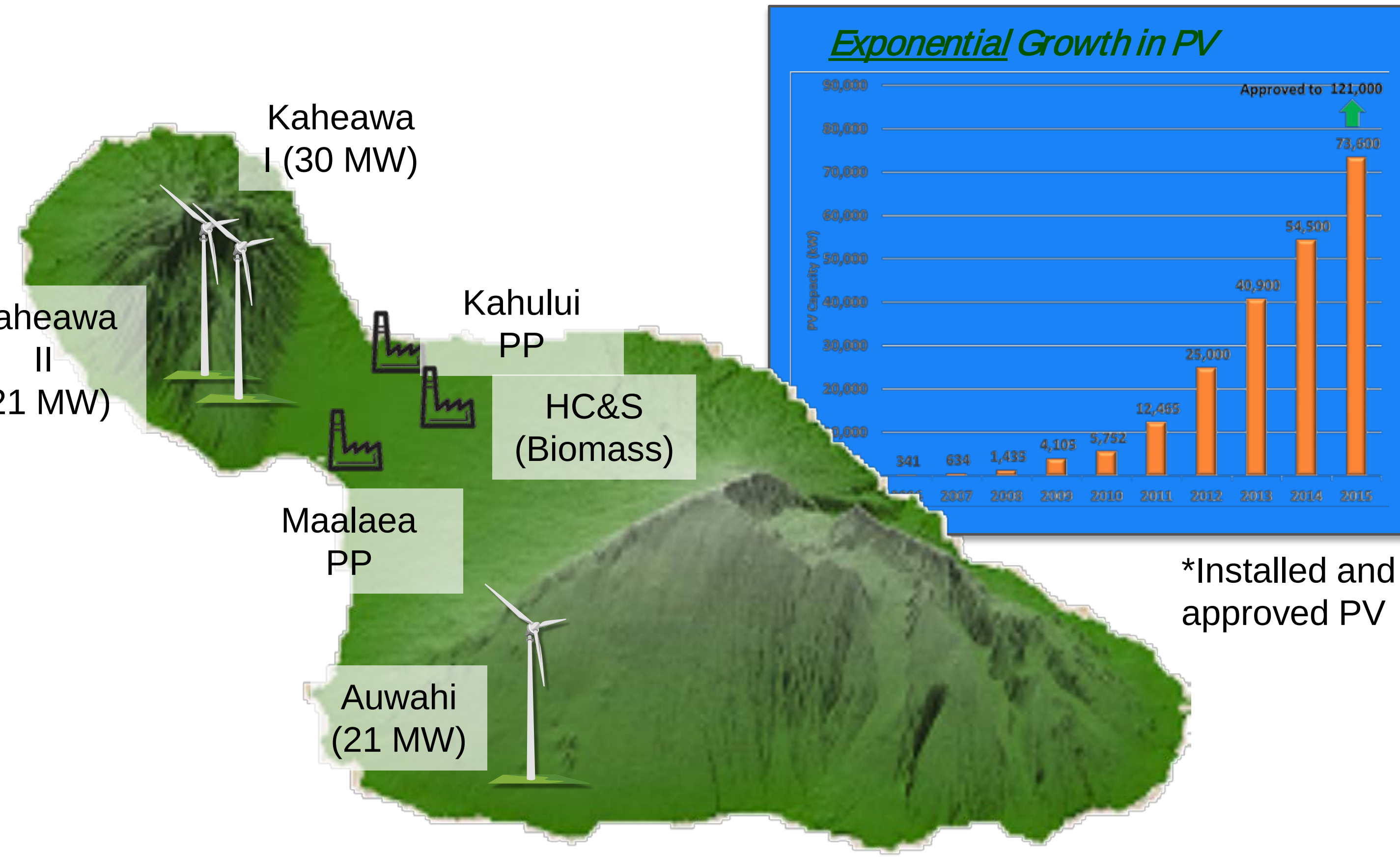
GridSTART
Hawai'i Natural Energy Institute | University of Hawai'i

Maui Island – the ideal demonstration site

72 MW Wind
121 MW PV*
193 MW Total

63,000 Customers

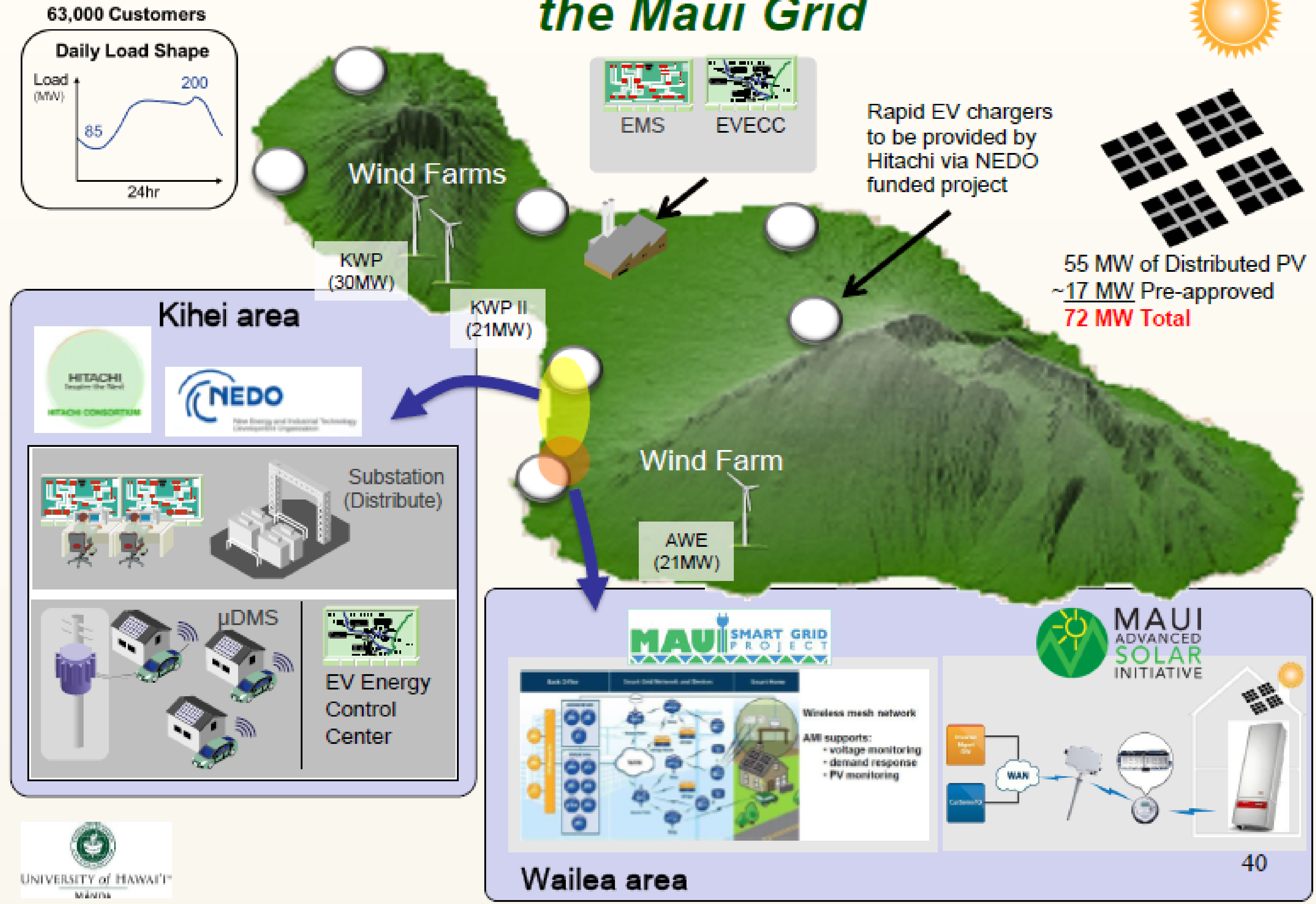




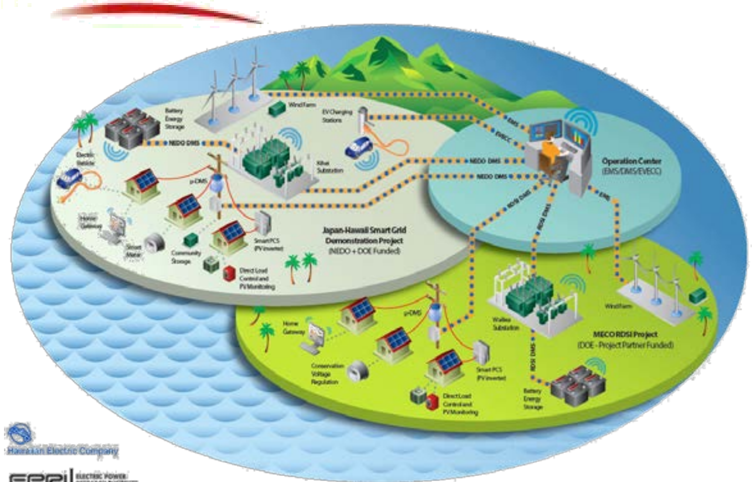
*Installed and approved PV

- **Abundant renewables - high penetration of wind and solar can negatively impact grid operations and reliability.**
- **Short driving distances**
- **Advanced smart grid technologies to manage load/response including smart inverters and eV have potential to enhance grid stability and balance demand**

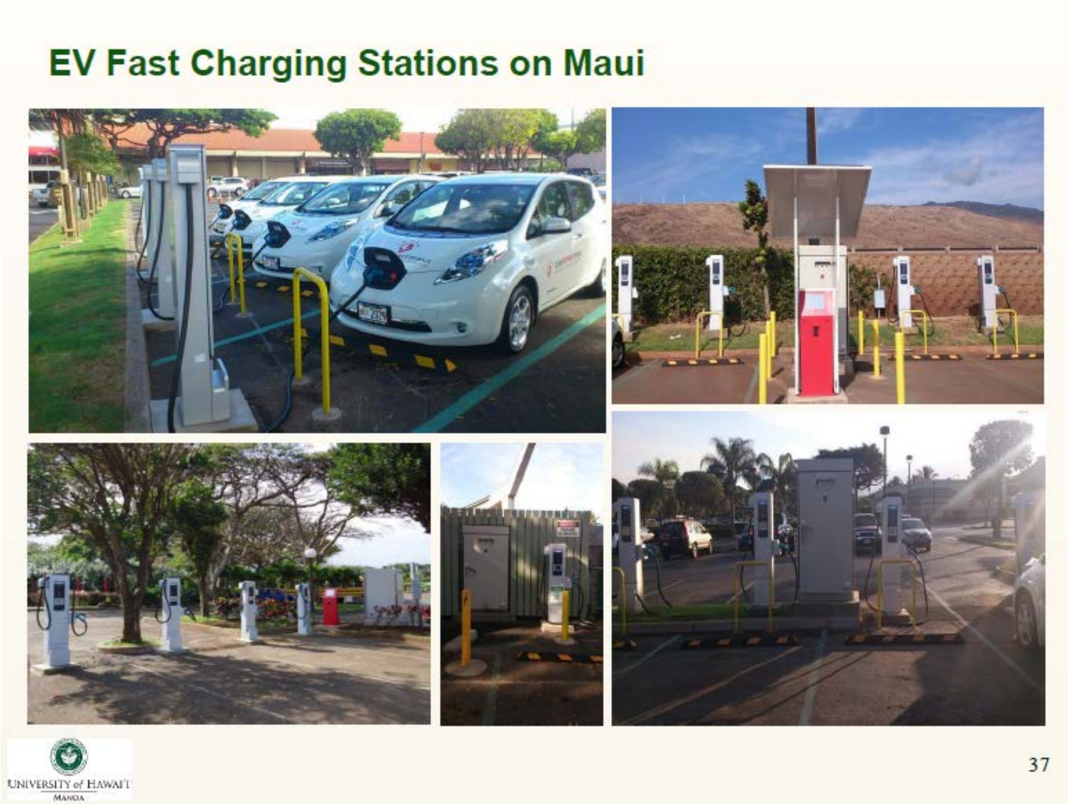
Integrate Renewables and Transform the Maui Grid



JUMPSmart Maui (A Japan-US Smart Grid Demonstration Project)



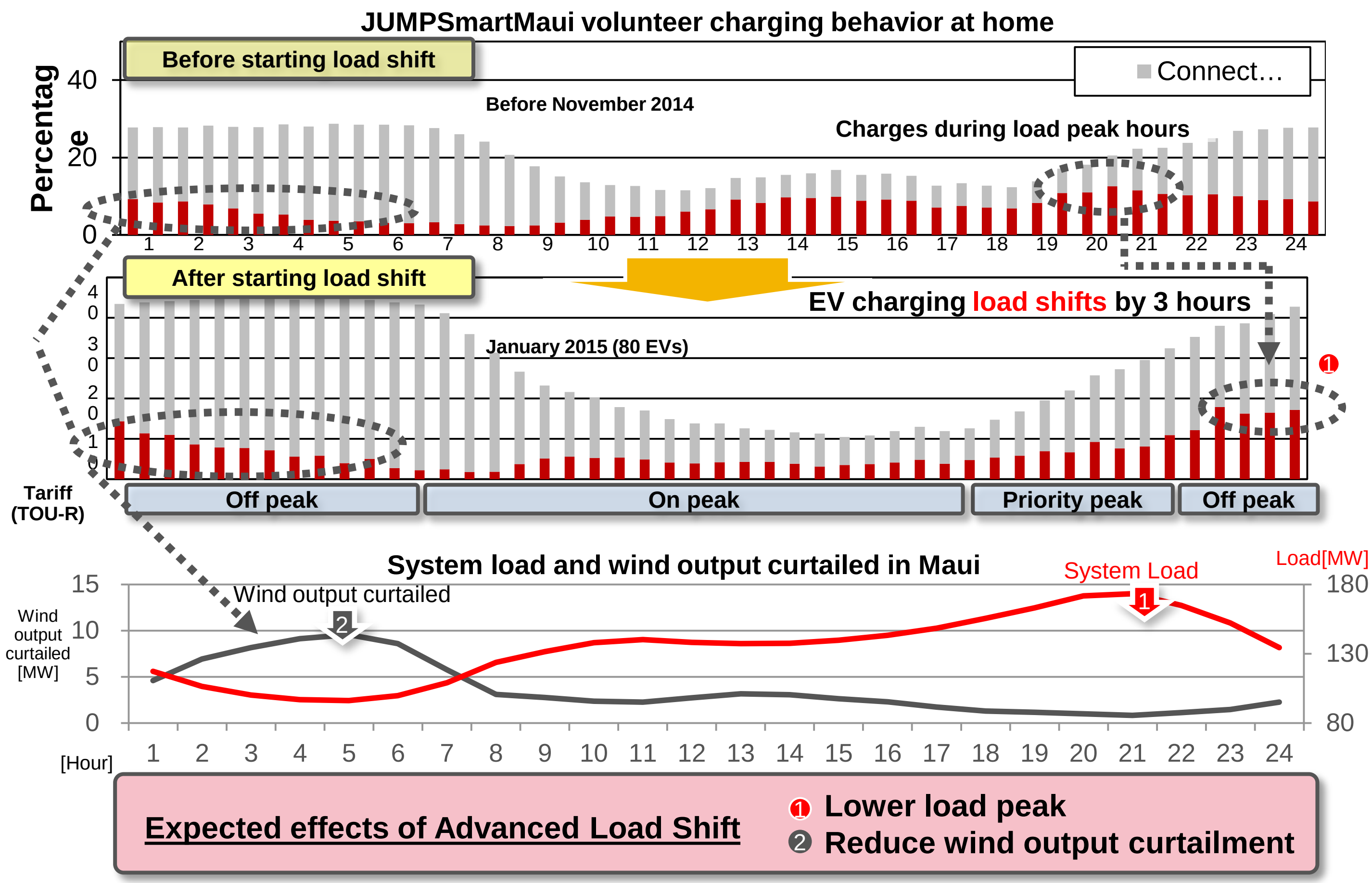
- **Demonstrate smart grid technology, including EV management to allow increased use of renewables. Renewables (Wind and Solar) friendly EV charging**
- **Support adoption of Electric Vehicles and renewable friendly EV charging**
- **Create more stable energy infrastructure to reduce costs of grid support services**



Registered EVs and Public Charging Stations in Hawaii, May 2015

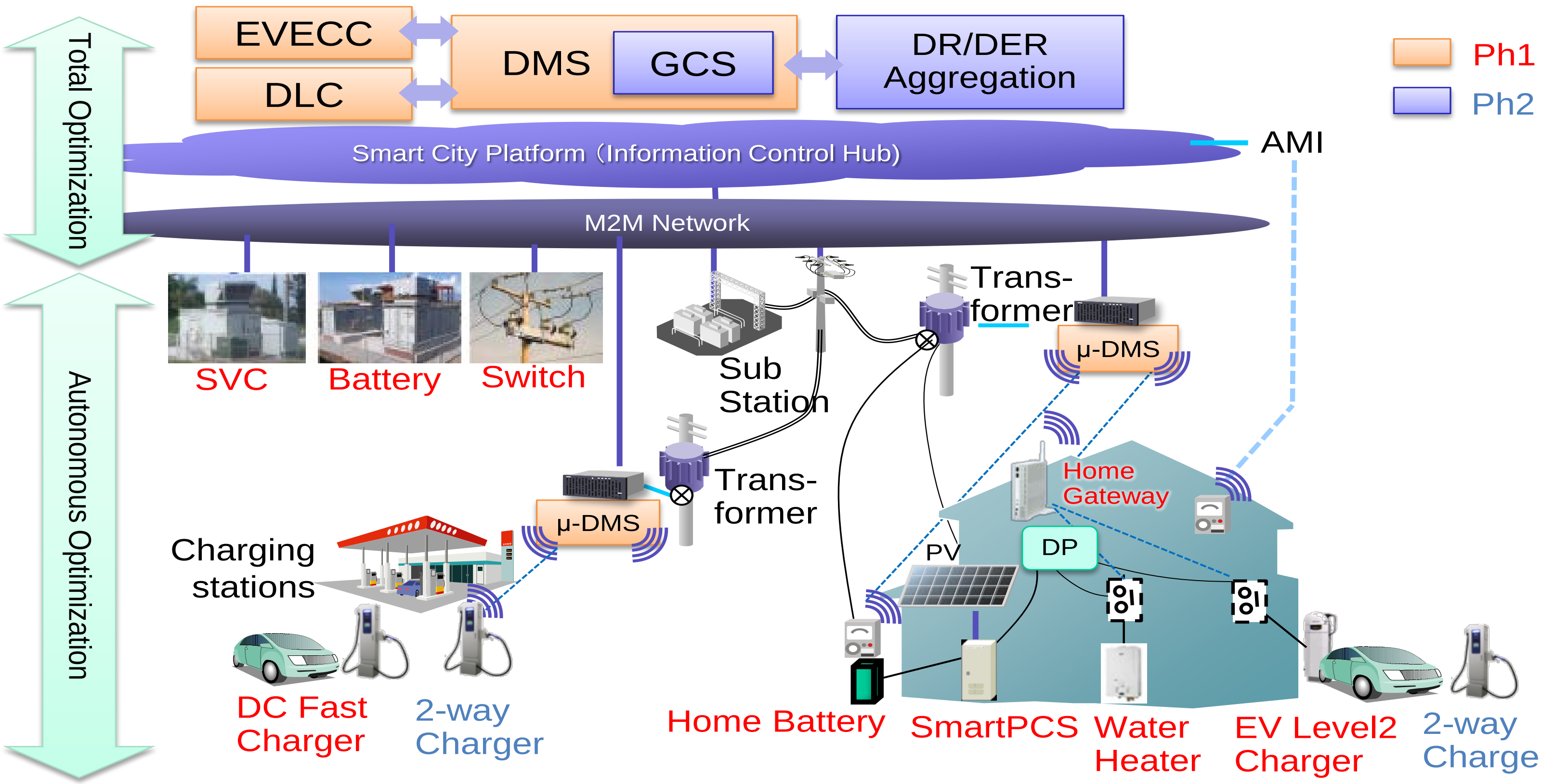
County	Electric Vehicles	EVs per 1,000 Residents	Level 2 Charging Stations	Level 3 Charging Stations	Total Ports
Oahu	2,571	2.59	244	5	249
Maui	629	3.86	68	35	103
Hawaii	160	0.82	51	2	53
Kauai	118	1.67	32	1	33
Total statewide	3,478	2.45	395	43	438

Use EV Charging to Shift Load



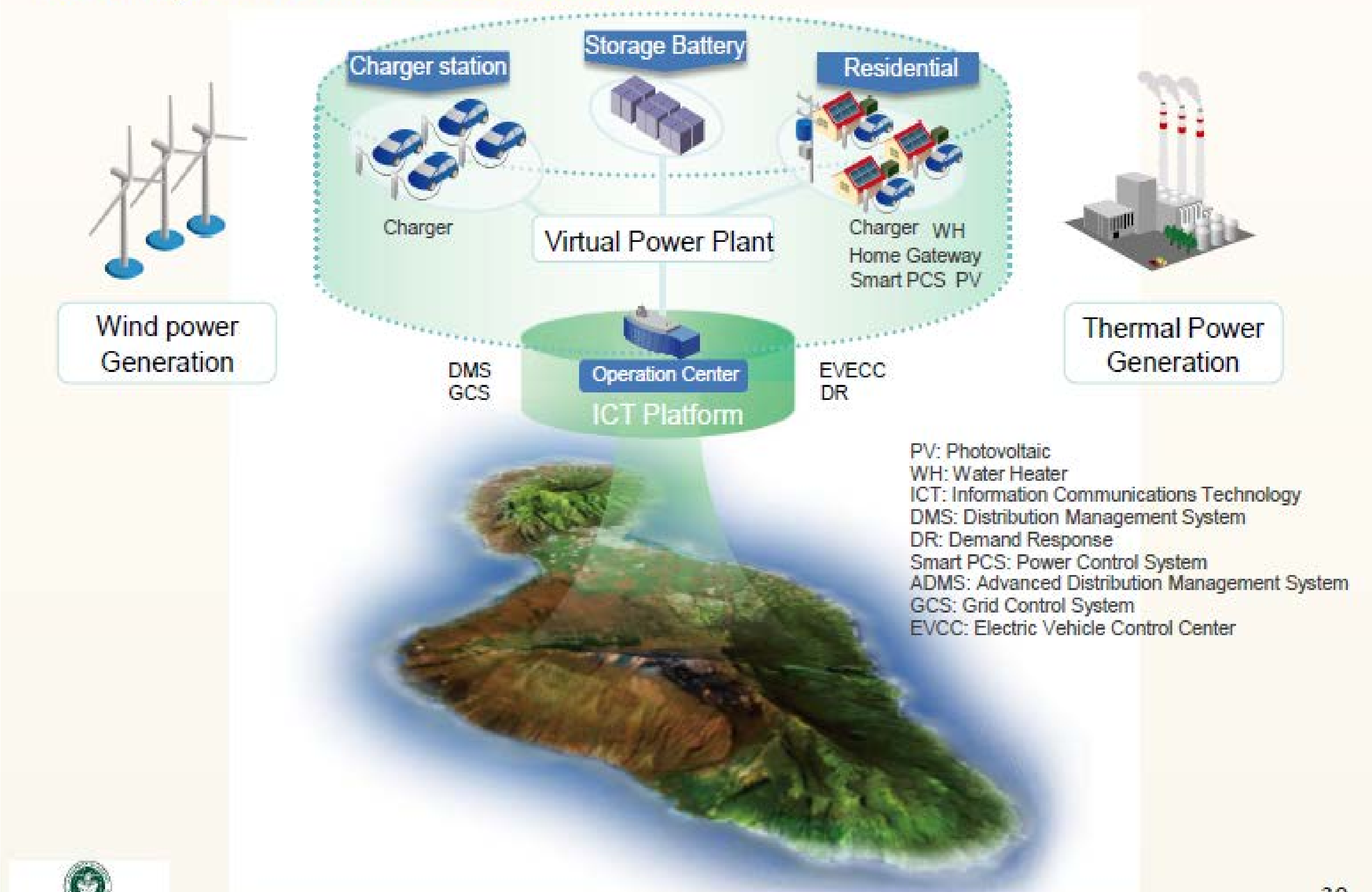
Phase 1 recruited 200 EV and 30 residential volunteers : in-home level 2 chargers, access to public fast chargers, and in-home monitoring.

Distributed and Hierarchical Architecture



- Phase 2: Recruitment of up to 300 volunteers underway
- EV-Power Conditioning System (EV-PCS) will allow volunteers to charge their Nissan LEAFs and discharge the power to their homes and businesses.
- Laboratory testing of EV-PCS ongoing

The "Big Picture"- Develop Virtual Power Plant Solutions on Maui



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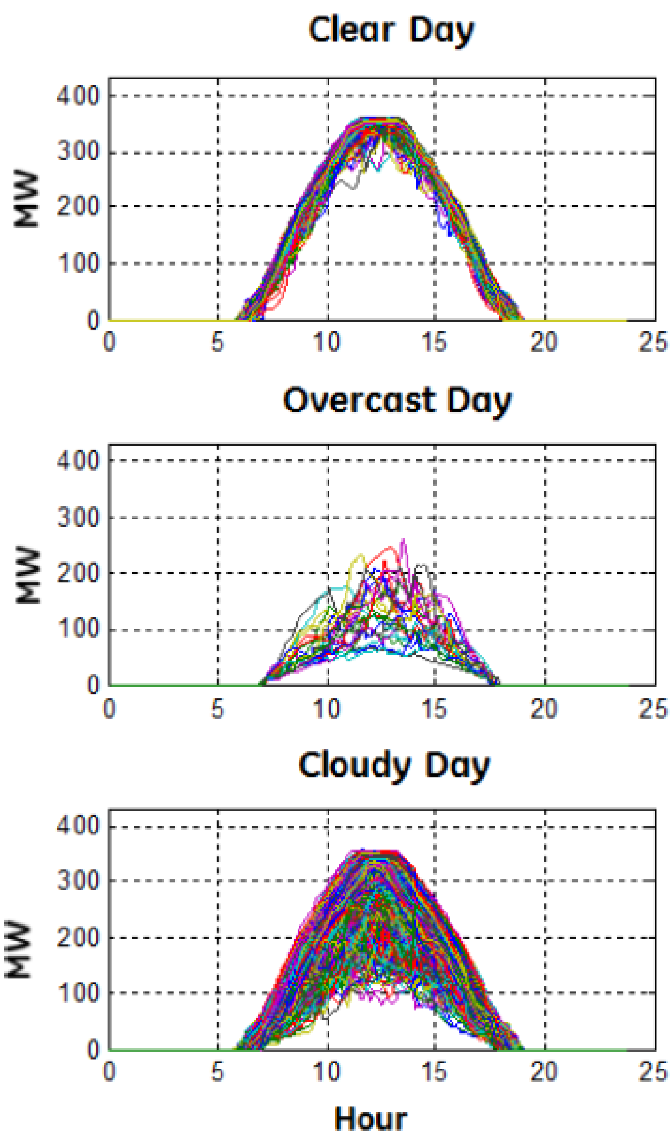
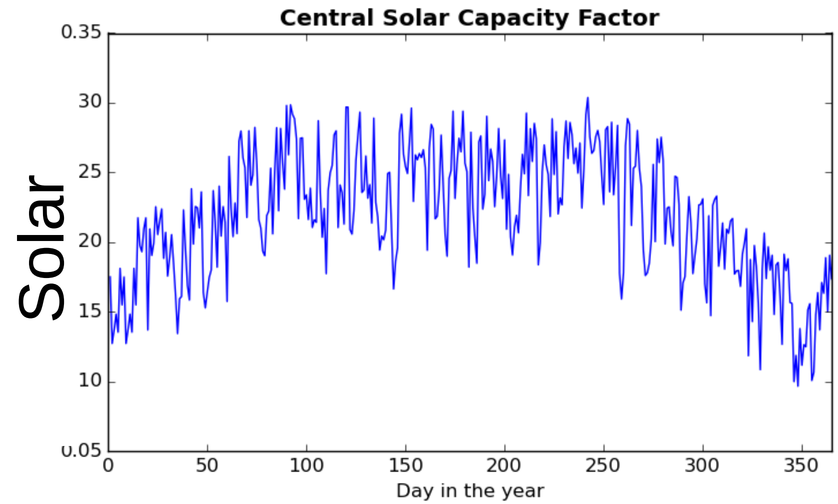
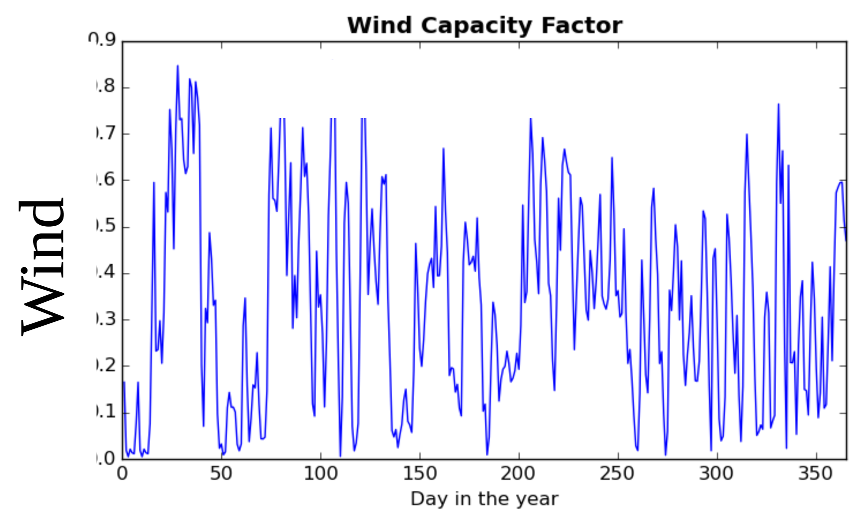
Wind and Solar Variability



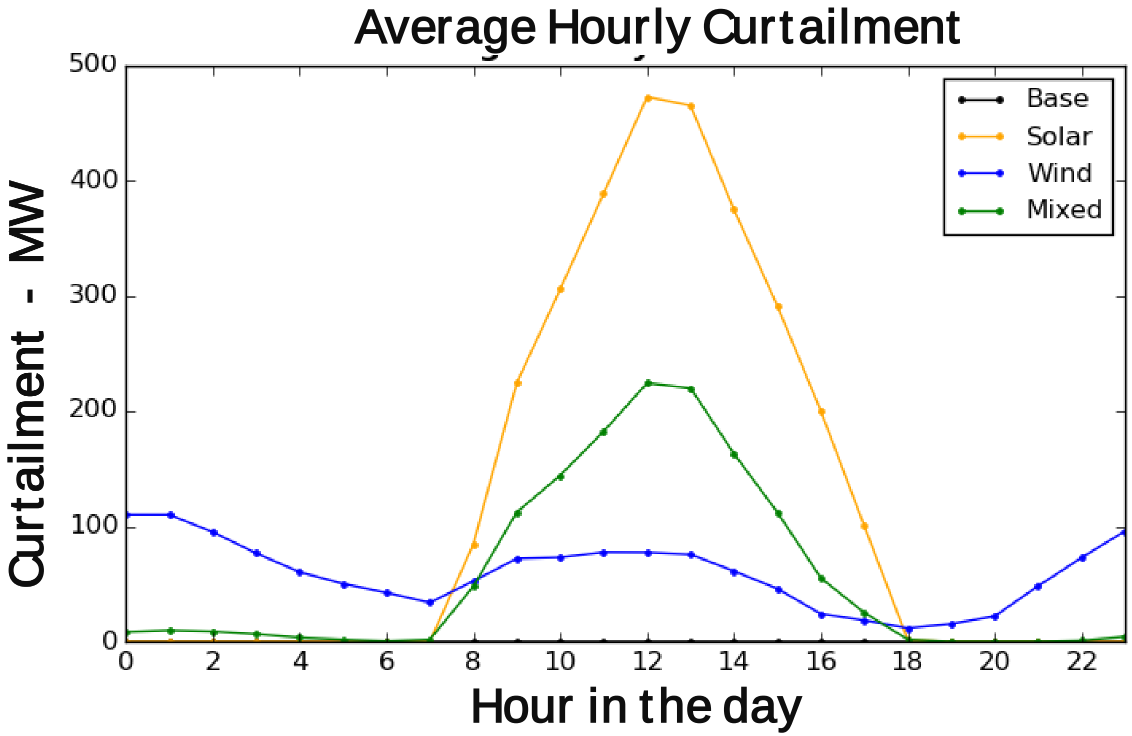




Day in the year

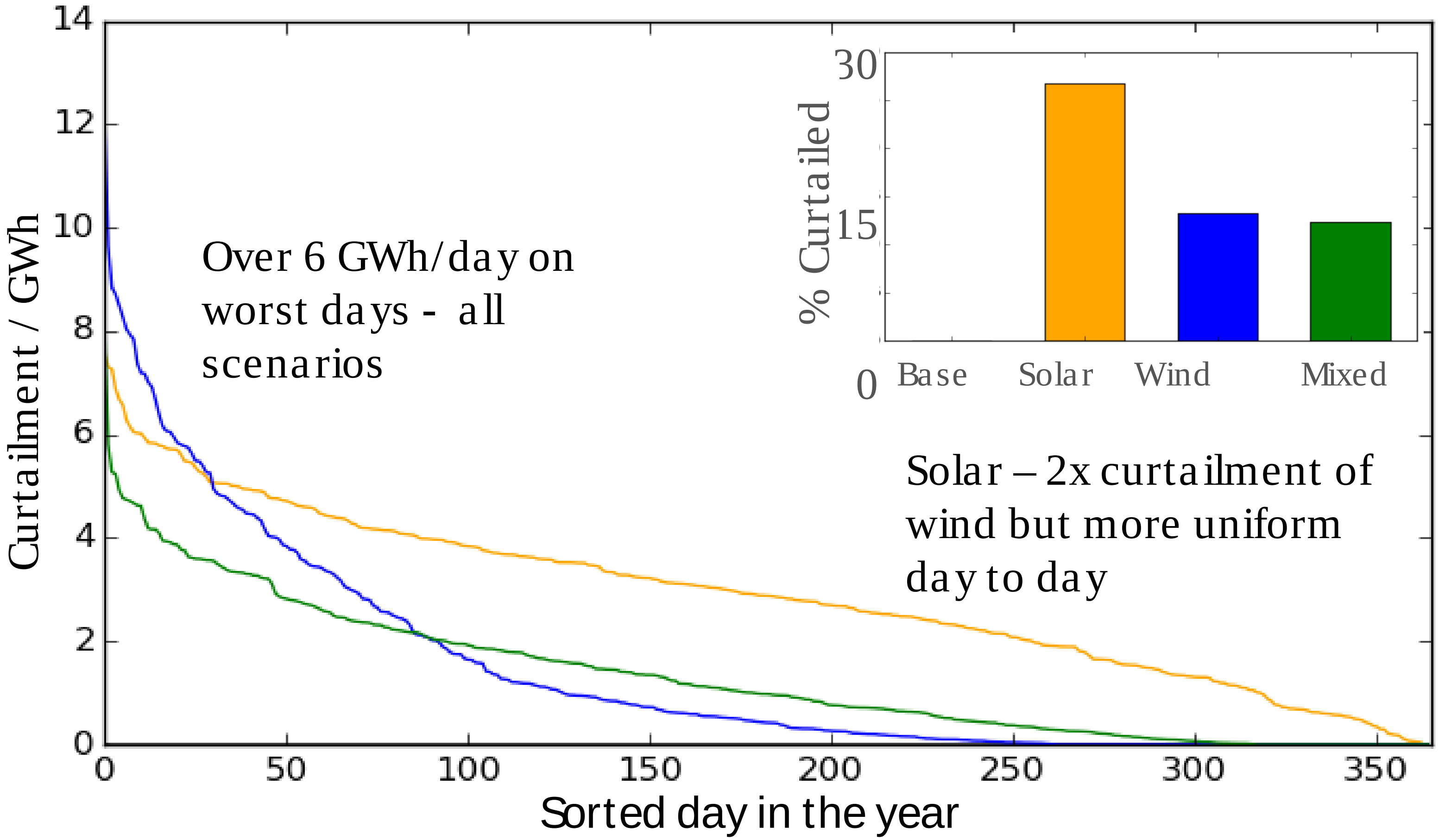
Curtailment by Hour of Day

Curtailment profiles may shift depending on resource mix and level of penetration – how to accommodate changing curtailment



- Results from model of Oahu, assuming advanced" grid, 2016 renewable expectation built out to 50% availability using wind, solar or mix
- Curtailment for high solar: 1060 GWh

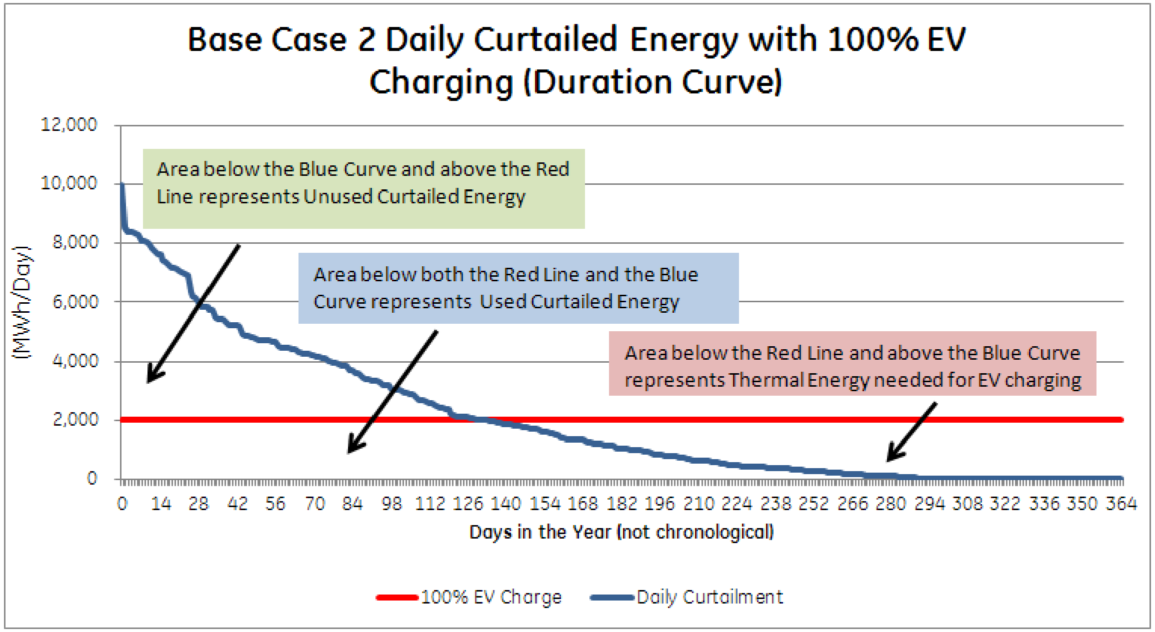
Curtailment by day of year (duration plot)



- Results from model of Oahu, assuming advanced" grid, 2016 renewable expectation built out to 50% availability using wind, solar or mix
- Curtailment for high solar: 1060 GWh (~ 300,000 eV@10kwh/day)

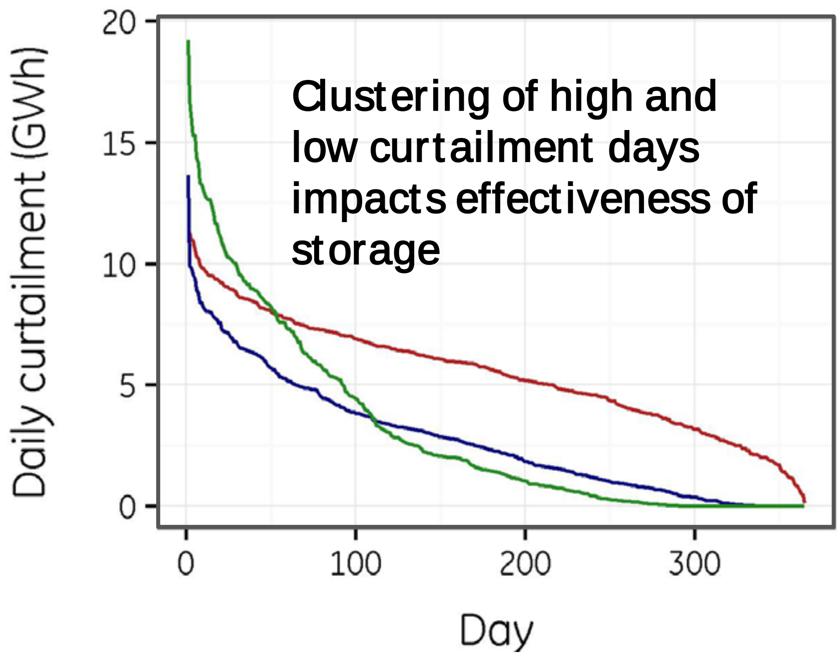
Analysis of EV to Capture Curtailed Energy

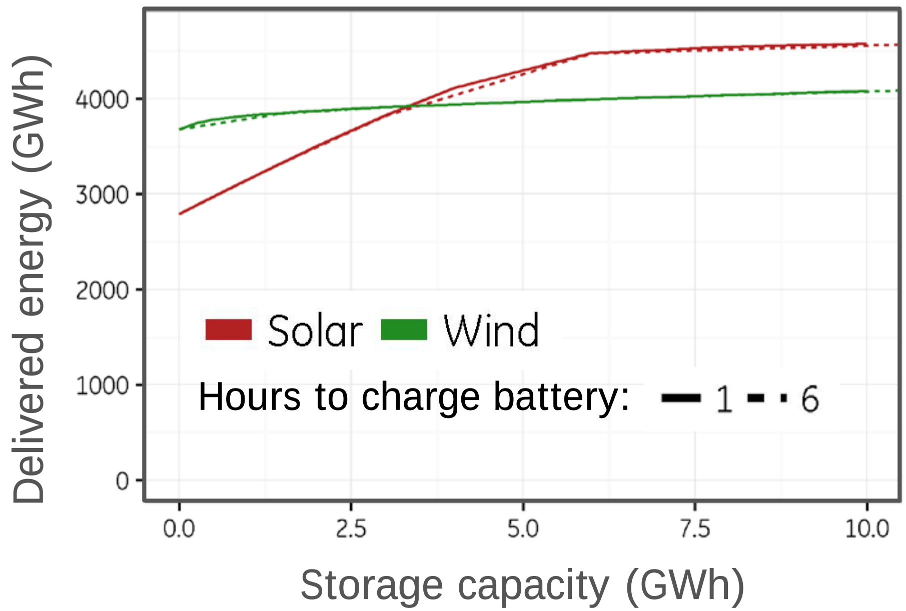
- **Model Oahu grid with different mixes of high penetration wind and solar generation (lower than previous slides)**
- **Assume sufficient EV penetration to 'absorb' total curtailed energy on annual basis (increase daily load by average curtailed energy)**
- **Evaluate impact of different daily charging profiles on uptake of curtailed energy.**
- **For multiple scenarios (not exhaustive) maximum capture of curtailed energy was 55% for "ideal" charge profile**
- **Capture under more realistic charge profiles limited to 30-45%**



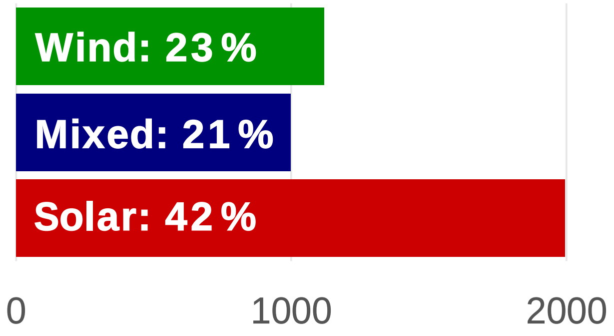
Effect of Storage on Curtailment

Advanced grid, 60% W&S penetration





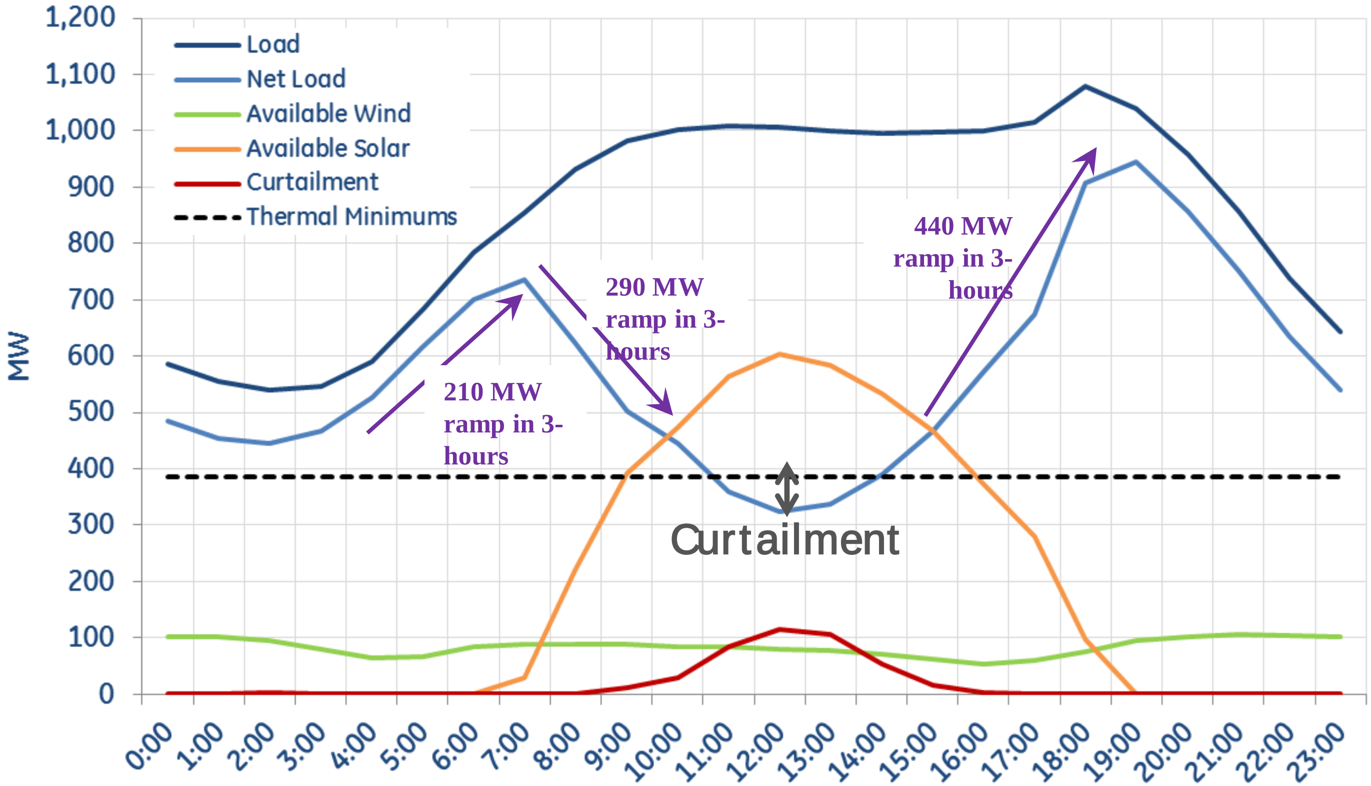
Annual curtailment (GWh):



- Battery storage not effective for shifting curtailed wind
- Power rating of batteries has little impact on reduction of curtailment. – buy kWh

24 Hour Load Profile with High Renewable Penetration

(Oahu; 200MW wind, 860MW solar; 26% available renewable)



Potential Issues: Curtailment, mid-day transients (stability), reliability of evening capacity, ramp rates

What Do We Need

- Better modeling and analysis to quantify high value applications of eV integration
  - ancillary services for reliability and stability
  - impact of resource and resource mix, grid system needs (ancillary services) for reliability and stability;
  - voltage stability on circuits
- Continue Standards Development
  - Reliability and stability for low inertia grids
  - Controls and communications for EV and smart grids

Moving beyond 30-40% intermittent renewables will require creative system integration and new technology.

MAHALO

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