V1G / V2G EXPERIENCES IN MAUI

Shinichi Kasai
Department Manager, IoT Business Promotion Division
Hitachi, Ltd.

SAE INTERNATIONAL

HITACHI
Inspire the Next

V1G / V2G Demonstrations in Maui

Hawaii's Unique Environment for V1G / V2G

- 100% renewables in electricity generation by 2045
  - Action plans in Hawaiian Electric's Power Supply Improvement Plans (December, 2016)
    - Maximize distributed energy resources
    - Make high use of demand response programs

- 100% renewables in ground transportation by 2045
  - Ranks second in the nation behind CA in the number of EVs registered per capita
  - 4 county mayors in Hawaii signed proclamation in December
  - Honolulu and Maui to transition all of their fleet vehicles to clean energy by 2035

V1G / V2G Demonstrations in Maui

JUMPSmartMaui Project* (2011~2016)

- Install / operate infrastructure to help the Island transition to clean energy transportation
- Help electrical grid introduce more renewables by utilizing distributed energy resources especially electric vehicles (EVs)

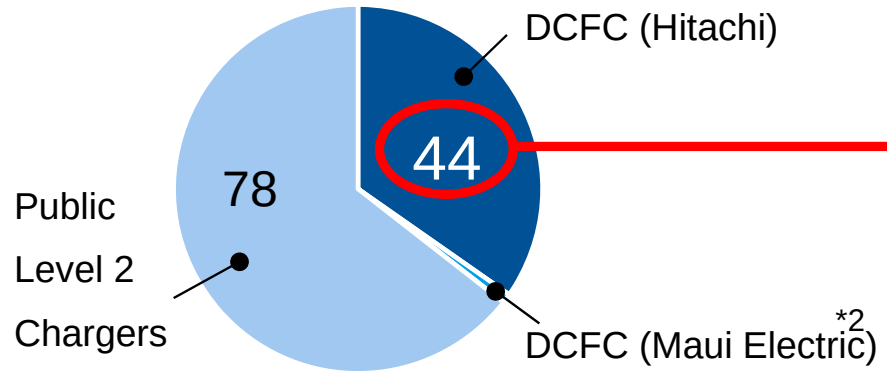
*The project was supported by Japanese government (METI / NEDO)

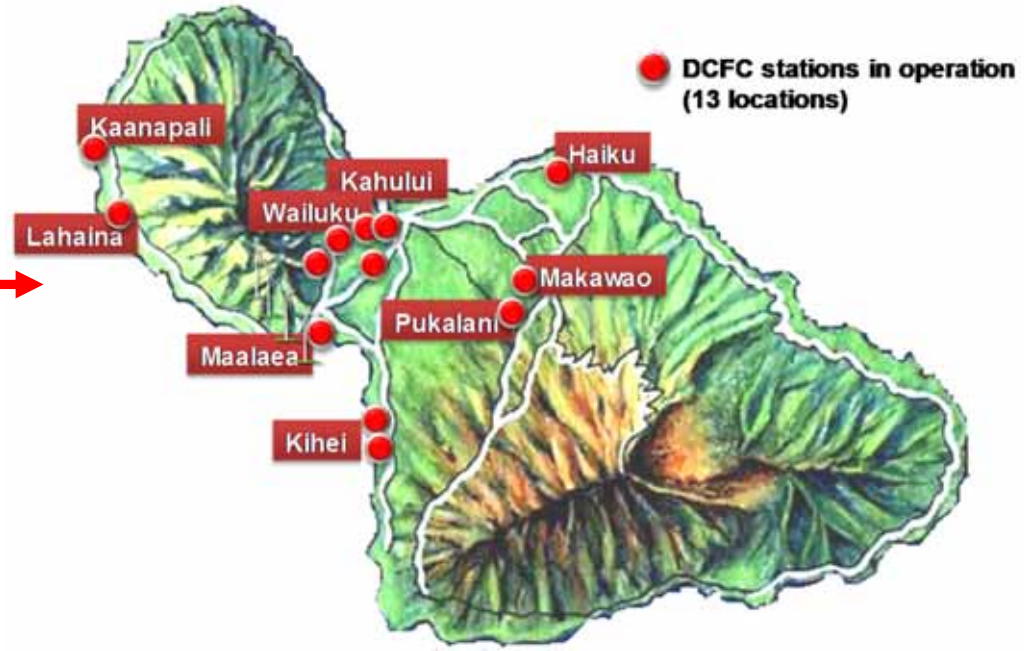
EV Charging Infrastructure

DC Fast Charging Stations being operated by Hitachi

- 13 stations with 44 ports are installed in JUMPSmartMaui

*1 EV charger ports in Maui County
(Sep.,2016)





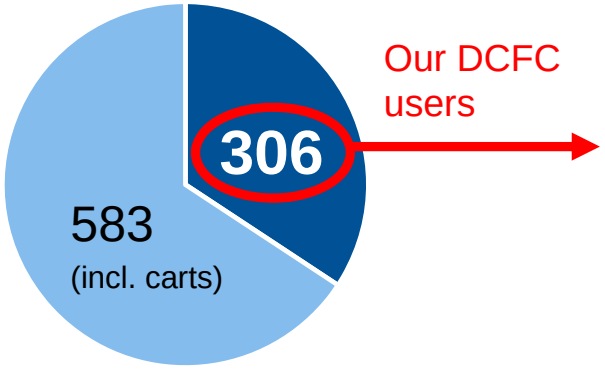
*1) Hawaii Energy Facts & Figures (May, 2017) / State Energy Office
*2) based on HECO website as of Oct.,2017

EV Charging Infrastructure

Charging Behavior at DC Fast Charging Stations

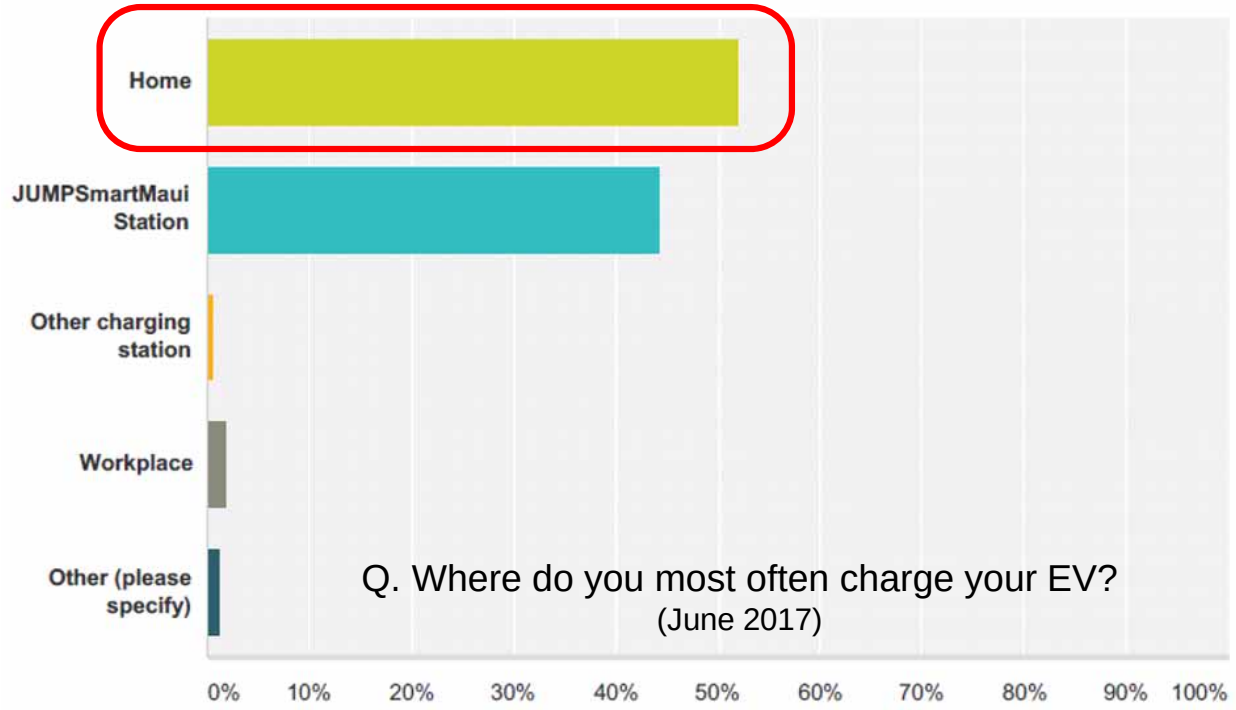
- Currently in commercial operation with ~300 users
- Even DCFC users charge at home often

Registered EVs in Maui Island



Total 889 (as of Nov.,2017)

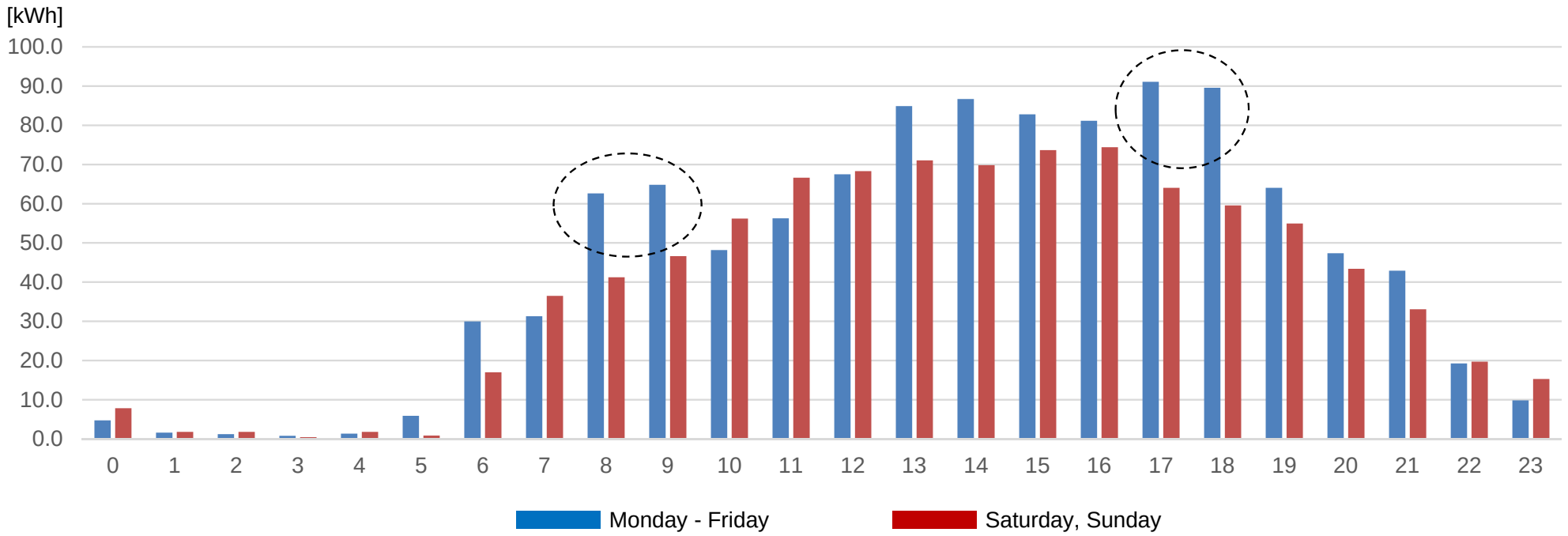
Source : Hawaii State Energy Office



EV Charging Infrastructure

Charging Behavior at DC Fast Charging Stations

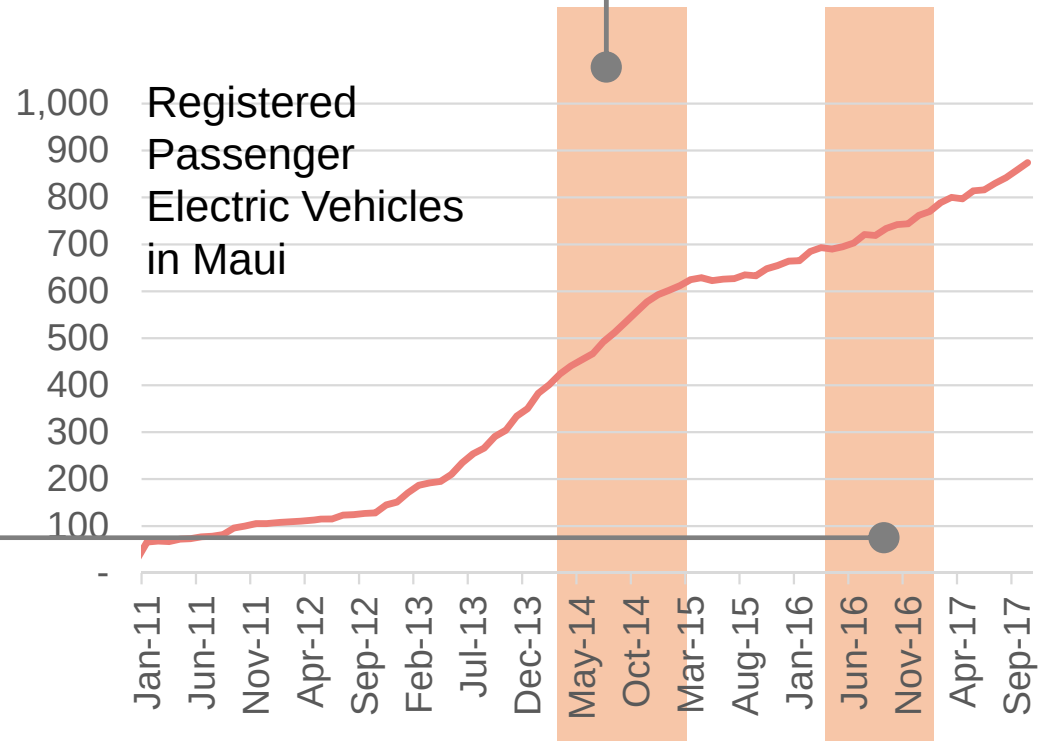
- Usage peaks at 5~6pm in weekdays
- Unless DCFC ports are enough, increase in charging at home after 6pm is expected



V1G / V2G Demonstrations in Maui

V1G / V2G Demonstrations Overview

- V1G Demonstration
  - 200 houses participated with 3rd party's level-2 charger
  - Peak home charging period overlaps that of grid demands
  - Managed charging based on utility's and the participants' needs
- V2G Demonstration
  - Additional 80 houses participated with Hitachi bi-directional charger
  - Managed charging / discharging

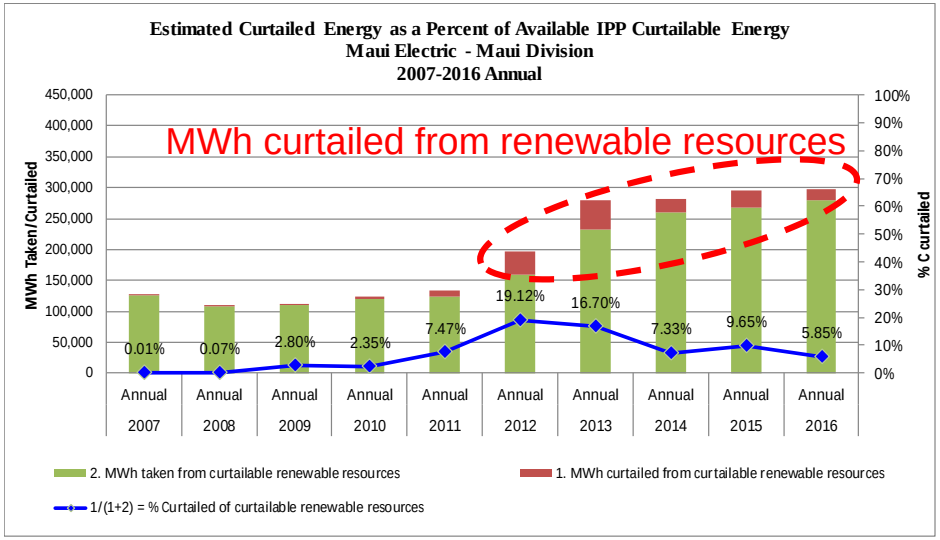


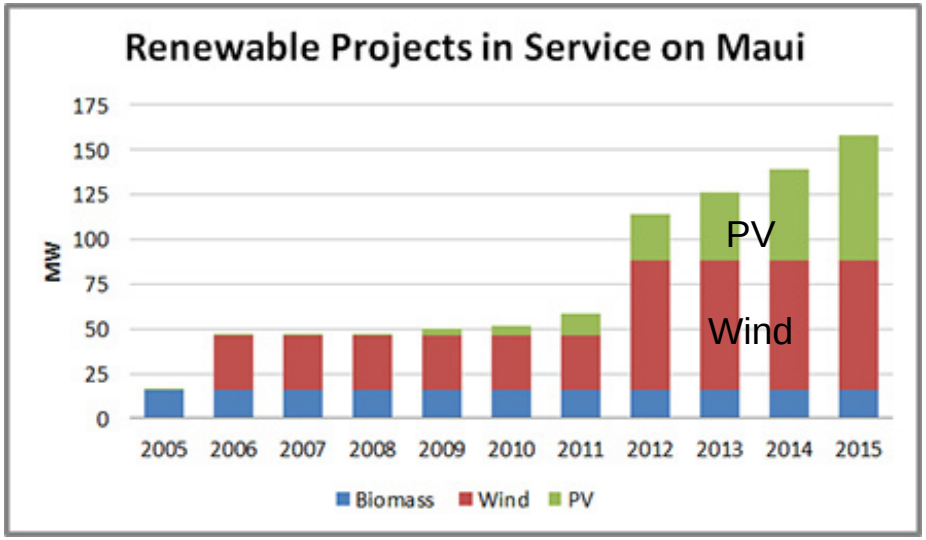
Source: Hawaii State Energy Office

Electrical Grid in Maui

Renewable energy percentage in Maui was already 36.9% in 2016

- Curtailed renewables in 2016 was equivalent to full charging of 1,000 EVs with 40kWh battery every day
- Highly populated customer-sited solar generation causes issues on grid operations



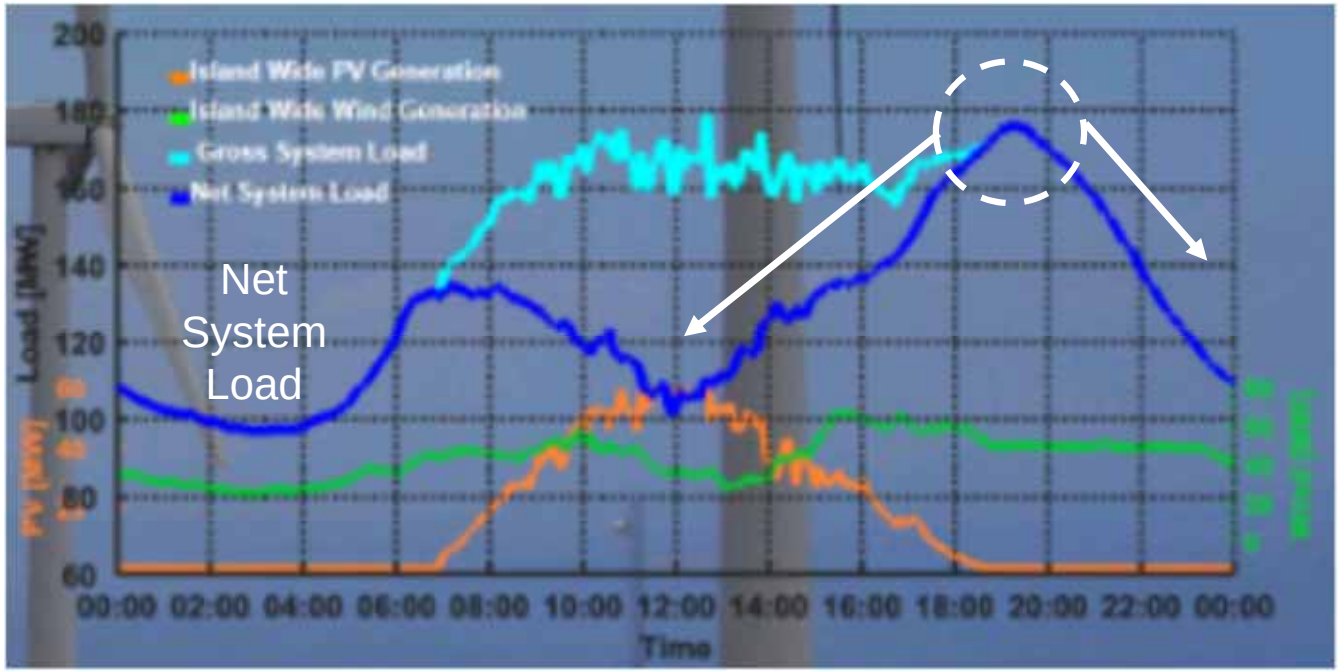


Source: Maui Electric

Electrical Grid in Maui

EVs can both cause and mitigate issues

- Loads in peak period (7~8pm) are expected to shift either during daytime or midnight

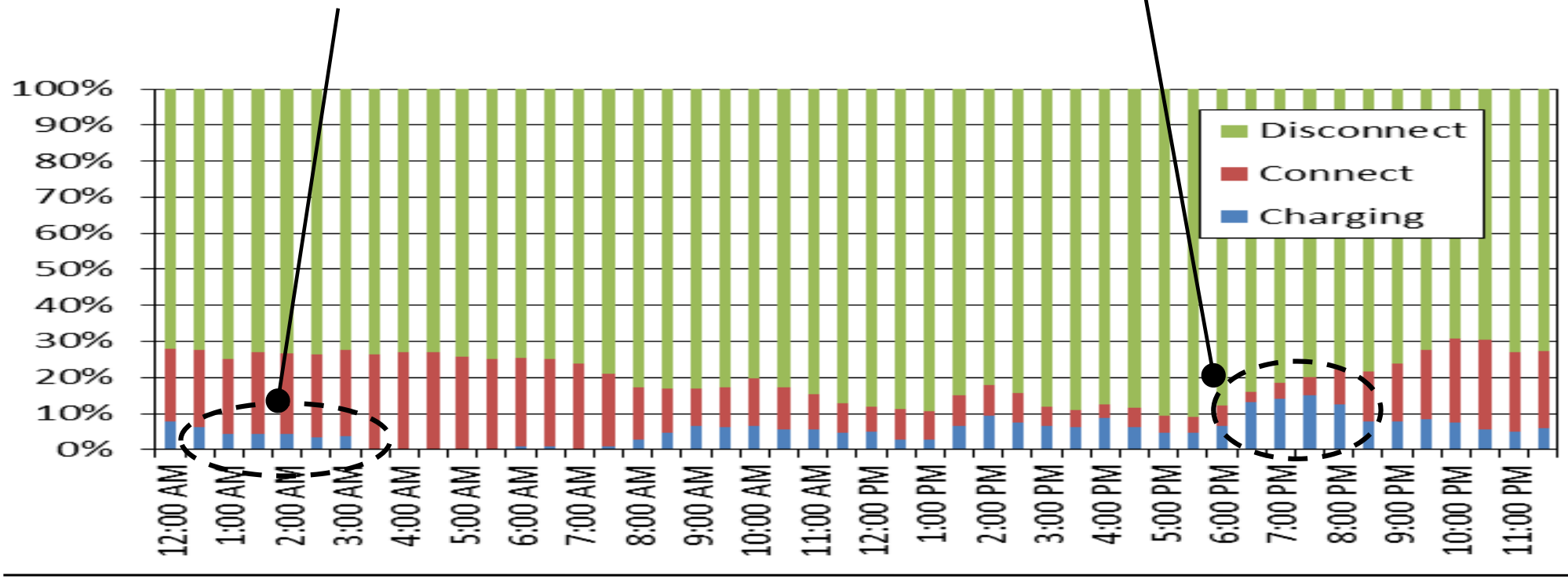


Source: Maui Electric

Home Charging and Utility Grid

Natural Charging Behavior of the Participants

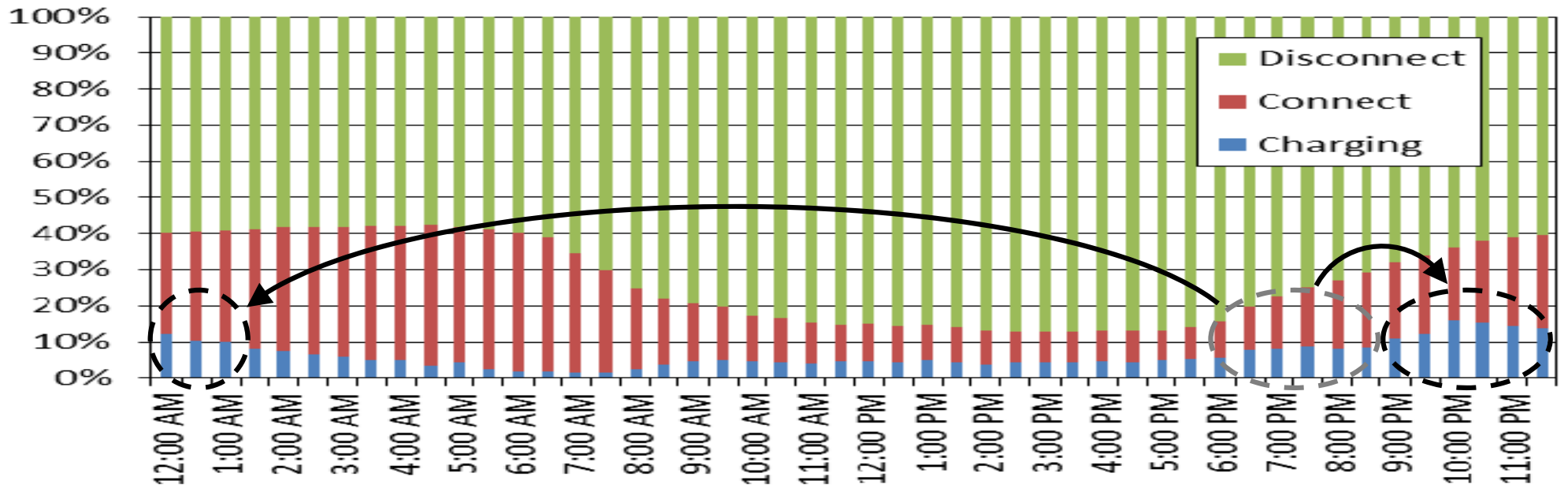
- Charging in peak at 7 ~ 8pm, when grid demand is also in peak
- Few charging at midnight, when grid demand gets minimum in a day



Home Charging and Utility Grid

Managed Charging Results

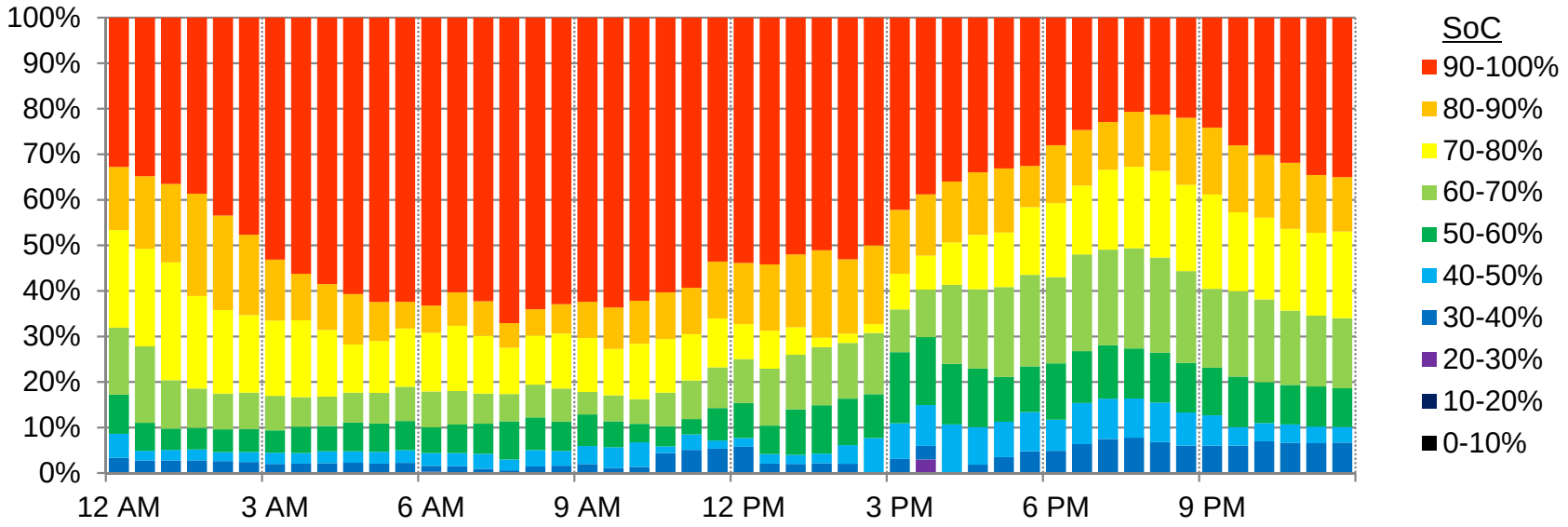
- Schedule charging based on hourly grid needs and requirement of each participant (e.g. full by 4am)
- Charging peaked 3 hours later and continued to midnight



Home Charging and Utility Grid

State-of-Charge (SoC)

- SoC of the EVs gets minimum ~7pm but still half of them have > 70% left
- Enough to support grid's peak demand period (and to be fully charged afterwards)



Home Charging and Utility Grid

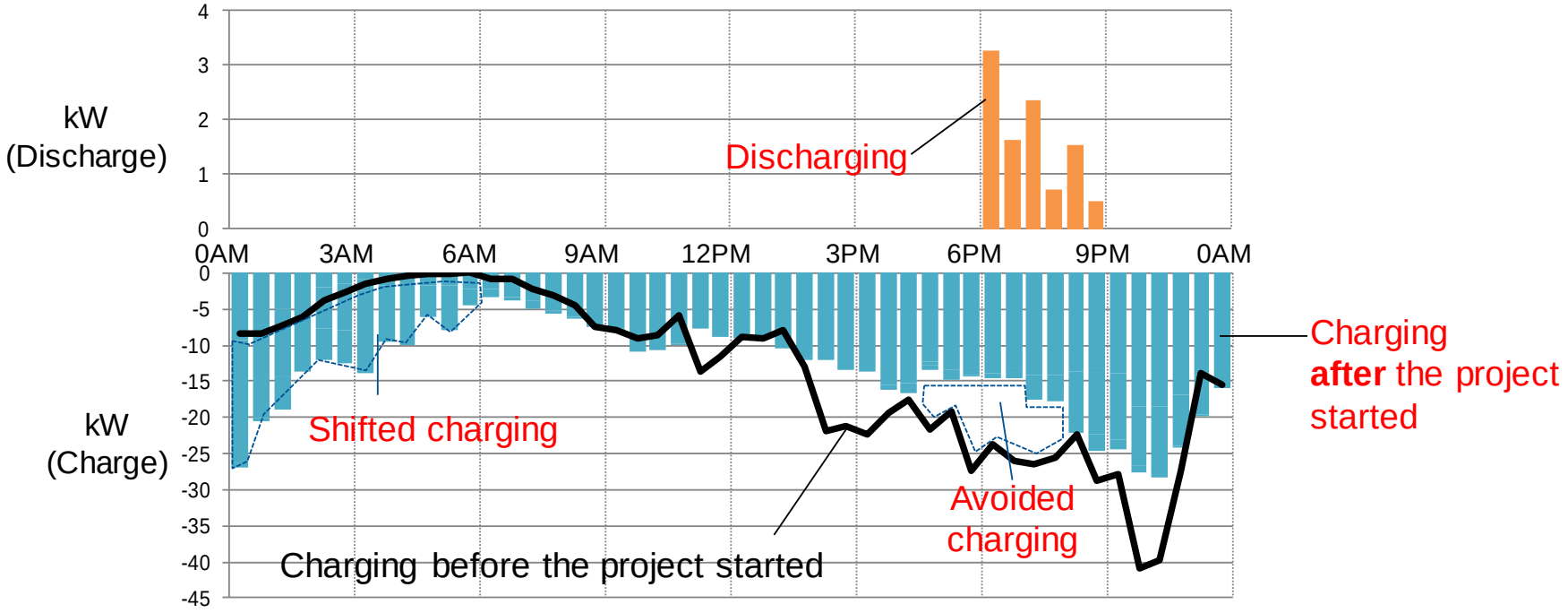
Hitachi Bi-directional Charger - Maui Demonstration Model

- Charging and discharging in CHAdeMO protocol at 6kW
- Remotely controlled by IEEE2030.5 (SEP2.0) interface
- Volt-Var control capability
- Vehicle-to-Load available when disconnected from the grid

Home Charging and Utility Grid

Managed Charging / Discharging Results

- Charging shifted to midnight (same as V1G demonstration)
- Discharging occurred during system load peak period



User Acceptance

Communication with Community

- Using EVs as energy resources is quite new for users and can be complicated
- Having EV charging infrastructure and interactions with grid are local interests
- Information sessions have been helpful to receive acceptance from community

Summary of V1G / V2G Demonstrations in Maui

Charging behavior at home can impact on grid operation with more EVs

•Natural charging peak at home overlaps system peak.

Charging EVs can be controlled without losing user's convenience

•Charging EVs during period with fewer system load is beneficial both for utilities and users.

•EVs avoided being charged during system peak can still be charged enough to be driven in the morning

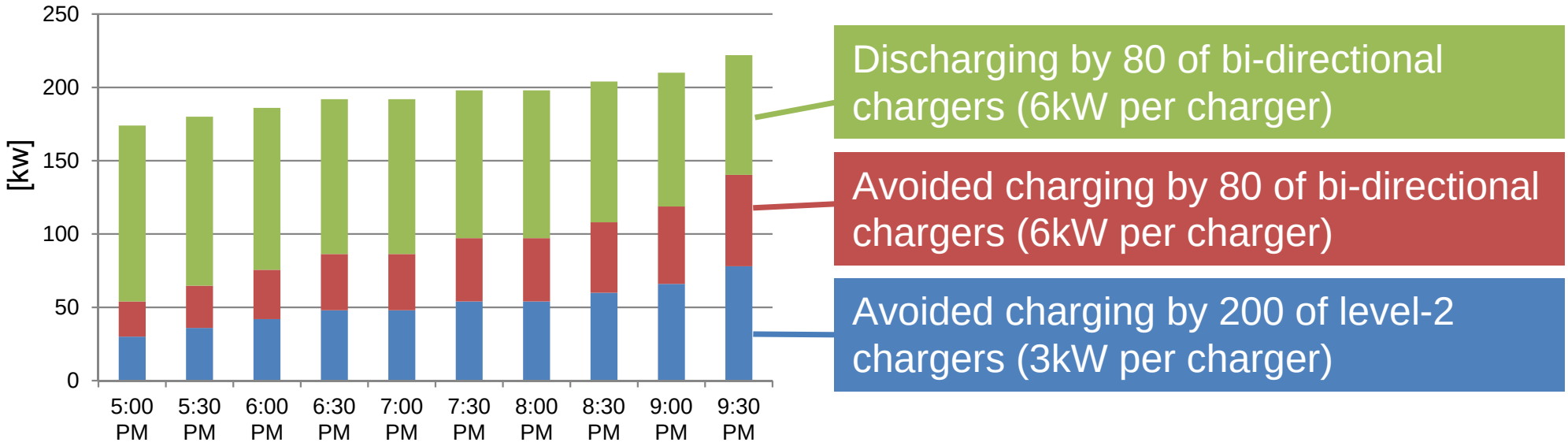
Many EVs at home have energy left to power loads during system peak

•EVs can not only be avoided being charged during system peak and also export power to home then.

Commercialization of V1G / V2G

Estimated Capacity of Aggregated EV Batteries

- with 200 Level2 chargers and 80 bi-directional chargers
- Based on what percentage of EVs can actually be under control

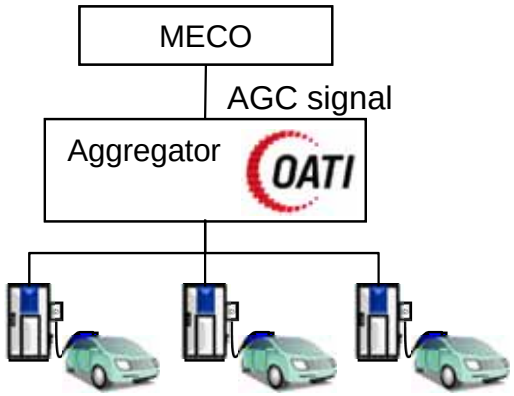


Commercialization of V1G / V2G

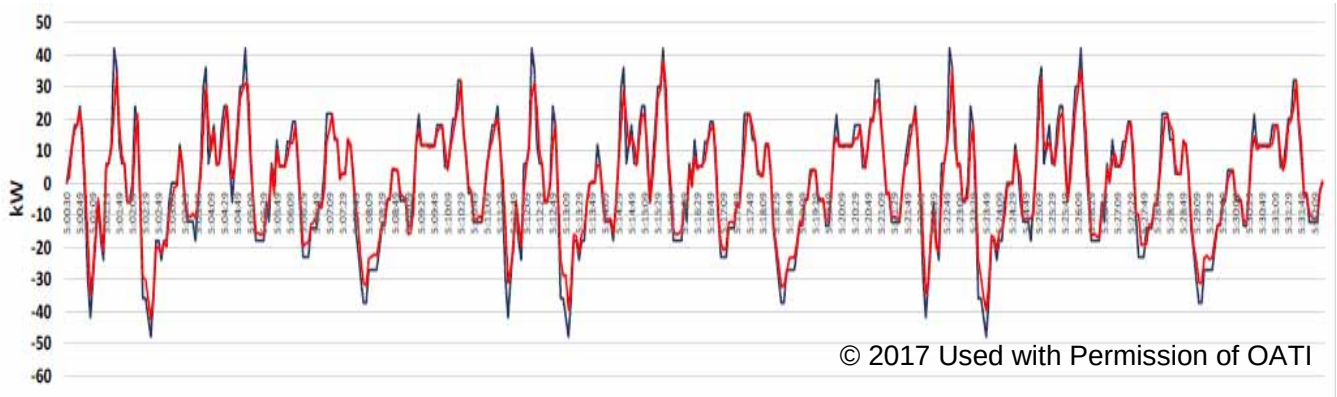
Frequency Control Demonstration by Hawaiian Electric (2017)

- 40 (out of 80 already installed) used to evaluate performance for Regulating Reserve
- Chargers controlled according to AGC signal in several second interval
- Evaluated high (> .97) in PJM scoring

Source : Hawaiian Electric “Implementation Phase I Status Report #5” (July 10, 2017)



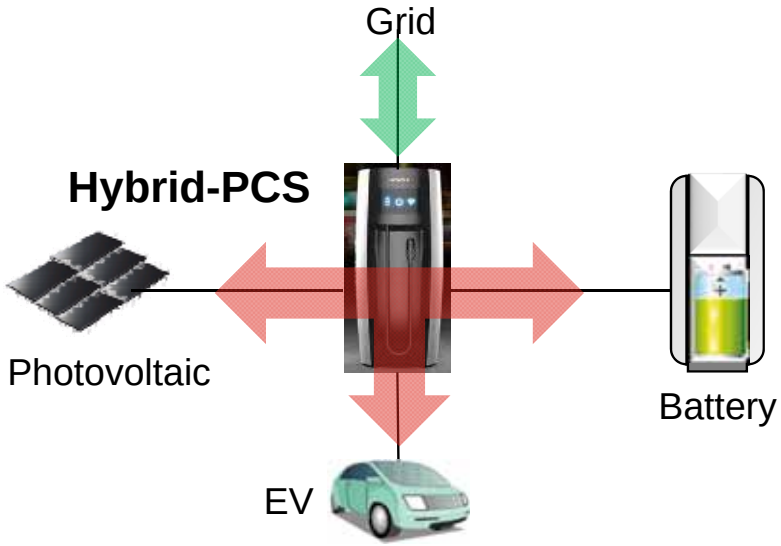
Bi-directional charger
(EV-PCS)



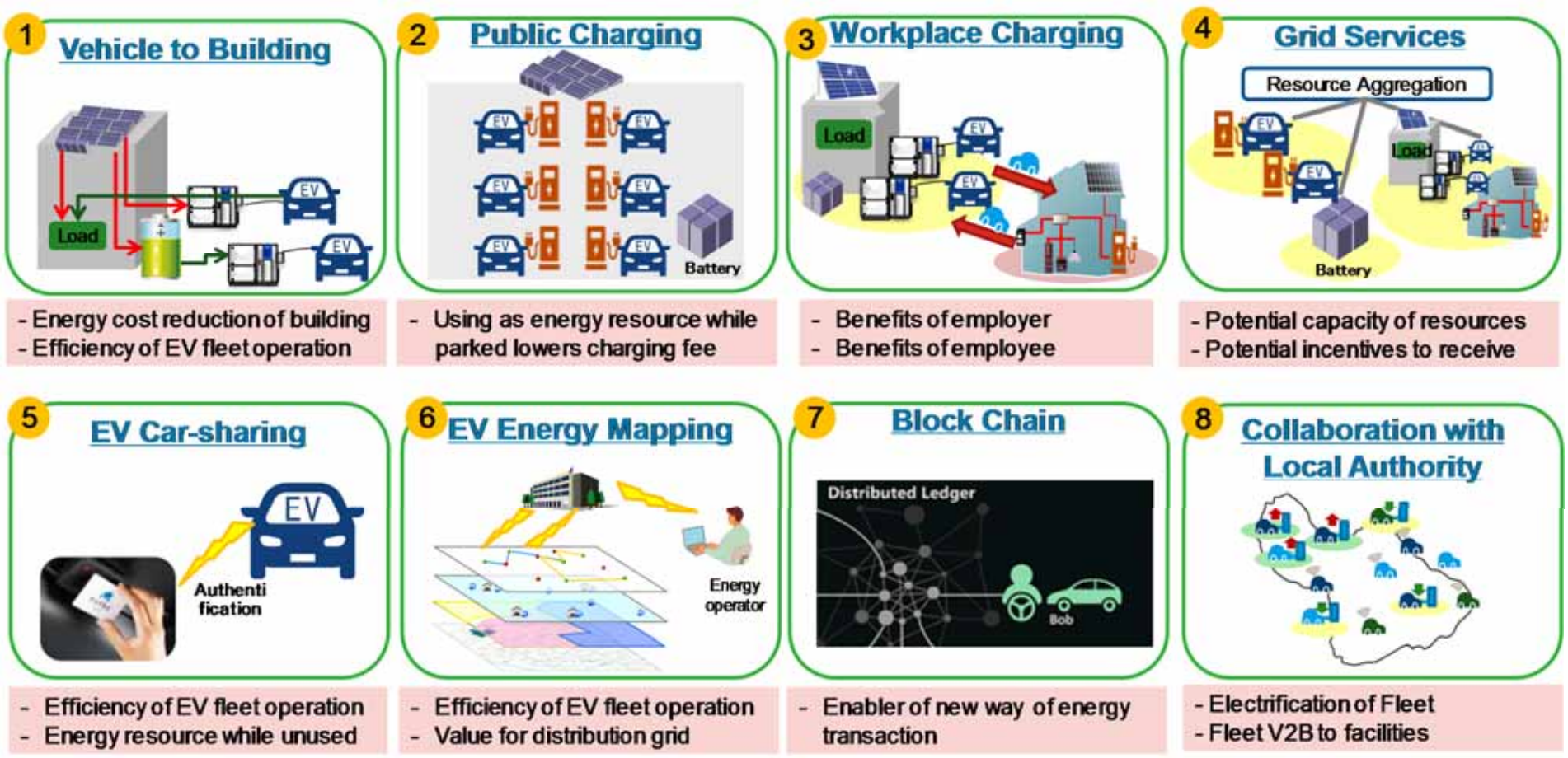
Commercialization of V1G / V2G

Hitachi Bi-directional Charger - Hybrid-PCS (Commercial Model)

- EV, PV and battery support with single PCS (power conditioning system)
- Efficient DC-DC EV charging from PV
- Available in mass production in 1Q / 2018



V2X Use Cases



V1G / V2G experiences in Maui

For more information on Maui demonstrations :

•NEDO Case Study Report

http://www.nedo.go.jp/english/reports_20130222.html#hawaii

•EPRI Smart Grid Demonstration Assessment Report

https://www.epri.com/#/pages/product/000000003002007129/

Thank you

Shinichi Kasai
Hitachi,Ltd.
shinichi.kasai.nv@hitachi.com