

Lanai Battery Project - *Background and Lessons Learned*

Abbas Akhil

Ron Pate

Sandia National Laboratories

HCEI Electricity Working Group Meeting

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Need Basis

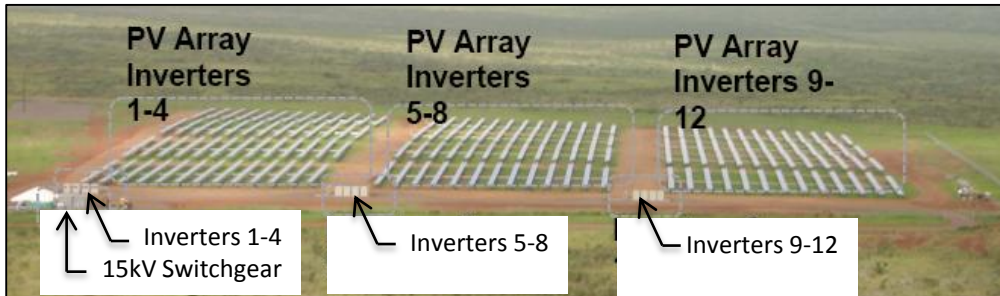
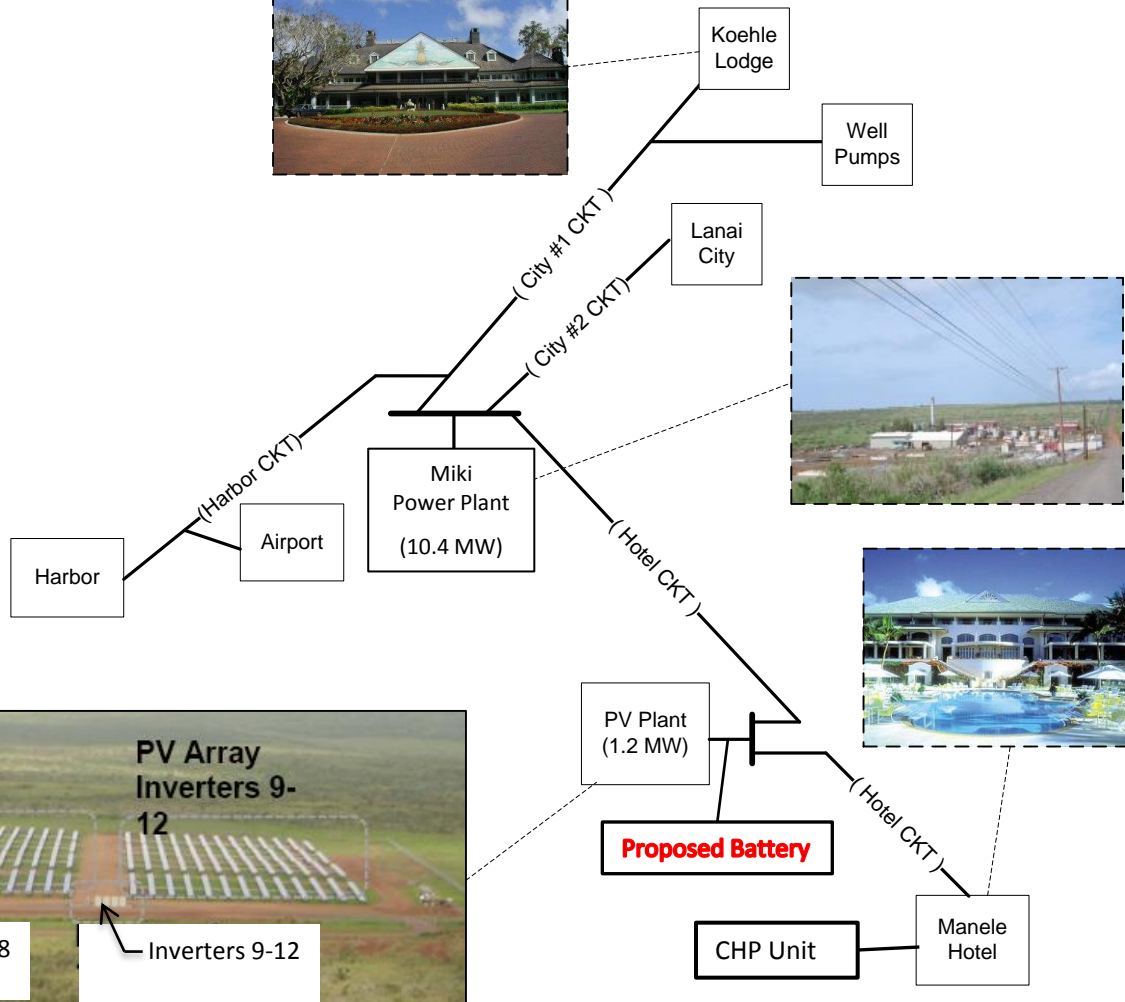
- KEMA interconnection study identified ramp rate of PV plant and system frequency as key criteria that battery system needed to control:
 - 6kW/sec for daily ramp up or ramp down during normal sunrise/sunset or after a PV station outage
 - 60kW/sec during intermittent operations due to weather events (sudden cloud cover)
 - Reducing to 40kW/sec during weather events when one of the two 2.5MW diesel gensets used for system regulation is unavailable due to maintenance

And

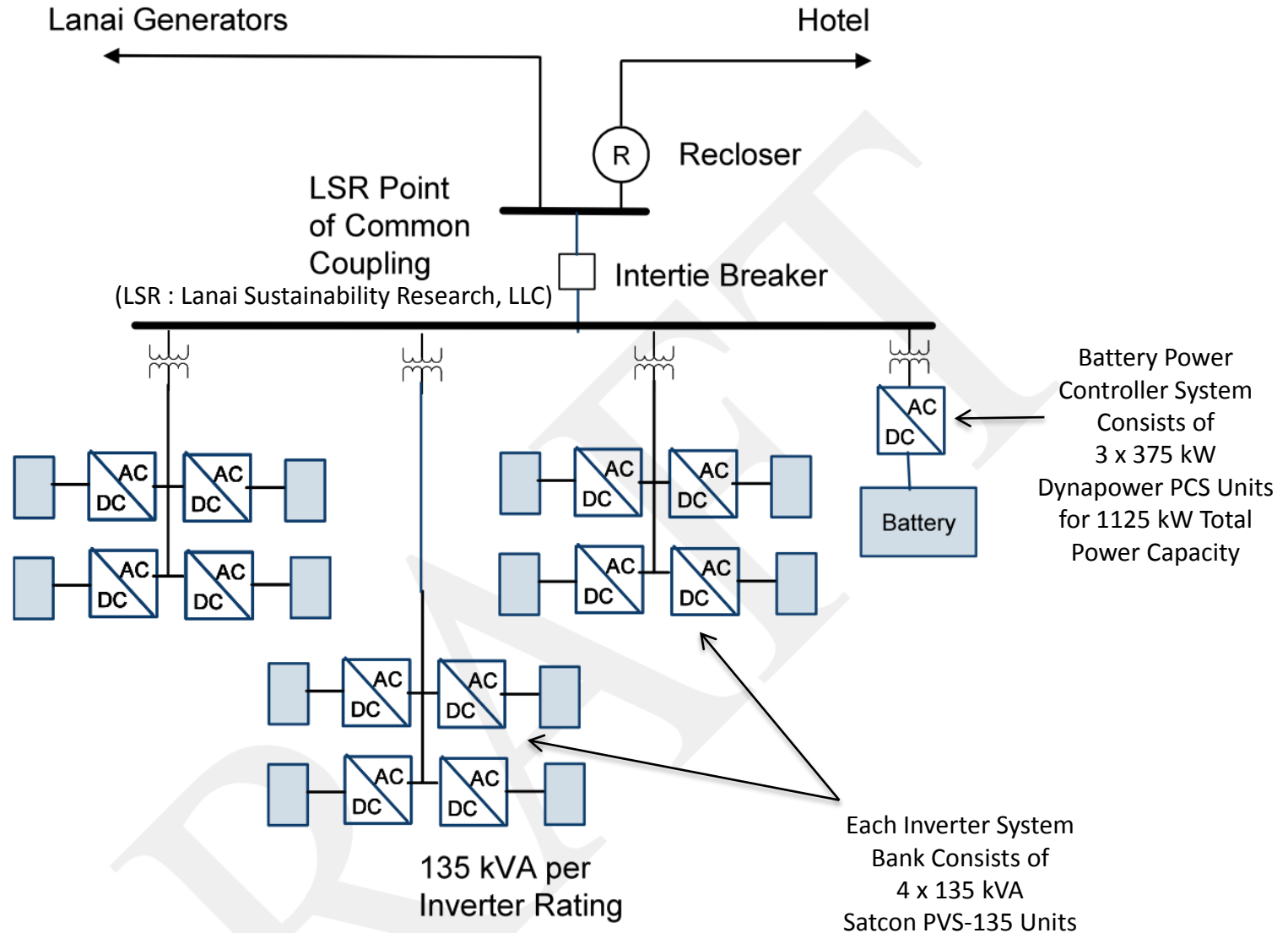
Maintain frequency deviations to within +/- 0.2Hz

- These requirements clearly indicate need is for a “power” not “energy” battery

Lanai Grid (incl. Battery)



1.2 MW PV and Battery



Background of Selection

- Power Purchase Agreement (PPA) between Castle & Cooke (C&C) and MECO signed before HCEI was initiated
- PPA specified 250 kW, 3 hour flow battery made by VRB Power Systems (Now Prudent Energy)
- Apparent mismatch between system need and battery specification in PPA
 - VRB also declared bankruptcy in late 2008

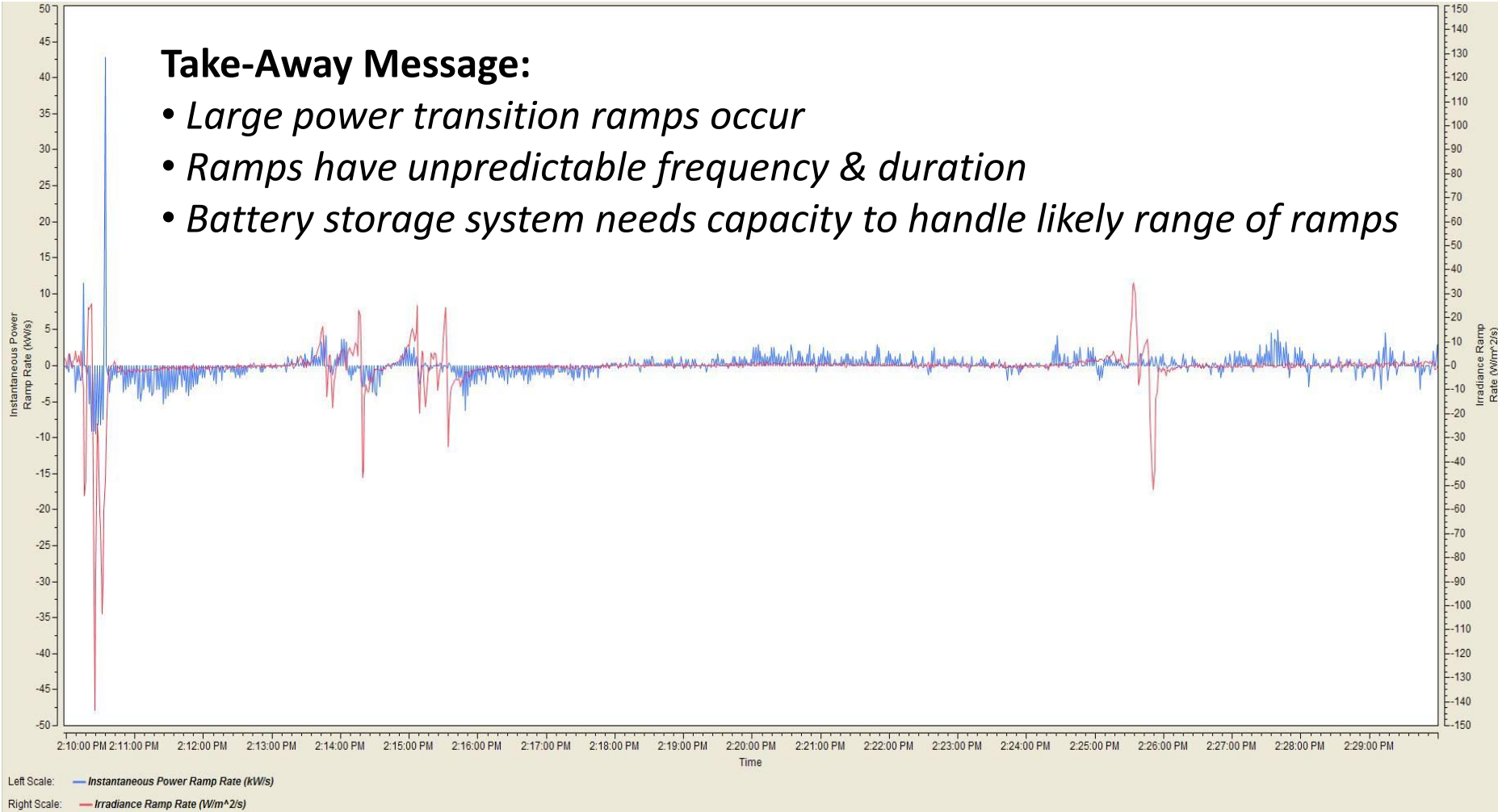
Revisiting Battery Sizing

- C&C revisited battery sizing and selection in 2009 with Sandia and NREL
- Battery sizing analysis by Sandia Labs, NREL and SunPower in early 2010
 - 1 second power and irradiance data from similar-sized PV farm
 - 10 months field-recorded data
 - Three independent approaches using common input data set
- Battery sizing considerations: Ramp rates, duration and frequency of ramps

1 Second Ramps in Plant Output

Take-Away Message:

- *Large power transition ramps occur*
- *Ramps have unpredictable frequency & duration*
- *Battery storage system needs capacity to handle likely range of ramps*



Source: SunPower Corp

Battery Sizing - Challenges and Outcome

- Challenges: Vast amount of data; random ramp rate pattern; uncertainty that all “events” are captured
- Recommended battery size: 450 – 700 kW; 250 – 500 kWh energy required to meet ramp rate support requirements

Battery Selection

- Under revised approach, C&C needed a 500 – 750 kW, approximately 1 hour, “turnkey” battery system, within a cost target
- A turnkey proposal from Satcon with GNB valve regulated lead-acid battery was received by C&C in December 2009
- Eventually, the Xtreme Power battery system was selected by C&C ... based on innovative and proprietary “dry cell battery technology” with both high energy and high power capability

Final Battery Selection

System Provided by Xtreme Power

- Installed battery size: 1.125 MW, 500 kWh
- Battery has been successfully commissioned
- Start-up issues resolved & system fully operational

