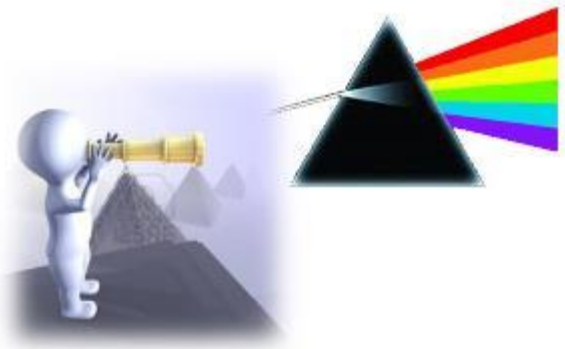


The Future Grid

DORA NAKAFUJI

MPSC MEETING, MICHIGAN

5/30/2019

Perspectives

- Why – Changing Landscape?
- Where do we want to be?
- Pathways Forward – Back to Basics
  - Heart: Vision & Direction
  - Mind: Partnership of Like-Minded Innovators
  - Soul: Resilience & Stewardship
- Q&A

Hawaii is the first state in the US to go 100% RPS

Our Current Condition

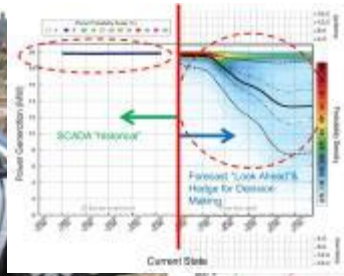
"Meet Nessie"

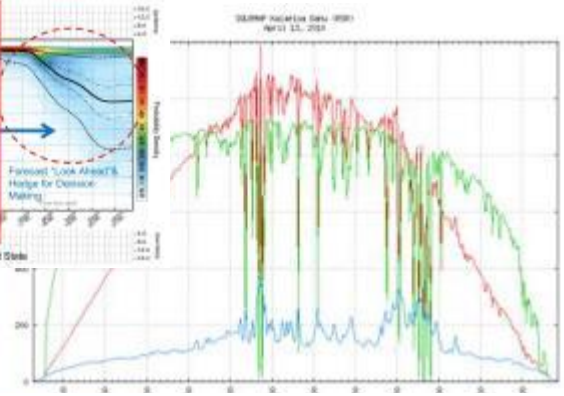
Typical Hawaii load profile – Evening Peaking

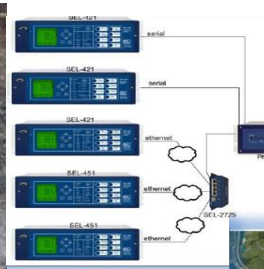
"Bessie the Elephant"

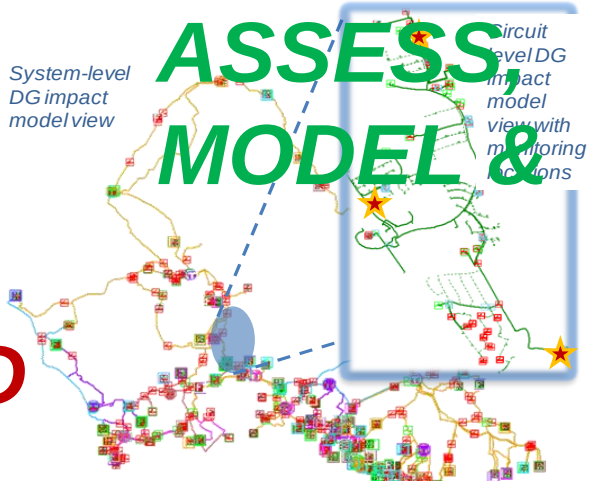
What's Our New State?

CONNECTING New Tools & Capabilities with Workforce & Customers

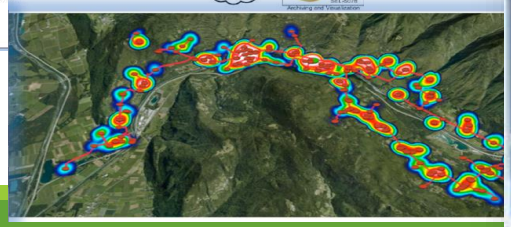




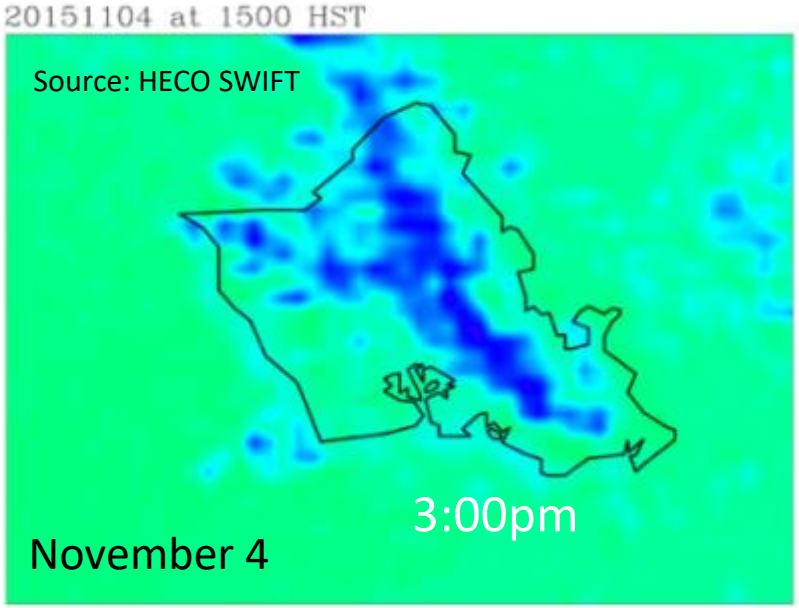


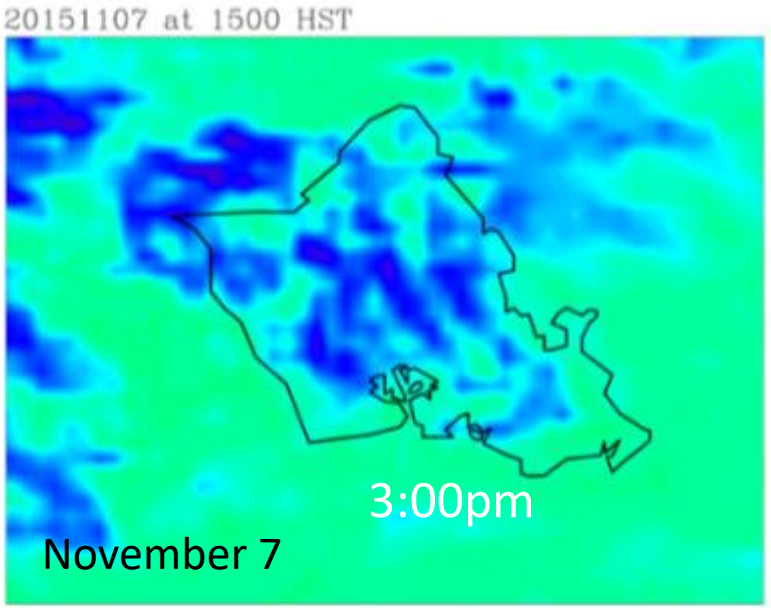


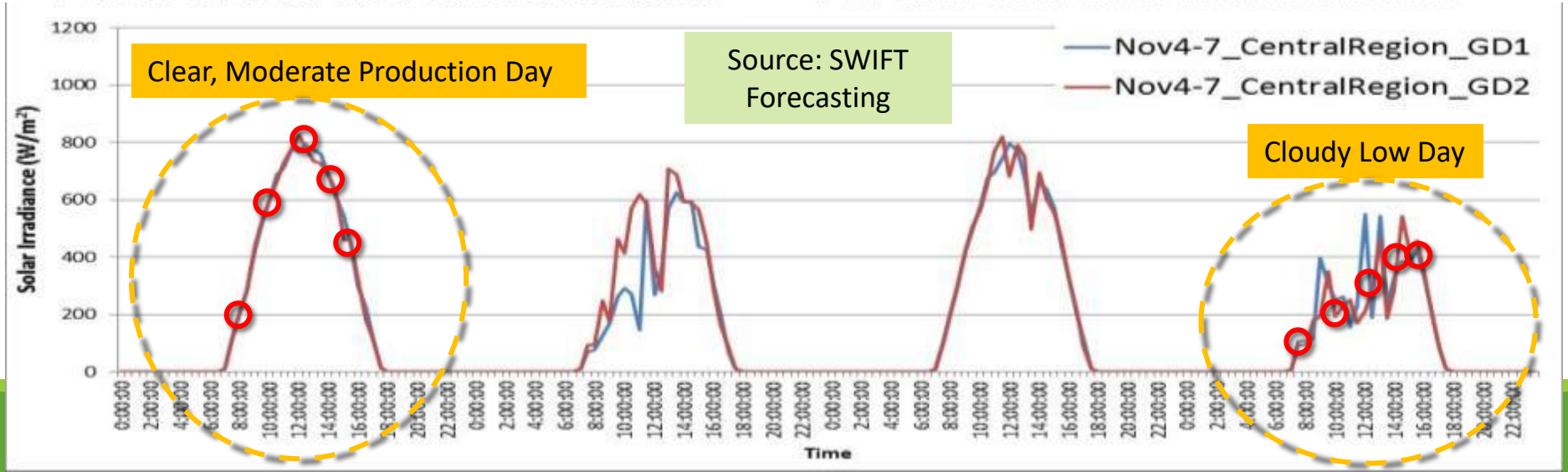
INFORMED
TO ACT



Sharing Experience: SWIFT Forecasting of Dynamic System Needs

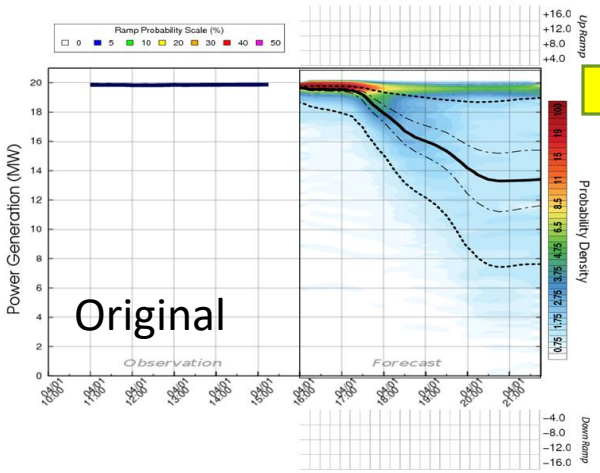


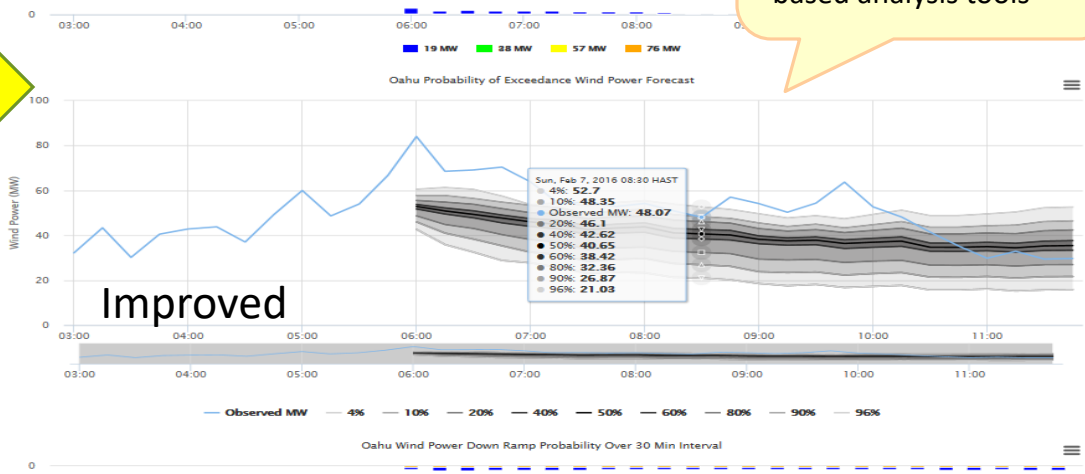


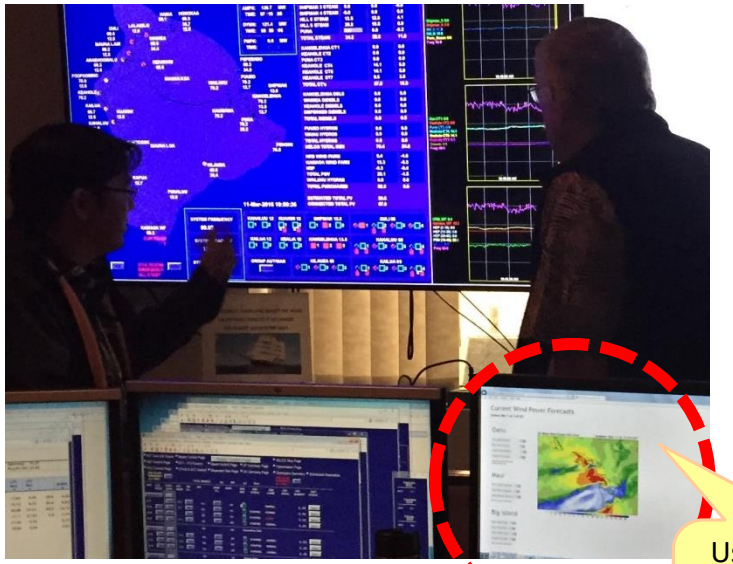


Informing New Insights

SWIFT Forecast tool: user informed display improvements & web-based analysis tools





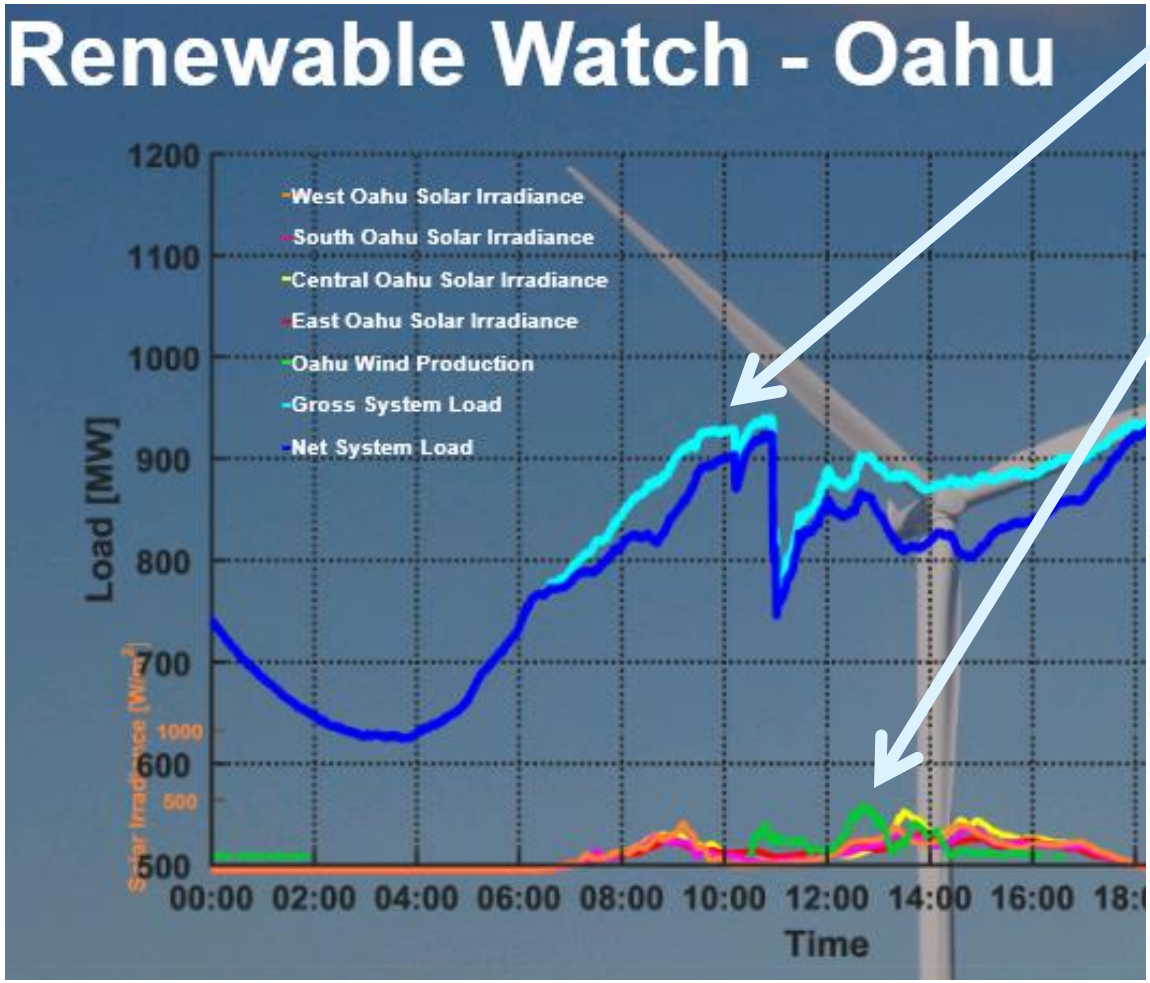


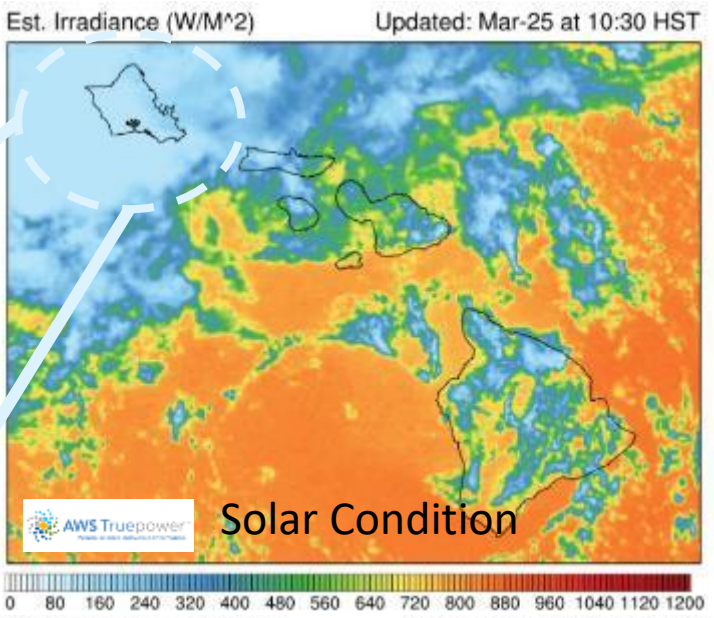
Using & learning to use DREAMS & SWIFT tools in System Operations

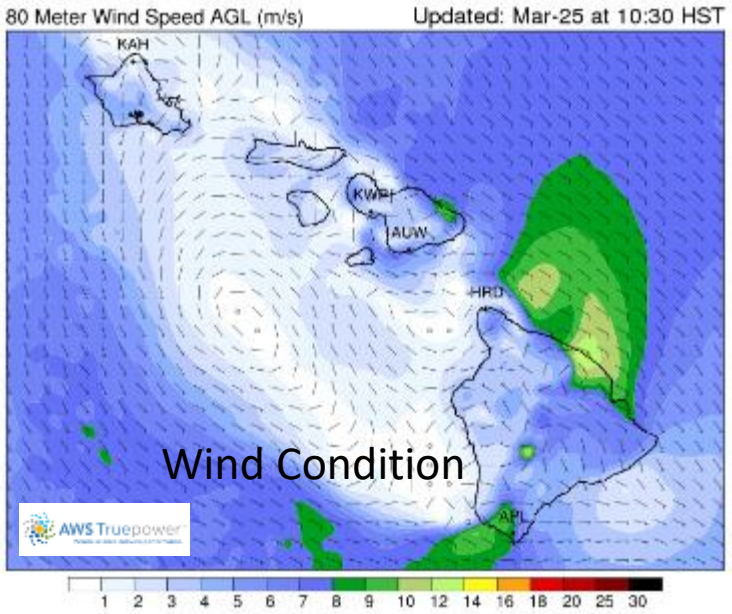
Upgraded LIDAR technology & Solar monitoring supporting real-time WindNET & SolarNET

Source: SEAMS for SHINES

Combining Visual Tools Provide Awareness & Insight on How to Operate in the Future with Renewables

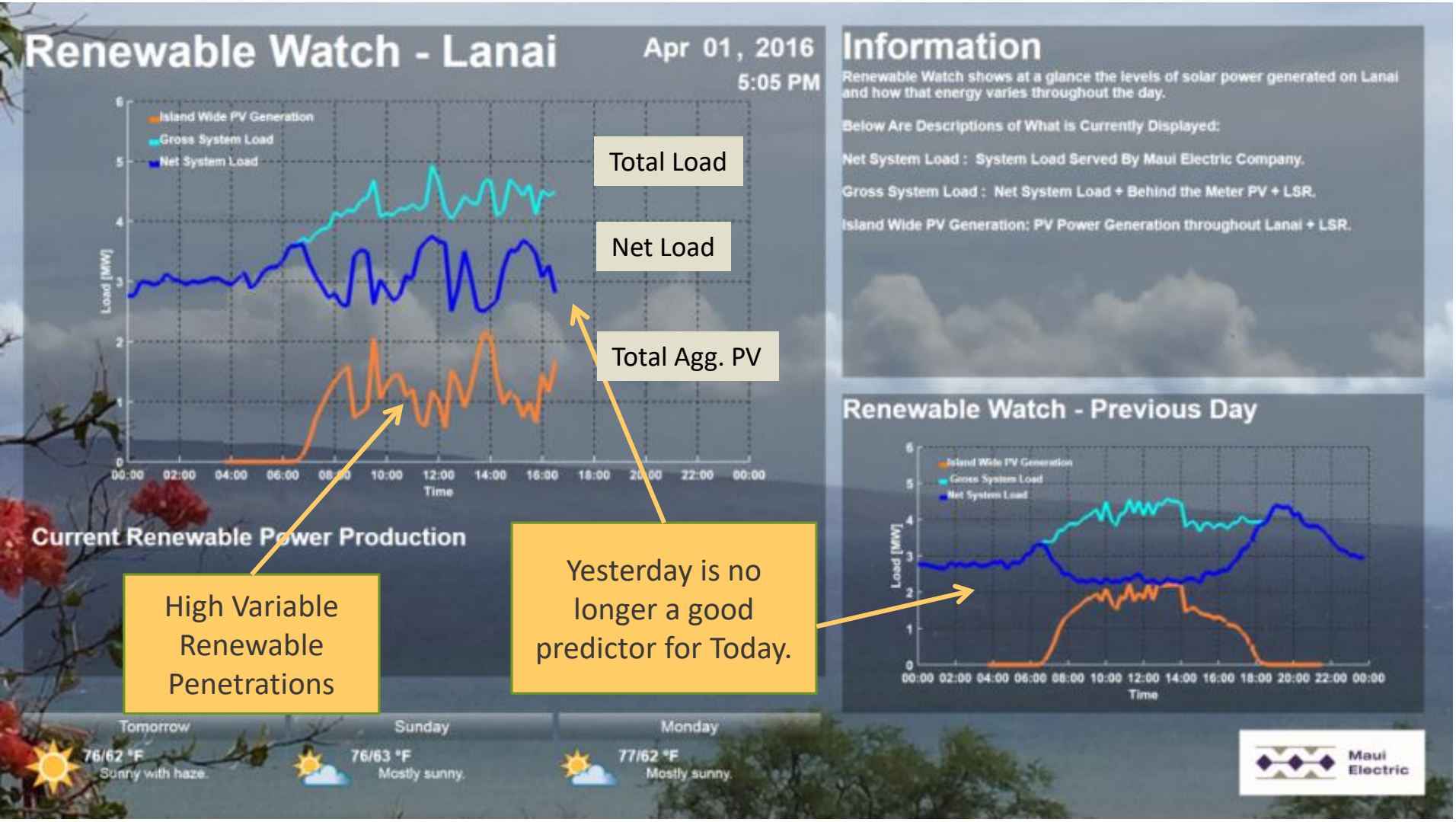






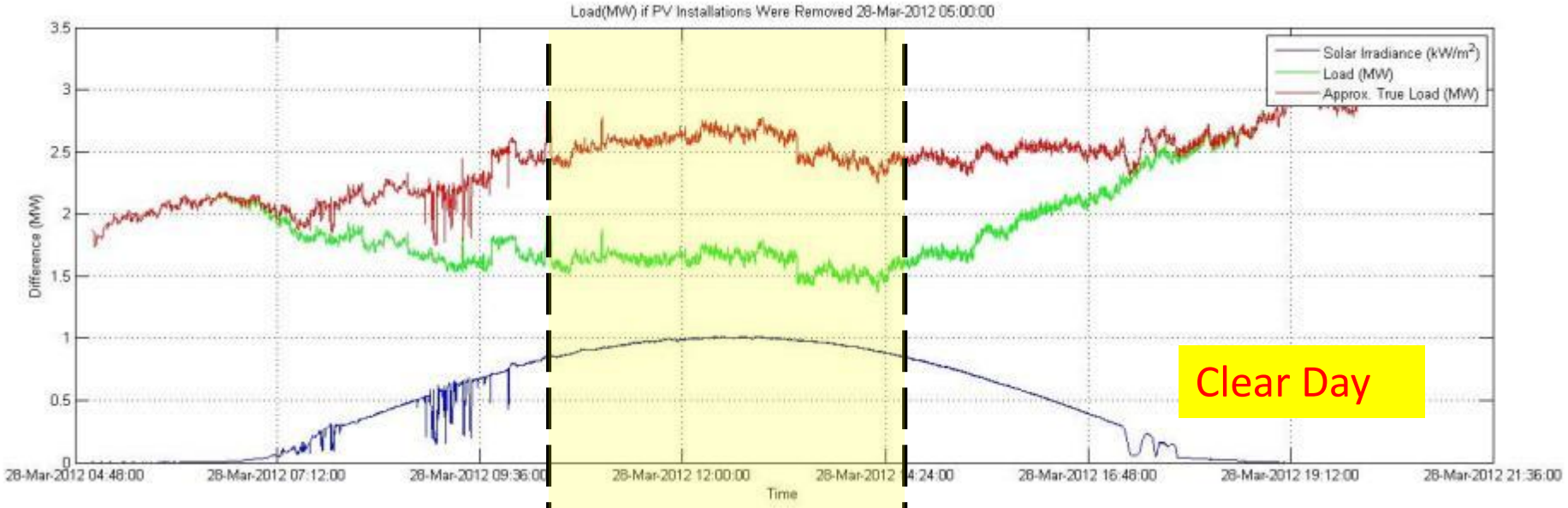
March 25, 2016
Non-Hurricane Conditions

Create Awareness of Impacts



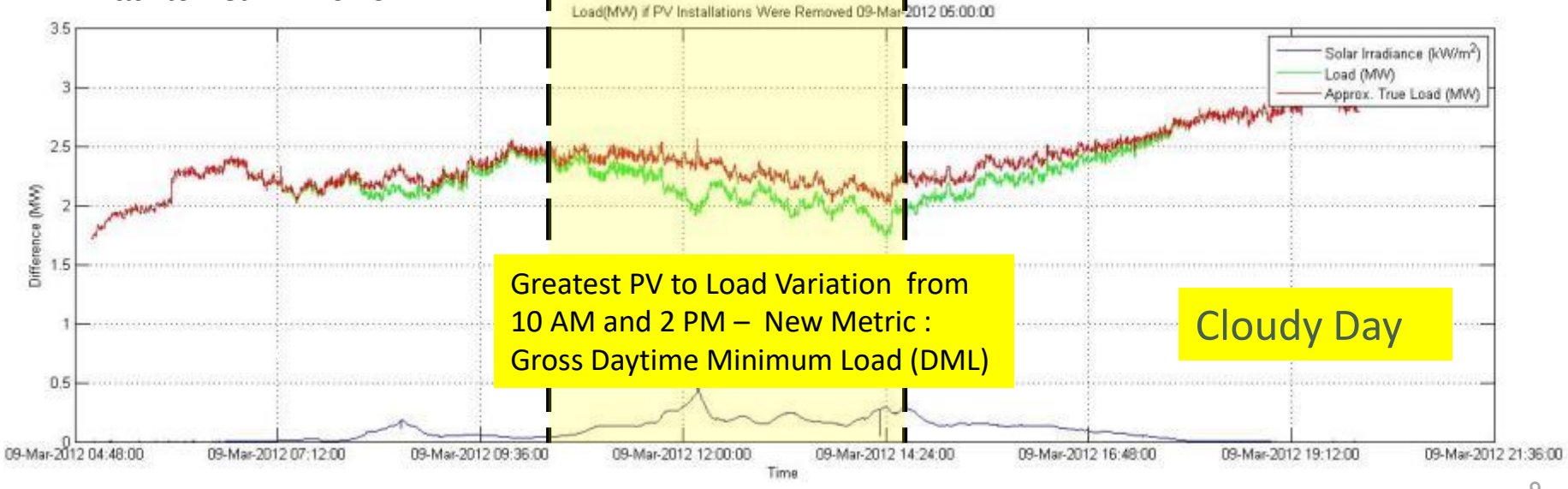
- ❑ How to use data to inform <u>planning and operations</u>?
- ❑ What <u>enhancements</u> are needed to use new data?

Need to "See" Solar Impact on Distribution Feeder & Loads (Net vs Gross) – NEW DML Metric



Clear Day

Irrad. to Est PV Power



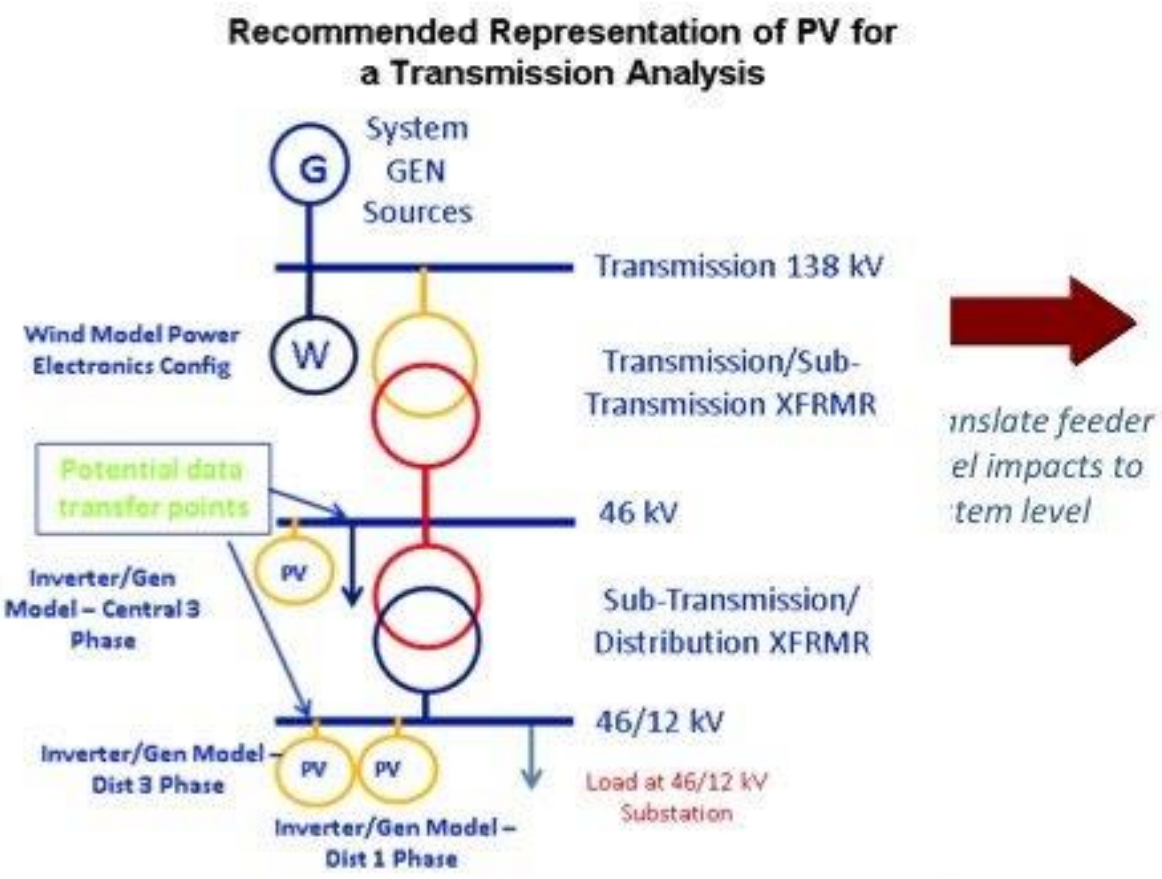
Greatest PV to Load Variation from 10 AM and 2 PM – New Metric : Gross Daytime Minimum Load (DML)

Cloudy Day

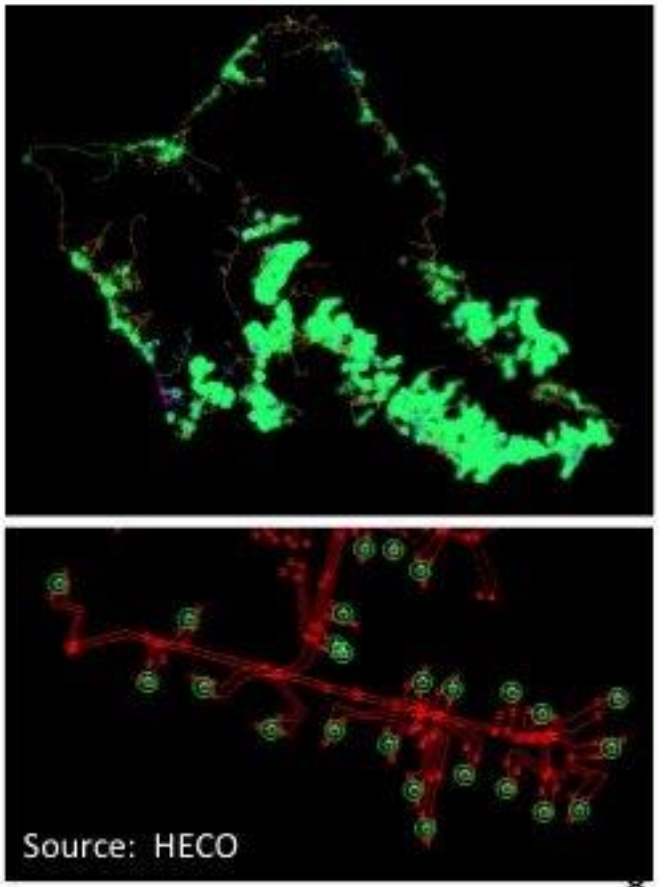
Proactive Approach Accounting for PV as Generation NOT as Negative Load

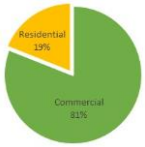
Source: HiP-PV SMUD/HECO

- Enables aggregation of DG impacts up to the 46kV transmission level
- Enables consistent baseline distribution model to expedite interconnection process
- Allows for "what-if" analysis to proactively assess impacts and maintain reliability



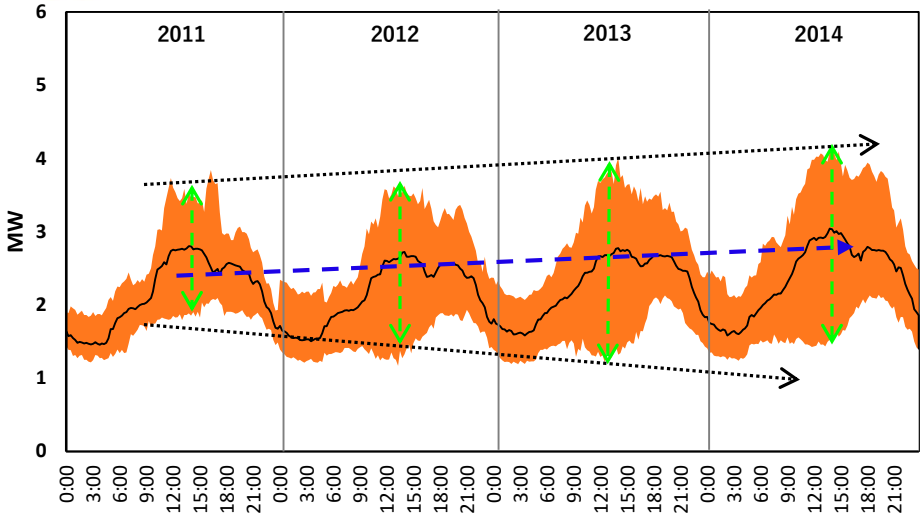
nslate feeder el impacts to tem level

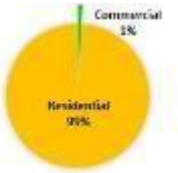




Annual Circuit Net Load

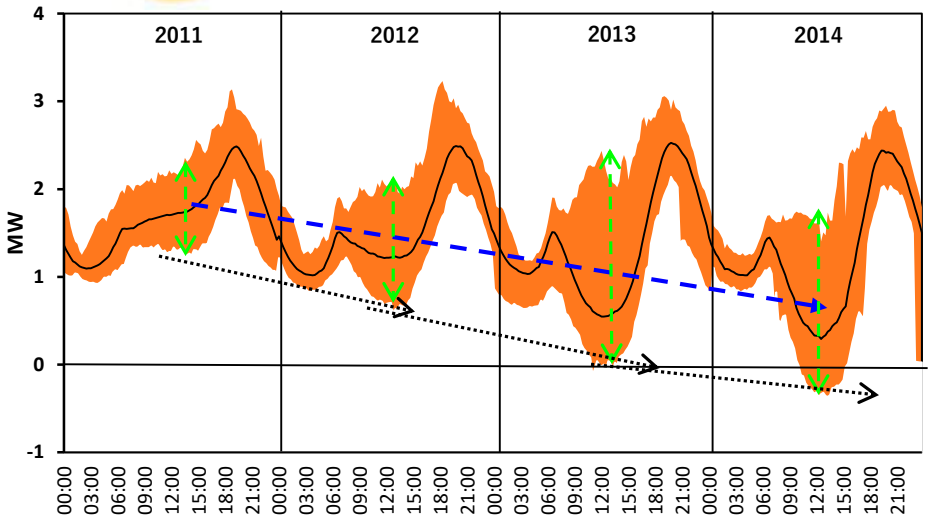
(80%Commercial/ 20% Residential Circuit)





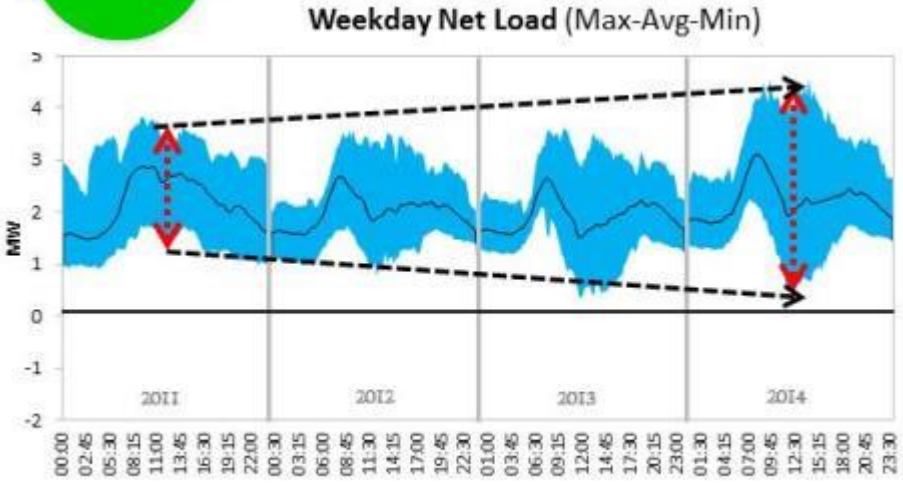
Annual Circuit Net Load

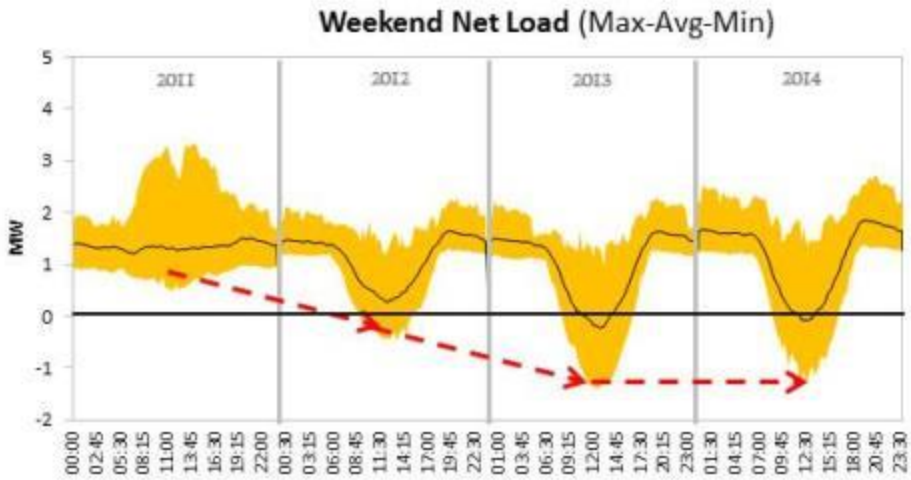
(99% Residential Circuit)



Circuit Weekday vs Weekend Breakout

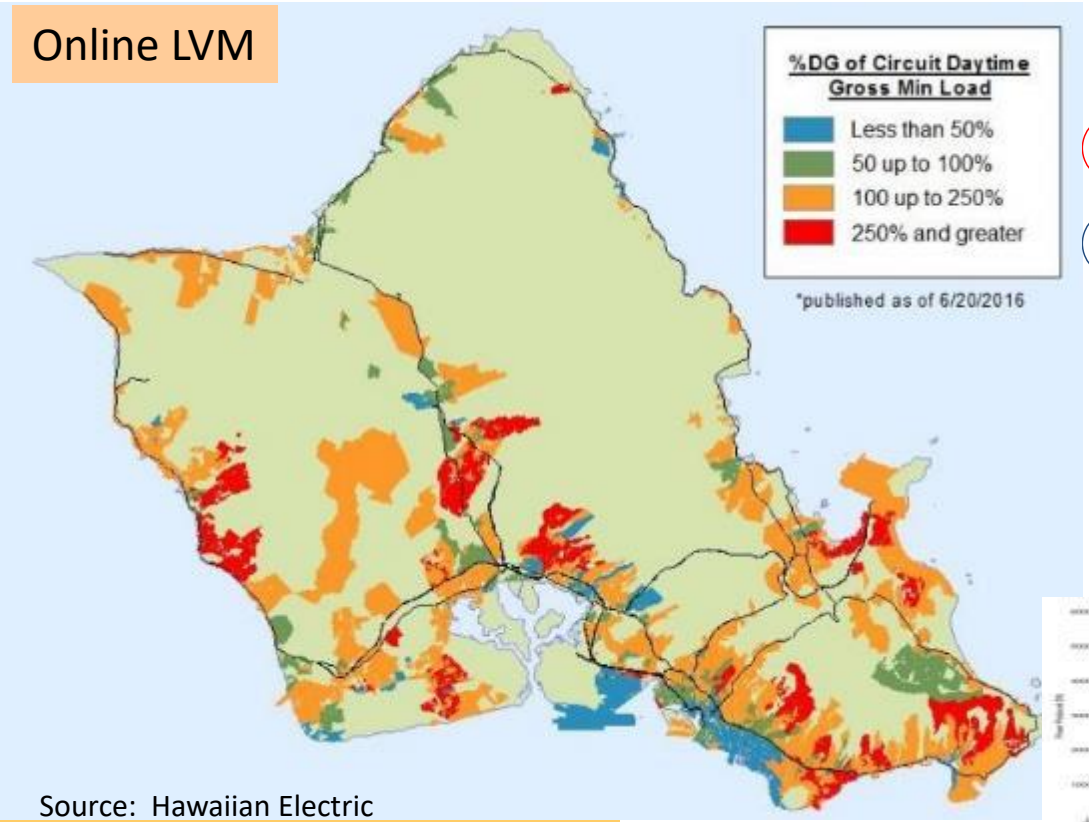
(100% Commercial Circuit)





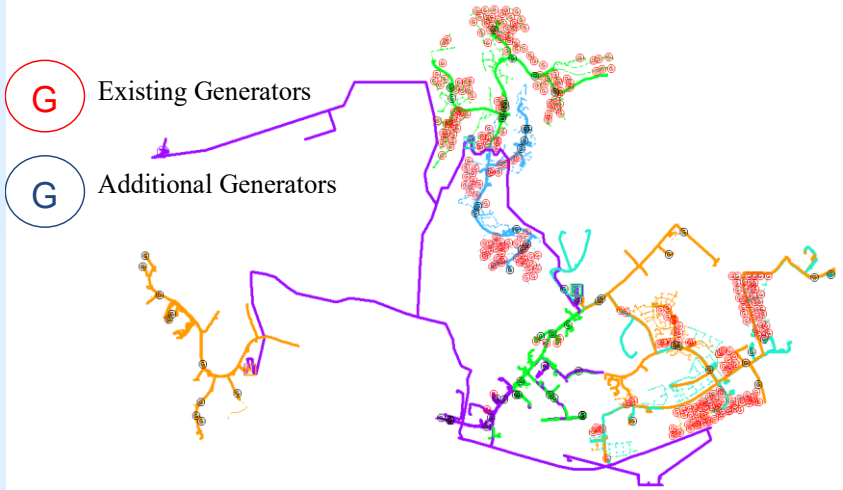
Awareness to See & Trend Distribution Impacts

Online LVM

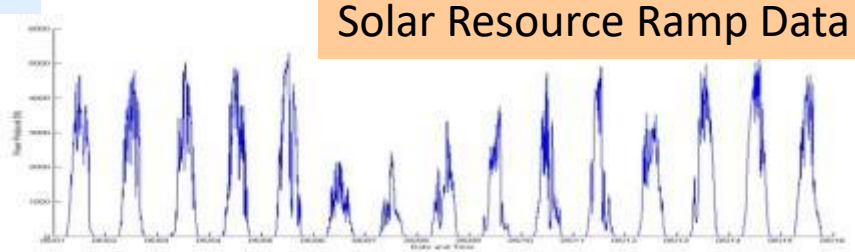


Source: Hawaiian Electric

DG Integrated into Model

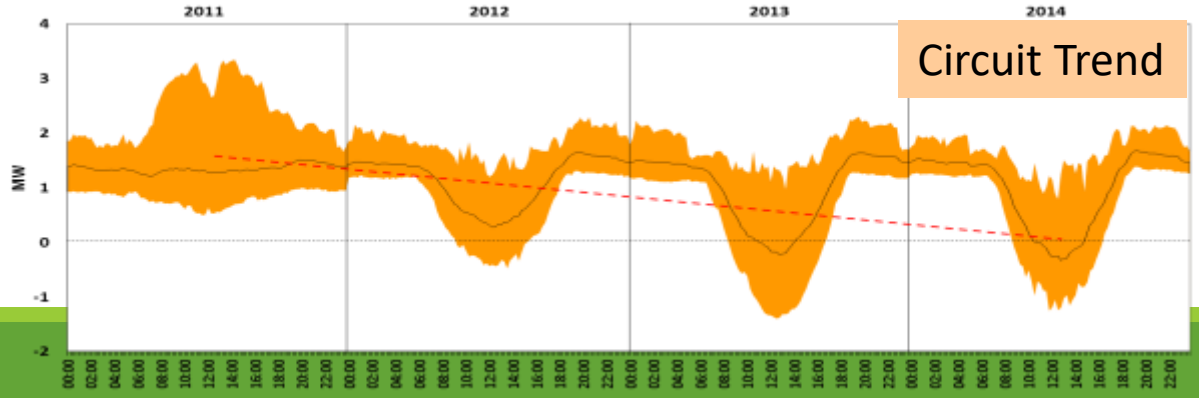


Solar Resource Ramp Data

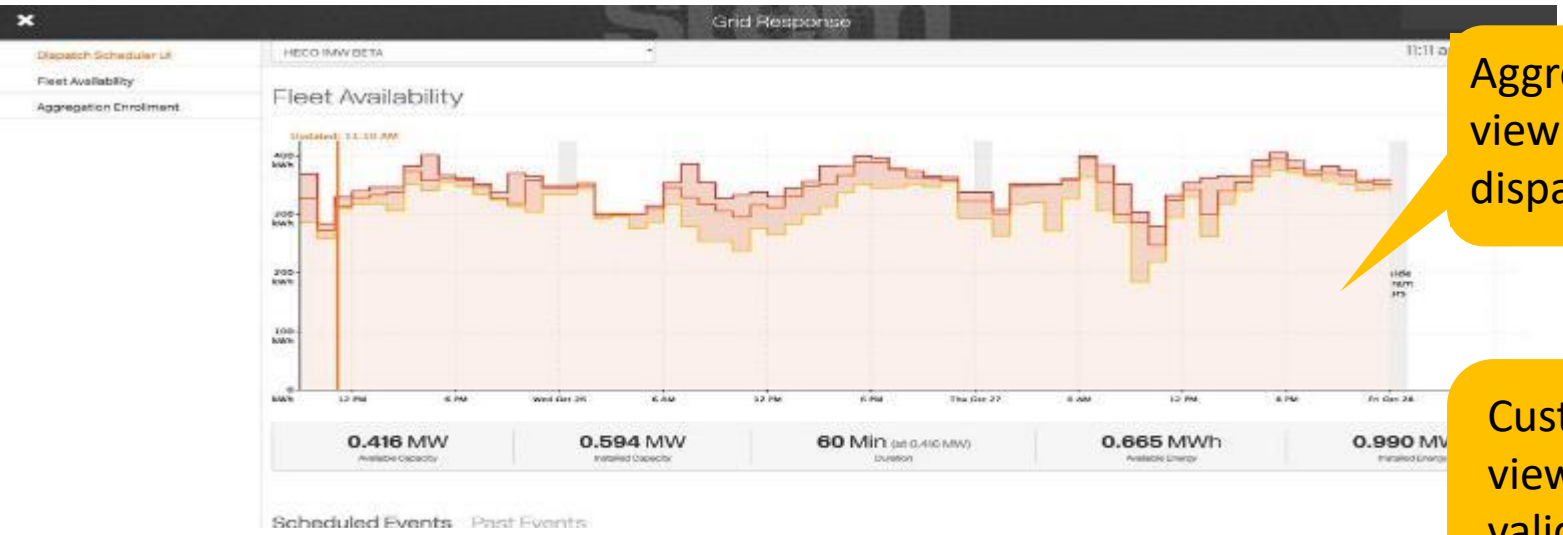


$$\%\ \text{DML Pen} = \frac{\textit{Installed MW}}{\textit{Gross Daytime Min Load}}$$

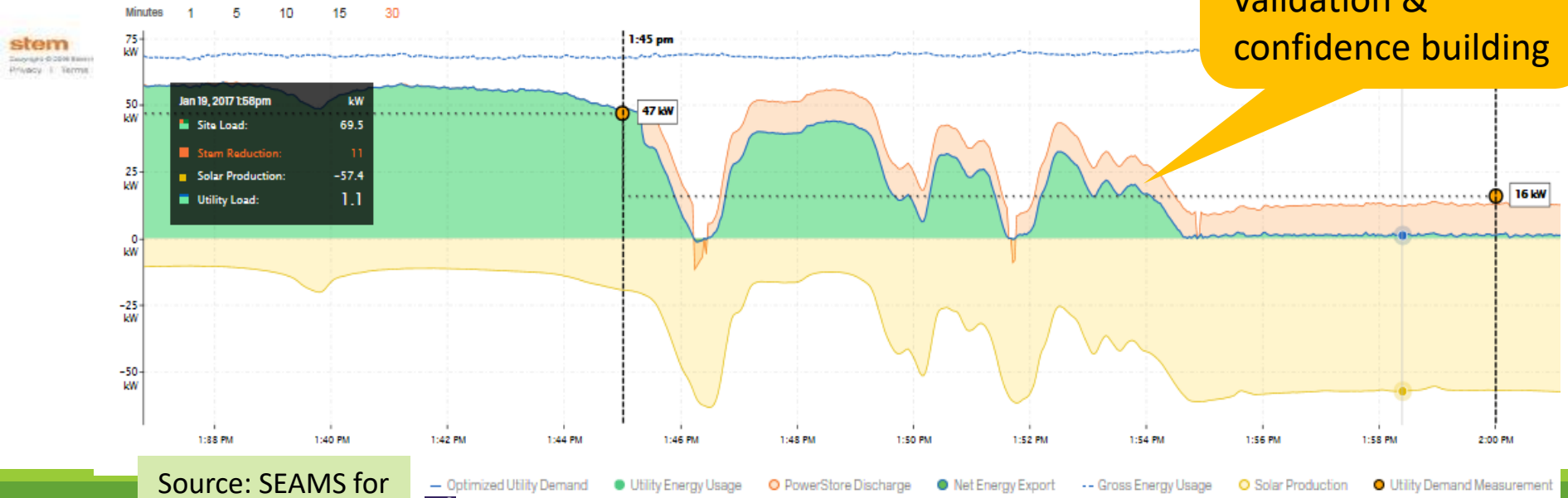
Circuit Trend



New Insights on Real-time Controls – Aggregated Fleet Data Interface & Info



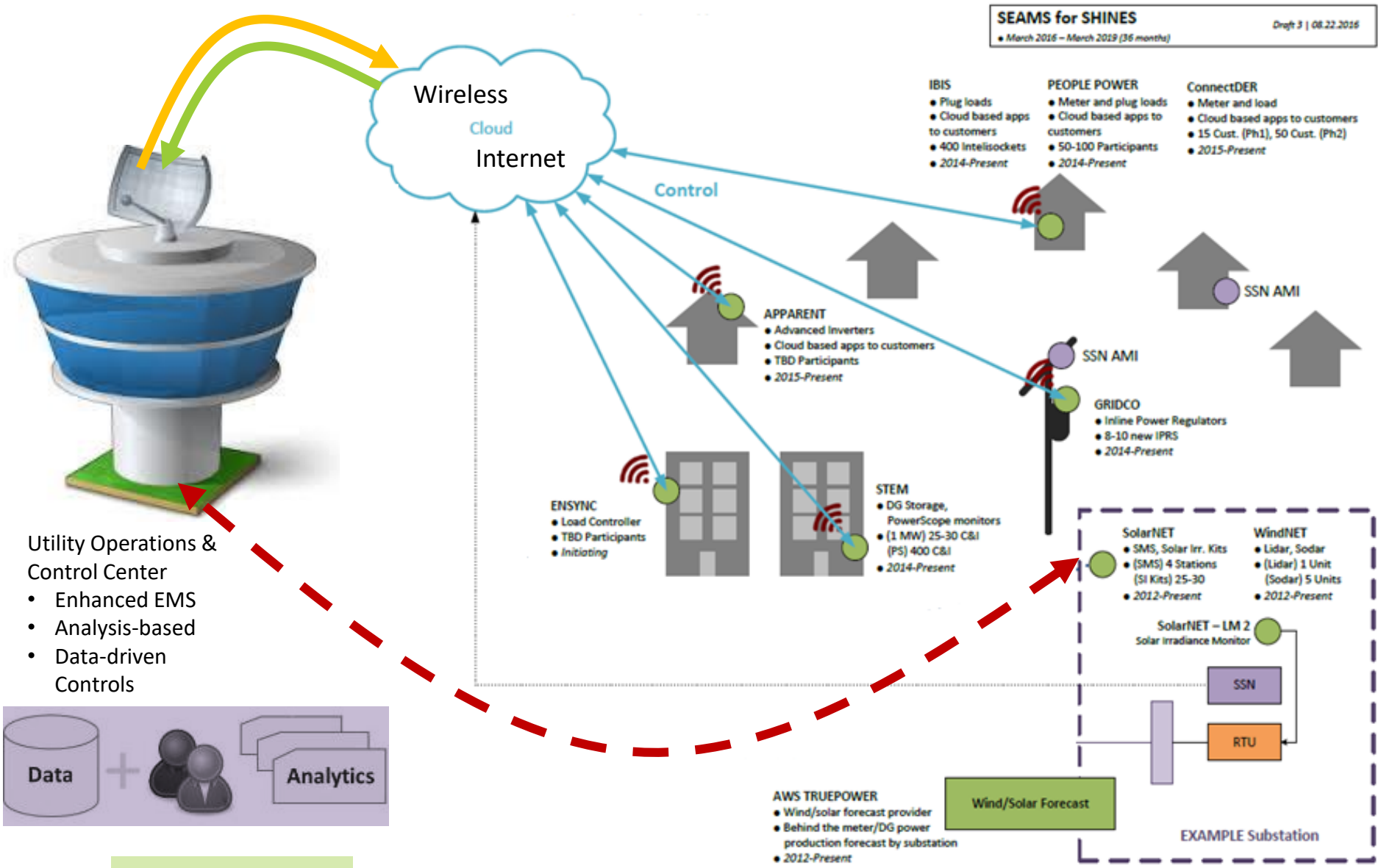
Aggregated fleet view supporting dispatch



Customer device view supporting validation & confidence building

Source: SEAMS for SHINES

Enhancing Visibility & Connecting Customer-Sited Devices

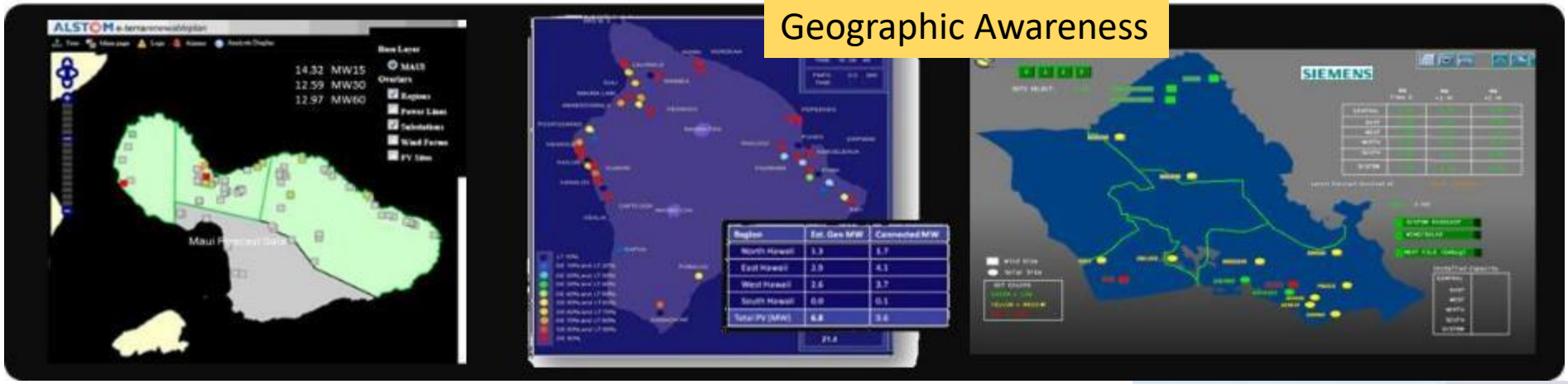


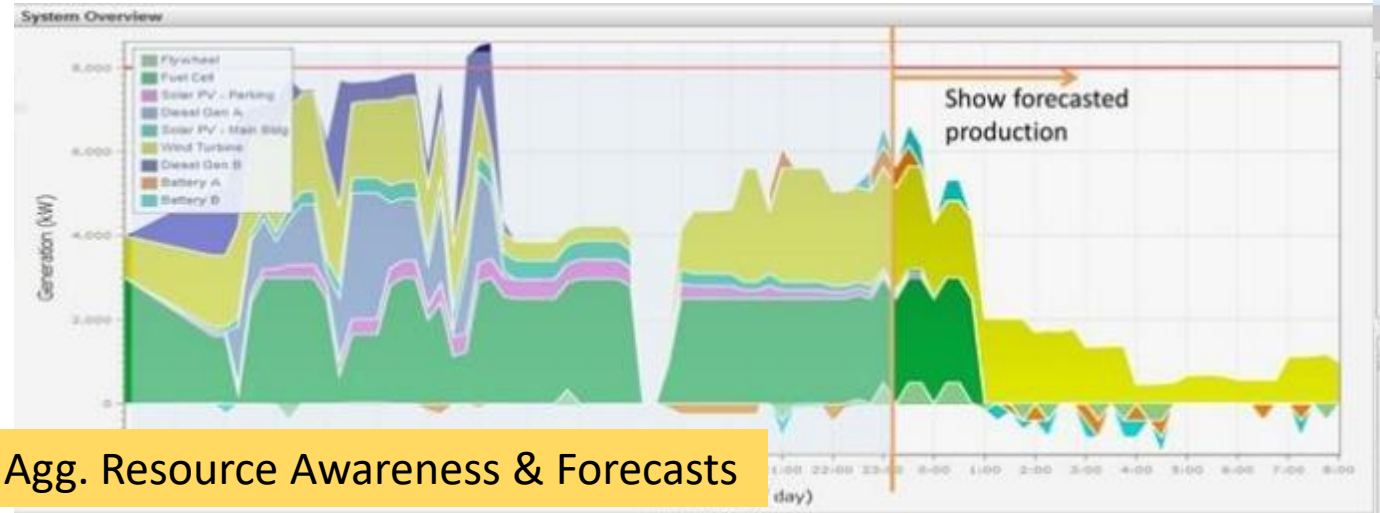
Utility Operations & Control Center

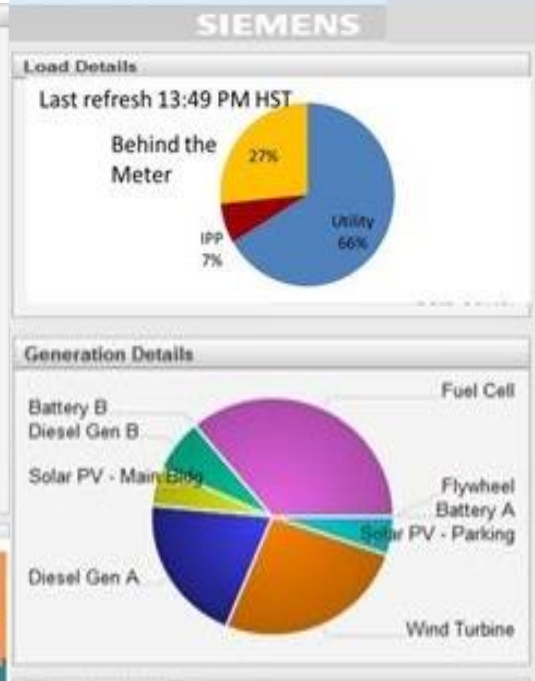
- Enhanced EMS
- Analysis-based
- Data-driven Controls

Source: SEAMS for SHINES

Future Direction: Visualization Tools for Seeing & Managing



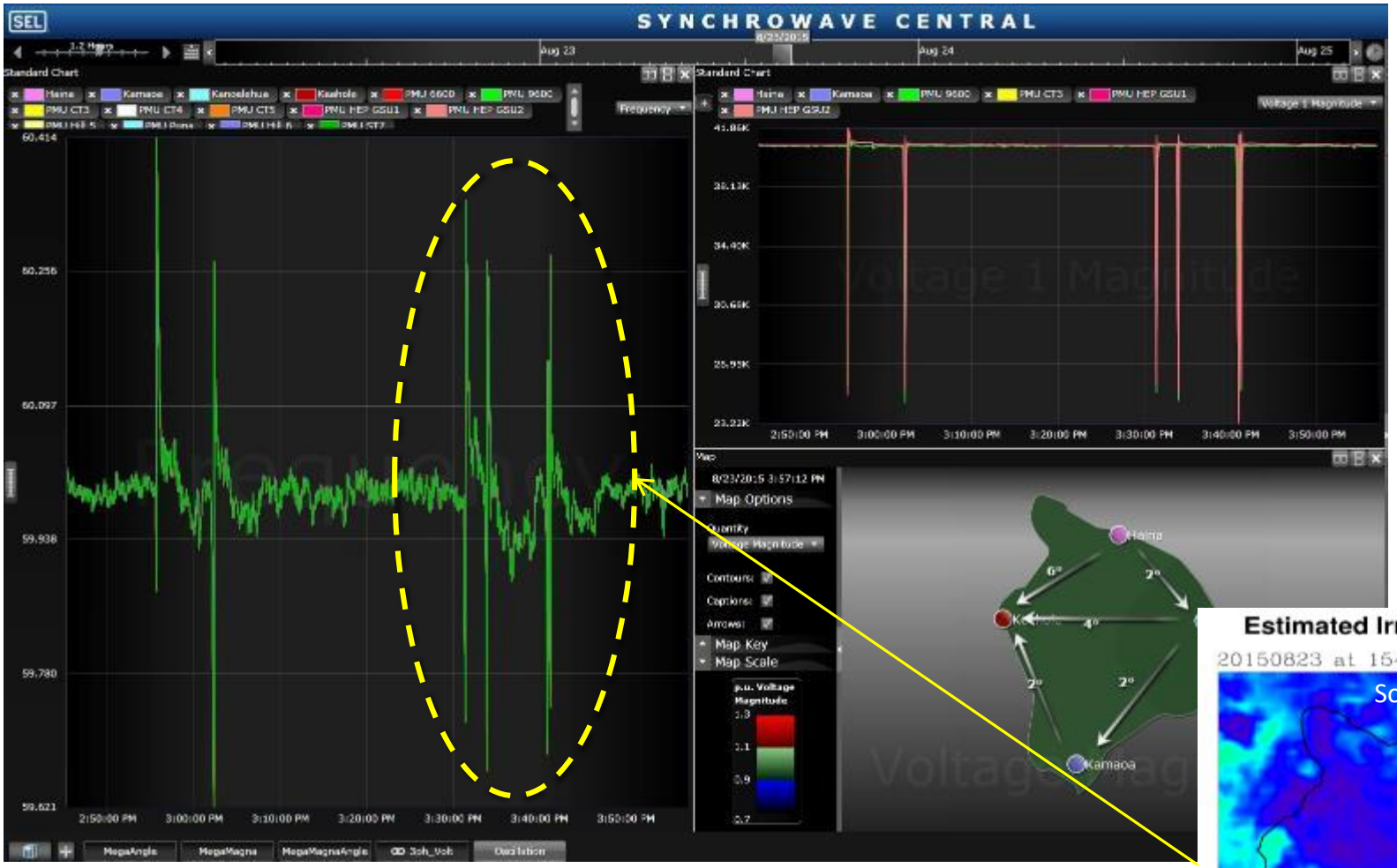




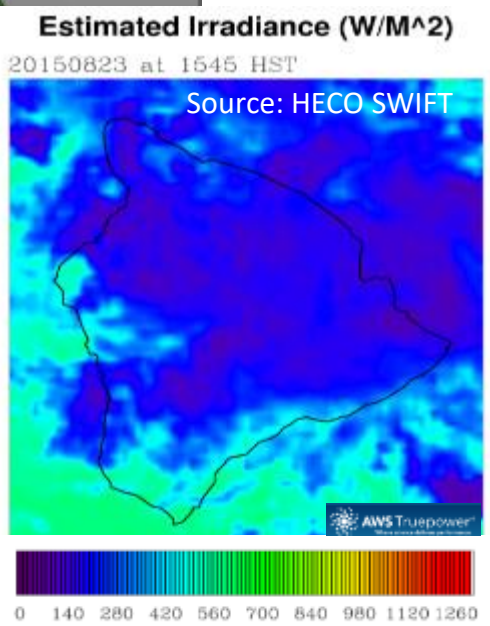
Source: Hawaiian Electric Companies

SEAMS for SHINES

New Feedback on DG Impacts and System Visibility Using Synchrophasors



Source: SynchroVIEEU



Source: US DOE HECO SynchroVIEEU project

Real-time visual of solar and cloud conditions over Hawaii island during event on 8/23 at 3:45pm.

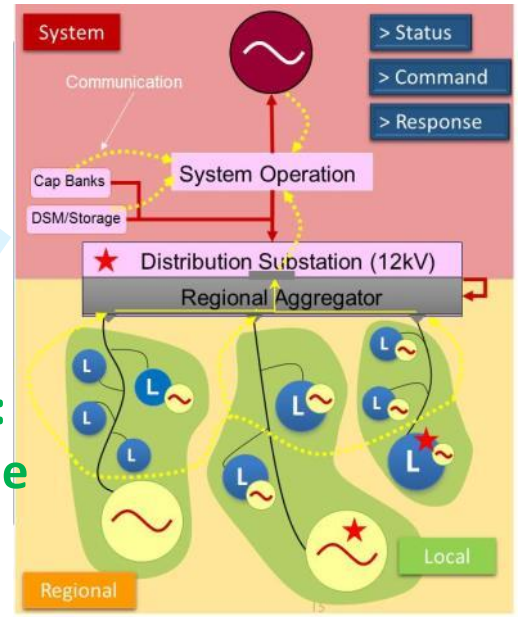
U.S. DEPARTMENT OF ENERGY

Possible Future

Status – what's it doing now?; on or off and characteristics

Availability – how much, how long and how fast? responsiveness

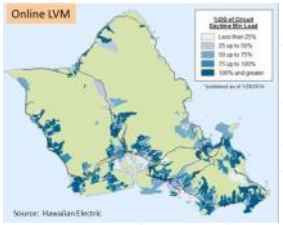
Controls – what can system do with it?



Not So Distant Future:
Orchestrated & In Tune

Tomorrow:
Shaping How & Where

Today:
Getting Access



References

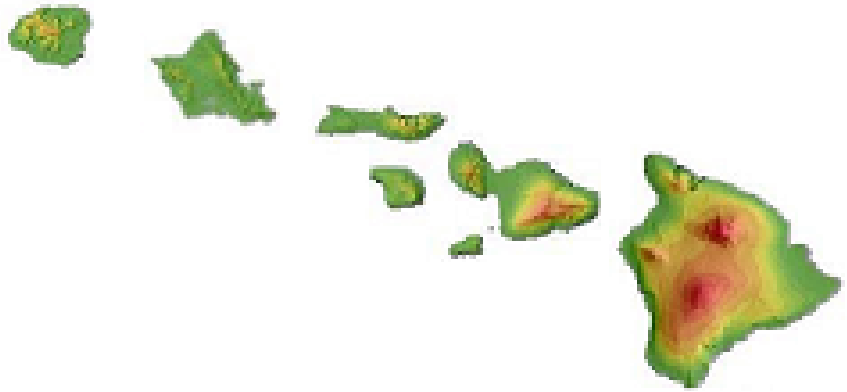
- https://www.greentechmedia.com/squared/dispatches-from-the-grid-edge/hawaiis-groundbreaking-path-to-a-fully-renewable-powered-grid
- https://www.tdworld.com/generation-renewables/visibility-enables-pv-integration
- https://www.hawaiianelectric.com/stem-inc-hawaiian-electric-and-hawaii-department-of-education-partner-to-bring-energy-monitoring-and-management-to-250-public-schools
- https://www.hawaiianelectric.com/hawaiian-electric-and-stem-inc-successfully-test-1-mw-of-energy-storage-at-29-commercial-customer-sites
- https://www.nrel.gov/docs/fy15osti/63007.pdf
- https://cdn.selinc.com/assets/Literature/Publications/Technical%20Papers/6750_IntegratingSynchrophasors_JB_20170130_Web2.pdf?v=20171110-151608

References: Grant Final Reports

1. Hawaii Utility Integration: Solar & Wind Integrated Forecasting Tool (SWIFT)
   - https://www.osti.gov/servlets/purl/1049311
   - https://www.nrel.gov/docs/fy15osti/63007.pdf
2. California CSI – High Penetration PV (HiP-PV) SMUD, HECO & PG&E Partnership
   - http://calsolarresearch.ca.gov/second-funded-projects?id=104:solicitation1-smud
   - https://calsolarresearch.ca.gov/images/stories/documents/Sol1_funded_proj_docs/SMUD/SMUD-HECO_Task-4_PilotVisual_FinalRpt_2013.pdf
3. USDOE – DREAMS Project https://www.energy.gov/eere/solar/distributed-resource-energy-analysis-and-management-system-dreams-development-real-time
4. USDOE SHINES – SEAMS for SHINES Project https://www.energy.gov/sites/prod/files/2017/05/f34/SHINES%20Program%20Review_HECO.pdf
5. USDOE OE – SynchroVIEEU Project https://www.naspi.org/sites/default/files/2016-09/maui_electric_nakafuji_synchrovieeu_20150324.pdf

Questions/Comments??

Mahalo



For more information please contact:

Dora Nakafuji, PhD
dnakafuj@ksbe.edu