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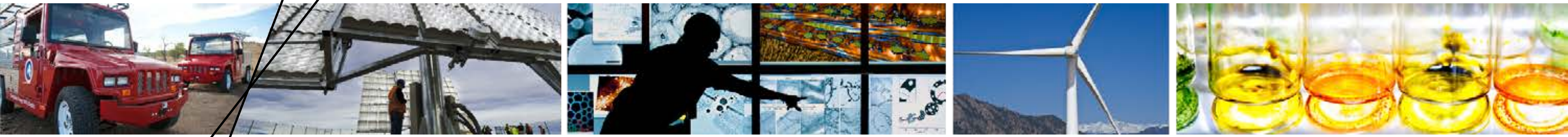
Western Area Power Administration

SunShot
U.S. Department of Energy

Distributed Generation Interconnection Collaborative (DGIC)



"Minimum Day Time Load Calculation and Screening"

Dora Nakafuji and Anthony Hong, Hawaiian Electric Co.
Babak Enayati, DG Techincal Standards Review Group

April 30, 2014

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Speakers

Dora Nakafuji
Director of Renewable Energy Planning
Hawaiian Electric Company (HECO)

Anthony Hong
Director of Distribution Planning
Hawaiian Electric Company (HECO)

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Chair of Massachusetts DG
Technical Standards Review Group

Kristen Ardani
Solar Analyst, (today's moderator)
NREL

Standardization of Minimum Daytime Load

Anthony Hong Dora Nakafuji

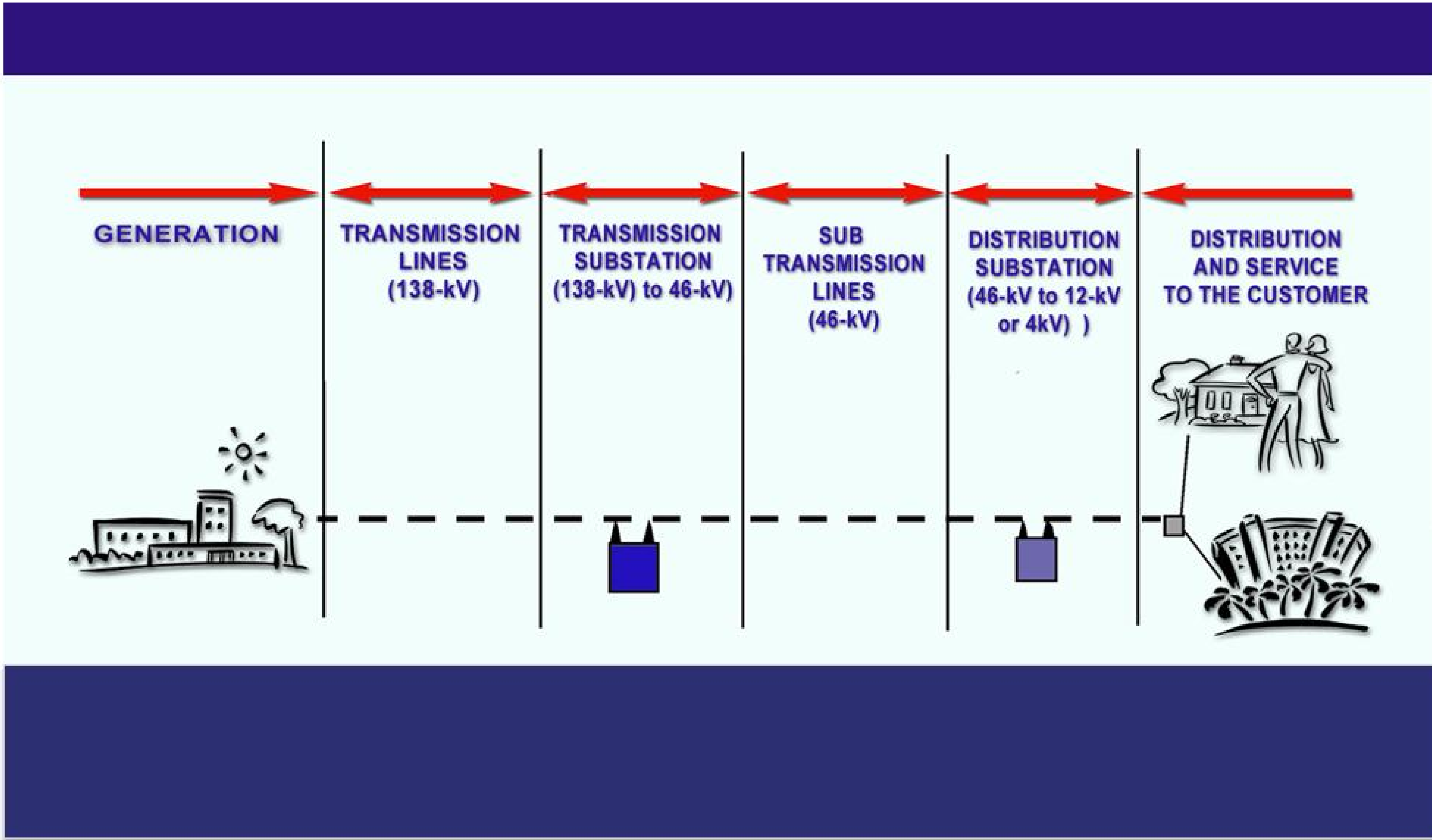
April 30, 2014
NREL-EPRI Webinar

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Topics

- What are the Conditions in Hawaii
- Distribution Planning Criteria
- Gross vs Net Load
- Standardization of Daytime Minimum Load
- Approach and Data Needs
- Next Steps

Distribution System



Planning Criteria for the Distribution System

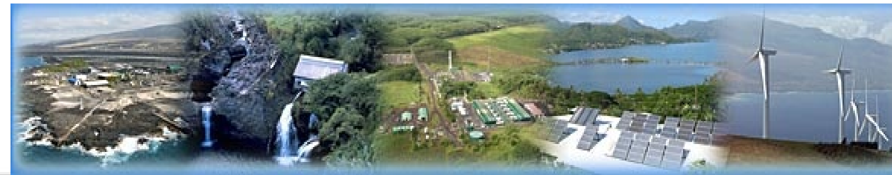
- The distribution system shall be planned on the basis of serving the predicted peak kva on any part of the system each year
- Additions to the distribution system will be planned for the year in which it is predicted for the following scenarios:
  - Normal capacity of any distribution system component will be exceeded under normal conditions
  - Emergency capacity of any distribution system component will be exceeded under emergency conditions
  - Voltage levels cannot be kept within required tariff limits

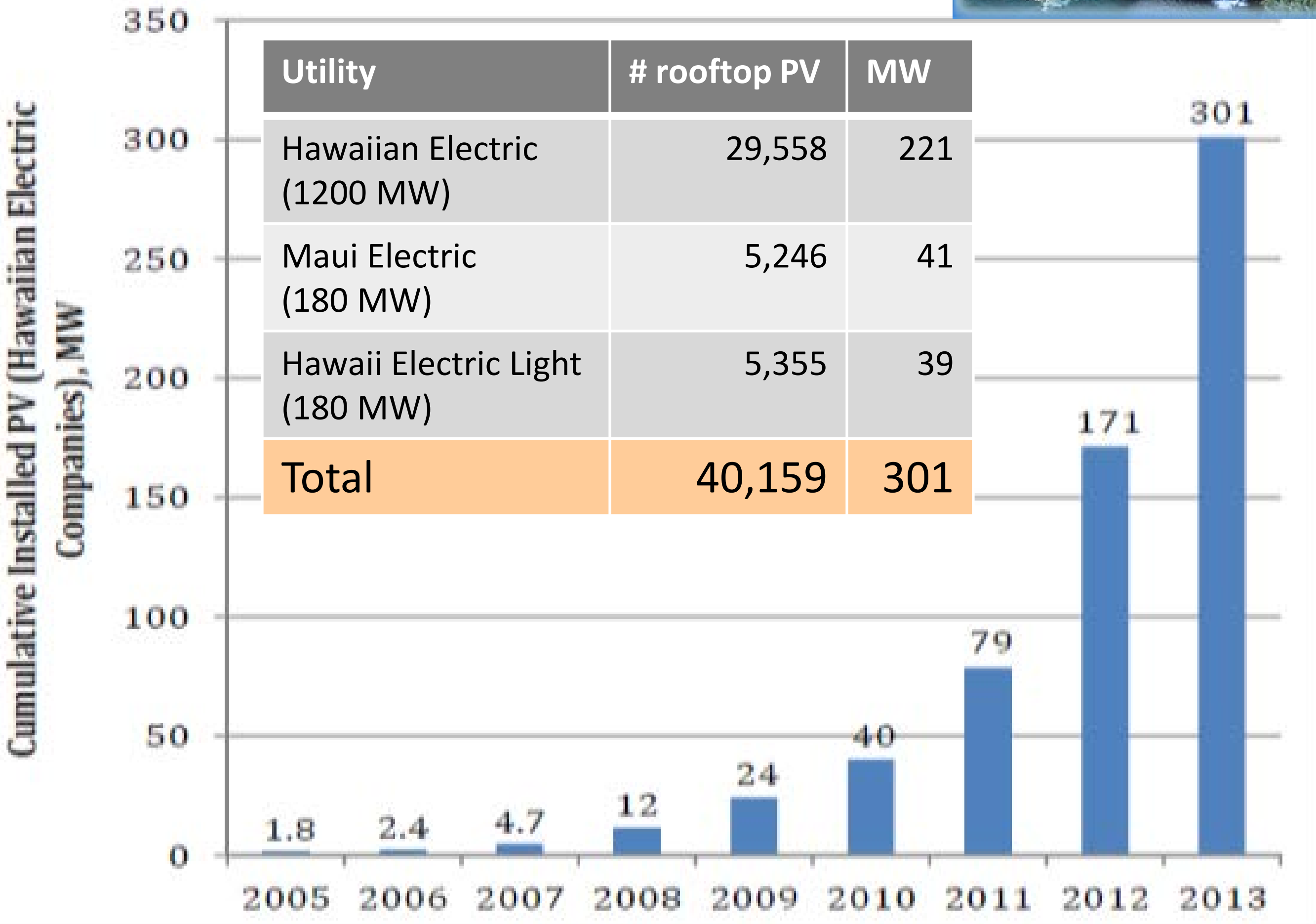
Distribution Load Forecasting

- Distribution load forecasting is geographically dependent and therefore very dynamic
- High variability in growth rates between lines
- Highly dependent upon customer plans (ex. – a new hotel can double the load on a distribution line)
- Useful forecasting for distribution system *rarely exceeds five years*

Where are we Today in Hawaii?

Aggregated PV as large as conventional utility generators





Utility	# rooftop PV	MW
Hawaiian Electric (1200 MW)	29,558	221
Maui Electric (180 MW)	5,246	41
Hawaii Electric Light (180 MW)	5,355	39
Total	40,159	301

- RPS - 40% renewables generation, 70% total (includes transportation)
- Energy efficiency standard of 30% by 2030 (3,400 GWh)
- **Generation from RE Sources**
  Oahu – 17%,
  Maui – 26%
  Hawaii – 42%,

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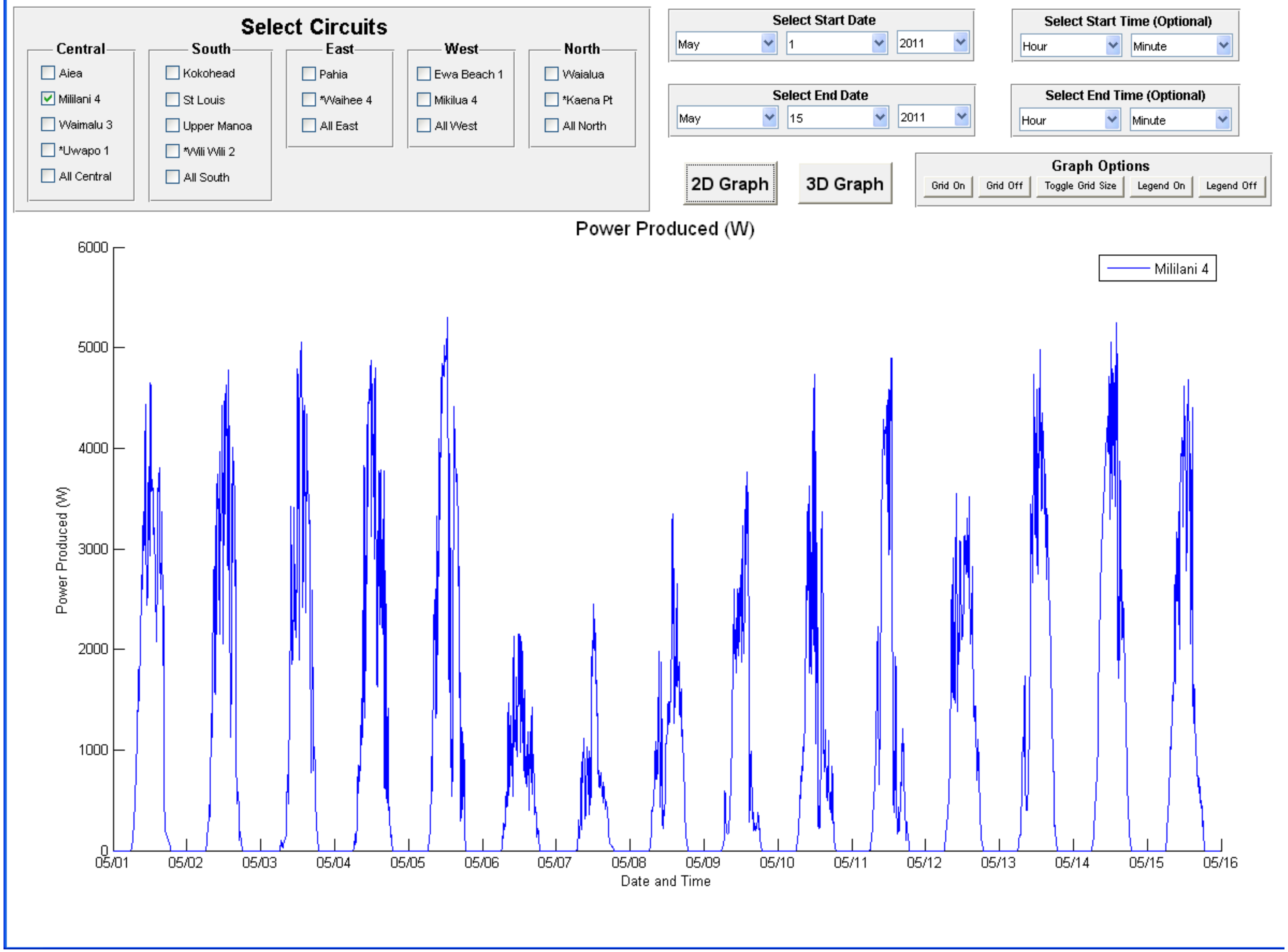
Maui Electric
Hawai‘i Electric Light

Typical PV System Output – Central Oahu



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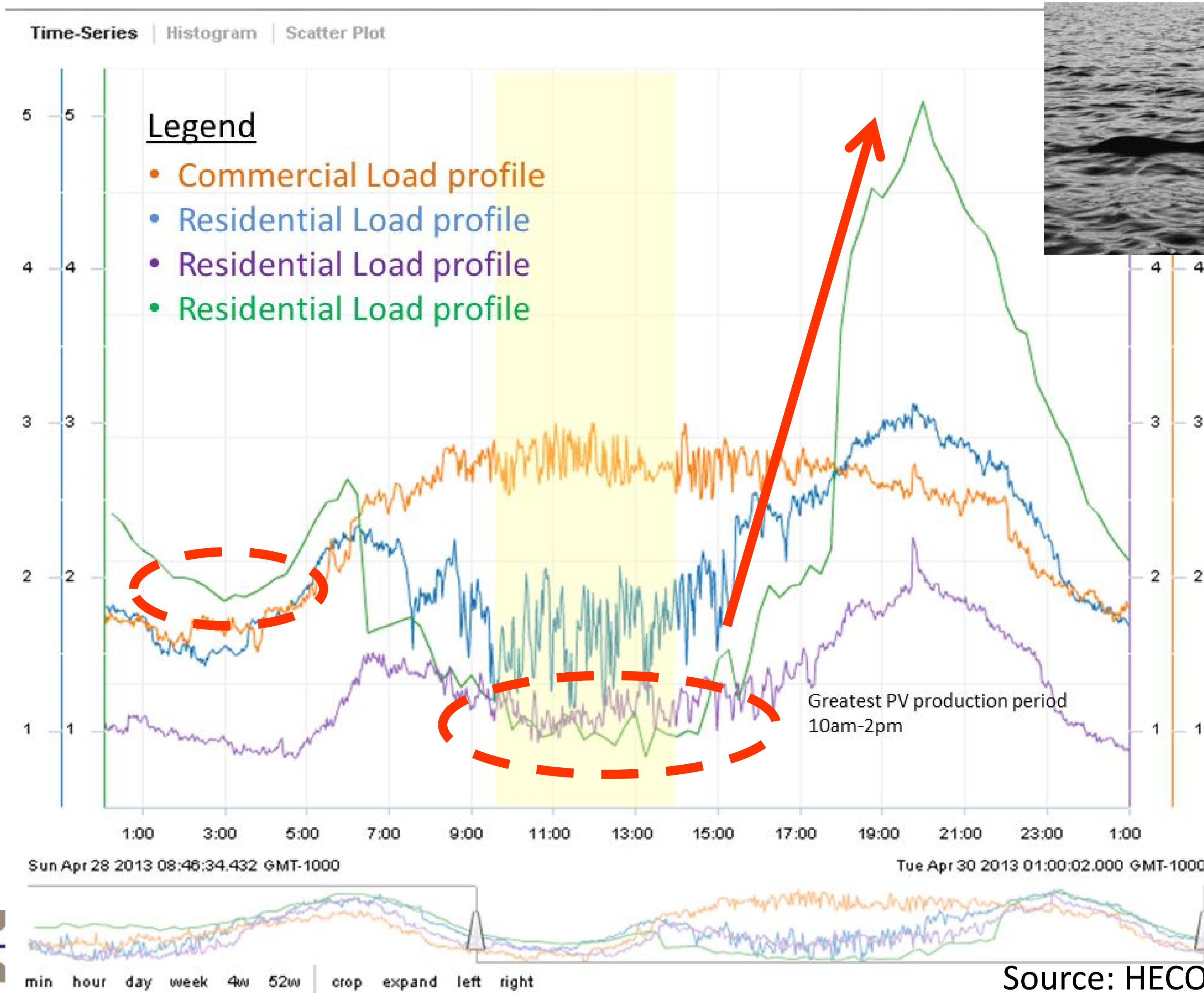
Maui Electric
Hawai'i Electric Light

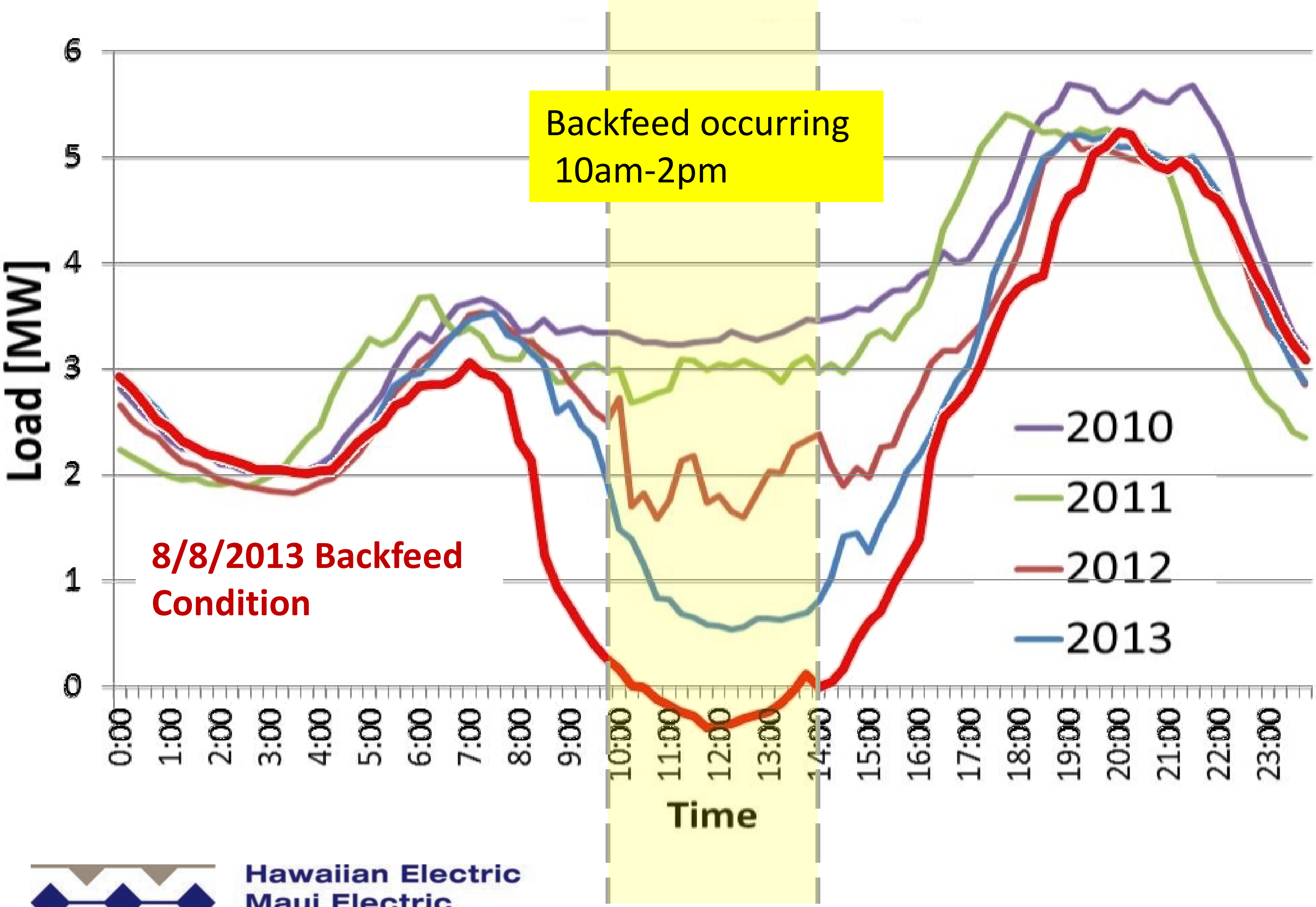
Trending Hi-Pen Circuits (12kV) – Loch Ness Profile



Source: HECO

Tracking Change – 46kV Level

Average Transformer Load (MW) - December



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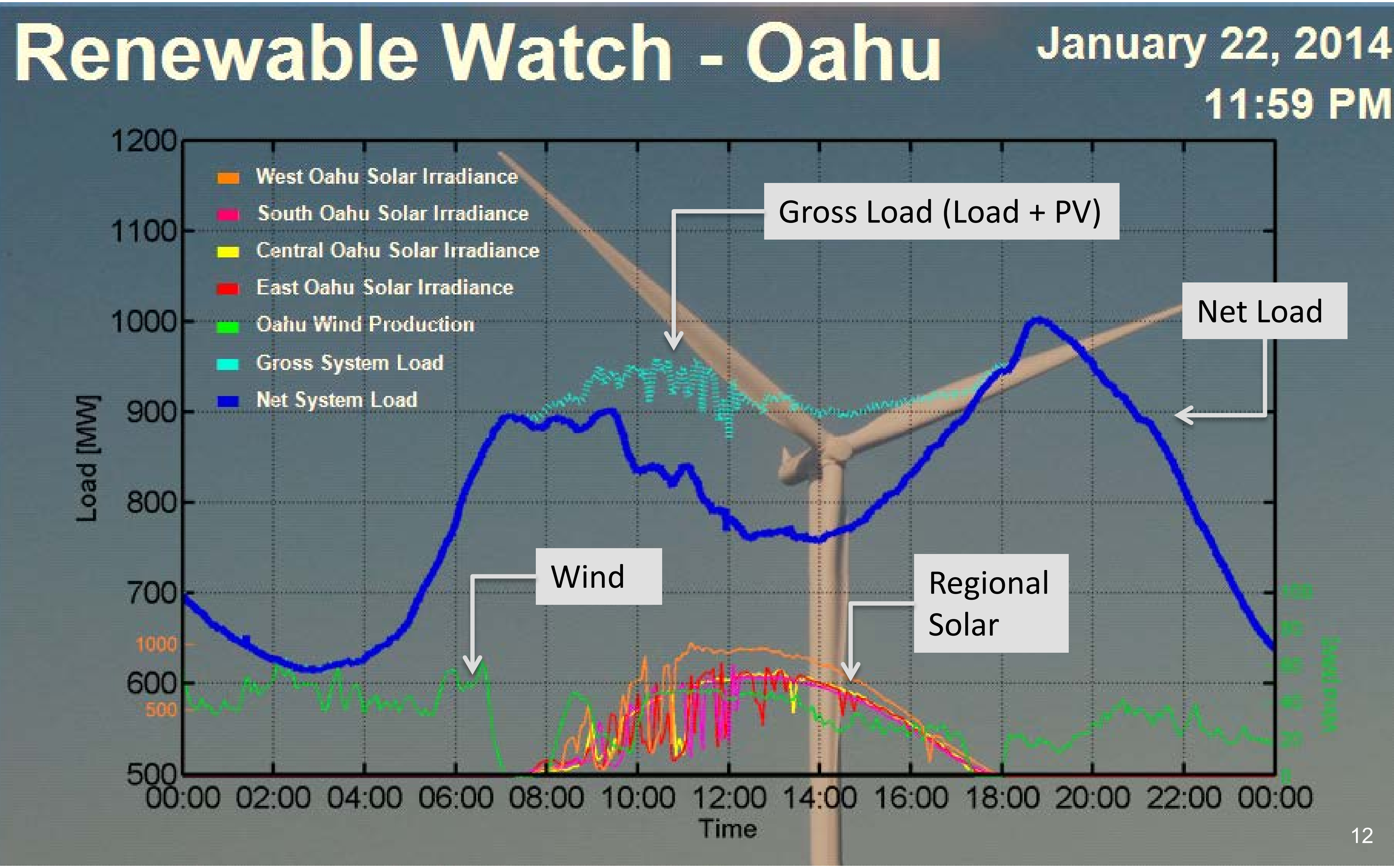
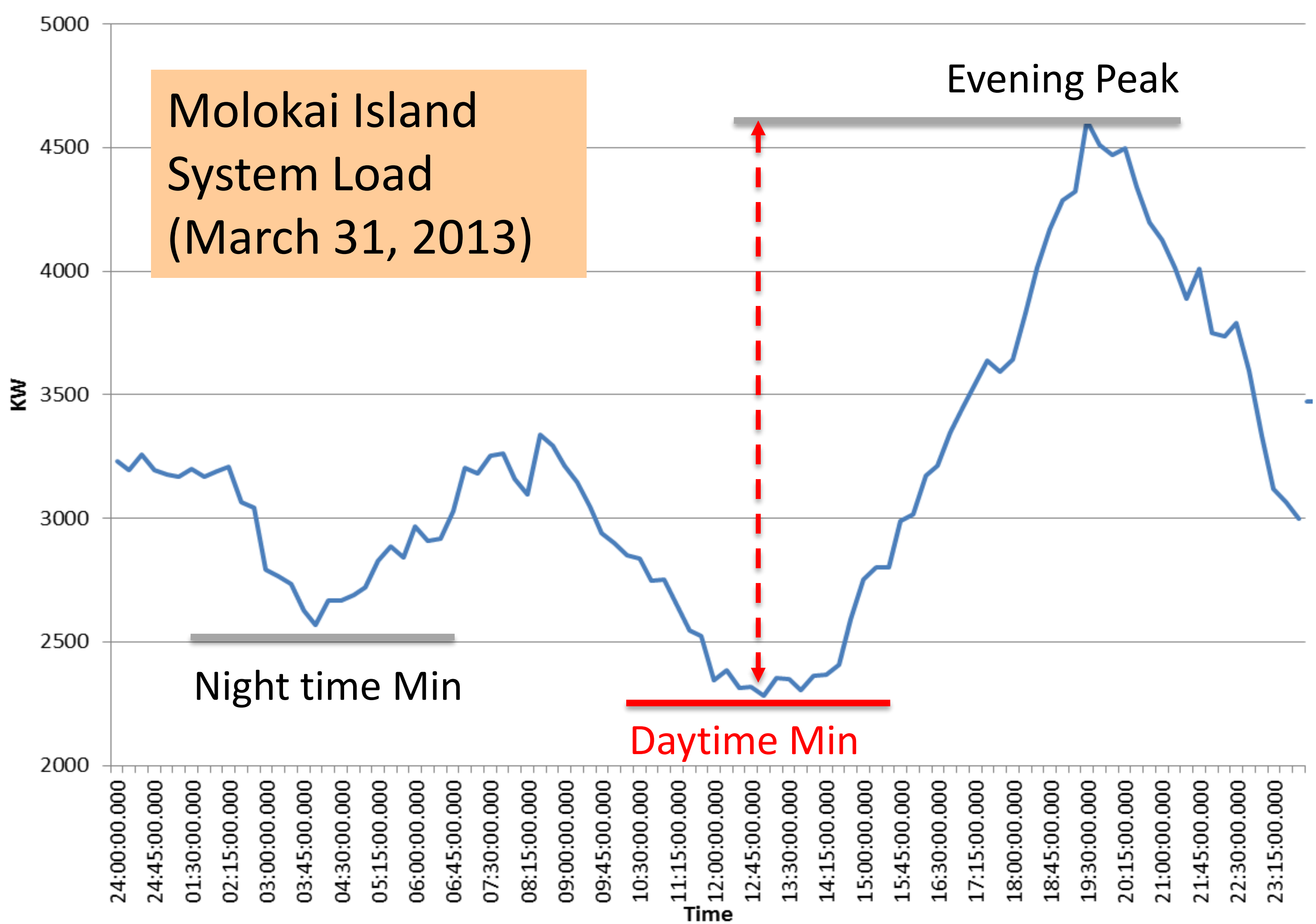
REWatch – DG is Impacting System Load



“Seeing” DG Impact on System Load



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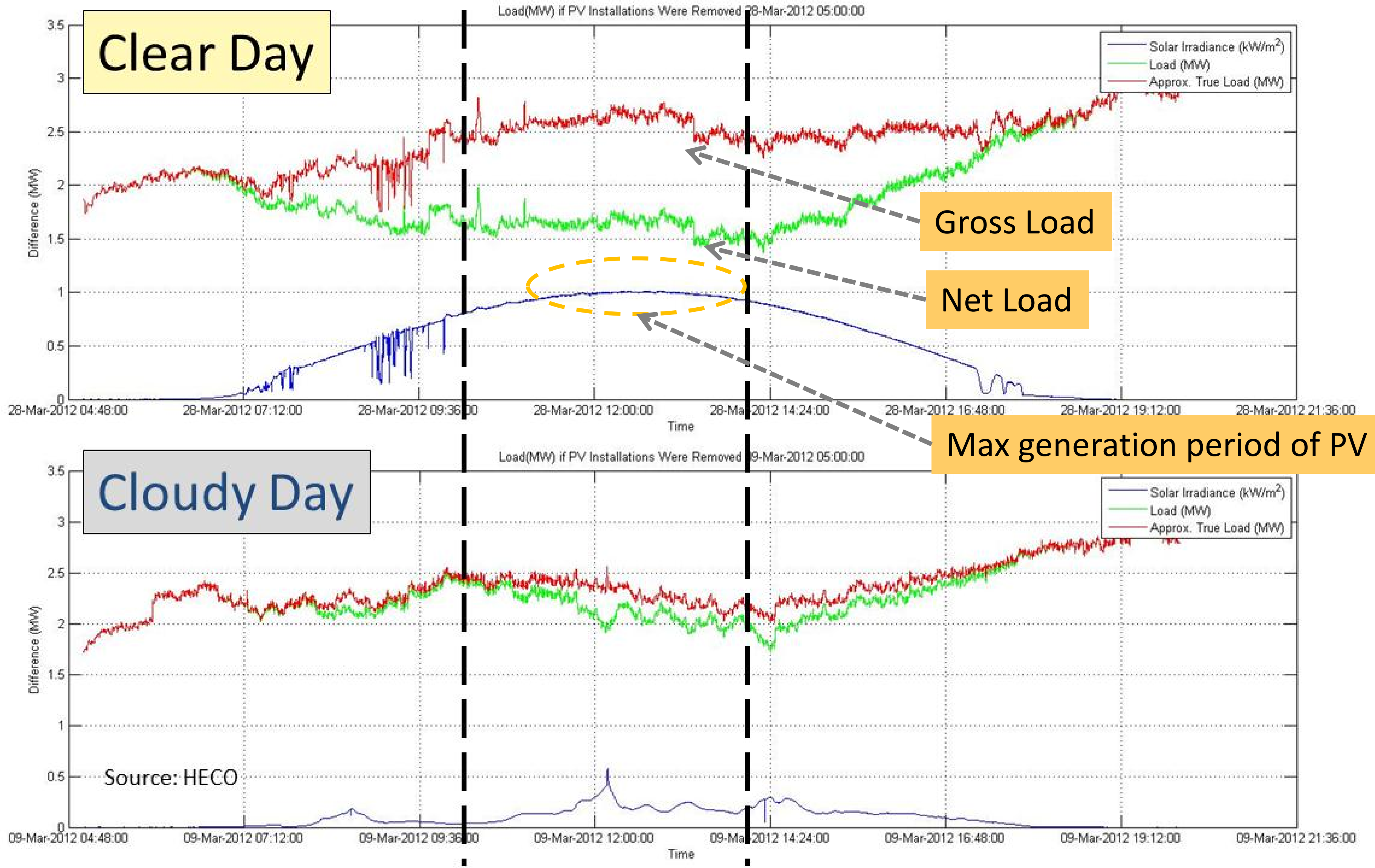
Gross vs Net? Understanding Solar Impact on Load



Greatest Feeder PV to Load Variation Between 10 AM and 2 PM

Assume Linear Relation. Between Irrad. & Power

Assessment Needs for Gross DML

- Method driven by the availability of data
- Determining feeder load
  - Measure, estimate, proxy for each distribution circuit (net load)
  - Ideally 1 min sampling resolution (minimum 15min to capture ramp rates)
  - Gather at least 1 year of 24 hour load (MW) profiles for analysis
  - Consider year to year impact over a 3-year rolling average to account for load changes due to PV penetration levels and annual and seasonal variability
- Gather solar irradiance field data representative of the area covered by the circuit
- Determine gross daytime minimum (DML) for feeder by adding the PV production back into the net load profile.
- Gross DML = Net DML + PV instantaneous generation at DML condition

Determining Gross DML for Circuits with Data (load & solar)

Approach

- Measured Net DML from each distribution feeders (SCADA at substation or line measurements)
- Solar irradiance from field measurements available to calculate feeder PV production based in installed Capacity per feeder (Example: capture clear day vs cloudy day): PV gen. on circuit
- Calculate Gross DML = Net DML + PV gen at time of Net DML

$$Gross\ DML\ Circuit = (Net\ DML\ Circuit) + \sum_{n=1}^{\#\ of\ gen} (PV_{\substack{gen.\\ on\ circuit}})$$

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Maui Electric
Hawaiʻi Electric Light

Determining DML for Circuits without Data (load & solar)

Approach for Feeders

- No measured load; derive Net Load for each distribution feeders (ratio, transformer split)
- No sensor, estimate the solar production from PV by assuming a % of the installed PV (assuming 100% of nameplate will not be generating due to alignment issues and other efficiencies) : %PV_Installed
- Calculate Gross DML = Net DML + %PV_Installed

$$Gross\ DML\ Circuit = (Net\ DML\ Circuit) + \%PV\_Installed$$

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Maui Electric
Hawai'i Electric Light

Feeders w/o Data?

Proxy Approach

- Where does Net DML of circuit come from for feeder w/o data (Feeder 1)?
- For Feeder 1 – can we characterize type of load? (Residential, Commercial, Industrial, mix)?
- Find nearby feeders (Feeder 2) of similar type and determine the ratio of Feeder 2 peak to capture profile shape (Proxy)
- Calculate the Ratio of Feeder 2 peak and Net DML between 10am-2pm and apply same ratio to Feeder 1 peak to get the Net DML for Feeder 1.
- Calculate Gross DML depending on availability of solar data (with or without solar data)

$$Gross\ DML\ Circuit = (Net\ DML\ Circuit\ estimated\ using\ Ratio) + \%PV\_Installed$$

Convert from Net to Gross Load for Planning & Operations

<u>**Approach for System**</u>

- **BEFORE**: System SCADA Load = System NET load

$$System\ Gross\ Load = System\ NET\ Load = (SCADA\ System\ Load)$$

- **NOW**: Summation of Regional Gross Load = System Gross Load

$$System\ Gross\ Load = (System\ Net\ Load) + \sum_{n=1}^{\#of Regions} (PV_{gen})$$

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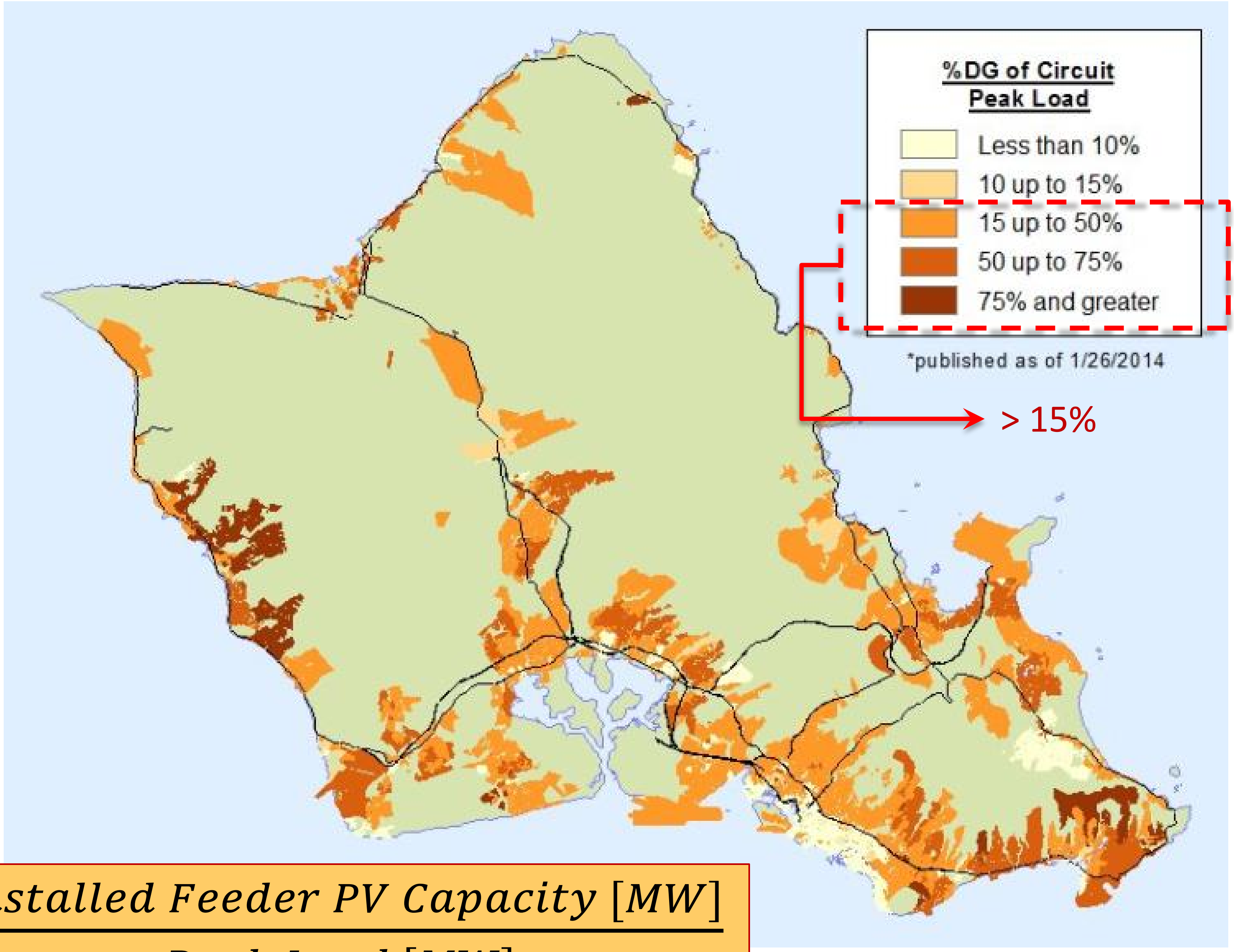
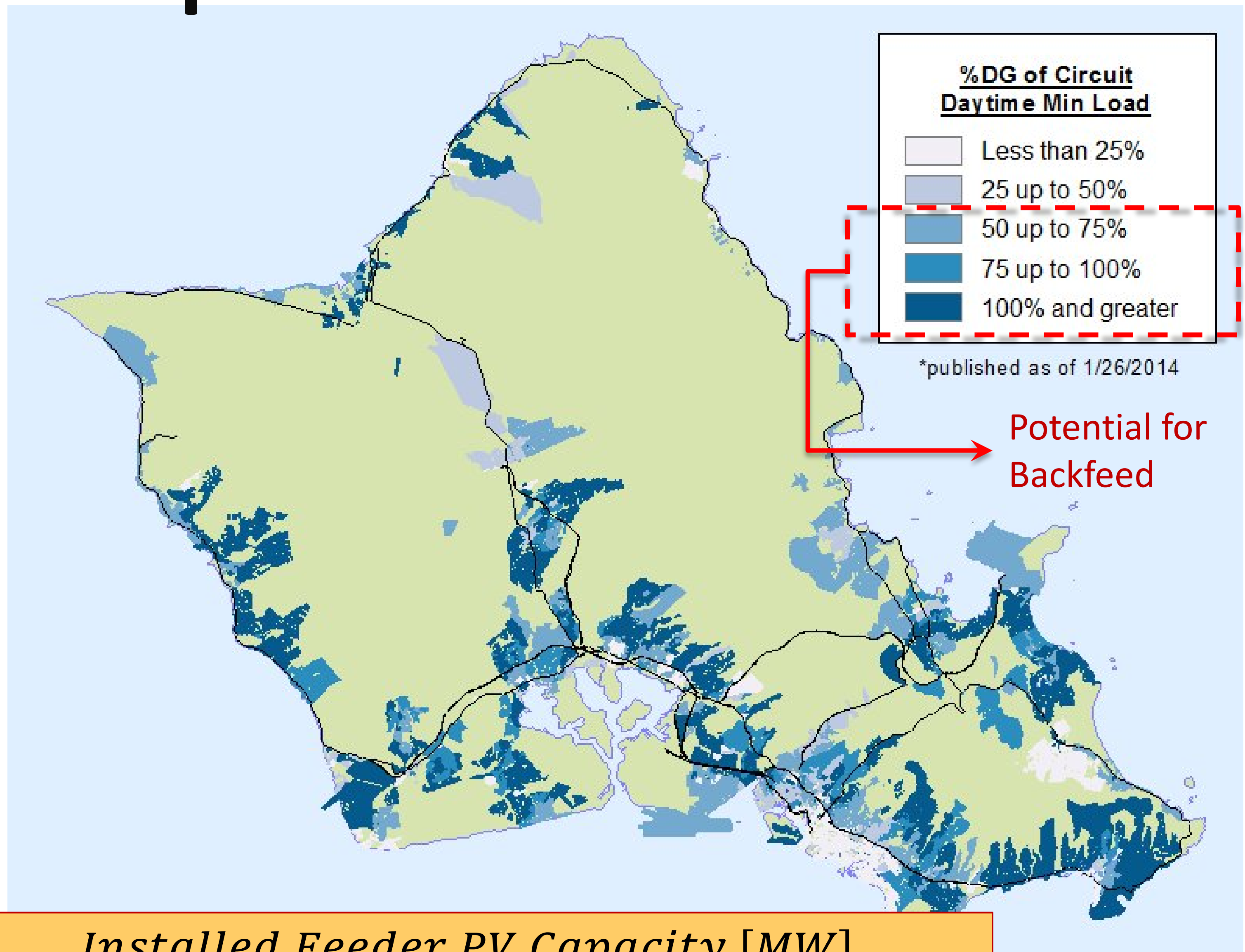
LVM Map for % Pen - Circuit Peak



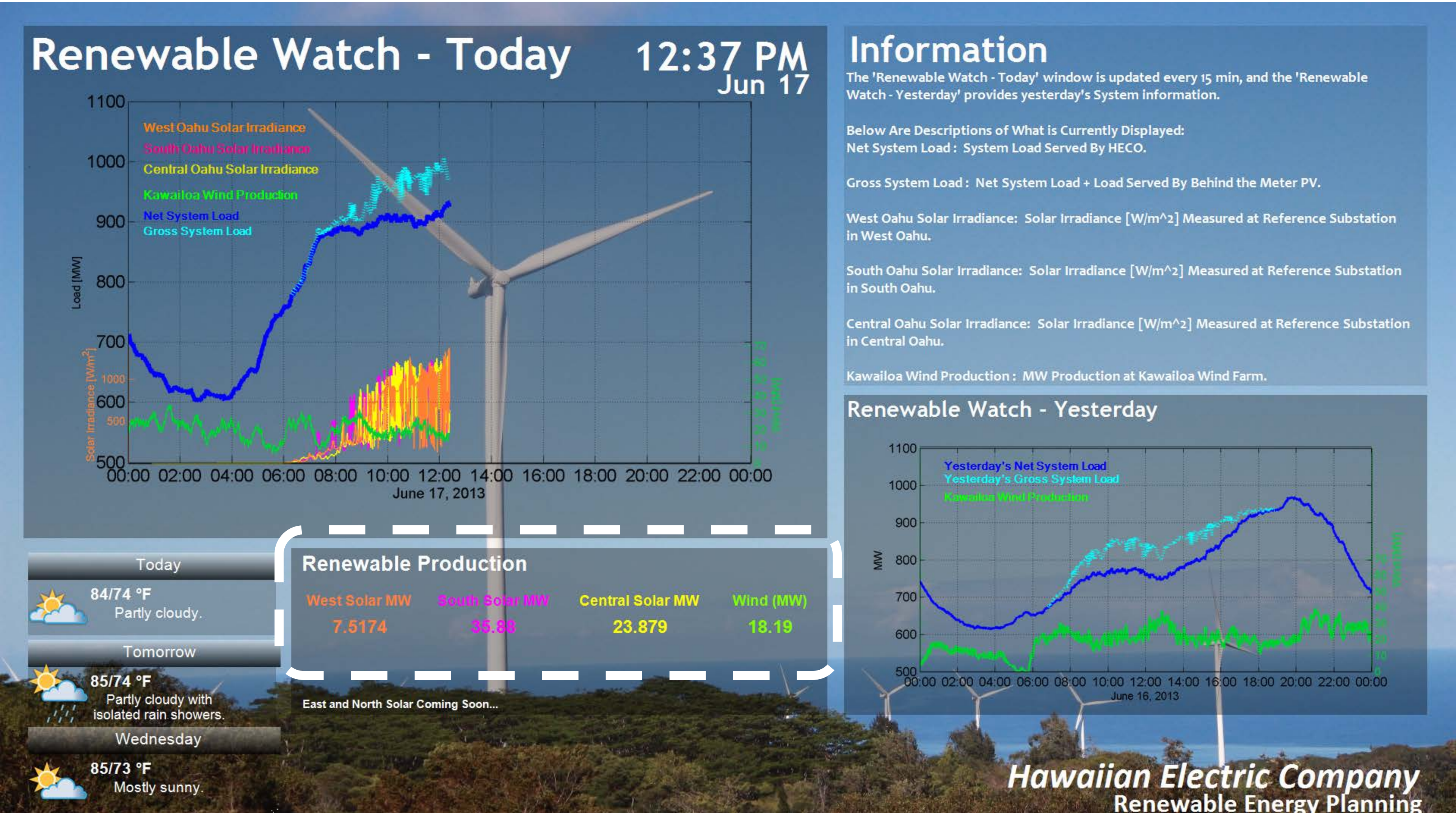
$$\% \text{ Pen} = \frac{Installed\ Feeder\ PV\ Capacity\ [MW]}{Peak\ Load\ [MW]}$$

LVM Map for % Pen – Gross DML



$$\% \text{ Pen} = \frac{Installed\ Feeder\ PV\ Capacity\ [MW]}{Gross\ Minimum\ Daytime\ (10{-}2pm\ load)\ [MW]}$$

RE Watch: Seeing the Value of Renewables on the Grid (Get Sense for Net and Est Gross System Load)



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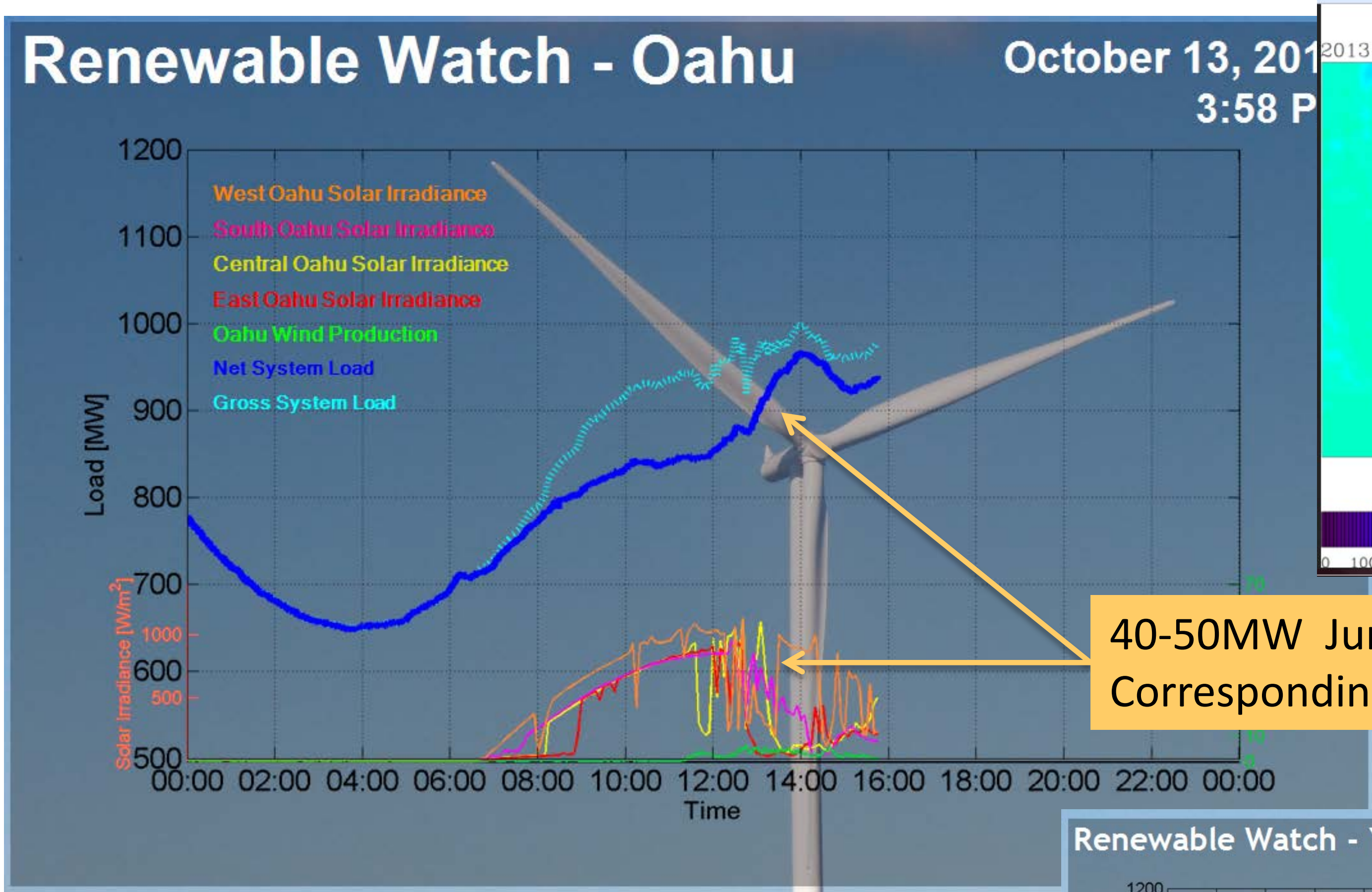
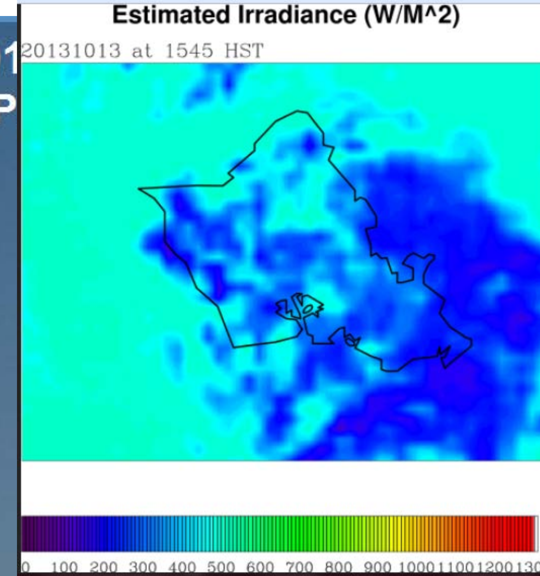
Impacts on Distribution Planning

- Backlog of NEMs requiring reviews under Rule 14H, especially on high penetration feeders (>120% DML)
- Need to conduct representative studies
- Changes to penetration policy
  - 120% for <100kW systems
  - Tracking of aggregated NEM customer impact
  - Field measurements between 10am-2pm

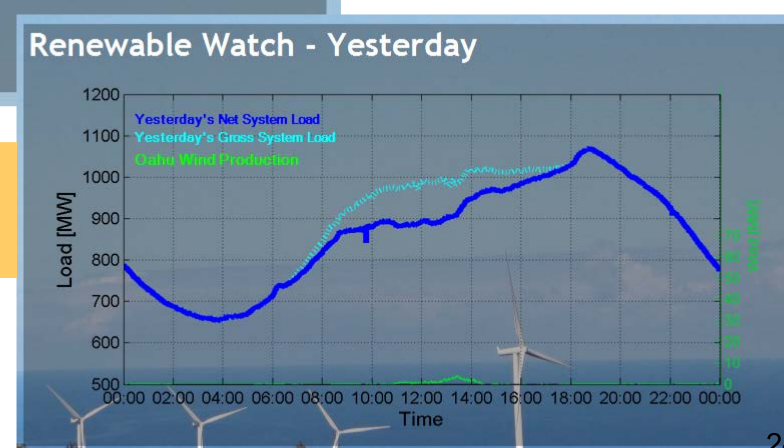
“Seeing & Validating” DG Ramp Impacts





40-50MW Jump in Load
Corresponding drop in PV

Yesterday is not a good predictor of Today anymore



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Need to Assess Impacts on System Performance

- Inverter trip settings – 57Hz
- Under frequency load shed
- N-1, N-2 contingencies
- Reserve planning
- System restoration
- Dispatch and maintenance protocol
- Load forecasting
- Planning models

Changing Standards

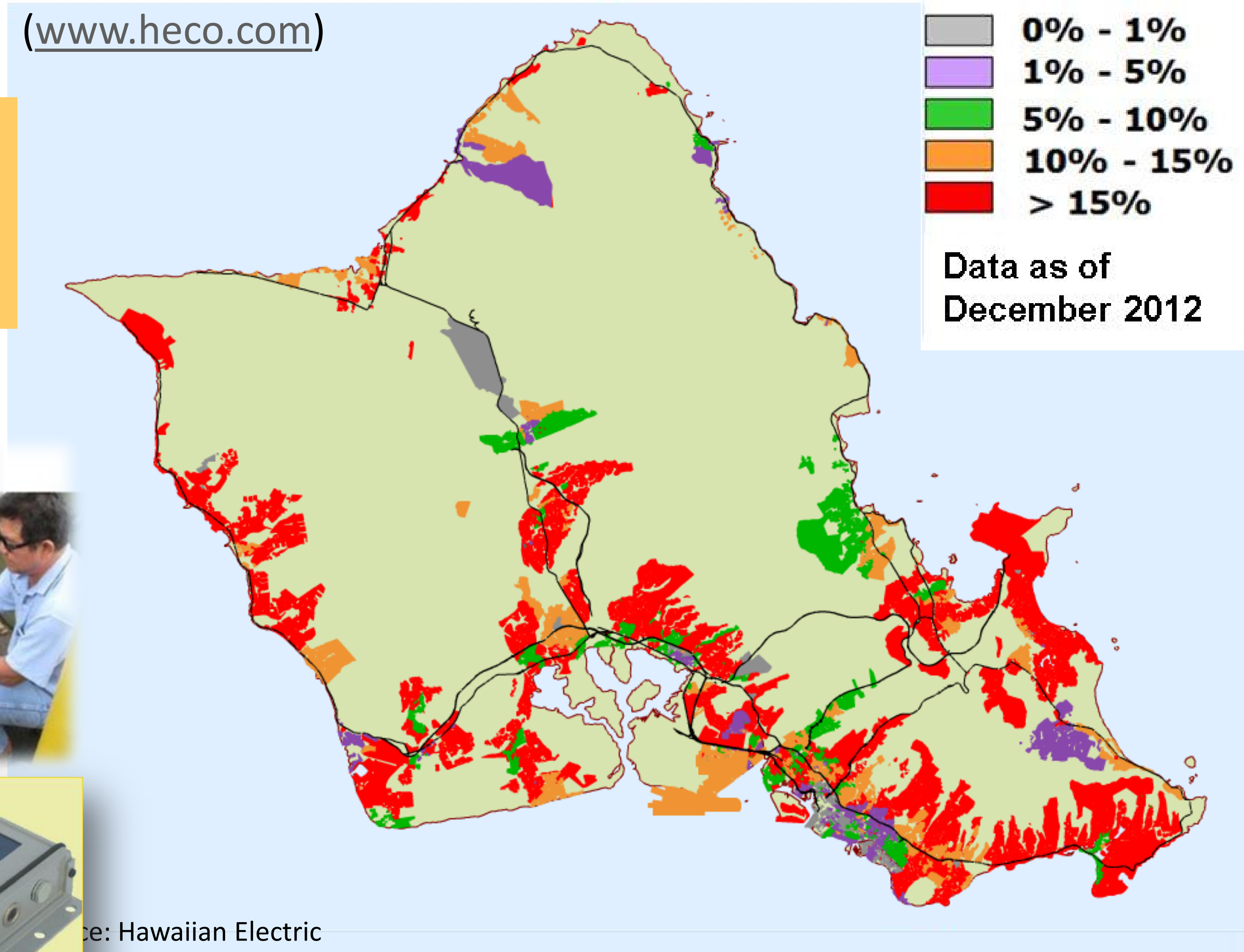
- IEEE revisions
- UL ratings
- Inverter specifications and TOV requirements
- Battery storage considerations

Visual Tracking of DG Penetration Change - Locational Value Map (LVM)

<u>BENEFITS</u>

- Visual tracking of DG penetration
- Location specific data
- Consistent format

HECO Locational Value Maps Trending Penetration Levels
(www.heco.com)



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Red areas indicate circuits with > 15% PV penetration

Continuing Efforts – Pulling it All Together

- Gaining confidence
- Recognize limitations
- Continue validation
- Integrate into process & tools (DREAMS)
- Training & partnership (UAT)

GO solar CALIFORNIA

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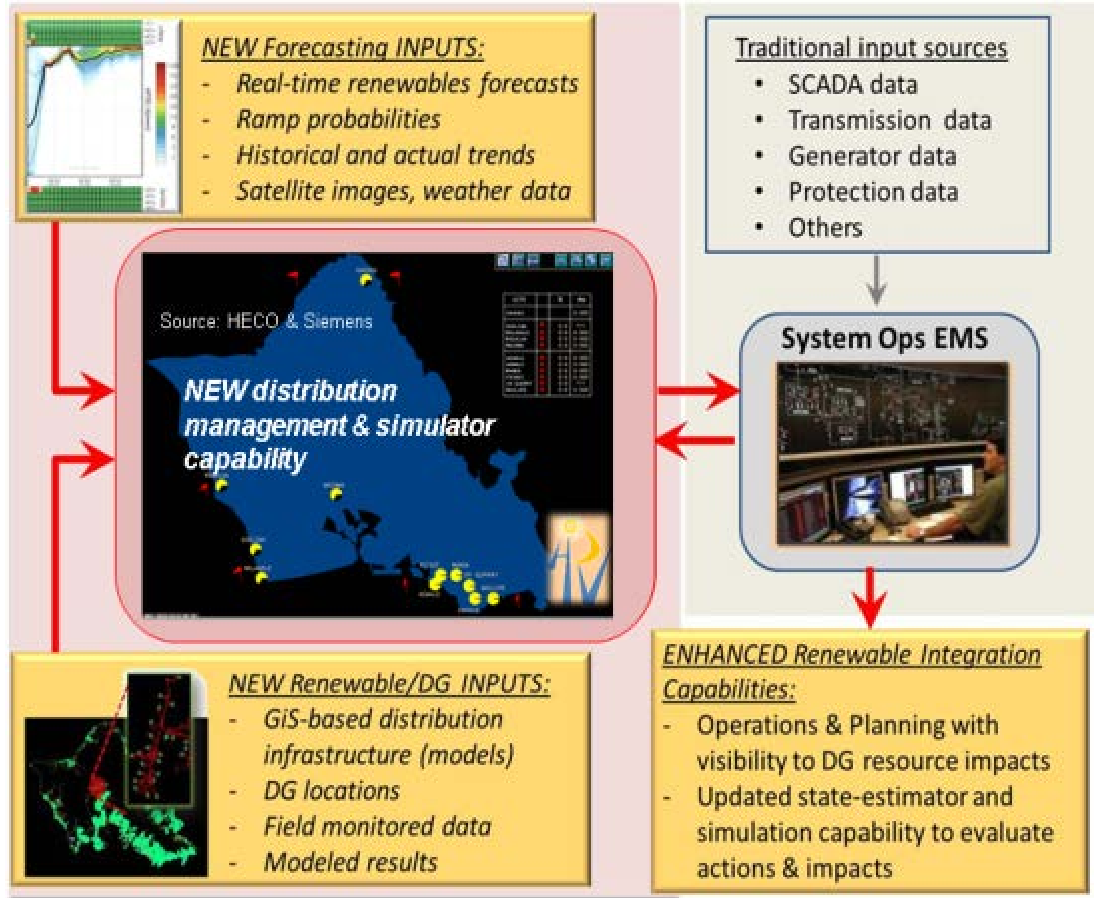

Distributed Resource Energy Analysis and Management System (DREAMS) Development for Real-time Grid Operations

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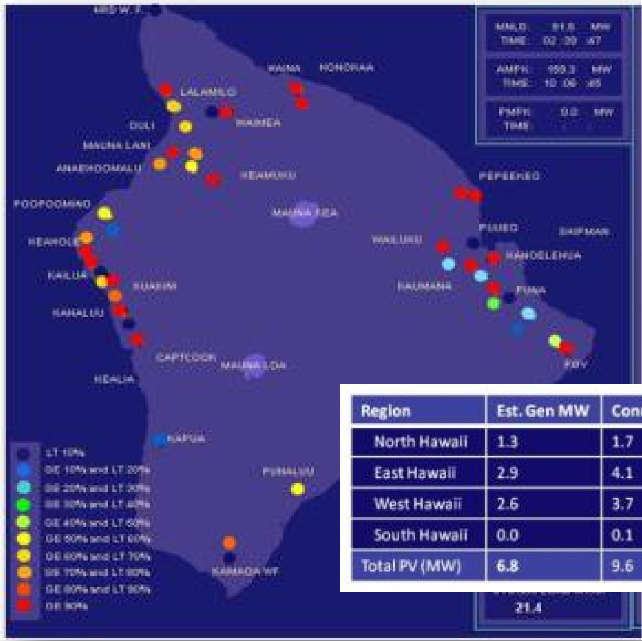
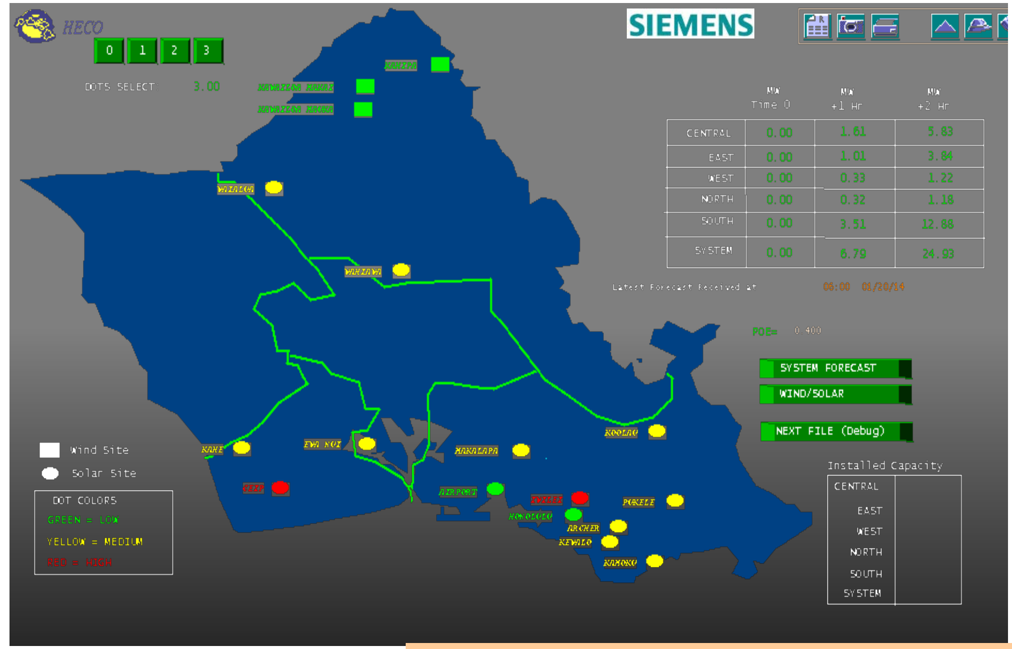
Maui Electric
Hawai'i Electric Light

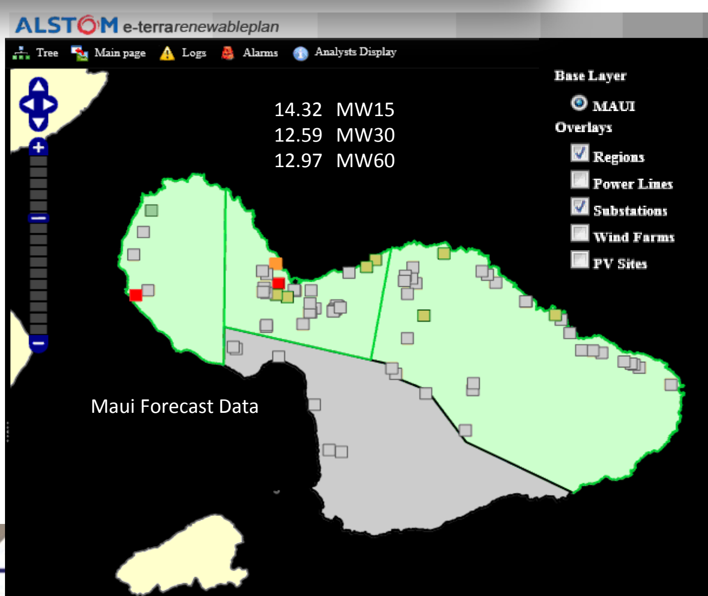
Progress on EMS Integration & Alerts to Help Operators

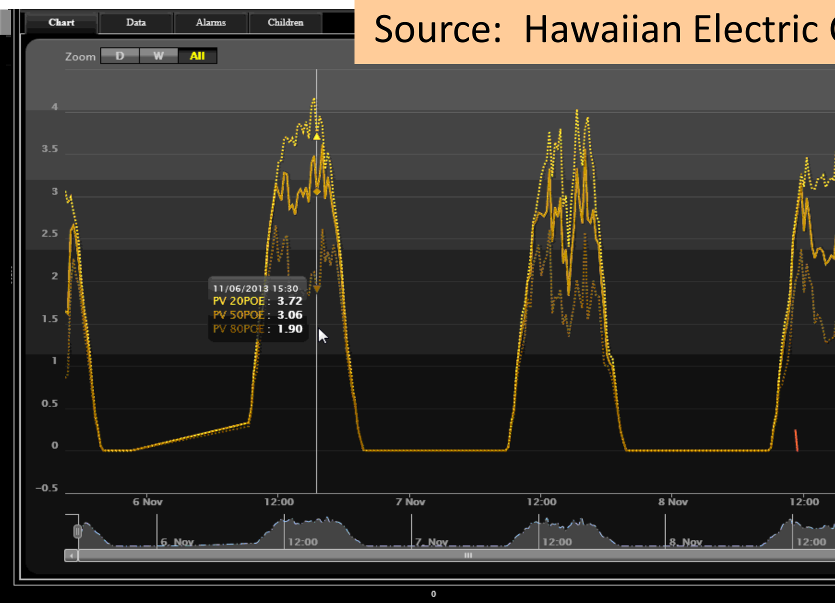


Region	Est. Gen MW	Connected MW
North Hawaii	1.3	1.7
East Hawaii	2.9	4.1
West Hawaii	2.6	3.7
South Hawaii	0.0	0.1
Total PV (MW)	6.8	9.6



Source: Hawaiian Electric Companies





DREAMS Initiative

- Goal: Integrate renewable forecasts with ramp statistics and DG impacts into EMS environment
- Benefits: Account for renewables & behind-the-meter generation in real-time operations & planning
  - Enable dynamic dispatch; improve load forecasting; reduce reserves levels and reduce operating costs
  - Develop new forecasting standards and integration procedures for high penetration renewable scenarios
- Develop robust EMS integration solutions and training with Utility Advisory Team (UAT)

Ready for Launch?

- Opportunities to leverage lessons learned
- Attract and collaborate on grants
  - US DOE Sunshots award
- Be part of the critical mass to drive needed change (standards, market, technology)

Hawaii is the Launch Pad

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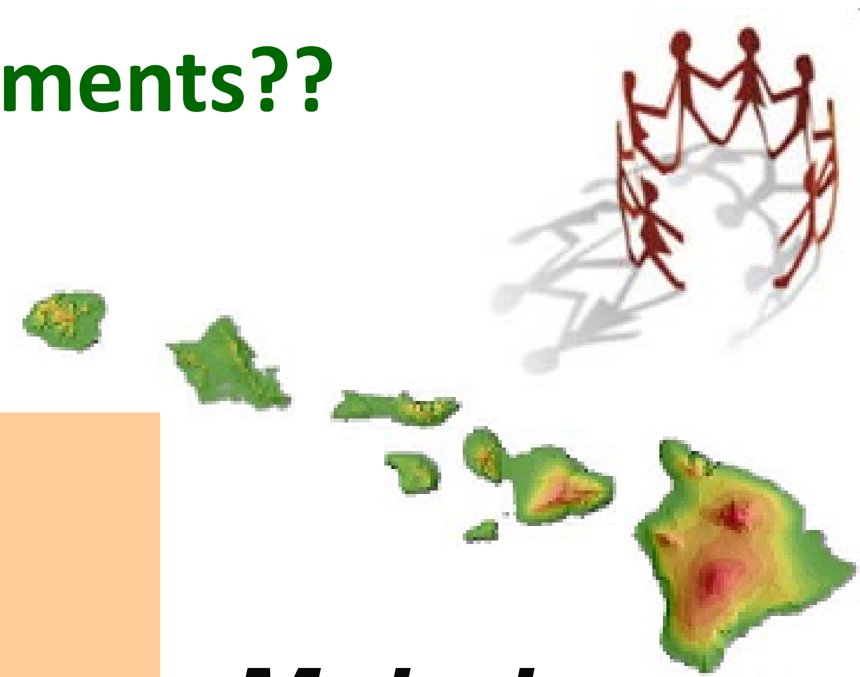
Maui Electric
Hawai'i Electric Light

Questions/Comments??



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Grid Technologies Department

Mahalo

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Supplemental Review: 100% minimum load screening adoption in the Commonwealth of Massachusetts

Babak Enayati

MA Technical Standards Review (MA TSRG) Chair

Babak.Enayati@nationalgrid.com Office: 781-907-3242

MA Technical Standards Review Group (MA TSRG)

- The TSRG was assembled through an agreement among the DG Working Group members. Details about this agreement can be found on page 30 of the *Proposed Changes to the Uniform Standards for Interconnecting Distributed Generation in Massachusetts **, the final report of the Distributed Generation Working Group (September 14, 2012).

*http://massdg.raabassociates.org/Articles/Final%20MA%20DG%20WG%20Report%209-14-12.pdf

MA Technical Standards Review Group (MA TSRG)

Goals:

1) **Review the MA Utilities' interconnection guidelines**
2) **Increase the commonalities among utilities with regards to DG interconnection practices**
3) **Provide technical support for incoming MA interconnection challenges**

MA Technical Standards Review Group (MA TSRG)

- **Website:** https://sites.google.com/site/massdgic/home/interconnection/technical-standards-review-group

- **Membership:**

  Utility Members:

  Chair: Babak Enayati, National Grid / 781-907-3242 / Babak.Enayati@nationalgrid.com

  Michael Brigandi, NSTAR / michael.brigandi@nstar.com

  Cynthia Janke, Western Massachusetts Electric / 413-585-1750 / cynthia.janke@nu.com (alternate: Erik Morgan)

  John Bonazoli, Unitil / bonazoli@unitil.com

  Non-Utility Members:

  Vice-Chair: Michael Conway, Borrego Solar / 978-610-2860 / mconway@borregosolar.com

  Reid Sprite, Source One / 617-399-6152 / rsprite@s1inc.com

  Michael Coddington, National Renewable Energy Laboratory / 303-275-3822 / Michael.Coddinton@nrel.gov

  Nancy Stevens, Director of Consumer Division, Massachusetts DPU

Supplemental Review Screens

- Penetration screen (Minimum load screen)
- Power quality and voltage screen
- Safety and reliability screen

Federal Energy Regulatory Commission (FERC) Order No. 792 (Issued November 22, 2013)

- Link: https://www.ferc.gov/whats-new/comm-meet/2013/112113/E-1.pdf
- Page 81 section b (Commission Determination)

- Section 143: The Commission finds that a 100 percent minimum load screen more appropriately balances these considerations than the 33 and 67 percent minimum load screens proposed by NRECA, EEI & APPA. We note that a 33 percent minimum load screen would be even more conservative than the existing 15 Percent Screen (which approximates a *50 percent minimum load screen)*
- Page 16: section 2.4.4.1.1 :

  Solar photovoltaic (PV) generation systems with no battery storage use daytime minimum load (i.e. 10 a.m. to 4 p.m. for fixed panel systems and 8 a.m. to 6 p.m. for PV systems utilizing tracking systems), while all other generation uses absolute minimum load.

Penetration Screen

- On March 13, 2013, the MA Department of Public Utilities ("Department") directs the technical standards review group to submit to the Department a proposal for the penetration level for the supplemental review penetration screen.

Technical Challenges

- Maintain minimum load on the feeder section

  1) Existing large customers (businesses, etc)

  2) Emergency feeder section switching (during storms)

Utilities agreed to perform the abovementioned analyses in the safety and reliability screen.

Technical Challenges

- **Impacts on protection (islanding, etc)**
  1. Rotating generators may island with 100% load for longer than 2 seconds.
  2. Inverters' active anti-islanding protection may fail to detect the island if large rotating generators are connected to the island and load matches closely with the total generation
  3. According to the Sandia report (SAND2012-1365), " Suggested Guidelines for Assessment of DG Unintentional Islanding Risk", inverters may fail to detect the island within 2 seconds, if total generation exceeds 67% of the load and reactive power match falls within 1% (anti-islanding study is required)

  http://energy.sandia.gov/wp/wp-content/gallery/uploads/SAND2012-1365-v2.pdf

  4. Impact on fault duty and coordination

- **100% screen limits the flexibility to deploy additional sectionalizing devices for reliability enhancement**

Utilities agreed to perform the above mentioned analyses in the safety and reliability screen.

Technical Challenges

- Voltage regulation
  1. Impacts of PV generation intermittency on the feeder section voltage (factors to be considered: distance to the substation, total load on the circuit, stiffness factor, etc.)
  2. Power Quality impacts of DG generation at the Point of Common Coupling (PCC) and the entire circuit (voltage, power factor (PF), etc).

Utilities agreed to perform the abovementioned analyses in the power quality and voltage screen.

Thank you

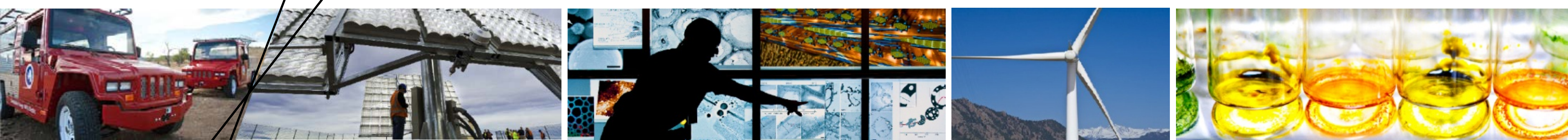
Questions?

Register for Next DGIC Webinar: May 28th

Enhanced Modeling and Monitoring Tools for Distributed PV Interconnection

- **This webinar will spot light rural cooperatives and municipal utilities. Featured speakers are David Pinney, Lead Software Engineer at the National Rural Electric Cooperative Association (NRECA) and Mark Rawson, Project Manager, Advanced, Renewable, and Distributed Generation at Sacramento Municipal Utility District (SMUD). The webinar will highlight NRECA's Open Modeling Framework, a software development effort with a goal of making advanced power systems models usable in the electric cooperative community. Participants will also learn about SMUD's pilot project focused on distribution feeder monitoring and the supply of data available to stakeholders for analysis and modeling. The webinar will kick-off with a brief overview of Green Tech Media's (GTM) new Grid Edge Initiative, by GTM's President and Co-Founder, Rick Thompson.**

https://www3.gotomeeting.com/register/386813198



Thank you!