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HIP-PV: PV VISUALIZATION & INTEGRATION UPDATE

Discussion Topics

- Project & Motivation

- Impact of PV on our Utilities today

- What Have We Been Doing?

- Has It Been Productive?
    - > Project results
    - > Examples of Spinoff projects using results from projects

- Q&A

Motivation - Timeliness of Partnership

- Exponential growth in levels of distributed generation "behind-the-meter" generation (variable & DG)

- Levels of penetration exceeding "rules-of-thumb" and standards used in traditional utility practices for planning & operations

- Industry lacks capability (tools/data) to effectively plan and account for PV impacts on the grid (especially at the distribution and DG level)

- Limited commercial solar forecasting capabilities, experience and integration at utilities

- Lack industry guidance (standards/best practices) for monitoring equipment, measurement parameters, modeling and data resolutions for planning & operational timelines

This was….

Our Operational View of Wind & Solar….

# SMUD/HECO High Penetration PV Initiative (HiP-PV)

Goal:

Enable appropriate capability to reliably plan and operate with high penetration of variable renewable resources on the grid especially during high impact conditions (e.g. variable weather, peak loads, minimum loads, contingencies)

Objectives:

- Inform and pilot the development of visual tracking, field measurement and validated analytical (modeling) capability including hardware and software integration needs to evaluate the impact of high penetrations of PV systems on our grids
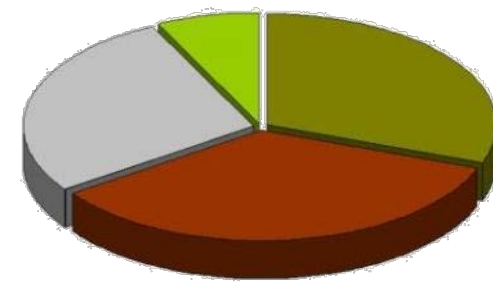- Collaborate with other utilities, validate and transfer lessons learned

Solar Energy Growth at SMUD
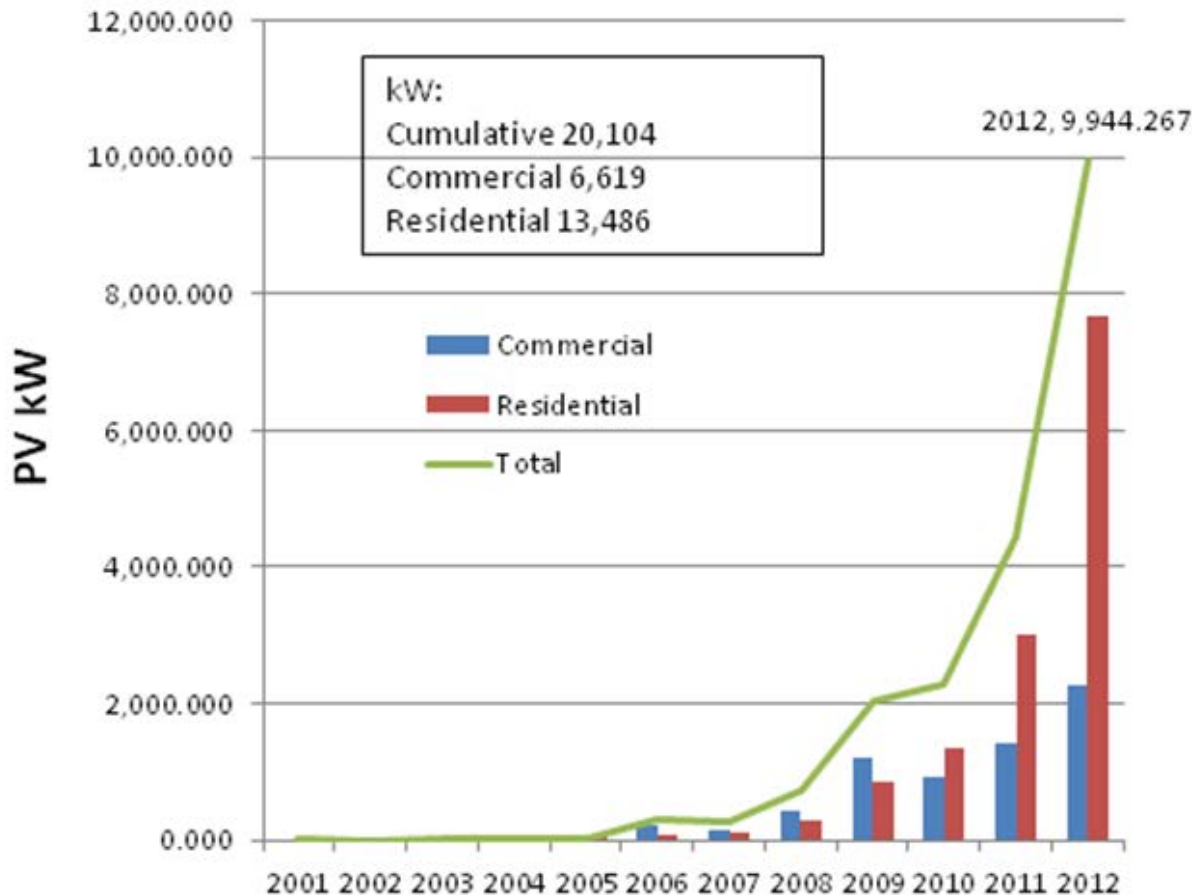

Installed and Forecast Solar Capacity
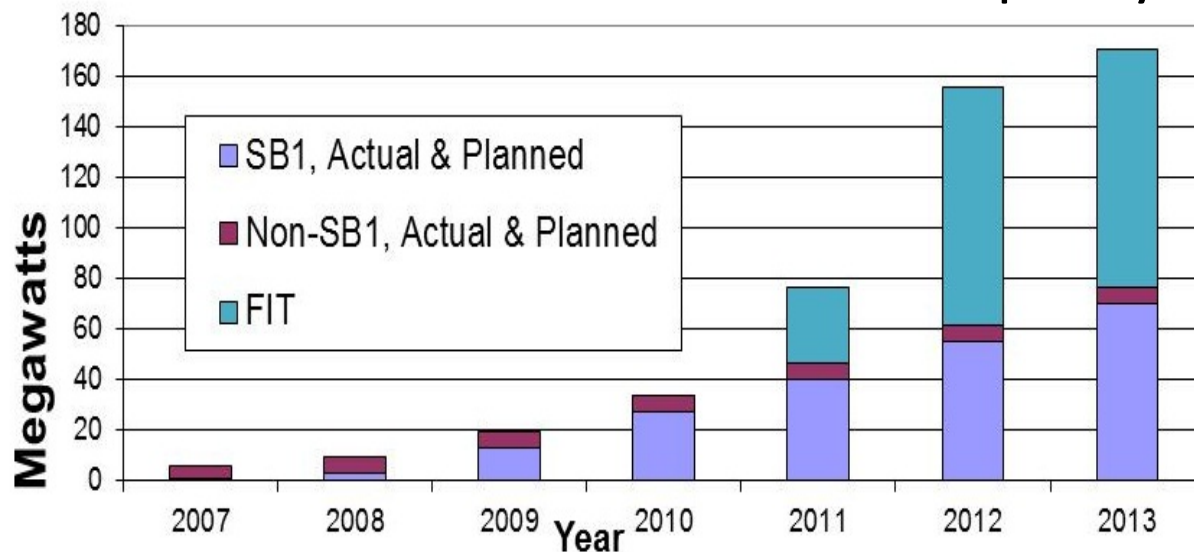
- Community solar projects
- FIT projects
- Aggressive CA RPS – 33% Renewables by 2020

DG Growth in Hawaii

JET FUEL	34%
ELECTRICITY	32%
GASOLINE/ MARINE FUEL	27%
OTHER	7%

kW:
Cumulative 20,104
Commercial 6,619
Residential 13,486

2012, 9,944.267

Commercial
Residential
Total

PV kW

Growth of distributed PV at HELCO, 2001-2012.

- RPS – 40% renewables from electricity, 70% total (includes transportation) by 2030
- Energy efficiency standard of 30% by 2030 (3,400 GWh)
- HECO – 17%, HELCO – 42%, MECO – 26%

Project Team & Approach

Task 1: Project Management

Task 2: <u>Baseline DG Modeling</u> of SMUD and HECO Systems

Task 3: <u>Field Monitoring and Analysis</u>

Task 4: <u>Visualization</u> Effort ← Emphasis of Today's Presentation

Task 5: Solar Resource <u>Forecasting</u>

Key Areas of Impact & Deliverables

- **Enhance T&D Modeling Tools & Inform PV Data Needs**
  - > Developed and validated method for accounting for impact of aggregated DG as generating on distribution feeders
  - > Completed upgrades on utility modeling tools for T&D infrastructure

- **Expedite Interconnection Process**
  - > Developed and applying cluster evaluation method for proactively assessing T&D impacts to expedite interconnections
  - > Proactive Process and Interconnection recommendations introduced in regulatory proceedings in Hawaii
    - Interstate Renewable Energy Council (IREC) January 29, 2013 Press Release (www.irecusa.org/2013/01/breakthrough-for-hawaiian-solar-power-announced-by-clean-energy-groups/)

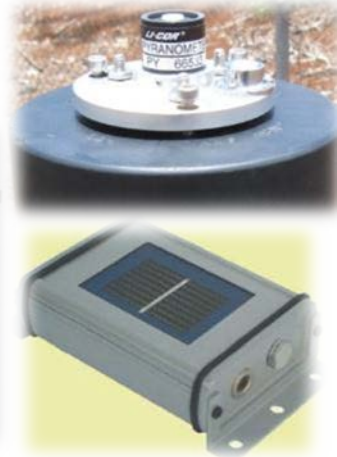# Key Areas of Impact & Deliverables (Con't)

- **Jump start development of Real-time Solar Forecasting Tool**
  - > Functional utility network of solar irradiance and distribution circuit monitoring devices in the field and integrated into SCADA
  - > Completed solar database representative of local conditions and resolutions (1sec to 15 min) for utility integration and R&D needs
  - > Working with industry EMS vendors and forecasters to integrate real-time solar forecasting data into operating tools/environment

- **Building Knowledgeable Energy Workforce through Outreach**
  - > Completed in-house utility training on data, tools and lessons learned
  - > Continuing workforce development/training efforts
  - > Presented on project and results at university and PV industry meetings
  - > Accepted/Invited to Industry presentations (i.e. AMS, SEPA, DistribuTECH, UWIG, AWEA, IEEE) & published peer reviewed industry journal articles (IEEE/PES, IJCNN)

Modeling & Sensor Deployments
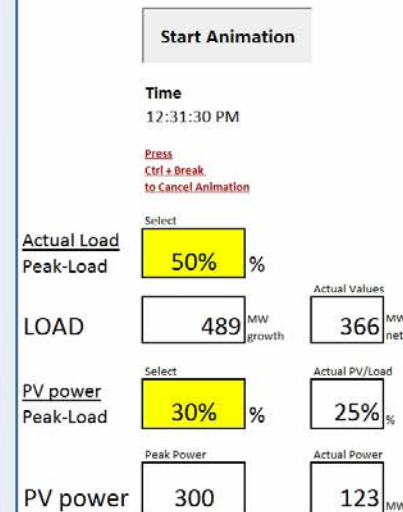

Source: HECO & SMUD

RESULTS

- Installed and integrated solar monitoring units
- Increased visibility to DG in the field (i.e. PV generation)
- Applying validated models for planning & operations
- "Heads up" on impacts through modeling

Source: HECO & BEW Engineering, a DNV Kema Company

Start Animation
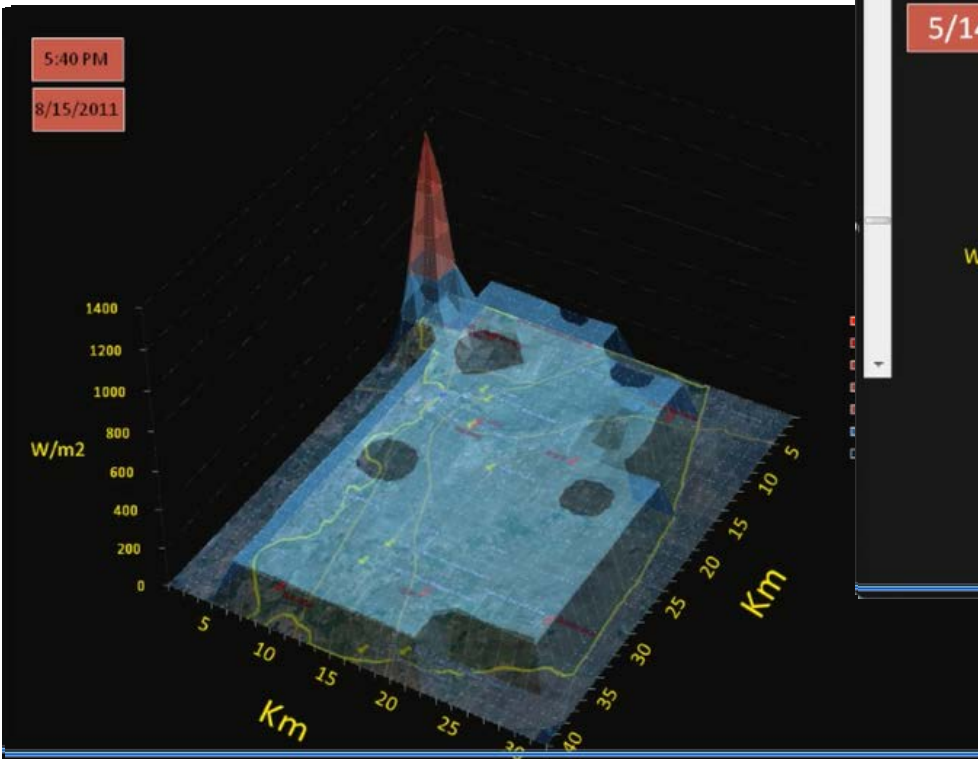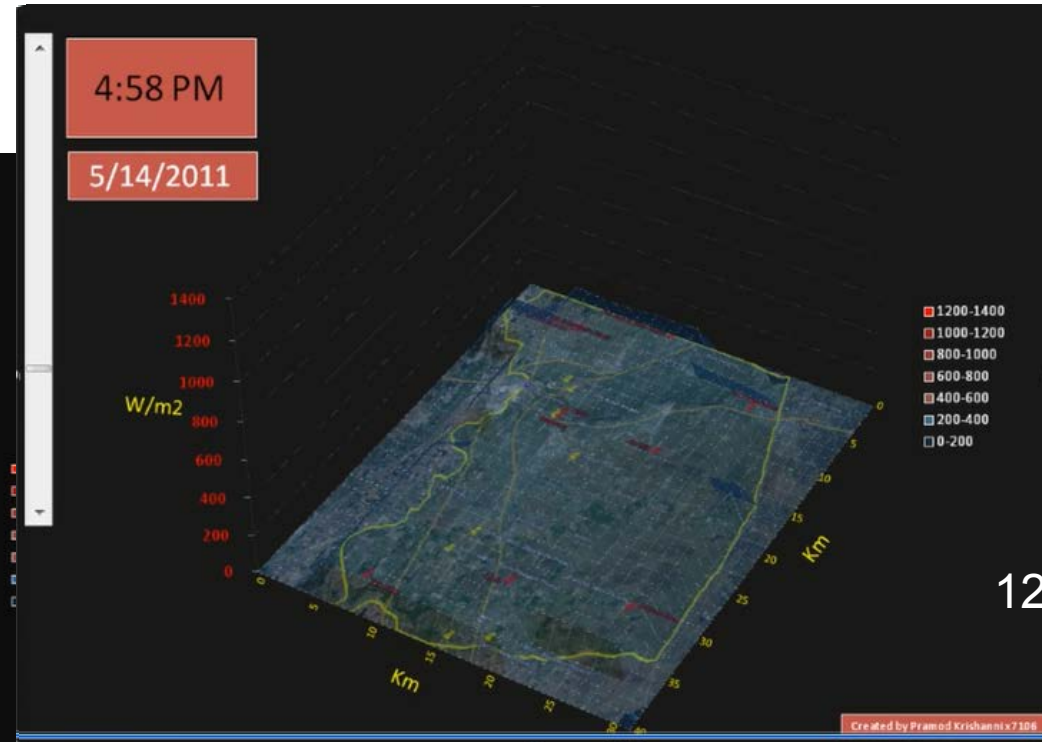
Time
12:31:30 PM

Press
Ctrl + Break
to Cancel Animation

	Select		Actual Values
Actual Load Peak-Load	50%	%	
LOAD		489 MW growth	366 MW net
PV power Peak-Load	Select 30%	%	Actual PV/Load 25% %
PV power	Peak Power 300		Actual Power 123 MW

Results: Solar Field Data Visualization Highlights the Magnitude of Resource Variability
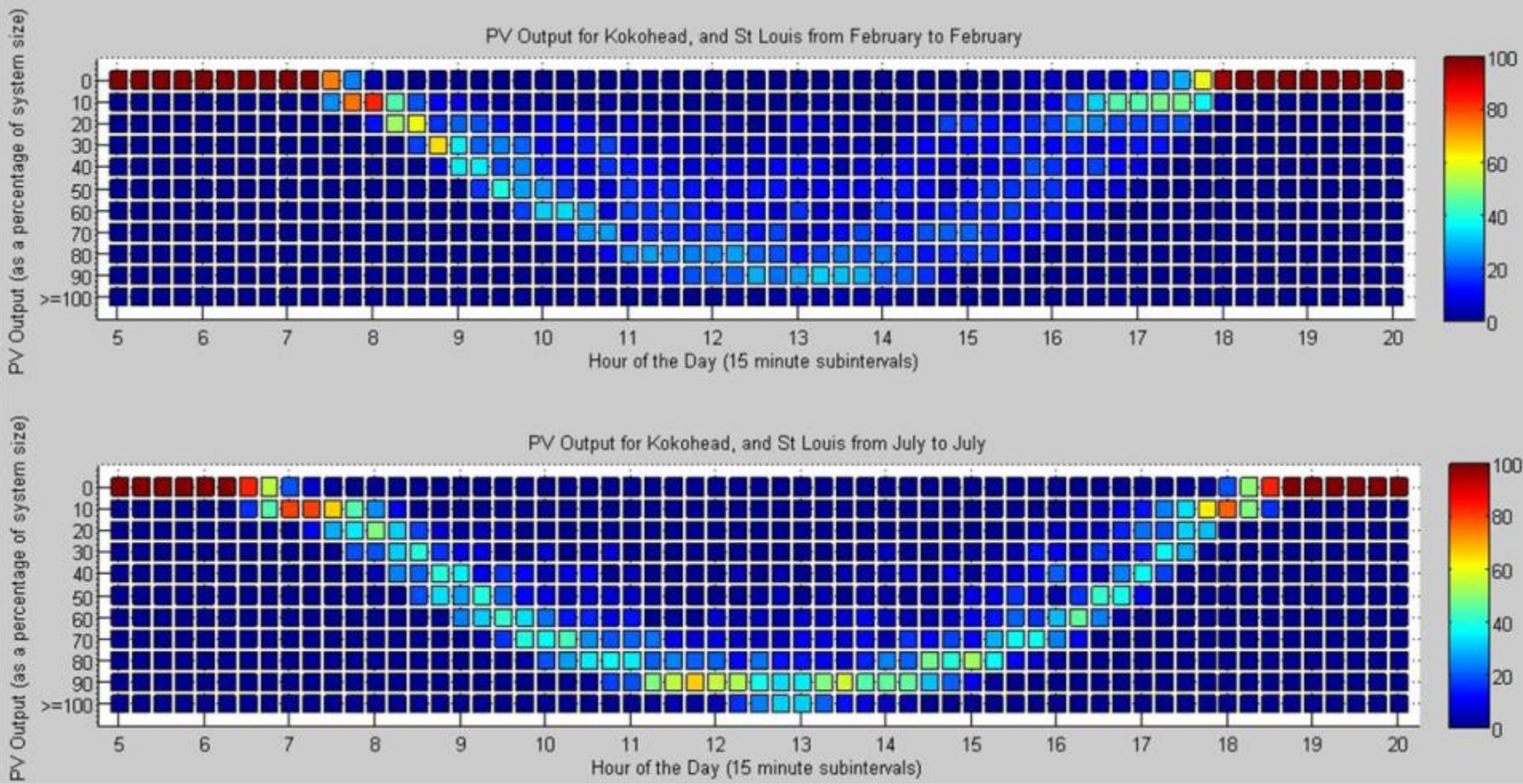
NEO Virtus Engineering, Inc

Cloudy Day Data

Clear Day Data

Ex: Probabilistic Metrics by Time & Location

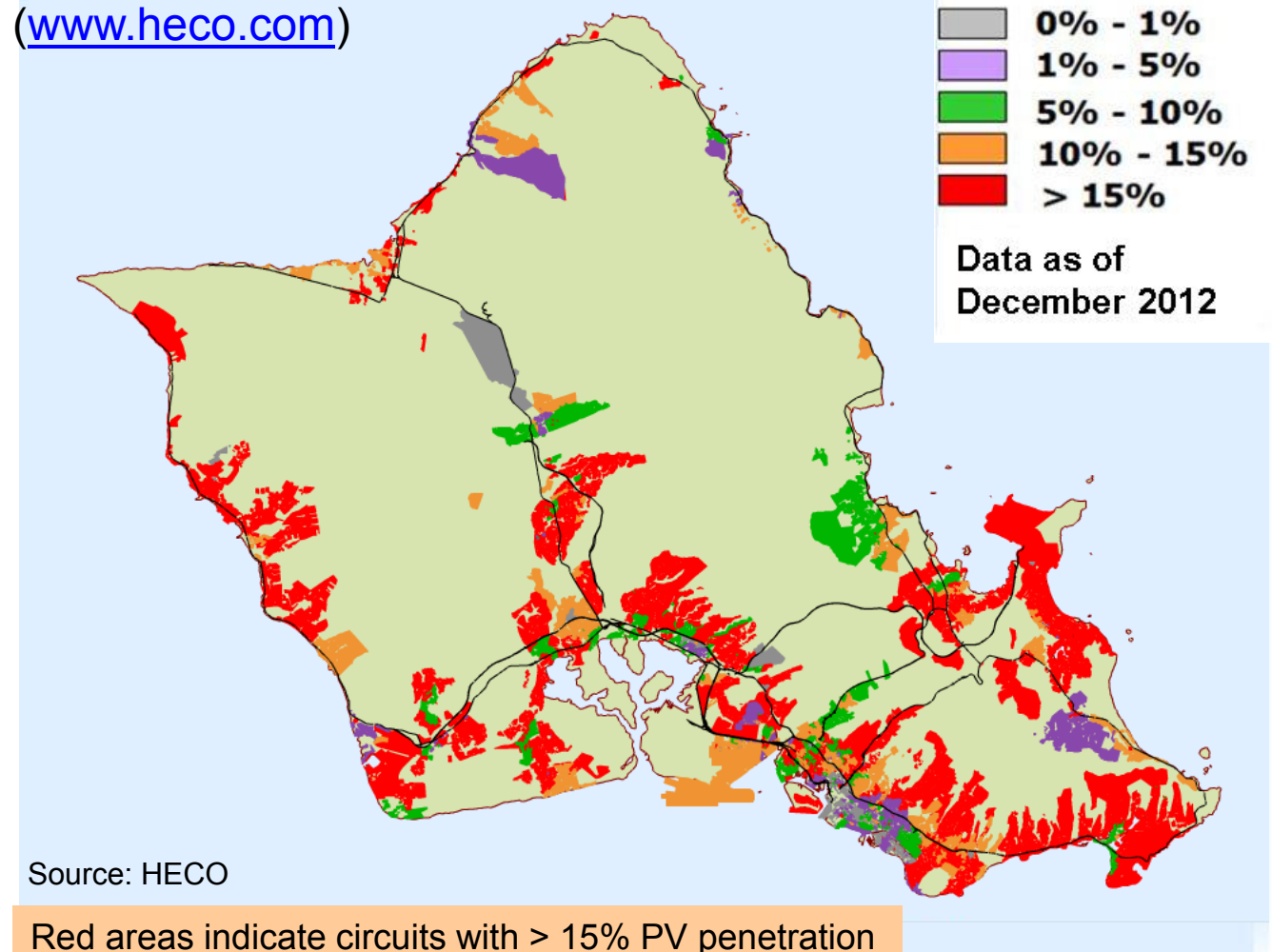Capturing statistical variation of PV with respect to time and by geographic location.

PV Output for Kokohead, and St Louis from February to February

PV Output for Kokohead, and St Louis from July to July

Visualization – A Picture is Worth 1000 Words

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

Legend:
- 0% - 1%
- 1% - 5%
- 5% - 10%
- 10% - 15%
- > 15%

Data as of December 2012

Source: HECO

Red areas indicate circuits with > 15% PV penetration

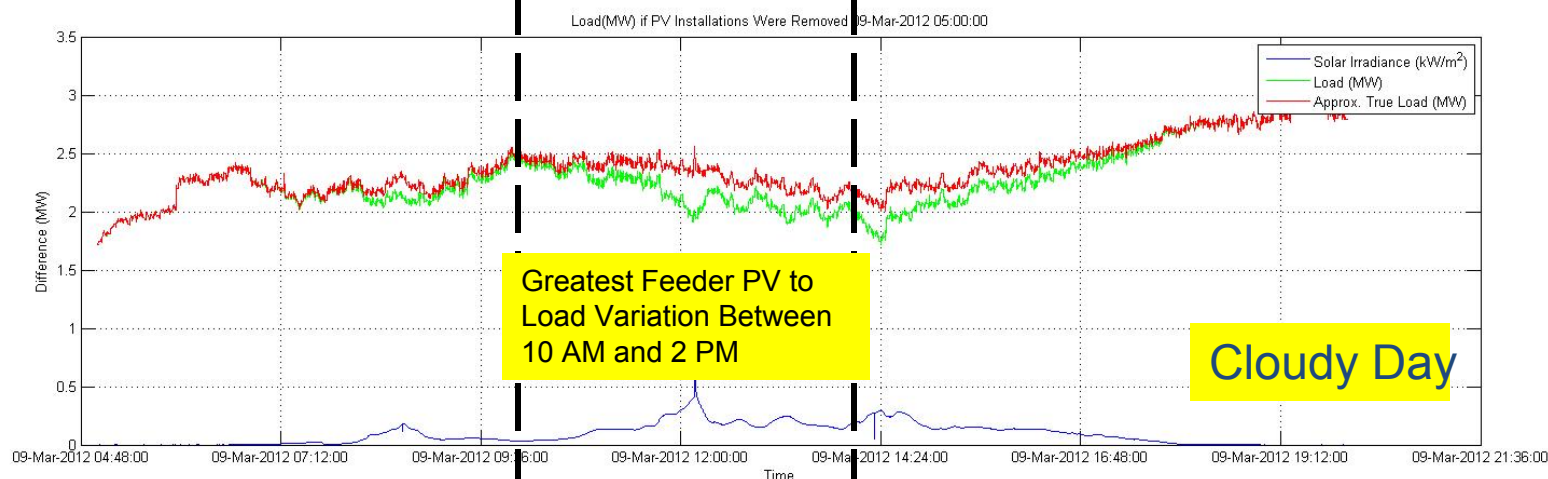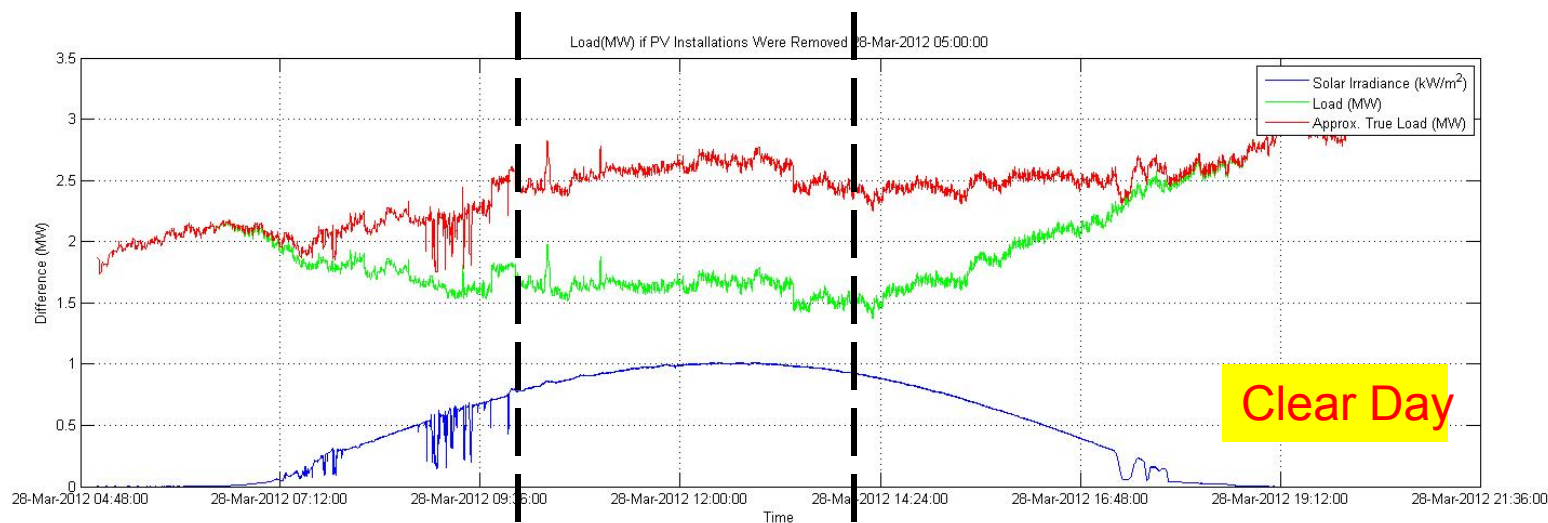### RESULTS
- Graphically view PV data to develop local measures and perf. metrics
- More effective data handling, mining and analysis medium
- Effective and transparent tool to communicate and track change

SunShot
U.S. Department of Energy

GO SOLAR CALIFORNIA

Solar Impact on <u>Feeder</u> Load : March 2012 Weekday

Clear Day

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

Cloudy Day

Irrad. to Est PV Power

SunShot
U.S. Department of Energy

GO SOLAR CALIFORNIA
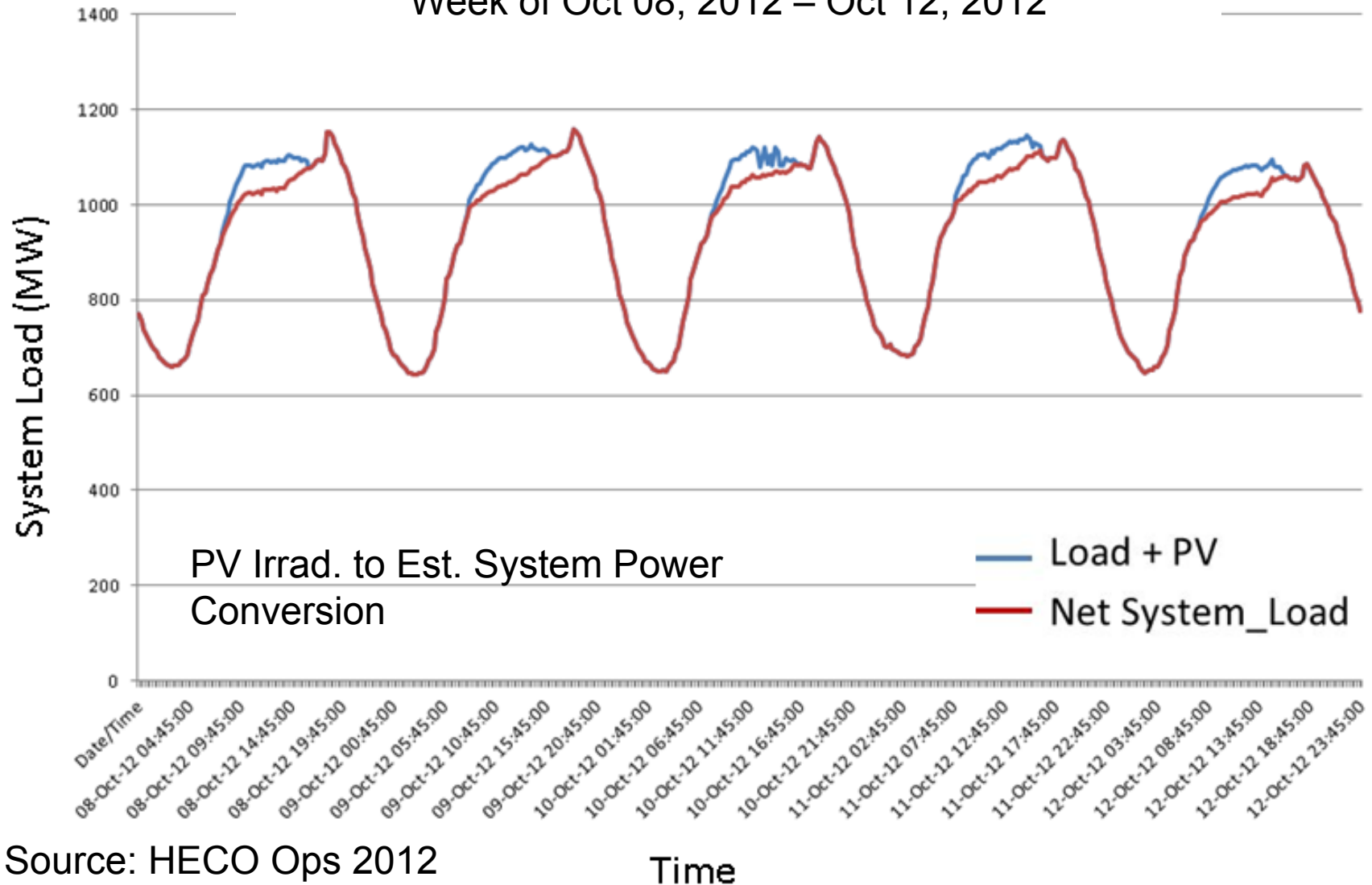
High Penetration

2013
Feb 13-14, San Diego, CA

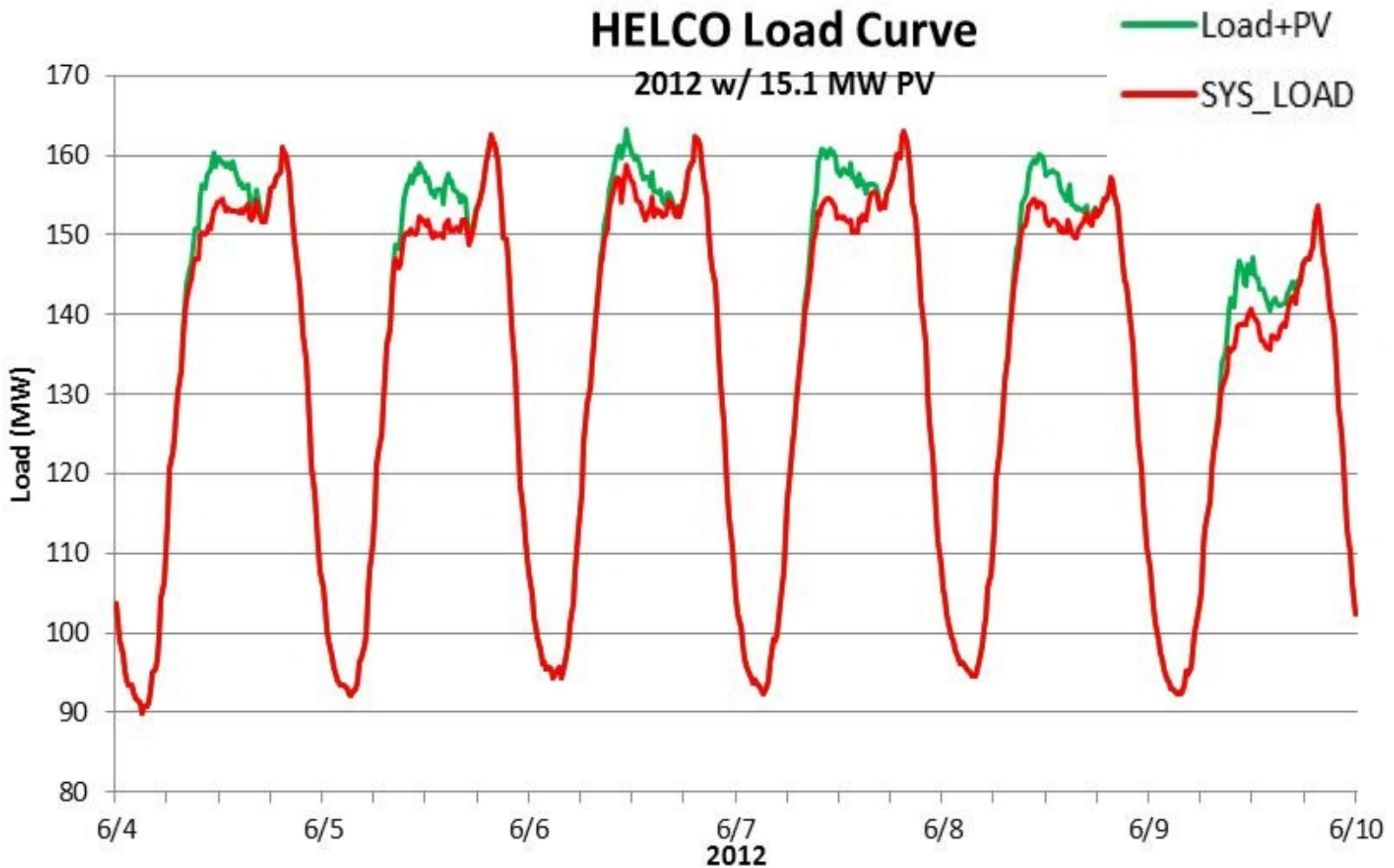# Ex: Inspired Development of GIS-based Common Platform for Monitoring and Assessing PV, DG/DR, EV
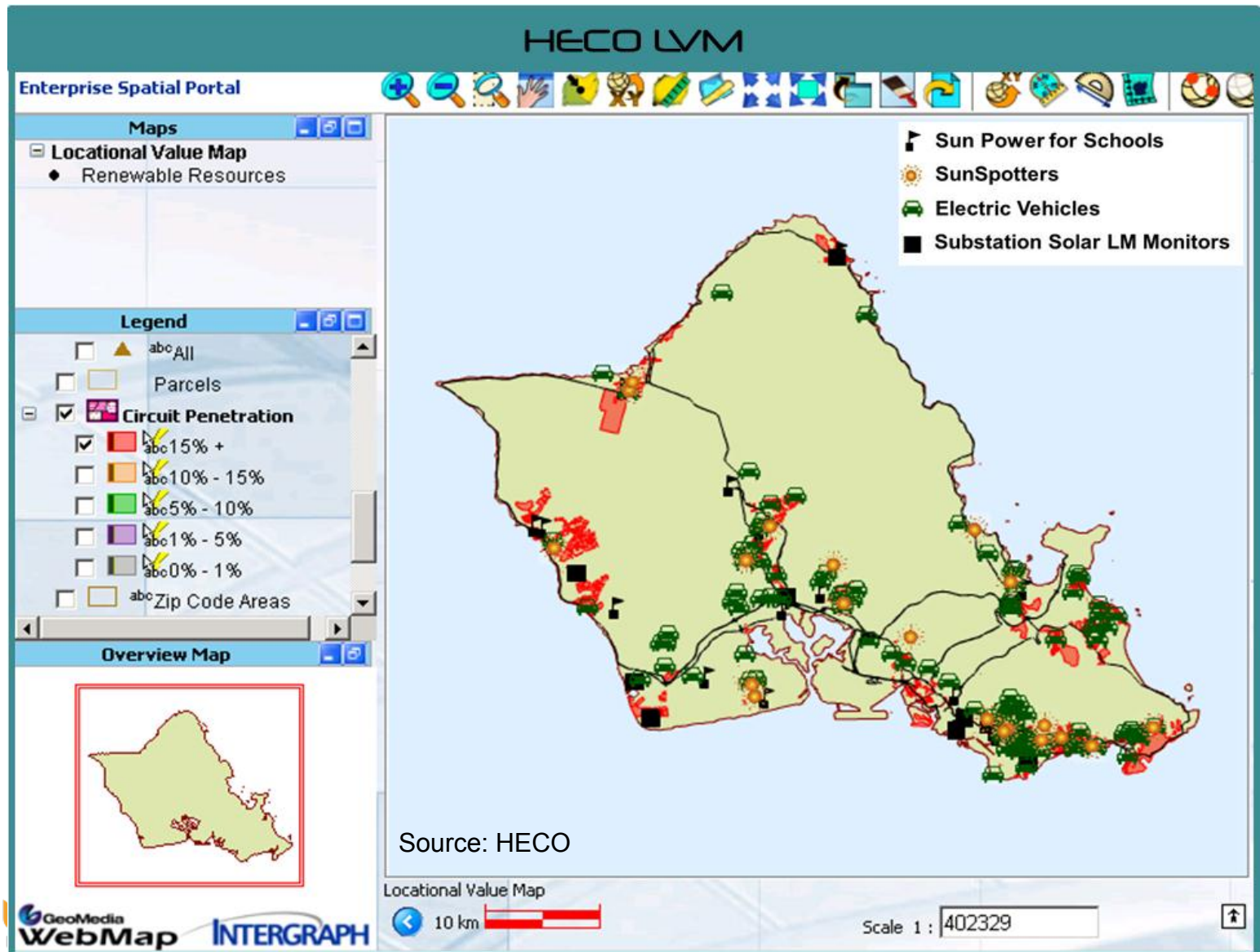
Source: HECO

"Seeing" DG PV Contributions onto the System

HECO System Load Curves with 100 MW of PV
Week of Oct 08, 2012 – Oct 12, 2012

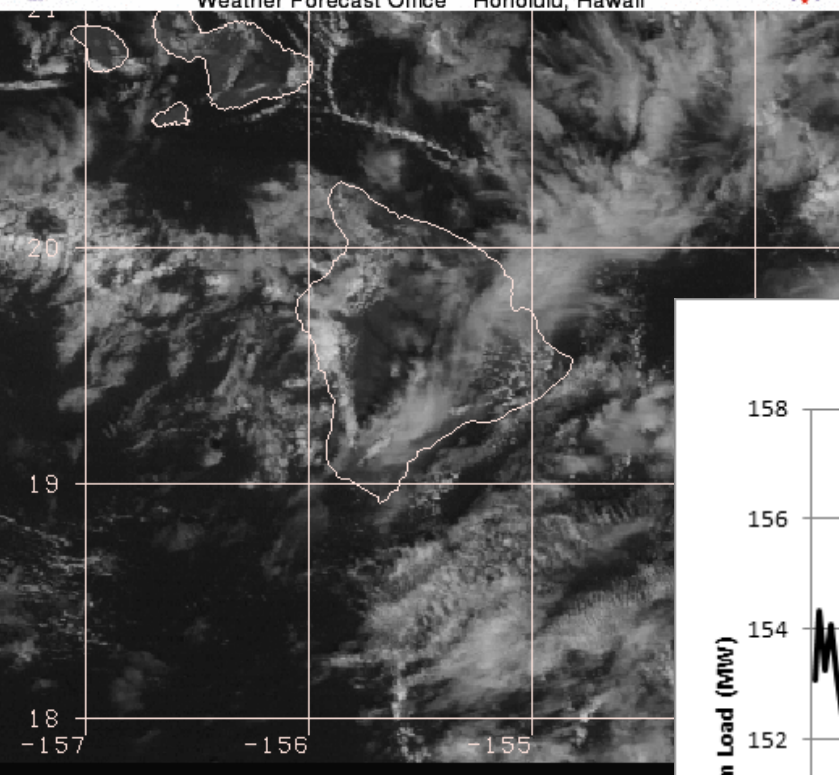PV Irrad. to Est. System Power Conversion

—— Load + PV
—— Net System_Load

Source: HECO Ops 2012   Time

"Seeing" DG PV Contributions onto the System

HELCO Load Curve
2012 w/ 15.1 MW PV

Legend: Load+PV (green), SYS_LOAD (red)

Y-axis: Load (MW), from 80 to 170
X-axis: 6/4, 6/5, 6/6, 6/7, 6/8, 6/9, 6/10 — 2012

Source: HELCO Ops 2012

Significance of System Impacts due to Solar Ramp Event

Big Island Visible Imagery
2030 UTC 06 DEC 2012
Weather Forecast Office   Honolulu, Hawaii

NOAA cloud layer
satellite imagery
10:30am – 12:30pm

Source: HELCO

PV Load Ramp

Thursday, December 6, 2012

- SYS_LOAD
- PV
- NORTH
- EAST
- WEST
- SOUTH
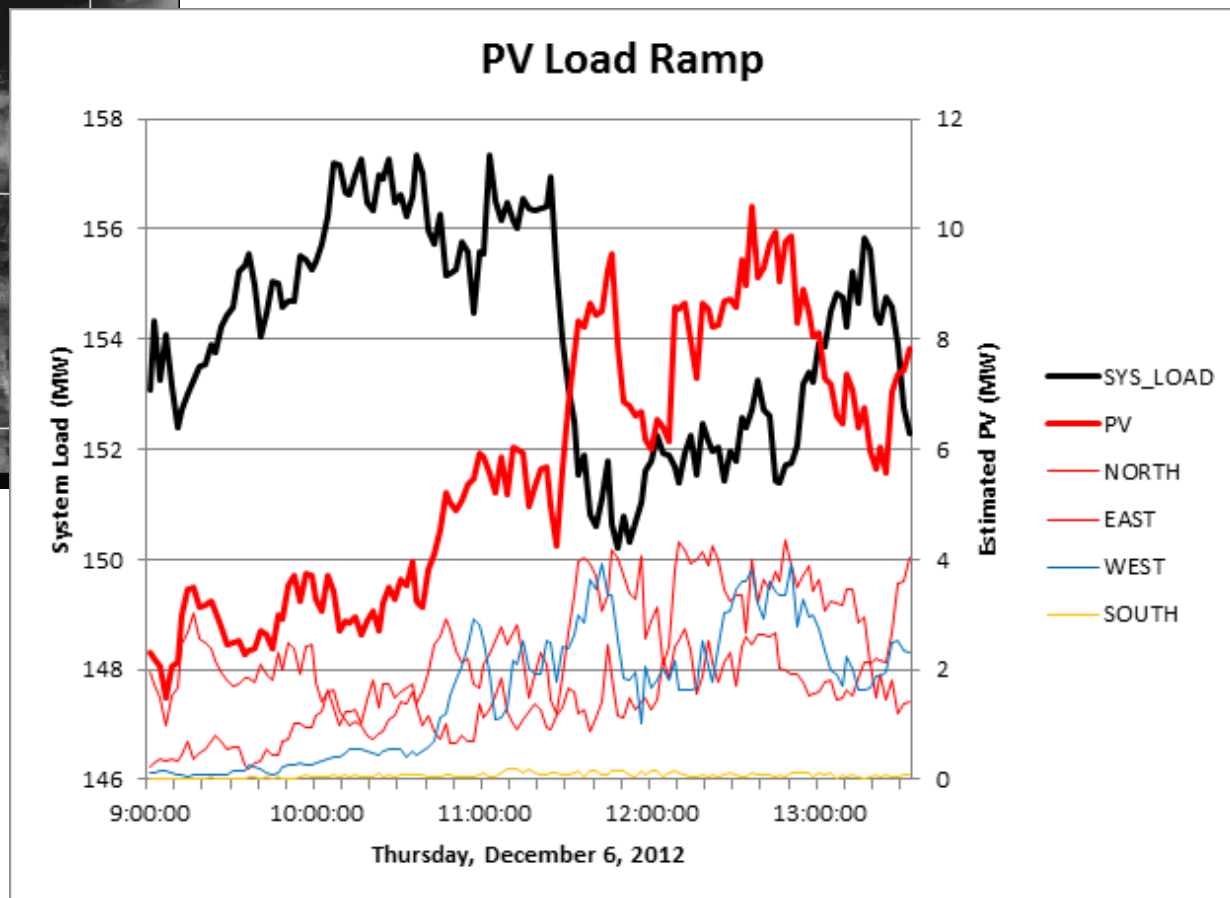
Ex. Jumpstart Real-time Regional Solar Forecasting (Supporting for Planning, Procurement & Customer Acct Mgrs)

9:45

2:15pm

Ramp down &up event

Source: HECO & AWS TruePower

Mobile App Online 10/2012

Estimated Irradiance (W/M^2)
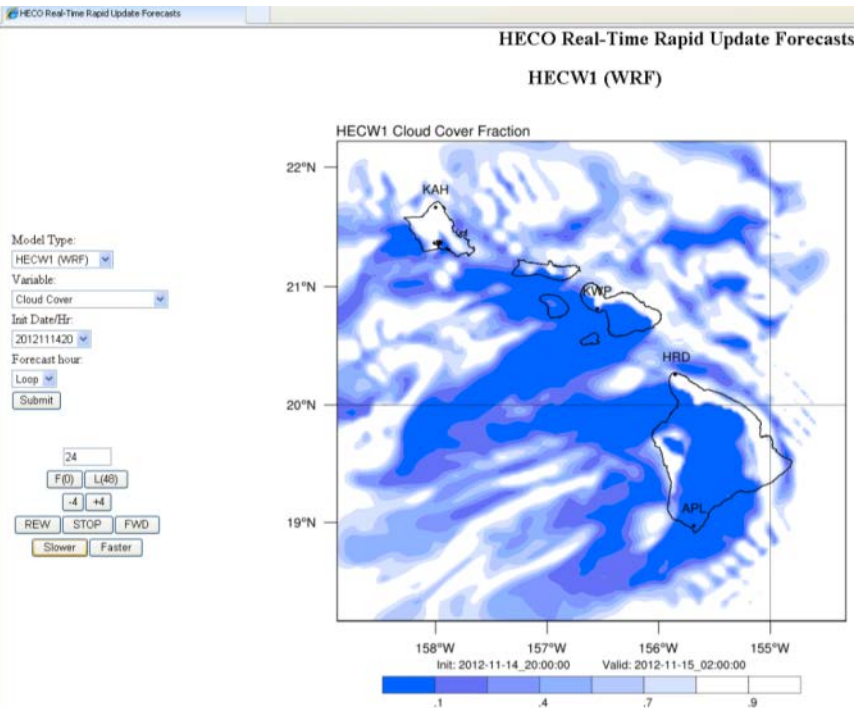
20121113 at 1200 HST

Persistence of cloud front
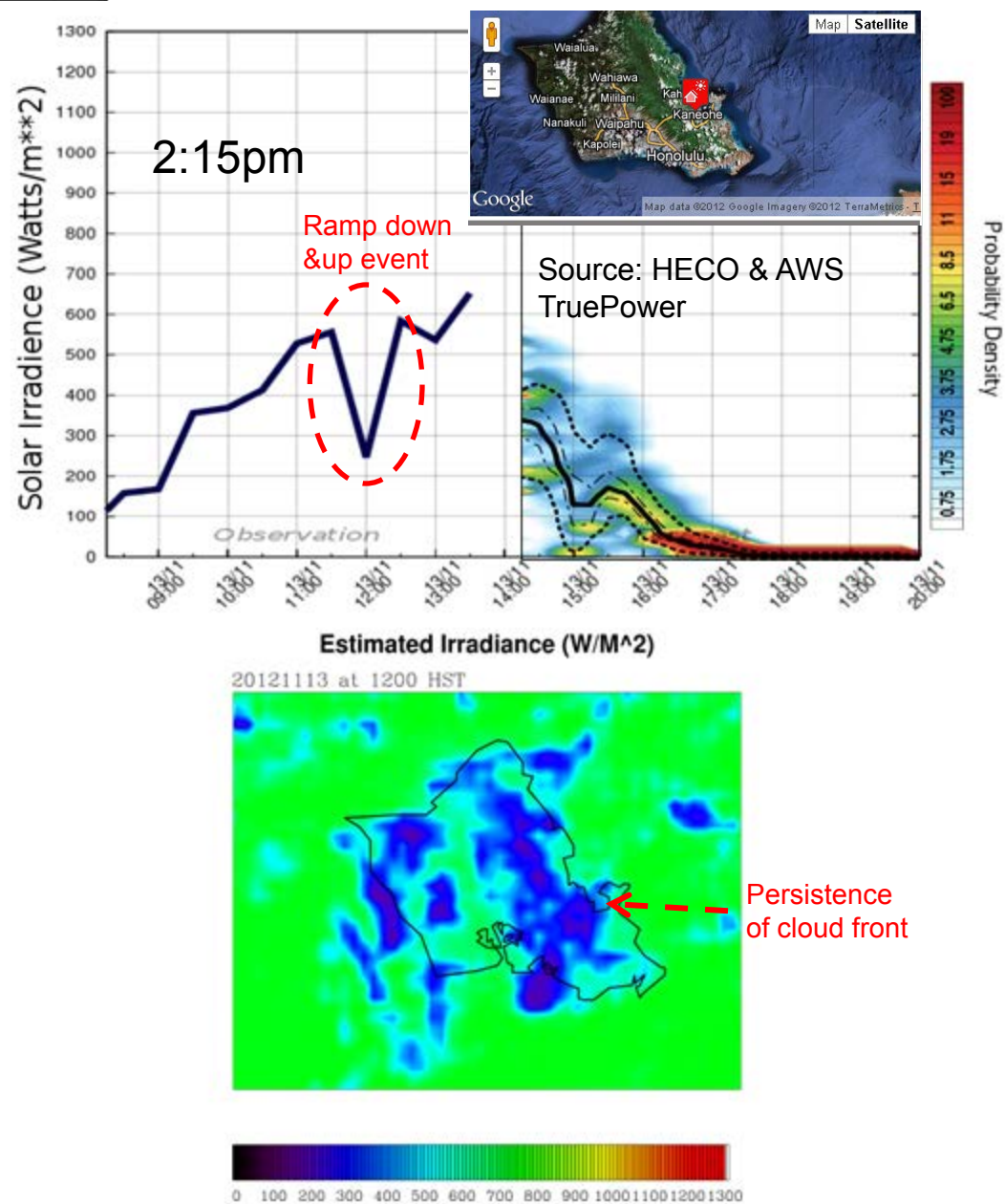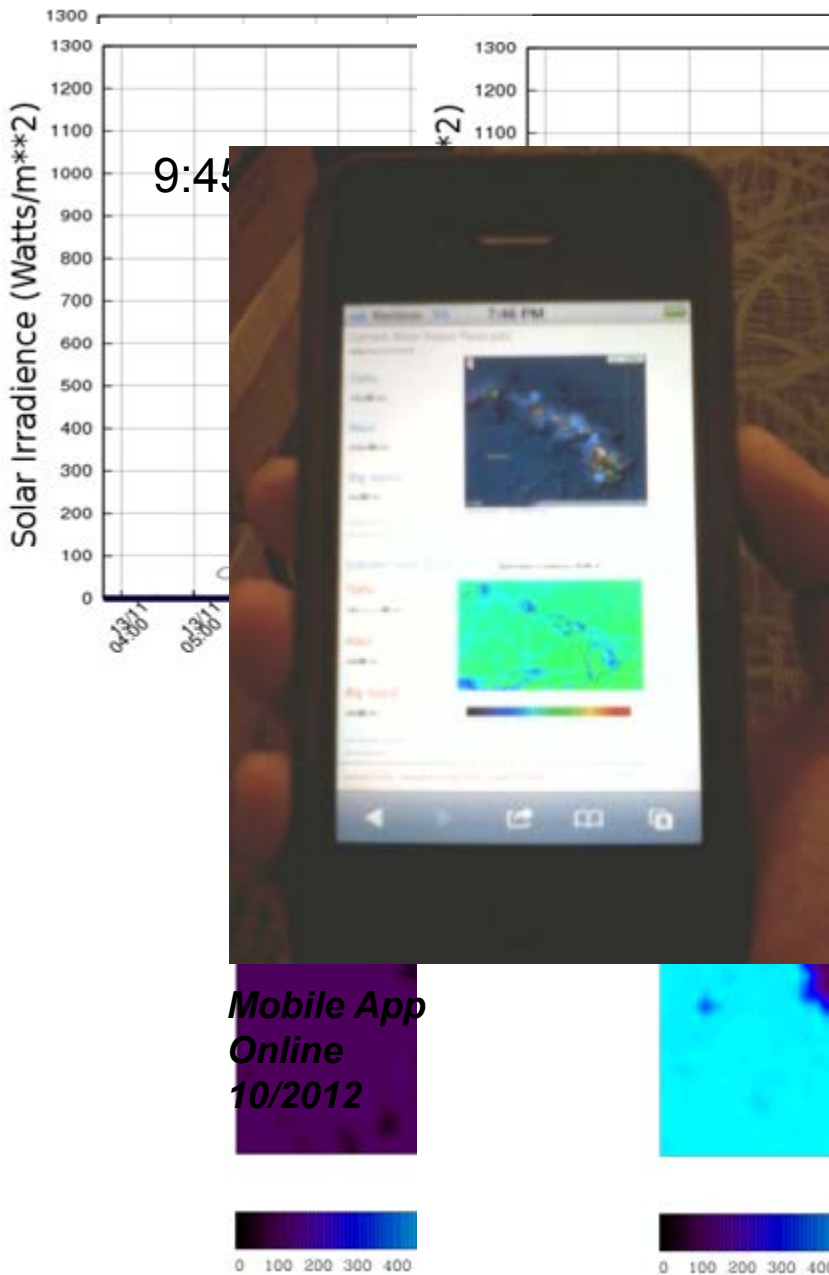
Ex. Field Data Supporting Industry Solar Forecasting & National R&D on Modeling Needs (US DOE SunShots Grant UCAR/NCAR Team)

All Islands

Source: HECO & AWS TruePower
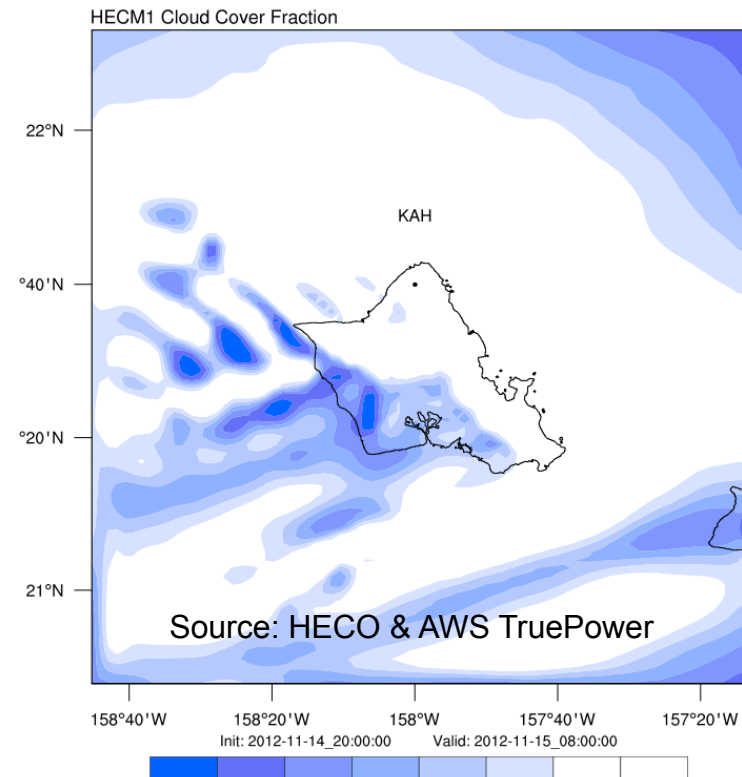

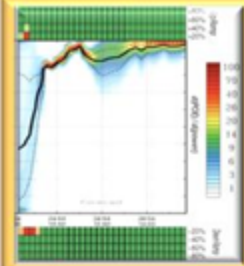HECO Real-Time Rapid Update Forecasts

HECME (MASS)

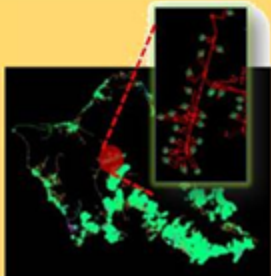Source: HECO & AWS TruePower

Island Specifics

Pulling it all Together – Visual Ops Tool

DMAS Development Project with DNV/AWS/Siemens on EMS Integration

NEW Forecasting INPUTS:
- Real-time renewables forecasts
- Ramp probabilities
- Historical and actual trends
- Satellite images, weather data

Traditional input sources
- SCADA data
- Transmission data
- Generator data
- Protection data
- Others

Source: HECO & Siemens

NEW distribution management & simulator capability

System Ops EMS

WindSENSE
Utilities
Industry
DOE

SolarSENSE
Utilities
Industry
DOE

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

NEW Renewable/DG INPUTS:
- GiS-based distribution infrastructure (models)
- DG locations
- Field monitored data
- Modeled results

ENHANCED Renewable Integration Capabilities:
- Operations & Planning with visibility to DG resource impacts
- Updated state-estimator and simulation capability to evaluate actions & impacts

Other Key Benefits

Efforts are helping to informing change (time and cost benefits):

- <u>Validation</u> of T&D models and new data (solar, circuit) needs
  - > BENEFIT: Informing where and what data needs to be collected
  - > BENEFIT: Enabling utilities to "see" and be proactive in planning
- Instilling <u>sense of confidence</u> to change at high penetrations
  - > BENEFIT: Field validated examples, experience/lessons learned
  - > BENEFIT: Engaging utility users to design, develop and understand "probabilistic heads-up" tools to manage future grid
- Ensuring <u>knowledgeable energy workforce</u>
  - > BENEFIT: Inform new standards and vendor product requirements
  - > BENEFIT: Maintaining interoperability & reliability functions and supporting sustainable change practices/procedures

Q&A & Discussions

Some Related References and Recently Accepted Presentation Venues

Date/Venue	
2013 DistribuTECH	Presentation – Cluster Evaluation Methodology Presentation – High Penetration PV and evaluation of impact on LTC
2013 UWIG	Presentation – Solar and Wind Integrated Forecasting Technology (SWIFT)
2013 PUC	Filing provided by the RSWG PV Subgroup on Proactive Approach: DG and PV modeling & Hawaii Rule 14H interconnection recommendations
2012 IEEE PES	Paper/presentation – Flicker Evaluation for PV Paper/presentation – Managing High Penetration of Variable Renewables including wind and solar
2012 UWIG	Presentation – WindNET and SolarNET deployment lessons learned
2012 SEPA USC	Presentation/Poster – HiP-PV Project

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MAHALO