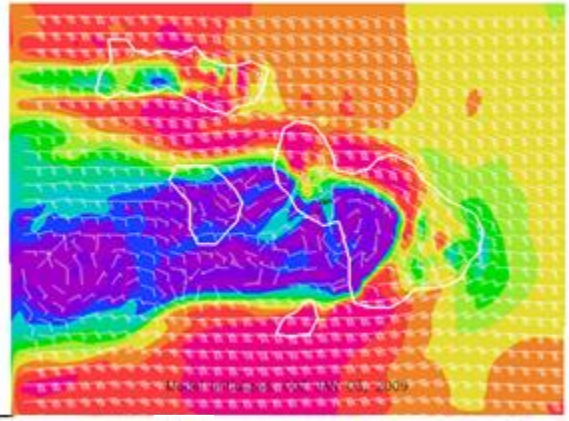
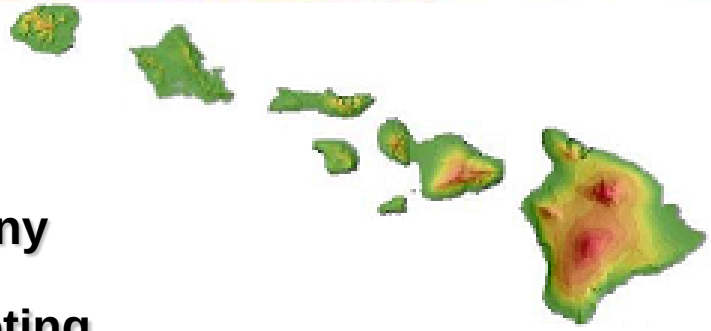
Hawaii Solar Forecasting Activities: Field Data & Visualization for Operations





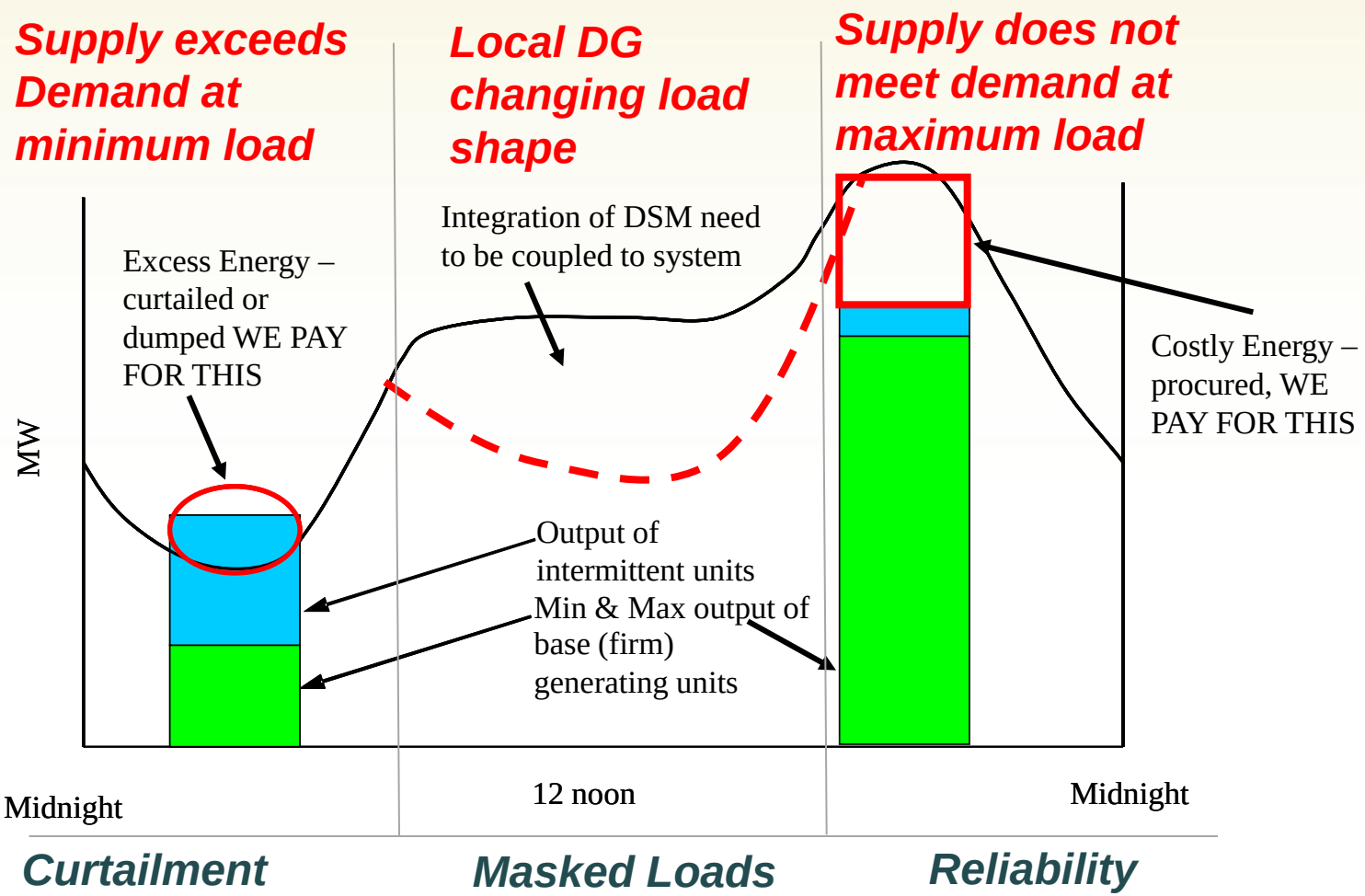
Dora Nakafuji

Hawaiian Electric Company

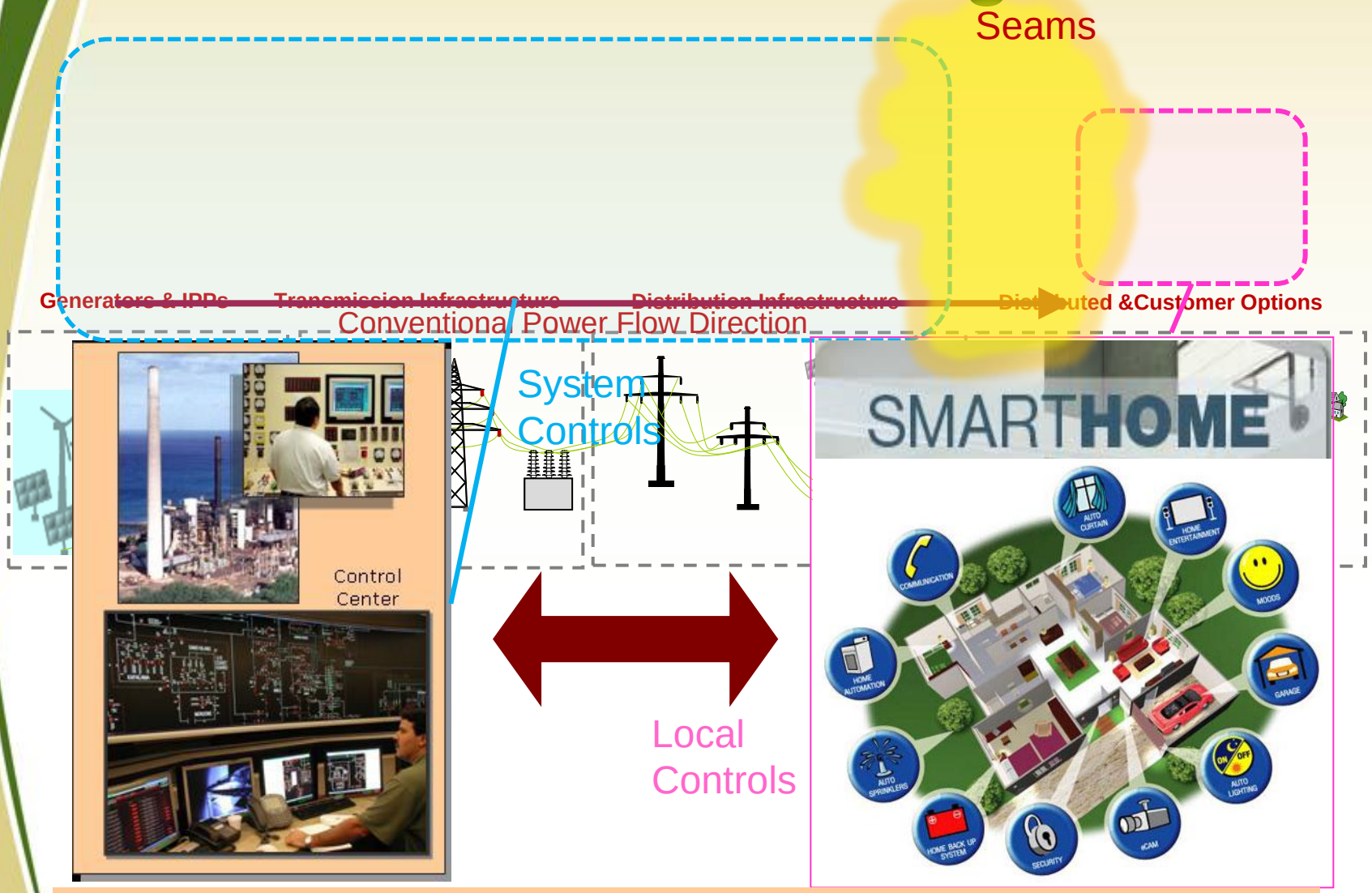
HCEI – Working Group Meeting

May 4, 2011

MOTIVATION:
Issues Being Encountered as Distributed Generation Penetration Increases

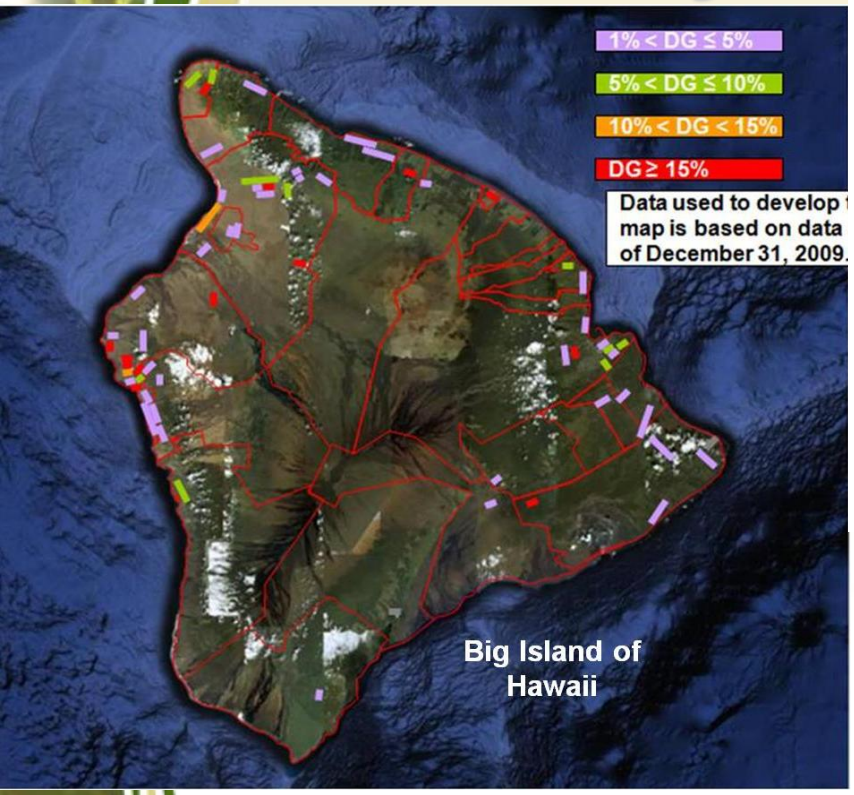


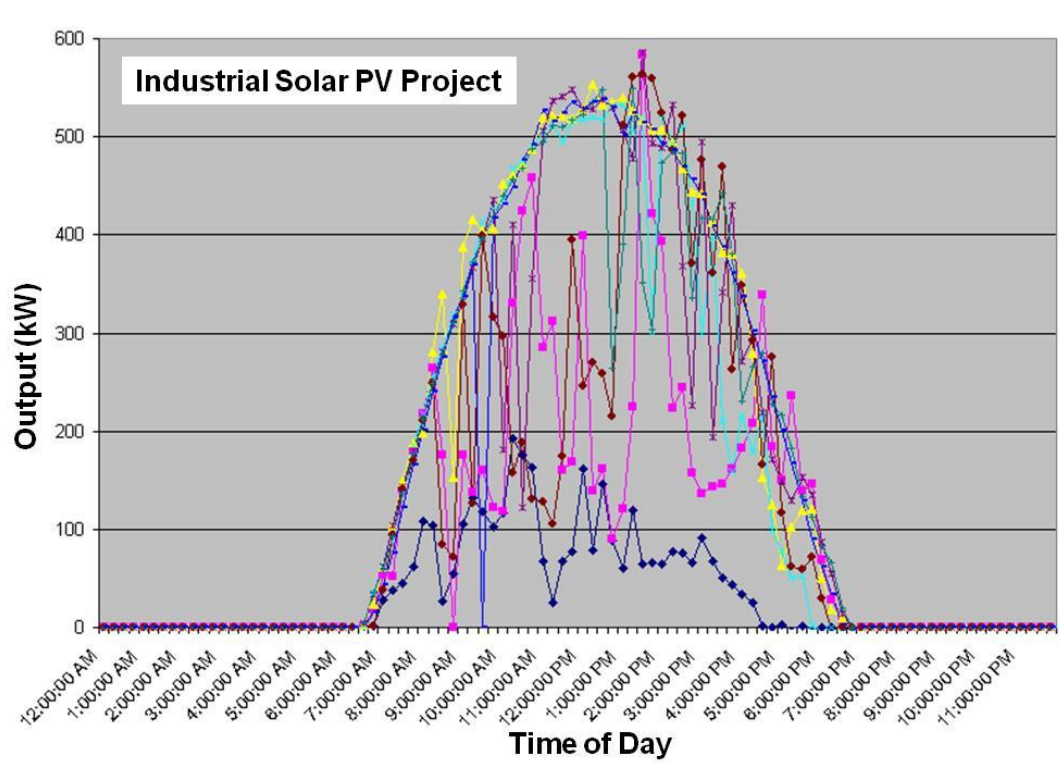
Electric Sector Paradigm Shift

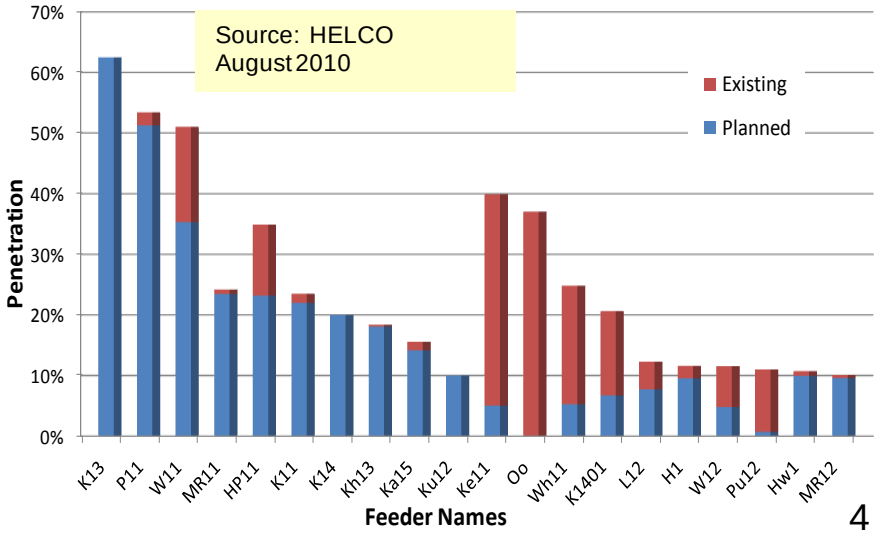


Work needed to bridge the gap by building “Seams”
Infrastructure for coordinating DG deployments with operations

Where are We Today?







$$\text{Circuit Penetration \%} = \frac{\text{Installed PV}}{\text{Max Circuit Load}}$$

Strategic DG Initiatives - Solar PV Focused

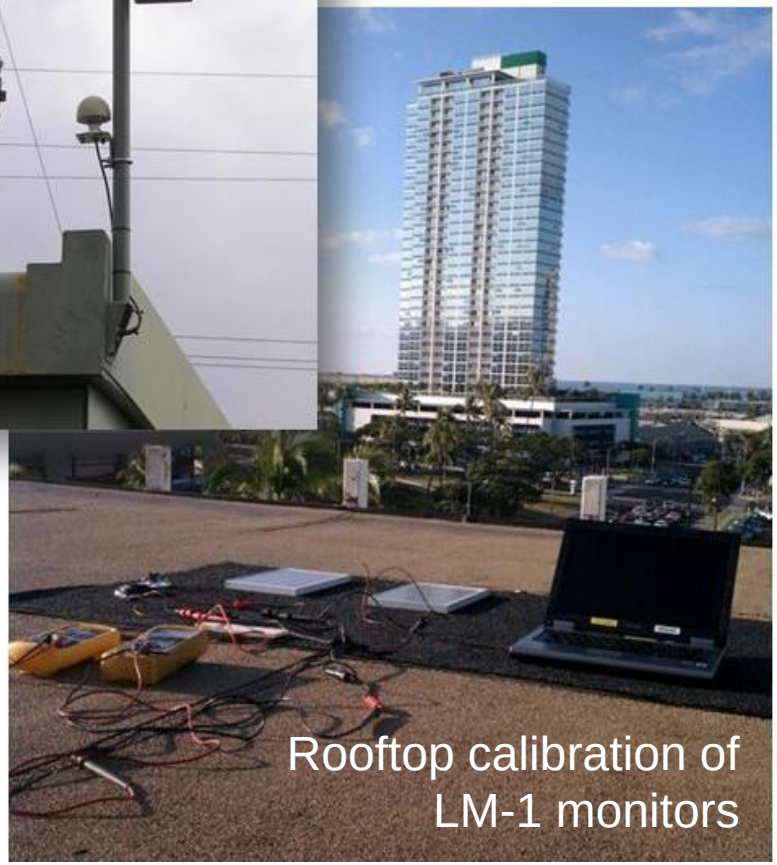
1. Sense & Monitor
2. Assess & Model
3. Inform to Act

Partnering to Develop New Forecasting Capability & Sustainable Variability Management Options

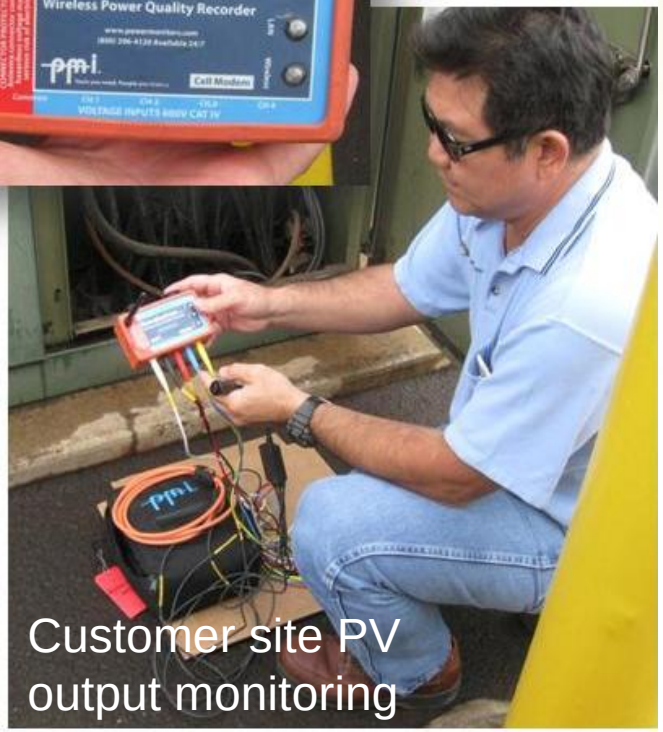
- High penetration solar analysis & scenario modeling
  - Identify and track high penetration PV circuits
  - Develop simulation capability to assess impacts
  - Evaluate new variability and load management technologies (including: substation upgrades, storage, local ramp “cushion” at plants, etc)
- Effective wind & solar ramp forecasting capability
  - Identify event triggers and correlated to times when the grid is more sensitive to variability
  - Develop tool within a timeframe to inform utility action/response
- Workforce training and outreach

SENSE & MEASURE

Field Validation Locations & Devices, Calibration & Select Customer Site Monitoring



Rooftop calibration of LM-1 monitors

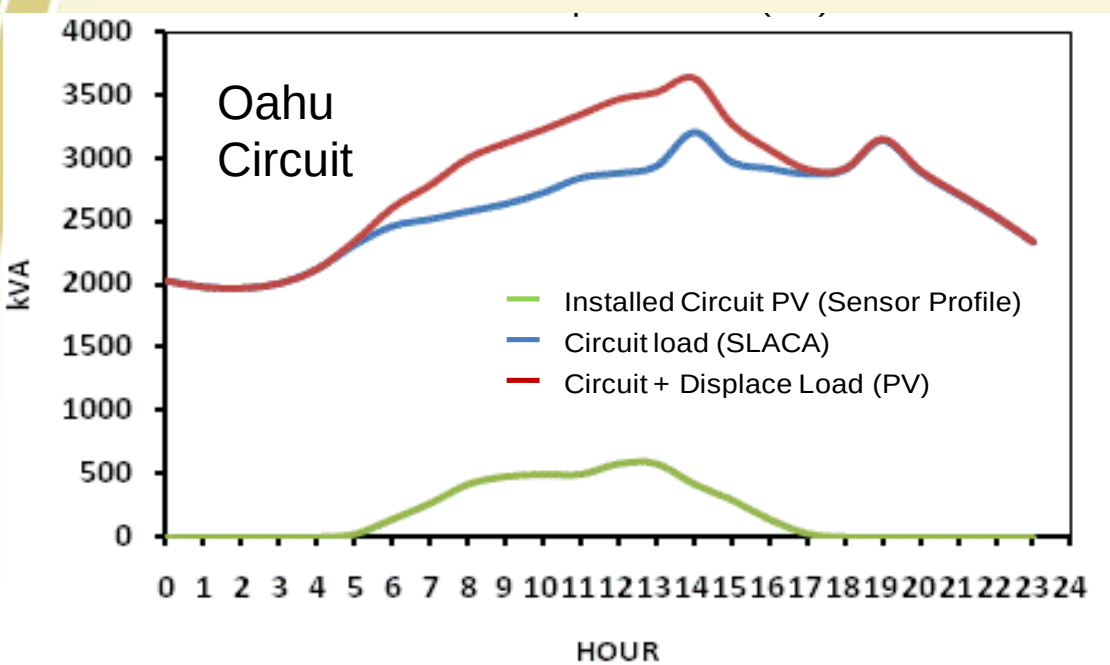


Customer site PV output monitoring

Gain insight on customer use and circuit level contribution of PV on grid

7

Hi-Pen PV Impact on the Grid - Substation Circuit Monitoring & Analysis (Operations)



- Enabling, low-cost capability to separate PV production and actual system load per circuit
- Correlate sensitive grid conditions with solar variability (max load, light load, storm conditions, contingencies, reserve plans)

Preliminary Results: Field sensor deployments and results are helping to increase visibility at the distribution level

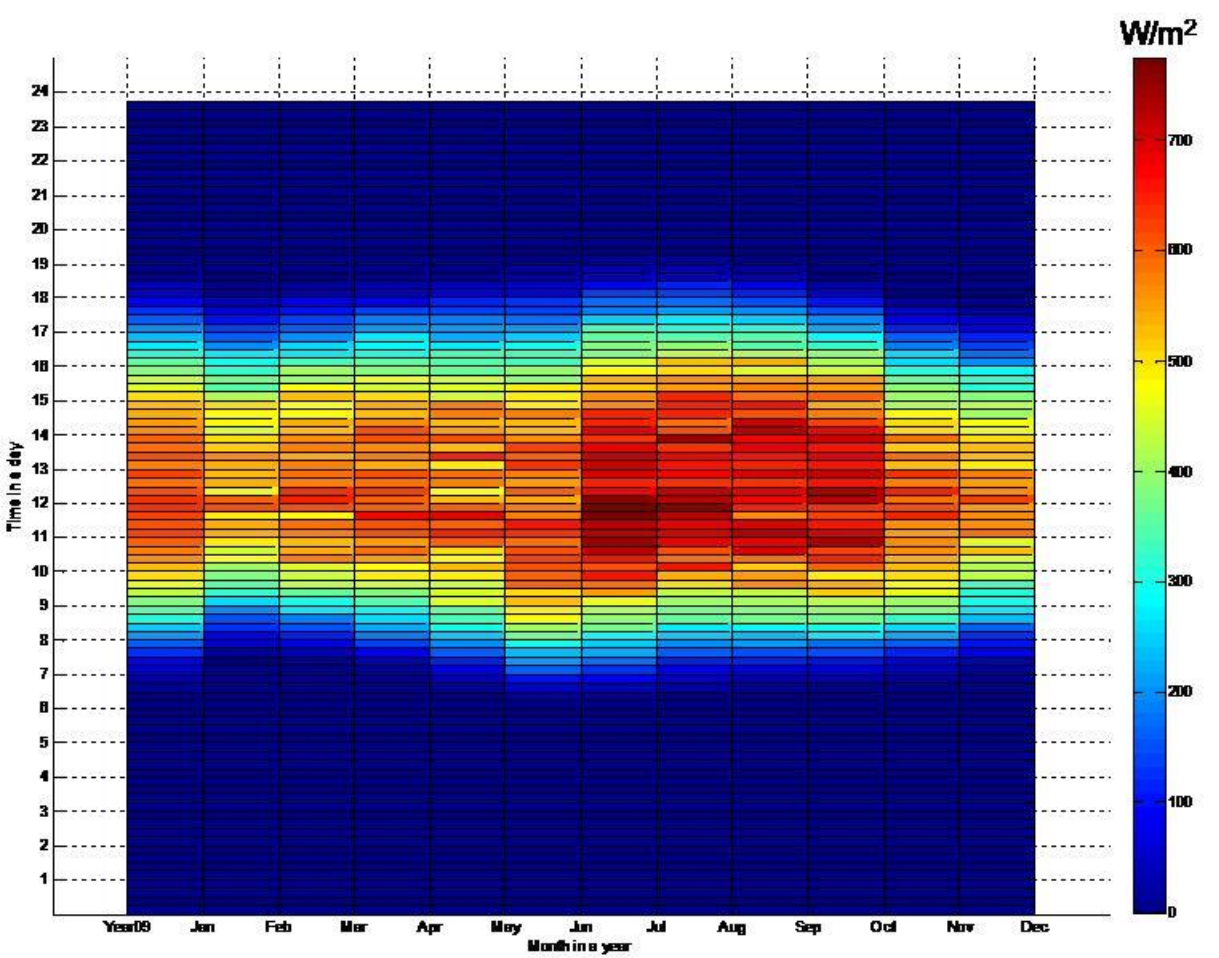
TJD-1 mobile solar irradiance sensors

LM-1 solar availability sensors

8

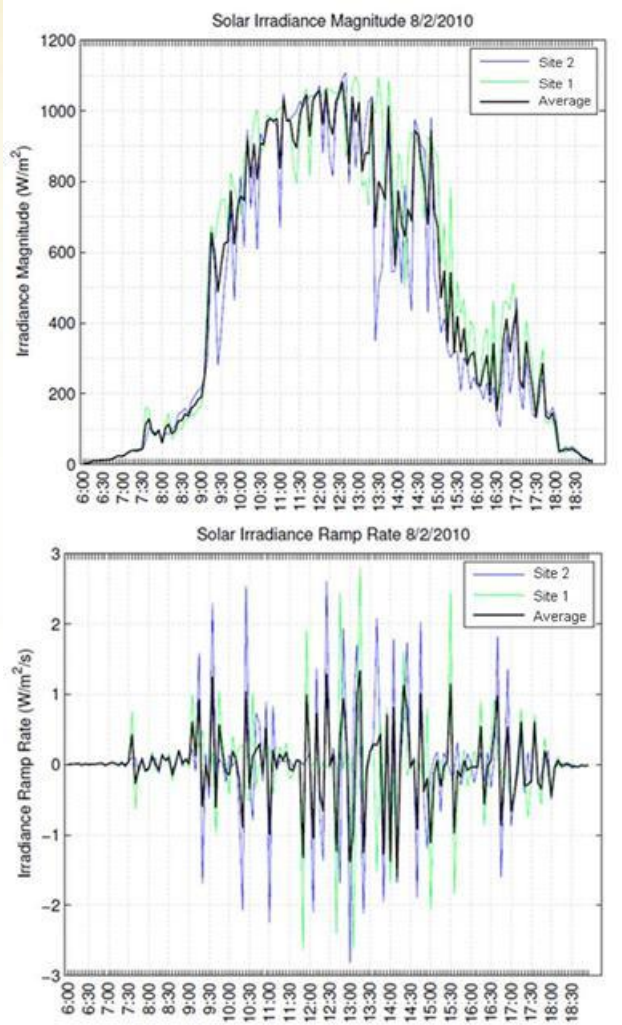
ASSESS & MODEL

Understanding the Solar Resource both Long-term & Short-term Variability (Planning)



Solar resource (W/m^2) variability over the year

Source: HECO



Sub-hourly solar variability

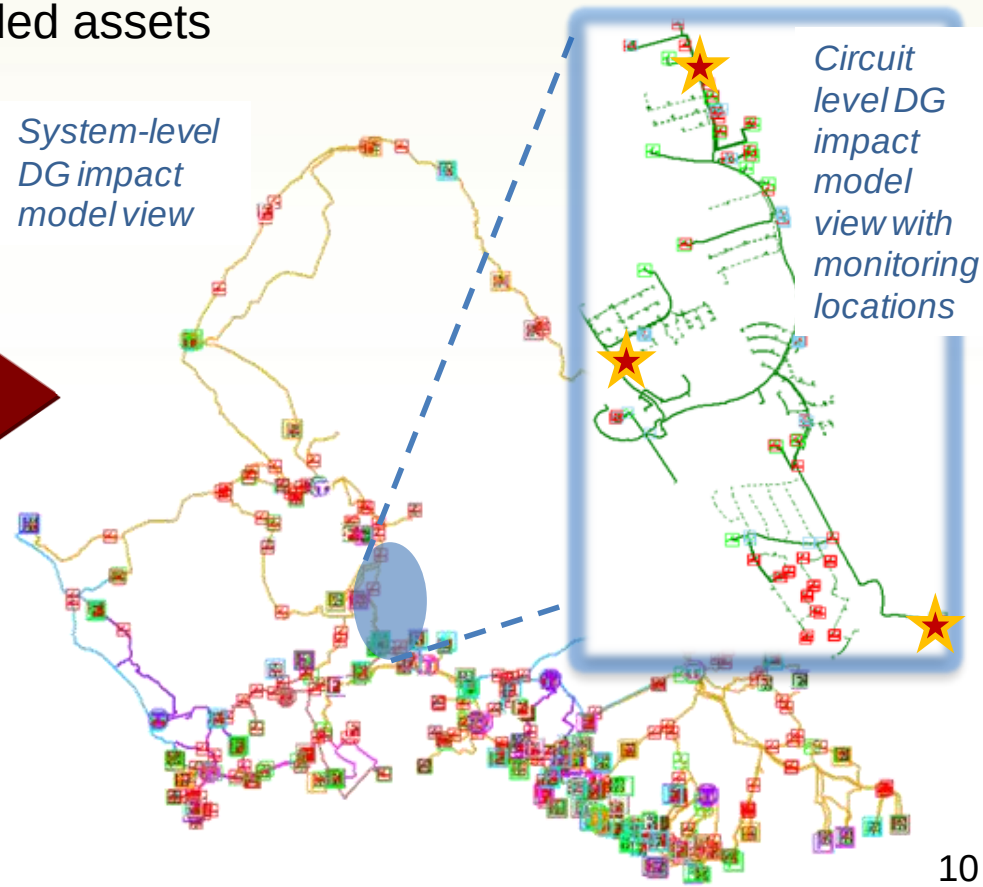
Understand how resource variability impacts the grid across different timeframes

Aggregated Scenario Model for DG

- Enables more accurate modeling of DG resources for planning
- Consistent distribution system model expedites modeling and analysis process
- Allows for “what-if” analysis to stay ahead of system change and minimize risks of stranded assets

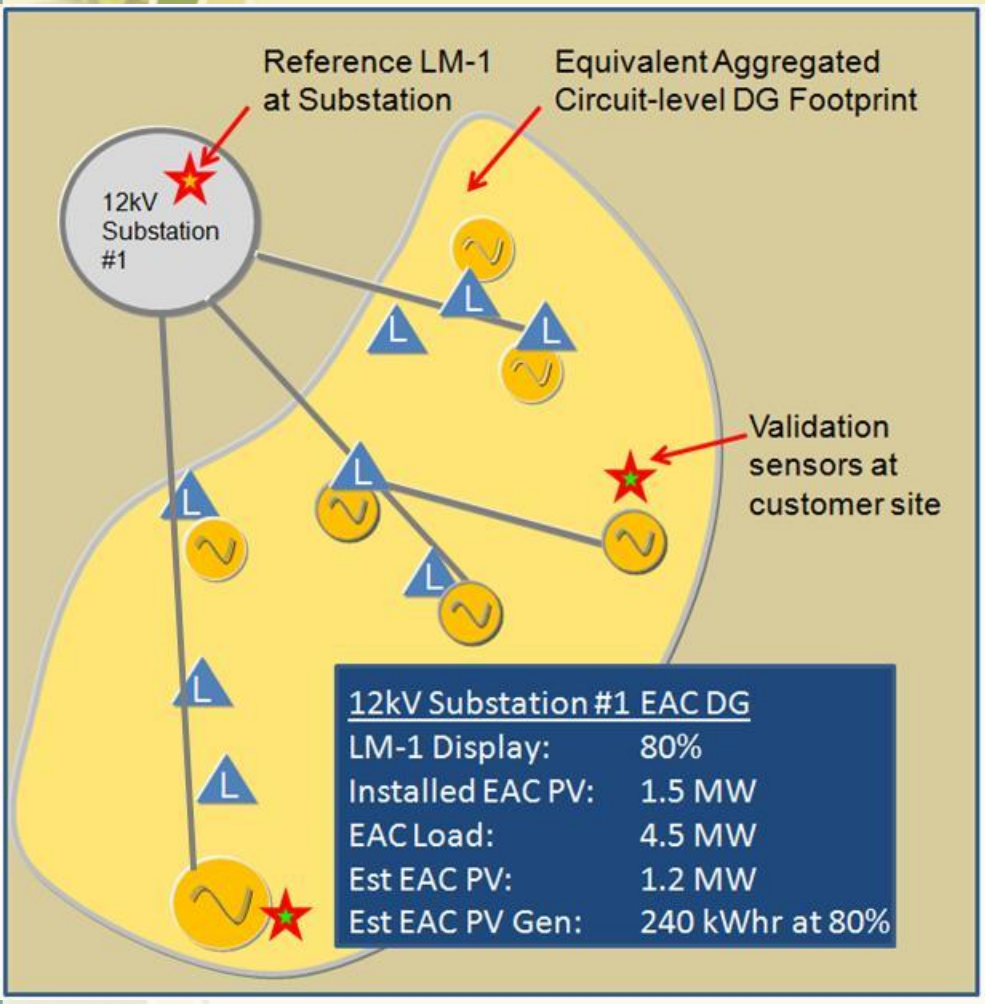
Automate conversion of DG resources into geo-rectified distribution model

System-level DG impact model view



Circuit level DG impact model view with monitoring locations

Aggregated Estimation Models: Equivalent PV Output by Circuits per Substation



- Characterize discrete and aggregated circuit load profiles at 12 kV substation (residential, industrial, commercial)
- Expedite circuit evaluations and aggregate DG impacts for planning
- Use reference LM-1 sensors to estimate solar resource output at location
- Be able to extend solar forecasting to account for aggregated impact of behind-the-meter generation

Monitoring → Engage field personnel; Gain experience

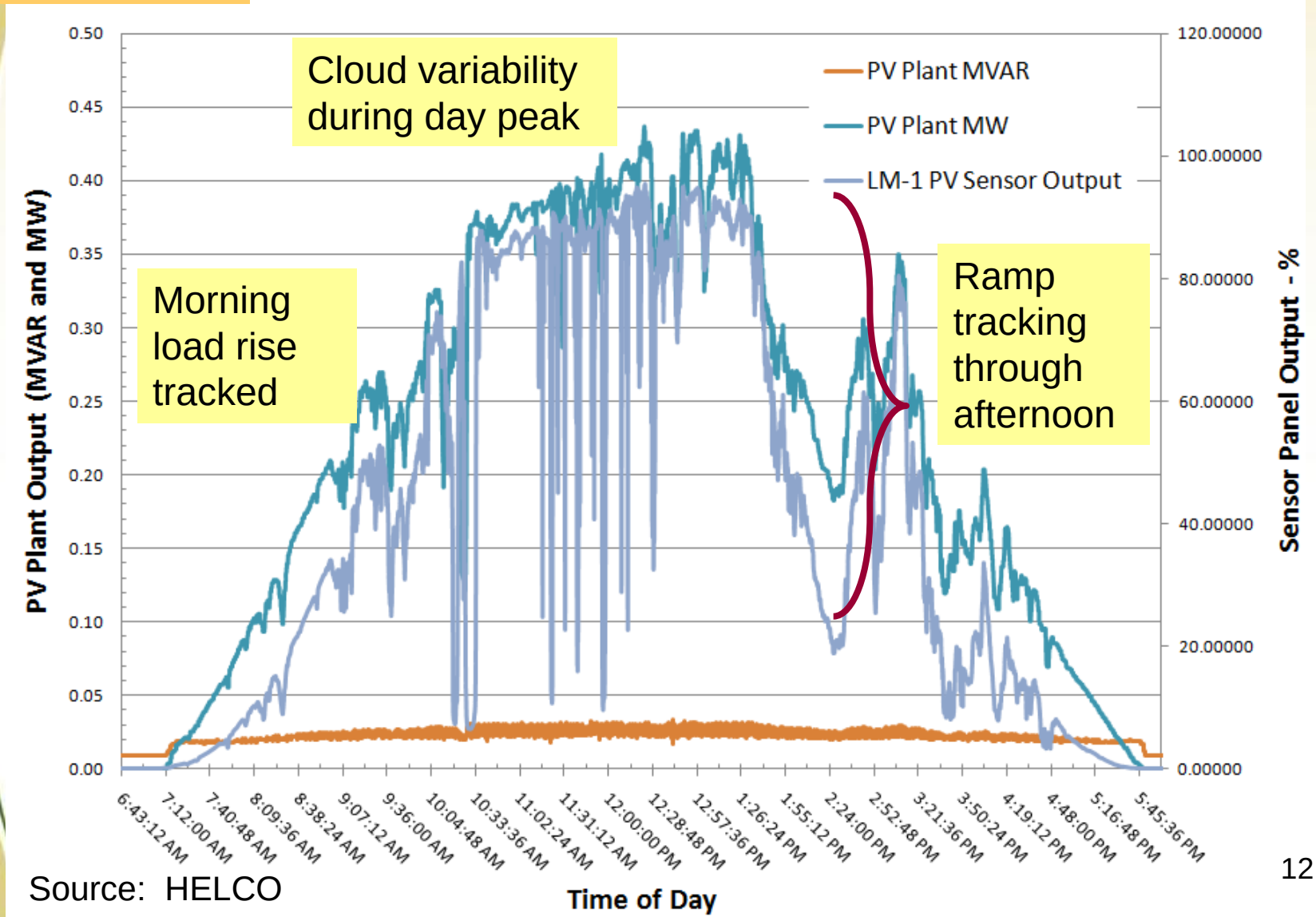
Validation → Customer sites; Employee Volunteers

Integration → Parameterization of ramp rates over various time intervals and locations

Industry Partners: SMUD/HECO Hi-Penetration Initiative, BEW Engineering, GL Noble Denton, AWS TruePower, CaISO, SCE

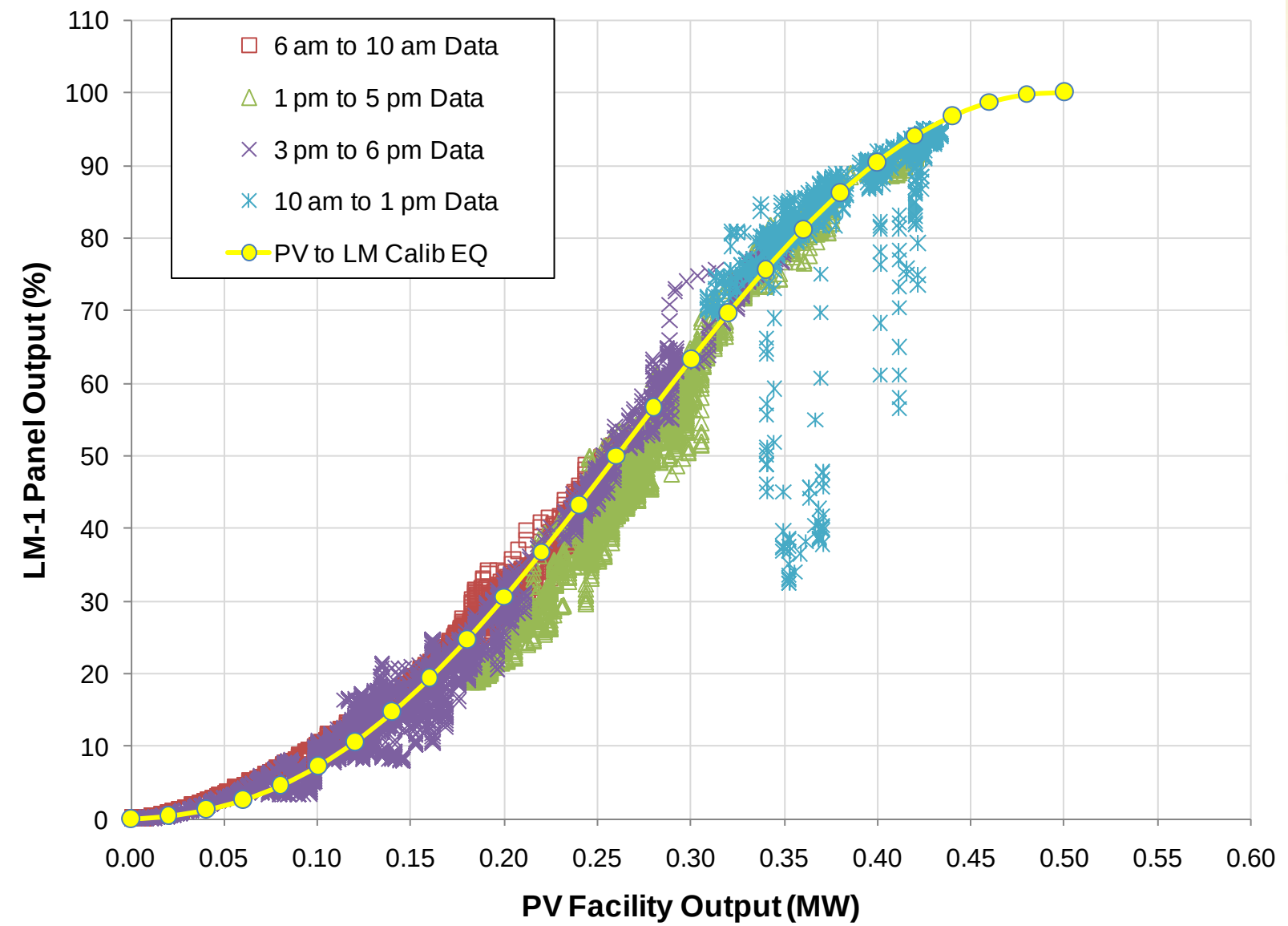
Preliminary Results of LM-1 Sensor & PV Site Comparisons

Increase Operational Visibility & Confidence

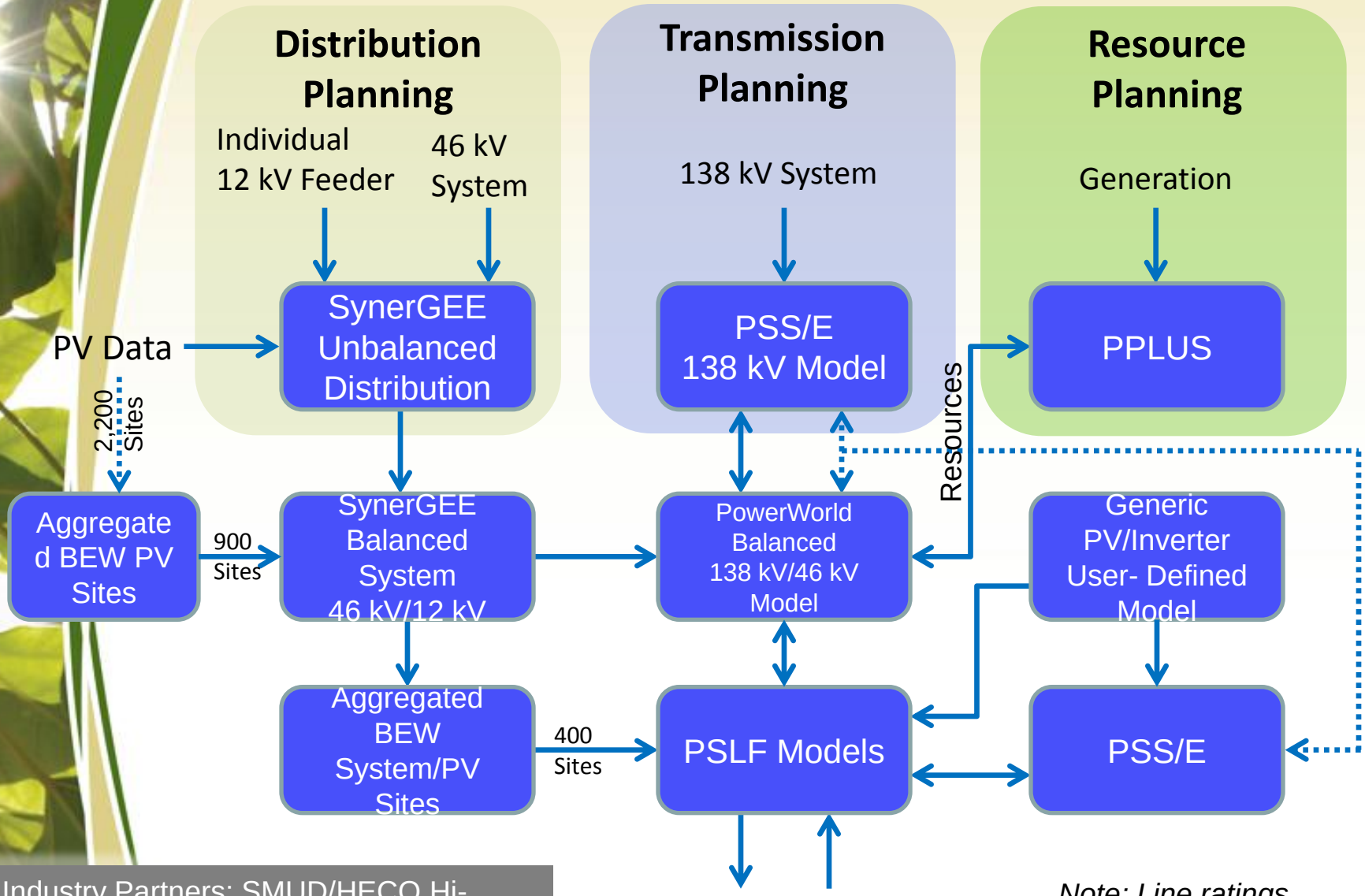


Source: HELCO

Calibration of LM-1 and PV Plant Output Across Grid Sensitive Time Periods



Graphical Flow of Model Interfaces

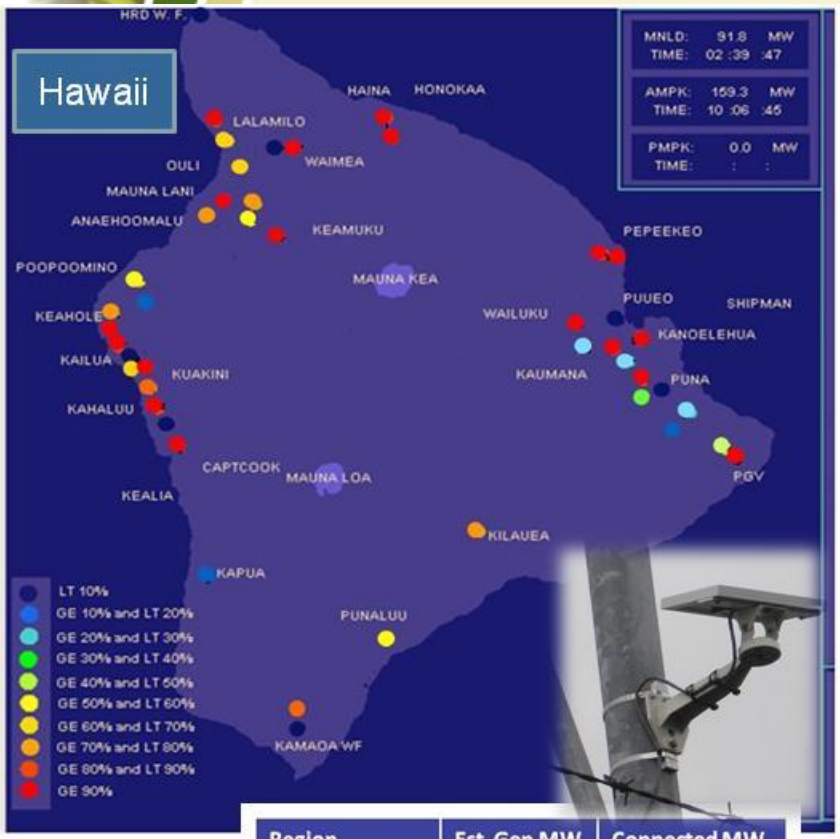


Industry Partners: SMUD/HECO Hi-Penetration Initiative, BEW Engineering, GL Noble Denton, GIS & EMS providers

Data Transfer Point

Note: Line ratings shown for Oahu system for illustration

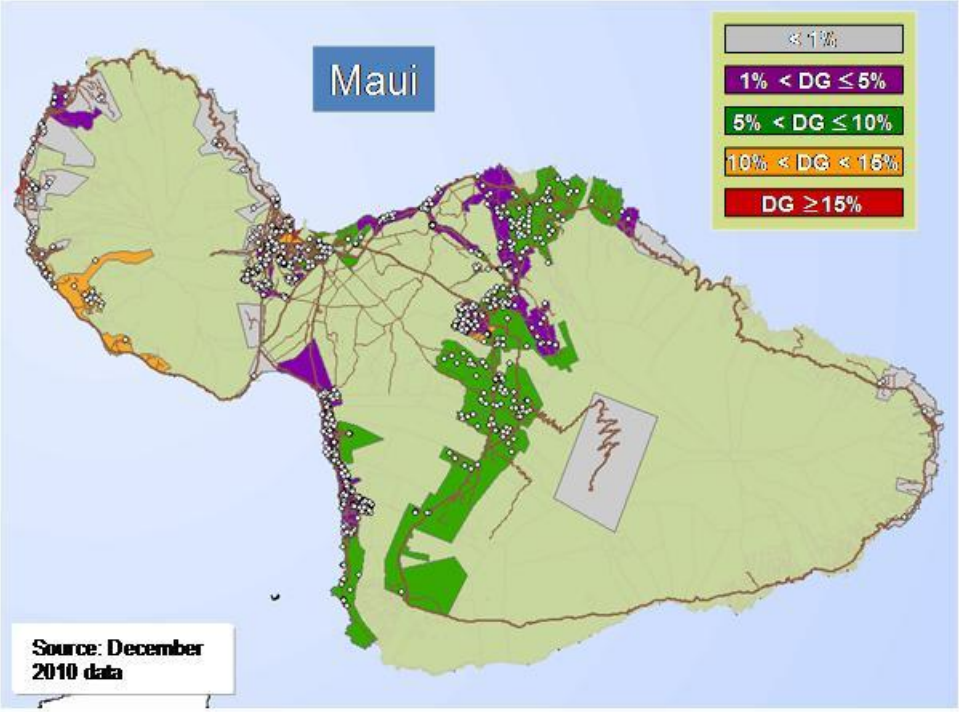
INFORM TO ACT:
Integration & Visualization Efforts



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

See and forecast production from aggregated PV resources

- Graphically display renewable resource output using LM-1 & geographic areas
- Develop overlay datasets (e.g. geographic information, circuit data, modeling results)
- Develop and pilot visualization analysis tool for hi-penetration planning & operations



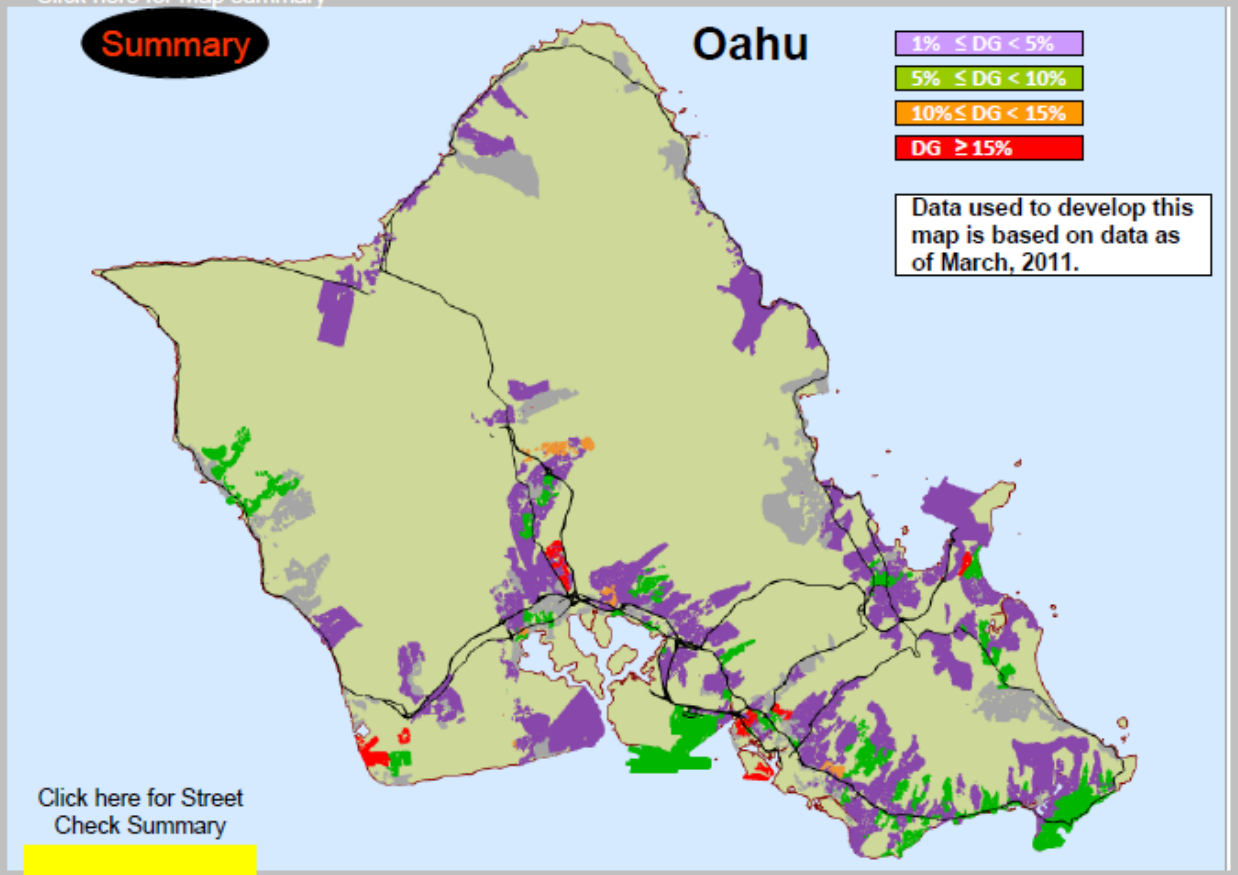
Oahu LVM and Subset of Penetration Levels by Street Names

Subset of Street names with penetration > 15%

10% ≤ DG < 15%
DG ≥ 15%

Street Name	Zip Code	Islar
ANUANU ST	96789	OAH
APAKI ST	96817	OAH
APAKI ST	96817	OAH
APOWALE ST	96797	OAH
AUIKI ST	96819	OAH
AUINA PL	96789	OAH
AUINA ST	96789	OAH
AULII ST	96817	OAH
AUMAKA PL	96797	OAH
AUPUNI ST	96817	OAH
AUPUNI ST	96817	OAH
AWAKUMOKU ST	96707	OAH
AWALAU ST	96797	OAH
AWAMOI PL	96797	OAH
AWAMOI ST	96797	OAH
AWANEI ST	96797	OAH
BANNISTER PL	96819	OAH
BANNISTER ST	96819	OAH
CHAMBERLAIN ST	96822	OAH
CLARK ST	96822	OAH
CLEMENT ST	96822	OAH
COLBURN ST	96819	OAHU
DEMOCRAT ST	96819	OAHU
DEMOCRAT ST	96819	OAHU
DILLINGHAM BLVD	96817	OAHU

Click here for Map summary



Click here for Street Check Summary

Street Check

Zip Codes

Click here to return to the Home Map

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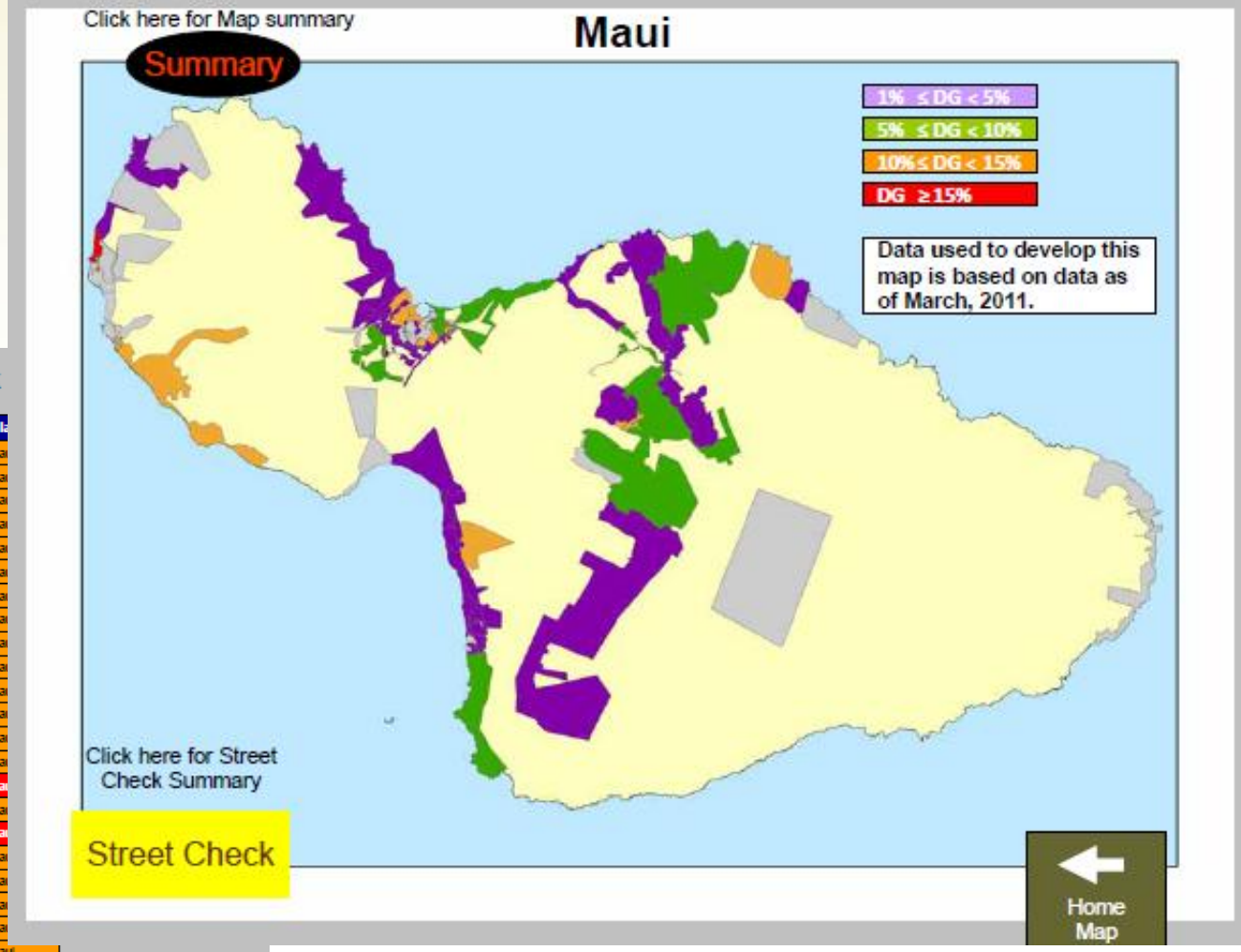
Maui LVM and Subset of Penetration Levels by Street Names

Subset of Street names with penetration > 15%



Street Penetration Check

10% ≤ DG < 15%
DG ≥ 15%

Street Name	Zip Code	Isl
HOOKELE ST	96732	Ma
HOOLAWA RD	96708	Ma
HOTEL ST	96761	Ma
HUAPALA PL	96761	Ma
HUELANI ST	96768	Ma
IAO LP	96793	Ma
IAO PL	96793	Ma
ILIAHI WY	96761	Ma
ILIKAHI ST	96761	Ma
IPU AUMAKUA LN	96761	Ma
IPU KAI LN	96761	Ma
IPU WAI LN	96761	Ma
KAAHUMANU AV	96793	Ma
KAAHUMANU AV	96732	Ma
KAANAPALI PKWY	96761	Ma
KAEO PL	96761	Ma
KAHEKILI PARK RD	96761	Ma
KAHILI PL	96761	Ma
KAHOOLAWE ST	96732	Ma
KAHULUI BEACH RD	96732	Ma
KAHULUI BEACH RD	96732	Ma
KAHULUI BREAKWATER RD	96732	Maui
KAI ALA DR	96761	Maui
KAI HELE KU PL	96761	Maui
KAI HELE KU ST	96761	Maui

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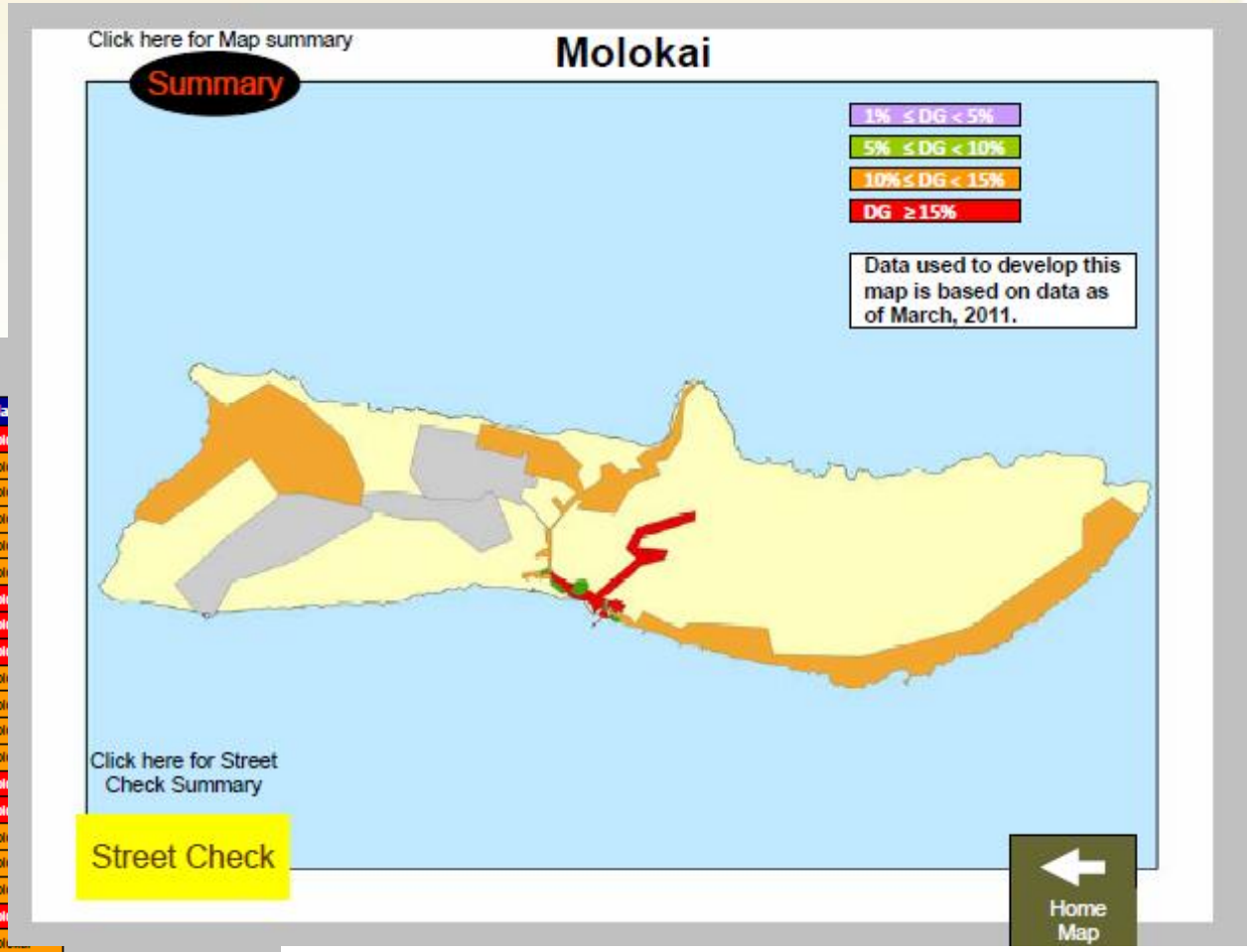
Molokai LVM and Subset of Penetration Levels by Street Names

Subset of Street names with penetration > 15%



Street Penetration Check

10% ≤ DG < 15%
DG ≥ 15%

Street Name	Zip Code	Isla
HAENA ST	96748	Mol
HALE KAWAIKAPU RD	96748	Mol
HAO KEEHI PL	96770	Mol
HAO KUNI PL	96770	Mol
HE PL	96757	Mol
HELO PL	96770	Mol
HIO PL	96748	Mol
HOAWA RD	96748	Mol
HOME OLU PL	96748	Mol
HOOULU PL	96748	Mol
HUILA ST	96757	Mol
HULIMOKU PL	96770	Mol
ILIAHI PL	96748	Mol
ILIO RD	96748	Mol
KAHANU ST	96748	Mol
KAHI PL	96757	Mol
KAHINANI PL	96748	Mol
KAIAKA RD	96770	Mol
KAIWI ST	96748	Mol
KAKAAKO RD	96770	Mol
KAKALAHALE ST	96748	Molokai
KAKALAHALE ST	96748	Molokai
KALAE HY	96757	Molokai
KALAMA RD	96757	Molokai
KALANIANAOLE AV	96748	Molokai

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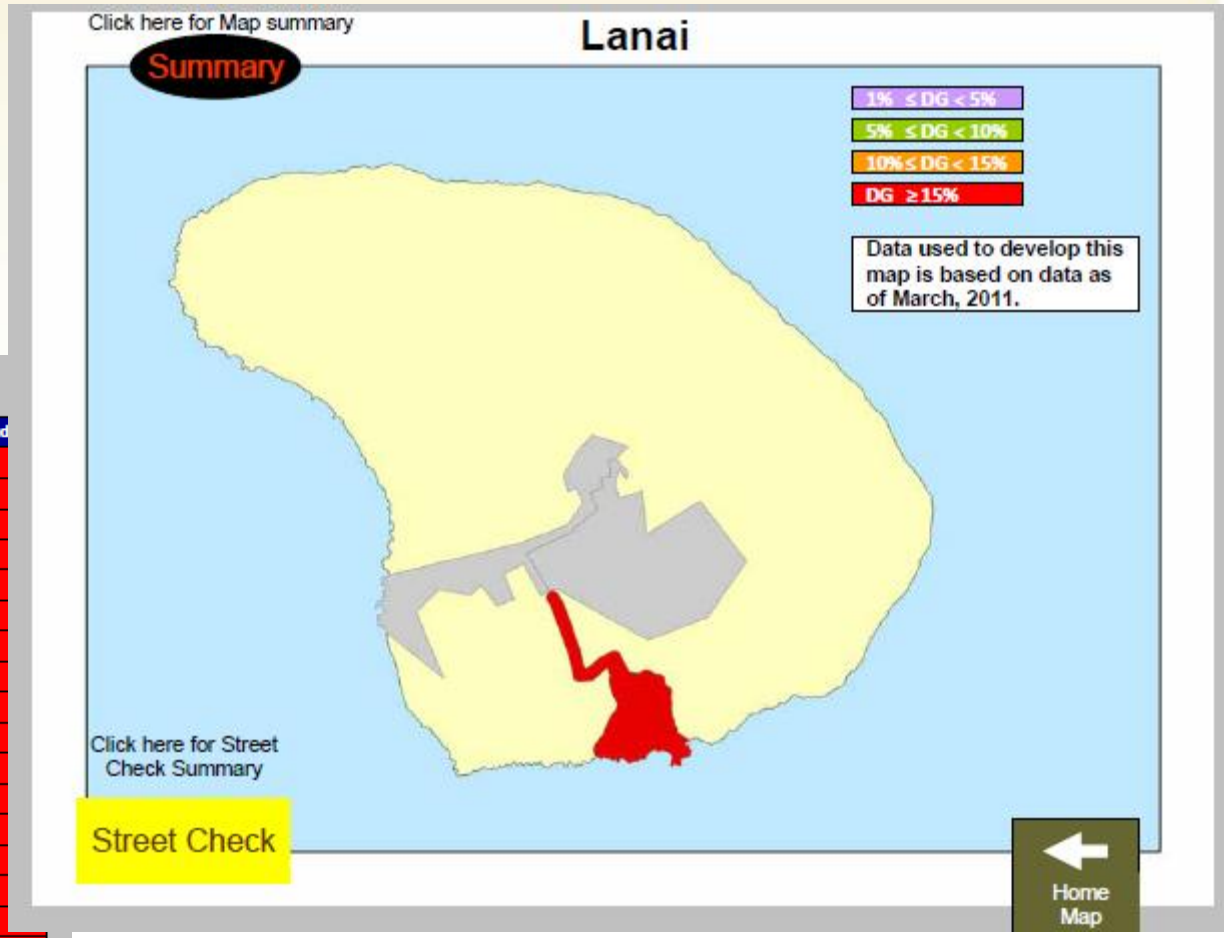
Lanai LVM and Subset of Penetration Levels by Street Names

Subset of Street names with penetration > 15%



Street Penetration Check

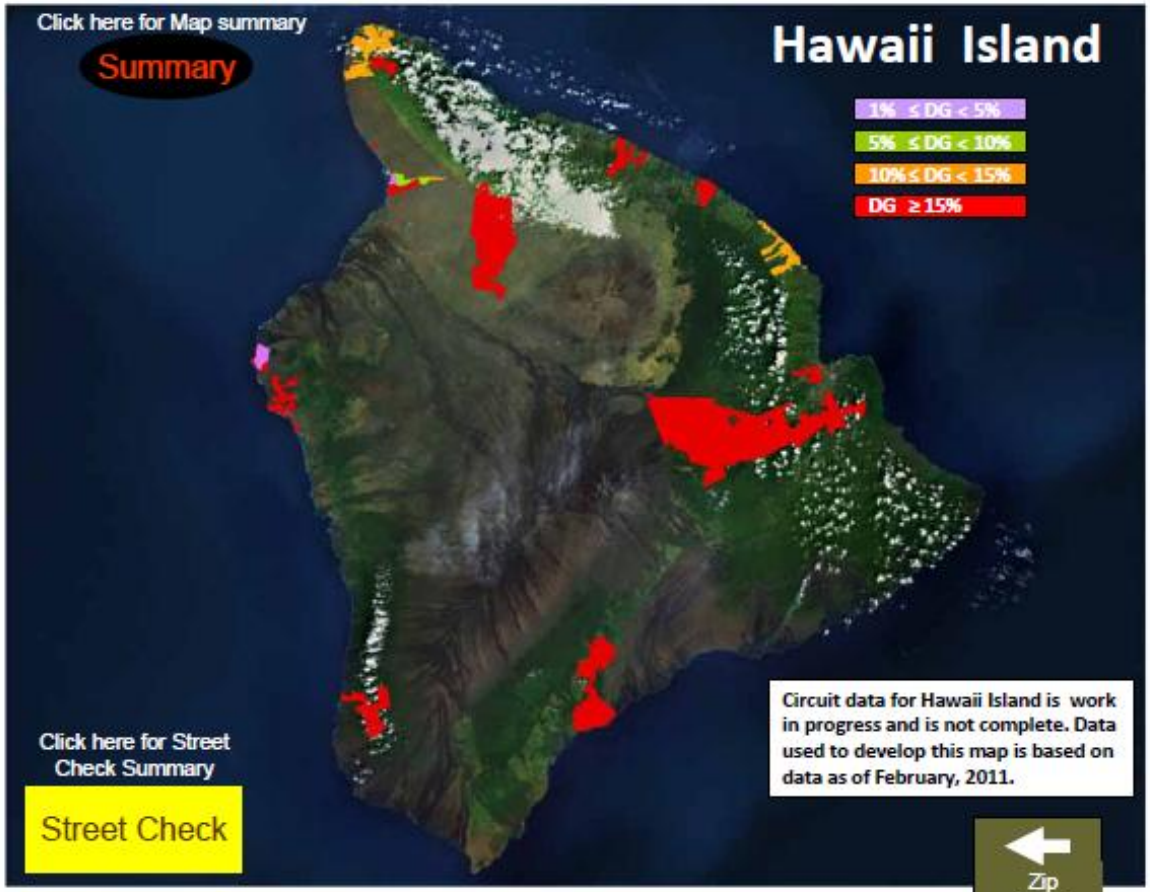
10% ≤ DG < 15%
DG ≥ 15%

Street Name	Zip Code	Island
AWEHI WY	96763	Lanai
AWIKIWIKI PL	96763	Lanai
CHALLENGE DR	96763	Lanai
E KAUHOLU PL	96763	Lanai
HULOPOE BEACH PARK RD	96763	Lanai
HULOPOE DR	96763	Lanai
KAPIHAA PL	96763	Lanai
KAUPILI RD	96763	Lanai
LAPA IKI PL	96763	Lanai
LOPA PL	96763	Lanai
MANELE BAY RD	96763	Lanai
MANELE HARBOR RD	96763	Lanai
MANELE RD	96763	Lanai
MAUNA LEI DR	96763	Lanai
MIKI RD	96763	Lanai
NAUPAKA PL	96763	Lanai
POLIHUA PL	96763	Lanai
UHALOA PL	96763	Lanai

Home Map

Hawaii LVM and Subset of Penetration Levels by Street Names

Subset of Street names with penetration > 15%



10% ≤ DG < 15%
DG ≥ 15%

Street Name	Zip Code	Isl
ALA KAHUA PL	96743	HA
ALA WAHI KANAAHO	96740	HA
ALAE ST	96720	HA
ALAPA ST	96740	HA
ALENA PL	96720	HA
ALENAIO LN	96720	HA
ALII DR	96740	HA
ALLIED QUARRY RD	96740	HA
ALOALII PL	96743	HA
ALOALO ST	96720	HA
AMAKIHI ST	96720	HA
AMAUI DR	96743	HA
AMAUI PL	96743	HA
ANE KEOHOKALOLE HWY	96740	HA
ANEKONA PL	96743	HA
ANEKONA ST	96743	HA
ANELA ST	96720	HA
ANINI ST	96740	HA
APOIKE ST	96720	HAWAII
AUPAKA PL	96740	HAWAII
AUPAKA PL	96740	HAWAII
AWAPUHI RD	96773	HAWAII
AWIKI PL	96720	HAWAII
BANANA RANCH RD	96719	HAWAII
BEERS RD	96719	HAWAII

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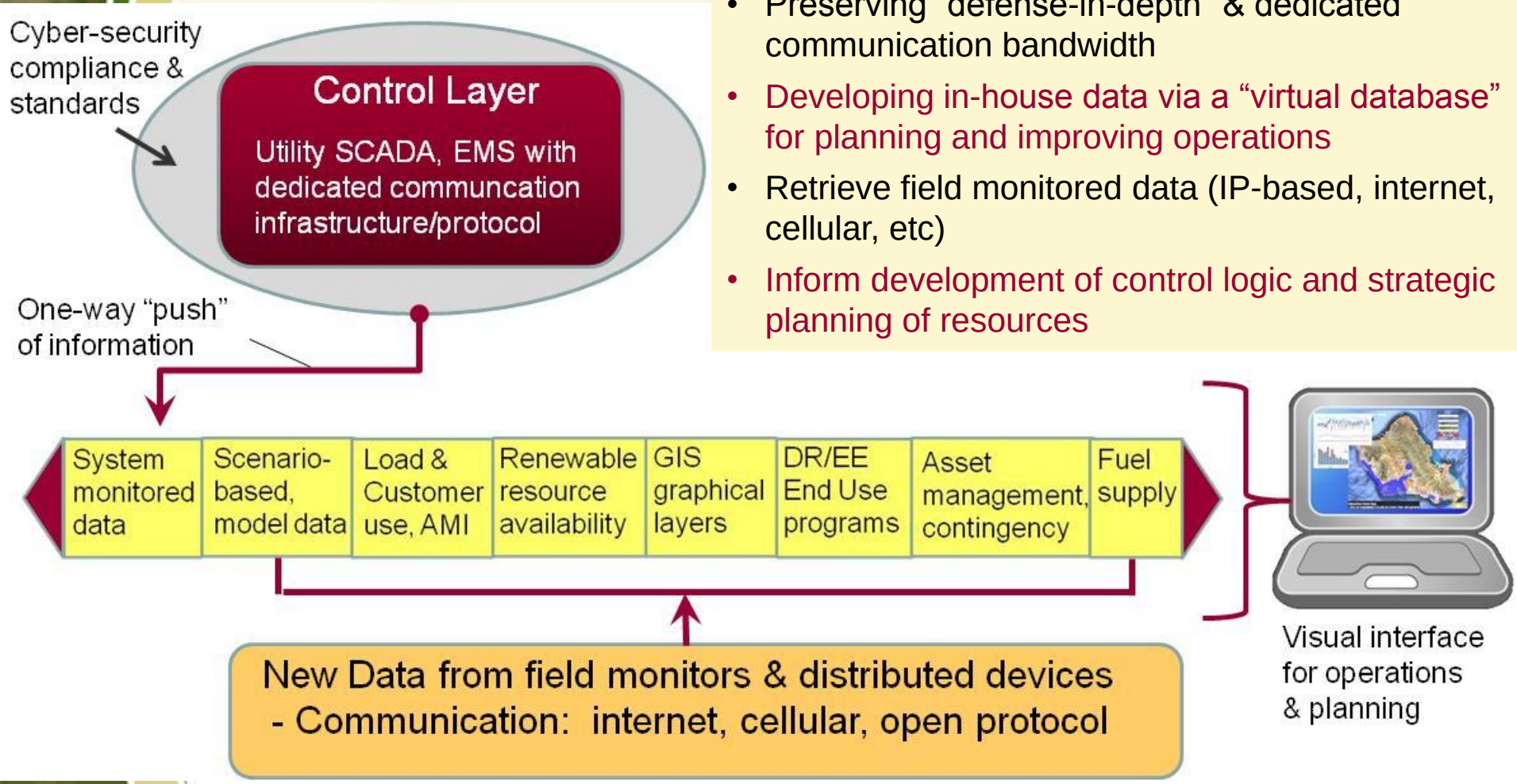
Building Visibility by Combining Data from Across the System

- Preserving "defense-in-depth" & dedicated communication bandwidth
- Developing in-house data via a "virtual database" for planning and improving operations
- Retrieve field monitored data (IP-based, internet, cellular, etc)
- Inform development of control logic and strategic planning of resources



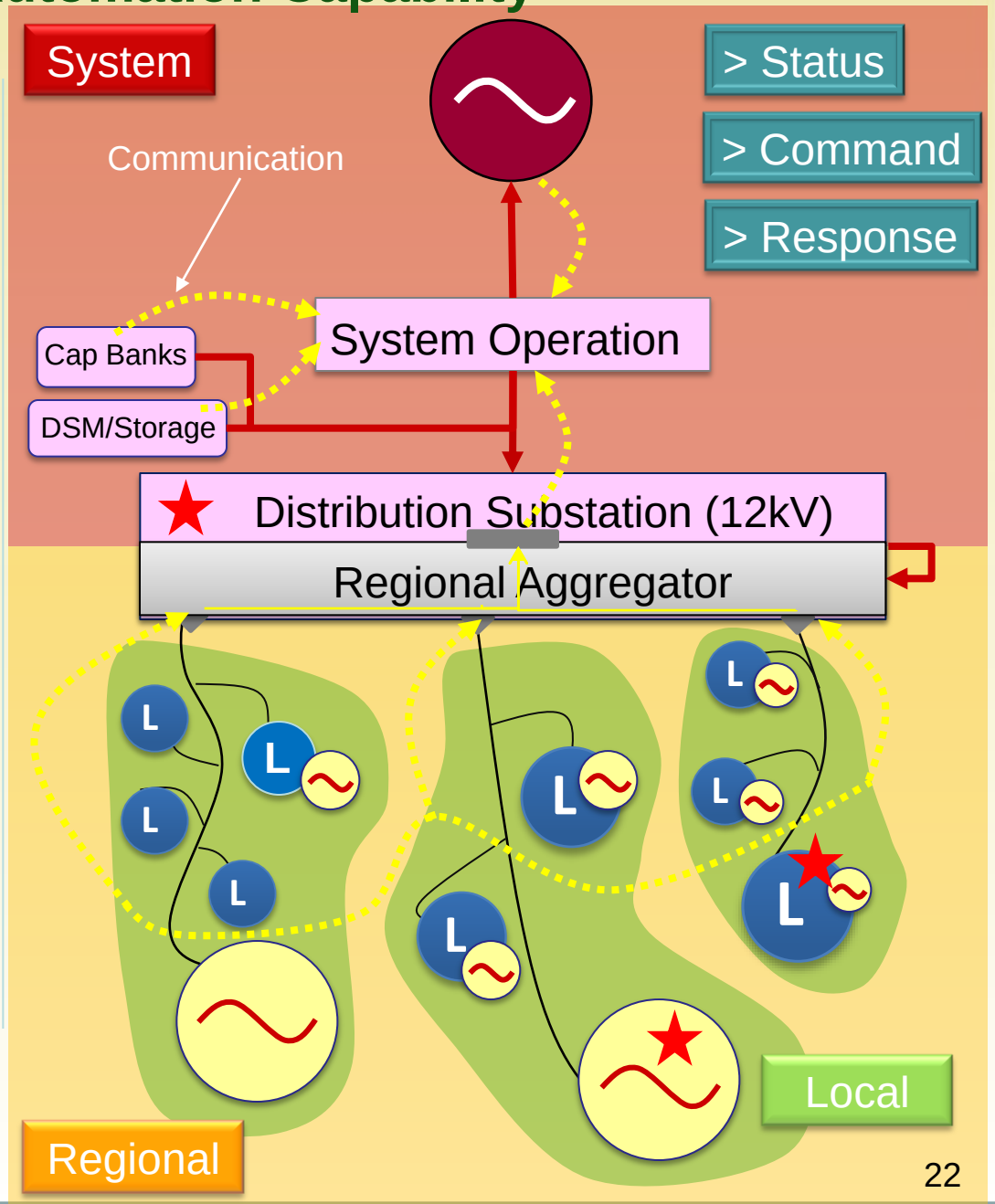
Enable Tiered (System, Regional & Local) Automation Capability

Monitoring
- Engage field personnel
- Gather & gain insight

Modeling
- Simulate response
- ID impact & sensitivities

Validation
- Pilot & iterate
- Communicate results

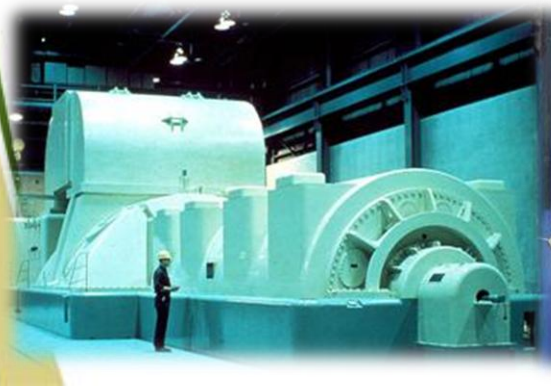
Integration
- Implement & re-evaluate for Ops & Planning

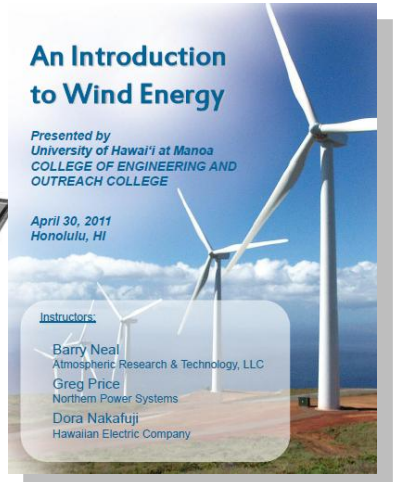


Objective: Strategically located "smart" technologies can enable reliable system, regional and local control.cc

Foundational & Rapid Workforce Training Concepts

- Utility/academia partnerships
  - Reinstate foundational electrical power generation curriculum
  - Provide hands-on training and internship
  - Build workforce pipeline to sustain green energy workforce for the islands
- Deploy technologies & conduct research on new technologies and gain operating experience via demonstration pilots
- Non-traditional short-course offerings to provide existing workforce continuing education, retooling and retraining opportunities



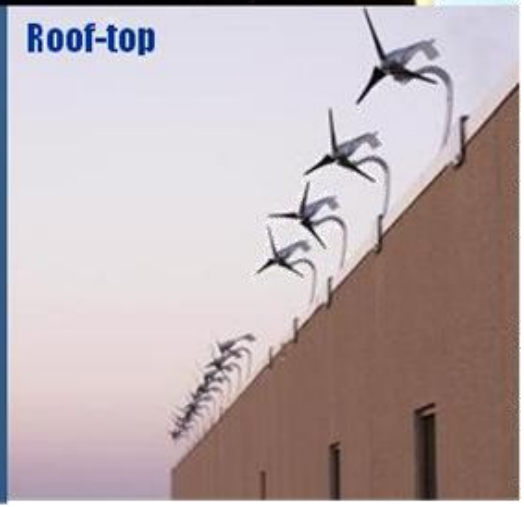


Today's Challenges!

V90 Largest land based wind turbine to date

Vestas V90, 3 MW
80m tower, 90m rotor

Tomorrow's Designs



Update on Wind

ARRA Funding of Hawaii Utility Integration (H.U.I) Deployment Initiatives

WindSENSE Utilities Industry DOE

WindNET Objectives:

- Deployment of remote sensing devices (sodar) on Hawaii (Big Island) for development of wind ramp rate forecasting pilot
- Leverage collaborations with CA, OR, HI utilities to operationalize an early warning capability for operators
- One of the first in the nation to deploy "upstream" remote sensors for utility ramp forecasting needs

WindNET Status:

- Project wrap up October 2011 – ARRA funds
- Continuing efforts for Oahu and Maui with Sodar and Temperature profiler field deployments
- Review meeting
  - September 22-23, 2010 Hilo, HI – conducted
  - July 12-13, 2011 Hilo, HI - Tentative
- Current efforts
  - Data collection & verification
  - Ensemble model comparisons (iterative)
  - Planning operators meeting to review results and discuss control room integration needs (e.g. process, tools)

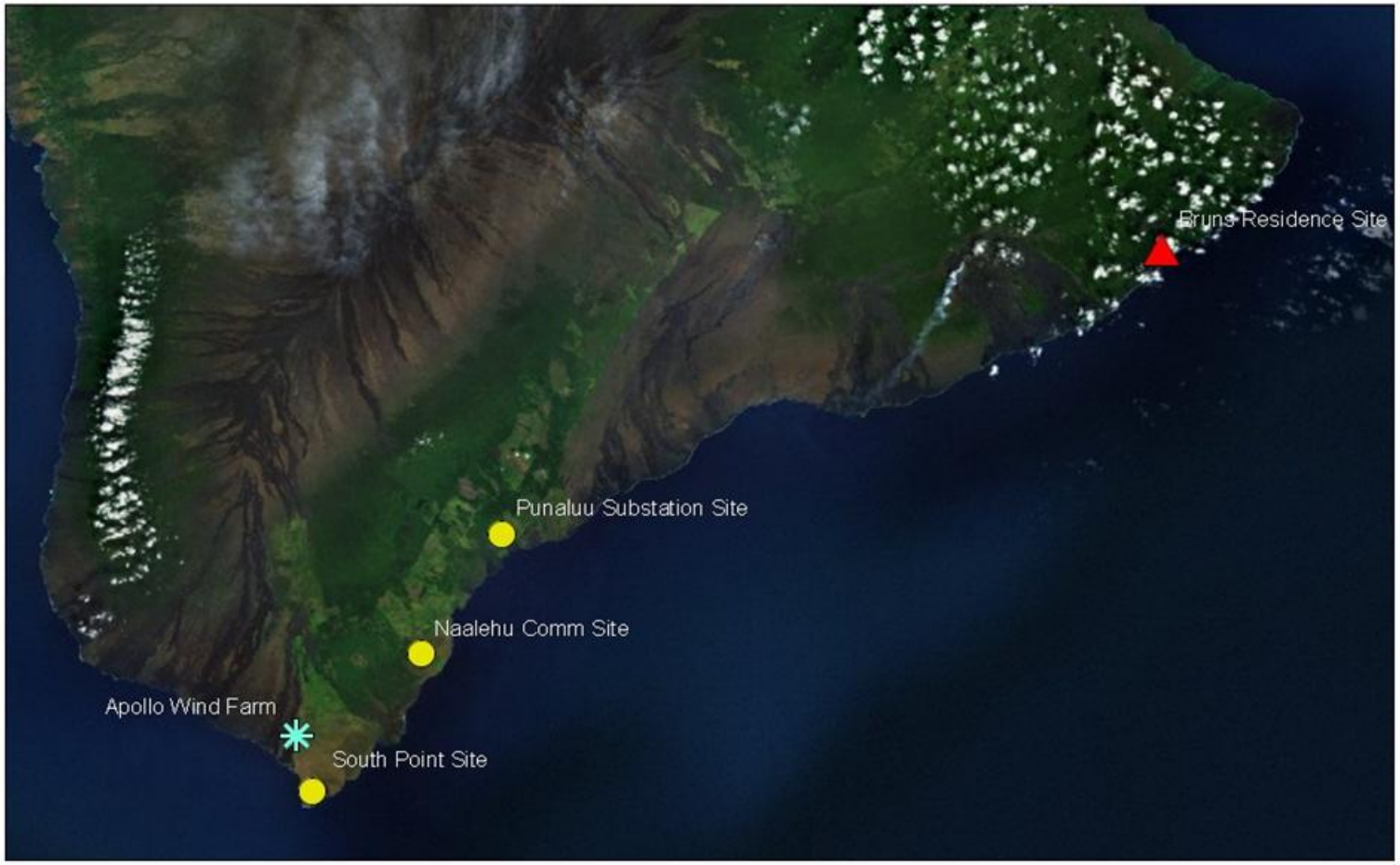
Industry Partners: HECO/HELCO/MECO, AWS TruePower, DHHL, US DOE/NREL
WindSENSE group including BPA, CaISO, SCE, PG&E, SMUD, LLNL, CEC

Exploring Various Siting Options

Proposed Site	Land	Access	Onsite Power	Overall
Kua O Ka La Charter School*	√	√	X	NO GO
National Park+	X	X	X	NO GO
Kamoa Switching Station+	X	√	√	NO GO
Punaluu Substation+	√	√	√	GO
Naalehu Comm. Site+	√	√	√	GO
South Point+	√	√	X	GO

*Radiometer site
+Sodar site

Final Site & Equipment Locations



WINDNET
EQUIPMENT LOCATIONS

Legend

Sodar Location

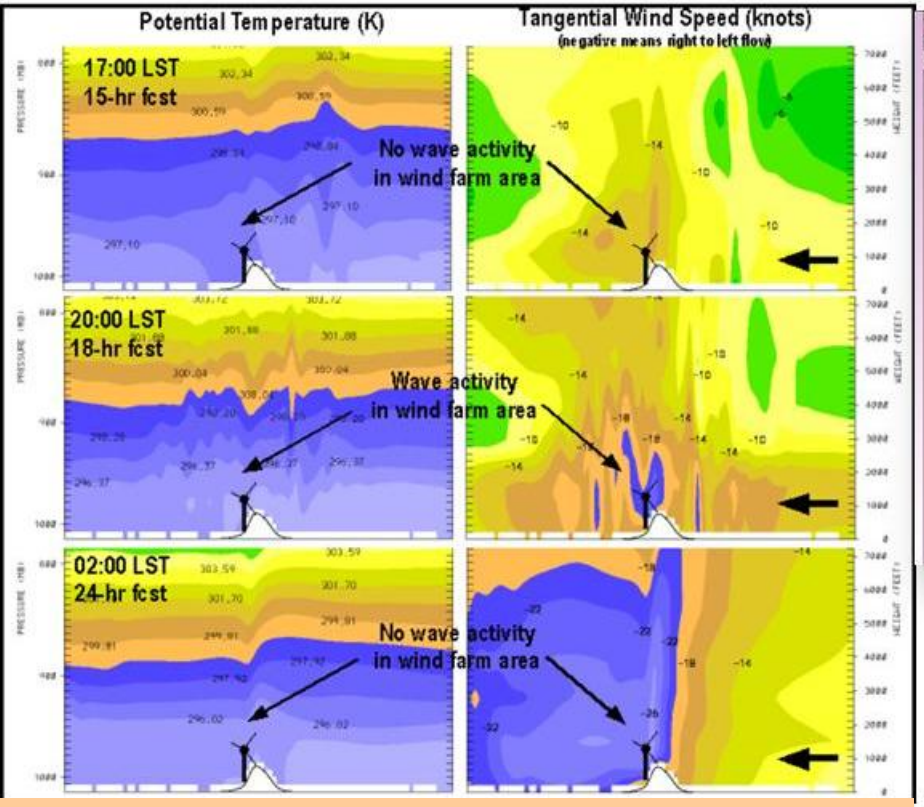
Radiometer Location

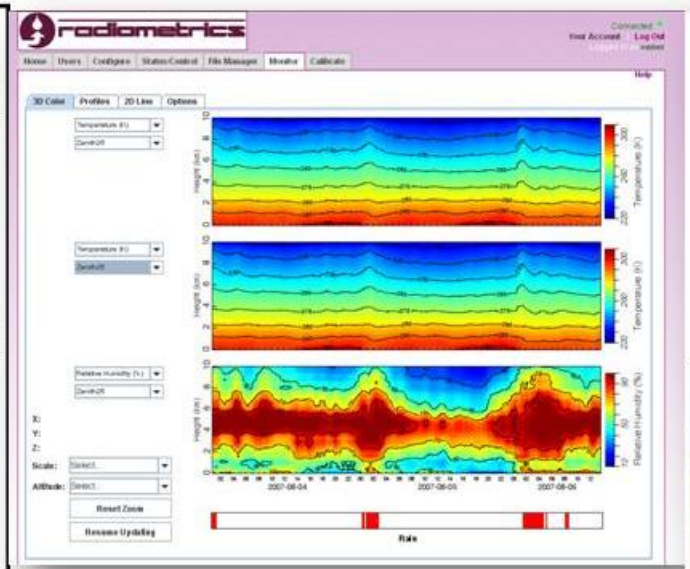
Wind Farm Location

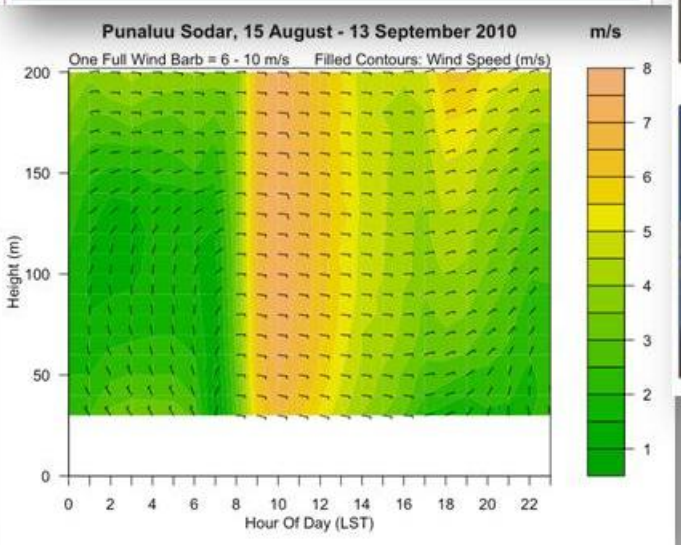
Reference

AWS Truepower

Non-Traditional Utility Equipment & Visualization Tools







Use state-of-the-art meso-scale models to identify key atmospheric indicators of ramp event and deploy remote measurement devices (sodar, temperature profiler) to verify

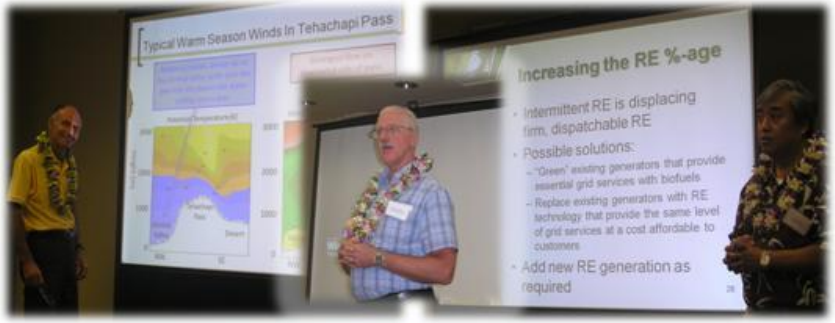
Substation Deployment

- More site security
- Leverage communication infrastructure
- Direct integration into control room

WindNET Ramp Rate Forecasting

- Remote sensing of prevailing conditions prior to wind facility
- Investigating capability to forecast for wind ramps
- Provide heads up tool for utility operators to prepare
- Involving local community and landowners through deployment activities
- Educating the utility workforce and community on remote tools and importance of wind forecasting

WindNET Project NEXT Update
tentative - *July 12-13, 2011 Hilo, Hawaii*



Topics to Cover:

- Results of observational targeting
- Field and utility deployment plan – use of Sodar network
- Ensemble forecast results for Hawaii

Questions/Comments??

Mahalo

Family of HEI Utilities

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