Grid Stability-Looking at High Penetration PV

Elaine Sison-Lebrilla, P.E.

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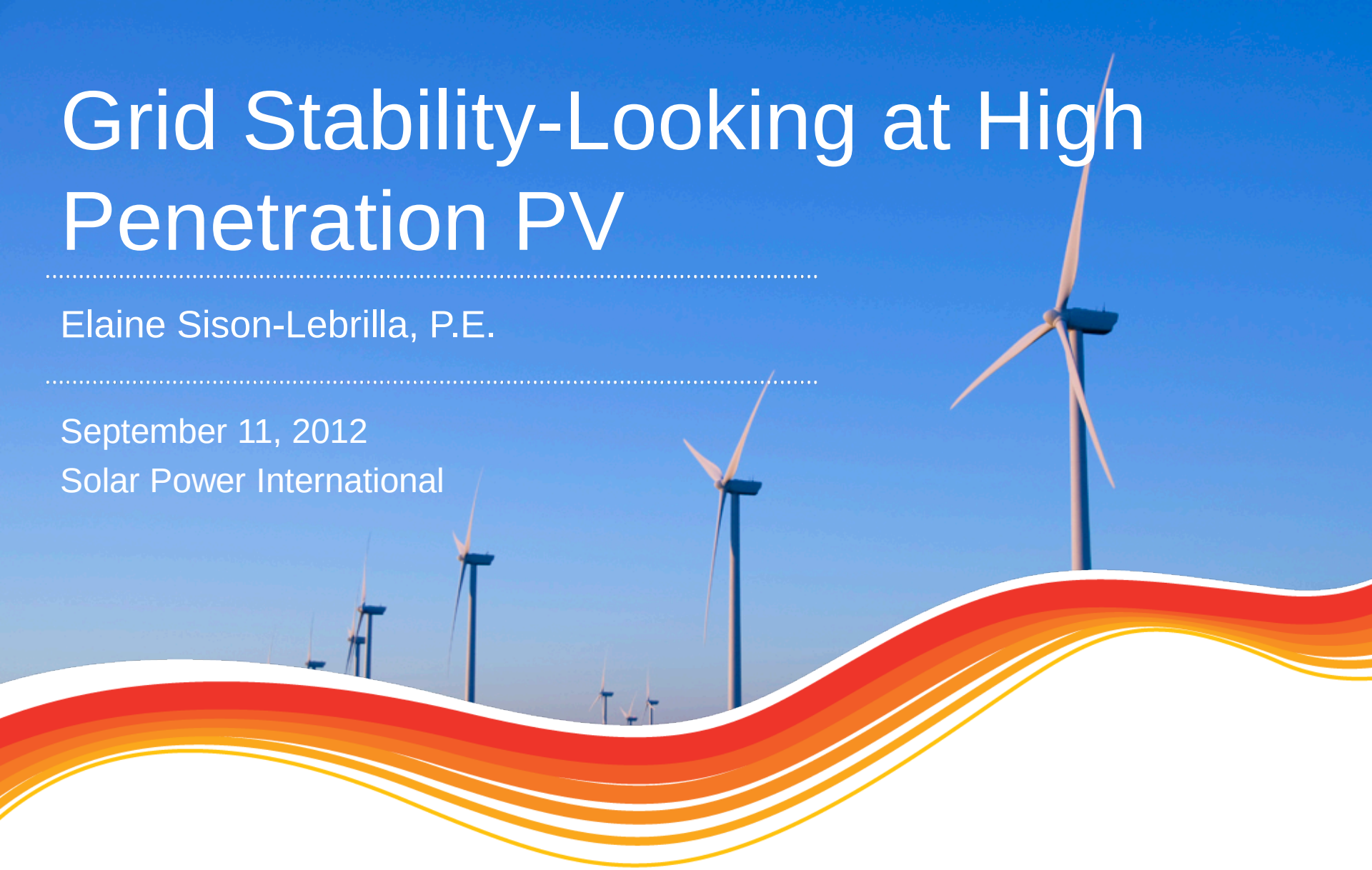
Solar Power International



Powering forward. Together.

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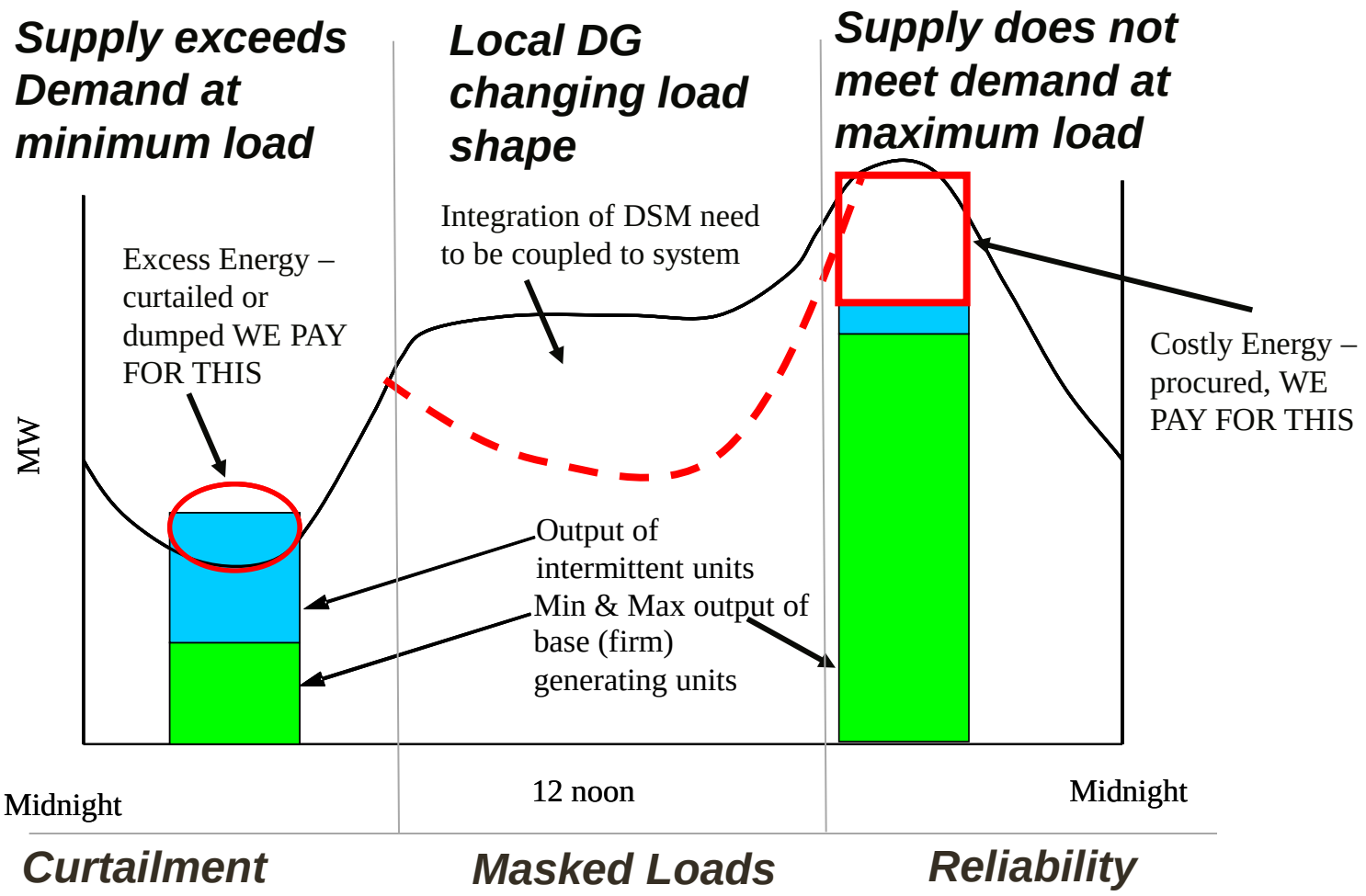
Issues Being Encountered as Penetration Increases



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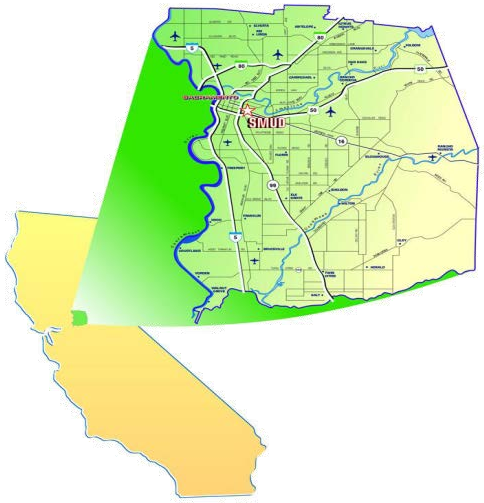
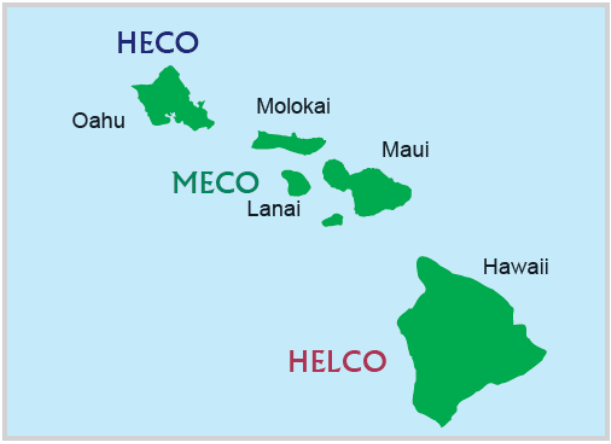


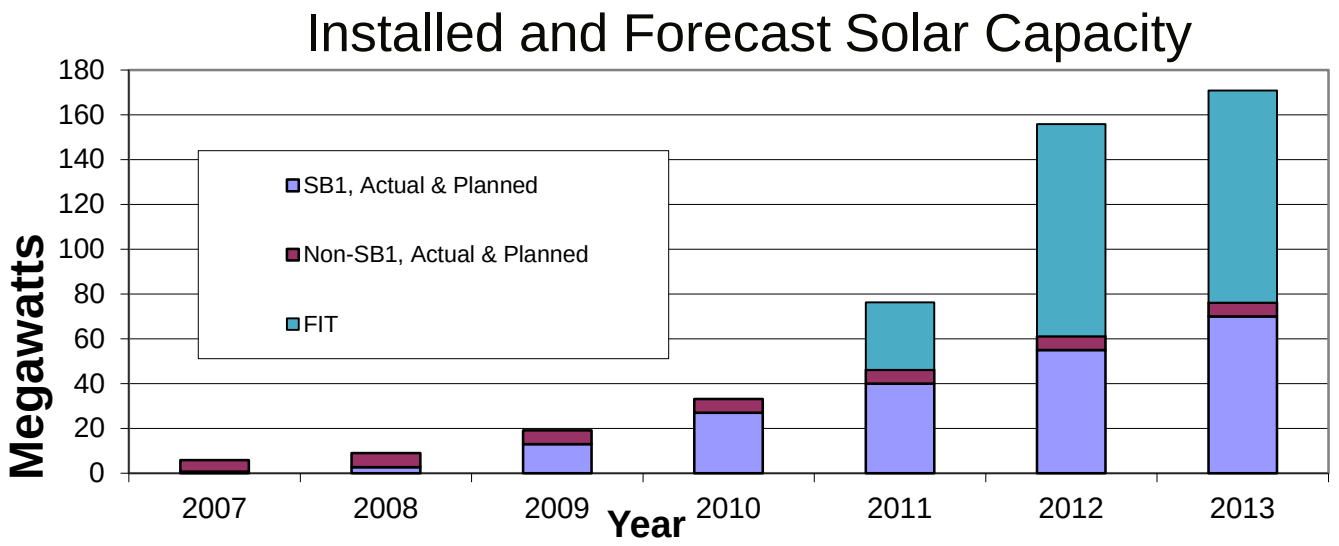
- Publicly Owned (Sixth Largest in U.S.)
- Service area of 900 square miles, serving 1.4 Million (Sacramento County and parts of Placer)
- Over 578,000 Residential, Commercial and Industrial customers

HECO

- Regulated utility, providing energy for the islands for over 100 years
- Hawaiian Electric Utilities (HECO/MECO/HELCO) serve 95% of the state's 1.2 million residents on the islands of Oahu, Maui, Lanai, Molokai and the Big Island Hawaii.



Solar Energy Growth at SMUD



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High Penetration PV Initiative Team

Team	Primary Staff
SMUD SACRAMENTO MUNICIPAL UTILITY DISTRICT The Power To Do More.SM	Elaine Sison-Lebrilla, Obadiah Bartholomy and David Brown
Hawaiian Electric Company	Tom Aukai, Dora Nakafuji (HECO) Laura Rogers, Hal Kamigaki (HELCO) Chris Reynolds (MECO)
B=W ENGINEERING	Ron Davis, Emma Stewart, Billy Quach, Slavko Vasilic
NEO Virtus Engineering, Inc	James Bing
EPRI ELECTRIC POWER RESEARCH INSTITUTE	Brian Seal

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High Penetration PV Initiative

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 capability including hardware and software to evaluate the impact of high penetrations of PV systems on our grid
- Transfer of lessons learned to other utilities

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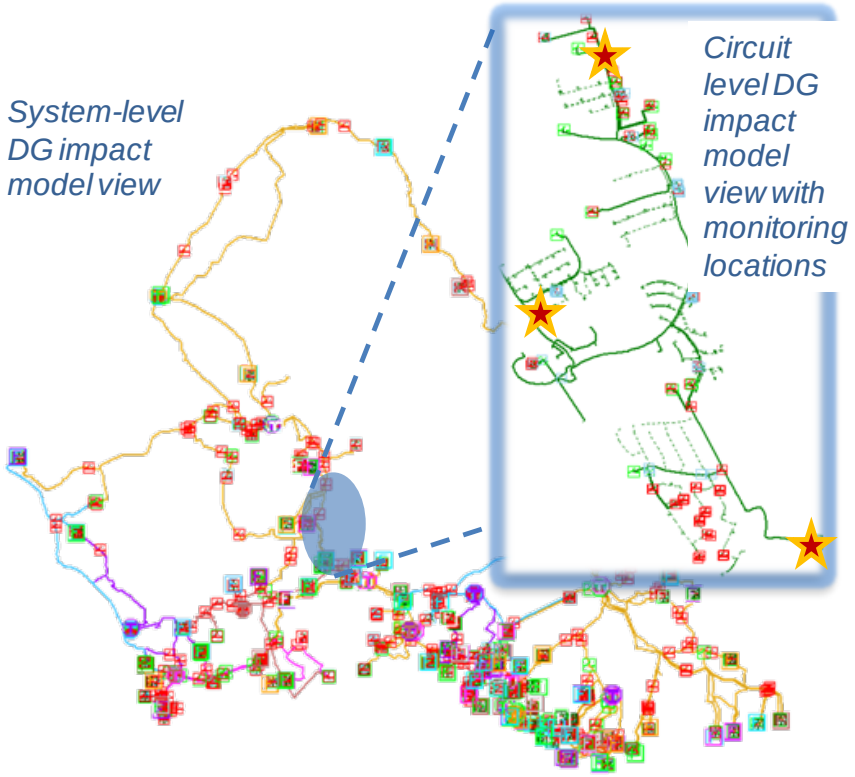
Baseline Modeling of SMUD and HECO Systems

- Identify high penetration circuits and characteristics
- Gather circuits data (i.e. voltage, loads, PV production) and baseline models
- Conduct distribution circuit and systems modeling
- Assess and visualize results



Objectives: Use DG models to simulate and track PV penetration levels for impact and potential value. Link results of distribution model (SynerGEE) to inform transmission modeling

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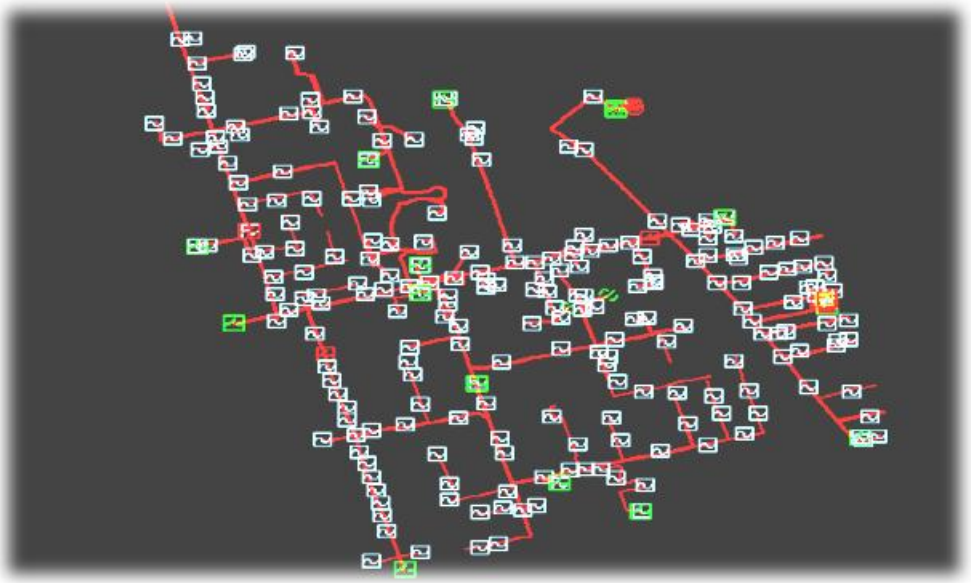
Field Monitoring and Analysis

- Install solar monitoring equipment
- Collect high resolution field data (seconds-minutes PV generation and load by circuit)
- Validate simulation runs with observed field data



Synergee model of Anatolia Subdivision

Objectives: Use simulation, testing and validated results to address grid impacts (e.g. protection, voltage regulation, VAR control, fault contribution, reverse power flows, etc.)

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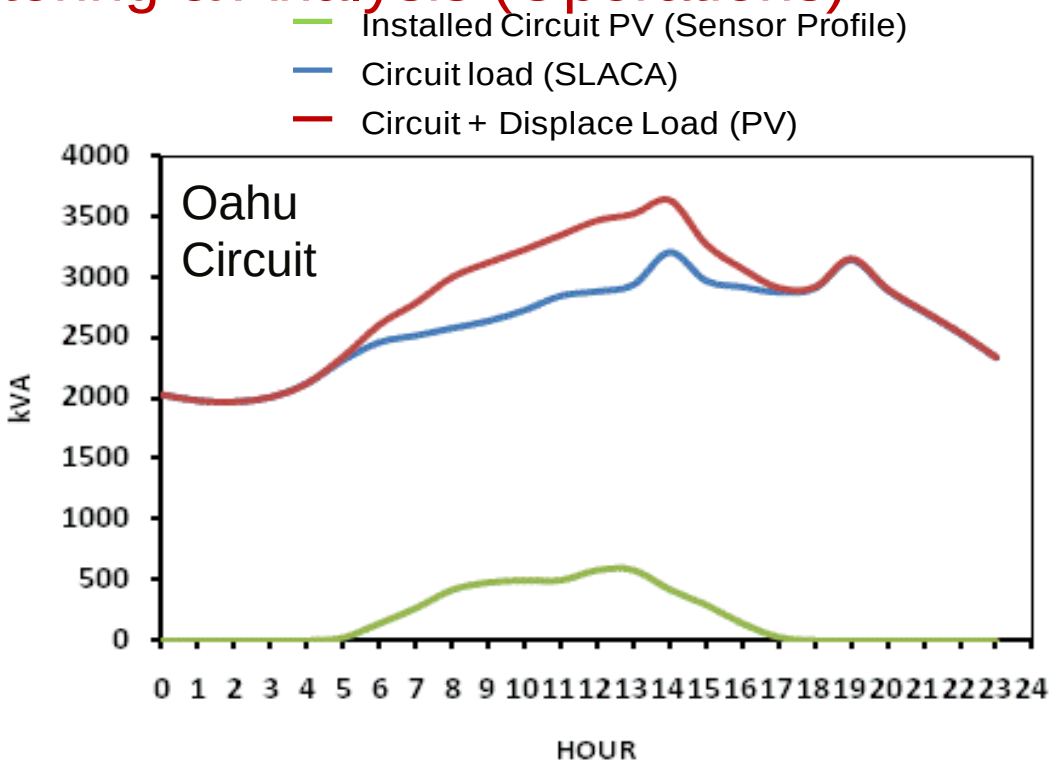
Hi-Pen PV Impact on the Grid - Substation Circuit Monitoring & Analysis (Operations)



- Low-cost capability to account for PV load and actual system load for planning & forecasting
- Correlate grid conditions with solar variability to assess impacts (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

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Field Validation Locations & Devices

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Feeder Model Setup and Scenario Cases with Assumed Minimum Load - EB

- E-B feeder has 1MW PV plant, 0.25MW Dairy Digester and prospective Co-Gen of up to 1MW
- Assumed maximum PV generation (Irradiance = 1,000 W/m^2)
- Load power factor not measured, set to 0.93
- Capacitors switched off
- Tap changer disabled - Feeder head voltage set to 123.0V, irrespective of the feeder loading and distributed generation
- Digester data for April not available, assumed output in early May
- Composite minimum load profile created for two arbitrarily chosen time intervals: April 1st to 20th, and April 21st to May 10th. Data from days with highly fluctuating PV was not considered
- Load flow analysis performed for the following case:
  - PV ON (1.00MW daily peak)
  - Digester ON (0.18MW over 24hrs)
  - Co-Generator ON (1.00MW over 24hrs)

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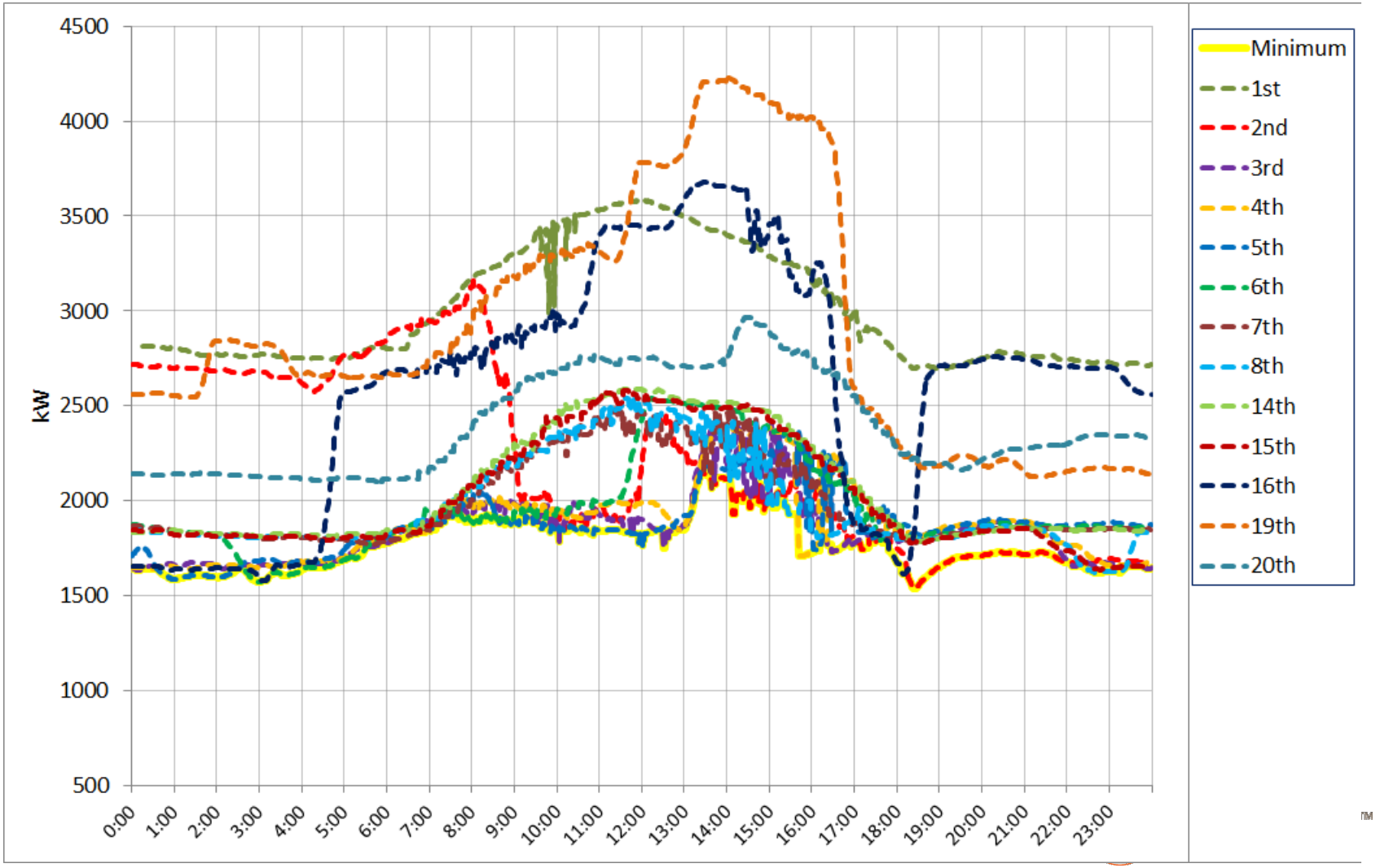
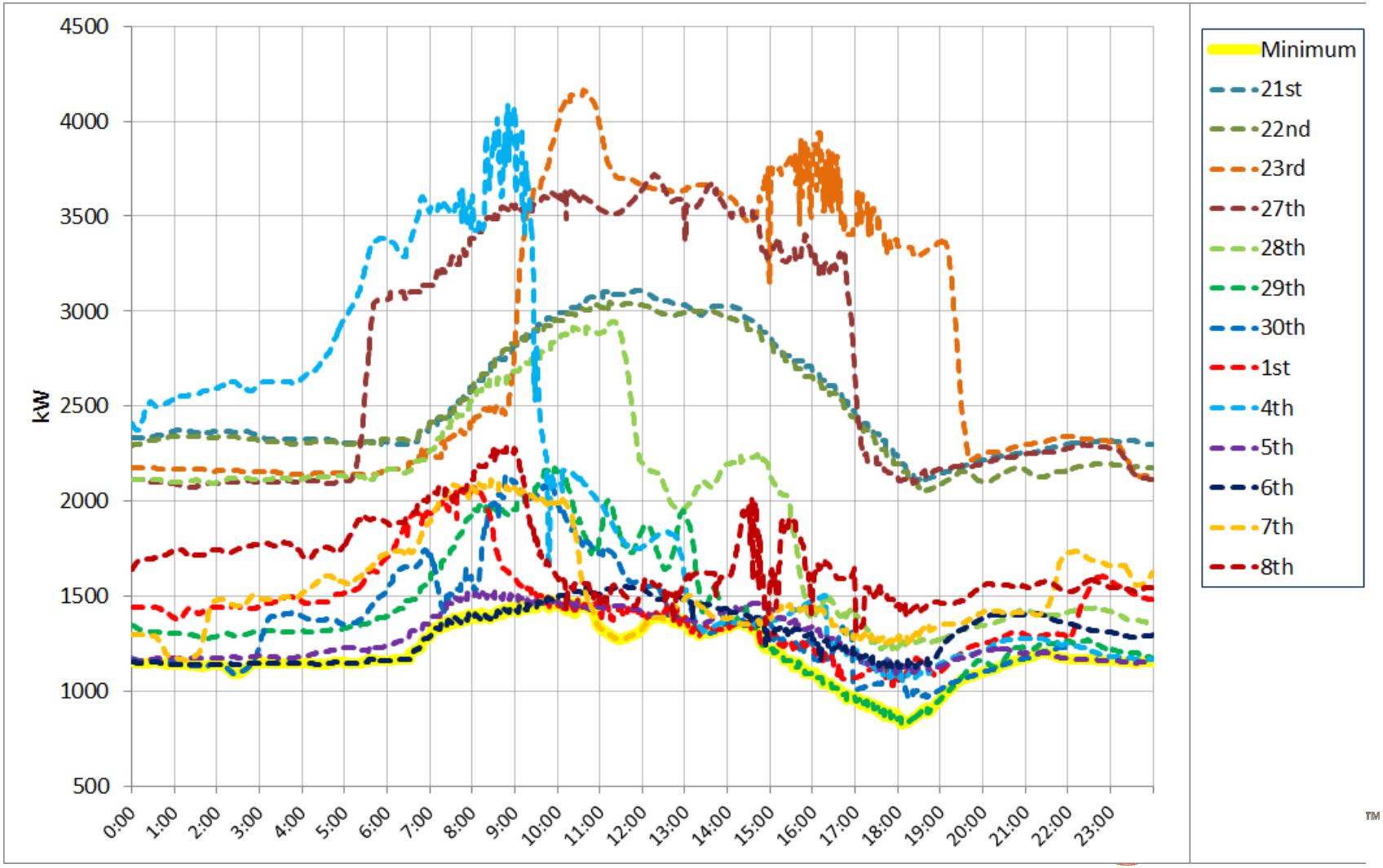
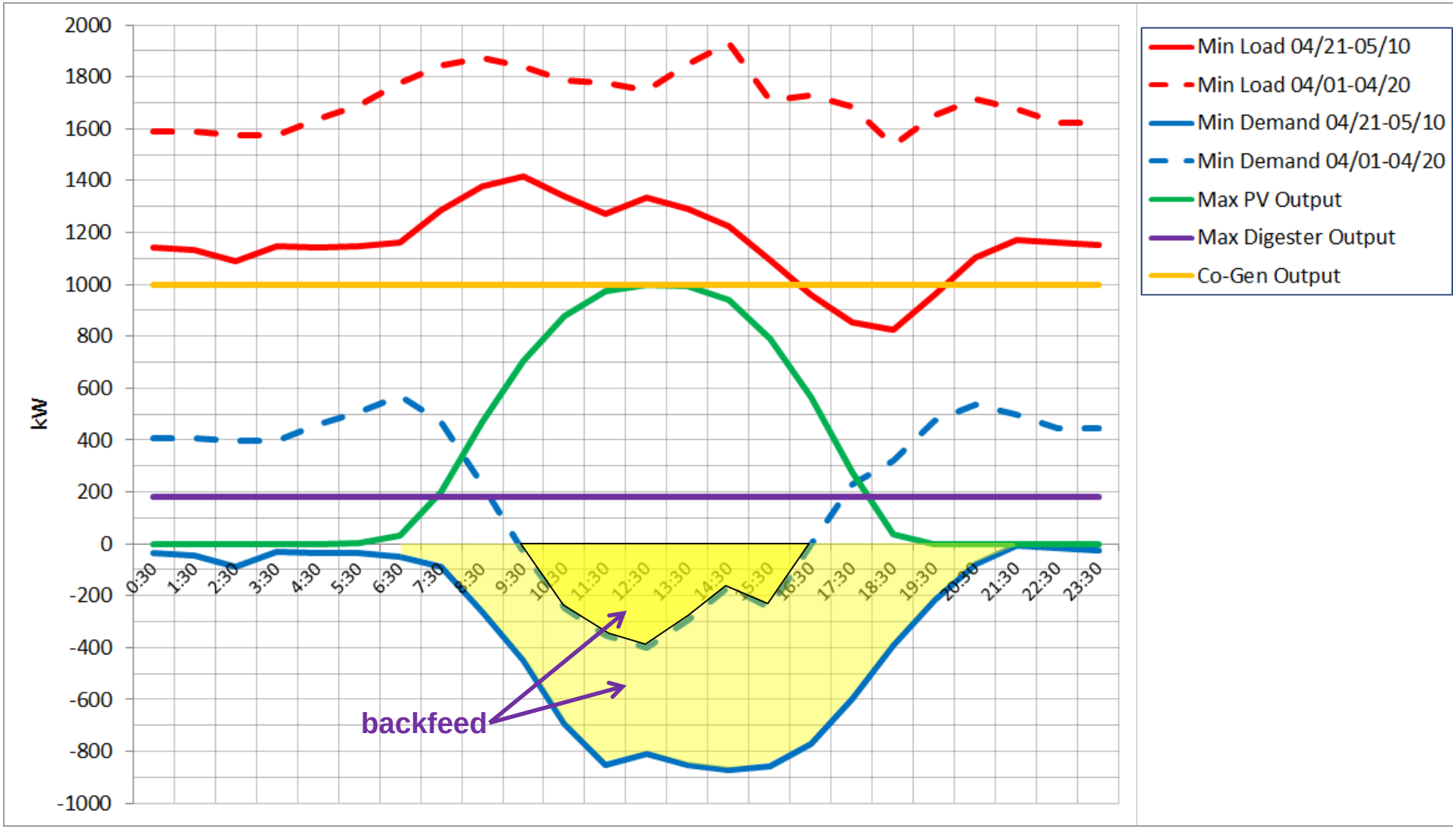
Composite Minimum Load 24-hour Profile between April 1st and 20th



Composite Minimum Load 24-hour Profile between April 21st and May 10th



24-hour Load Flow Results – kW Profile



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E-B Feeder Study Summary with Co-gen producing 1MW max

- Negative demand (backfeed) possible:
  - April 21th and May 10th
    - any time during 24 hrs
    - greater than 0.50MW between 9am and 6pm
    - max 0.88MW between 2pm and 3pm
  - April 1st and 20th
    - between 9am and 5pm
    - max 0.40MW between 12pm and 1pm
- Max/Min feeder voltage (feeder head voltage set to 123.0)
  - April 21th and May 10th : 126.1/122.4 Volts
  - April 1st and 20th : 126.0/122.2 Volts
- Note: major load switching (>1MW) observed on multiple days
- Enabling Regulator had no effect on backfeed intervals or magnitudes

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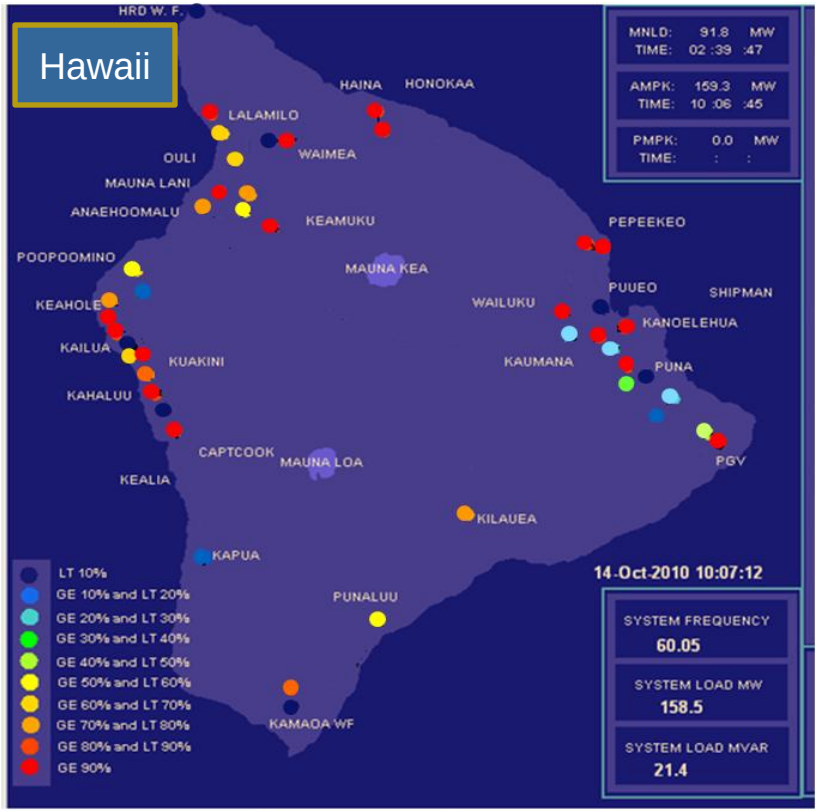
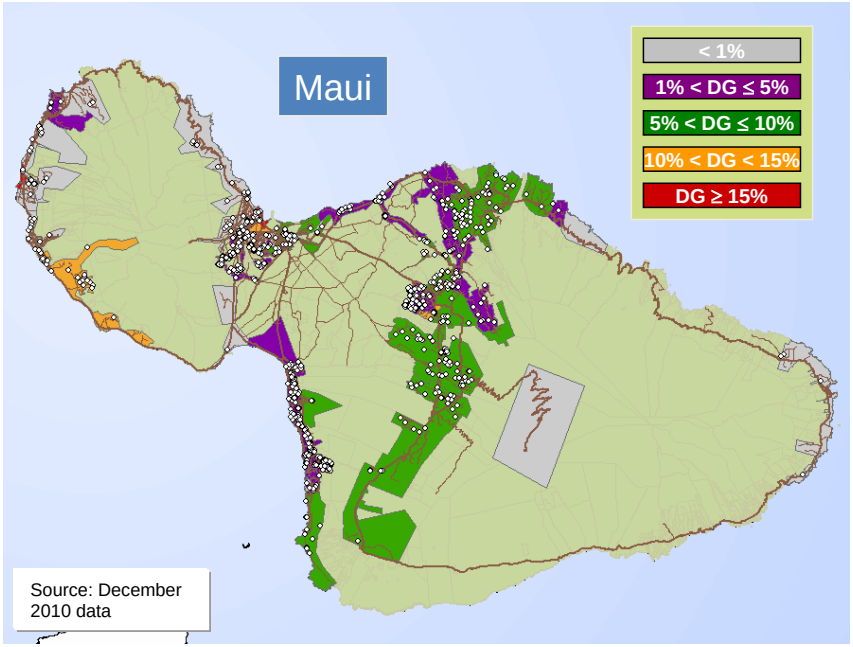
High Penetration Solar/Wind Visualization Analysis Pilot



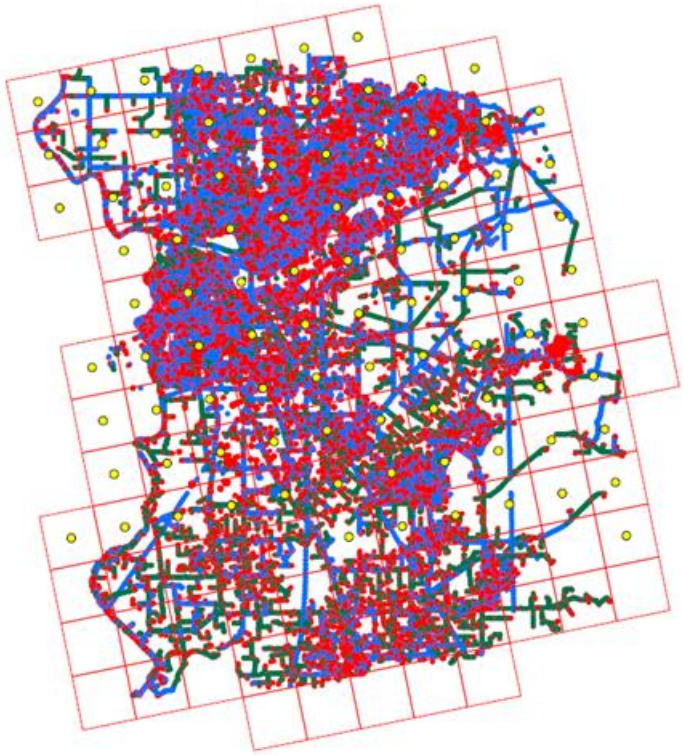
Region	Est. Gen MW	Connected MW
North Hawaii	1.3	1.7
East Hawaii	2.9	4.1
West Hawaii	2.6	3.7
South Hawaii	0.0	0.1
Total PV (MW)	6.8	9.6

- Graphical display of renewable resource monitoring & development areas
- Develop overlay datasets (e.g. geographic information, circuit data, modeling contours)
- Develop and pilot visualization analysis tool for planning and operations



Solar Resource Data Collection & Forecasting (NEO Virtus)

- Deployment of Network of 70 Solar Irradiance monitors, cell modem data collection, 1 minute data
- Modeling/solar forecasting using NOAA weather forecasts, validated using ground network
- Assessment of resource variability across much of the service territory over the year
- Development of a forecasting tool for solar characterization and cloud impacts on system



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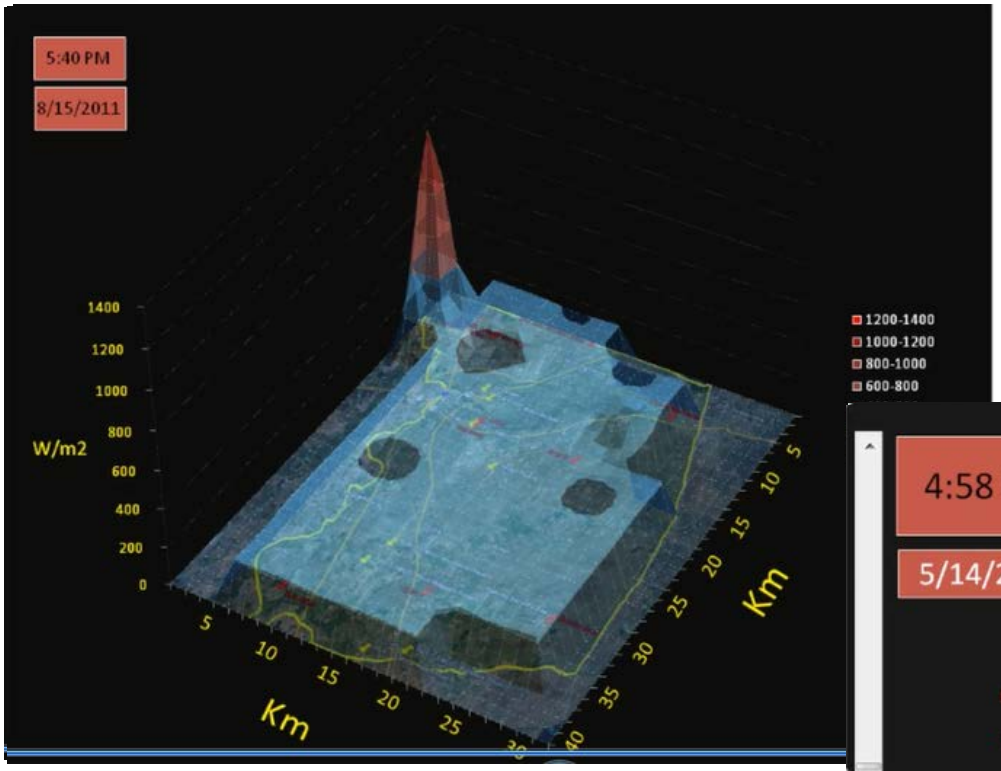
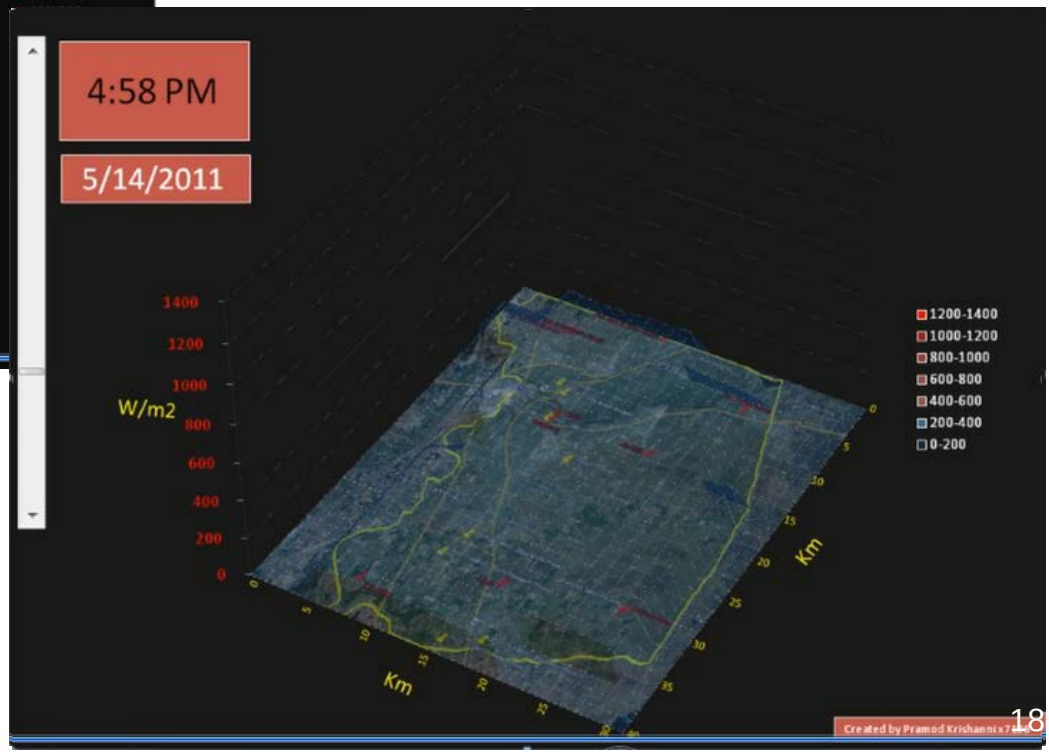
Solar Resource Data Collection & Forecasting



Clear Day

Cloudy Day



NEO Virtus Engineering, Inc

Thank You

For more information please contact:

Elaine Sison-Lebrilla
esison@smud.org
Renewable Energy Program Manager
Energy Research a& Development Dept.
Sacramento Municipal Utility District

Dora Nakafuji
dora.nakafuji@heco.com
Director of Renewable Energy Planning
Hawaiian Electric Company

http://www.calsolarresearch.org/Funded-Projects/solicitation1-smud.html