SEEING IMPACTS OF HIGH PENETRATION PV

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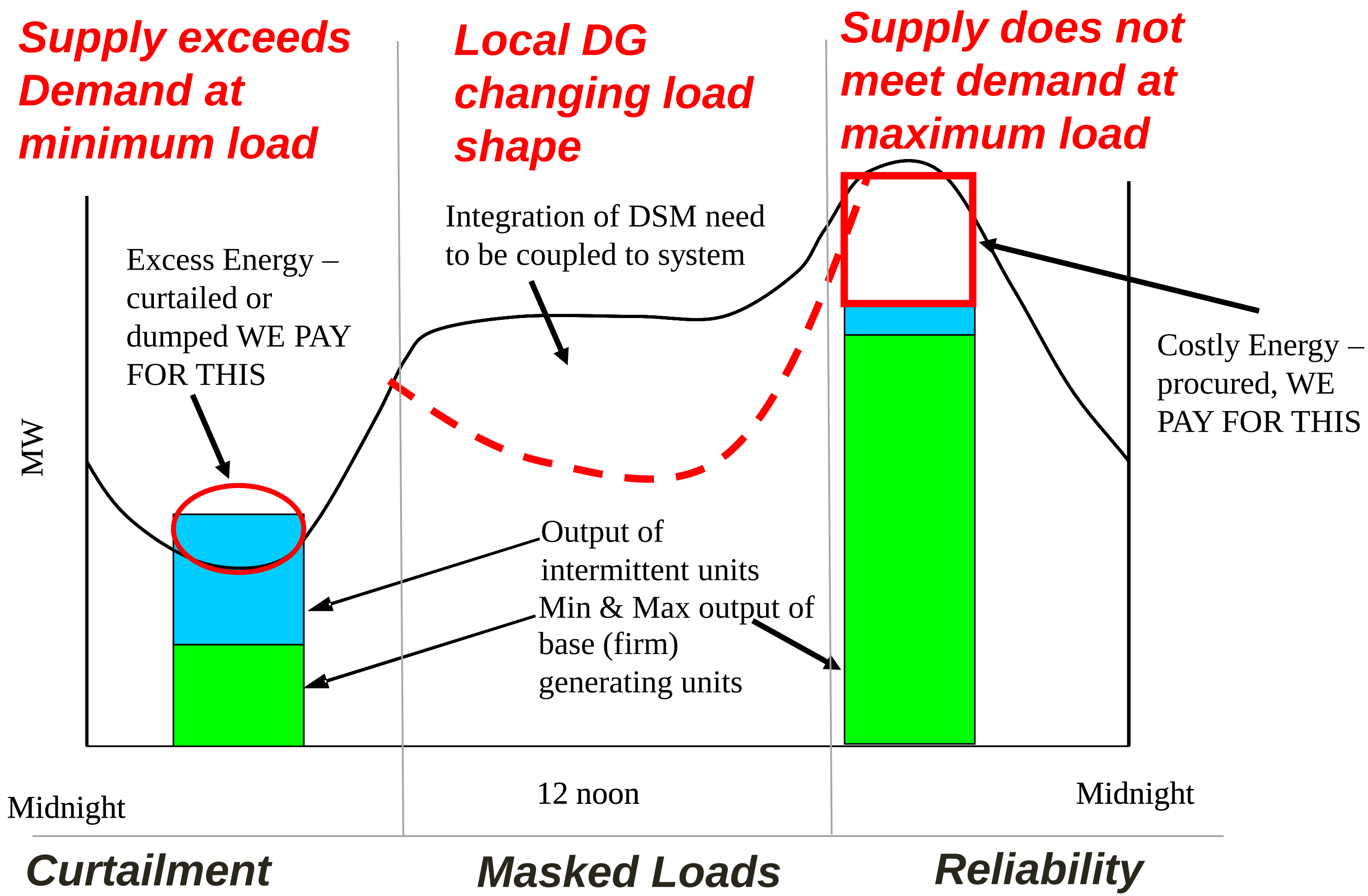
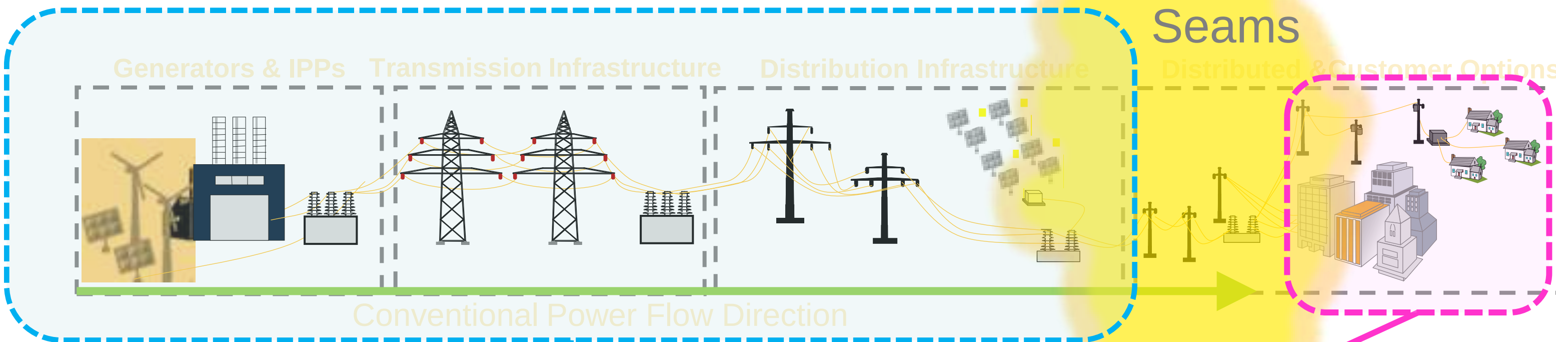
Overview

- Background
  - Drivers/Challenges
  - Major Transformational Areas
- SMUD/HECO High Penetration PV Initiative
- Discussion/Q&A

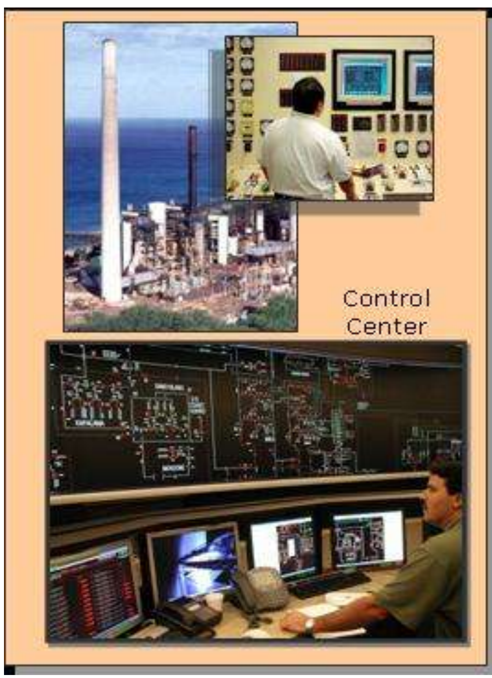
Issues Being Encountered as Penetration Increases



Electric Sector Paradigm Shift



System Controls



Local Controls

Work needed to bridge the gaps for “Seams” Infrastructure and Coordinated Response & Control Logic with utilities

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Integration Questions

- Policy: RPS and climate goals
- Market: Emergence of *Variable renewable* resources and distributed resource incentives
- Interoperability of the Grid: Infrastructure and process changes to accommodate higher levels of variable and distributed resources

Requires Alignment of Policy, Market & Technology

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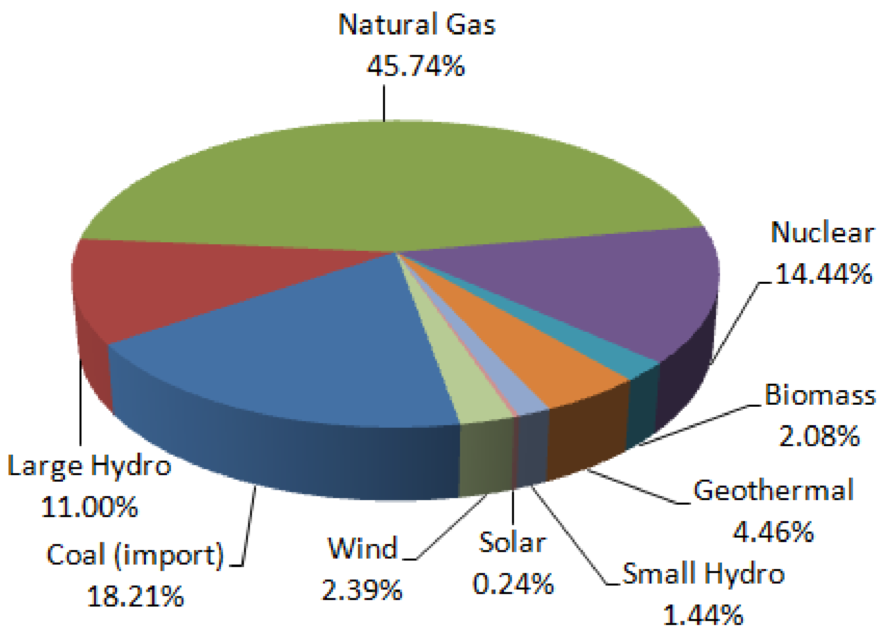
Preserve Utility Guiding Principles

- Reliability of Service
- Maintain cost-effectiveness for Customers
- Ensure robust & secure infrastructure
- Sustainable resources
  - Diverse, flexible and balanced portfolio
  - Knowledgeable workforce
  - Tools to do things “in house”

CA & HI Energy Picture

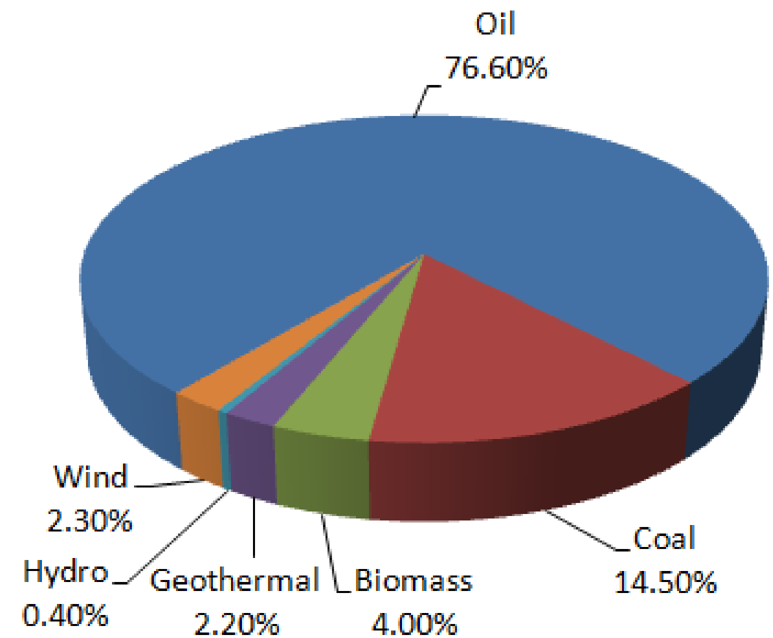
California

- Primary resource is natural gas, 80% imported from other states & Canada
- Top 10 generation plants are gas, nuclear and hydro resources
- Nearly 25% of electricity consumed is imported from neighboring states



Hawaii

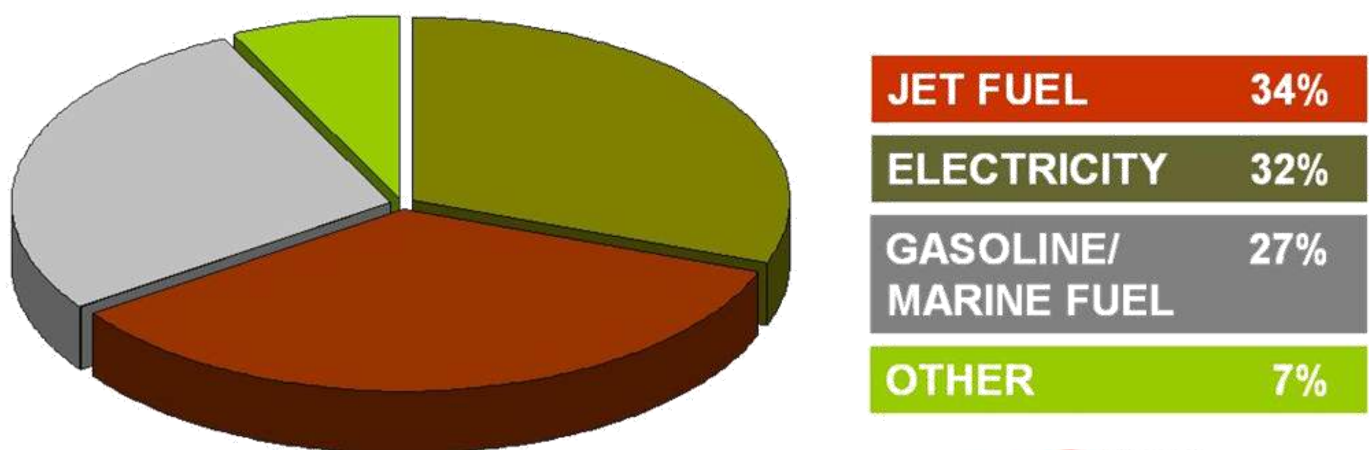
- Primary resource is petroleum, 90% imported (30% for electricity, 60% transportation)
- Top 10 generation plants are petroleum, coal, and waste resources
- Islanded systems



* Source: CEC 2008; HECO 2008

Background – HECO & Hawaii's Energy Use Today

- 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 and Molokai and the Big Island Hawaii.
- Primary energy source (90%) is imported crude oil



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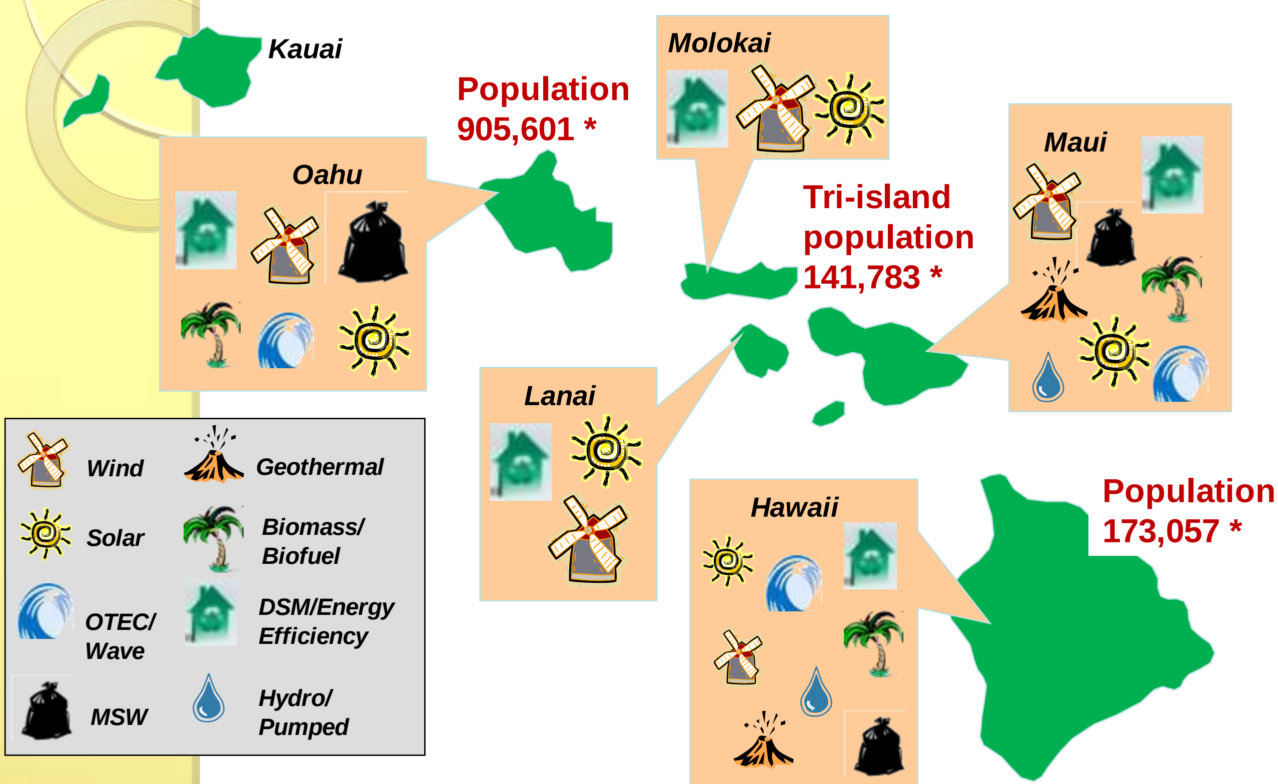
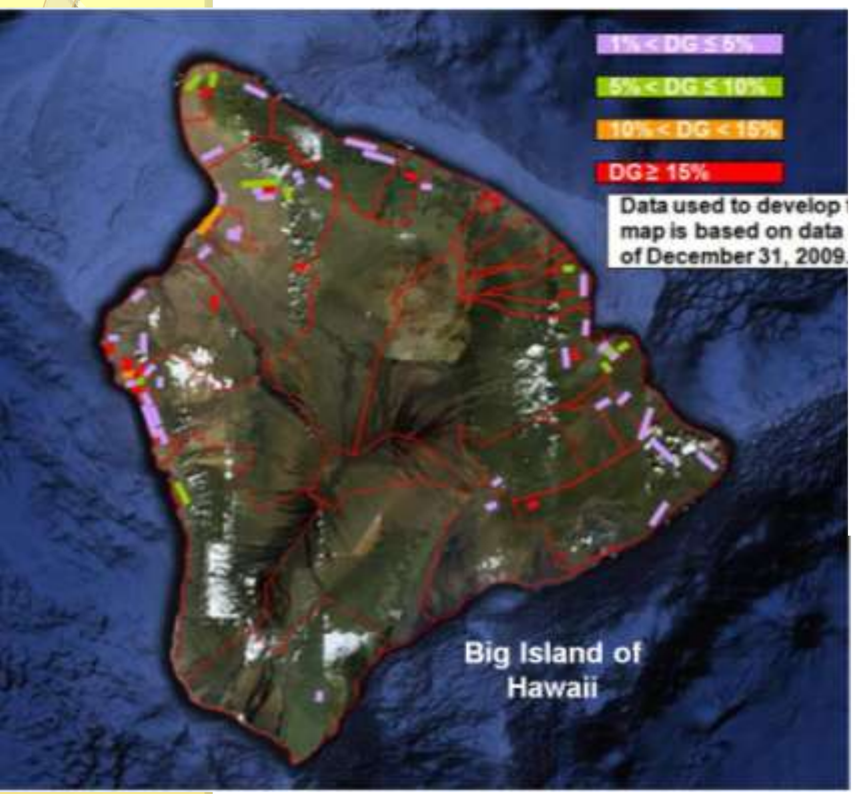
Where are we Today?

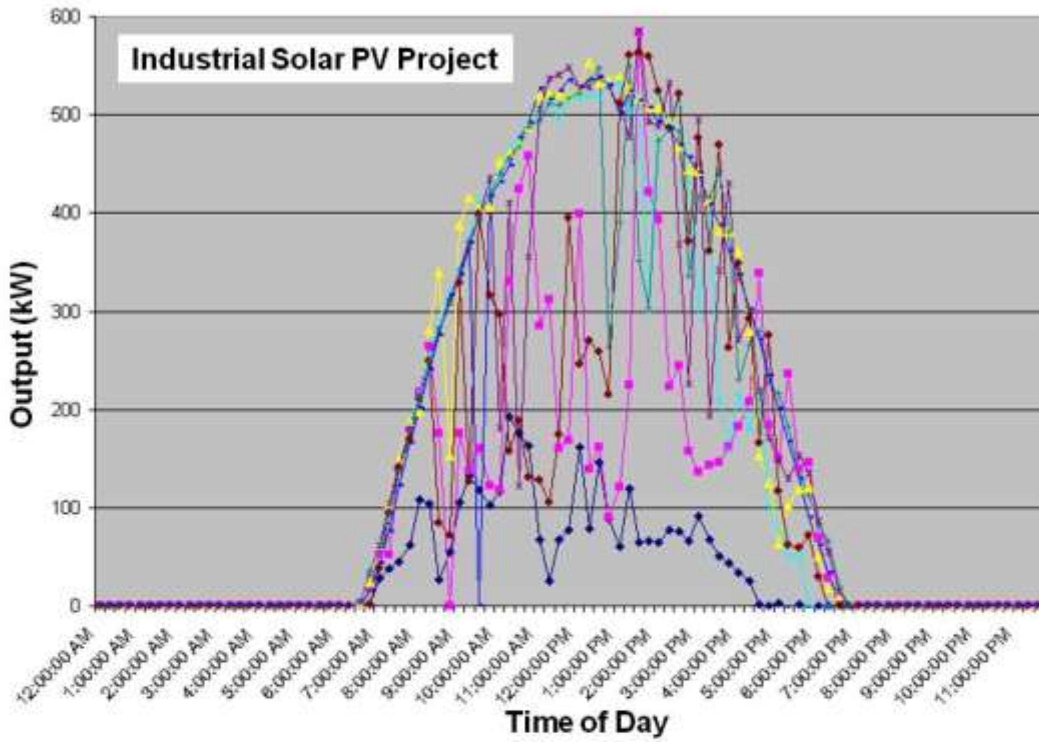


* U.S. Census estimates as of July 2007

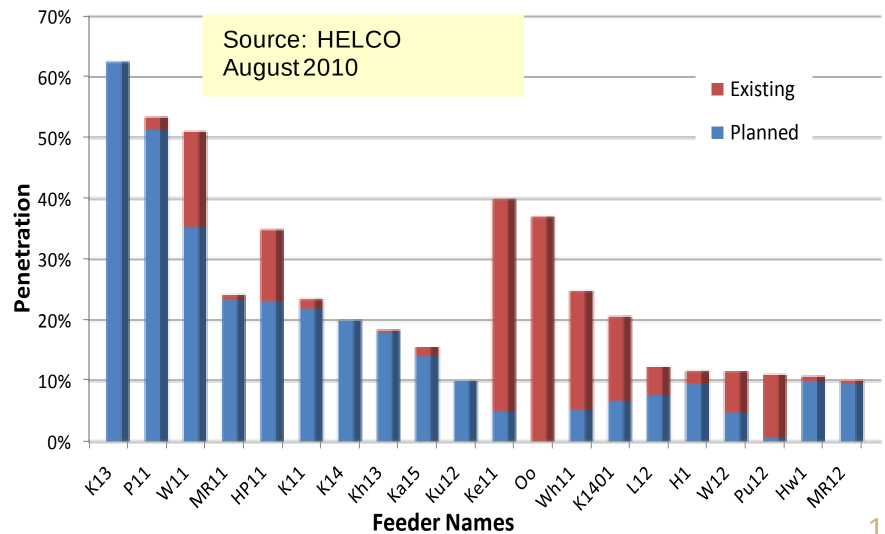
- Act 155 established RPS – 40% renewables from electricity, 70% total (includes transportation)
- Energy efficiency standard of 30 by 2030 (3,400 GWh)
- HECO – 15%, HELCO – 39%, MECO – 23%

Where are We Today?





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



Background - SMUD

- 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
- Record peak demand-3,299 MW on July 24, 2006
- Aggressive 23.5% Renewable supply by 2010; 37% by 2020
- GHG Reductions by 2050 (10% of 1990 levels, <350,000 metric tonnes/year)
- CSI Goal of 125 MW, Feed-In Tariff of 100 MW

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Background-Renewable Supply

SMUD Renewable Energy Program	2009 Supply Goal	2009 Actual	2010 Goal	2020 Goal
RPS	17.5%	18.8%	20%	33%
Greenergy	3.5%	3.5%	3.9%	4%
Totals	21%	22.3%	23.9%	37%

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Where are we Today?

- Currently, about 20 MW of distributed PV, no visible impacts
- Feed-In Tariff contracts - 100 MW to be installed in 2011-2013 timeframe, in 5 MW increments
- CSI goal is 125 MW of roof-top PV
- Expect to see impacts to grid with higher penetration.

SMUD/HECO High Penetration PV Initiative & Team

Team	Primary Staff
SMUD Sacramento Municipal Utility District The Power To Do More.℠	Elaine Sison-Lebrilla, Obadiah Bartholomy and David Brown
Hawaiian Electric Company	Tom Aukai, Dora Nakafuji (HECO) Laura Rogers, Hal Kamigaki (HELCO) Chris Reynolds (MECO)
BEW Engineering	Ron Davis, Emma Stewart, Billy Quach
NEO Virtus Engineering, Inc	James Bing
SUNPOWER	Brock LaPorte, Matt Galland

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

Grant Background

- Application submitted Fall 2009
- March 11th, CPUC Resolution approved entering into grant agreements with SMUD and other proposed grant recipients
- May 6th, SMUD Board Authorized implementation of the High Penetration PV Initiative Project
- June 10, 2010, effective date of the CPUC/Itron/SMUD funding agreement.

Why This Effort is Timely?

ADDRESS COMMON ISSUES

- Emerging levels of distributed generation "behind-the-meter" generation is increasing
- Levels are exceeding "rules-of-thumb" used in standard utility practices for planning
- Operations lack visibility to control and plan for impact of variable renewables on the distribution grid
- Industry lacks capability (tools/data) to effectively plan for PV impacts on the grid
- No commercially available capability exists to meet solar forecasting needs

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Why SMUD/HECO Partnership?

- Aggressive state RPS policies in both California and Hawaii
- SMUD/HECO have very similar system attributes
- SMUD/HECO utilizing similar system and distribution modeling tools
- Facing similar high penetration PV challenges – HECO has high penetration over 30% on a number of circuits
- Cost-effective solutions needed to maintain reliability

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Issues & Risks

- Aggressive 2 year project schedule
- Investigative nature of efforts
- Multiple high-penetration sites to consider (HECO/HELCO/MECO)
- Internal resources needed to support rapid deployment of field monitoring devices
- Subject to regulatory agencies (in California and Hawaii) review and benefits reporting
- Involvement of several parties

Task 1: Project Management

- Project Administration & Budgets
- Status Meetings
- Technology Transfer Venues
  - Discuss Approach with partners
  - Learn and communicate "lessons learned"
  - Inform new tools, process and procedures

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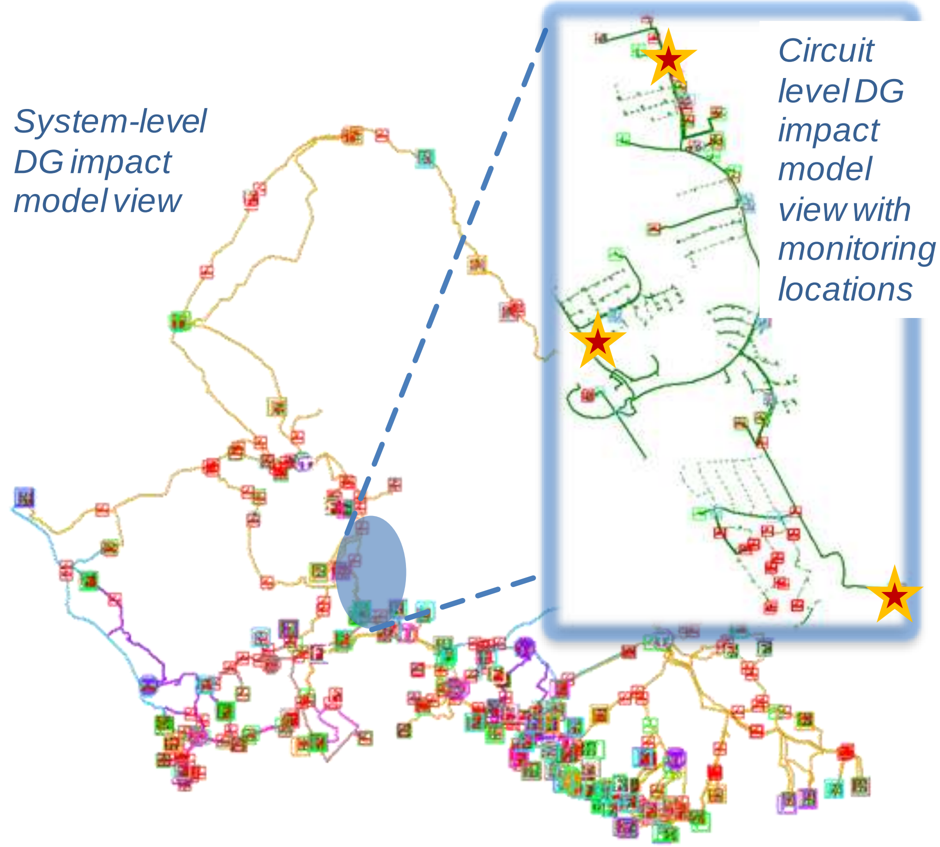
Task 2: Baseline Modeling of SMUD and HECO Systems

- Identify high penetration circuits and characteristics
- Gather circuits data (i.e. voltage, loads, PV production, faults) 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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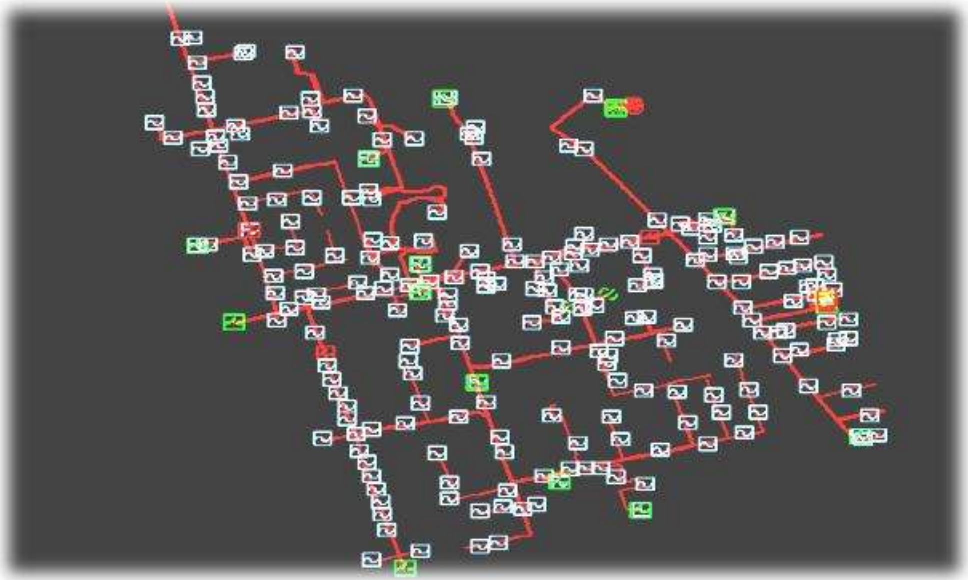
Task 3: Field Monitoring and Analysis

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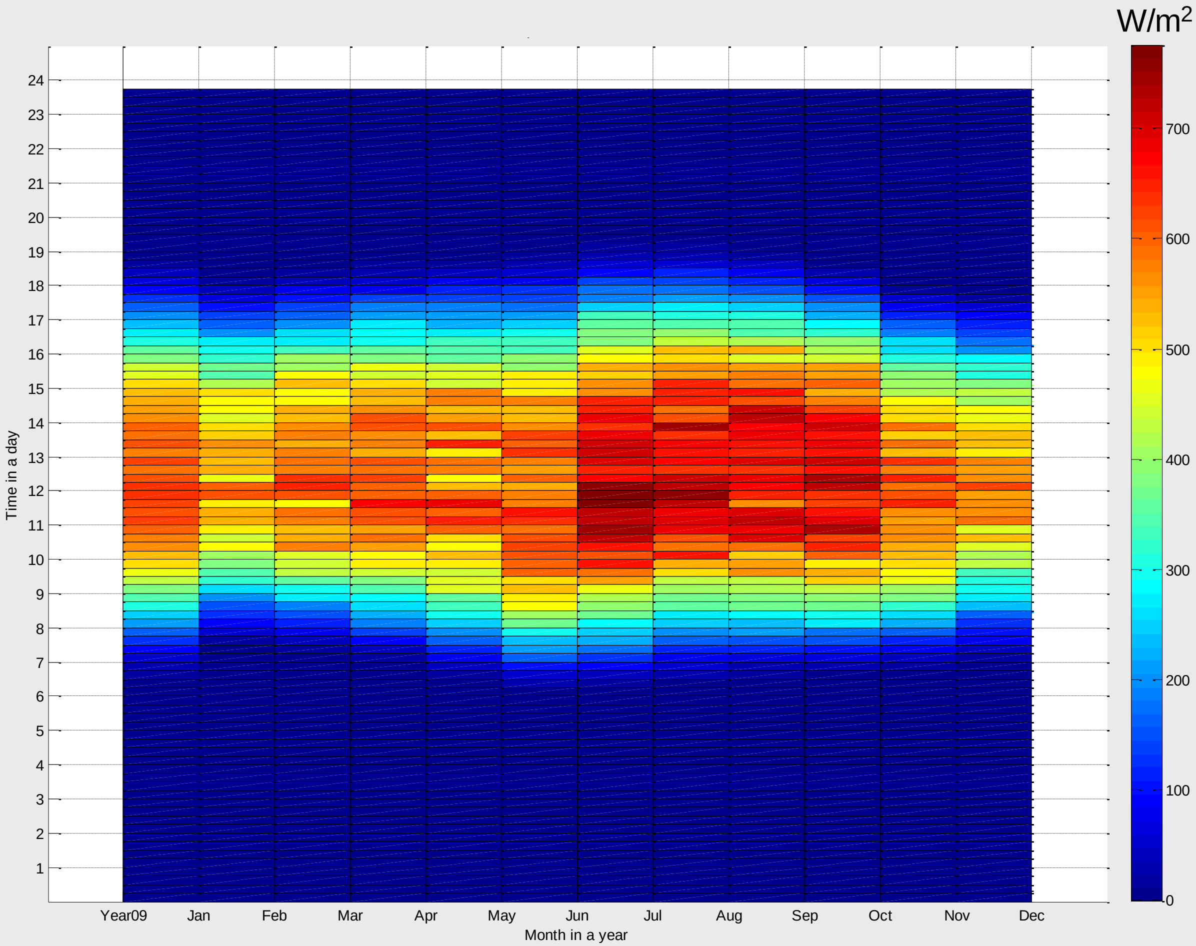
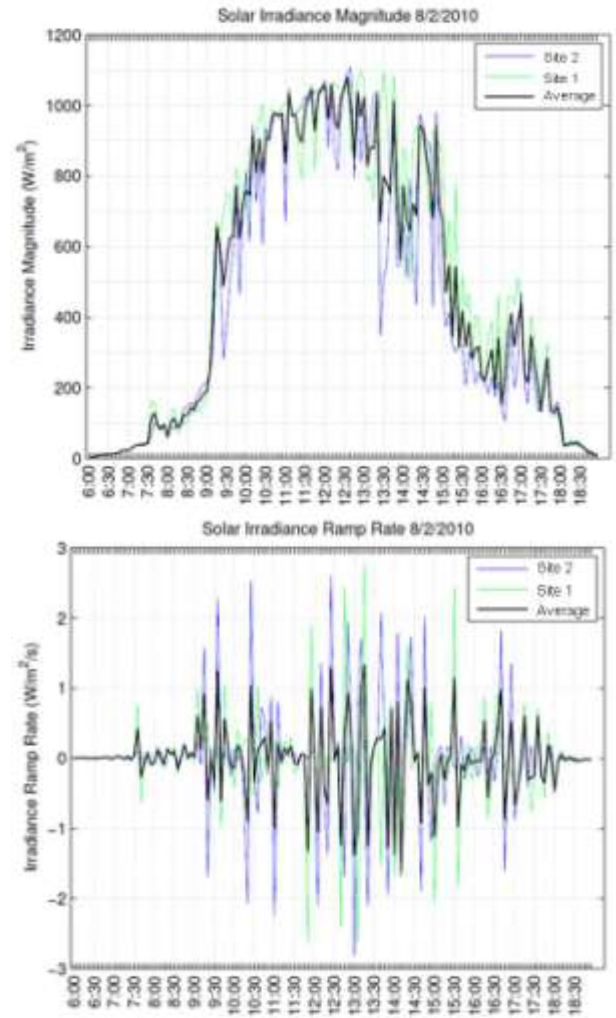
Understanding the Solar Resource both Long-term & Short-term Variability (Planning)

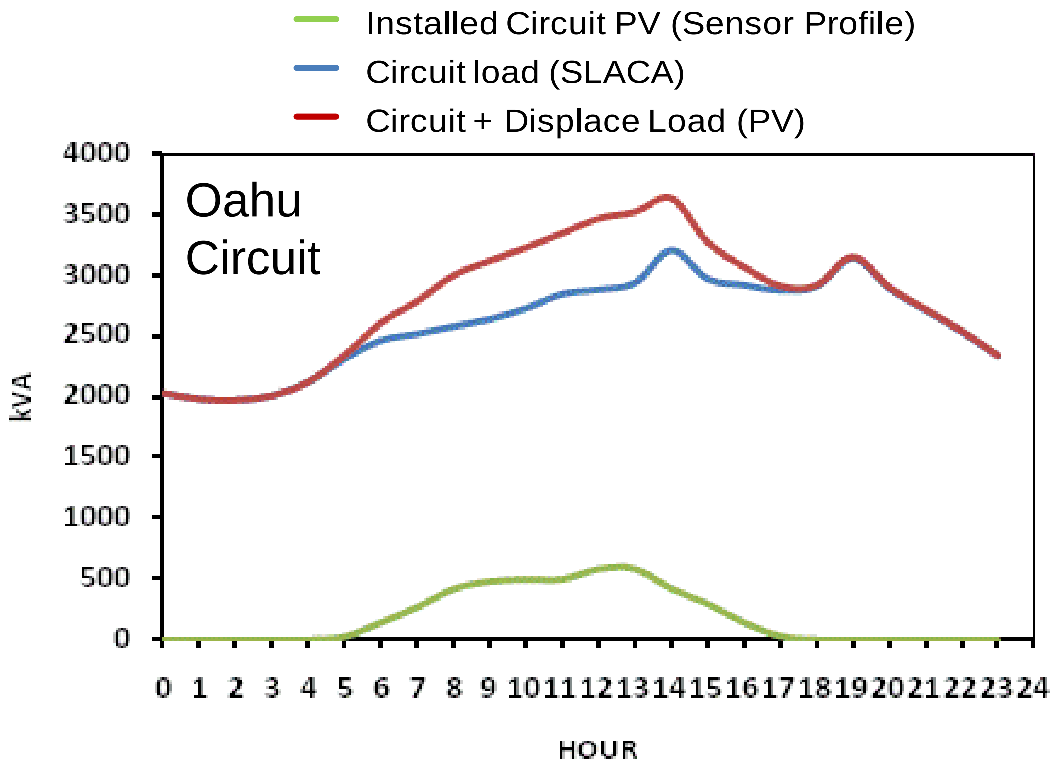


Solar resource (W/m²) variability over the year
Source: HECO



Sub-hourly solar variability

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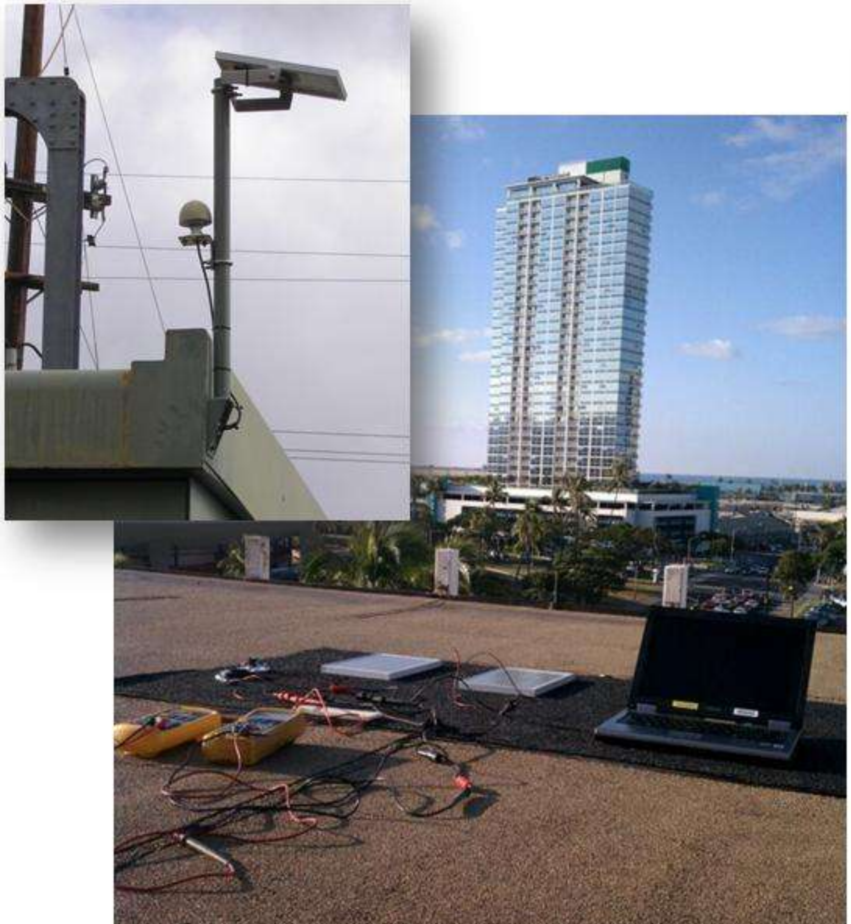
Field Validation Locations & Devices: Calibration & Select Customer Site Monitoring

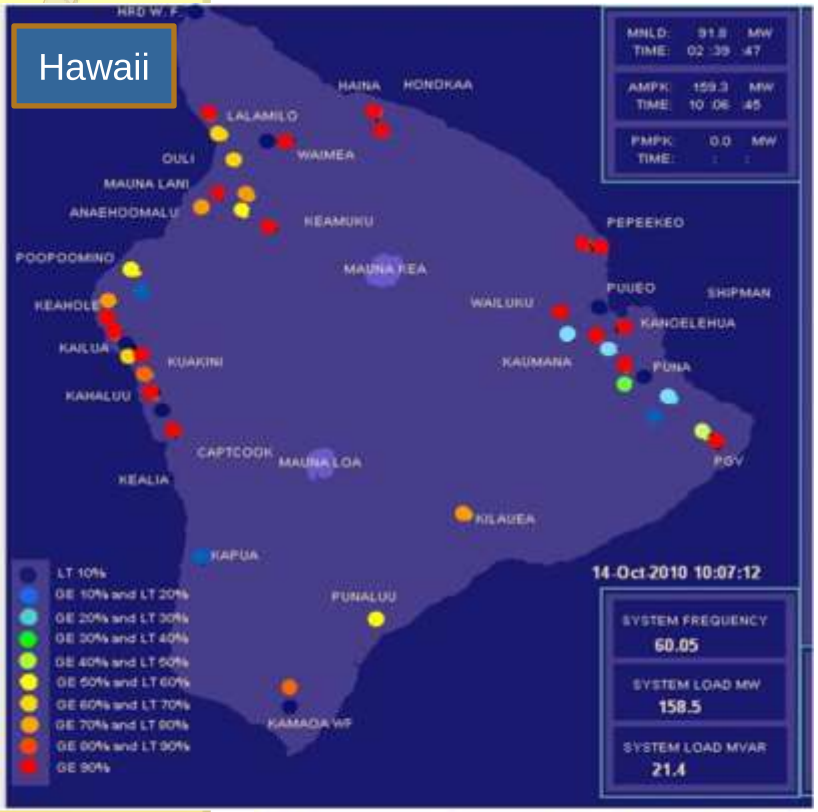


Customer site PV output monitor

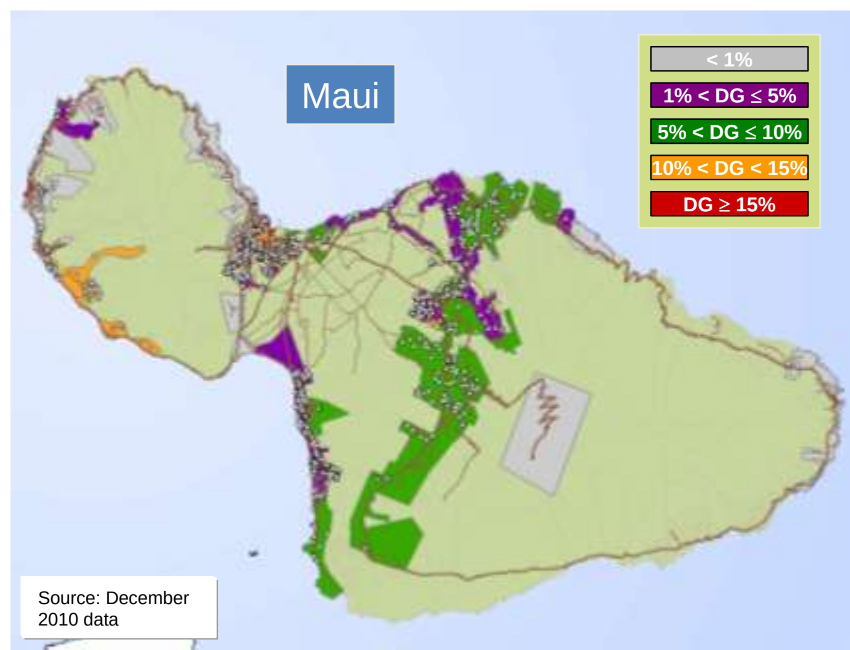
Rooftop calibration of LM-1 monitors

Task 4: High Penetration Solar/Wind Visualization Analysis Pilot

- Graphically 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

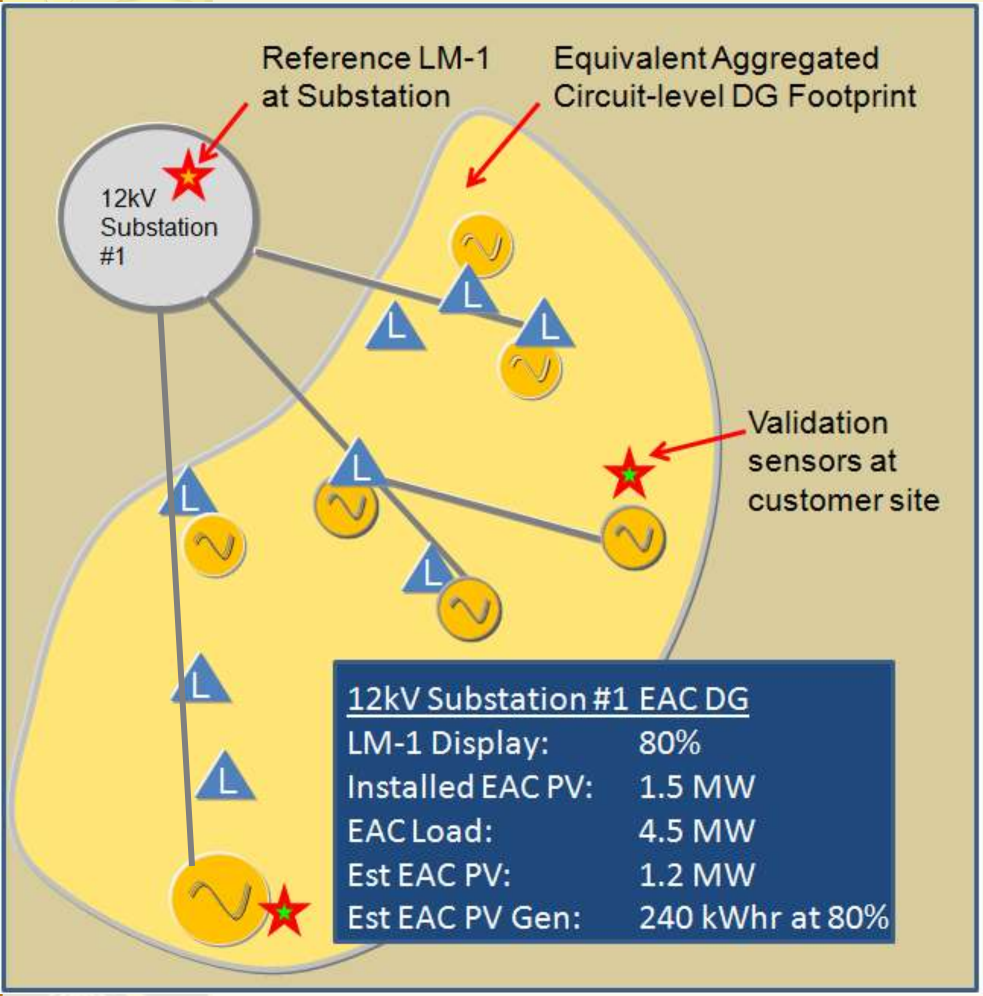


Region	Est. Gen MW	Connected MW
North Hawaii	1.3	1.7
East Hawaii	2.9	4.1
West Hawaii	2.6	3.7
South Hawaii	0.0	0.1
Total PV (MW)	6.8	9.6

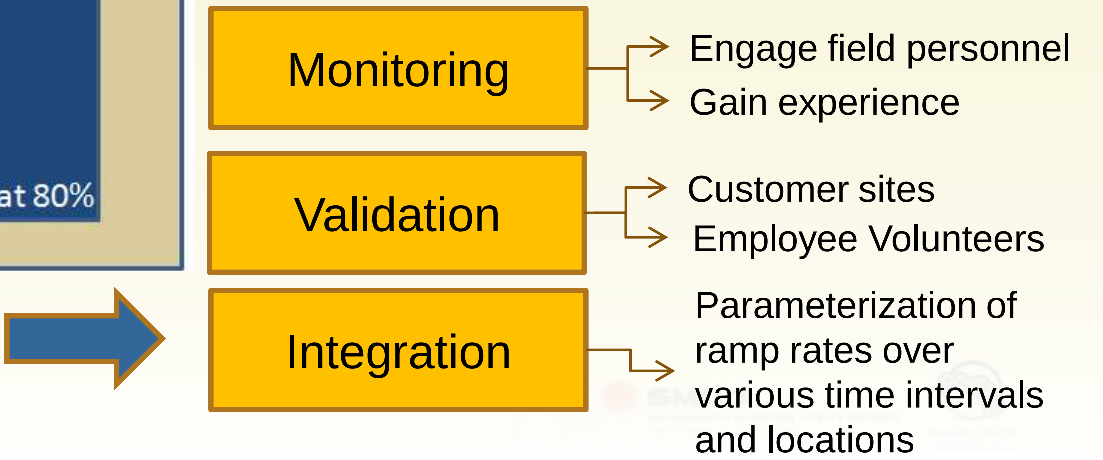


Data to Improve Distribution & Planning Models

Inverter and Aggregated PV Models

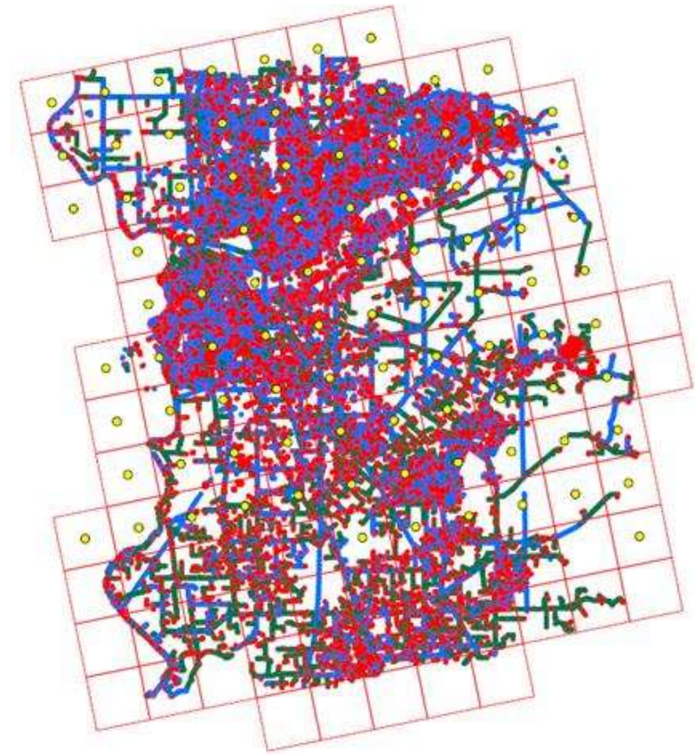


- Characterize discrete and aggregated circuit load profiles at 12 kV substation (residential, industrial, commercial)
- Expedite circuit evaluations and aggregate impacts for planning
- Use reference LM-1 sensors to estimate solar resource output at location
- Be able to project solar resource potential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



Task 5: 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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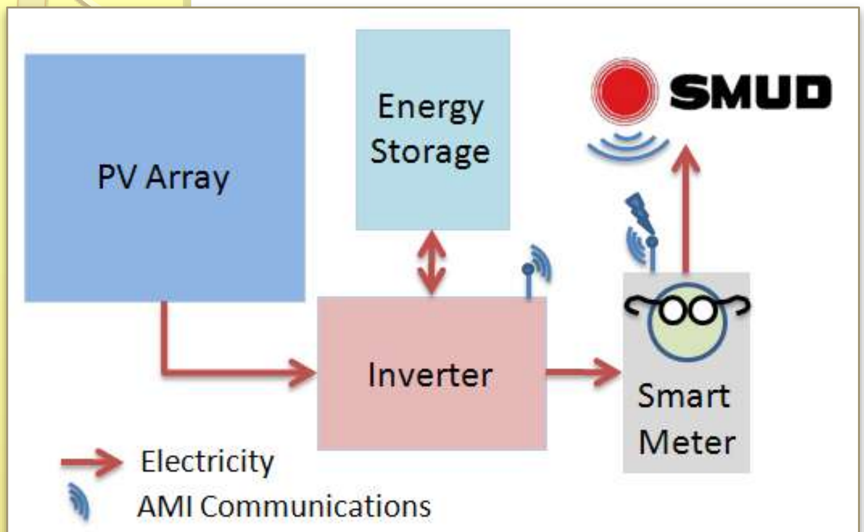
Solar Resource Data Collection

Pre-prototype irradiance monitor

Prototype irradiance monitor

Inverter Communications (SunPower) – Task 3.3



- Demonstrate Inverter Monitoring via AMI communication from smart meter to inverter
- Demonstrate receiving data, querying for faults, sending control signals
- Utilized as actively controlled contributors versus passive devices on the grid

Conclusion

- Drivers for increasing Renewable Energy
- Challenges with higher levels of variable renewable generation
- Collecting information and looking for solutions with the SMUD/HECO High Penetration PV Initiative

Thank You

Questions/Comments??

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