SunShot
U.S. Department of Energy

SHINES Program Review 2017

BP1 – Project Review

SEAMS for SHINES

Integrating System to Edge-of-Network Architecture & Management for SHINES Technologies on High Penetration Grids

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

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February 10, 2017

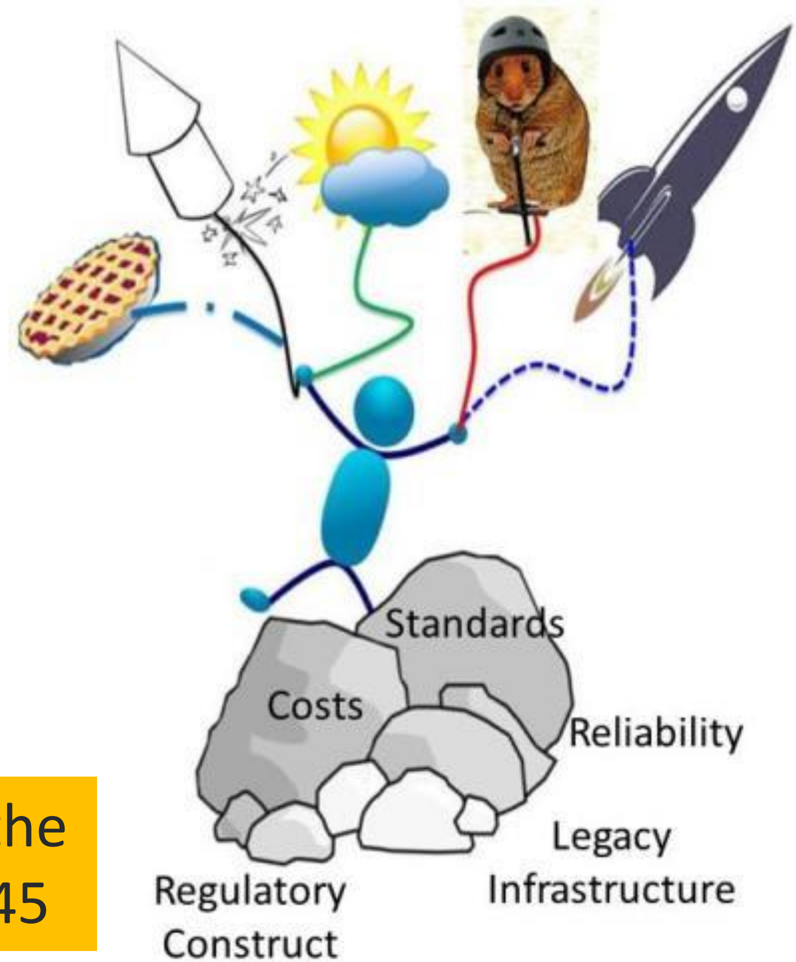
energy.gov/sunshot

Renewable Energy Planning

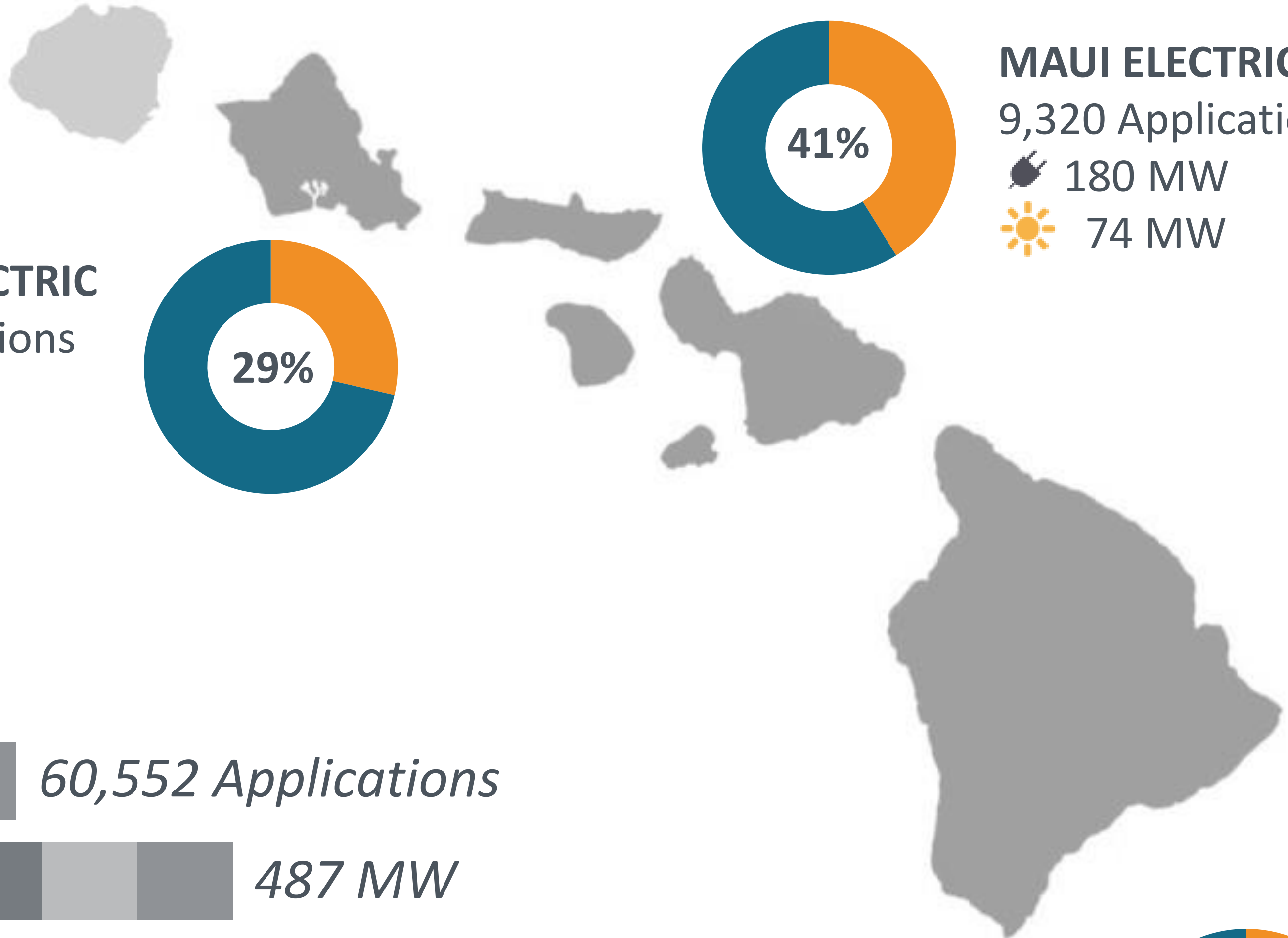
Sharing Perspectives

- Motivation
- Project Overview & Team
- 1st Year Progress
  - Event Analysis
- Looking Ahead
- Takeaways

Hawaii is the first state in the US with a 100% RPS by 2045



Hawaii is the first state in the US with a 100% RPS



MAUI ELECTRIC
9,320 Applications
180 MW
74 MW

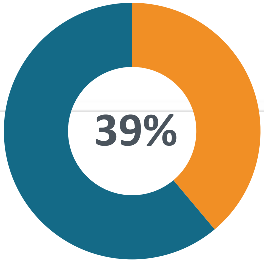
HAWAIIAN ELECTRIC
41,568 Applications
1200 MW
343 MW

Tri-Company Totals

60,552 Applications

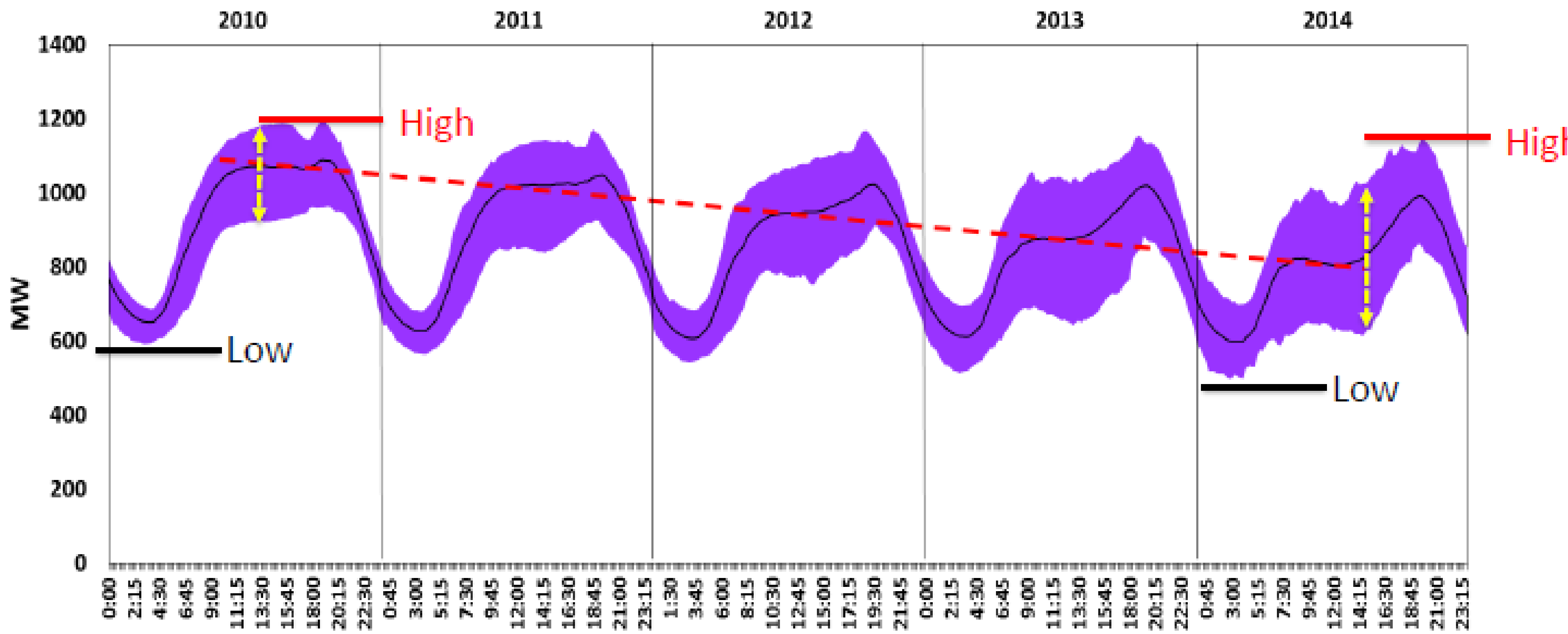
487 MW

HAWAII ELECTRIC LIGHT
9,664 Applications
180 MW
70 MW



Change in Net System Load Trend over 4 Years

Oahu – Net System Load 7/2010 – 7/2014



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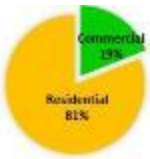
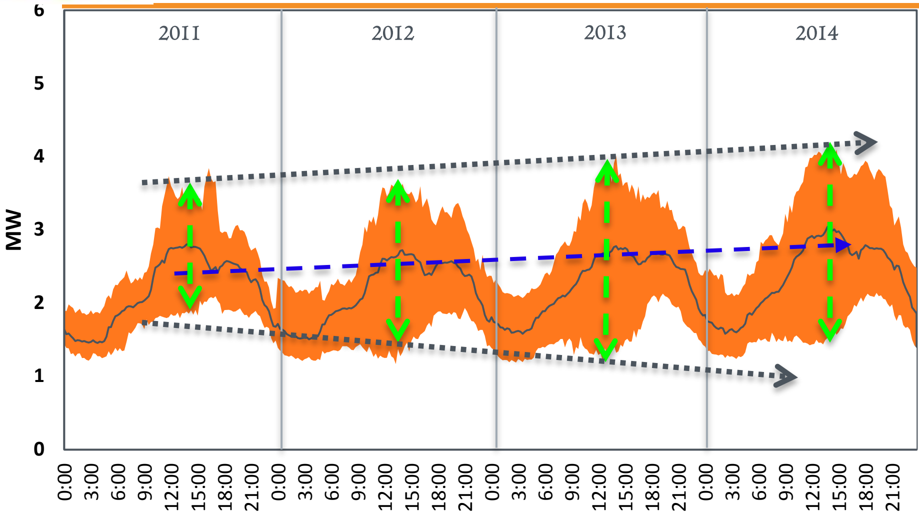
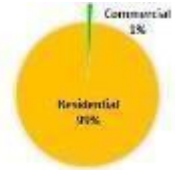


Annual Circuit Net Load

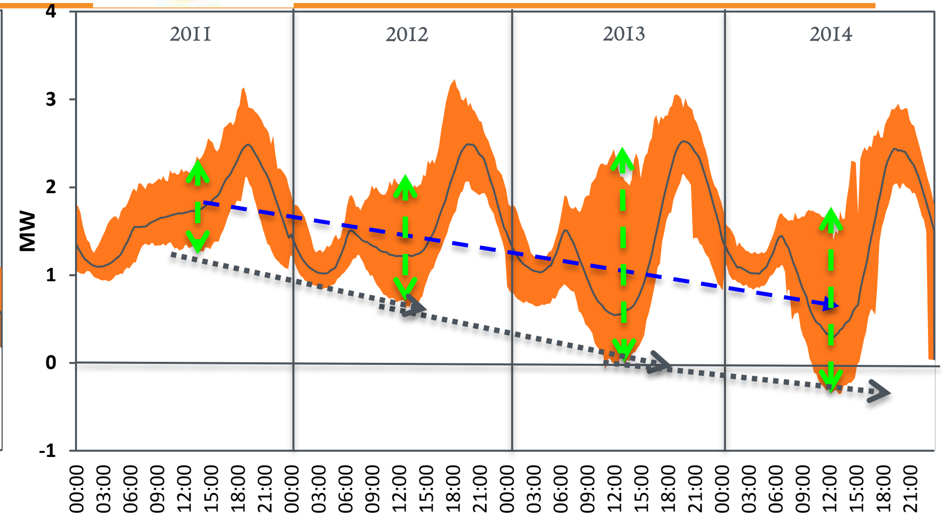
(80%Commercial/ 20% Residential Circuit)





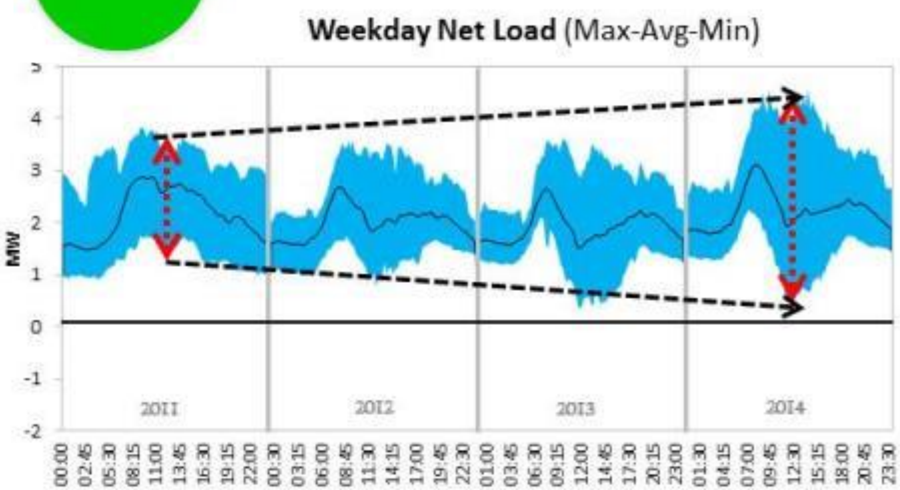
Annual Circuit Net Load

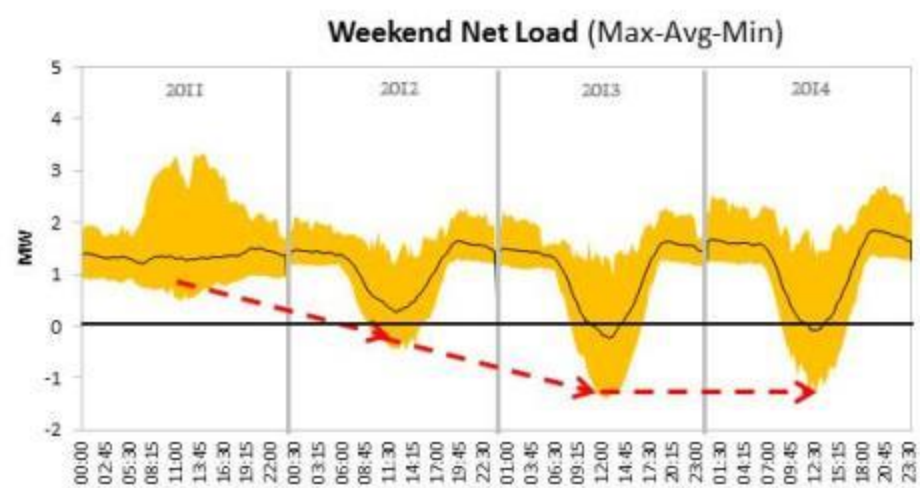
(99% Residential Circuit)



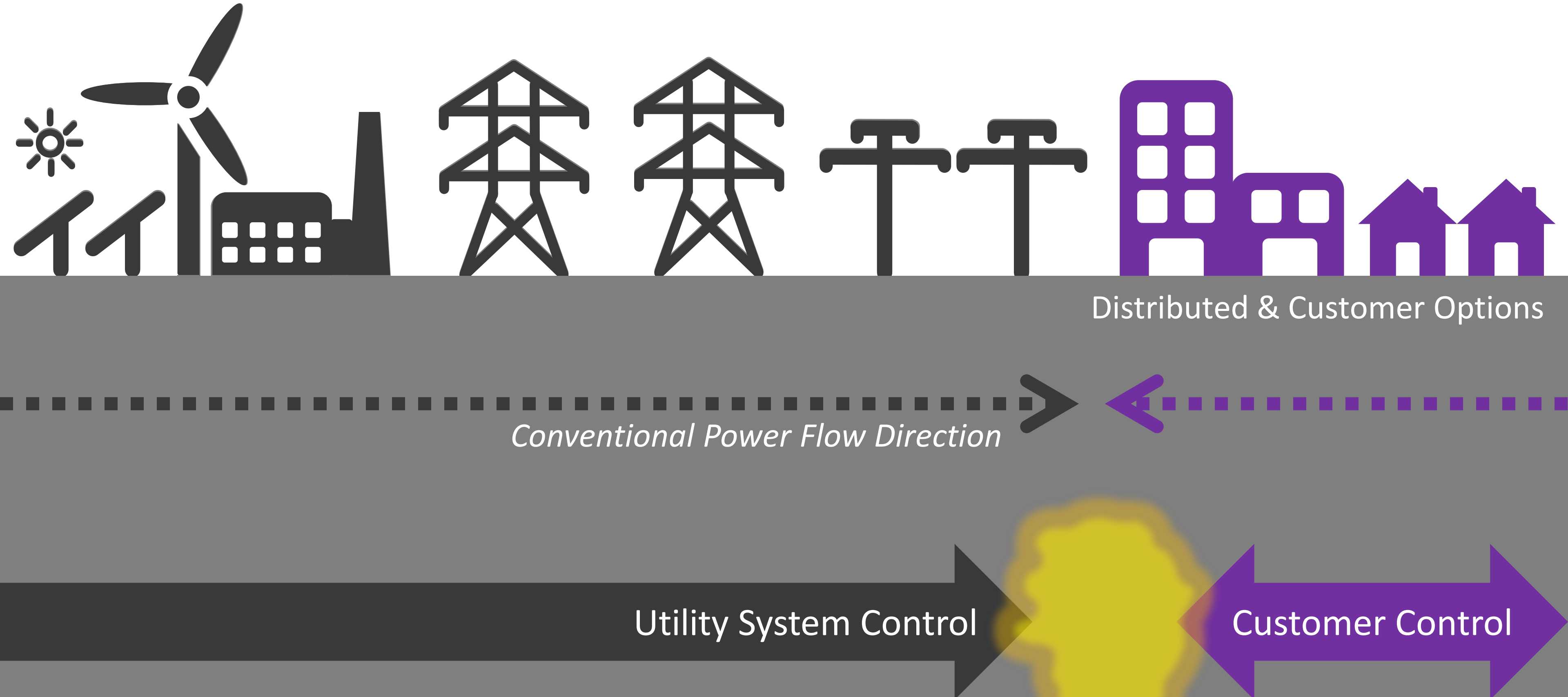
Circuit Weekday vs Weekend Breakout

(100% Commercial Circuit)





CLOSING THE GAP WITH SEAMS

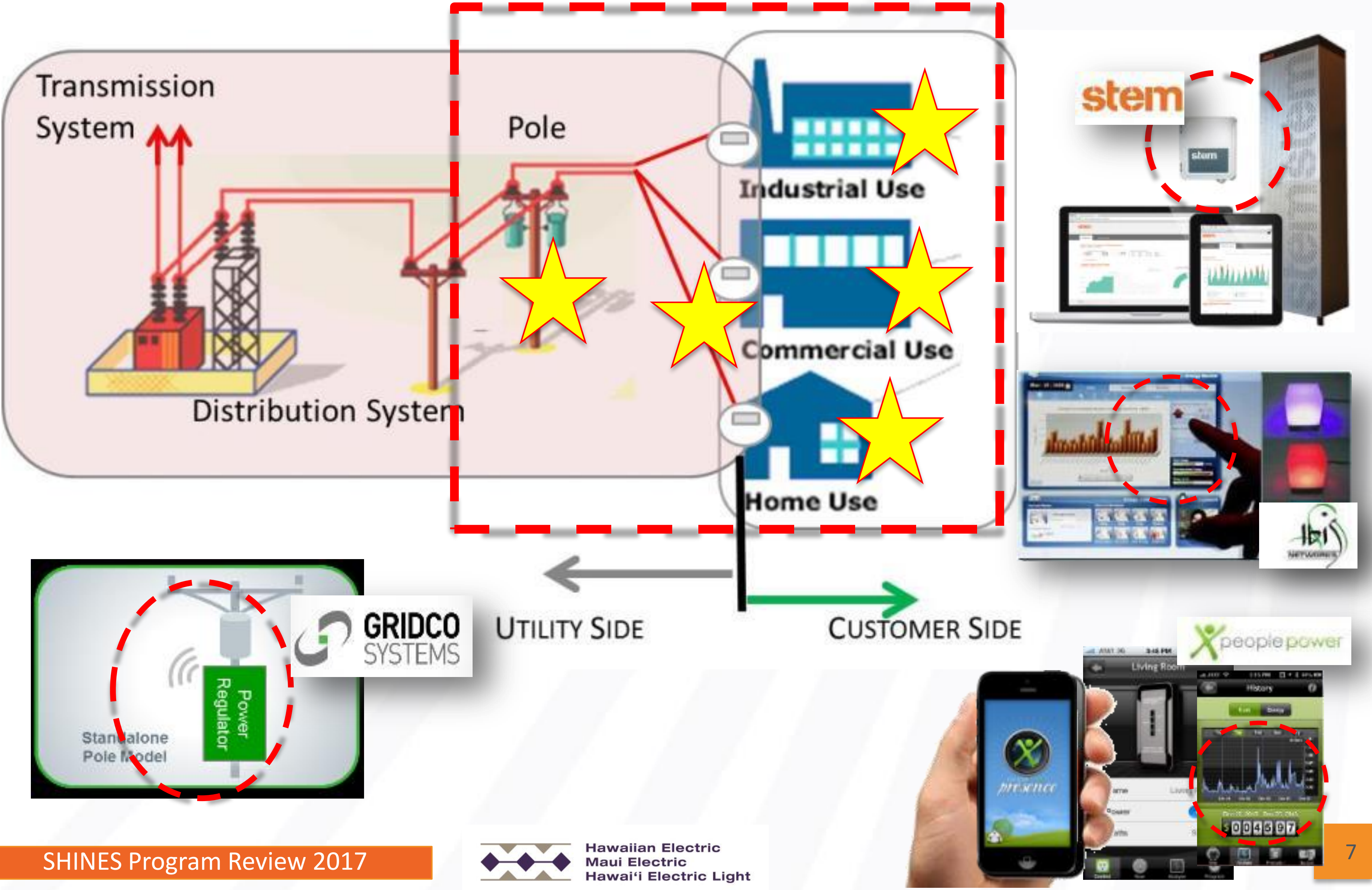


Improving the Utility to Customer Interface

THE GAP

Communication, monitoring, and data analysis infrastructure for “SEEING & MANAGING” distributed generation (DG) and variable distributed energy resources (VDER)

Approach: *Leverage Smart Technologies & Intelligence to Jumpstart Desired Edge-of-Network Capabilities*



SEAMS GOALS: Visibility & Controls

STATUS

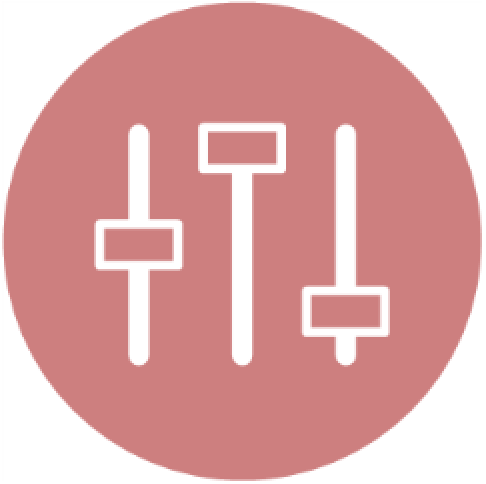
Indication if resource is active or inactive

Are you ON or OFF?

AVAILABILITY

Visibility to type of resource and amount of assured grid response (GR)

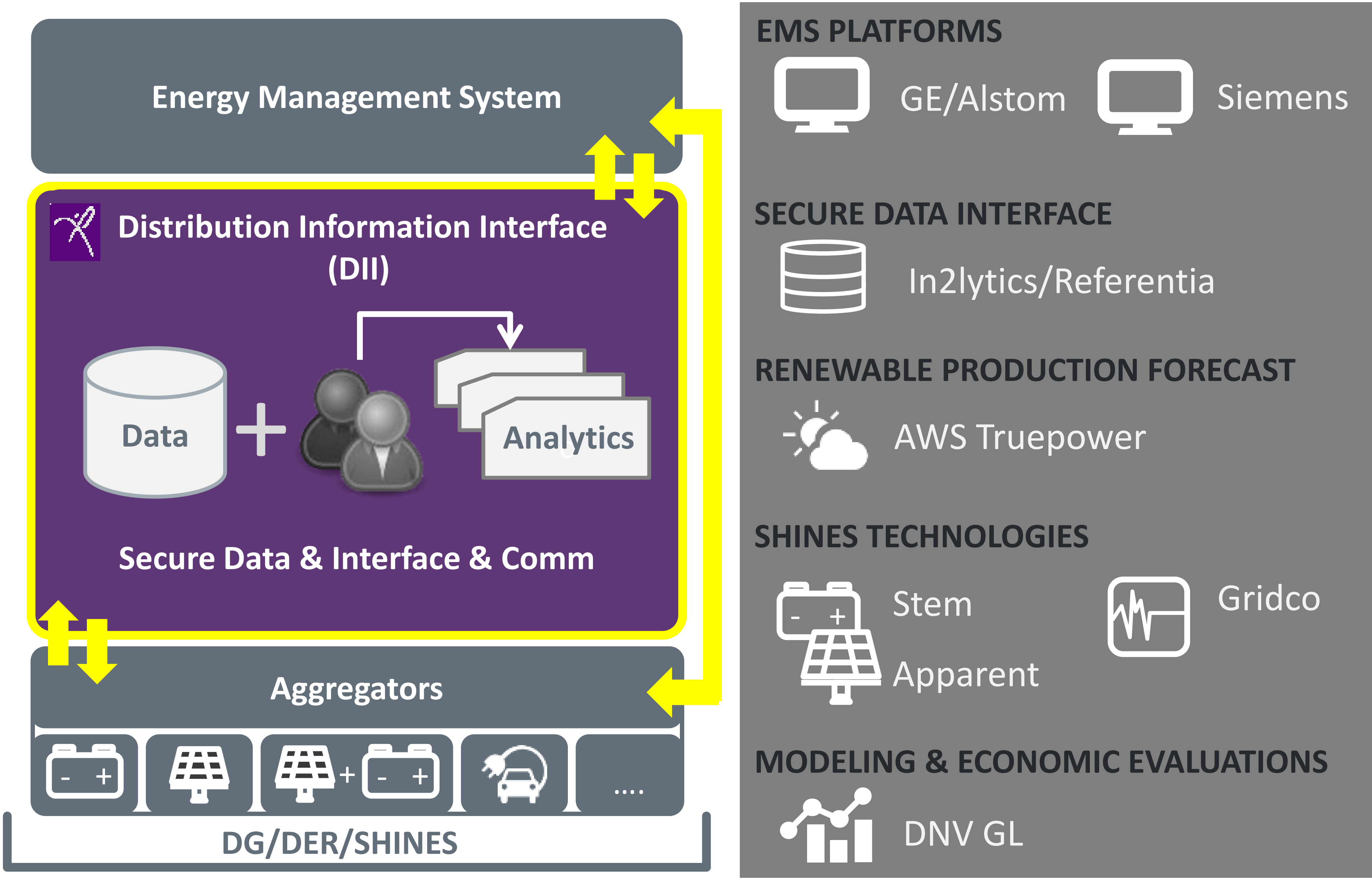
When and How can you provide?



CONTROL

Controls to reliably support the grid (system, regional and local) when needed

Dispatchable?



SEAMS for SHINES Project

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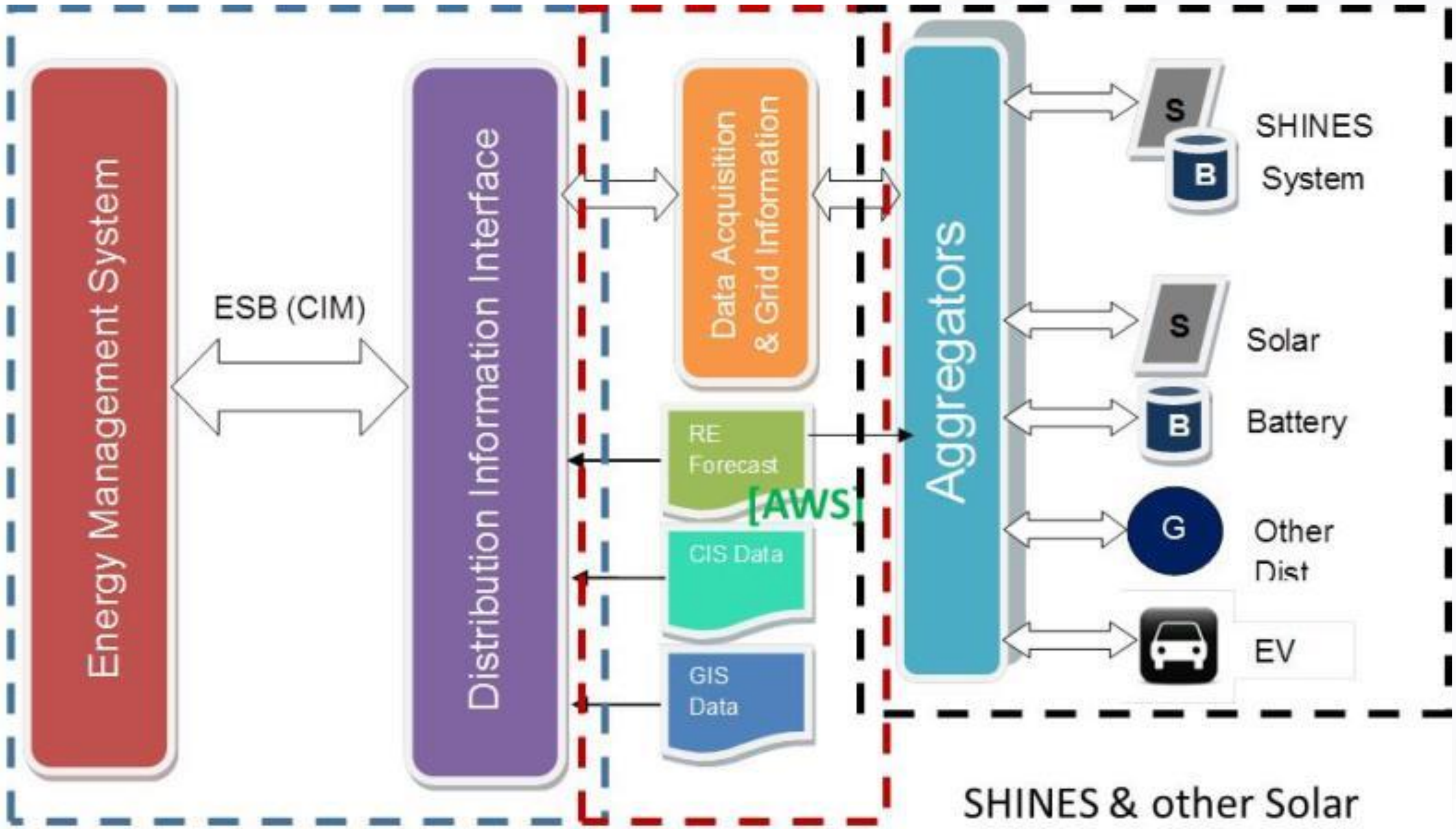
DII Data & Access Architecture



EMS platform Agnostic with DII interface capability **[Siemens & Alstom]**

Secure Data & Interface **[Referentia]**

SHINES & other Solar and Battery Deployments **[Stem, Apparent, Gridco & Others]**

Economic & Cost/Benefit Evaluations **[DNV GL]**

Main Objectives

GAIN CONFIDENCE & EXPERIENCE

leveraging commercially available behind the meter intelligent VDER technologies with control

INFORM & DEVELOP CONSISTENT AND PRACTICAL STANDARDS & PROCEDURES

for grid interactive plug-n-play (CIM, communication protocols, data architecture & analytics)

EVALUATE DATA REQUIREMENTS AND INTEGRATE CONTROLS

into familiar utility operating environments

COLLABORATIVELY ENGAGE

and gain experience (utility, vendors, customers)

Project Tasks

1. Project Management (UBAT coordination)
2. SHINES Site Design & Deployment
3. SEAMS Architecture Development
4. Demonstration & Cost Evaluation
5. Technical Outreach

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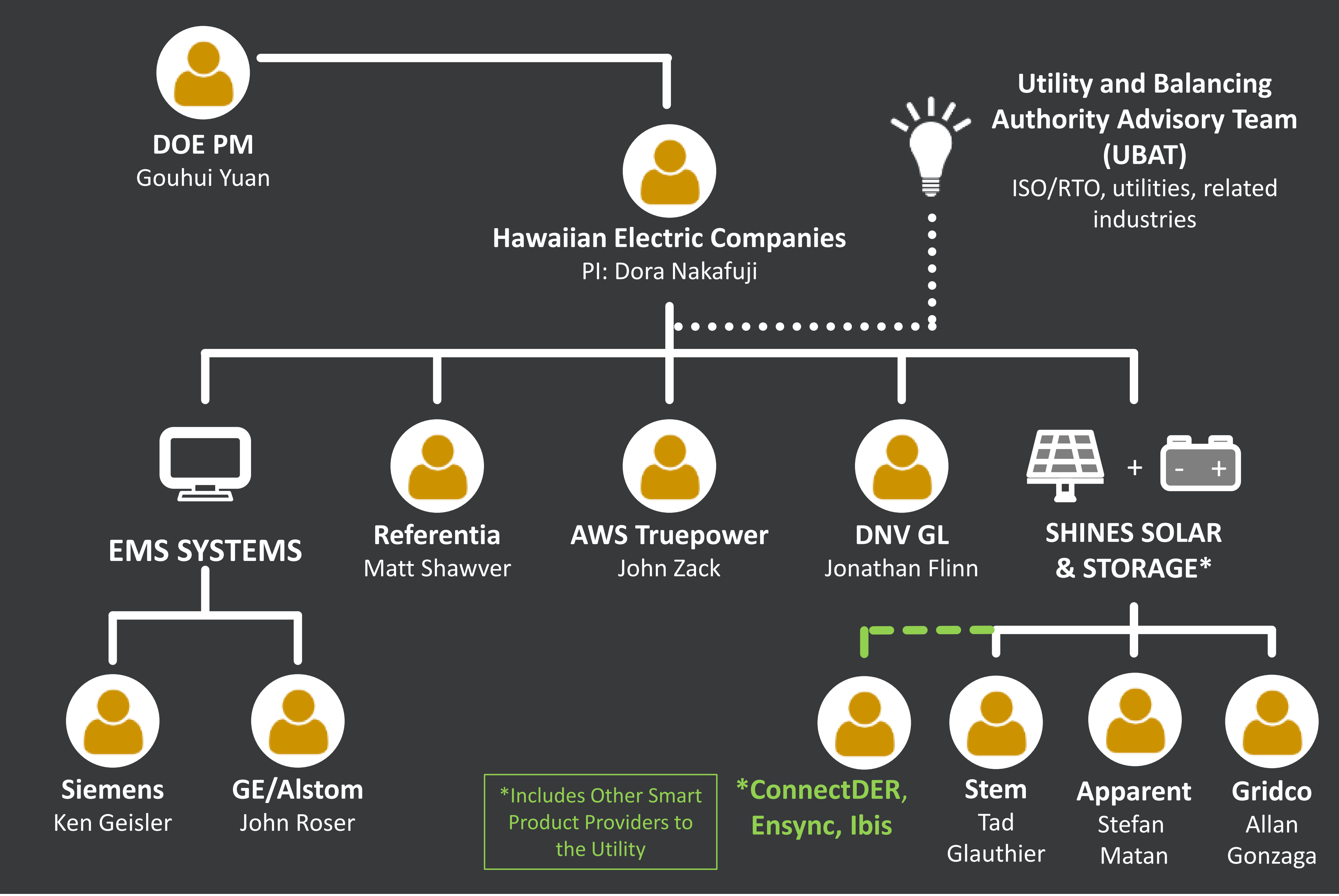

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Project Team

Utility/Balancing Authority Advisory Team (UBAT)

- Balancing Authorities: CAISO, NYISO, MISO, WAPA, BPA
- Utilities: Sacramento Municipal Utility (SMUD), Kauai Island Utility Cooperative (KIUC), Tucson Electric Power (TEP), Arizona Public Service (APS), Southern California Edison (SCE); Pacific Gas & Electric, Snohomish County PUD, ComEd, Sharyland Utilities, Duke Energy, Silicon Valley Power, SDG&E, Guam Power, Exelon, HECO/MECO/HELCO, Emera, EDF, Austin Power

Outcome & Benefits

Built in review/advisory team: Utility & Balancing Authority Advisory Team (UBAT)

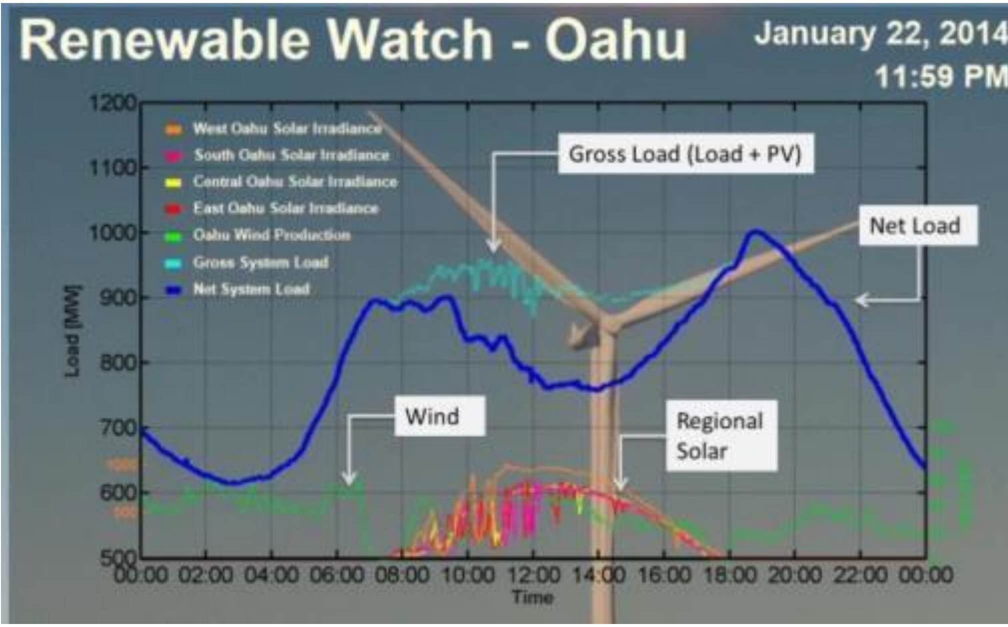
Workforce modernization and retooling for the future grid

Establish data logistics, transfer and analysis requirements ensuring access to the right data by the right people at the right time

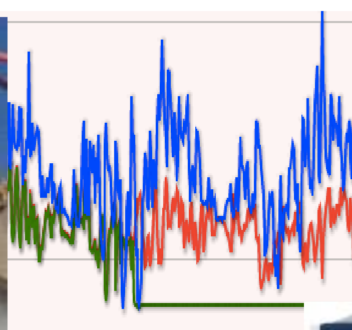
Demonstrate integrated capabilities via a platform for discovery

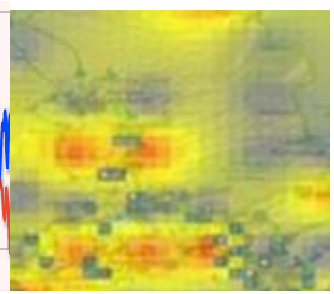
Leverage industry cost sharing and collaborations to close gaps linking system to edge of network

Beyond the Status Quo



Customer Access & Flexibility





Utility Visibility, Controls & Predictive Analytics in the SEAMS

BP 1 Tasks

- Task 1.1 – Project Planning & Team Coordination
  - Deliverables
- Task 1.2 – SHINES Site Deployment Reviews
- Task 1.3 – SEAMS Data Interface & Architecture Design
- Task 1.4 – Review of Cost Model & SHINES Data Requirements
- Task 1.5 – Technical Outreach
- Task 1.6 – Go-No-Go #1

Task 1.1: Project Management & Team Coordination

- This task covers the administration and project/team coordination. Organization and project follows the SOPO and PMP. Efforts also include coordinating a Utility/Balancing Authority Advisory Team (UBAT) meetings and communication feedback. The team is organized as shown in Figure 2.2. Hawaiian Electric staff act as primary project managers and leads.

- **Value Proposition:** Regular update meetings will support steady progress and quarterly reporting requirements defined by DOE along with coordinating of Go/No-Go decision points within the SEAMS project scope based on annual review schedule. Creation of UBAT provides industry feedback for developing robust SEAMS solutions and facilitates sharing of results.

- **Metric Justification:** Formation of UBAT advisory team ensures broader, mainland utility applicability of demonstrated efforts.

Task 1.2: SHINES Site Deployment Reviews

- This task establishes a list of SHINES project deployment locations based on criteria including utility interest, customer sites and viability of SHINES technology given current circuit penetration levels using publicly available Locational Value Maps (LVM maps) provided by Hawaiian Electric. LVM maps provide a visual representation of the distributed behind-the-meter PV penetration levels on our circuits. Our customers can access the LVM look up via the Company website (www.hawaiianelectric.com), query by their street address and check on their penetration levels to provide an indicator of how quickly their interconnection agreements may get processed.

- **Value Proposition:** This task focuses on the review and assessment of distributed energy resources on the islands to identify high penetration circuits where SHINES technology can be optimally sized and sited. Review and assessment will consider the existing information: installed capacity, customer types on the circuit and existing infrastructure configurations. This will help ensure a diversity of locations and broad look at SHINES application to address distribution circuit conditions for application beyond Hawaii. Information considered will be used to prioritize sites based on need and a consolidated methodology for siting and review to be finalized with the team.

- **Metric Justification:** A standard methodology and rubric to accelerate finding appropriate customers with interest and load conditions/in-situ devices conducive to grid support can significantly reduce the time it takes to right-size and capture appropriate SHINES features. Over 80 circuits on Oahu are already experiencing high penetration in-situ PV conditions. A projected list of potential sites and a target to evaluate 40 C&I customers cover 50% of the known highly penetrated circuits. We anticipate a diverse sampling of customer sited devices and circuit conditions across the islands to inform distribution automation and control logic design for system. Within project timelines and budgets, 30 potential deployments are anticipated with a stretch goal to get a total of 40 C&I customers returning near real-time data. Data access from a diversity of sites and circuits using IPRs (Figure 2.4), Powerscopes and others (Figure 2.5) in concert will help confirm and validate the customer load and device data impacts on the circuit.

Task 1.3: SEAMS Data Review & Interface Architecture Design

- This task focuses on the Distributed Information Interface (DII) for data to link from SEAMS to SHINES with EMS coordination and control logic development. The DII platform will serve as a proxy for data management, data analysis and data exchange between the EMS and future distributed data management systems (DMS) with enhanced DG control logic such as for SHINES technologies. As part of this effort, DII platform will serve as development platform to work out data structure, mapping and connectivity issues as well as address secure data exchange from each management system to another. There is interest in seeing how these learning algorithms use real-time forecasting data to improve learning algorithms and how big of an effect weather dependency has on controls and learning algorithm performance at the circuit level. Data transfer protocol will be handled within the DII so EMS functions can be linked to VDER information for the 5 preliminary C&I sites.

- **Value Proposition:** Initial field data from C&I customers will be made accessible via SHINES web-based tools. DII architecture development and passing of data via the REDatabase platform achieves connectivity between SHINES and utility operational tools like EMS, ADMS and OMS. Initial integration requires EMS to have access to the SHINES data in order to develop real-time control logic for future integration. EMS providers can consider development of EMS logic given visibility and access to near real-time SHINES data via the DII architecture.

- **Metric Justification:** Design of the DII relies on database automation and interface between a number of platforms (some available today and some not yet available) making up the DII. Converging on an initial set of required data, interface protocol to uplink VDER and enable EMS to access via secure DII within existing environments will be critical for meeting cost effective management and integration for increasing levels of SHINES technologies.

Task 1.4: Review of Cost Model & SHINES Data Requirements

- This task focuses on the review and assessment of the SHINES technology pre-deployment and post-deployment using actual performance data collected from the SHINES technology over a minimum period of 1 year (within project timeline). The System Advisor Model (SAM) (or similar LCOE tool if the SAM tool is not able to appropriately represent the SHINES attributes) will be evaluated by the team in order to offer guidance regarding the tool's ability to model the general SHINES solution and advance capabilities.

- **Value Proposition:** SAM Advisor Model or similar tools will be used to evaluate the viability of the SHINES technologies consistent with DOE FOA targets for meeting LCOE by 2020. Integration of in-situ technologies with intelligent software is anticipated to provide significant cost savings and be more cost-effective for customers and remains consistent with DOE FOA targets without having to incur additional costs and risks by starting from a new system. This proposes a number of value added options for early adoption customers who may already have an existing PV or storage device and is looking to implement and participate in grid management opportunities.

- **Metric Justification:** Traditional LCOE cost models do not factor in the integrated controls and retrofit capability of this team's unique SHINES technologies. Guidance on how best to model the SHINES technologies unique to the PV inverter and storage provider will be developed by the team. .

Task 1.5: Technical Outreach

- This task supports the dissemination of lessons learned and best practices resulting from this project to a broader stakeholder community via training and conference venues. The team will target submitting at least two abstracts to industry conferences or vendor user workshop for project presentation per year. Task also covers conducting the 1st UBAT team in-person meeting at a host utility site. Lessons learned will all be documented and shared with UBAT as well as through industry venues such as conferences (i.e., SEPA USC, NASPI, DistribuTECH, UVIG), EMS User Workshops or other update meetings as required by DOE as part of the project.

- **Value Proposition:** This task supports the development of the necessary communication strategies, training and abstract opportunities with the project team and a UBAT industry team to ensure communication of robust and diverse solutions.

- **Metric Justification:** Abstract submission must be planned in advance of industry venue and support the timely dissemination of lessons learned and practical value-add of US DOE funded industry activities. Information supports more rapid uptake and access to industry needs and grid modernization progress.

Task 1.6: Go-No-Go Decision

- Evaluation of Go-No-Go

BP 1 Milestones & Deliverables - Completed

- All Tasks initiated
- Milestones achieved
- Deliverables completed as planned

Milestone	Achievement/Project Value
M1 Formation of UBAT advisory team consisting of utility and balancing authority representatives	UBAT representation from at least 4 utilities contending with high penetration and automation concerns and at least 1 balancing authority will ensure broad applicability of project products and lessons learned.
M2 Siting and sizing methodology for SHINES technologies	A consistent process for evaluating SHINES will be critical for adoption of PV enhanced by storage technologies. As a system, the two technologies will have a different performance than individually and establishing a consistent methodology supports adoption process.
M3 Powerscope and/or utility IPR real-time load and device deployment and data acquisition	Deployment of field devices has typically been the most challenging and time consuming. Working out deployment and field challenges early in the process will help keep project on track.
M4 Data architecture design for VDER information uplink within DII	DII serves as a proxy for various data integration and analysis needs. As many of the established data platforms used by utilities today are not integrated, data nomenclature and transfer formats are incompatible. Design early in process can help begin to map out inconsistencies to proactively resolve.
M5 Determine input requirements for SAM model and SHINES technologies.	FOA requires use of SAM for LCOE determination. Early determination of SAM tool input requirements and capability to model the SHINES attributes will be critical for cost evaluation needs. (1Q 2017 – in progress)
M6 Submit at least 2 abstracts per year to industry conferences or user workshops	Conference venues and workshops typically require 6-9 month lead time. Early identification of proceedings and venues of interest will ensure abstract write-up, communication and development needs to improve efforts.
M7 UBAT Kickoff Meeting	Prepare and conduct UBAT meeting to review project objectives and advisory role of UBAT membership to ensure broad applicability of project products and lessons learned. Prepare meeting materials.

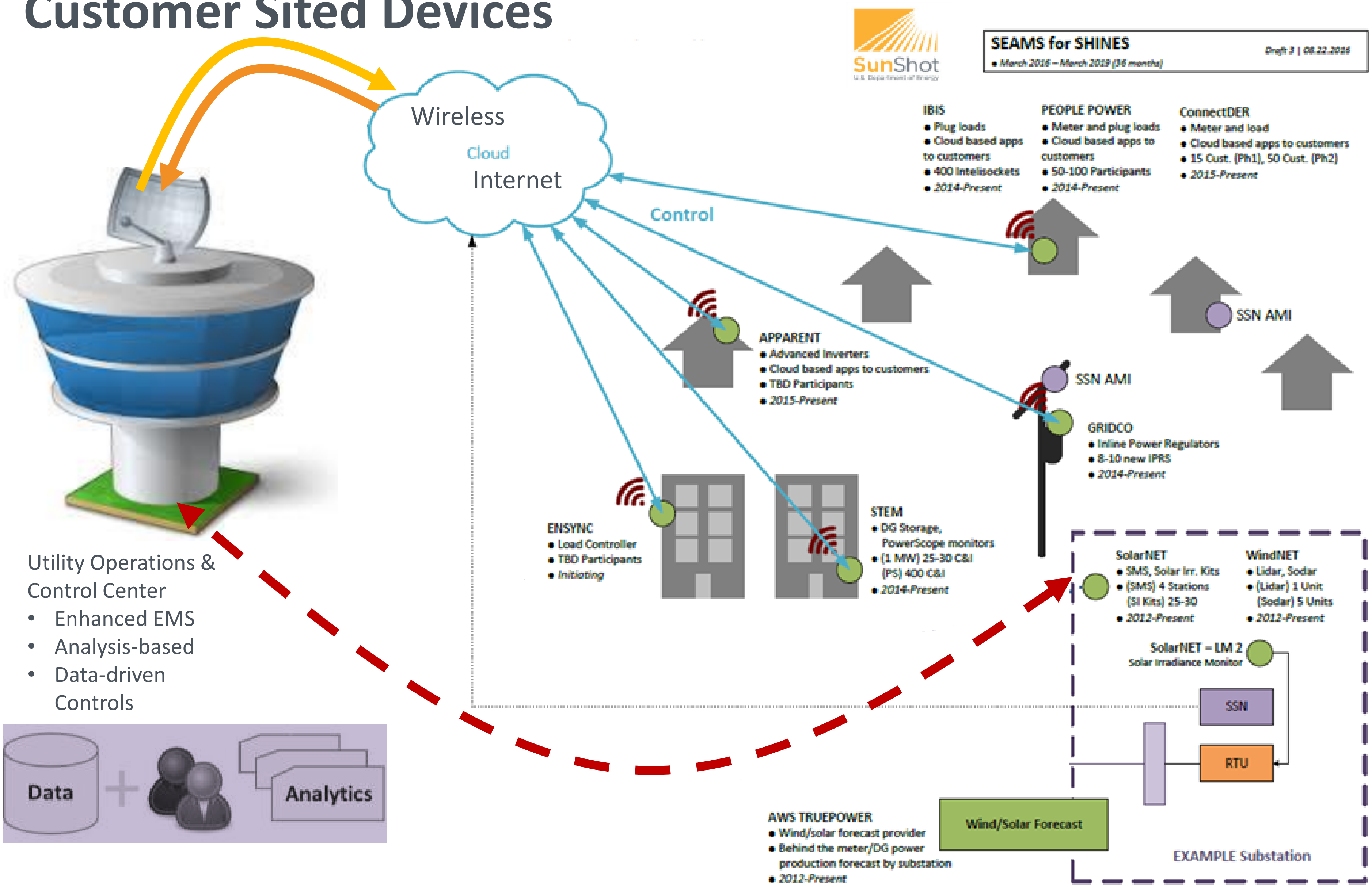
BP1 Deliverables include:

Task	Deliverable Description
Task 1.1	– Quarterly status reports per requirements – UBAT Team list
Task 1.2	– Interim Siting Methodology
Task 1.5	– 1st Conference Abstract – 1st UBAT Coordination Meeting & Materials
Task 1.6	– 1st Go-No-Go Materials

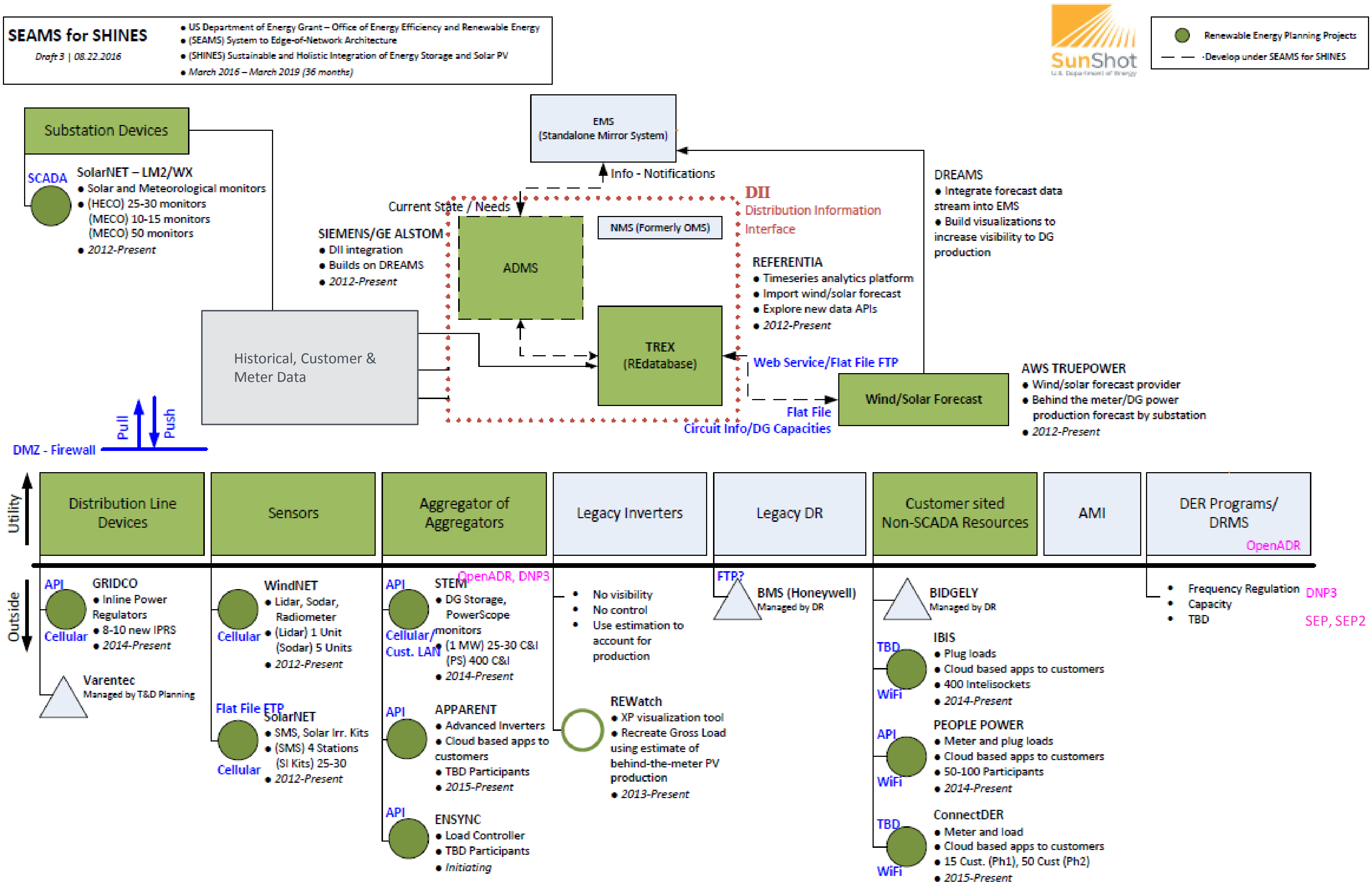
Year 1 Lessons from the SEAMS

- Game plan
- Concentrating on Field Deployments
- Customer Engagement & Education
- Quality Checks
- New data interfaces (APIs, visual & analysis tools)
- Outreach (publications, presentations, industry recognition awards)
- UBAT Team, Kick-off at WAPA April 2016
- UBAT webinars (AWS, Referentia, others to be scheduled)

Physical Architecture - Enhancing Visibility through Customer Sited Devices



Data & Networking Architecture

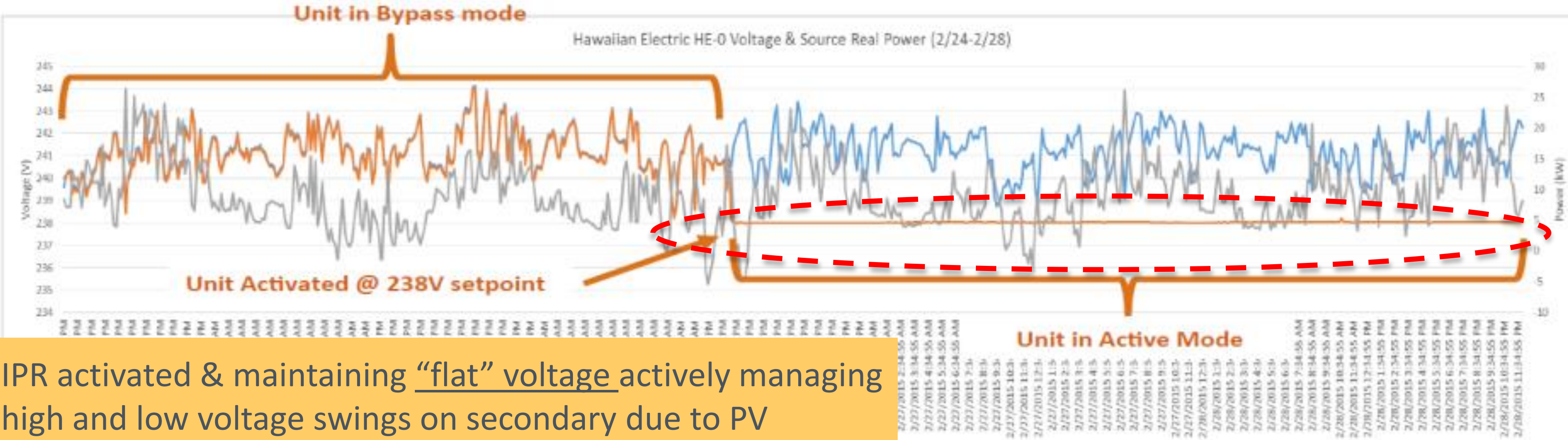


SHINES Site Deployment Reviews

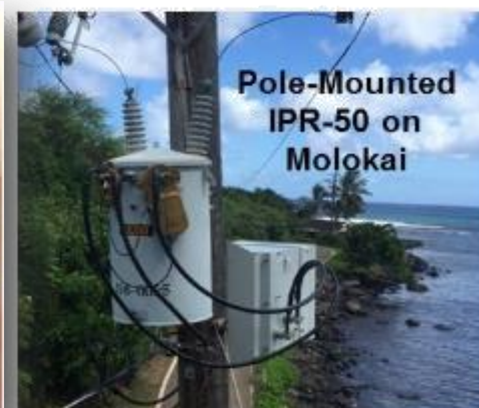
- Siting for SHINES technologies was driven primarily by customer need. While residential and commercial/industrial customers (C&I) were reviewed and continue to be reviewed for deployments, initial set of Powerscopes and smart plugs were deployed at schools, key account customers and small/medium commercial accounts that were on the borderline of two utility rates. Sites considered include:
  - Subset of C&I customers and public schools in Hawaii with high demand charges whose “peaky” load may benefit from PV, storage or both. Current plans are to follow-up with State of Hawaii public schools with Stem monitoring devices (PowerMonitors) and identify those that have high thresholds and are close to the next rate class.
  - Approximately 2000 NEM customers (residential) on highly penetrated circuits which will require additional planning review prior to interconnection. These are the last customers on the legacy NEM program that need to be cleared. Currently in discussions with planning to identify a subset of circuits with high DML penetrations to evaluate. Using LVM (Figure 1) to prioritize impacts based on kW penetration and circuit day time minimum load.
  - List of high penetration circuits with voltage extremes due to high penetration of PV has also been recently compiled. While these locations may require additional infrastructure upgrades due to impact of high levels of PV, continuing discussions if SEAMS for SHINES technologies like the Gridco IPR can address concerns. Still working through internal procedures regarding draft standards for deployment and pilot sites.

Demonstrating New Technologies to Reliably Integrate More Renewables

Mitigating Customer Complaints due to Hi-Pen PV



IPR activated & maintaining <u>"flat" voltage</u> actively managing high and low voltage swings on secondary due to PV



http://www.elp.com/articles/powergrid_international/print/volume-21/issue-3/features/2016-projects-of-the-year-powergrid-international.html

In the Field and on the Internet
https://www.youtube.com/watch?v=oJDFVsecm18

Empowering Customer Savings and Enhancing Grid Responsiveness

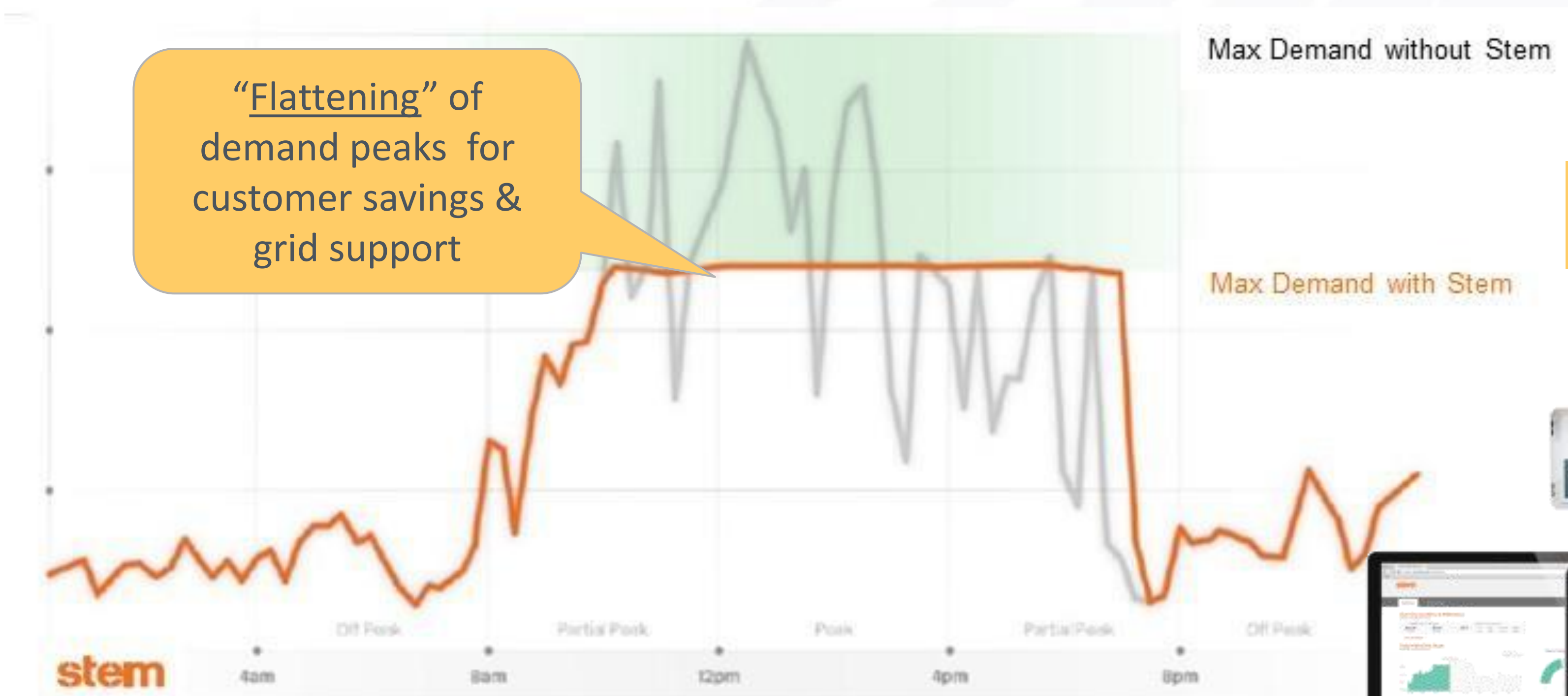
How it Works – Customer Benefits

- Predicts customer energy usage 30 days in advance
- Customer configurable charging of on-site battery with PV or at cheaper TOU times
- Anticipates costly peak events and releases stored energy for demand management

DUAL VALUE for Customer & Grid

How it Works – Grid Benefits

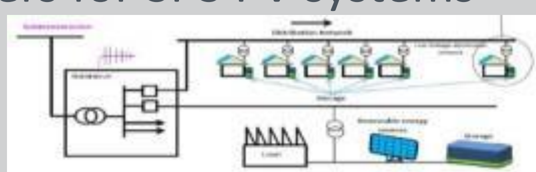
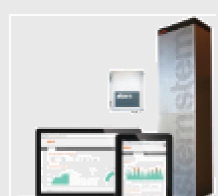
- 24/7, on demand access to storage for smoothing out peaky loads and PV variability
- Lower cost aggregator model offering agility, scalability & controls
- Build confidence through use experience



Customer-Sited Storage

Smart Power for Schools – Site Engaged & Energy Smart (SEES Initiative)

Empowering & Educating the Next Generation

STEM Powerscopes 	Real-time monitoring and visual tools to create awareness of electricity use (how much & by what and when) to influence behavior change
IBIS Intellisocket controllable plug loads deployment 	Controllable plug load deployment & interactive web-portal to see & manage AC usage
Apparent Smart Inverters for SPS PV systems retrofits 	Advance inverter & controls for improving power quality and grid integration
Intelligent Battery Storage systems * 	Use of storage to manage PV variability (*PV systems installed under Ka Hei program)

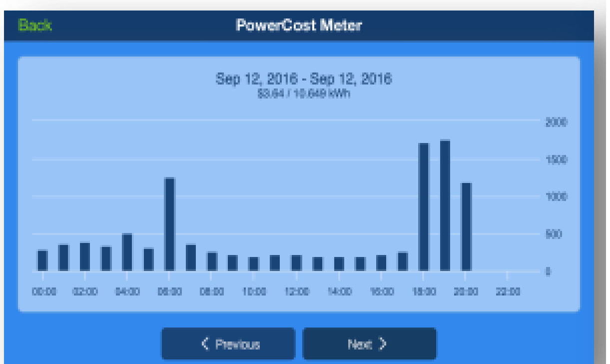
Partnership: Hawaiian Electric
Dept of Education & Stem

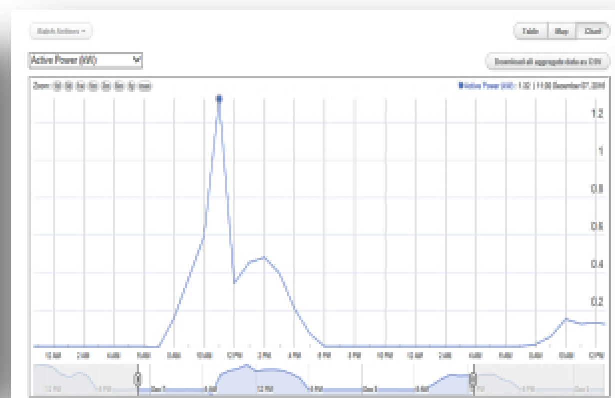
New Sources of Customer Data

Utility approved Blueline device attached to utility meter.

ConnectDER Meter Interconnect

Stem Powerscope





PowerSpotters – On-site Monitoring

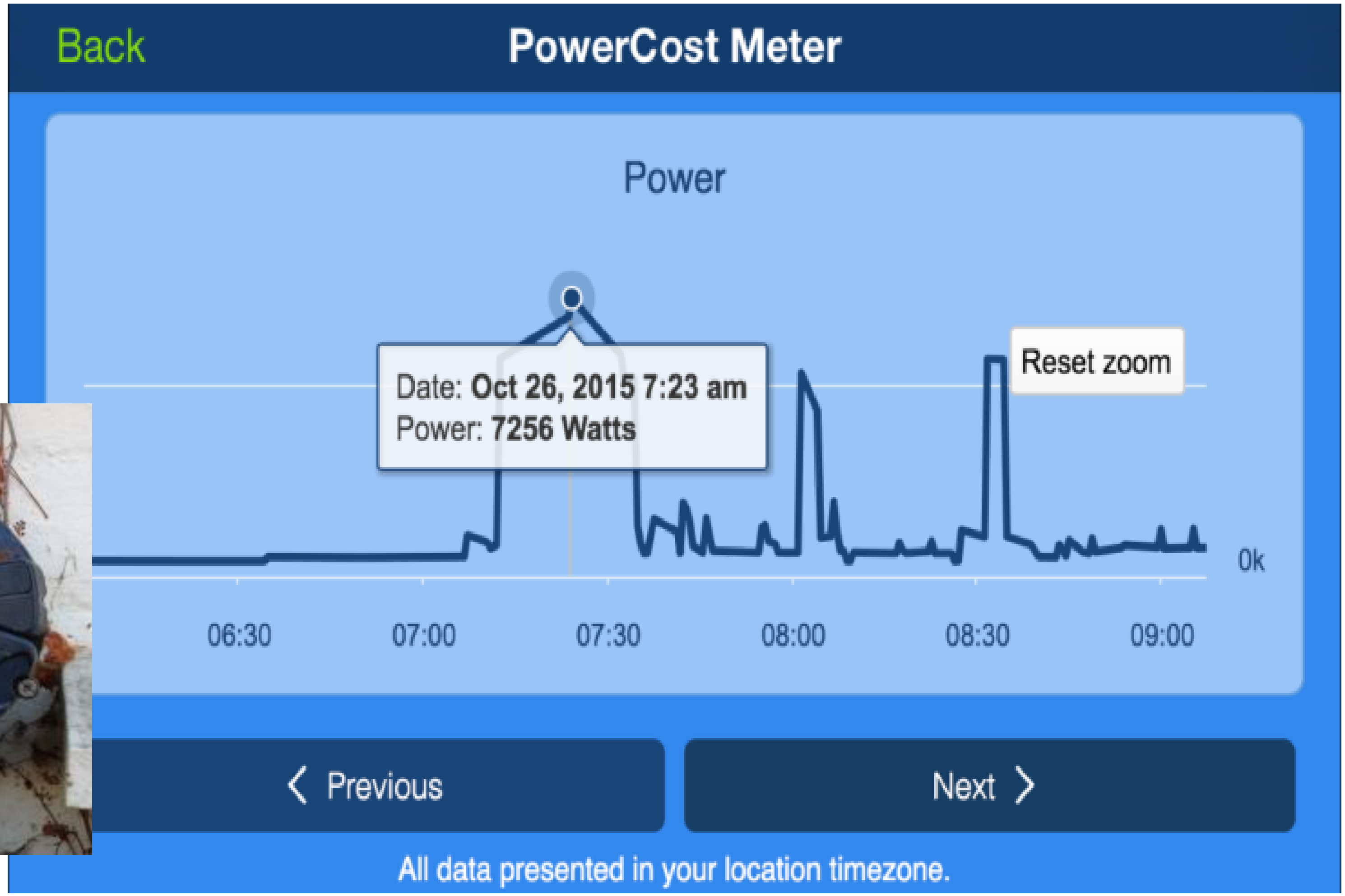
Blue Line Meter Reader and WiFi Bridge

TED Spyder Individual Circuit Monitoring Tool

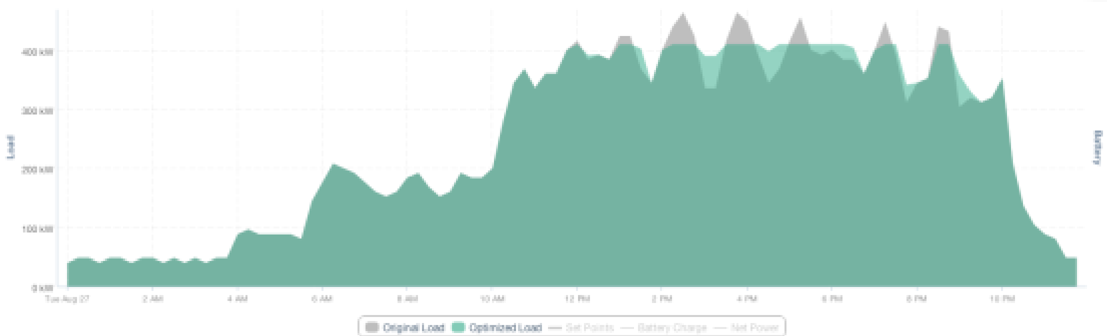
Presence Gateway

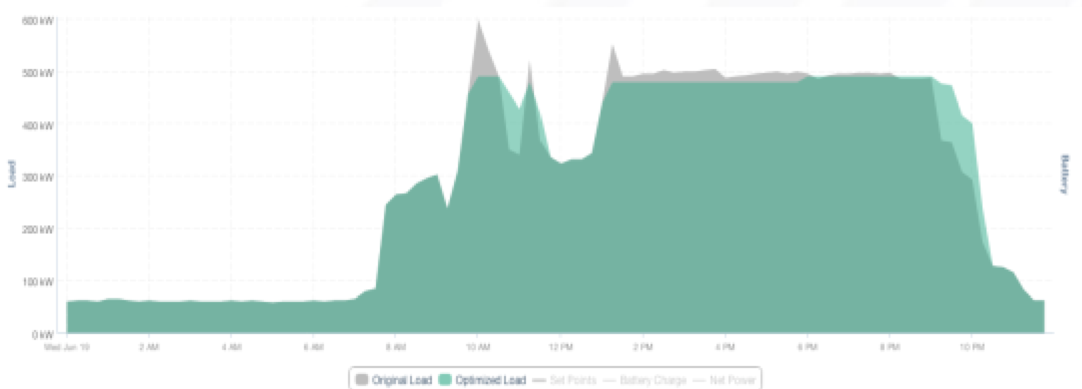
Centralite Plug

Connecting Utility & Customers: Web Apps



Communicating Using Visuals (Load Shapes)





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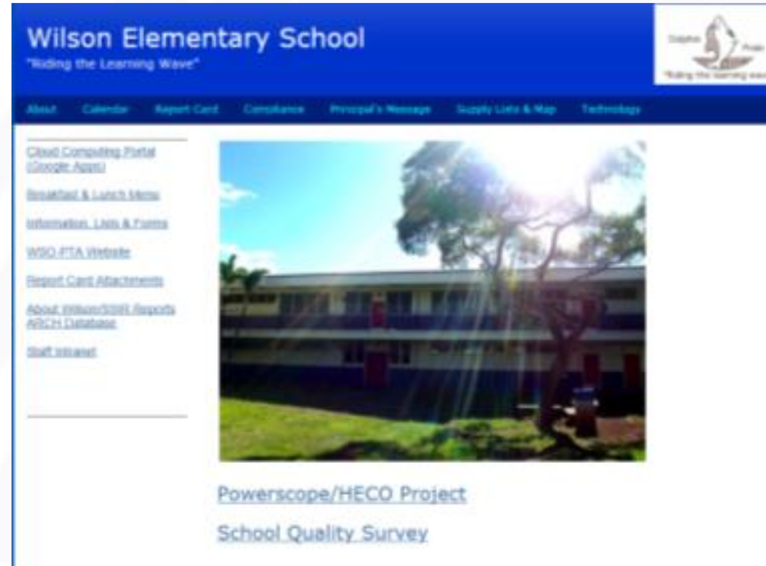
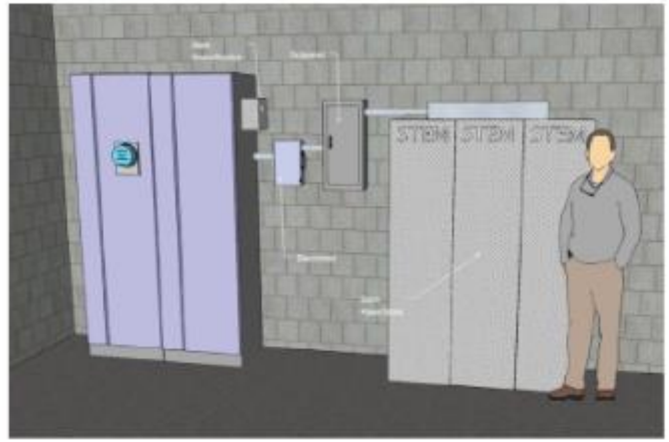
Educating: Enrichment Material & Interactive Training

- School Fair – Demos
- Smart Power for Schools – K-12 Companion Worksheets to Powerscopes in all Public Schools; High School senior project
- Community Activities – Girls Scouts Science Fair
- University level – summer interns & graduate student research projects
- Train the Trainers – Teachers & Facility Managers
- Utility Customer & Key Accounts – Training on Proactive tools
- New interconnection procedures



Streamline Processes: Deployment & Commissioning



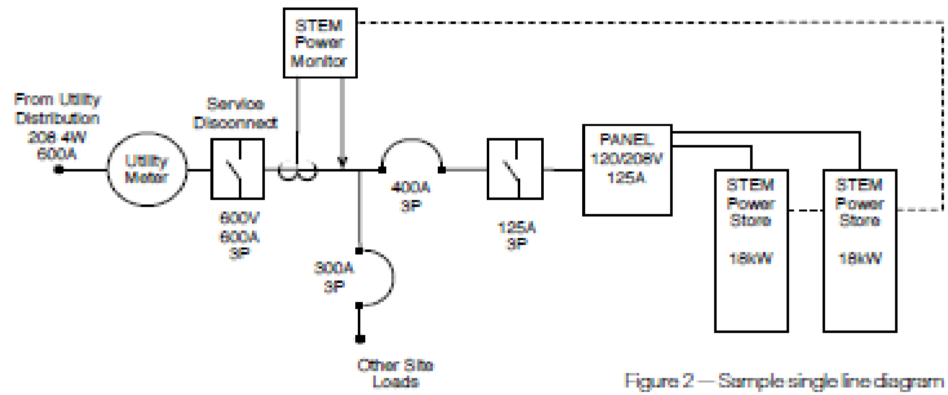


Figure 2 — Sample single line diagram

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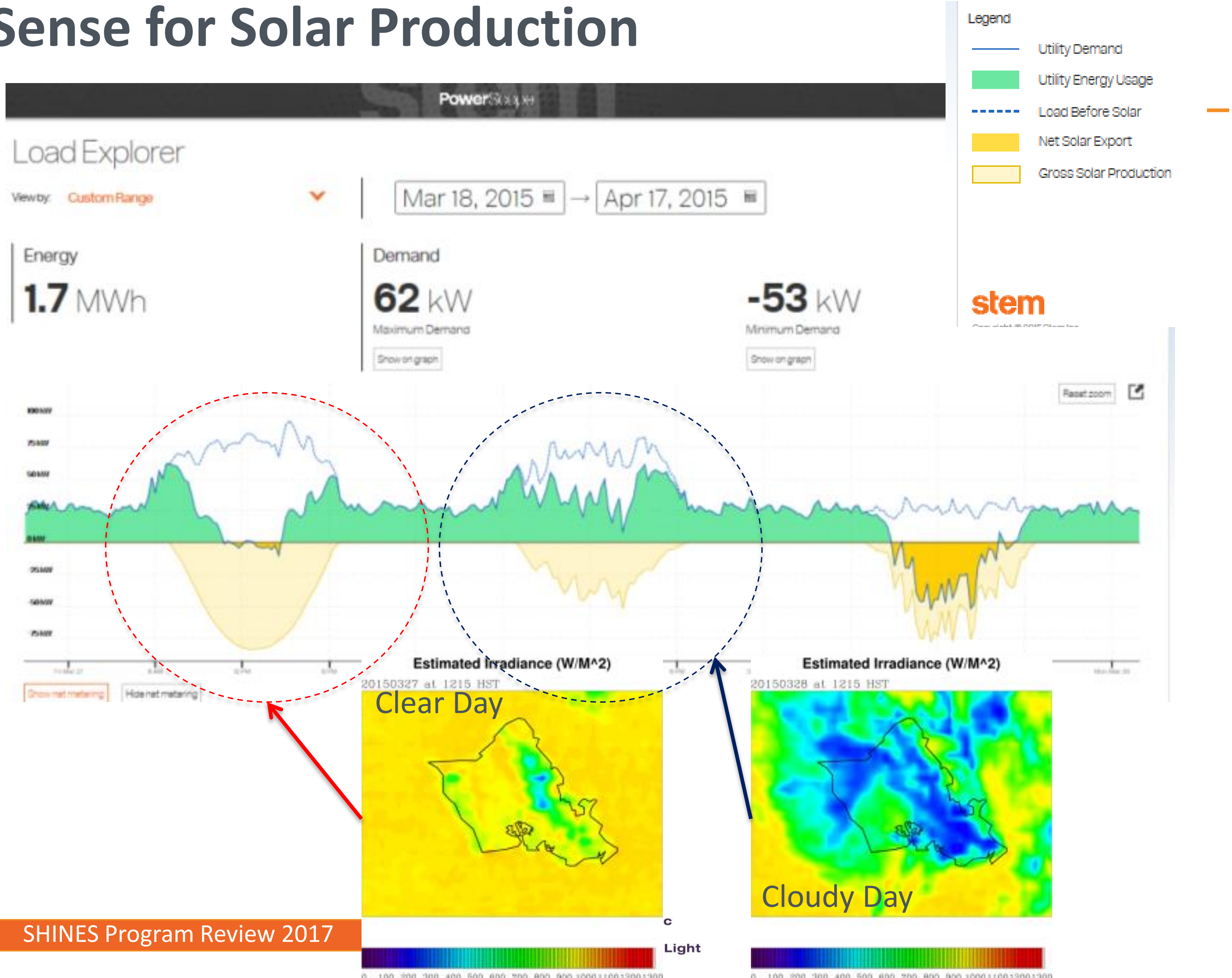
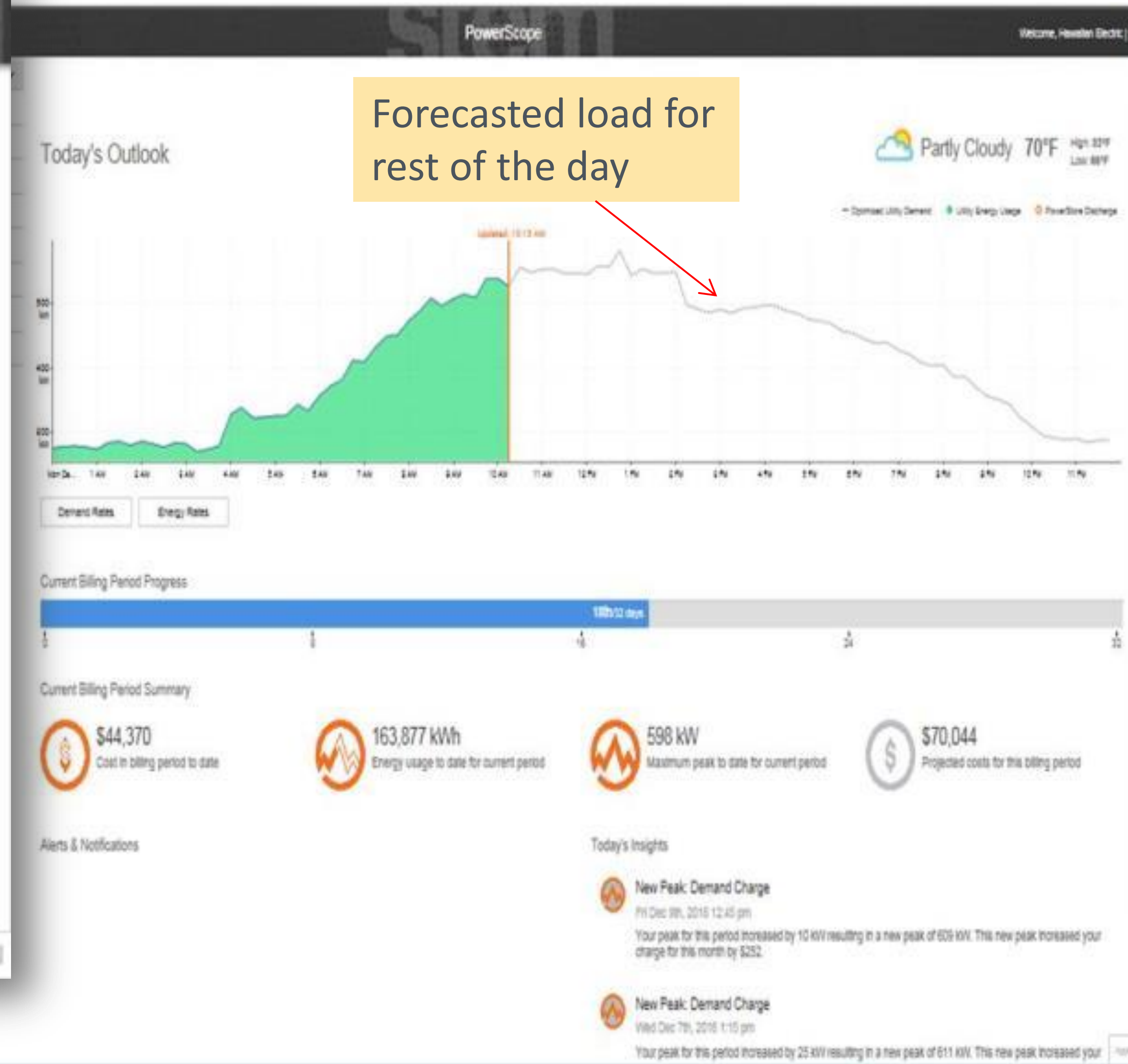
Maui Electric
Hawai'i Electric Light

Sense for Solar Production



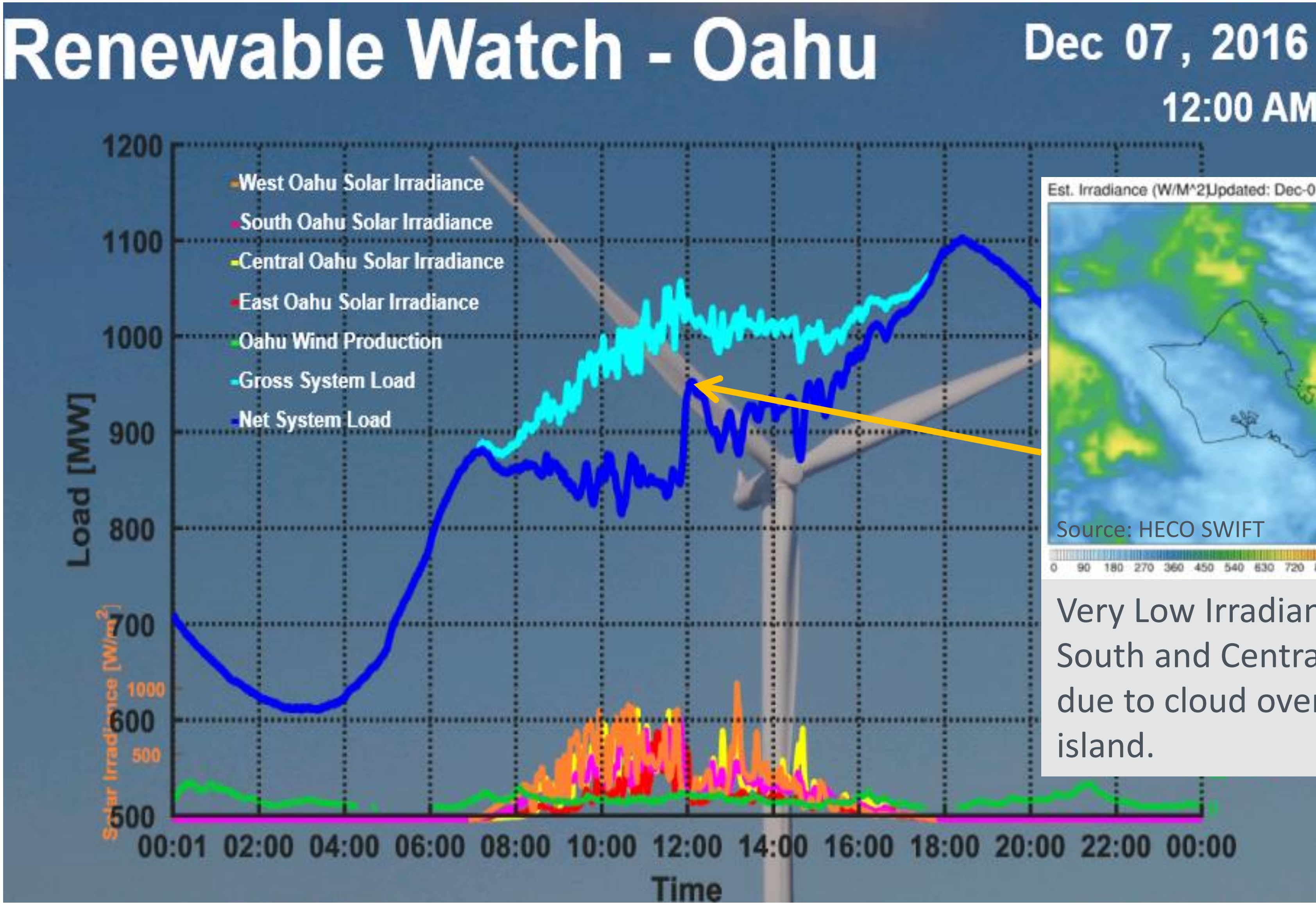
Quality Checks - Real-time Tracking and Load Forecast

Mobile app view



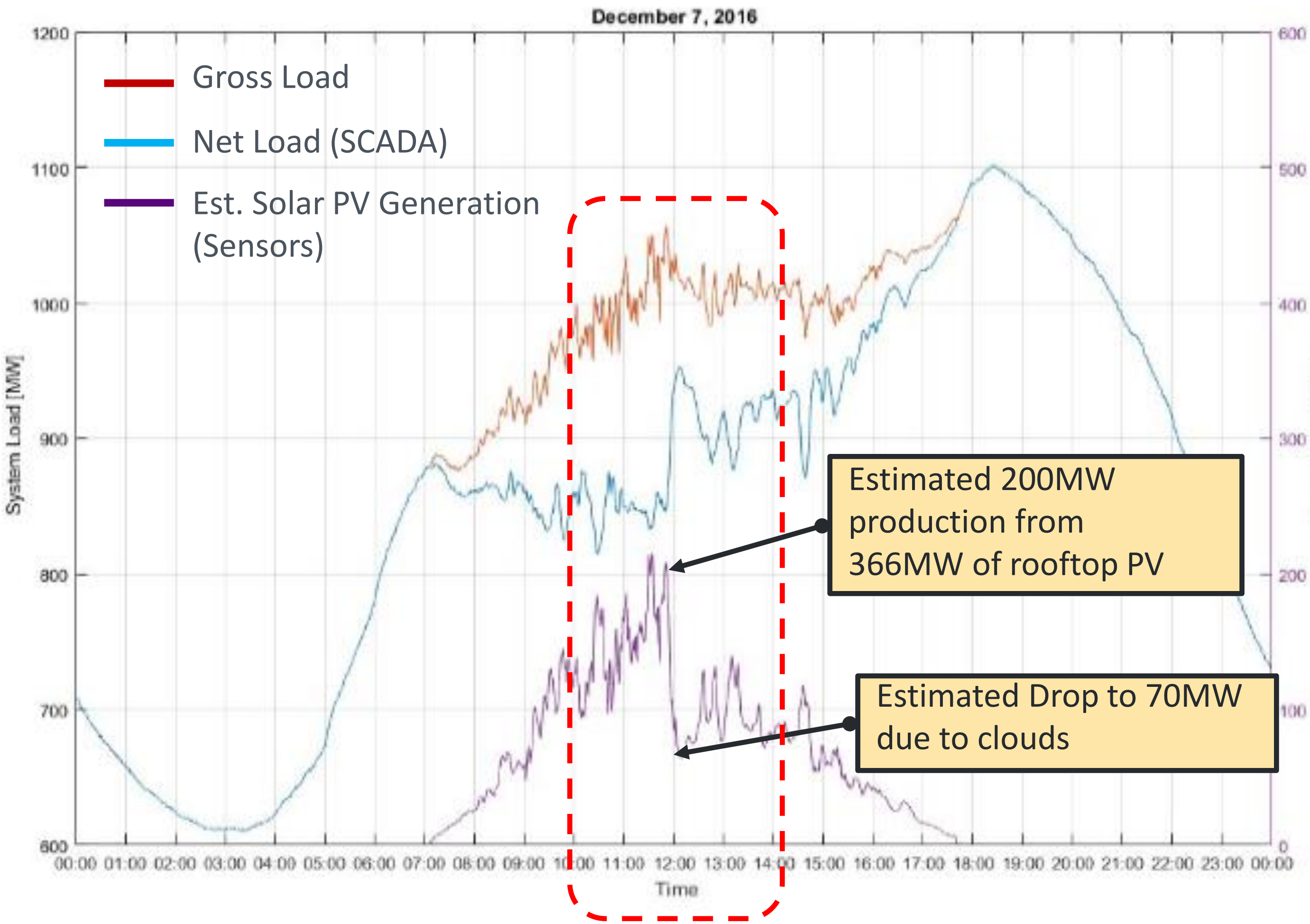
Forecasted load for rest of the day

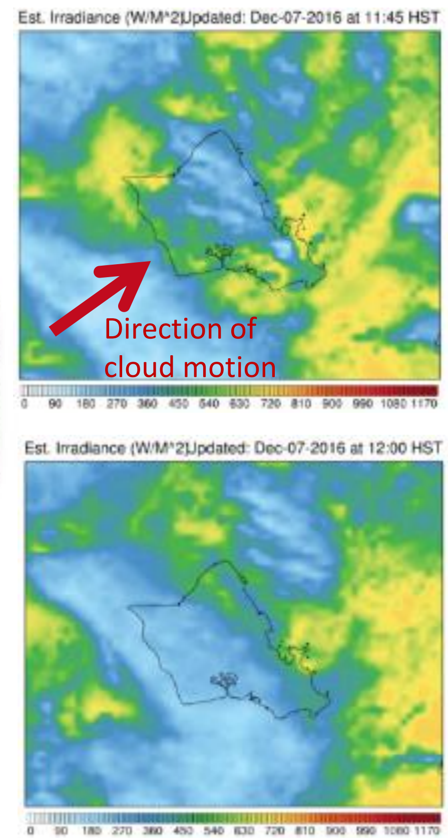
BUILDING CONFIDENCE: REWatch Visual Tools Capture 100 MW VDER Ramp-Up Event & Impact on System Load



Very Low Irradiance over South and Central Oahu due to cloud over entire island.

Capability to Estimate "Masked" Generation from 366 MW of Roof-Top-PV Systems





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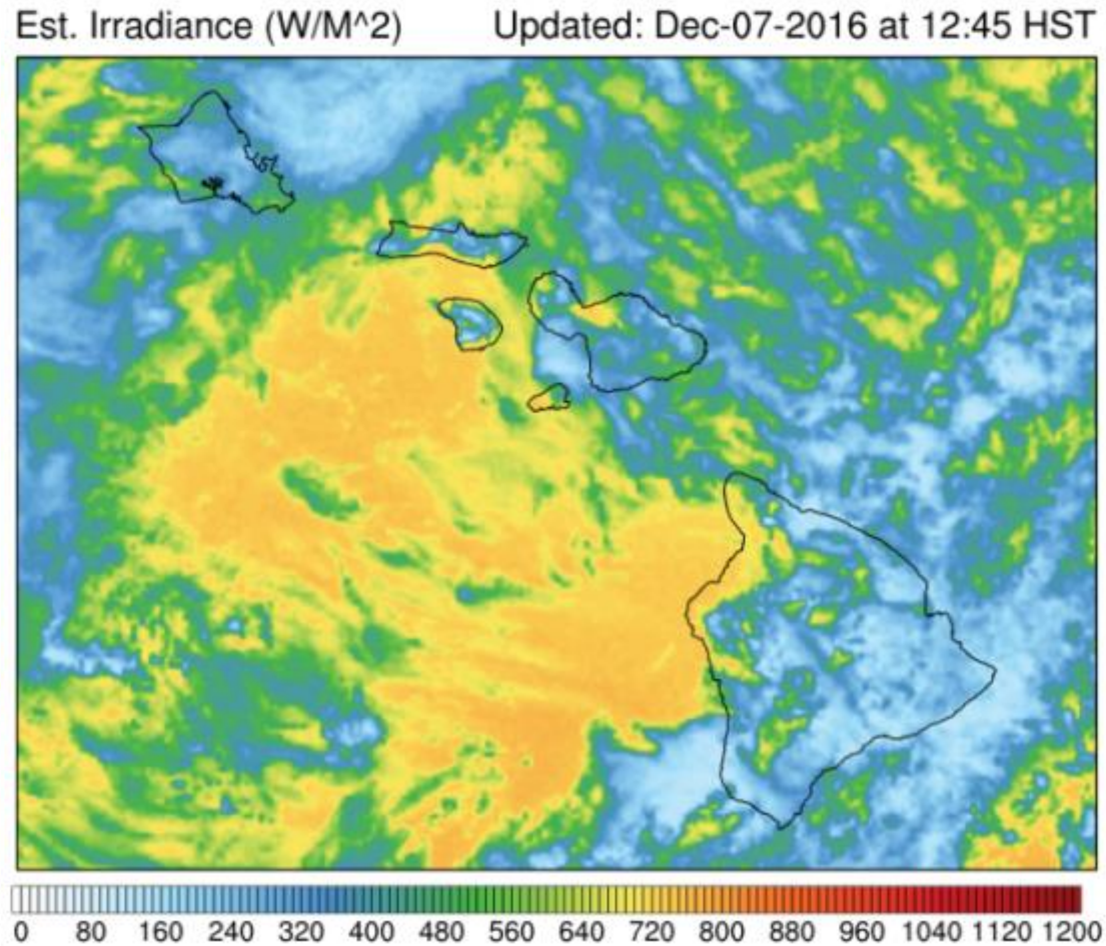
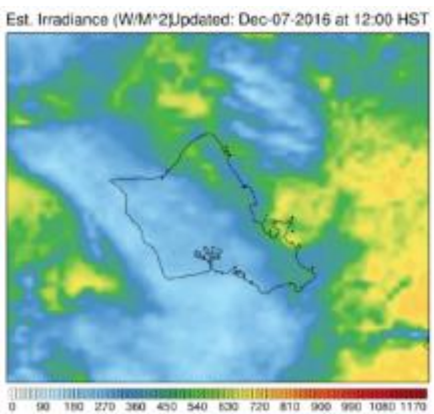
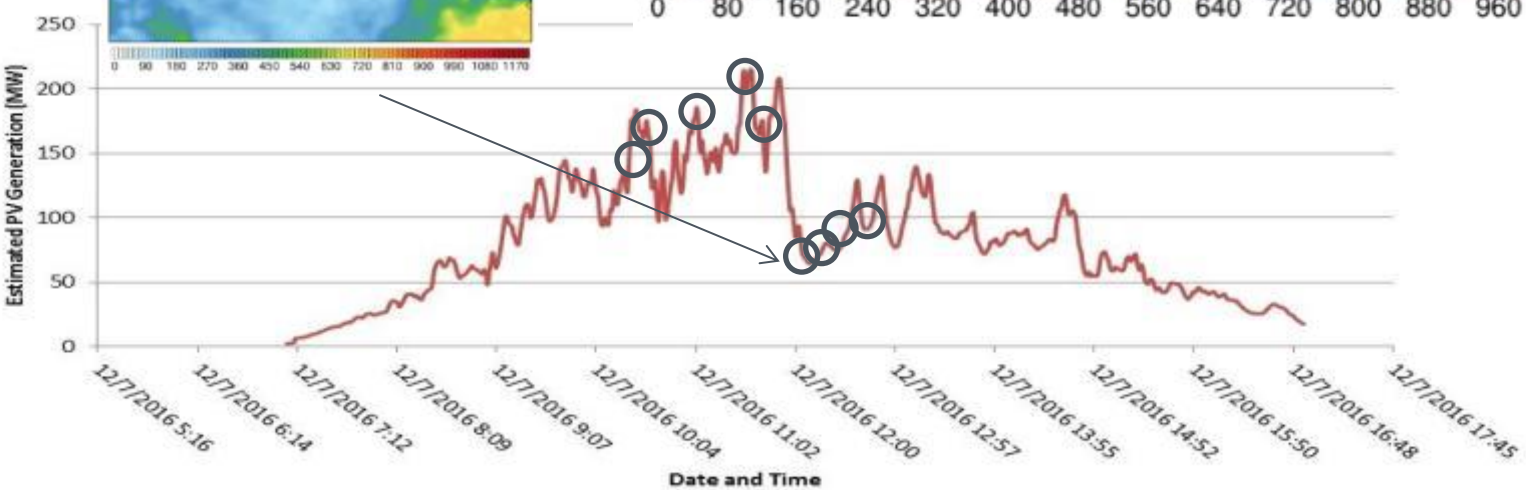
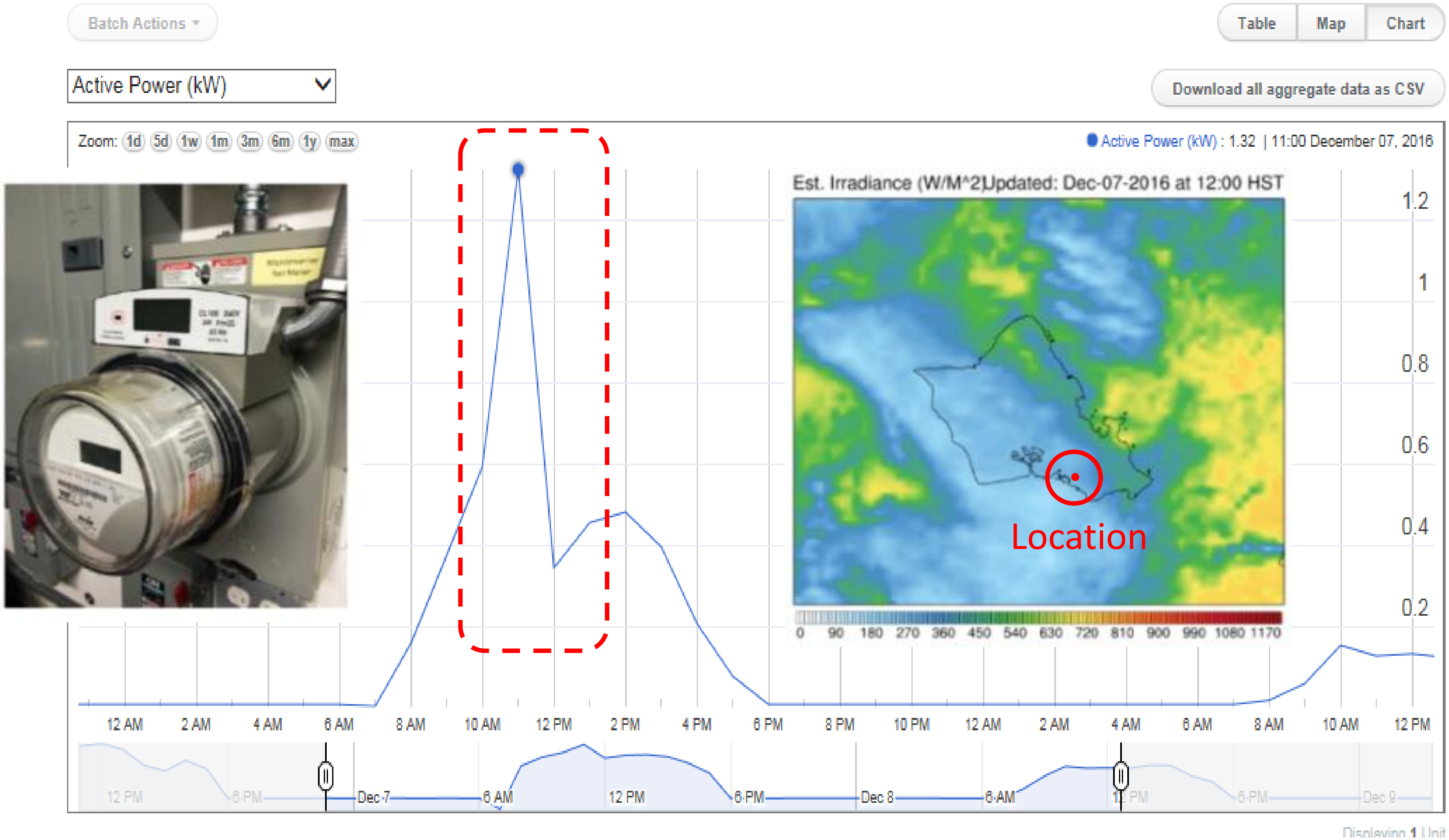
Animation using SWIFT Solar Irradiance Maps – 12/7/2016







VALIDATION: ConnectDER Recording at Ward PV station



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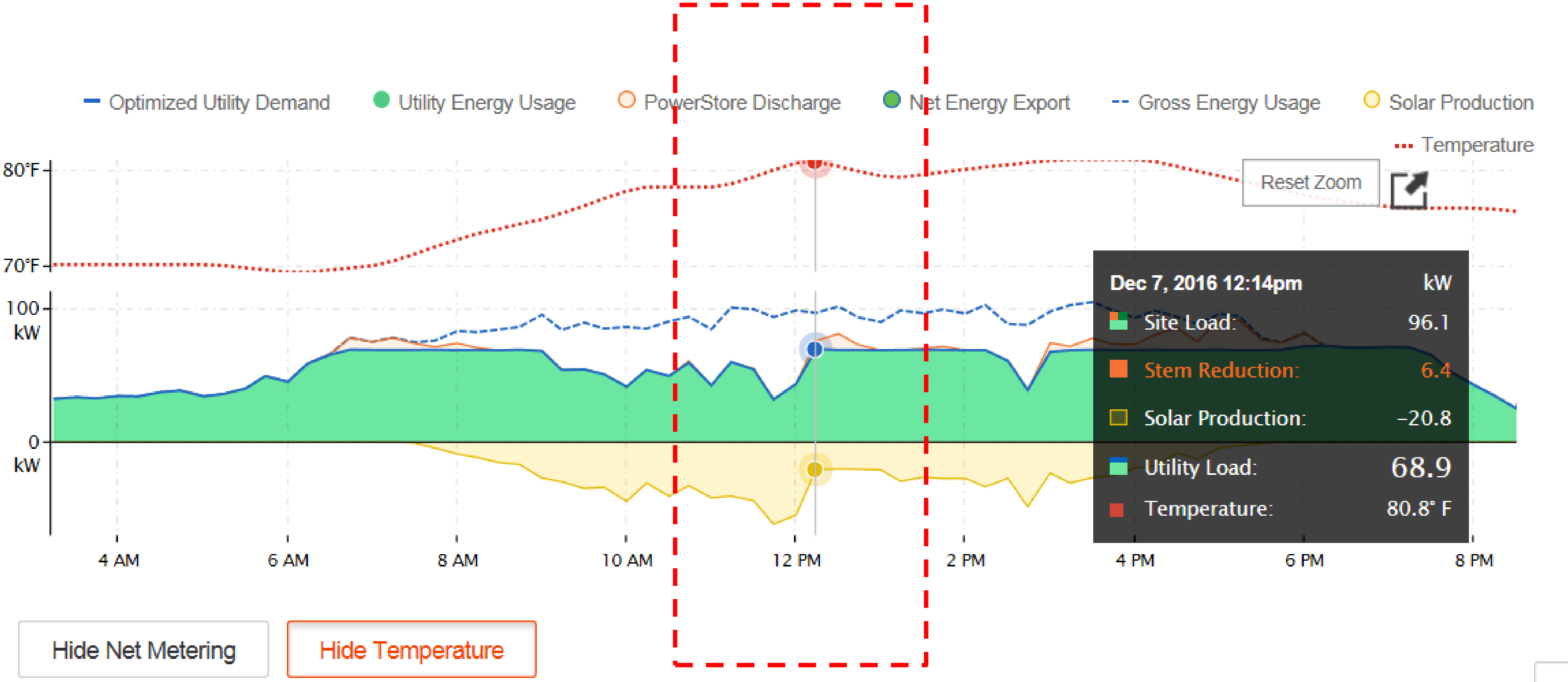
NEW Visibility & Confidence in Grid Response from Customer-sited DER: Stem Powerscope & Battery Discharge

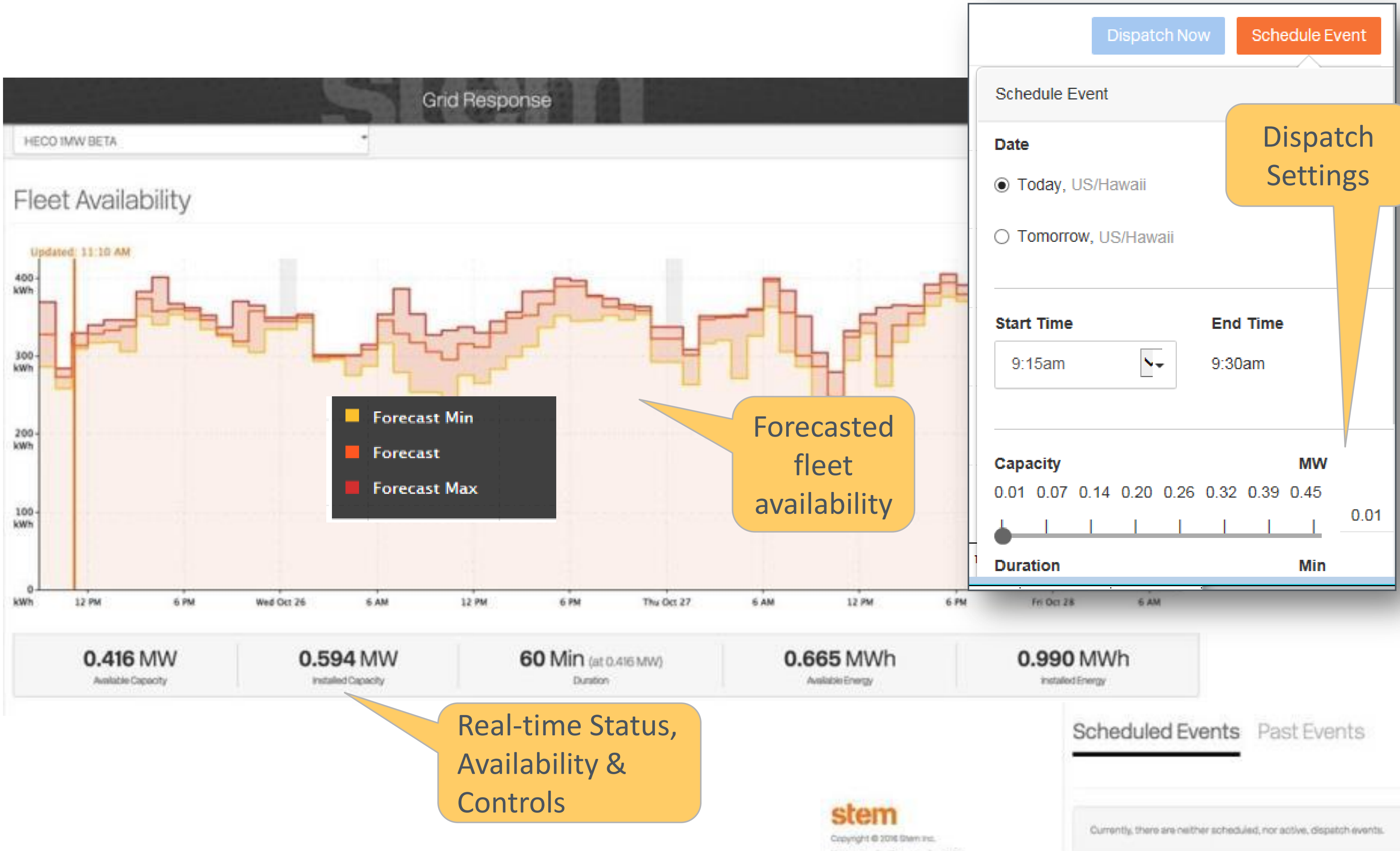


- Intelligent storage demonstrated response to drop in customer PV, maintaining level load at customer site through controlled discharge of PV.
- Provided grid response support during event (6.4kW at 12:14pm)

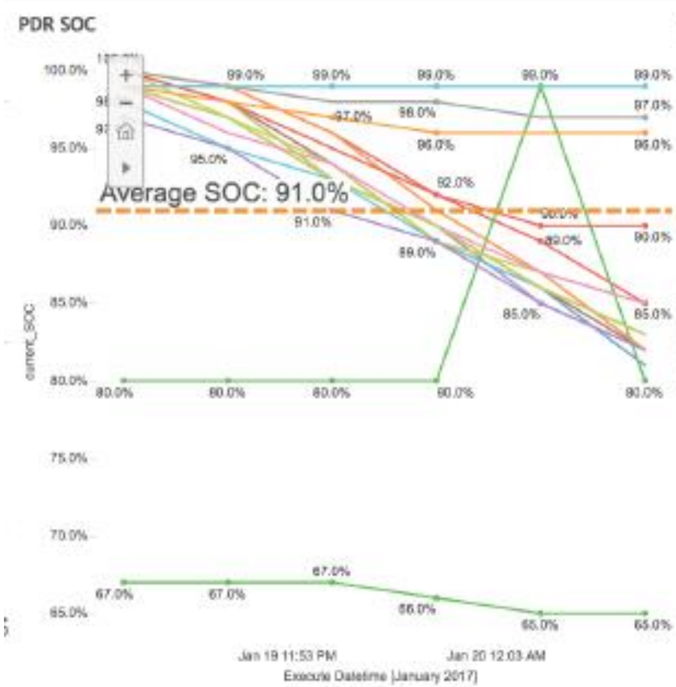
Looking Ahead – Progress for BP2 & BP3

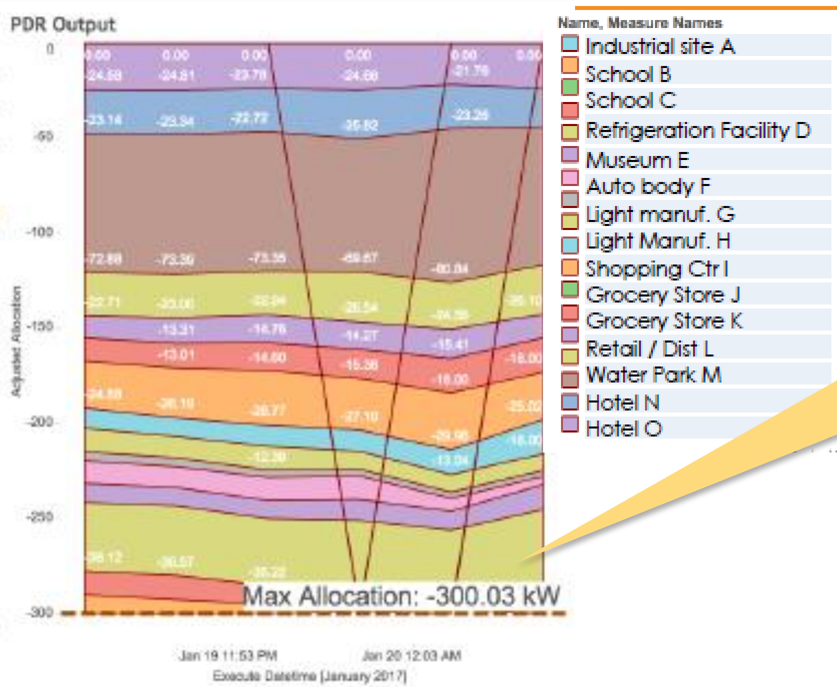
- Project Management
  - UBAT 2017 (April/May)
- Continue Rollout of SHINES Technologies
  - SHINES Technologies and renewable forecast integration & data backhaul
    - Stem (storage), Apparent (smart inverter/storage/PV),
    - ConnectDER (PV controller), Ibis (intelligent sockets), Ensync (BEM controller), Peoplepower (inhome app & devices)
  - Standard Plug-n-play scheme for data integration
  - Real-time API development
- EMS Integration
  - Dashboard & EMS logic development
- Cost & Modeling
  - SAM model evaluation
  - Power Flow & Load Model verification of operability
- Technical Outreach
  - Industry Conferences: Distributech, SPI, AWEA
  - Smart Power for Schools all island train-the-trainers
  - Workforce development and internships

Aggregator Interface & Real-time Dispatch Testing

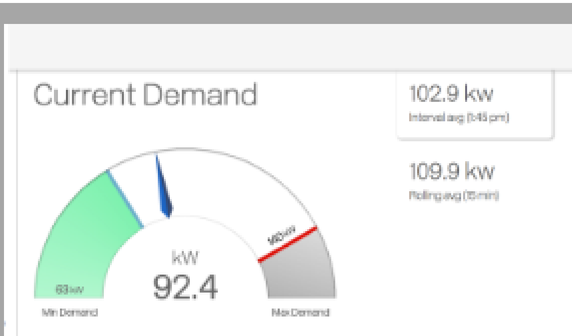


Immediate Feedback & Certainty





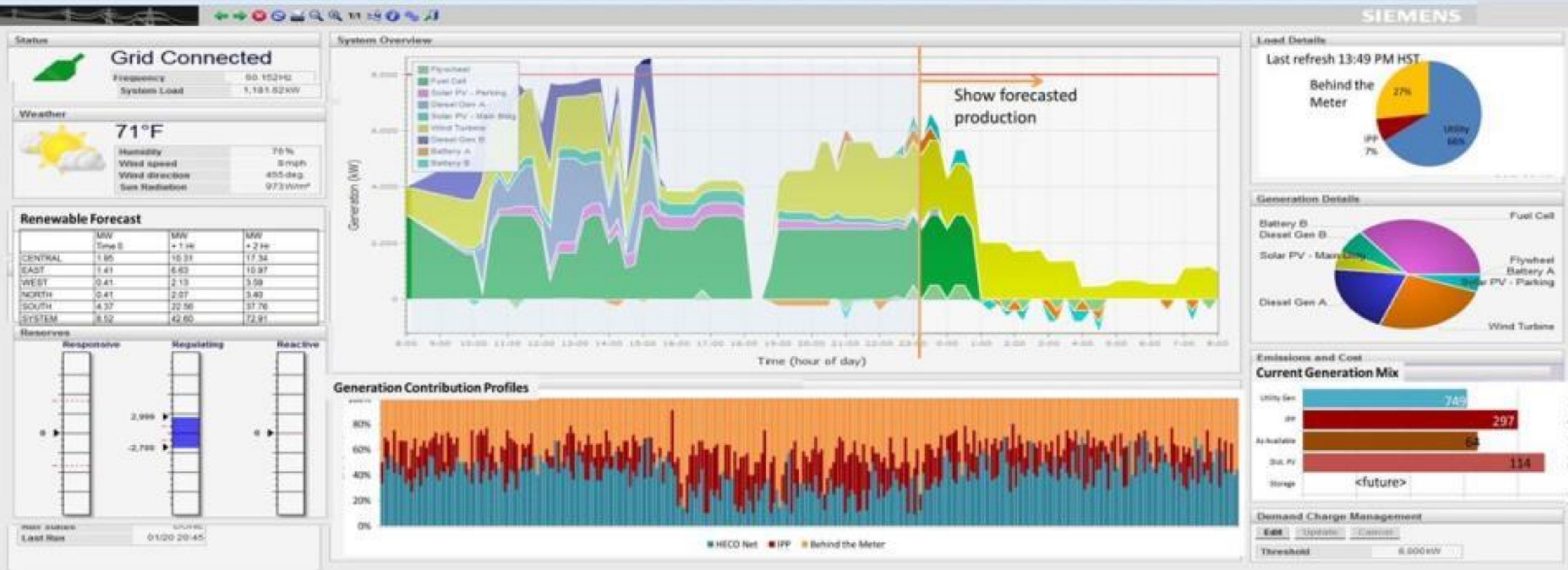
System View of real-time Fleet Dispatch



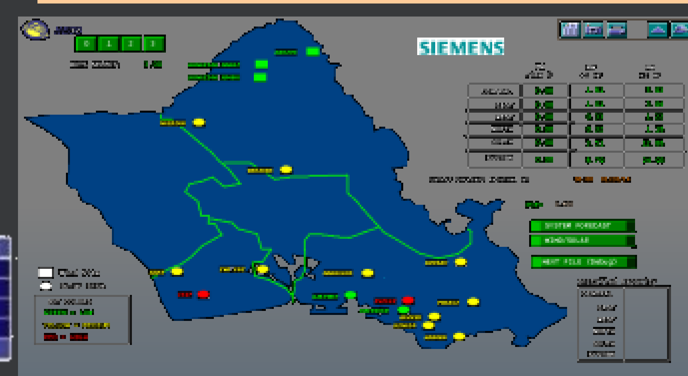
Customer View of the storage in real-time

Date and time in HST

NEXT STEPS: Integrating VDER into Grid Tools to "See & Manage"



Source: Hawaiian Electric Companies



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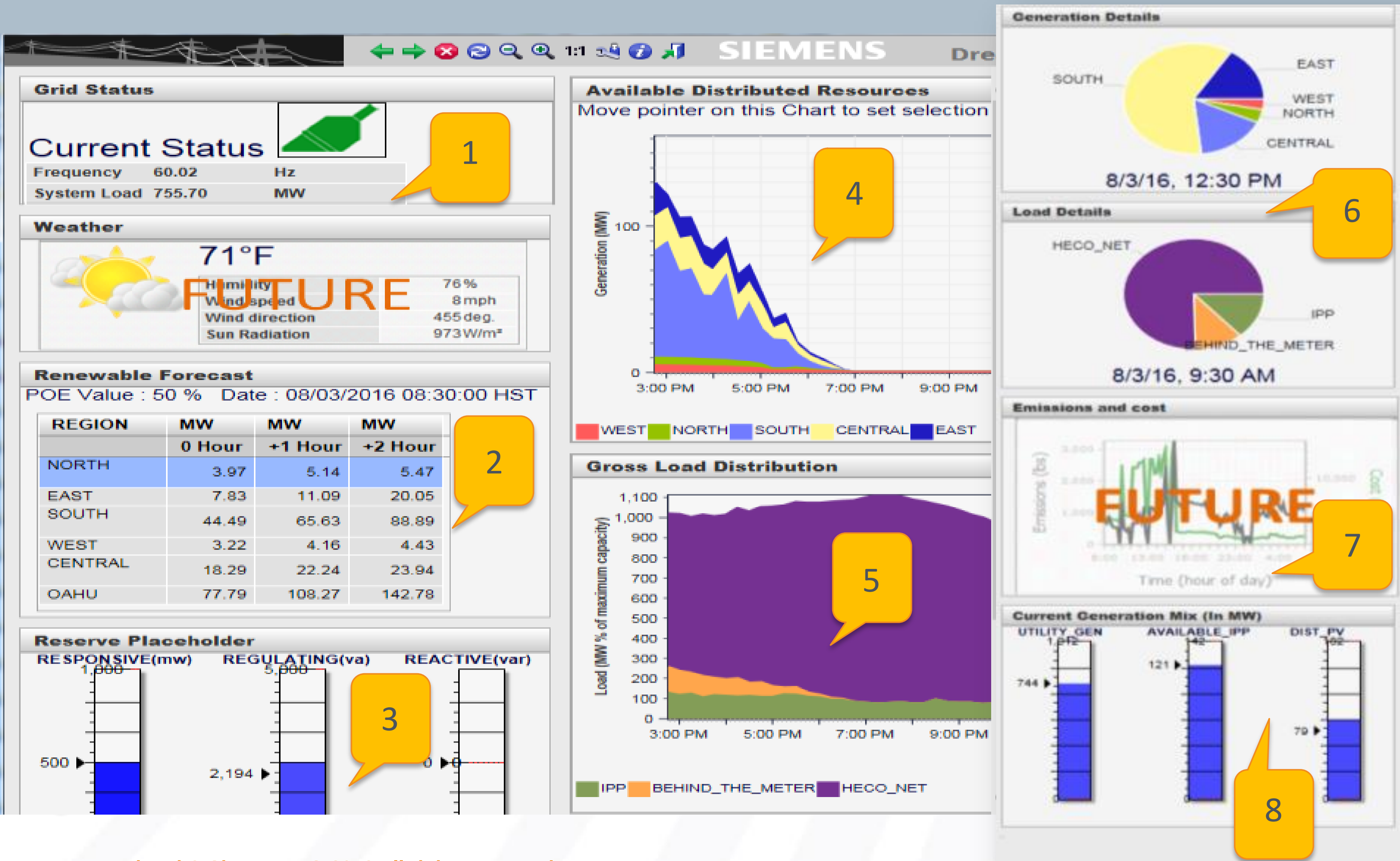
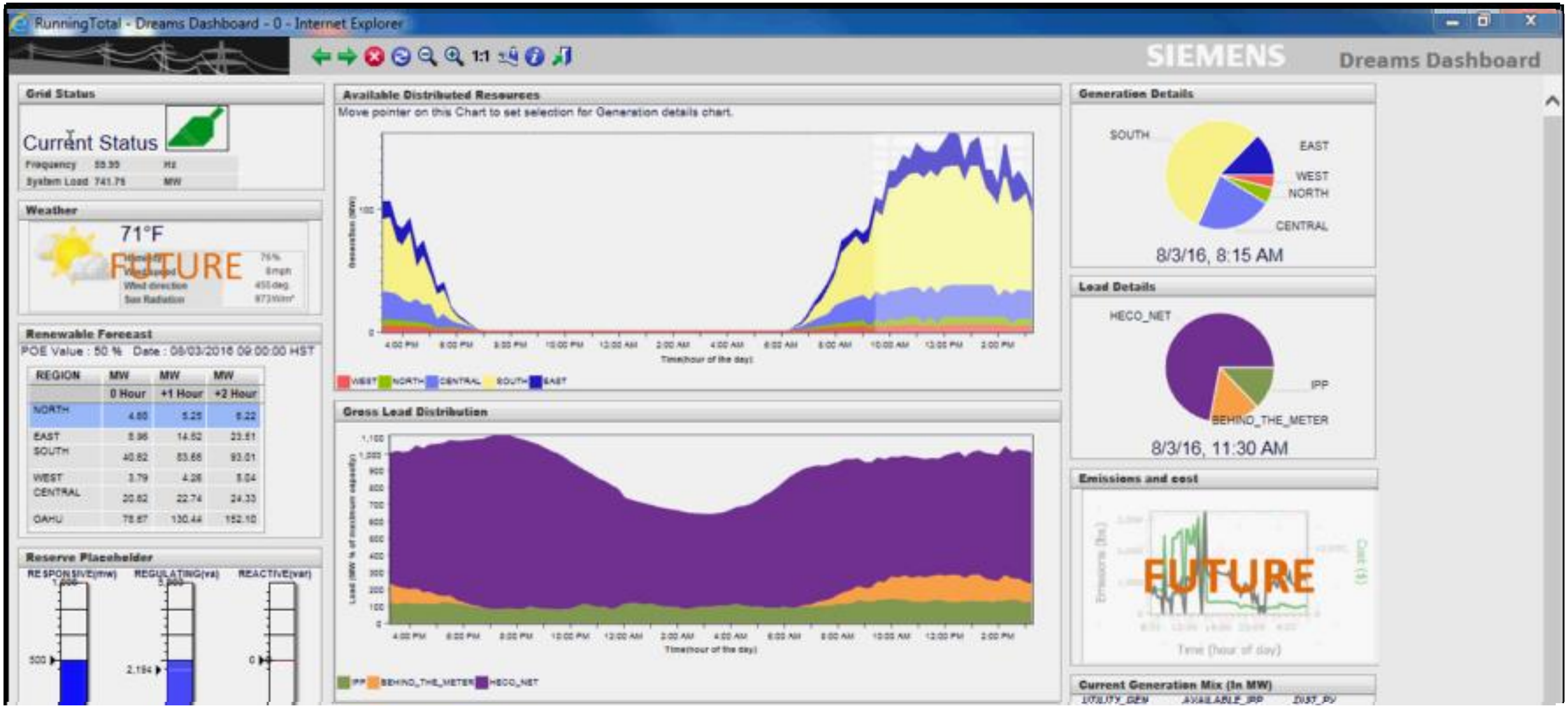
Dashboard – Immediate Awareness

SIEMENS



Screen Shots



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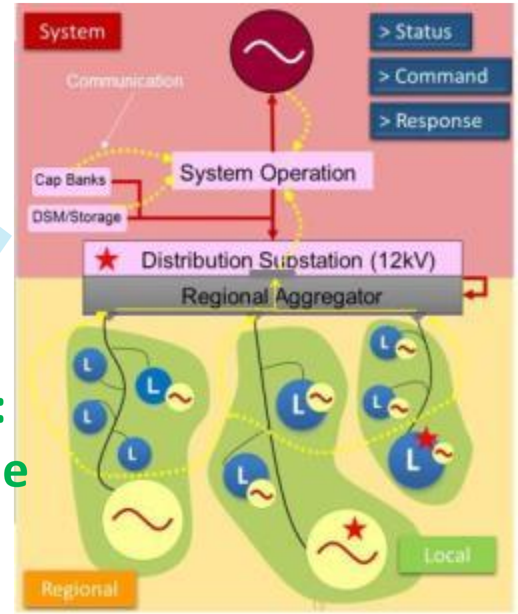
Project End Goal: Enhanced Operational Awareness to Variable Distributed Energy Resources (VDER)

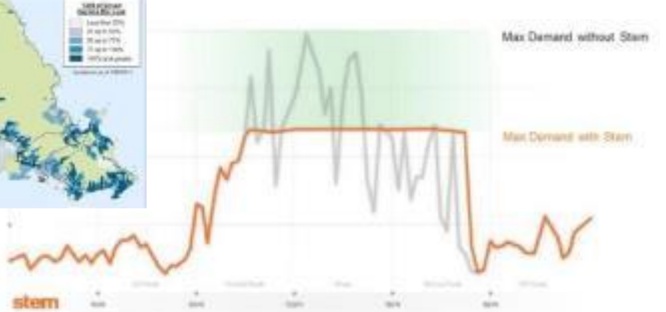
- **Status** – what's it doing now?; on or off; characteristics
- **Availability** – how much, how long and how fast? responsiveness
- **Control** – what can system do with it?



Not So Distant Future: Orchestrated & In Tune

Tomorrow: Influencing How & Where

Today: Getting Access



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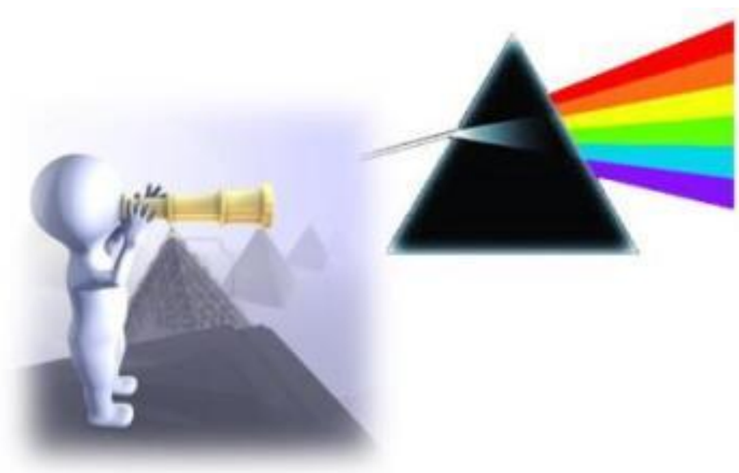
Key Takeaways

- *Value of SHINES can only be realized if distributed benefits (performance metrics and interoperability targets) are economically and reliably made <u>visible</u> via system to edge-of-network integration (SEAMS)*
- *Must move beyond the Status Quo*



Building on prior grant activities and collaborative partnerships focusing on energy resilience and economic stability

Questions/Comments??

Mahalo for the Support

For more information please contact:

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