Tools Development for Grid Integration of High PV Penetration

CPUC CSI RD&D Solicitation #3

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Background

- CPUC CSI RD&D Solicitation 3 builds off previous studies
  - CEC Locational Value Analysis
  - CEC Intermittency Analysis Project
  - CEC Northern California Regional Integration of Renewables
  - CPUC Combined Heat and Power Study
  - CPUC CSI RD&D Solicitation 1
- Hawaii Electric Company Projects
  - PV nodal estimating tool
  - Transmission and distribution integration studies on high impacts of PV

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Industry DG Concerns

- Emerging levels of distributed generation “behind-the-meter” generation is increasing
- Levels are exceeding “rules-of-thumb” used in standard utility practices for planning
  - Installed levels of DG are a continually moving target
- Industry lacks capability (tools/data) to effectively plan for PV impacts on the grid
- Currently no cost-effective, commercially available capability exists to meet solar forecasting needs and industry standardization of monitoring equipment is lacking
- Integrating utility departments and software communications is essential for sustainable renewable deployments (transmission, distribution, operations, forecasting, financing)
- Developing a collaborative of utility staff, developers, regulatory agencies to develop a cooperative framework for a sustainable and cost effective renewable expansion plan
  - Combining utility optimal locational value of development strategies with public and private preference
  - Integration of energy efficiency, renewable development while reducing greenhouse emissions

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CPUC CSI RD&D #1 SMUD/HECO HiP-PV Initiative Analysis Goals & Tasks

OVERALL STUDY GOALS

- Improve observability and visibility of operations and planning, to impacts of HiP-PV on the distribution feeders
  - Conclude on level of measured data required in the future to improve visibility for operations and planning
- Determine validity of common analysis filters
- Quantify impact on select feeders to demonstrate new modeling and analysis techniques
- Inform how future studies and interconnect processes can be expedited
- Changing perception of how to deal with high renewable penetrations (solutions to address problems)
- Technology transfer/outreach and publication
- Apply results and support strategic studies
  - Example: GE Hawaii Solar Integration work (HSIS)

TASKS

1. Feeder Selection

2. Data Collection and Review

3. Definition of Analysis Points

4. Base Case Definition

5. Model Validation

6. Detailed Analysis

7. Conclude on HiP-PV Impacts feeder of interest

8. Conclude on administrative screens for Feeder Studies

9. Plan roadmap for future Feeder/Regional Analysis Goals based on Results

10. Reporting

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BEW's CPUC CSI RDD #1 Objectives

- Identify high penetration analysis needs for each circuit
- Identify additional data parameters and placement of high-fidelity monitoring equipment
- Record and collect a minimum of 6 to 12 months of load data and solar data
- Collect electrical equipment nameplate data for the distribution feeder: DG, inverters, energy storage, circuit data (conductor size, length, loading), switchgear, transformers, fuses, etc.
- Investigate varying incremental levels of PV penetration and determine potential mitigation solutions
- Develop a methodology for extending the findings using simulation tools to inform and expedite interconnection studies at higher penetrations

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Portfolios of Renewable Integration Activities: Supporting Solar Initiatives

- Support Transformative Efforts
- Develop Integration Tools & Capabilities
  - Resource characterization, sensor deployments & field monitoring
  - Data management and analysis tools
  - Model enhancements & field validation
  - New visualization & decision aids
  - Operationalize “look-ahead” wind & solar forecasting with ramp event capability
- Integrate & Enhance Processes/Procedures
- Workforce Development and Pipeline
- Outreach & Collaborations

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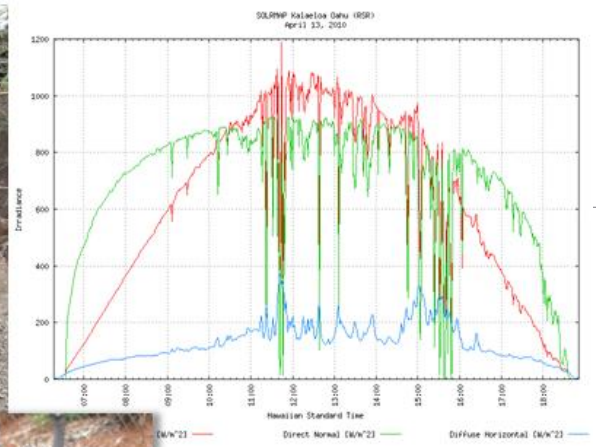

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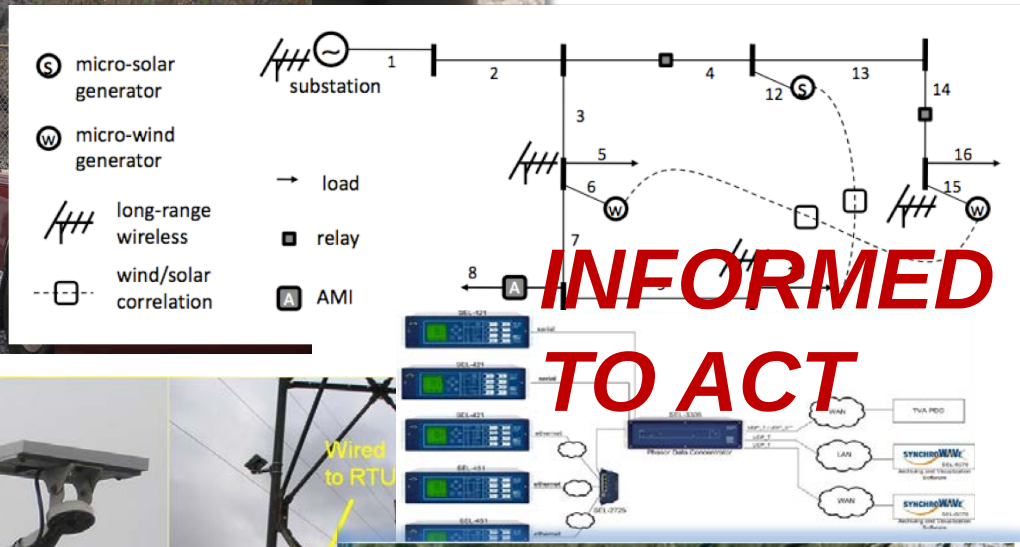

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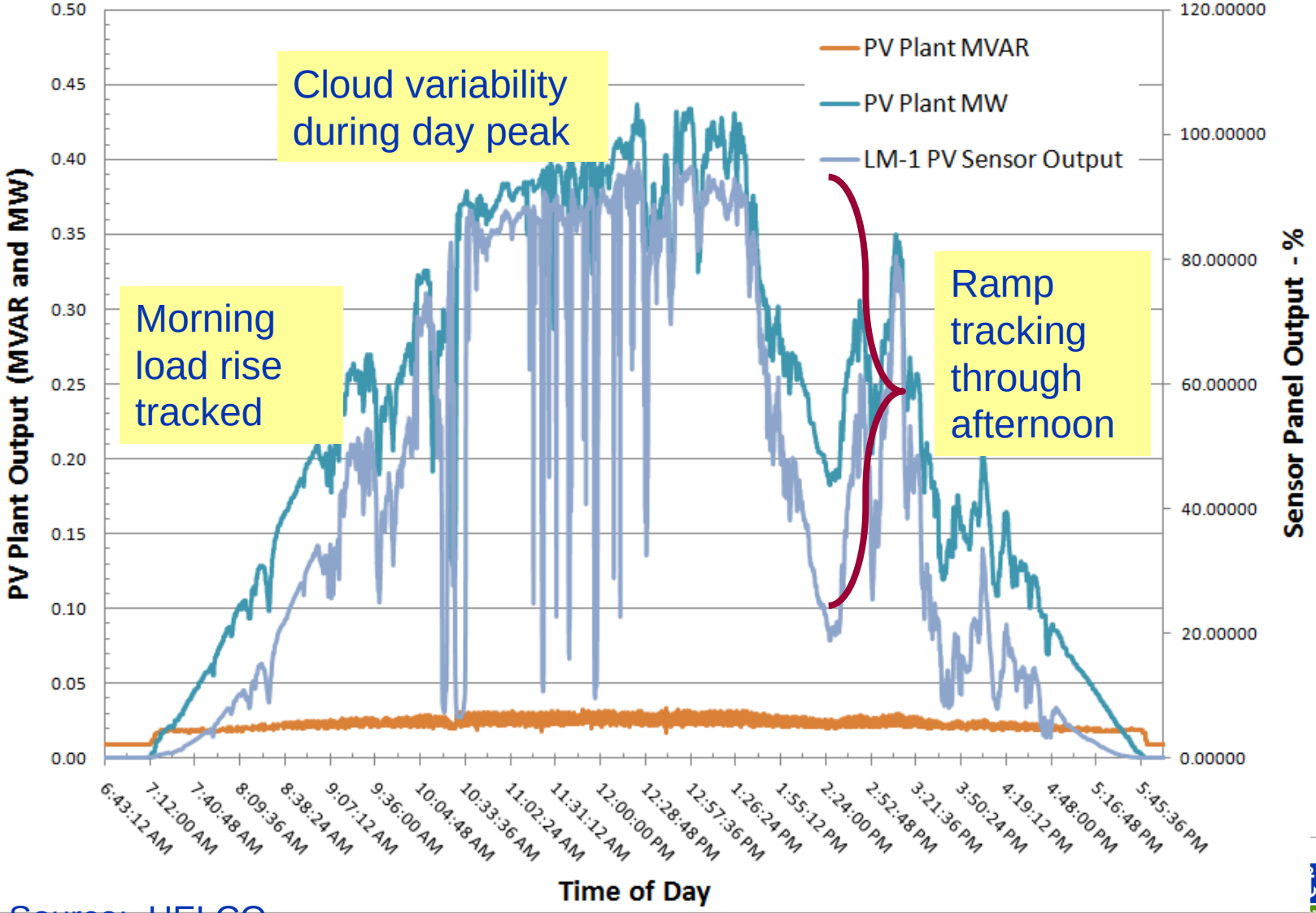
Field Validation (Operational Needs)



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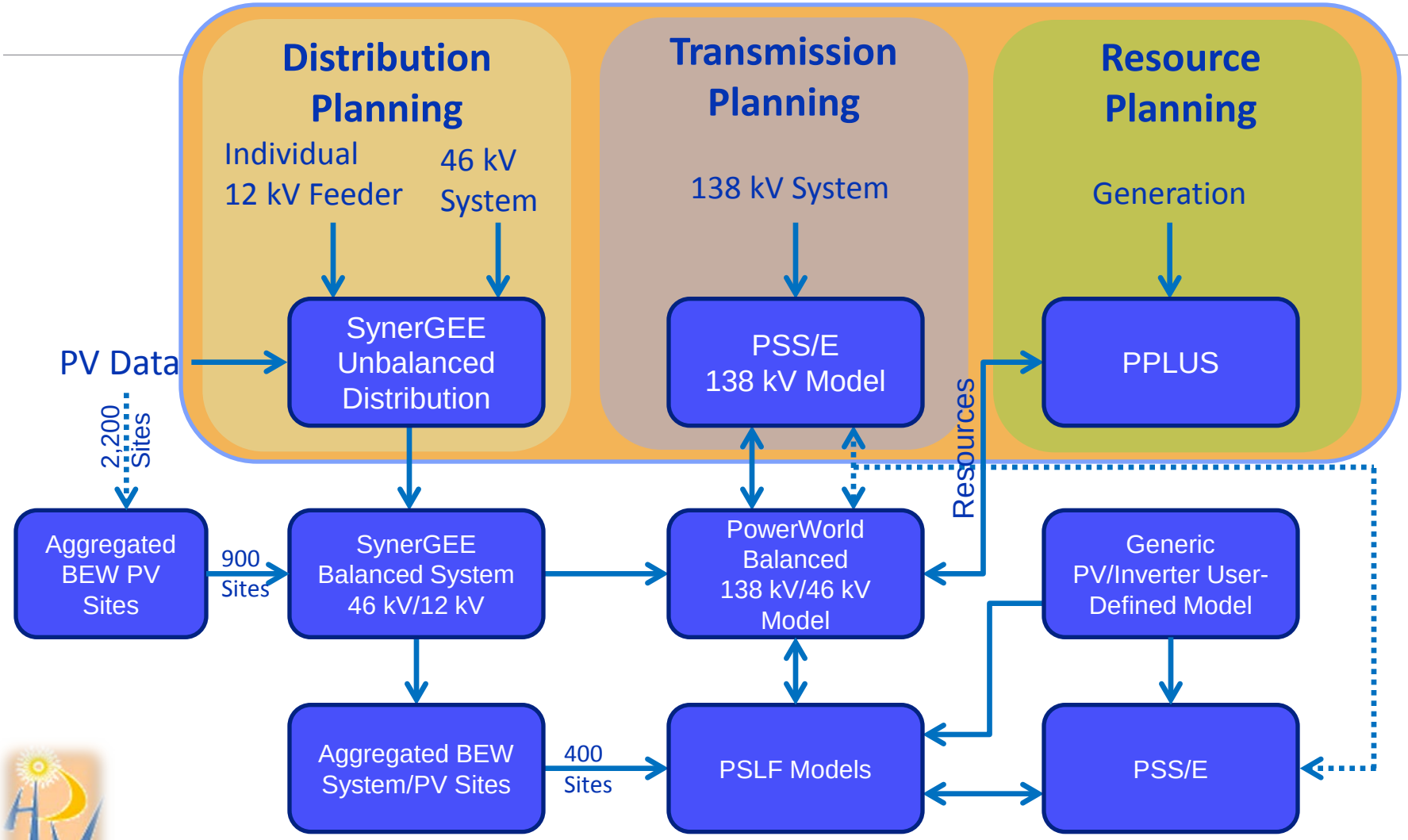
Facilitate Interface Between T&D Models



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

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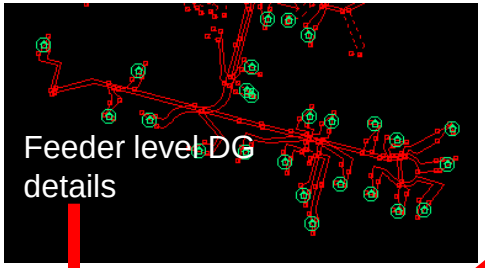
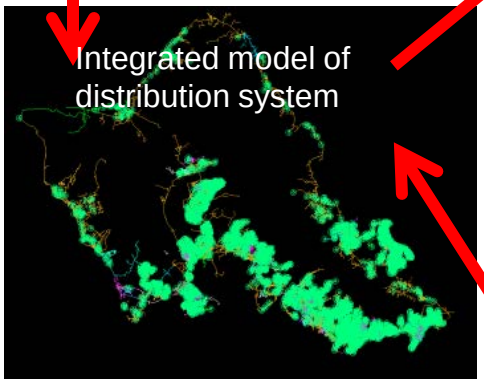
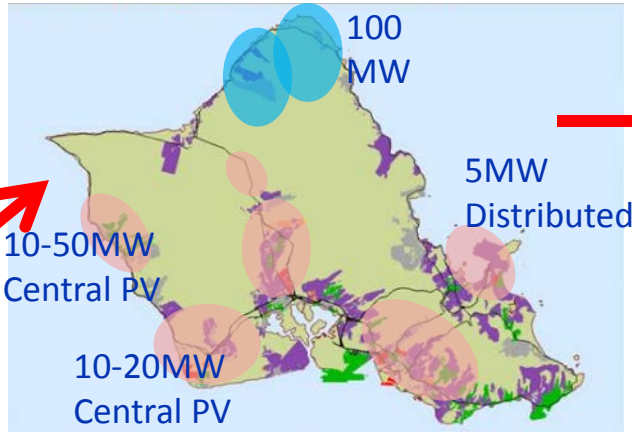
Enable Ability to Evaluate Impacts from DG to System back to DG Level

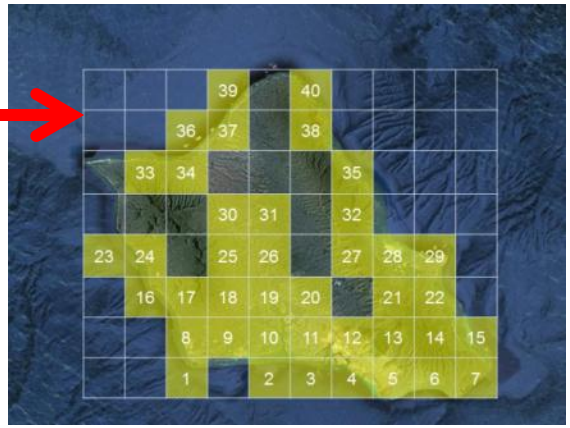




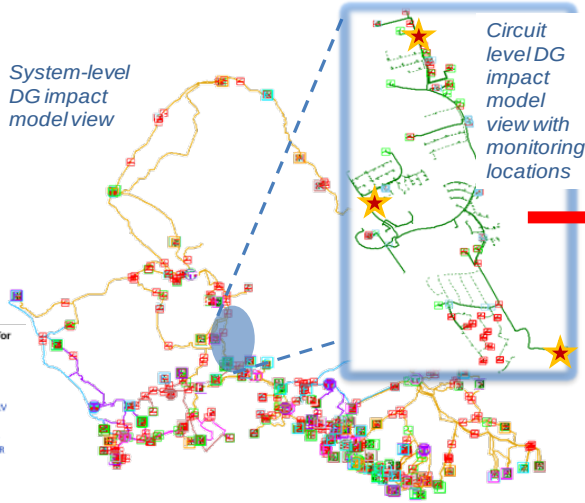
Develop complete distribution model with DG generation

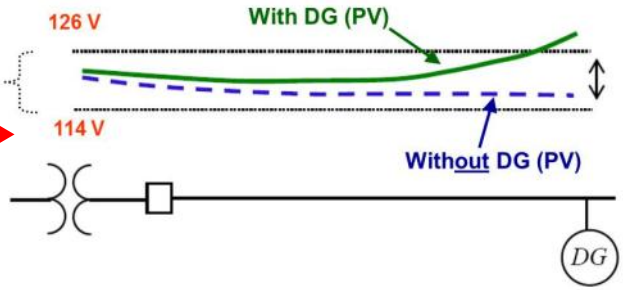


Identify DG and Central PV Scenarios for HSIS Study

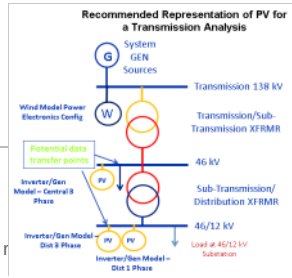


Aggregate individual DG generators for transmission modeling





Inform & expedite feeder level studies (nodal & clusters)



Model & field verification

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Findings: Expedite Studies by Aggregating and Categorizing at Different Local, Nodal & Regional Levels

Single Large Site

- Feeder Voltage Profile & Thermal Limitations
- LTC Settings & Backfeed
- Flicker

Local Node

- Feeder Voltage Profile & Thermal Limitations
- Tap Changer Cycling Backfeed & LTC Settings
- N-1 Contingency Conditions
- Anti-Islanding Trip
- Flicker & Harmonics

Regional Cluster

- Feeder Voltage Profile & Thermal Limitations
- Tap Changer Cycling Backfeed & LTC Settings
- N-1 Contingency Conditions
- Anti-Islanding Trip
- Flicker & Harmonics

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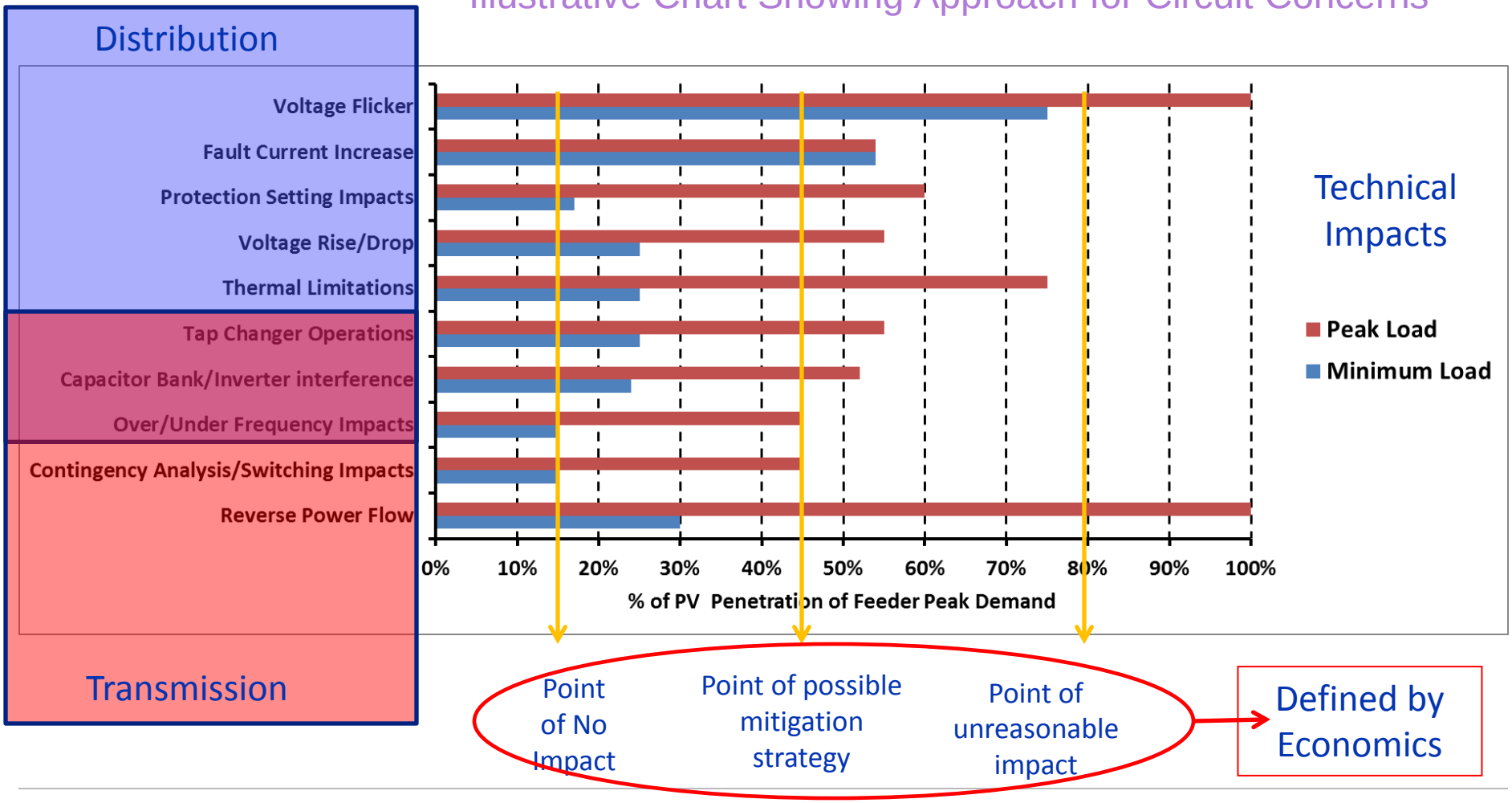
Goal of Steady State Analysis Studies

Illustrative Chart Showing Approach for Circuit Concerns



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CSI RD&D 3 Participating Utilities

- BEW Engineering
- Sacramento Municipal Utility District
- Hawaii Electric Utilities
  - Hawaii Electric Company
  - Maui Electric Company
  - Hawaii Electric Light Company
- Pacific Gas & Electric
- City of Roseville

SMUD/HECO
High Penetration PV Logo

Itron CSI RD&D Program Manager

GO solar CALIFORNIA

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Project Participants

Team	Primary Contact
BEW ENGINEERING	Ron Davis
SMUD SACRAMENTO MUNICIPAL UTILITY DISTRICT The Power To Do More.℠	Elaine Sison-Lebrilla
Hawaiian Electric Company Maui Electric Company Hawaii Electric Light Company	Dora Nakafuji
PG&E Pacific Gas and Electric Company	Chase Sun
CITY OF ROSEVILLE CALIFORNIA	Scott Vaughan

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Project Tasks

- Task 1 – Project Management
  - Ron Davis will serve as PM for the overall project
- Task 2 – Nodal Approach for Strategically Locating PV
  - Subtask 2.1 – Utility Data Collection and Validation
  - Subtask 2.2 – Methodology Development
- Task 3 – Case Studies of Evaluating Distributed PV on Distribution Grids

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Subtask 2.1 – Utility Data Collection and Validation

- Select a wide variety of distribution feeder configurations with unique characteristics such as line regulators and capacitor banks, existing high PV penetrations, smart community subdivisions, overhead and underground lines and other attributes

Utility	Number of Feeders	Number of Clusters
HECO, MECO, HELCO	6 to 24	6 to 8
SMUD	5 to 15	2
PG&E	5	
Roseville	5	
Total	21 to 49	8 to 10

- SMUD has solar home subdivisions, long rural lines, and high forecasted PV penetration areas
- HECO has existing high PV penetrations ranging from 40% to 135% of feeder load
- Roseville has a 3 wire distribution system, good potential for PV installations and one area that is experiencing feeder issues
- PG&E will provide additional feeders to develop a mix of feeder profiles and will use CYME for internal feeder studies

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Subtask 2.1 Cont'd

- Utilities will:
  - Install and collect solar and load data on selected feeders
  - Provide feeder characteristics, profiles and other data
  - Assist in calculating mitigation costs
- BEW will:
  - Validate actual data to simulated results
  - Conduct steady state, contingency, dynamic, transient and other studies
  - Validate various distribution models such as SynerGEE, Sincal, CYME, etc.

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Modeling and Field Verification for Analysis of Results

Monitoring

- Identification of high penetration feeder circuits
- Evaluation of load characteristics over a period of time capturing high and low load conditions

Modeling

- Characterize circuit based on loading profile and generalize for modeling purposes
- Convert GIS database to SynerGEE format
- Identify corrections and where to correct (BEW/utility)

Validation

- Gather Field data and verify model and analysis output

Integration

- Feed distribution impacts into system level models
- Continue monitoring and model validation as part of planning process
- Develop visualization tool and decision aids for operations & planning

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Subtask 2.2 – Locational Value Analysis Tool

- Integration of the distribution grid and a global visual mapping tool (i.e. GIS compatible platform specified by the utility) into an expanded locational value analysis (LVA) tool and methodology
- Visual map locates potential PV development areas such as roof space and vacant lots
- Goal is the development of a tool that provides PV energy estimates to be integrated into a database management tool developed by BEW

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Subtask 2.2 Cont'd

- Goal is the development of a tool that provides PV energy estimates to be integrated into a database management tool developed by BEW
- Leverage work done by HECO, SMUD, PG&E and others to develop a tool that integrates the best of all methodologies
- Utilize an automated interface to easily transfer data between distribution modeling tools (single phase, unbalanced) and transmission system level balanced power simulation tools
- BEW is developing a screen nodal PV energy estimation tool

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Task 3 – Case Studies of Evaluating Distributed PV on Distribution Grids

- Demonstrate tool's ability to solve distribution feeder issues
- Use the feeders and cluster grouping from Task 2 to demonstrate and validate high PV impacts under steady state, contingency, transient and dynamic scenarios

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PV Penetration Analysis Steps

- Extract (GIS) or build (when GIS not available) SynerGEE model
- Collect and apply detailed equipment information
  - Transformers, switches, fuses distributed loading, capacitors, inverters, PV panels etc.
- Collect PV data for area of interest if available
- Analyze PV performance
  - Associated weather data
- Collect full system sub-transmission/transmission model, and dynamic data
- Model inverters
  - Future detailed SynerGEE model, or
  - Existing equivalent impedance model, and
- PSLF dynamic inverter model

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PV Step Analysis Cont'd

- Perform base case load flow analysis with and without existing PV
  - Single point in time, minimum load day, and maximum load day
  - Perform basic fault current analysis with/without existing PV
- Repeat load flow and fault current analysis for potential and predicted PV cases
- Verify feeder performance with measured data (load flows, voltage levels etc.)
- Repeat analysis after verification of data
- Conversion of data for transient analysis
- Conduct advanced post-validation studies including:
  - Protection coordination
  - Harmonic and Flicker studies
  - Islanding study (voltage and frequency limits)
  - Transient study

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