EPIC Program Research Symposium:

Demonstration of Integrated PV systems and smart inverter technology using advanced distribution sensors

3 December 2015

Outline

- **Overview** of your project plans
- **Issues and challenges** the research is addressing
- Project **status**
- **Core innovations** of the project related to generation and integration
- **Relation** to ongoing state proceedings or programs
- **Recommendations** on future technology needs and/or research beyond this project

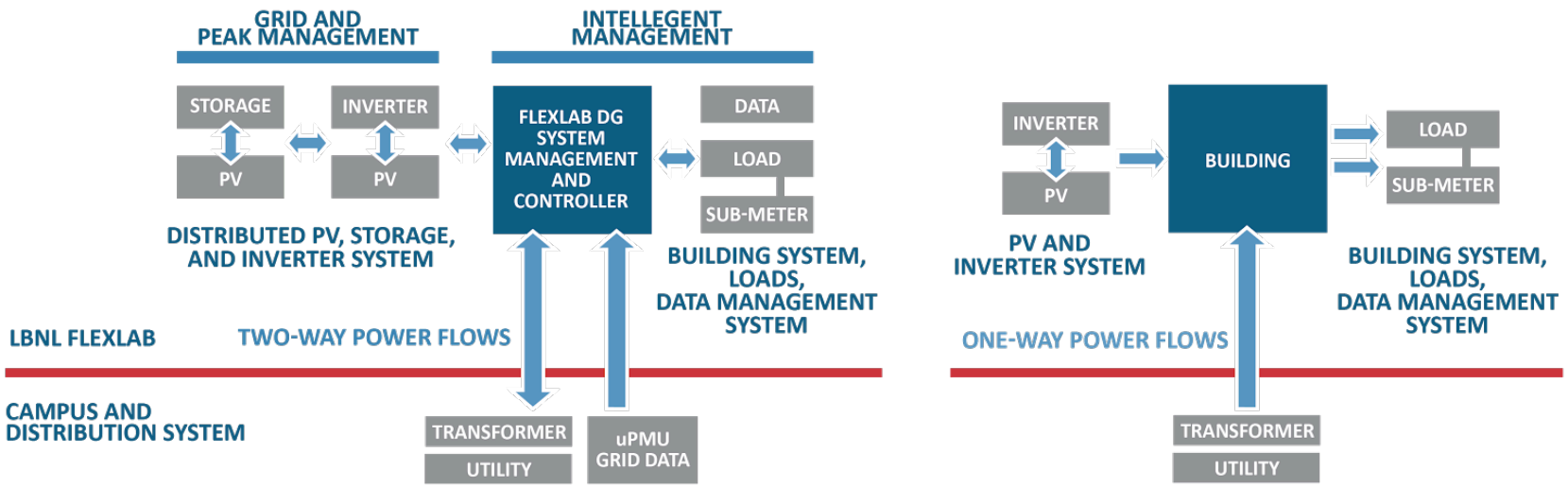
Agreement Goals

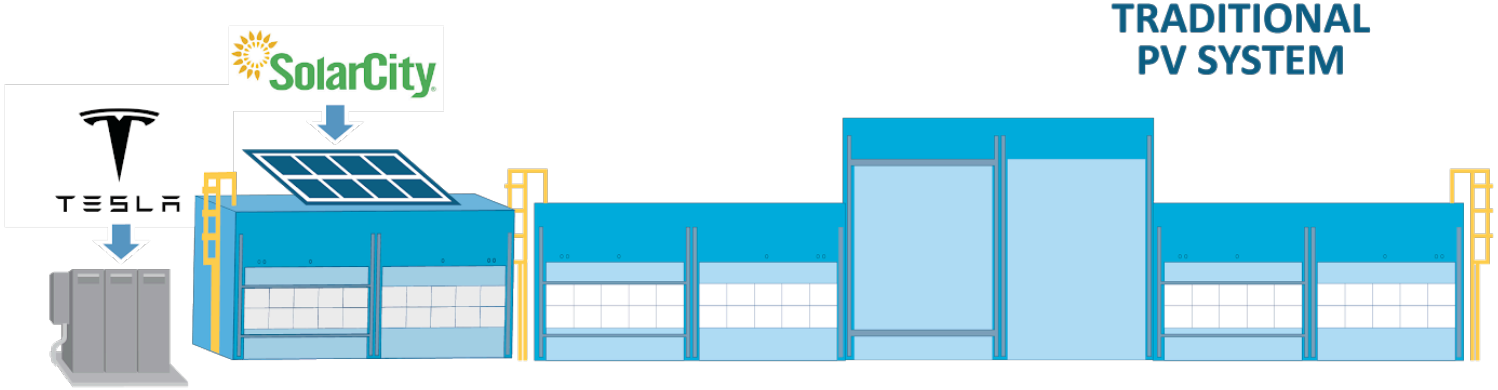
- This project addresses
  - real-time visibility of masked load;
  - variability and dynamic voltage impacts;
  - installation, performance, and cost challenges with the advanced PV technologies and systems.
- Project will provide
  - pilot scale demonstration of integrated, advanced PV and storage system at a state-of-art test bed in LBNL's Facility for Low Energy Experiments (FLEXLAB).
- System to be developed in this work uses smart inverter control to enhance and optimize grid support and system performance.
- Goal is evaluation of distribution synchrophasor units (µPMU) data to support specific visualization and control applications on distribution circuits.
- The project includes
  - a 13 to 15 kilowatt (kW) PV electric generating system and
  - 14 kW (56 kilowatt-hour [kWh]) battery storage installation at FLEXLAB
- Will also investigate smart PV inverter capabilities and distribution circuit optimization and advanced control

Project Plans

- **Demonstrate** correlation between μPMU data and existing grid conditions at LBNL (e.g. voltage regulation, sags, swells, thermal impacts)
- **Utilize data collected** to develop and simulate control strategies for inclusion of solar and storage to mitigate grid issues using co-simulation to verify approach(es) chosen
- **Deploy control strategies** at FLEXLAB to confirm ability of inverters to support grid
- **Evaluate project's technical and economic success** based on total energy generated and saved, improvements in voltage sag ride through, and other local grid incidents

Smart PV and Inverter Control for High Penetration of Renewables





Key Goals

- Demonstrate **correlation between uPMU data and grid anomalies** (voltage regulation (sags, swells), reverse power flow, thermal impacts) measured on LBNL distribution feeders.
- Simulate then demonstrate the **effectiveness of ZNE objective control strategies** to allow inverter based grid control
- Collect data to show **impact of solar and storage controls on mitigation of voltage issues**
- Show project success via **measureable improvement in response to voltage sags** and other power quality incidents before and after technology deployment.

Technical Approach & Methodology

2015: Set up	2016: Baseline and Developments	2017: Tests with PV and Storage	2018: Analysis & Report
Install additional uPMUs	Collect baseline data	Collect data and event information	Description of available data
Develop plans with FLEXLAB	Construction: solar panels and storage at FLEXLAB	Run with solar and storage	Impact of solar and storage
Develop model, integrate with VIRGIL, test	Test model	Analyze data vs model predictions	How well data fit model predictions
Develop preliminary control algorithms	Test and fine tune control strategies	Use control strategies with solar and storage	Control algorithms Operational enhancements

Project Status

- We have identified the site for installation of PV and storage.
- We are planning the test system construction now
- μPMU data collection and analysis at 12 kV level is in progress

Issues and Challenges this work addresses

- Limited visibility and diagnostic capabilities in today's power distribution networks
- Existing instrumentation limited to clustered high PV penetration areas; does not progressively learn as the distribution grid evolves
- Future grid with large numbers of distributed, non-rotating solar photovoltaic (PV) systems will require different and more complex control mechanisms
- No framework available to take advantage of a mix of distributed resources and integrate load modeling and control.

Core Innovations

- Integration of solar and storage in a controllable way to permit fast response to voltage fluctuations
- Grid monitoring with timely local response

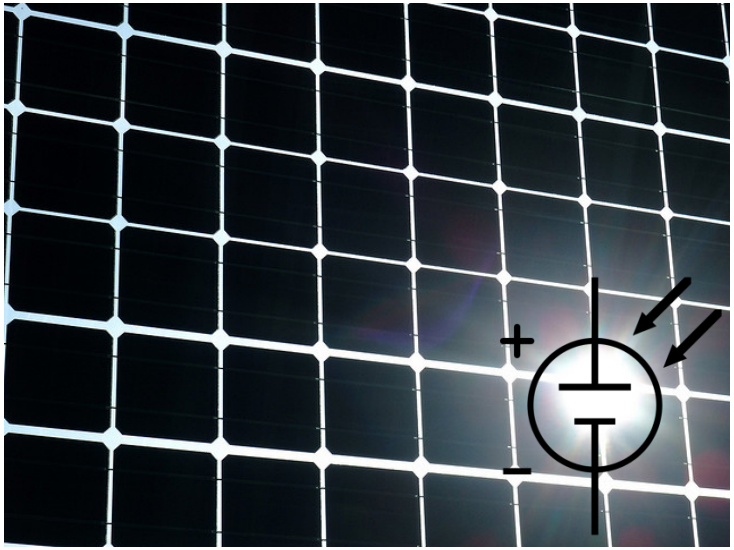
Anticipated Benefits for California IOU Ratepayers

- Improved distribution grid reliability
- Improved context for PV introduction and coordination
- Reduced costs from lower infrastructure spending and increased penetration of PV
- Improved ability for PV and storage to detect and respond to grid conditions, thereby reducing overall energy costs

Specific Technology Innovations & Products

- Control strategies to better integrate solar and storage to alleviate grid issues in real time
- Reduce cost of distributed generation and improve ‘plug and play’ of photovoltaic (PV) systems
- Improve communications and control between multiple deployments of PV to serve grid needs
- Provide foundation for enhanced PV deployment in California

Questions?



EXTRA SLIDES

Distribution Phasor Measurement Units

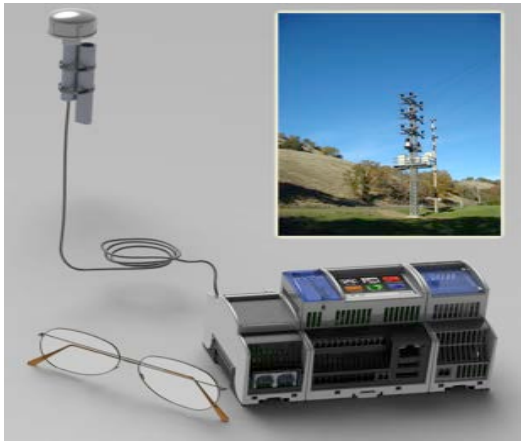
Funded Projects

ARPA-E Project:

Micro-Synchrophasors for Distribution

Cybersecurity for Energy Delivery Systems:

Intrusion detection and visualization with distribution synchrophasors



Utility and field site partners
Southern California Edison, Sacramento Municipal Utility District, Southern Company, National Renewable Energy Laboratory, UC San Diego, Riverside Public Utility, NEETRAC

Research Question: Can synchronized distribution level phasor measurements enhance planning for power flow and system control, security and resiliency in the modernized grid?

Approach

Develop a network of high-precision phasor measurement units (µPMUs) to measure voltage phasors with unprecedented accuracy (~ 0.01°)

Study diagnostic and control applications for µPMU data on distribution systems and develop suitable algorithms including load identification and impedance calculation

Challenges include multiple sources of measurement error and noise: learning what matters

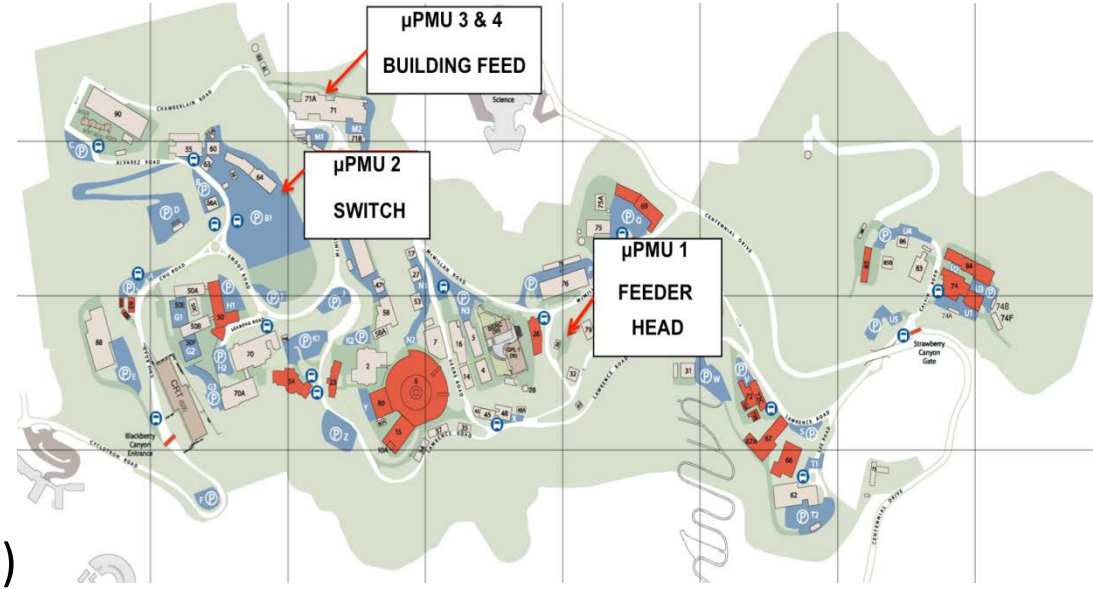
Performance metrics include angular resolution, overall accuracy, latency; key objective is to match data quality with applications

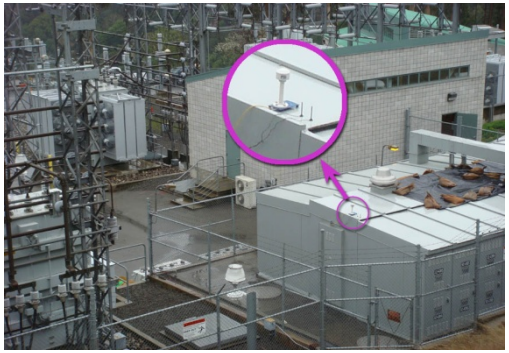
Develop useful, practical tools for a new type of visibility and management of distribution circuits

ciee California Institute for Energy and Environment

Pilot Site Installation - LBNL

- Installed µPMU devices in 4 locations at LBNL – from substation (feeder head) to Building 71
- Coupled with existing measurement system on site
- Measuring high fidelity voltage and current magnitude and phase angle (512 samples/cycle)
- Developed LBNL system model and advancing research in model validation and calibration
- Preliminary challenges include communications, calibration, and commissioning of sensors



New Work: Early detection system for grid-network cyber attacks - working with Computational Research Division

Grizzly Peak µPMU 1