# IMPACT OF HIGH PV PENETRATION ON DISTRIBUTION CIRCUITS

**Public Utilities Department**

Board of Public Utilities
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## DISTRIBUTION SYSTEM

1. Legacy system
   Power-flow in one direction from substation to the load

2. Planned annually to serve the predicted peak MVA
   a) Capacity not exceeded under normal or emergency conditions
   b) Voltage levels within required tariff limits

## DISTRIBUTION PLANNING ISSUES

Three barriers to the integration of PV systems:

1. Inaccurate models due to limited data availability
2. Limited accuracy of measured data sources
3. Inadequate tools to simulate high penetration levels



## HIGH PENETRATION PV IMPACT

1. Overload distribution equipment
2. Reverse power-flow
3. Voltage rise and voltage variations
4. Frequent operation of equipment
5. Exceed interruption ratings of protective devices

# NEW DISTRIBUTION PLANNING TASKS

Analyze PV penetration and variability

1. Identify high penetration analysis requirements
2. Identify additional data considerations to be collected and locations to place monitoring equipment
3. Investigate incremental levels of PV penetration and analyze PV levels that adversely affect the system



# COLLABORATION WITH EXPERTS

1. RPU needed assistance from industry leaders to evaluate the impact of high penetration PV
2. DOE grant funding became available in 2013 for optimizing grid performance with PV
3. RPU entered a partnership on a DOE grant opportunity with Lawrence Berkeley National Laboratories, UC Berkeley, Power Standards Lab, and California Institute for Energy and Environment

## MICRO-PHASOR MEASUREMENT UNITS (uPMUS)

Three-year, $4.4 M ARPA-E OPEN project (2013-2016)

1. Research partners LBNL, UC Berkeley, PSL, and CIEE
2. Field installations at ***Riverside Public Utilities***, Southern California Edison, Pacific Gas & Electric, Alabama Power, Georgia Power, Tennessee Valley Authority



## uPMU TEAM

1. Developed network of high-precision distribution µPMUs
2. Built Database for collecting data
3. Developed applications for distribution systems



## OVERVIEW OF PROJECT

1. RPU previously identified key issues
2. Deployed µPMUs at key feeders
3. Utilized µPMU data to improve accuracy of the distribution model
4. Utilized validated distribution model to determine the impact of the high penetration PV
5. Evaluate results to determine if previous assumptions were accurate



## MONITOR 2 FACILITIES

RPU 7.5 MW

UCR 500 kW

# INSTALLED 5 uPMUs




# HIGH-PENETRATION PV IMPACT

| Assumptions | Validation | Correction |
|---|---|---|
| Overload Equipment | Validated | Load Transfer |
| Reverse Power-Flow | Validated | Additional Load to Offset PV |
| Voltage Rise/Variations | Validated | Evaluating Voltage Regulation Equipment |
| Frequent Operation of Voltage Control Devices | Validated | Change Control Settings, Relocate and/or Remove Equipment |
| Mis-coordination of protective devices | No Occurrence | Upgrade to Digital Relays |

## NEXT STEPS

1. Model and simulate events to plan for future changes

2. Simulate events to provide intelligence in reacting to outages and emergency conditions

3. Utilize a combination of GIS, distribution planning tools and measured data to achieve objectives



## RECOMMENDATIONS

That the Board of Public Utilities receive and file the status report for the Impact Of High PV Penetration on Distribution Circuits.