# High Penetration PV Effects on Electric Distribution Systems

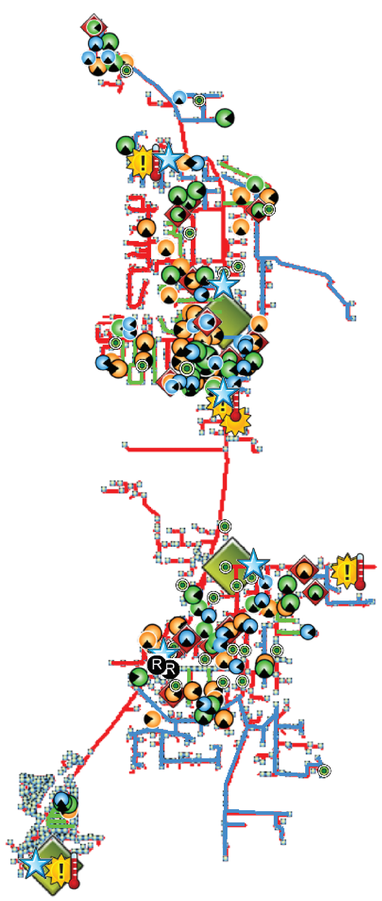
APS and its partners are studying the effects of a high penetration of PV distributed energy on a load-carrying electric distribution feeder when levels reach or exceed 30% of total load. All photovoltaic systems are currently deployed and real-time (1 sec.) data is continuously being collected and transmitted to APS for analysis.

## Highlights

- **Modeled feeder in both commercial and open source software**
- **Data acquisition deployed**
- **Advancing the capability to manage a high penetration of photovoltaics**
- **High penetration on feeder achieved**
- **Smart inverter integration**
- **Maintain deployed PV systems for 20+ years**

## Phases and Milestones

**High Penetration PV Deployment on Flagstaff Feeder**



**Deployment Complete** Residential: 467 kW from 125 solar rooftops Typical size: 2, 3, 4 kW each

Commercial: 400kW roof and ground mount system at school

Utility-scale:500kW PV solar power plant

**Phase 1**
**Jan 2010** DOE Phase 1 award

**Apr 2010** Arizona Corporation Commission approval

**Jun 2011** Baseline model, DAS prototypes, initial inverter evaluation and PV deployment

**Phase 2**
**May 2012** PV & DAS deployment complete

**May 2012** 30% Feeder PV Penetration

**Jul 2012** High Penetration PV model, smart inverter integration, data collection

**Phase 3**
Validate model

Extend feeder model

Study smart inverter functions

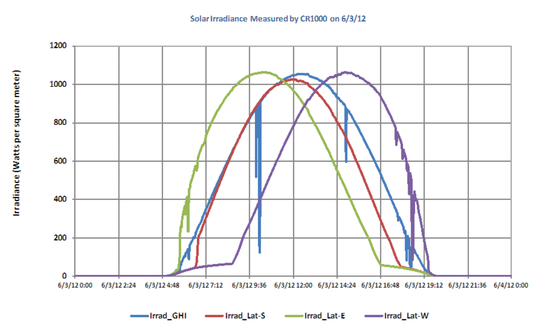
**Phase 4**
Study smart inverter functions

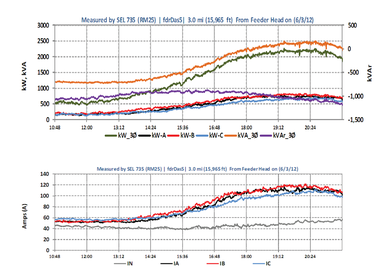
Study energy storage

**Phase 5**
Report results

Cost benefit analysis

## Real-time Data Aquisition: Early Results



## Data Acquisition System Information

### Residential PV
13 select residential PV sites along feeder

PV system output measurements

SEL 734 PQ meters

Real time 1 second data

Over 70 separate measured parameters

Wireless radio network

### Feeder
6 locations along feeder

Measurements taken at feeder primary conductors

SEL 735 PQ meters installed

Real time 1 second data

Over 70 separate measured parameters

Capable of cross-device triggering and capture

Wireless radio network

### Weather Station
7 locations in Flagstaff (4 on feeder)

Campbell Scientific CR1000 data loggers

Real time 1 second data

10 measured parameters

Wireless radio network

### Substation
Substation relay

Energy Management System (EMS)

Real time 10 second data

9 measured parameters

### Project Partners
U.S. Department of ENERGY

ASU

GE

NREL

ViaSol ENERGY SOLUTIONS