



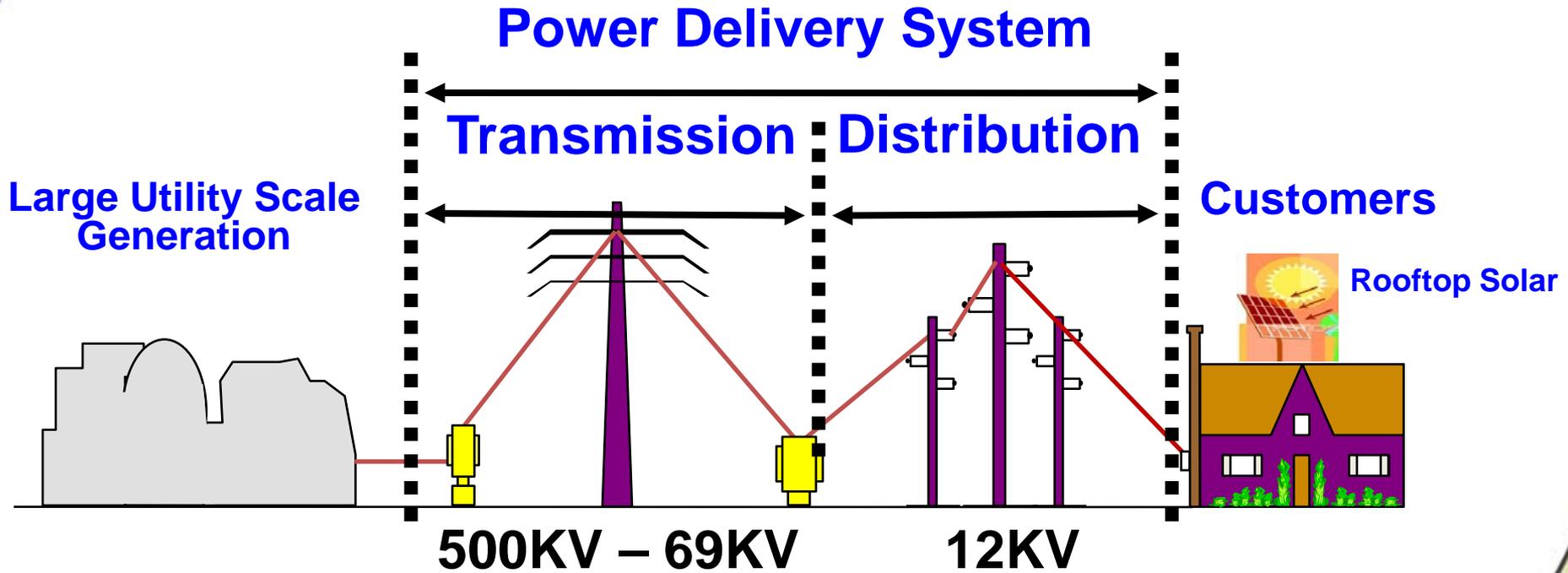
# **Empowering Customers**

## **Reliability and Customer Owned Generation**

***John Coggins, Senior Director***  
***Power System Planning & Engineering***  
***Salt River Project***

**June 20, 2014**

# Power Delivery System “The Grid”



# Electricity Terminology

- **Voltage:** Analogous to pressure in a water pipe
  - Usually measured in Volts (V) or Kilovolts (KV)
- **Current:** Analogous to amount of flow in a water pipe
  - Usually measured in Amps (A) or Kiloamps (KA)
- **Power:** Voltage x Current
  - Usually measured in Watts (W), Kilowatts (KW) or Megawatts (MW)
- **Energy:** Power x Time
  - Usually measured in Kilowatt-hours (KWh) or Megawatt-hours (MWh)

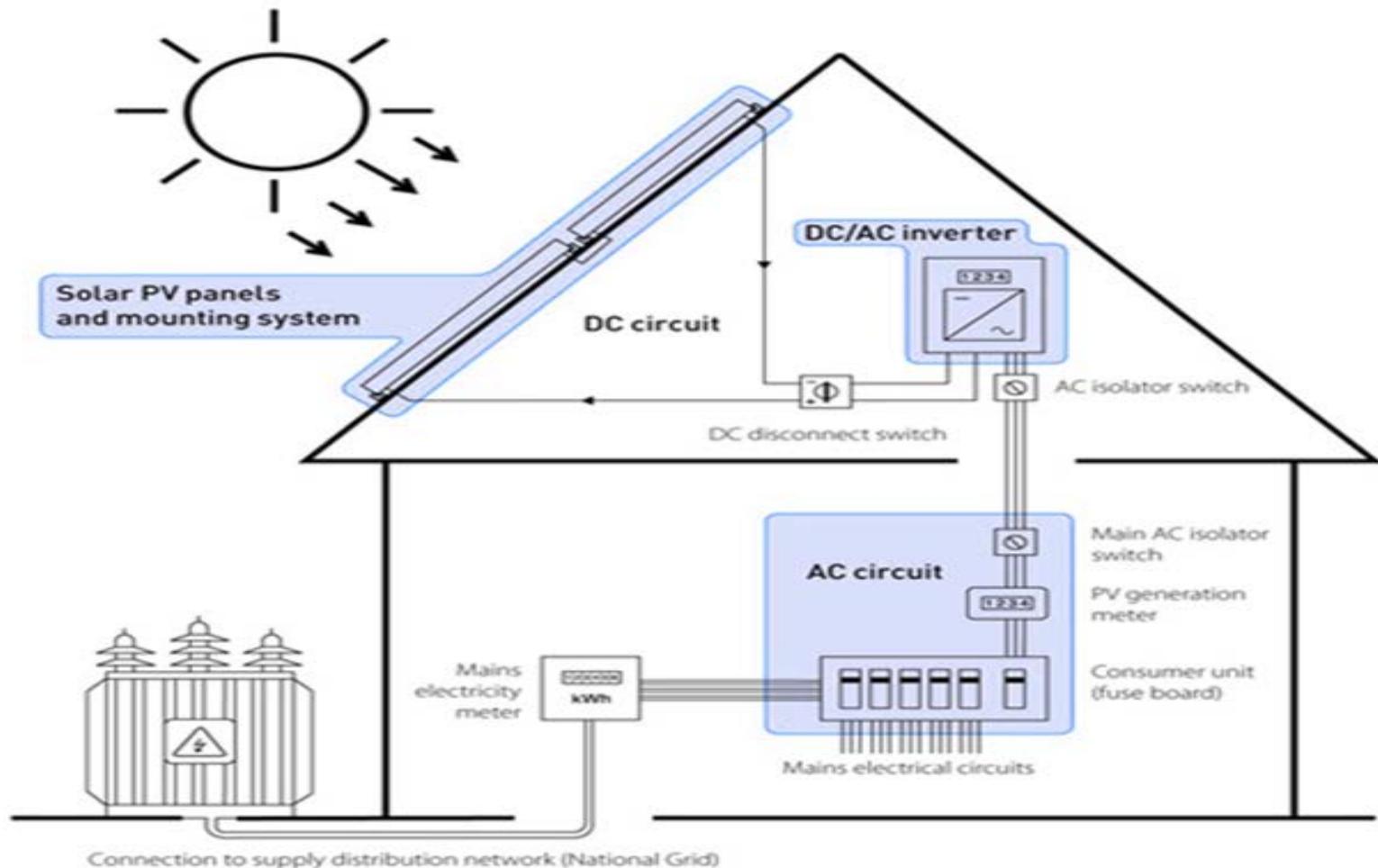
# Distribution System Attributes

- **Distribution system:** the portion of the power grid that connects directly to homes and businesses
  - Originally designed for power to flow in one direction: to the customers
  - Today also enables customer owned generation
  - Hundreds or thousands of circuits; each one is unique
  - Must maintain proper voltage for each circuit

# Why Does Voltage Matter?

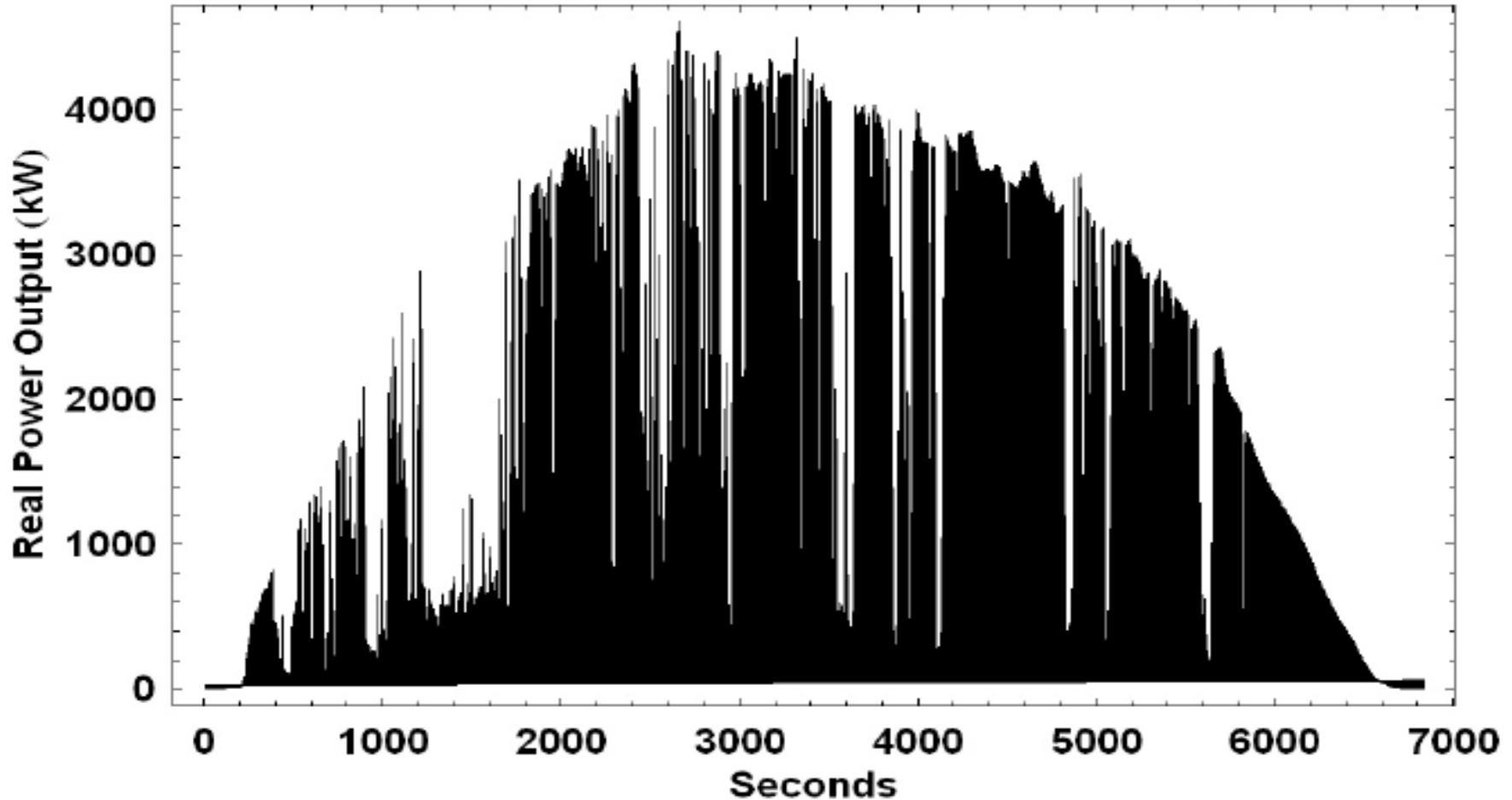
- Customer appliances and equipment are designed to operate within a specific voltage range
  - Appliances within the home have a shorter life if voltage is consistently out of range
  - Manufacturing processes and equipment may not even operate without proper voltage
  - Lights may flicker if voltage suddenly fluctuates

# Customer Owned Generation Mostly Rooftop Solar Today

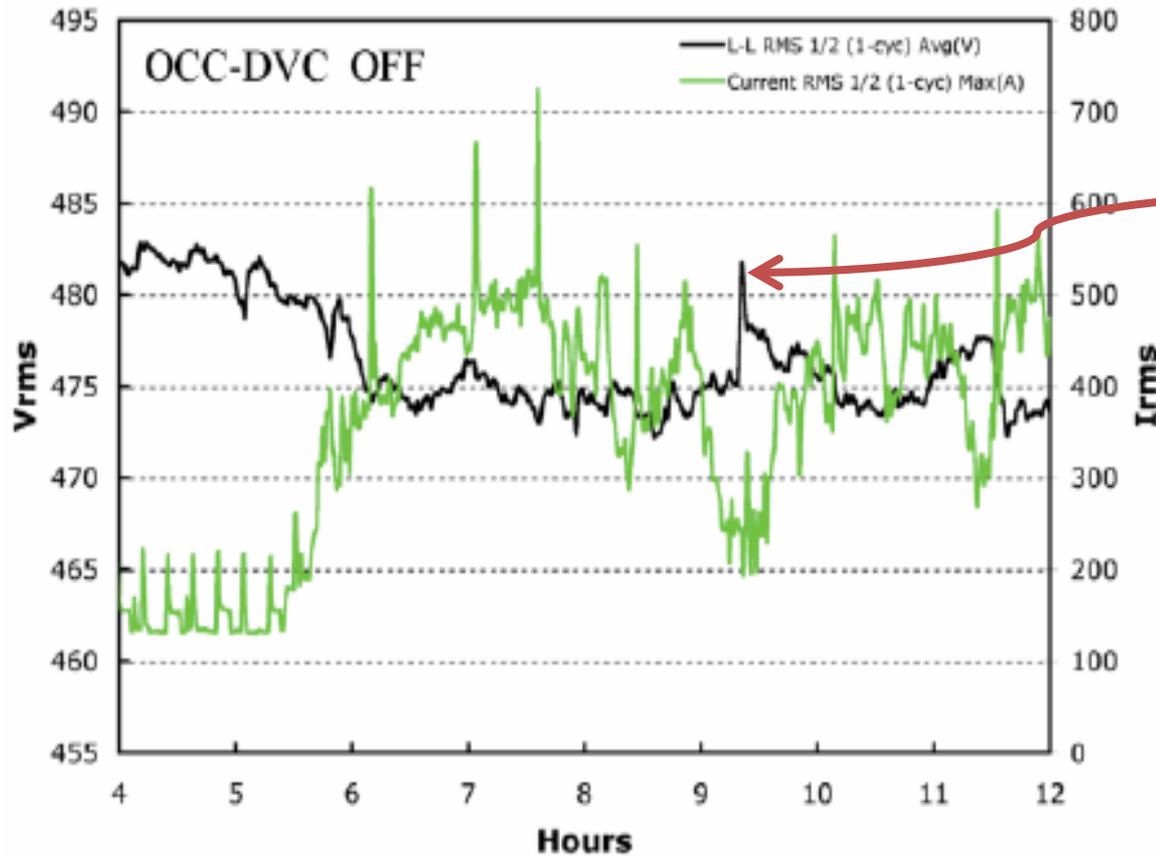


# Rooftop Solar Variable Output With Intermittent Cloud Cover

Springerville AZ, One Day at 10 Second Resolution



# Rooftop Solar Variable Output Inverter Characteristics



**PV system  
voltage with  
traditional  
inverter\***

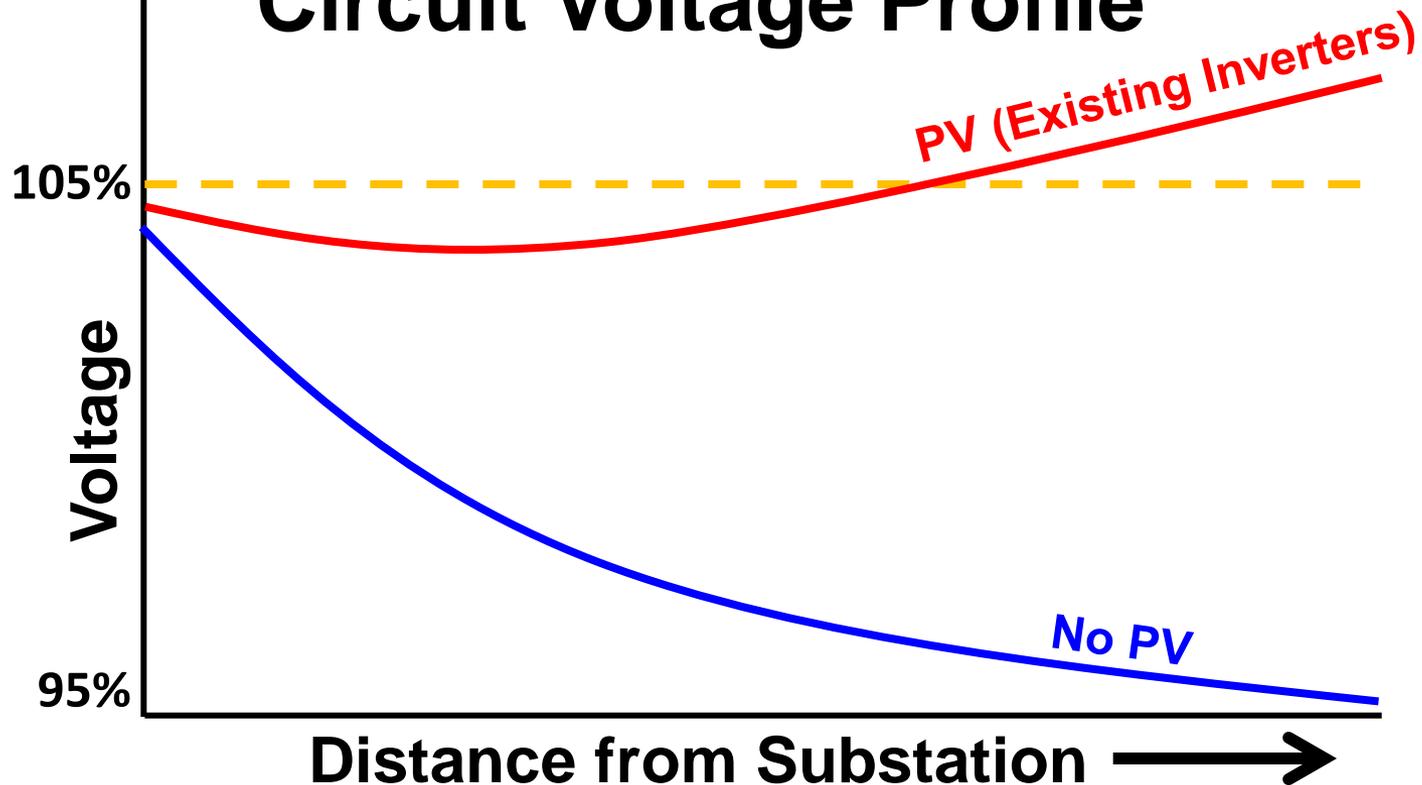
\*384 kVA PV system on SDG&E 12kV system

# Variability Impacts Transmission System

- Peak demand firming
- Regulation
- Load following

# Variability Impacts Distribution System

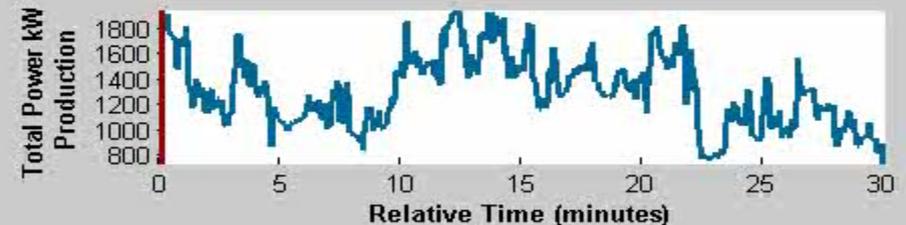
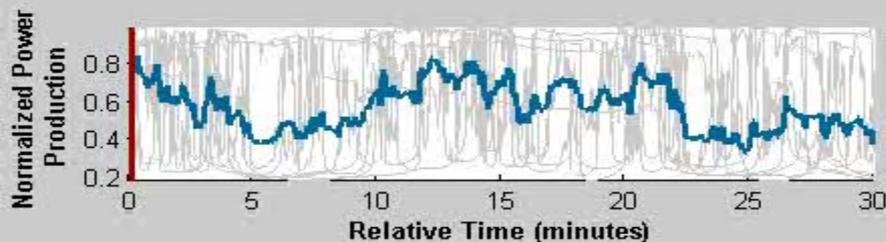
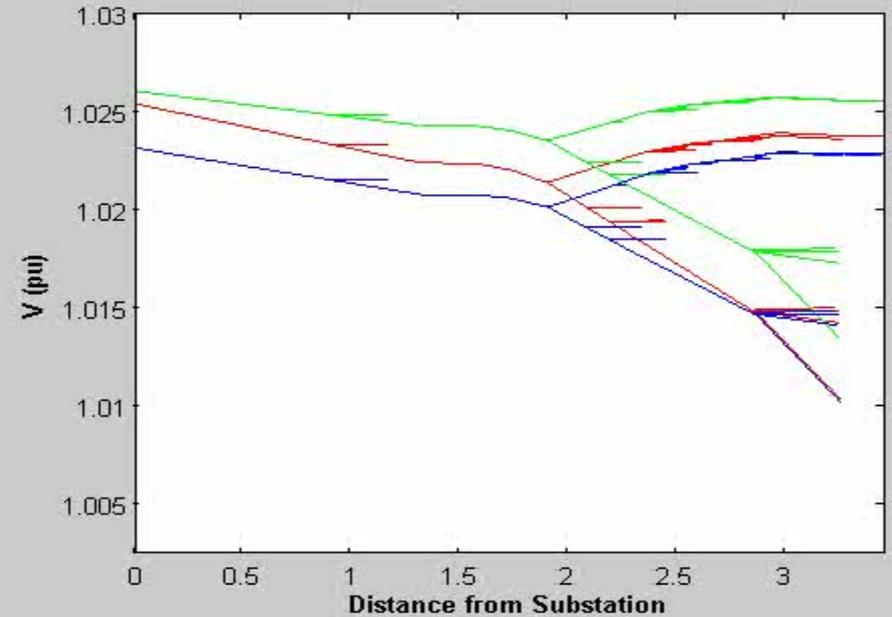
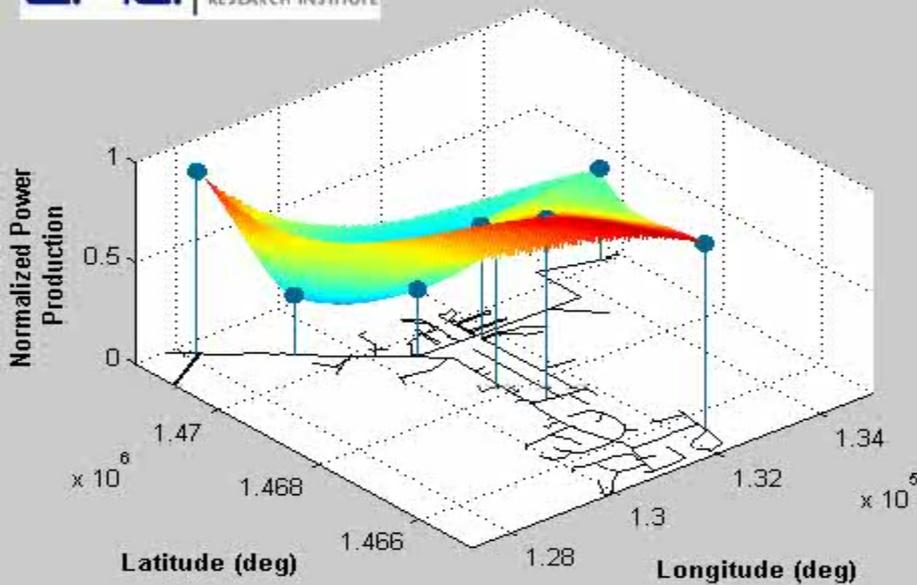
## Circuit Voltage Profile



# Variability Impacts Distribution System Video

© 2011 Electric Power Research Institute, Inc. All rights reserved.

1 fps  
0:01 min:sec



# High Penetration Readiness Customer Owned Generation

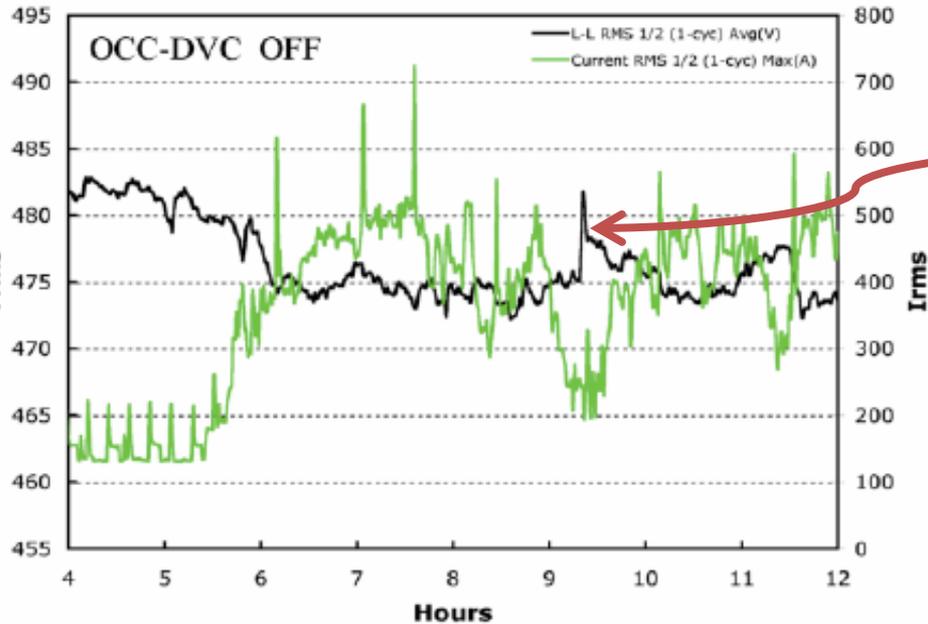
- Robust core electric system infrastructure
- Enhance interconnection requirements
- Integrate other strategies that build upon interconnection infrastructure (future)

# Enhance Interconnection Requirements – Phase 1

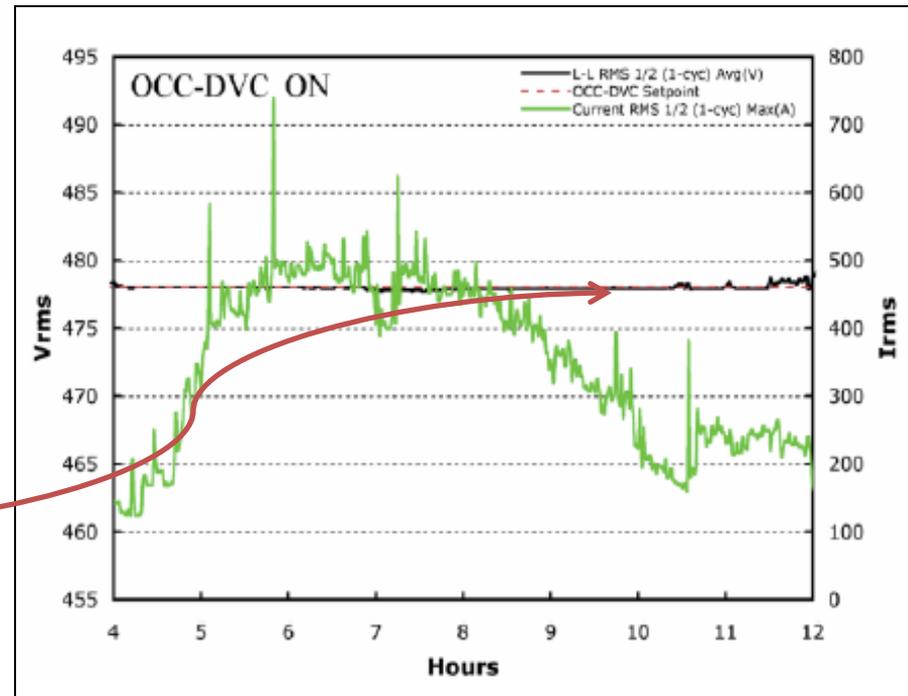
- Require “intelligent inverter”
  - Adjustable settings for voltage control
  - Two-way communication capabilities for future use

# Intelligent Inverter Impact on Voltage

**PV system voltage with traditional inverter\***



**PV system voltage with intelligent inverter\***



\*384 kVA PV system on SDG&E 12kV system

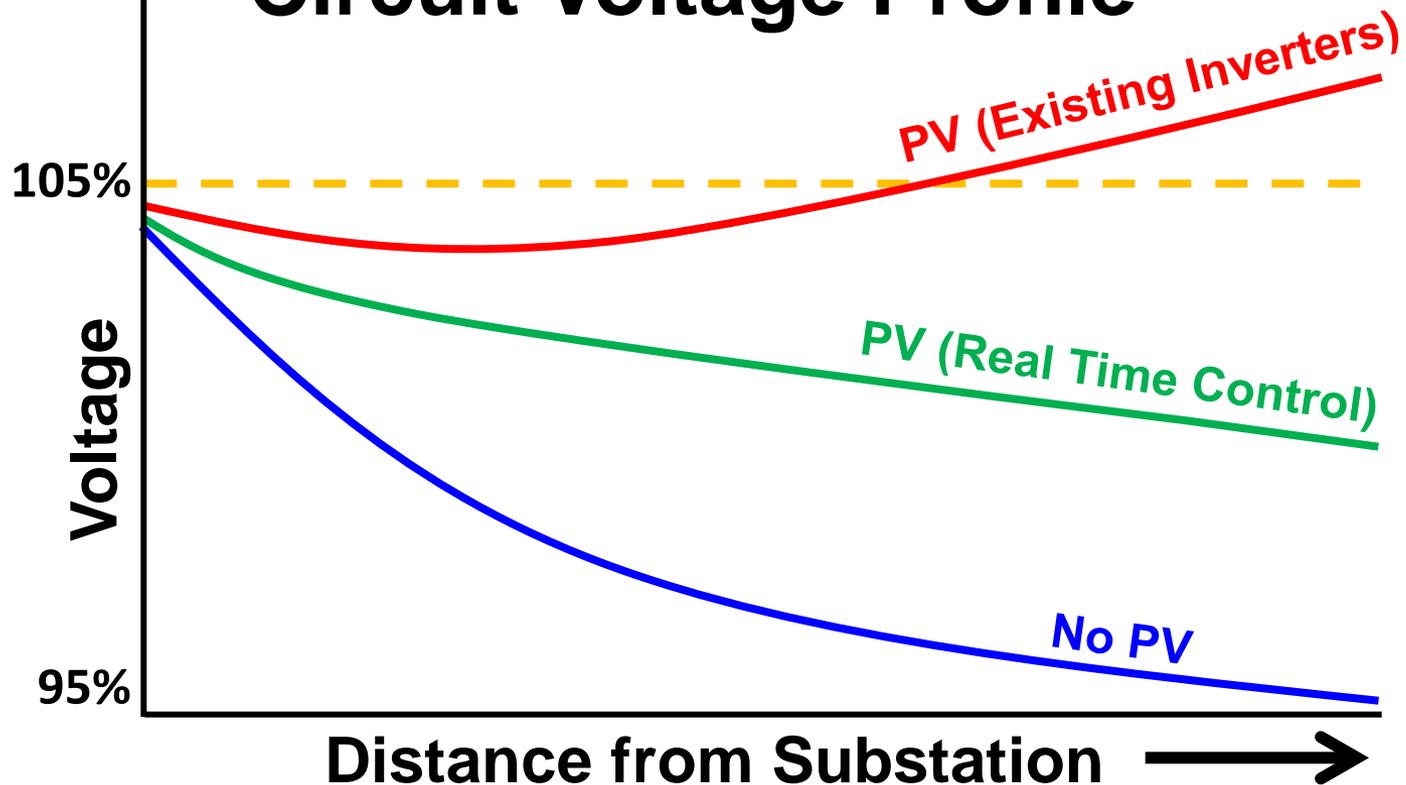


# Enhance Interconnection Requirements – Phase 2

- Transform challenge into opportunity
- Two-way communication and control of intelligent inverter
  - Real time adjustments to enhance grid operations
- Requires new communication infrastructure
  - “Last mile” wireless or fiber
- Requires “distribution management system”

# Real Time Voltage Management

## Circuit Voltage Profile



# Potential System Enhancements Building Upon Communication Infrastructure

- Energy efficiency savings from conservation voltage reduction (CVR)
- Enhanced use of distribution automation to reduce duration of power outages
- Enhanced management of system margins to potentially reduce capital additions
- Alternative future communication options for advanced metering

# Key Next Steps Technology

- Industry standards for intelligent devices
- Expanded utility communications infrastructure
- Big data management and analytics