Field Verification of High-Penetration Level PV with Advanced Power Conditioning Systems

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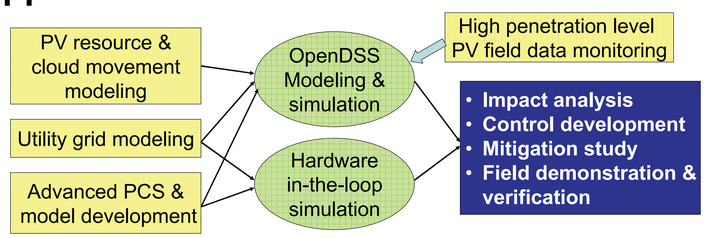
PHOTOVOLTAICS

Objectives:

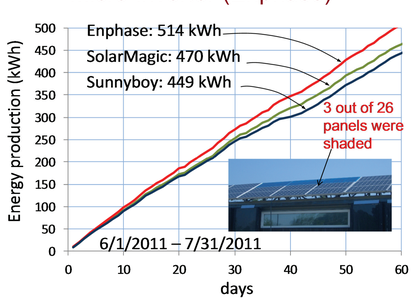
- Demonstrate energy production with different PCS architectures
- Evaluate design issues and power quality compliance of PCS
- Study impact of high penetration levels of PV on distribution grid

Approaches:



VT Solar House PCS Energy Production Study with Different PCS Architectures

- Three PV branches configured with:
  - String PCS (SunnyBoy)
  - Series DC Optimizer (SolarMagic)
  - Micro-inverter (Enphase)



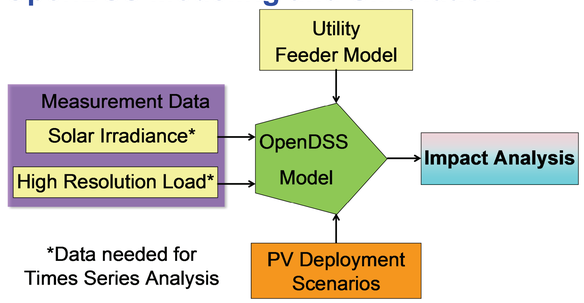
Energy Production Results with Shading:

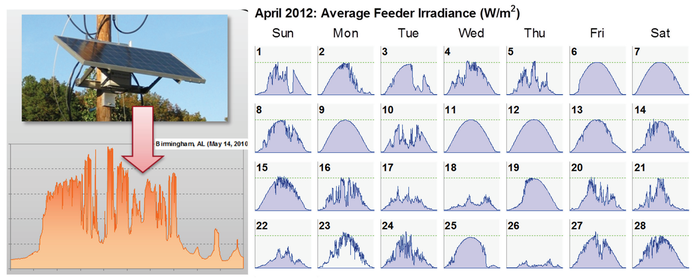
- Shading significantly affects string inverter output
- Power optimizer helps energy gain for string inverters

VT Microinverter Development

- 25-45V input, 240V output, 250W
- High efficiency (96%CEC) with soft-switching DC-DC and all MOSFET based inverter
- High reliability without phase leg shoot-through fault concerns
- No electrolytic capacitor, rejecting double line-frequency ripple with a two-stage power conversion design

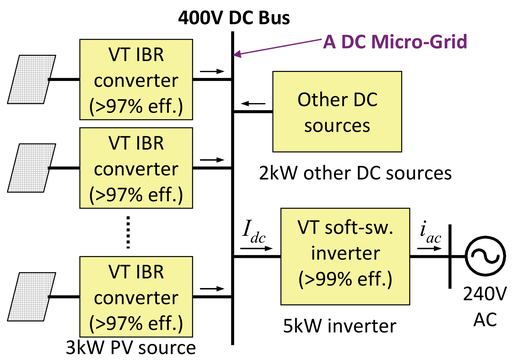
OpenDSS Modeling and Simulation





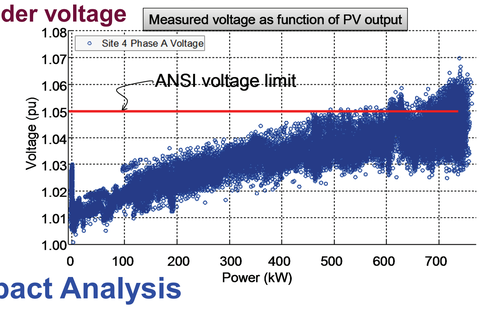
VT IntelliSOLAR™ Demonstration System

- High efficiency (>97%CEC) galvanic isolated DC-DC converter outputs form a DC micro grid
- No aluminum electrolytic capacitors or cooling fans
- Ultrahigh efficiency soft-switching inverter with 99.1% CEC weighted efficiency
- Low output THD, <1.8% at Full load



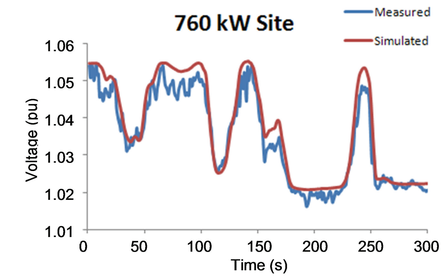
Field Measurement Data

- PV outputs show significant impact to the feeder voltage



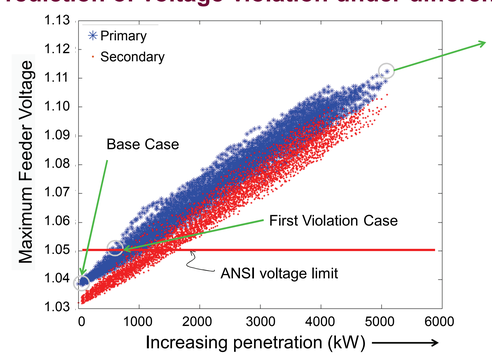
Simulation Results

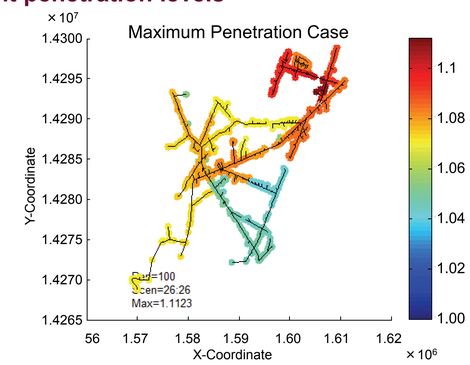
- Voltage fluctuations are well predicted



Impact Analysis

- Prediction of voltage violation under different penetration levels





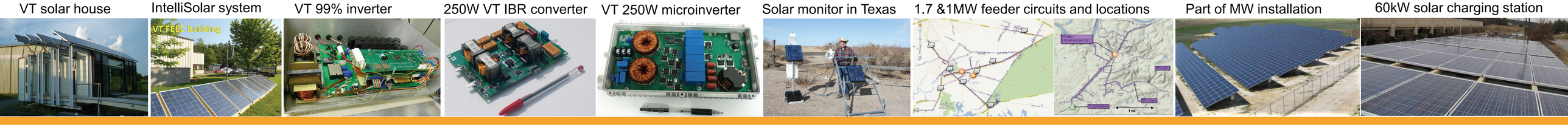
Summary of Project

- Successfully developed and demonstrated a highly efficient and reliable PV PCS
- Deployed an energy production installation for cost effectiveness study
- PV resources and High Penetration Grid Modeling and Simulation Using Field Measurement and Monitoring Information

Future Work

- Field demonstration with advanced PV PCS
  - Install 25-kW PV system at VT Kentland Farms Research Facility
  - Install 100-kW PV system at Western Research Institute, Laramie, WY
- Modeling and simulation
  - Hardware-in-the-loop simulation for advanced control development
  - Incorporate cloud movement and PCS models into OpenDSS
  - Study mitigation with advanced PCS features, such as VAR and frequency control

VT solar house | IntelliSolar system | VT 99% inverter | 250W VT IBR converter | VT 250W microinverter | Solar monitor in Texas | 1.7 &1MW feeder circuits and locations | Part of MW installation | 60kW solar charging station



SunShot U.S. Department of Energy

Acknowledgement: This project is supported by the U.S. Department of Energy SunShot Initiative.

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