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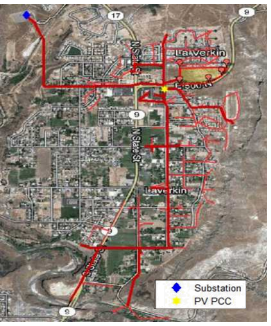

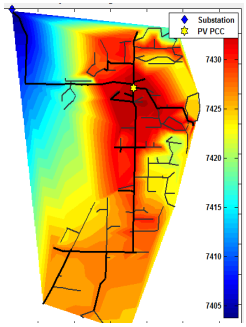

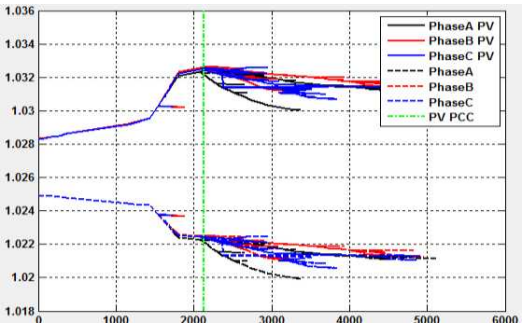

Locational Dependence of PV Hosting Capacity Correlated with Feeder Load

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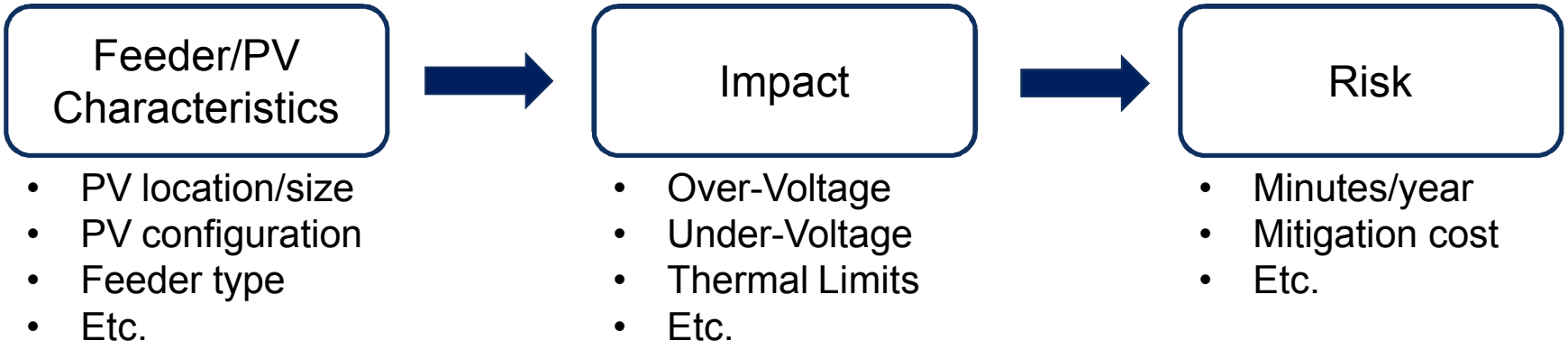
Outline

- Introduction
- Hosting Capacity Analysis Methodology
- Results
- Analysis
- Conclusions / Future Work

Introduction

- Develop a technique to establish feeder impact due to high PV penetration
- For use in determining necessity of full interconnection studies

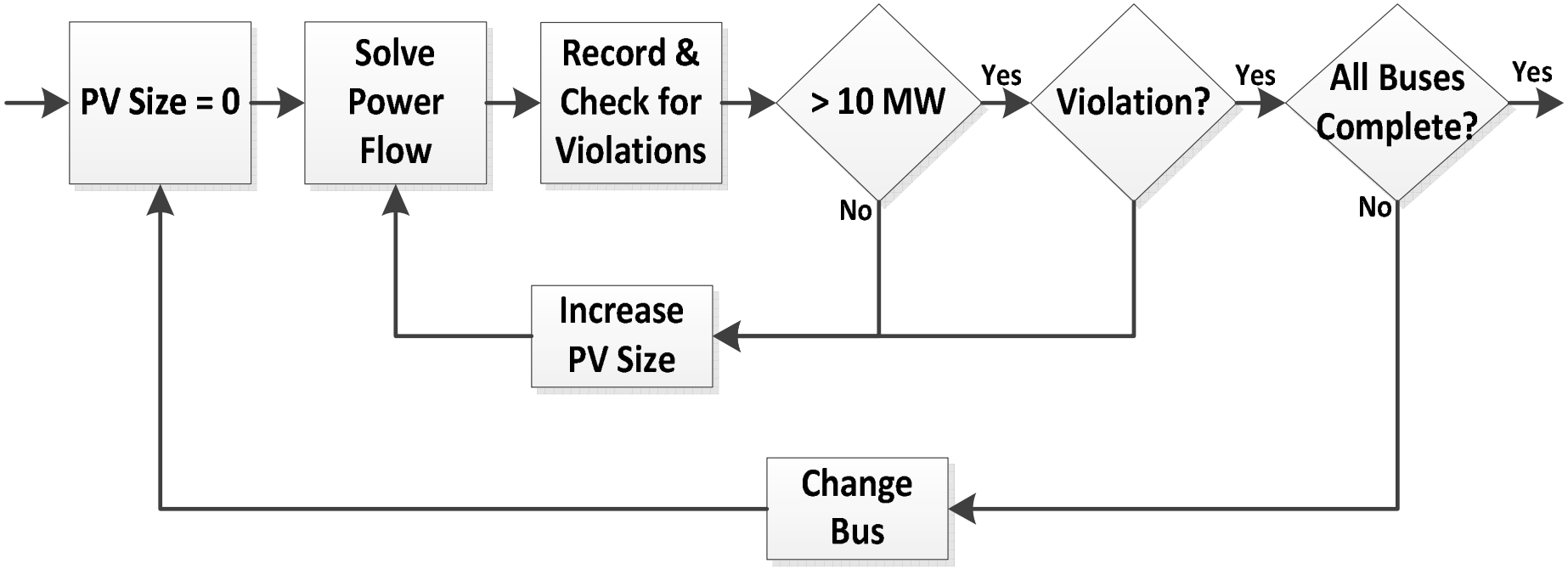


- This paper looks at locational hosting capacity
  - Analyze impact on feeder due to range of PV sizes/locations

Analysis Methodology

1. Place a single PV plant on a bus
   - Focus for this industrial feeder is large 3-phase systems
   - Simulate worst case
     - i.e. PV outputting rated power at unity power factor
2. Solve steady-state power flows (3ϕ unbalanced)
   - Several different load levels and PV sizes
3. Check for Violations
   - Voltage violations outside ANSI C84.1 Range A
   - Thermal violations for overloaded lines and transformers above 100% of their nominal rating

Analysis Methodology

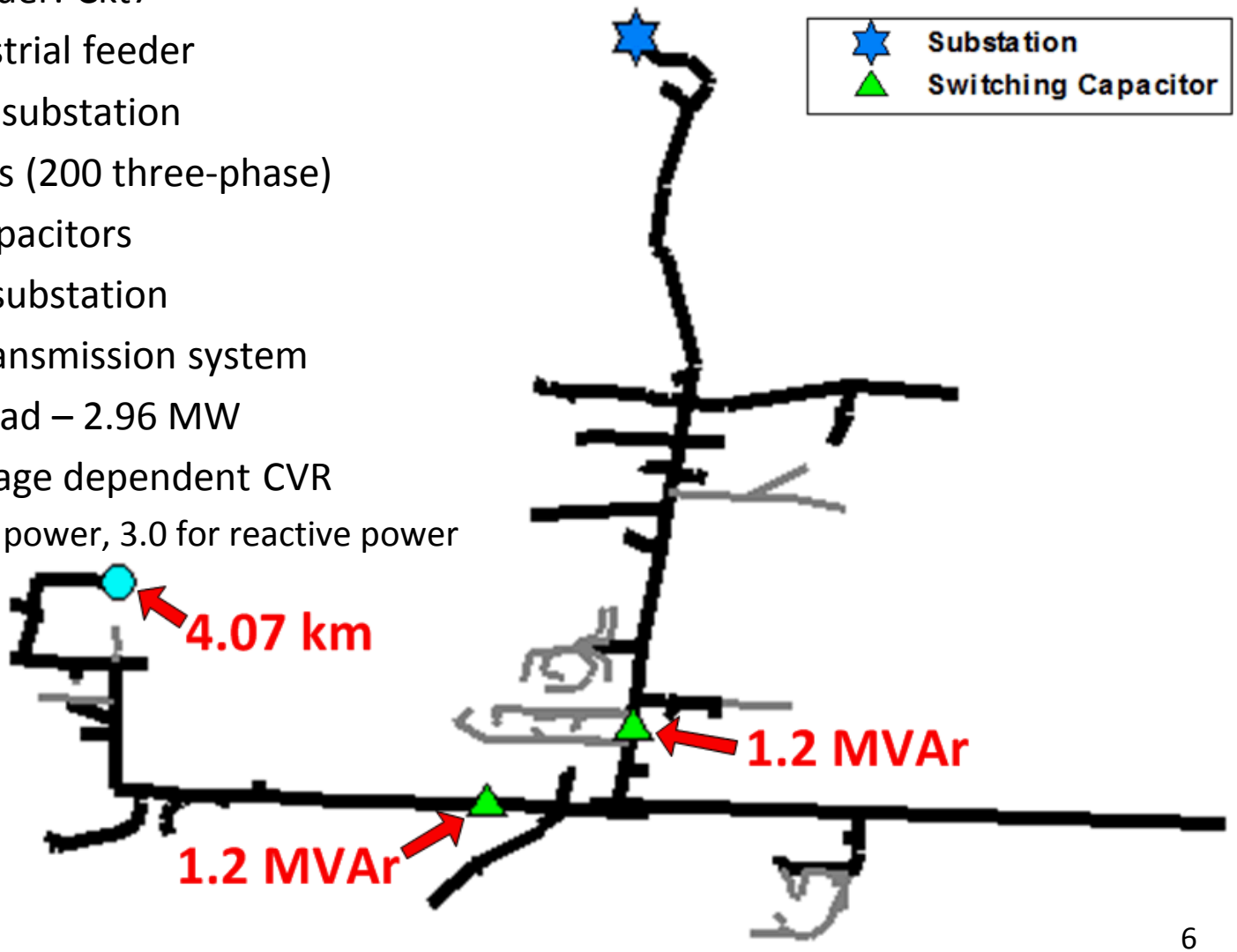


Loop through all 3-phase buses, increasing the PV size until a violation occurs

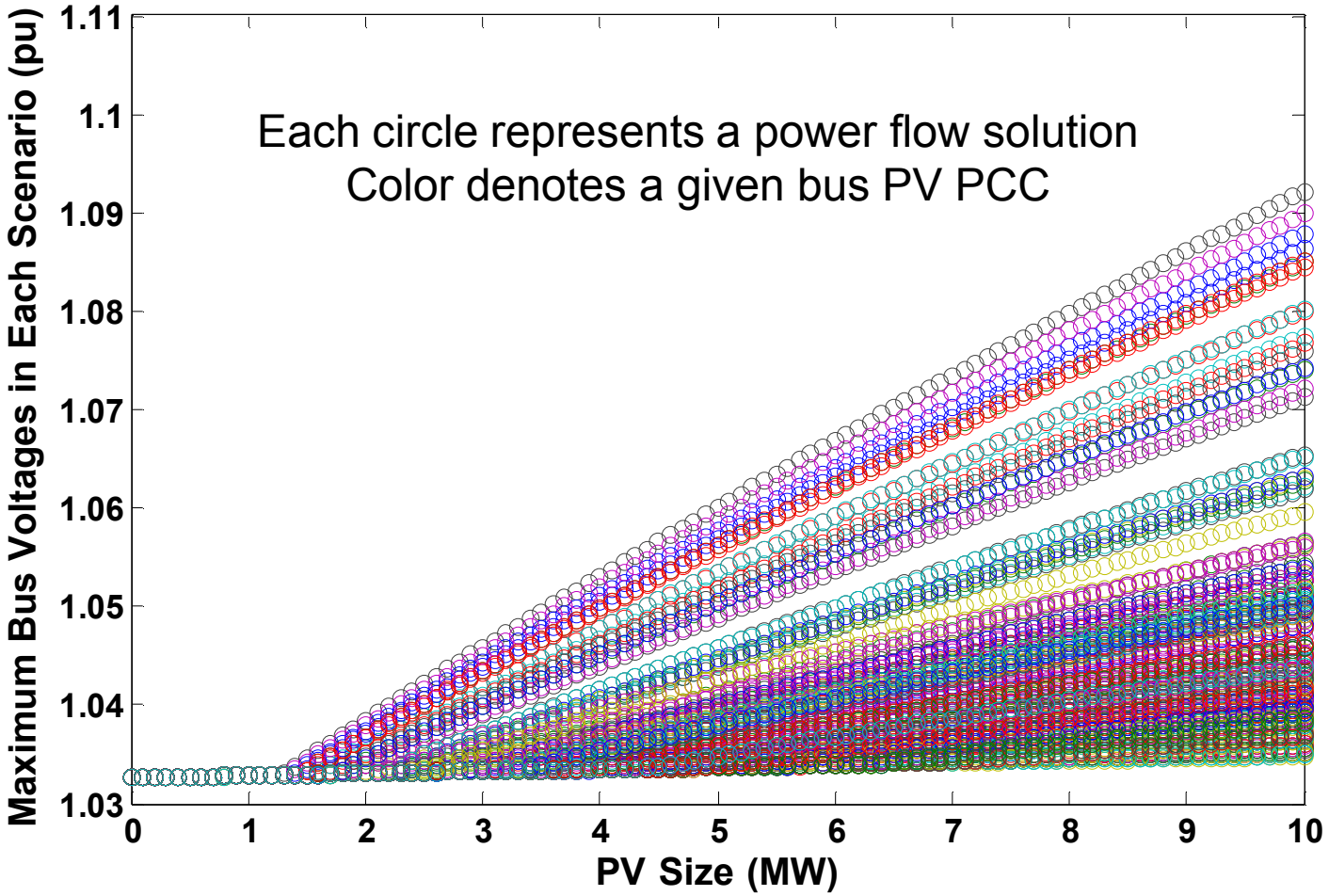
Power flow is solved in OpenDSS and all other analysis/looping is done using MATLAB through the COM

Study Feeder

- EPRI's test feeder: Ckt7
- 12.47 kV industrial feeder
- 4km length to substation
- 288 total buses (200 three-phase)
- 2 switching capacitors
- 14 feeders at substation
- Stiff, 115kV transmission system
- Peak feeder load – 2.96 MW
- Loads are voltage dependent CVR
  - 0.8 for real power, 3.0 for reactive power

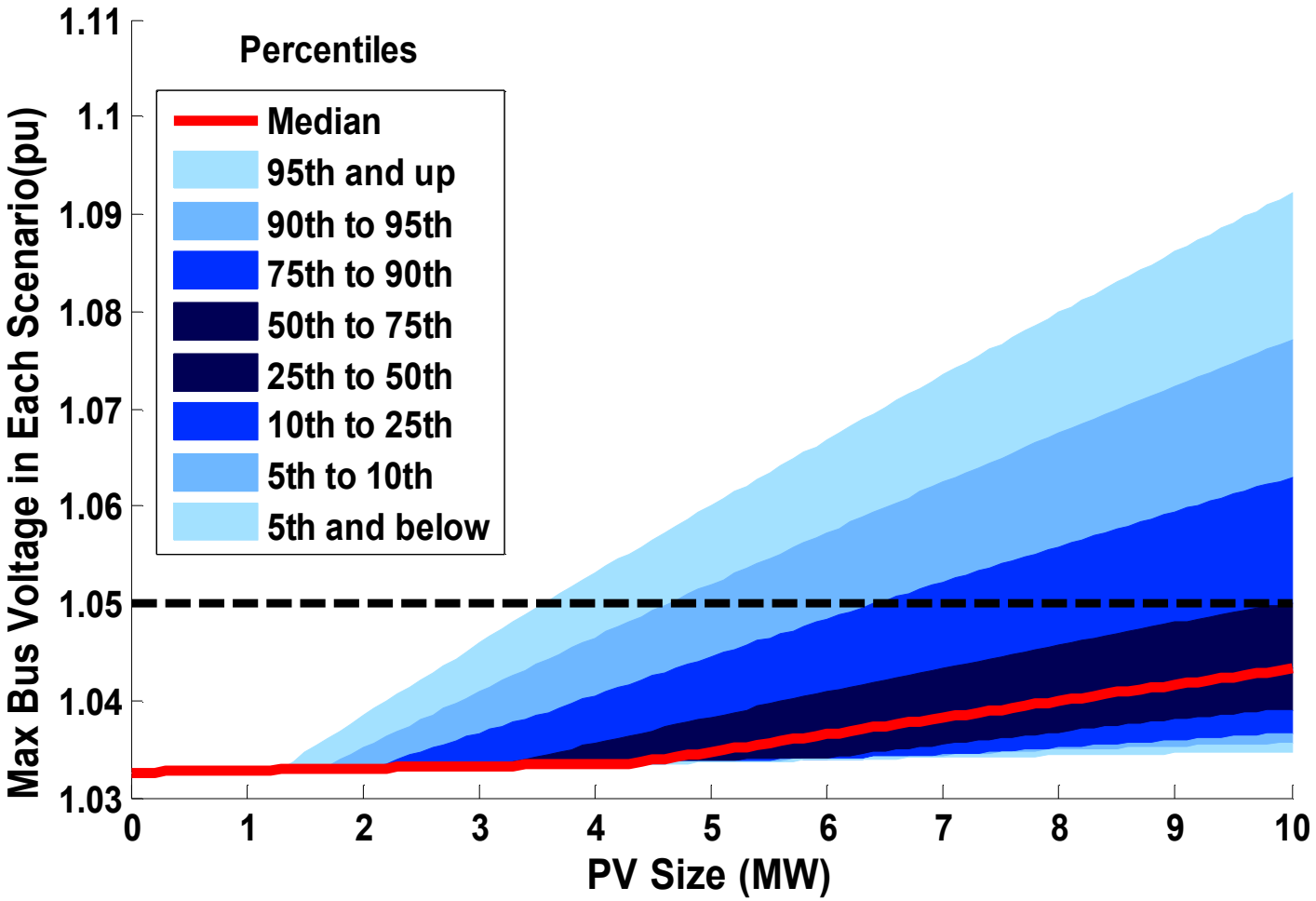


Voltage Violations – Over Voltage



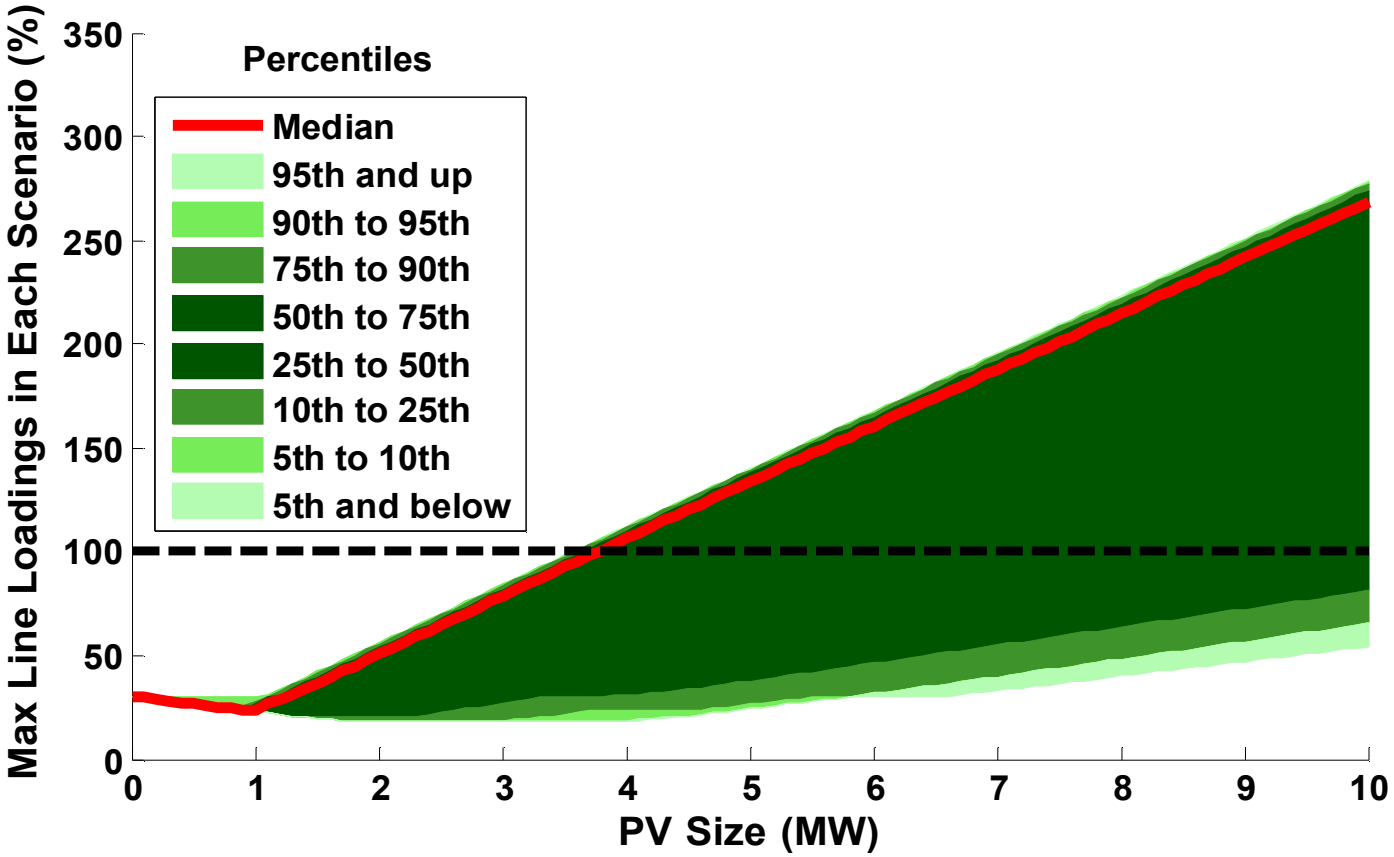
Effect of PV size on max bus voltage under 50% load.

Voltage Violations – Over Voltage



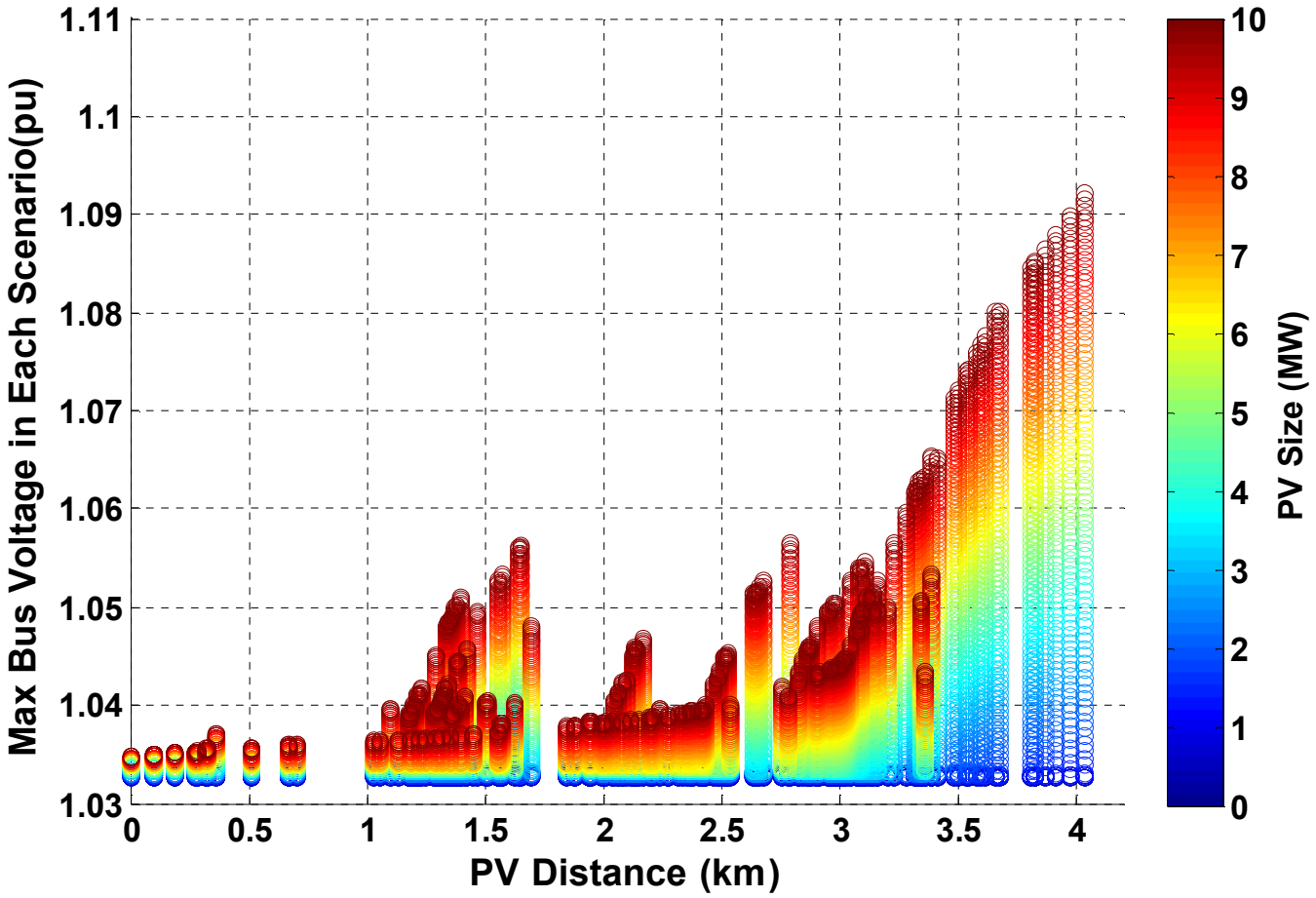
Effect of PV size on max bus voltage under 50% load, shaded by the percent of PCC bus scenarios that occur at that region

Thermal Violations – Line Overloaded



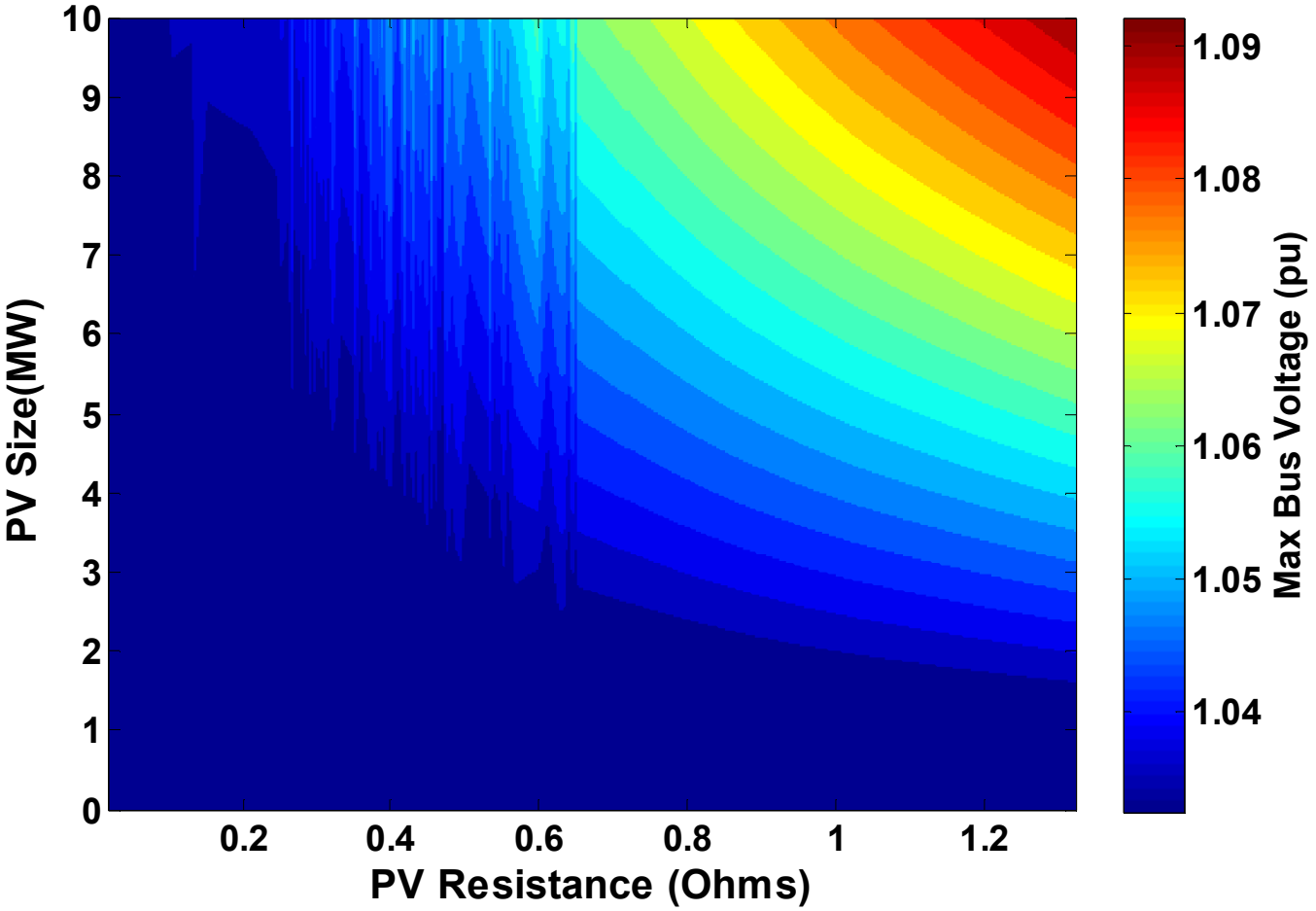
Effect of PV size on max line loading under 50% load.

Analysis – Max Bus Voltage



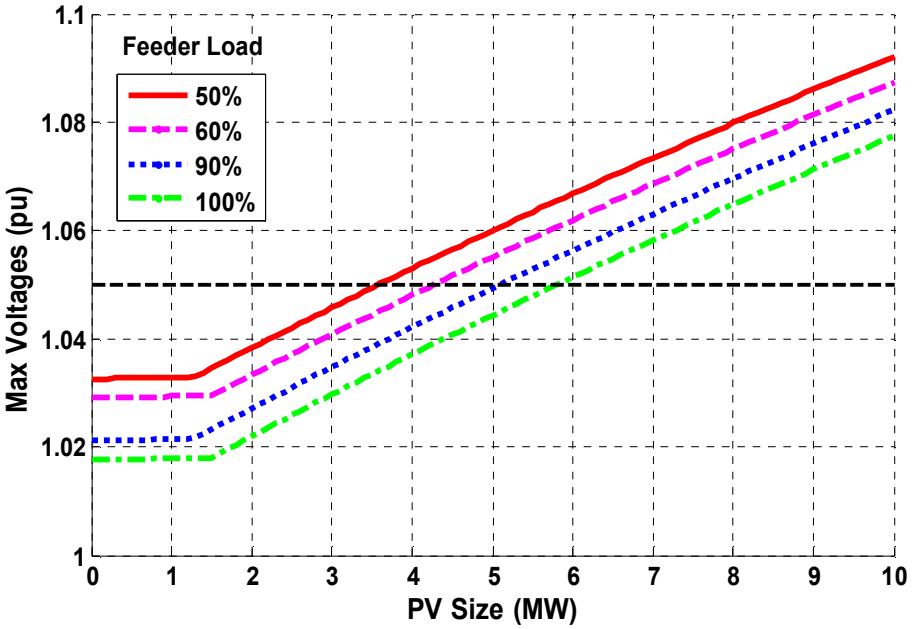
Effect of central PV size and distance to substation on max bus voltage under 50% load.

Analysis – Max Bus Voltage

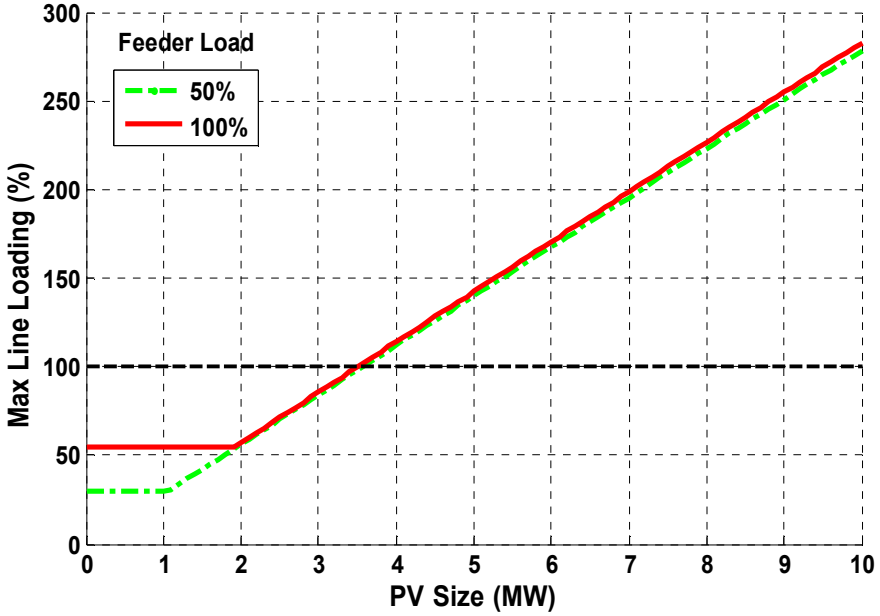


Max bus voltage as a function of PV size and resistance to substation under 50% load.

Analysis – Function of Feeder Load

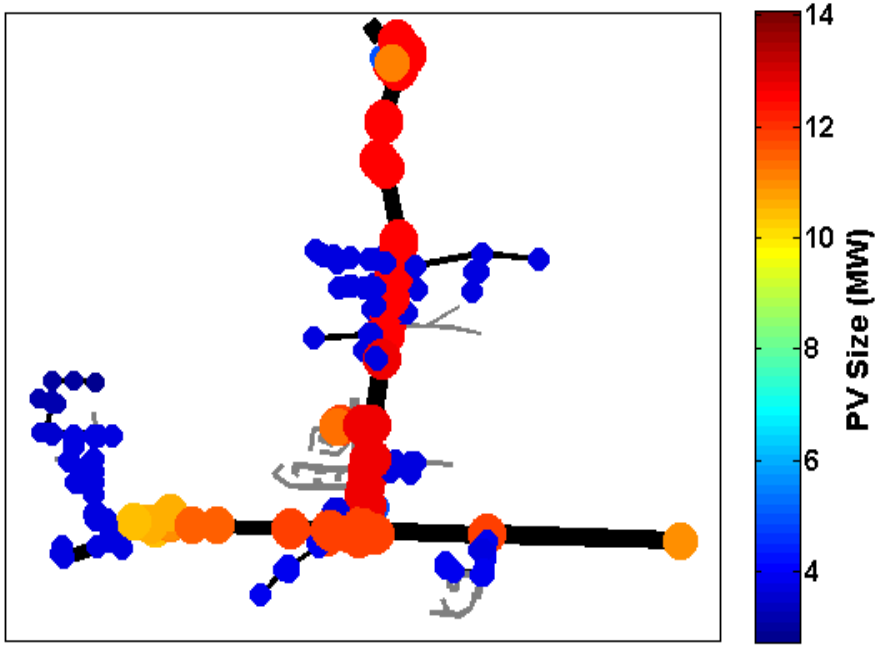


Maximum feeder bus voltage for any PCC at each PV size.

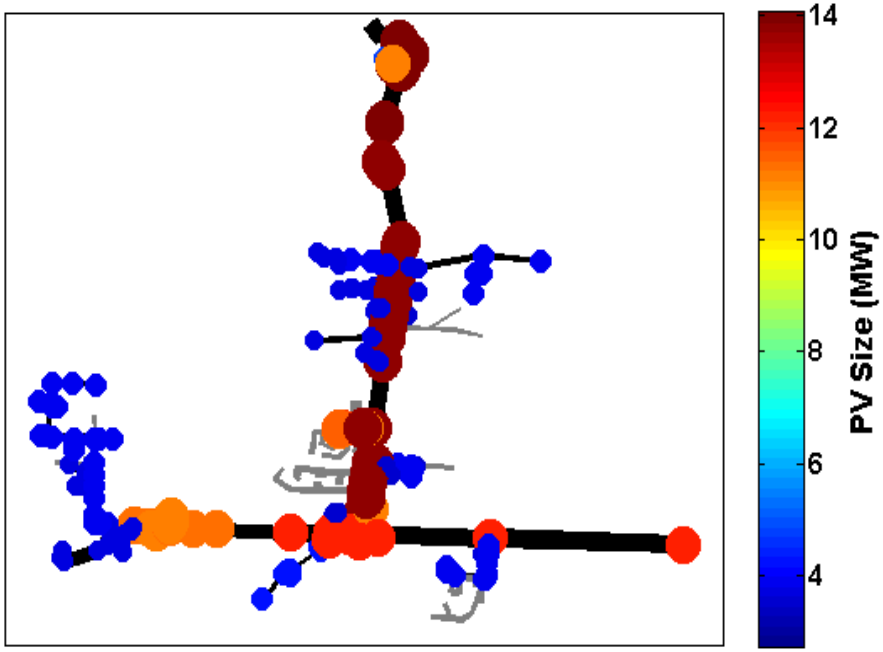


Maximum feeder line loading for any PCC at each PV size.

Results – Locational Hosting Capacity



Maximum allowed PV size at a single bus under 50% load.



Maximum allowed PV size at a single bus under peak load.

Conclusions / Future Work

- Demonstrated analysis methodology for investigating hosting capacity
  - Hosting capacity in Ckt7 dictated by thermal limits
  - Feeder load had little impact
- We have since expanded the methodology:
  - More feeders investigated
  - Voltage regulation operation and hysteresis bands
  - Consideration of PV ramping
  - Distributed PV scenarios
  - Feeder protection coordination
  - Smart inverters