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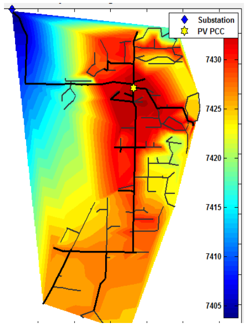

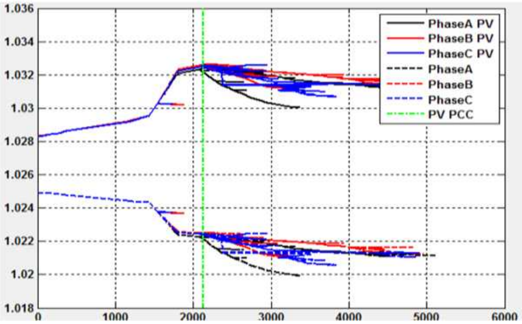

Technical Evaluation of the 15% of Peak Load PV Interconnection Screen

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Introduction

- High penetrations of PV on a distribution system can impact power quality, reliability, and the standard grid operation
- Therefore, before PV systems are allowed to interconnect with the grid, they must be studied to analyze and mitigate any impacts
- PV interconnection policies vary, but many utilities use a standard small generator interconnection procedure (SGIP)
- PV that does not require detailed study is placed on a fast track by a screening process

Background: Fast Track Screening

- Objective of the fast track to avoid full interconnection studies for PV systems that do not need it. Full interconnection impact studies are time consuming, slow the growth of PV, and expensive.
- On the other hand, fast track screening should not allow PV interconnections that will negatively impact the grid
- One common interconnection screening threshold (IST) fast tracks PV smaller than 15% of the peak load
- Previously, very little work has been done to research and perform technical evaluation of the interconnection screening methods

Analyzing Accuracy of 15% Screen

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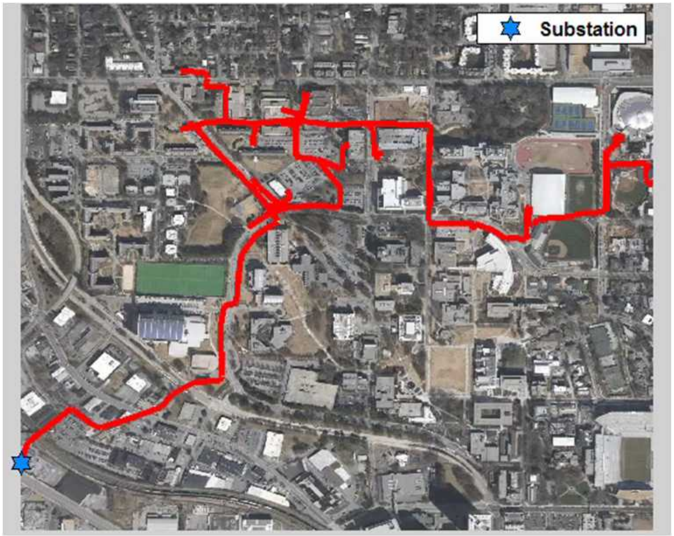
- The accuracy of the 15% of peak load screen is analyzed by comparing the screen to a large range of different distribution systems under high PV deployment scenarios and the feeder's hosting capacity
- The accuracy of the 15% interconnection screen is compared to the simulation results from ~1.5 million different PV scenarios
- Metrics are introduced to not only compare the screen to the feeder's minimum PV hosting capacity, but to also analyze the distribution of the feeder's locational hosting capacity and the number of violations and false-positives that the screen allows
- This is an important concept because it analyzes the locational risk for areas of the feeder that can handle various sized PV interconnections

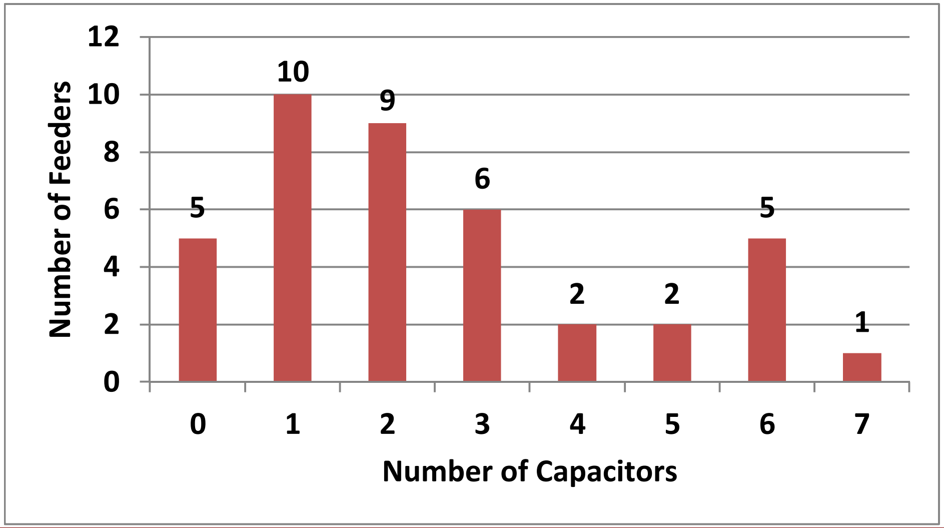
Outline

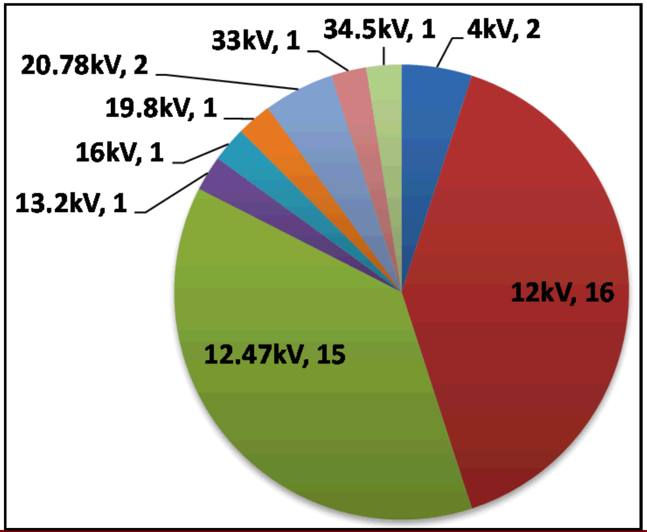
- Determine the hosting capacity of distribution feeders
  - Database of distribution systems
  - Hosting capacity methodology
- Develop interconnection screening metrics
  1. Screen accuracy ratio (SAR)
  2. Violations the screen allowed (VSA)
  3. Potential percent increase (PPI)
- Calculate the accuracy of the 15% of peak load screen

Distribution Systems for Analysis

- 40 actual distribution systems located in the United States (~10 different utilities)
- Each model includes the full details about substation impedance, voltage regulator settings, capacitor switching controls, an approximate model of the secondary system, and a year of SCADA data

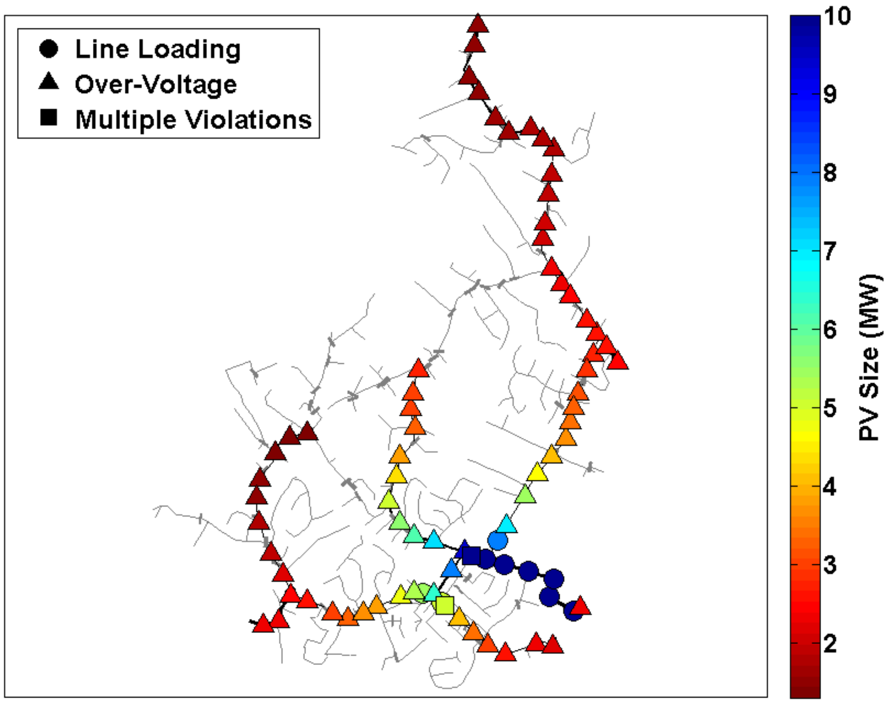






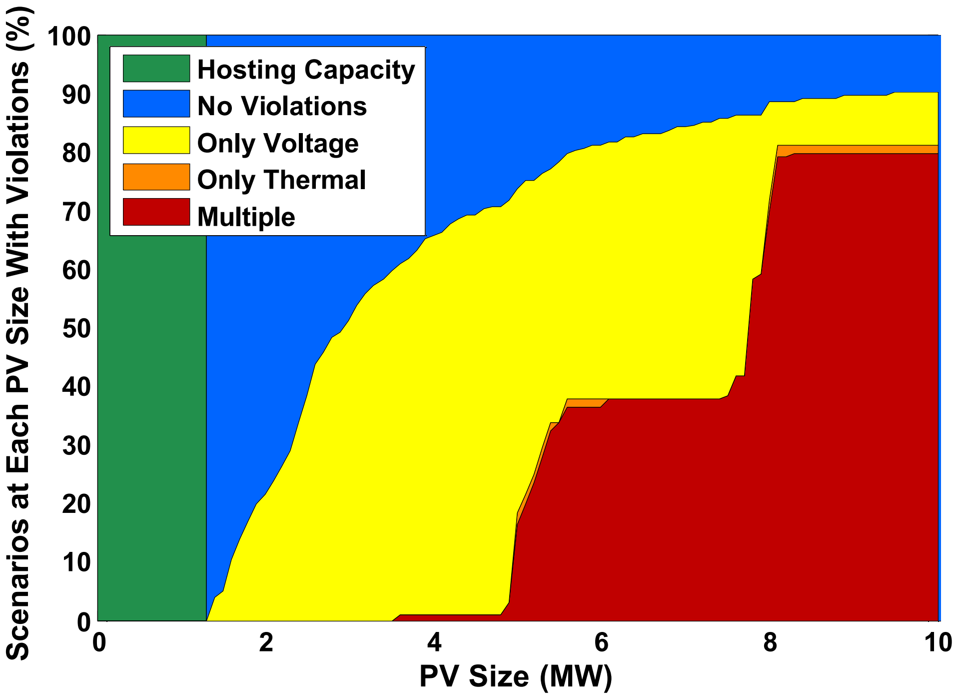
Hosting Capacity Analysis

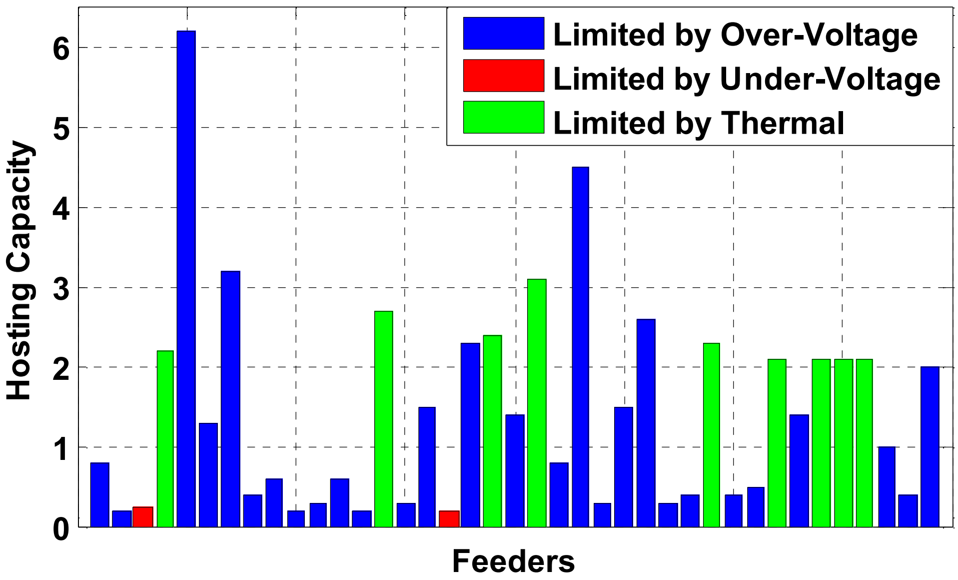
- 15% Screen is compared to a detailed analysis of a large number of potential PV scenarios (combinations of PV size and location) to determine if there is any impact to the operation of the distribution system
- For each PV scenario, a series of simulations are performed in OpenDSS to detect any potential violations caused by the PV interconnection
  - Range of feeder load values that occurred during daytime hours of 10am to 2pm in the year
  - Range of all potential states of the feeder (regulator taps and switching capacitor states)
  - Temporary over-voltages are considered with extreme ramps in PV output faster than the voltage regulation equipment can react



Hosting Capacity Results

- The hosting capacity and feeder impact signature is determined for each feeder
- This includes a percentage of the feeder that can handle that size PV system, and what type of issue was caused (risk)



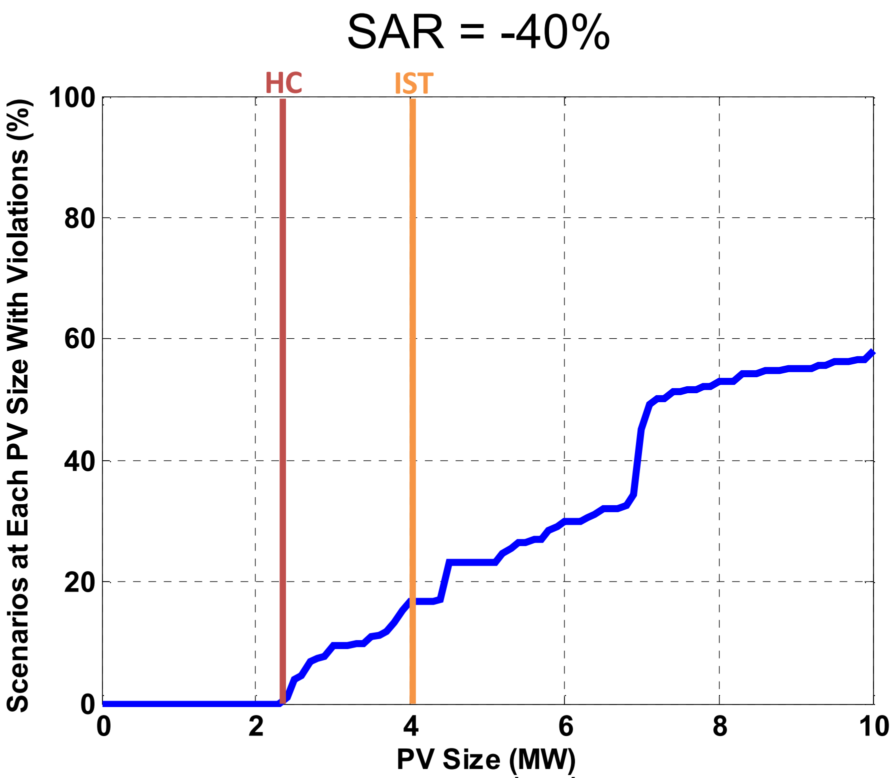


Metric Definition – Screen Accuracy Ratio (SAR)

- Calculates how close the 15% Interconnection Screen Threshold (IST) is relative to the minimum hosting capacity (HC) for each feeder

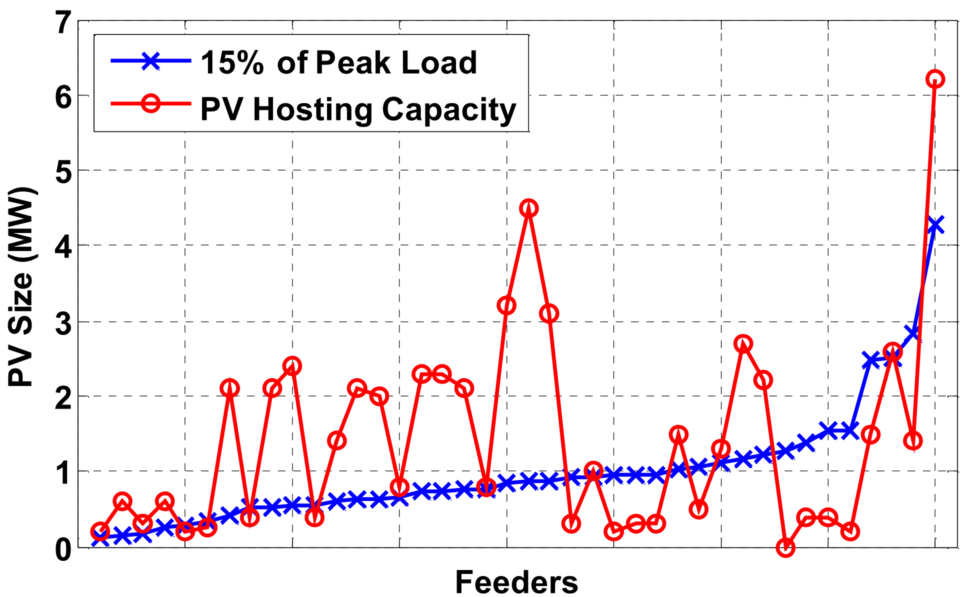
$$SAR = \frac{HC - IST}{IST} * 100$$

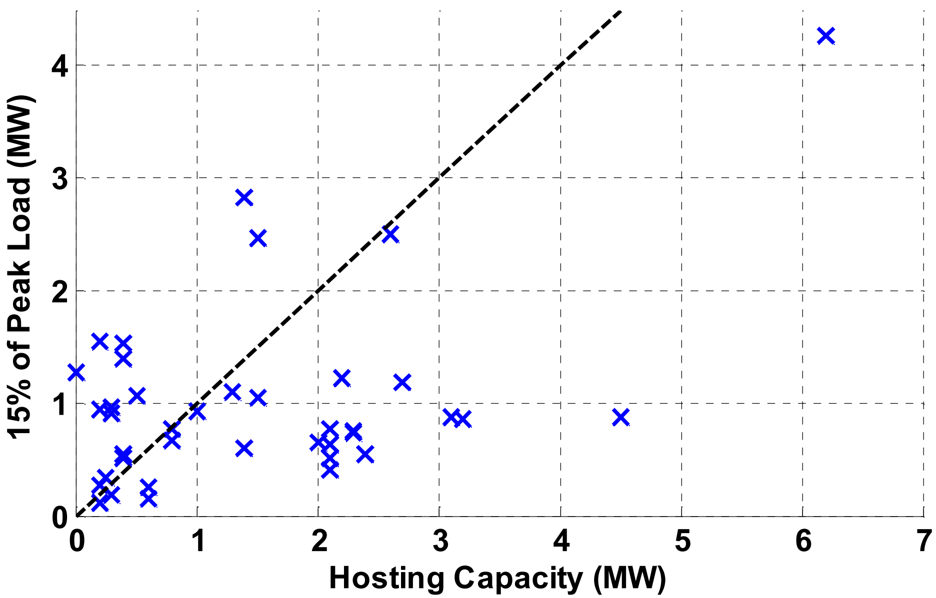
- Could be positive or negative
- Similar to a percent error calculation
- Should be positive to be conservative and ensure that any PV sizes and locations that could potentially cause issues are studied in more detail



Results – Screen Accuracy Ratio (SAR)

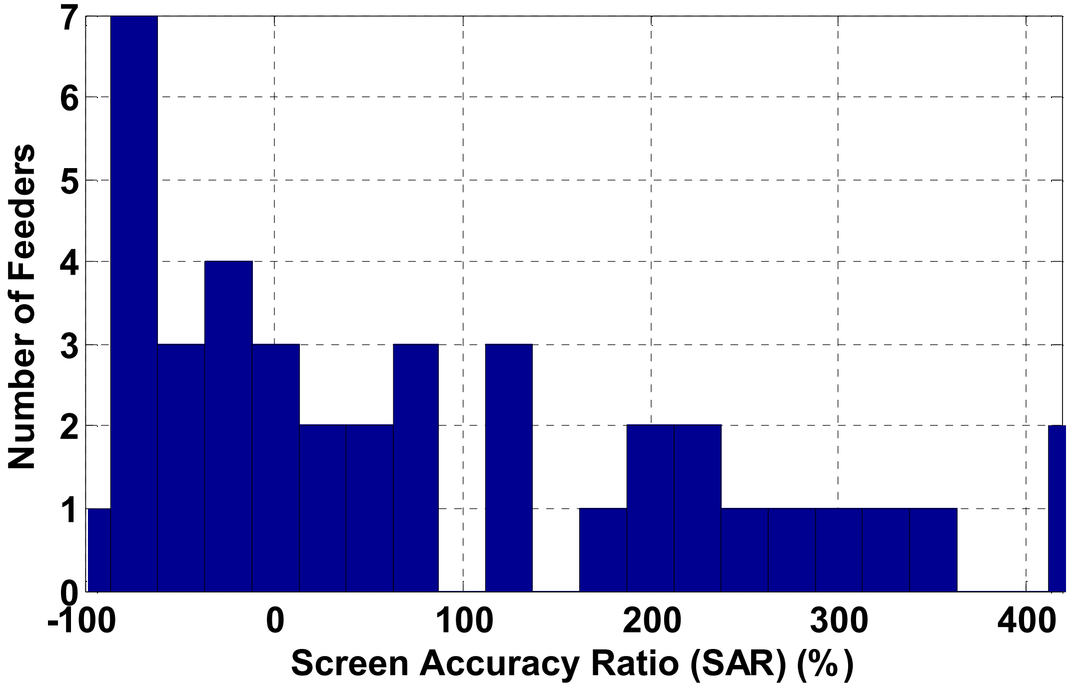
- For the 40 feeders, the hosting capacity is not correlated with the peak load
- The feeders where the PV hosting capacity (red) is below the 15% IST (blue) are particularly concerning (negative SAR value) because the screen allows PV interconnections that would potentially cause problems
- Feeders far to the right of the dashed black line would result in high SAR values, which means unnecessarily increased study time for the utility





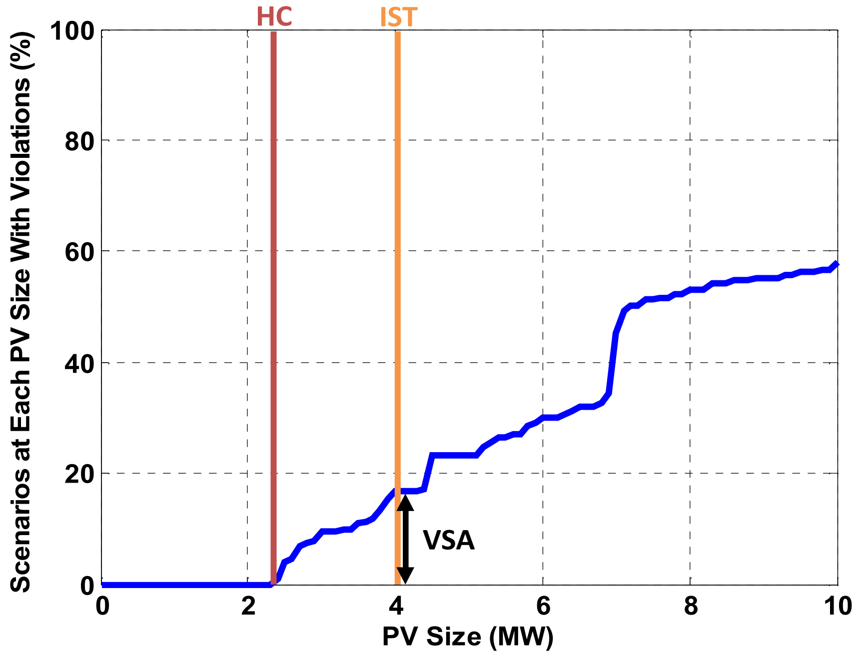
Results –
Screen Accuracy Ratio (SAR)

- The SAR error value is calculated for each feeder
- A max of SAR=418%, where the HC for that feeder is more than 4 times larger than 15% of peak load screen
- A min of SAR=-95%, where the IST is much higher than the feeder's HC
- On average, SAR=83%



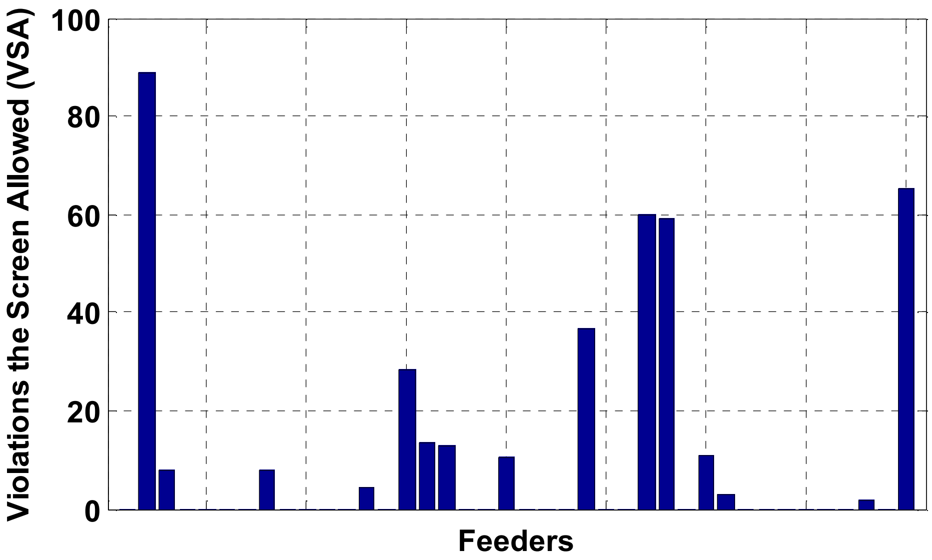
Metric Definition – Violations the Screen Allowed (VSA)

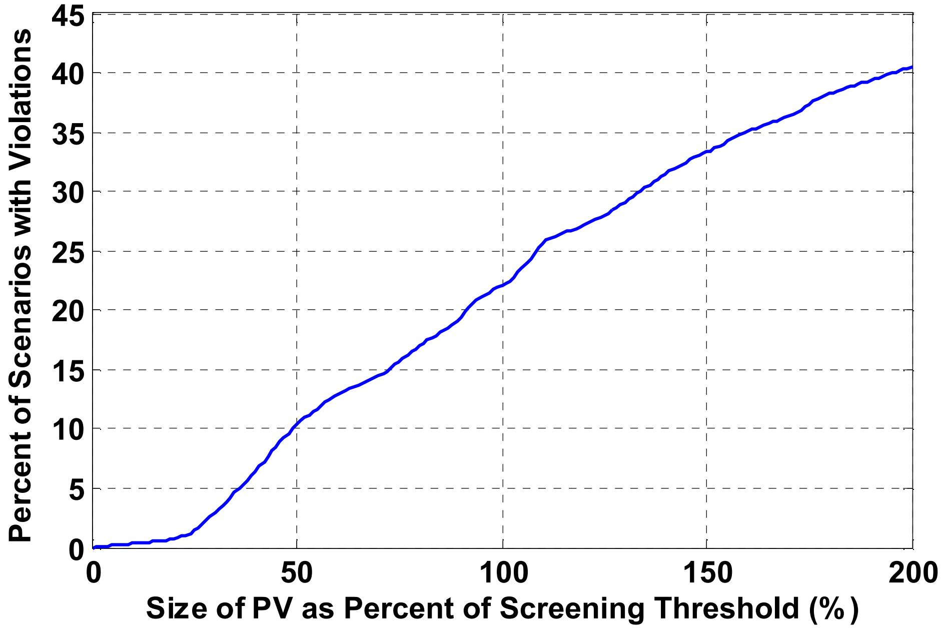
- When SAR is negative, the screening criteria will pass potential PV interconnections that will cause violations on the feeder
- This is a serious issue because these PV systems will not be studied in detail, and could have potential impact to power quality and reliability
- This error metric is simply the number of violations the screen allowed (VSA) in percent of the feeder for a PV system that is 15% of peak load



Results –
Violations the Screen Allowed (VSA)

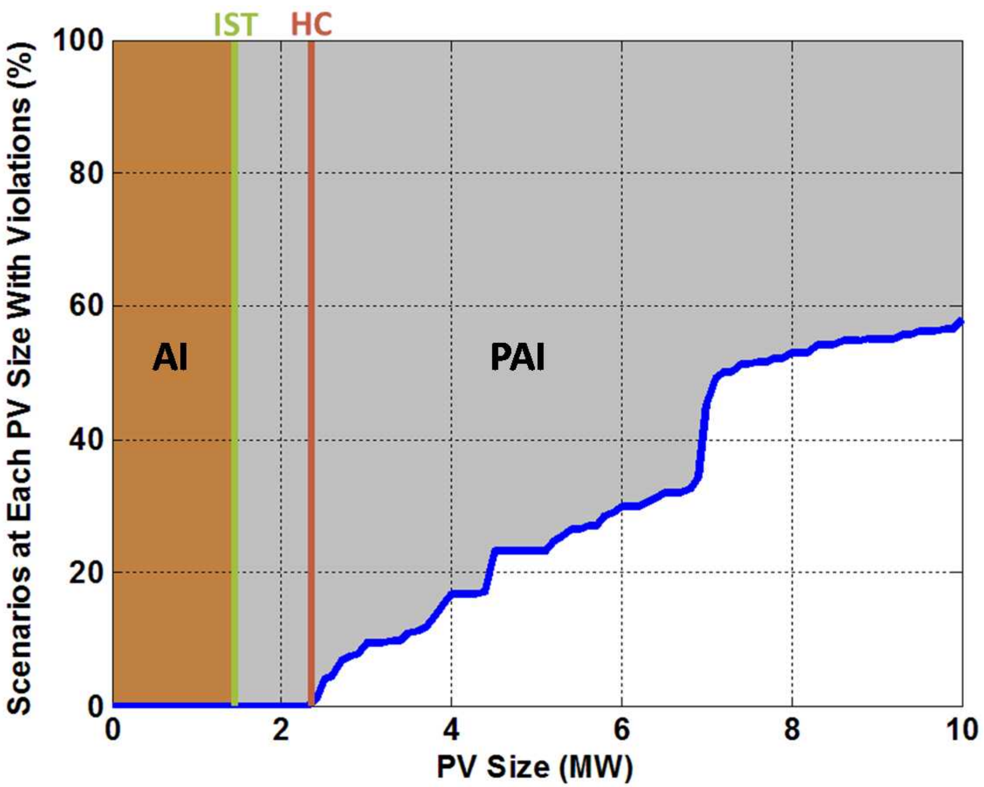
- The VSA error metric is shown below for each of the 40 feeders individually
- VSA is calculated for all feeders together for the percent of all buses that, when connected with the maximum PV size allowed by the screen, will result in issues on the feeder.
- Placing the maximum PV size allowed by the 15% of peak load screen randomly on one of the 14,207 buses of the 40 feeders will result in issues 22.1% of the time.





Metric Definition – Potential Percent Increase (PPI)

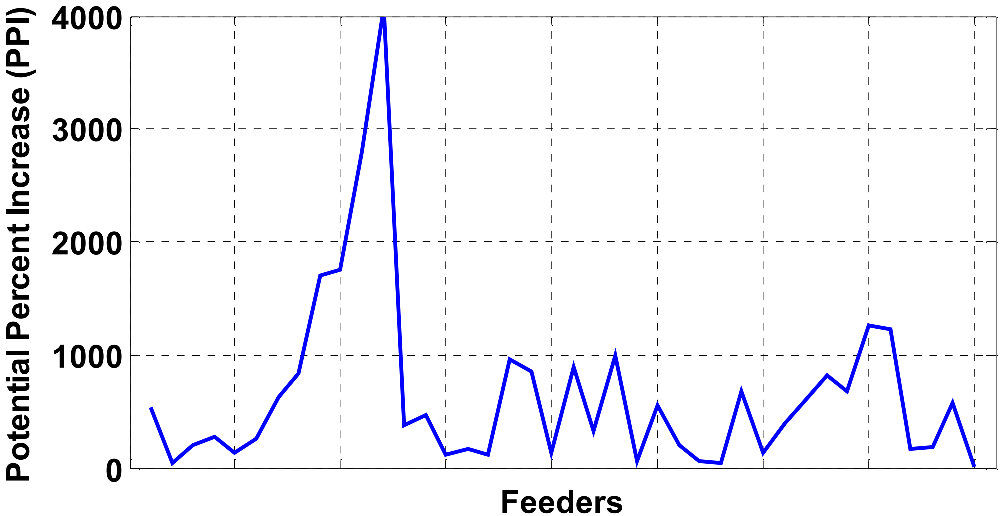
- The final metric includes some locational information for how much more PV certain areas of the feeder can handle
- Beyond the 15% of peak load allowed interconnections (AI), there are many potentially allowable interconnections (PAI) that would not cause any issues and should have been passed
- These false positives in the screening process provide the motivation for more accurate screening methods



$$PPI = \frac{PAI}{AI} * 100$$

Results – Potential Percent Increase (PPI)

- PPI only represents potential improvement and not error in the screening
- Calculating the PPI per feeder can result in some extremely high values for feeders with a small number of allowed interconnections (AI)
- Similar to the VSA metric, the average PPI is calculated for all feeders by summing the allowed interconnections (AI) and divided by the summation of potentially allowable interconnections (PAI) of all feeders
- The potential percent increase (PPI) results in 295% more potential PV interconnections that do not cause violations than are currently passed



Conclusions

- Novel analysis of the accuracy of the 15% of peak load PV interconnection screen compared to wide range of PV scenarios on 40 different real distribution feeders
- Three new error metrics were developed to quantify the accuracy of the screening method for identifying interconnections that would cause problems or incorrectly send a large number of allowable systems for more detailed study
- With a screen accuracy ratio SAR=83%, the minimum PV size that will cause any issues is twice as high as the 15% screen on average
- The violations the screen allowed VSA=22.1% demonstrates that the screen is passing a considerable percentage of interconnections that could cause problems
- The potential percent increase PPI=295% shows the potential for improvement in more advanced screening methods

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Questions?