Enabling High Penetration of Distributed PV through the Optimization of Sub-Transmission Voltage Regulation

SunShot National Laboratory Multiyear Partnership (SuNLaMP) Workshop

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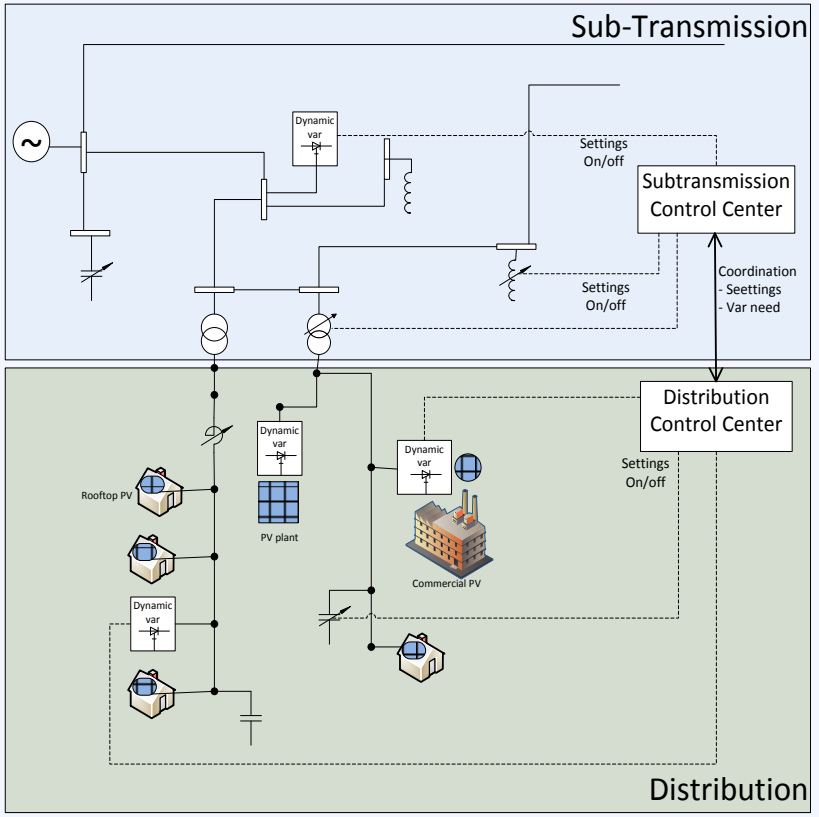
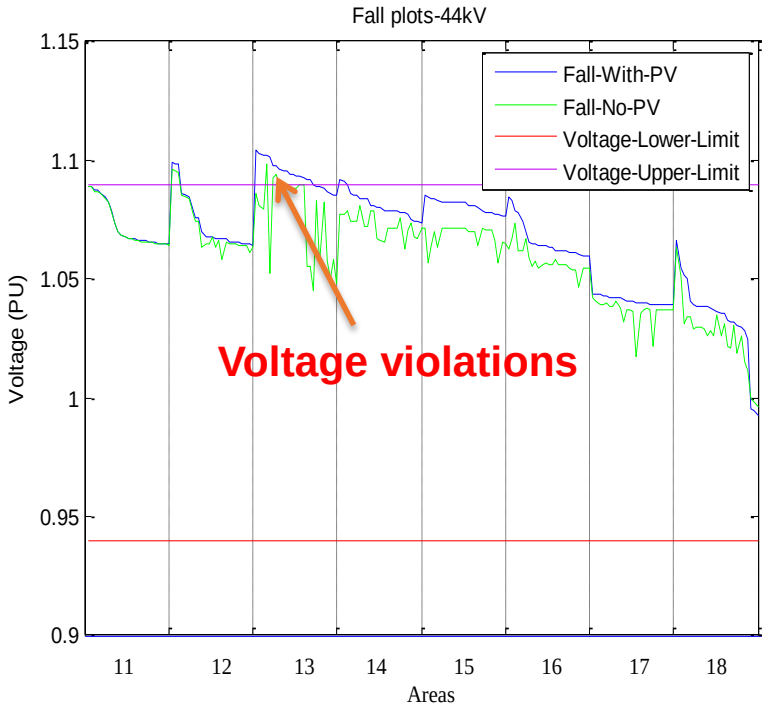
Presenter: Dr. Nader Samaan (PNNL)

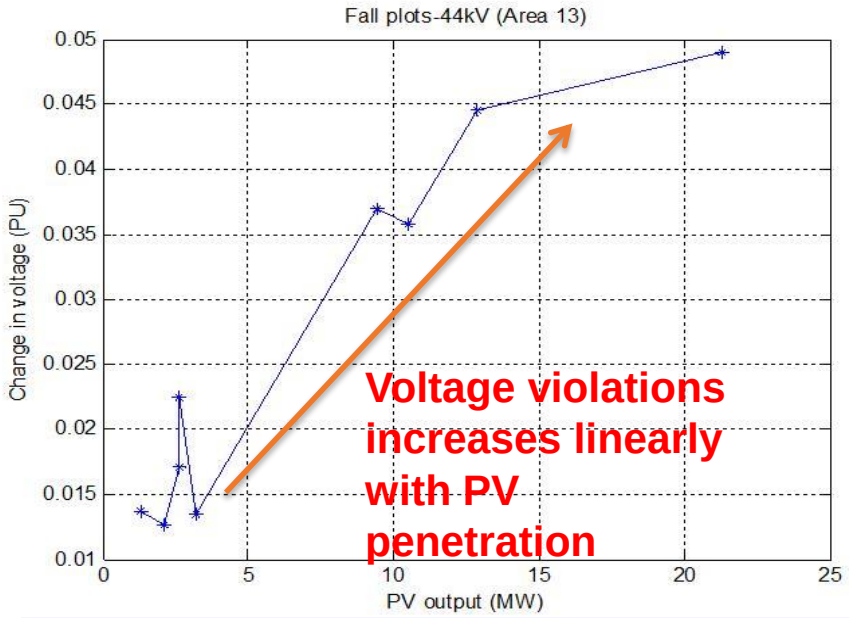
Project Team: Prof Alex Huang (NCSU),
Prof. Ning Lu (NCSU),
Dr. Yazhou Jiang (GE),
Dr. Greg Smedley (OCC),
Mr. Brant Werts (Duke Energy)



(CReST-VCT)

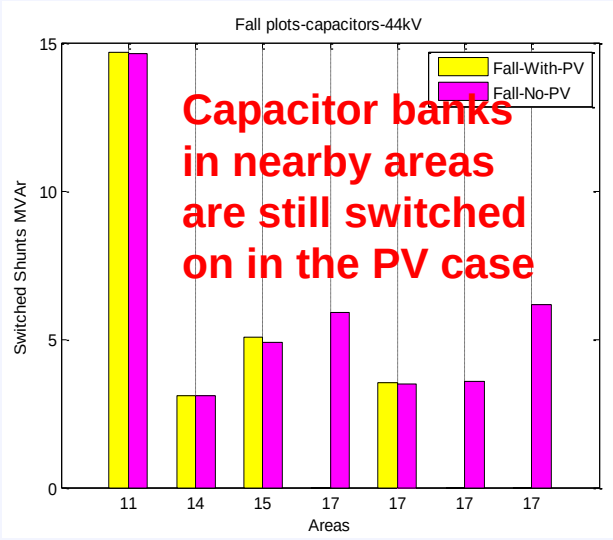
PNNL Study Showed Volt/Var Regulation Challenge at Sub-Transmission





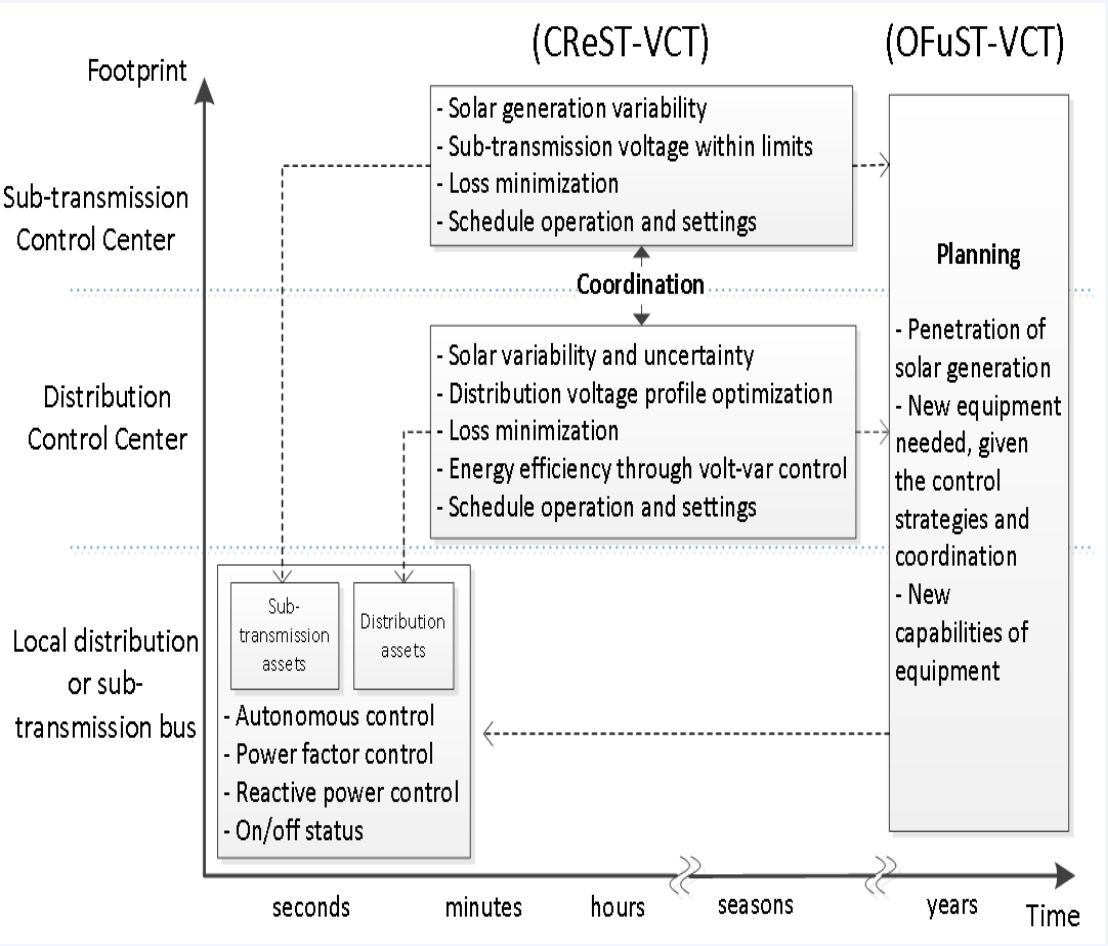
System voltage magnitudes increase almost proportionally when the PV outputs increase

- Under modest penetration of distributed PVs, controlling overvoltage becomes a challenge at the sub-transmission level
- Voltage regulation challenges at sub-transmission are a barrier for high penetration of photovoltaics (PVs). New PV projects target interconnection to sub-transmission to reduce interconnection cost.



No coordination of capacitors bank switching

Project Objectives



Coordinated Real-time Sub-Transmission Volt-Var Control Tool (CReST-VCT)

Optimal Future Sub-Transmission Volt-Var Planning Tool (OFuST-VPT) for short- and long-term planning.

Key Milestones & Deliverables

Year 1:	Stand-alone prototype of CReST-VCT
Year 2:	Simulation demonstration of CReST-VCT and prototype of OFuST-VPT
Year 3:	Field demonstration of CReST-VCT, industry outreach, final report and the codes for the two tools

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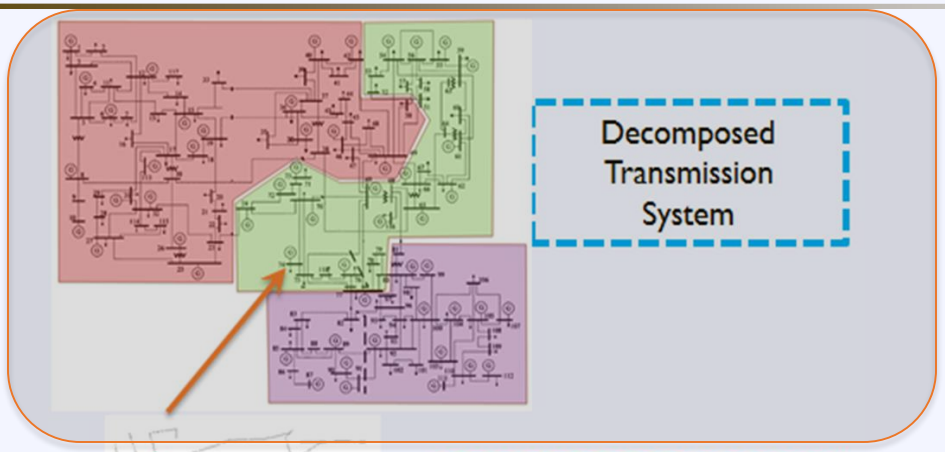
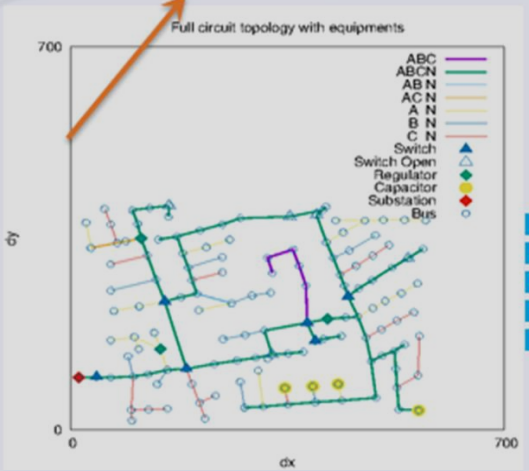
Scalability of the solution: Co-optimization of transmission and distribution Voltage

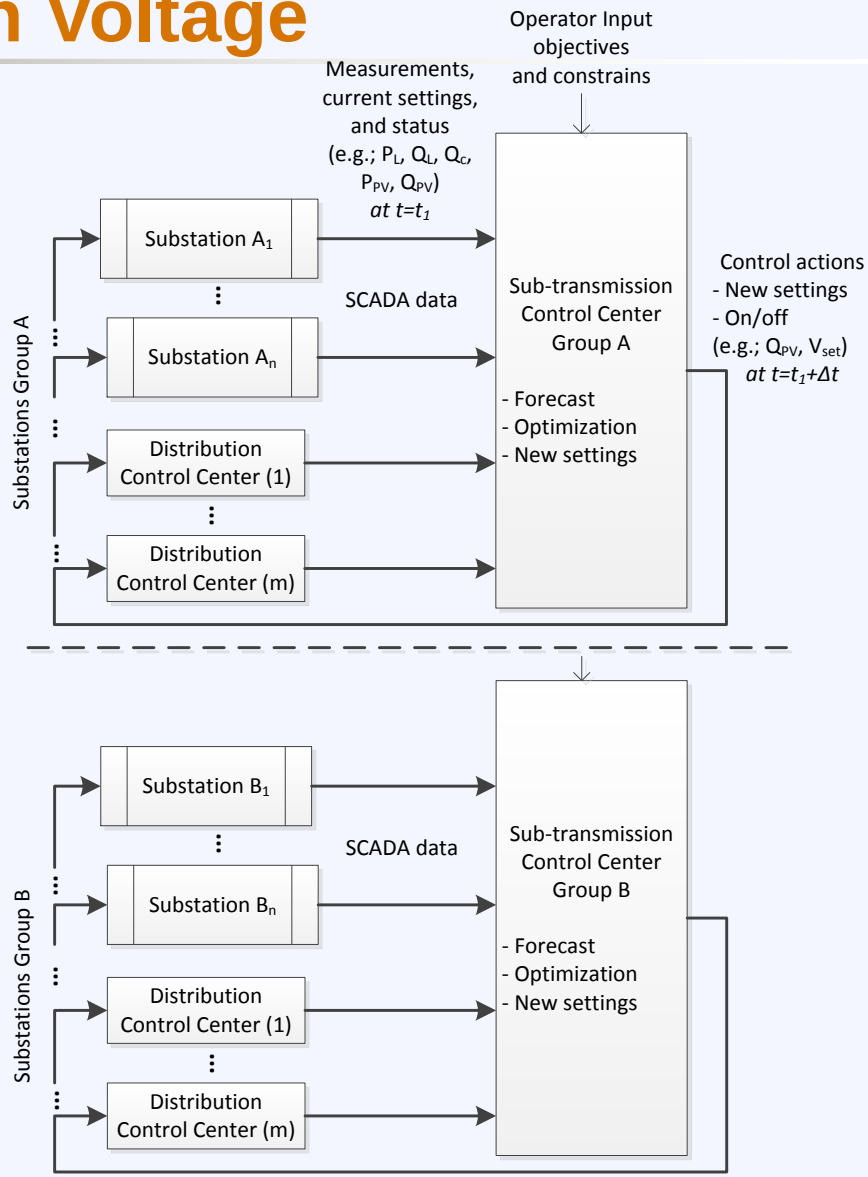


Decomposed Transmission System

Reduced Distribution Model

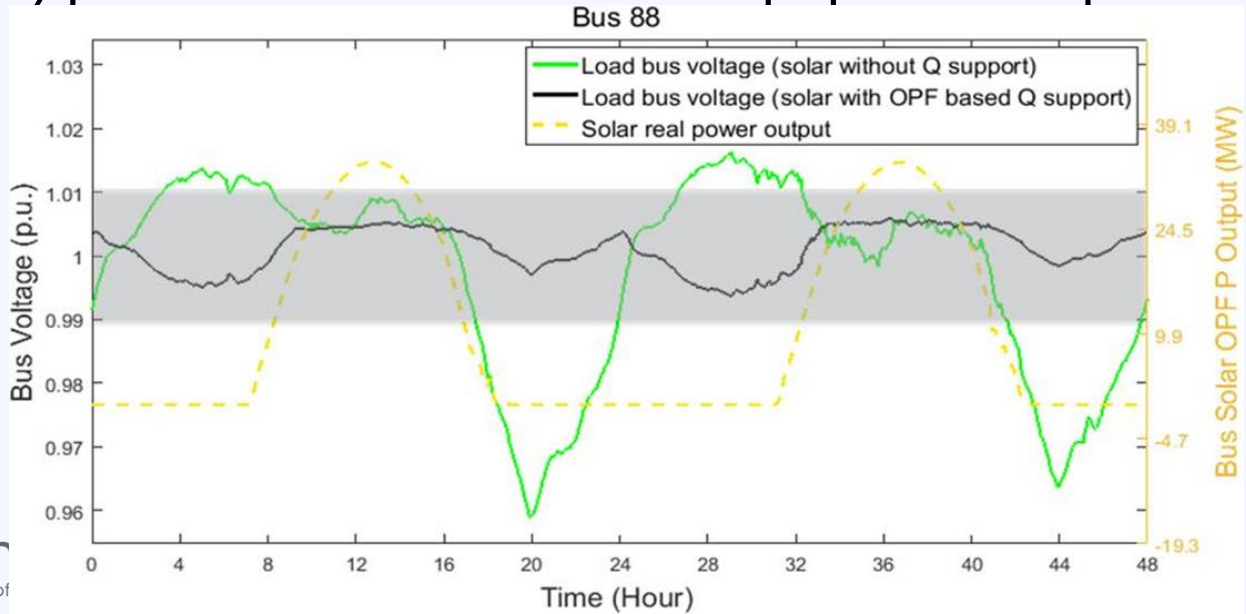


Full Distribution System

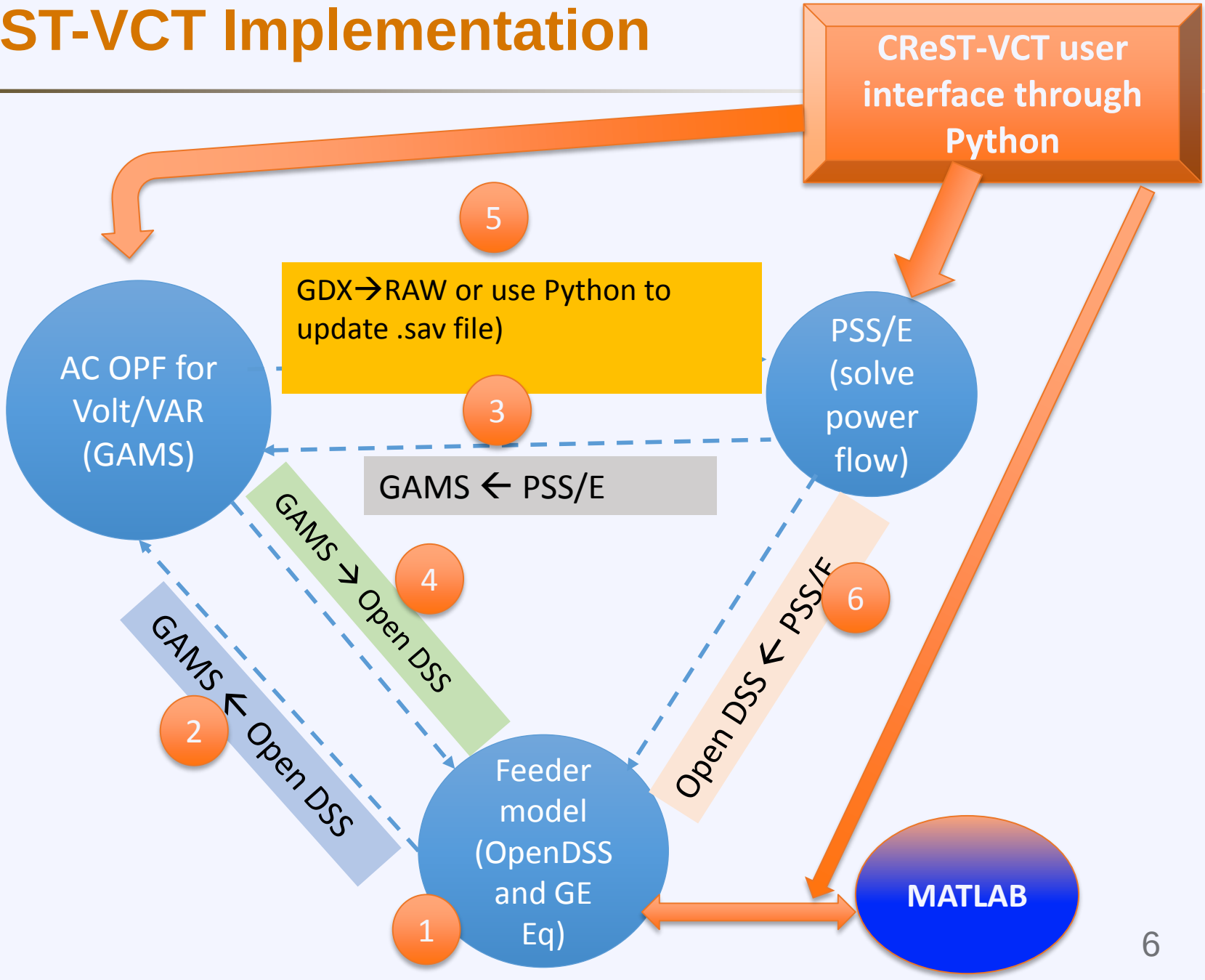


Project Achievements

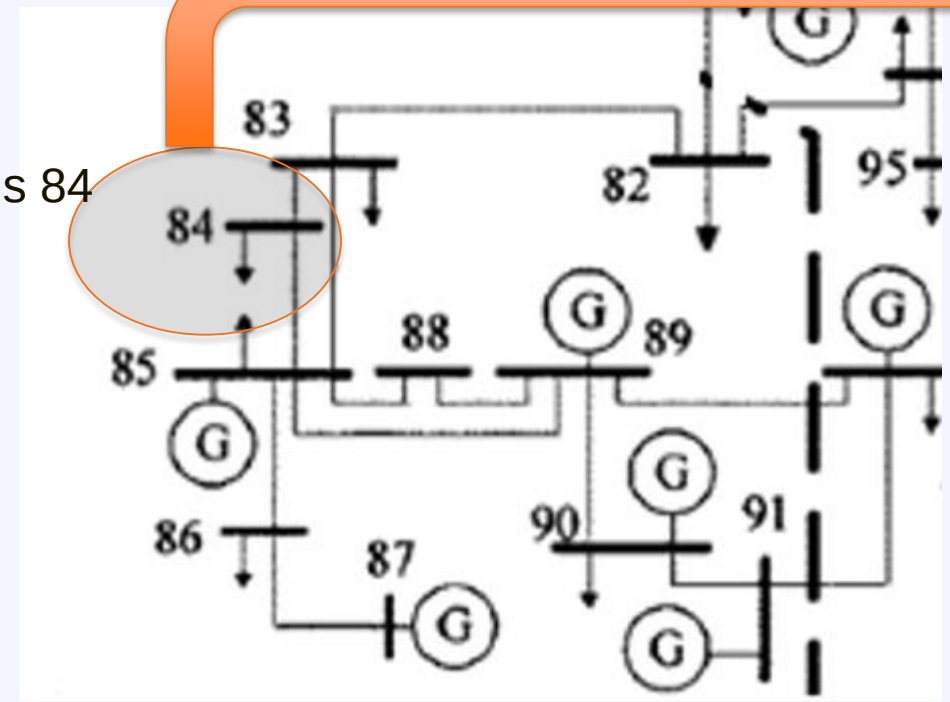
- Demonstrated CReST-VCT on IEEE 118-bus/ IEEE 123 node test systems
- Completed advanced synchronous generator capable PV inverter control models and integrated into CReST-VCT
- Developed and tested via simulation load-side control options for full IEEE 123-node system and two Duke Energy distribution feeders in OpenDSS
- Wrote white paper summarizing characteristics of reactive power compensation devices to be modeled in CReST-VCT
- Finalized prototype of distribution system model reduction tool
- Seven (7) peer-reviewed conference papers accepted

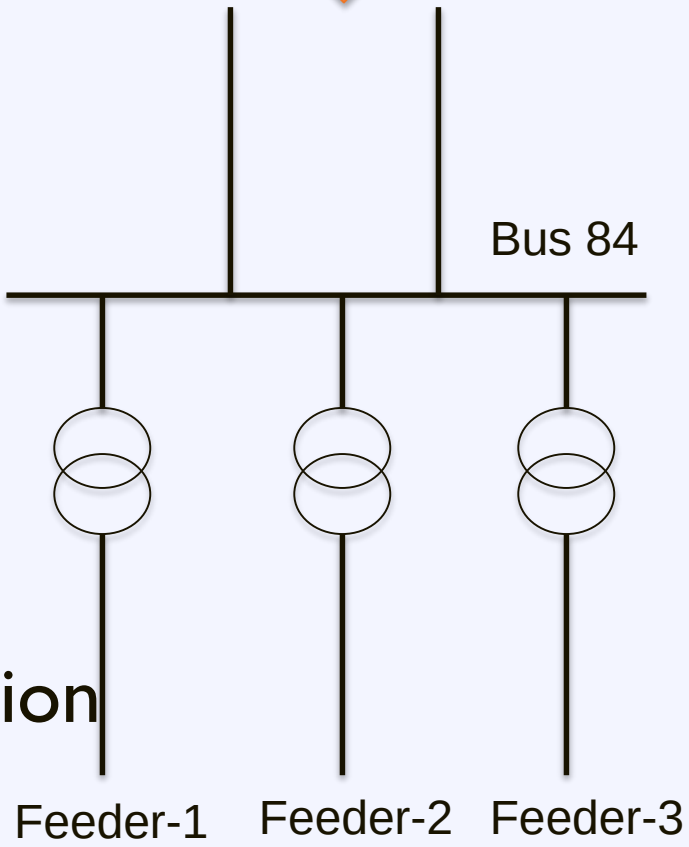


CReST-VCT Implementation



Simulation Scenario – 3 IEEE 123 feeders connected to Bus 84 of the IEEE 118 bus system





- 30% PV penetration on Transmission
- 100% PV penetration on Distribution

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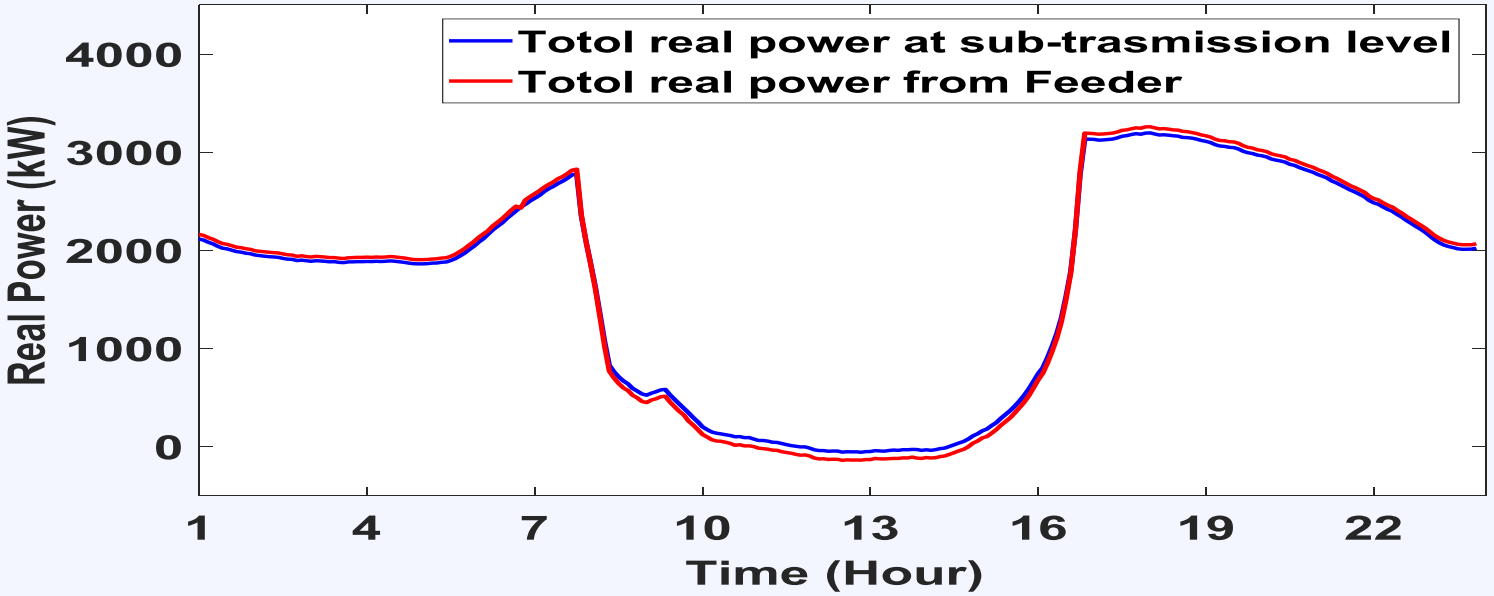
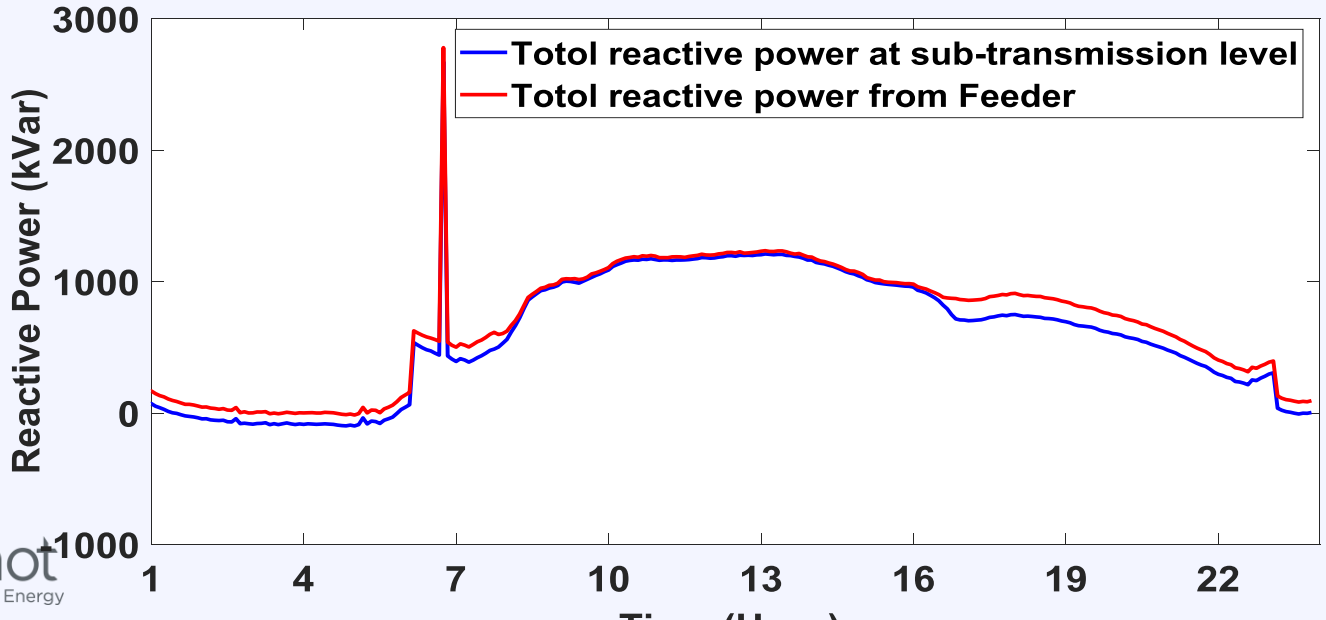
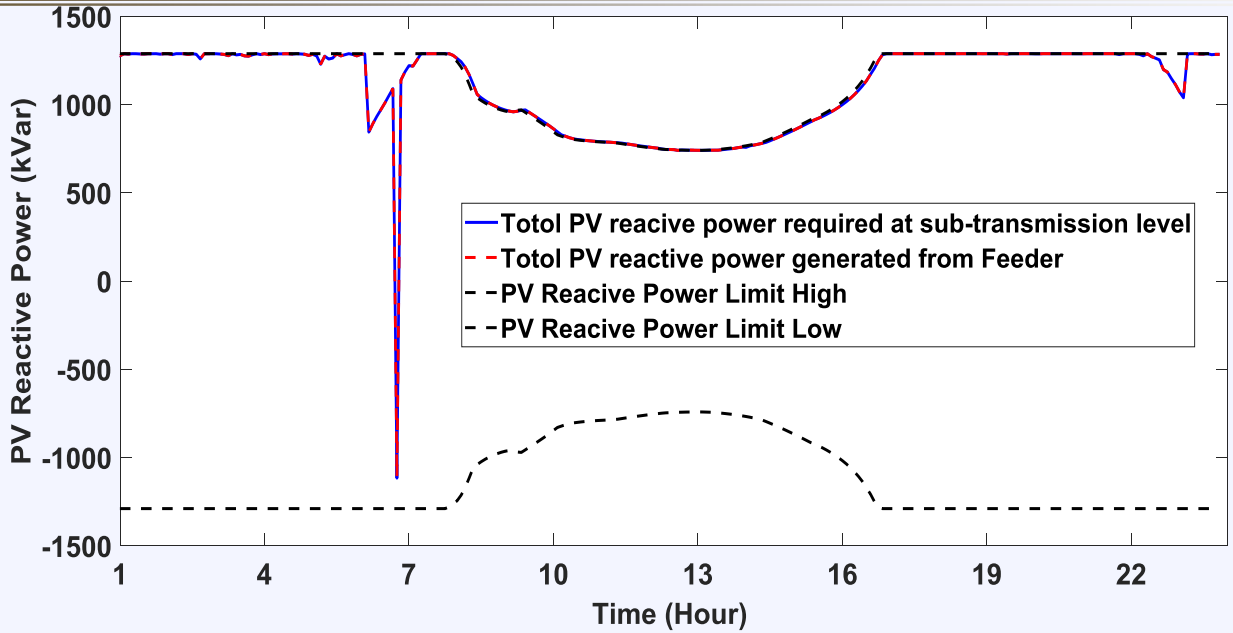
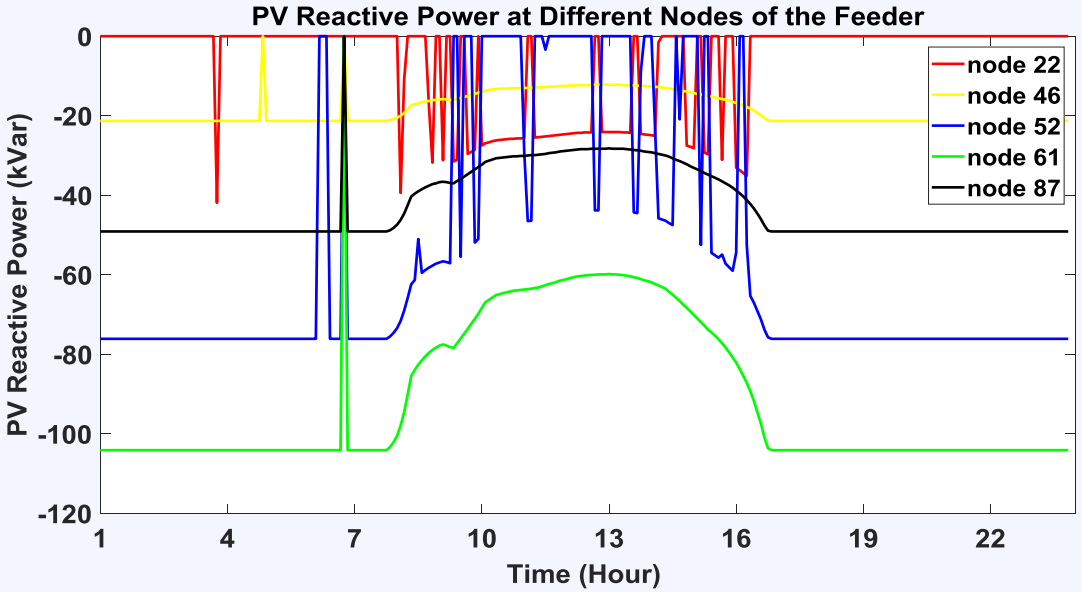
Real and Reactive Power (transmission vs. distribution)





PV Reactive Power (aggregated at substation vs. output of distributed units)





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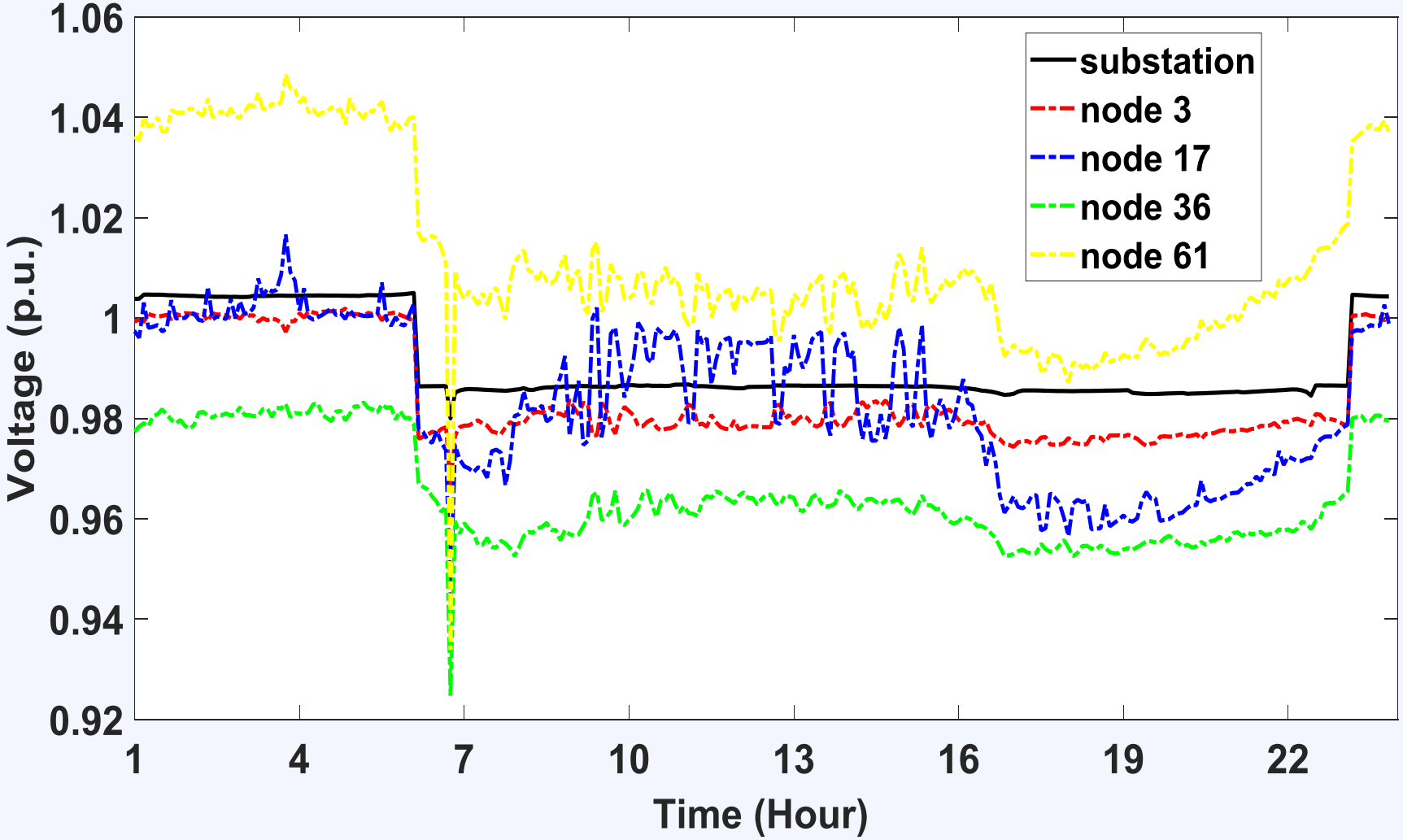
Voltage Profiles (substation vs. distribution nodes)



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Performance of CReST-VCT

- The optimization time is about 1 hour of simulation time for one full day (total of 12 interval per hour * 24 hours per day = 288 optimization points per day).
- By analyzing the results, we found less than 1% of infeasible solutions out of 105,120 optimization points in one year.
- There are two risks related to computation and solvers for the optimization model at each 5 minute time step. These two risks are:
  - The time to solve the optimization problem is larger than the optimization step of 5-min (risk level is low)
  - Solver infeasibility of the optimization problem (risk level is medium)
- There are a number of mitigation options that are applicable to one or both of these two

Questions?

- Thanks!
- Contact Information:
- Nader Samaan, Ph.D., P.E.
- Sr. Power Systems Research Engineer
- Electricity Infrastructure Group
- Pacific Northwest National Laboratory
- P.O. Box 999, MSIN J4-90
- Richland, WA 99352
- Phone: (509) 375-2954 (O)
-
- Email: nader.samaan@pnnl.gov

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