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Conservation Voltage Reduction with Distributed Energy Resource Management System, Grid-Edge, and Legacy Devices

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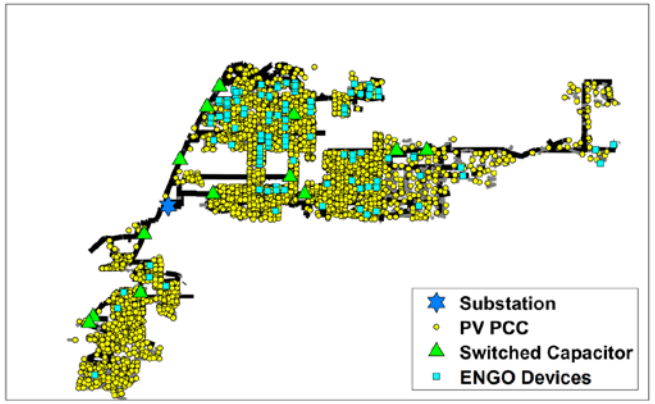
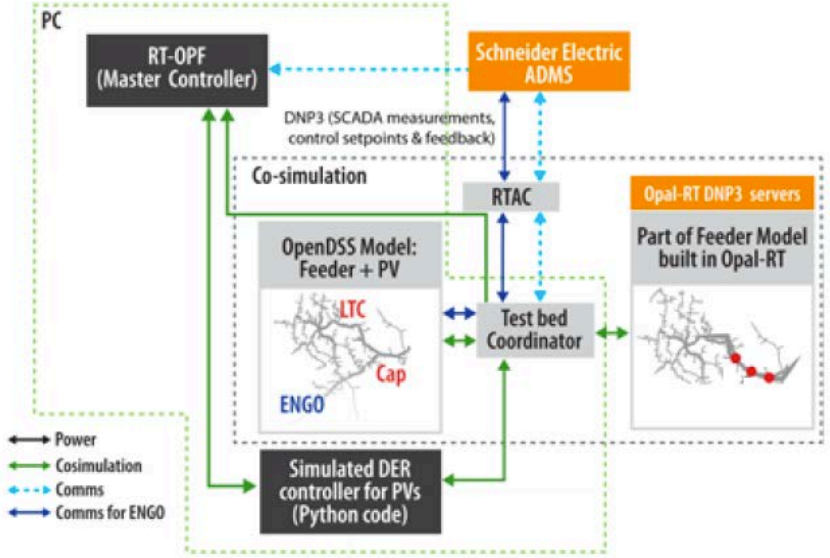
Background

- Conservation voltage reduction (CVR) performed traditionally by legacy devices (load tap changer, voltage regulators, capacitors)
- Distributed energy resources can provide fast regulation and support CVR
- Studied coordinated operation of advanced distribution management systems (ADMS) and DER management systems (DERMS) for CVR and voltage regulation
- ADMS controlled legacy devices and grid-edge devices, prototype DERMS controlled distributed PV smart inverters
- Observed energy savings of up to 4.7% in the real distribution system while maintaining voltage regulation

Experimental Setup, Scenarios



Xcel Energy's distribution System



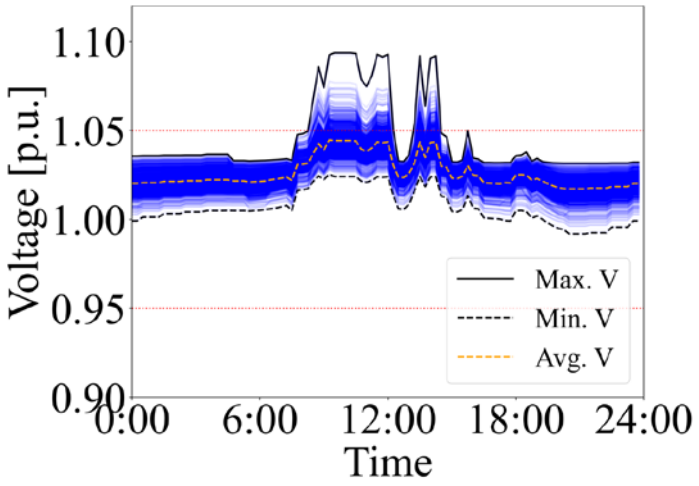
ADMS Test Bed Setup

Simulation Scenarios

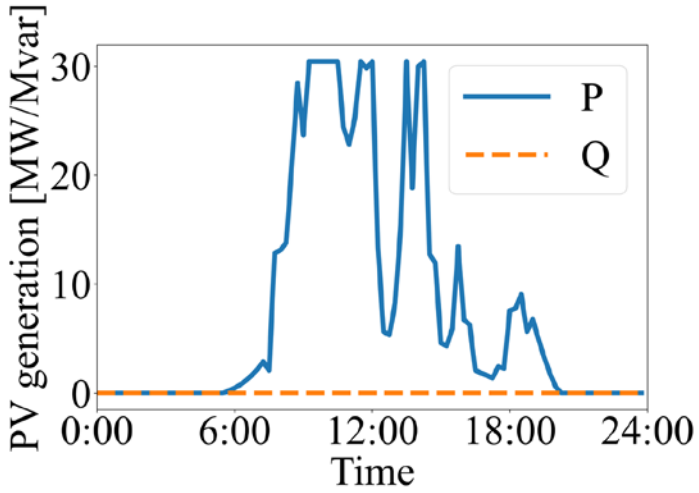
Scenario	Legacy Devices	ENGO units	PV Smart Inverters
Baseline	Local control	-	Unity power factor
S1	ADMS	ADMS	Local Volt-VAR-Watt control mode
S2	ADMS	ADMS	RT-OPF

- 4 feeders with peak load of ~35 MW
- Min. load ~12 MW; Added PV ~200% of min. load
- Schneider Electric's ADMS, real-time optimal power flow (RT-OPF) based prototype DERMS
- Multi-timescale simulation using OpenDSS, OPAL-RT, and HELICS

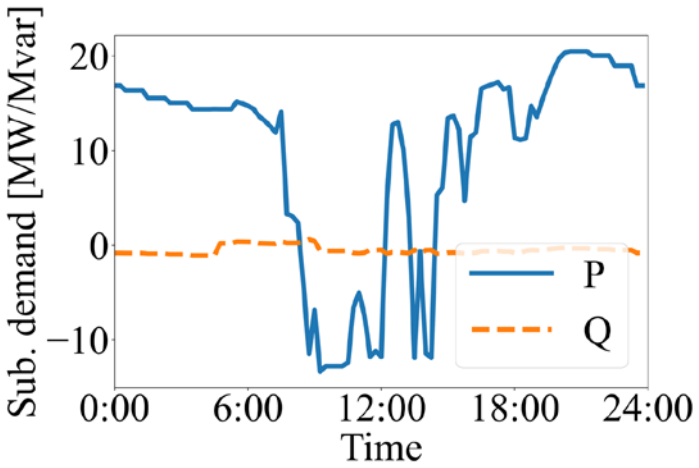
Baseline Results



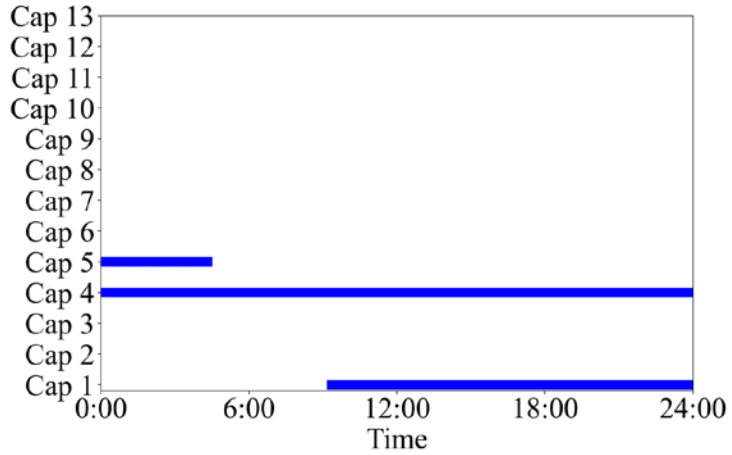
Bus voltages



Total PV generation

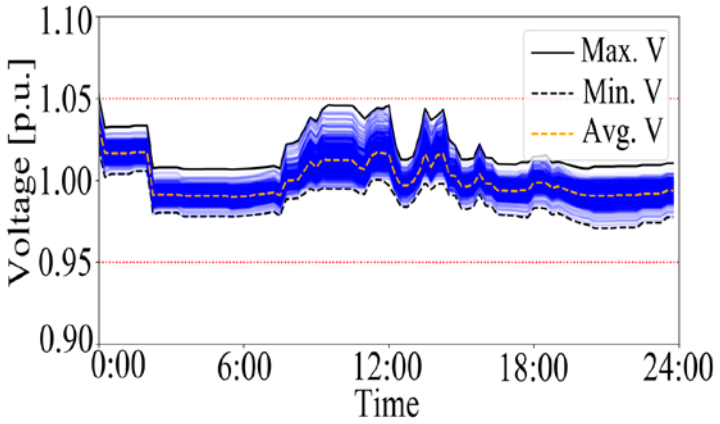


Substation demand

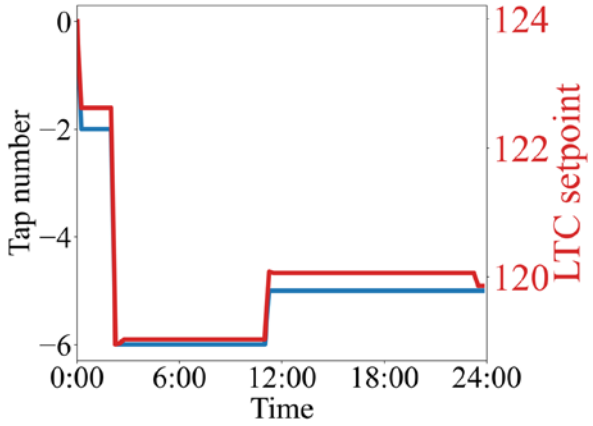


Capacitor bank statuses

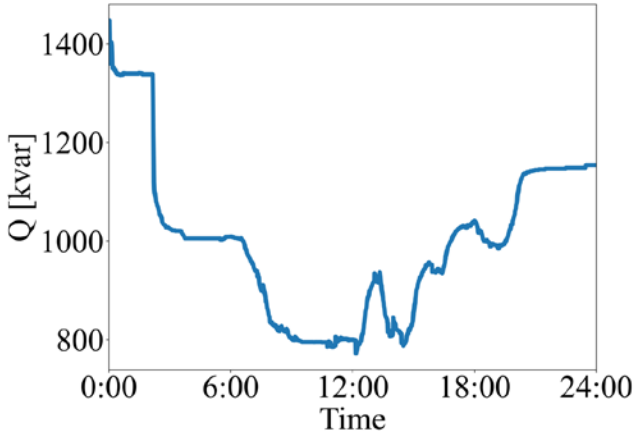
S1 Scenario Results



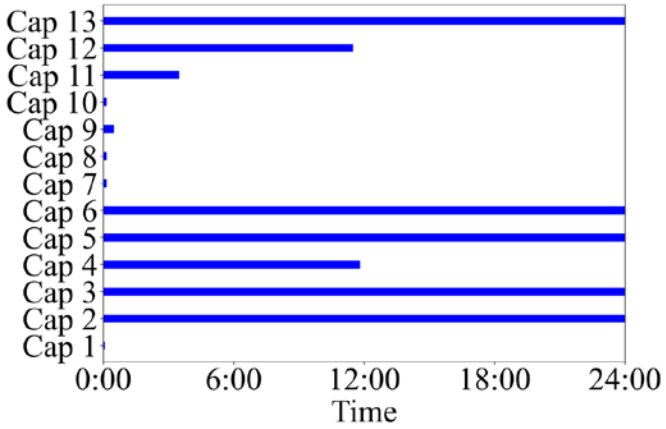
Bus voltages



LTC set point and tap changes

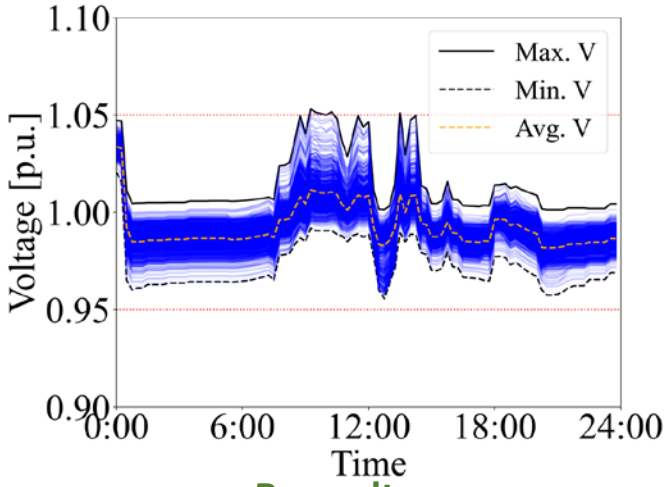


Total ENGO Q output

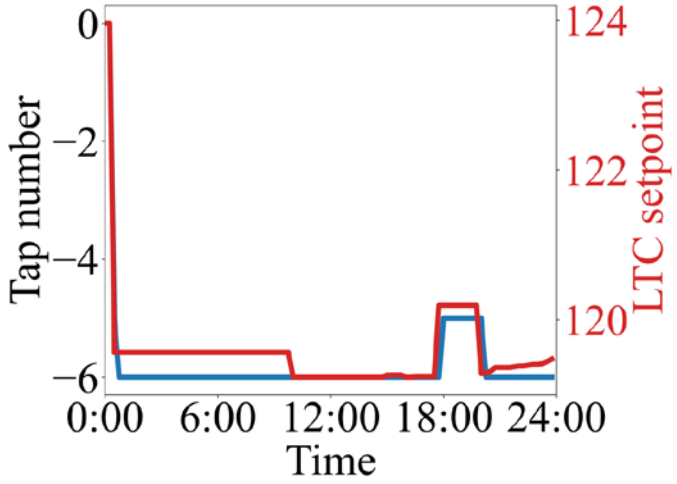


Capacitor bank statuses

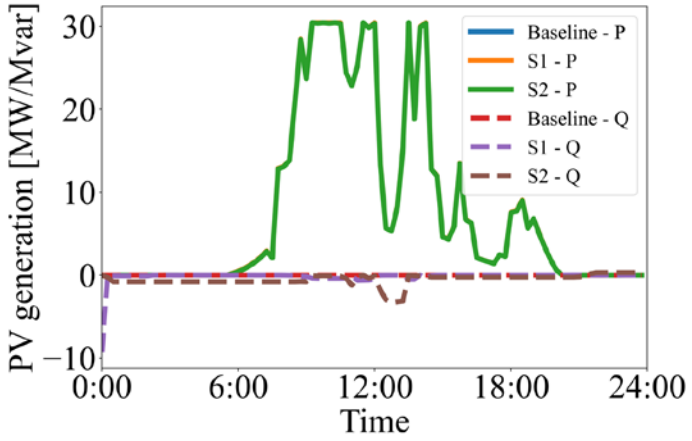
S2 Scenario Results & Metrics



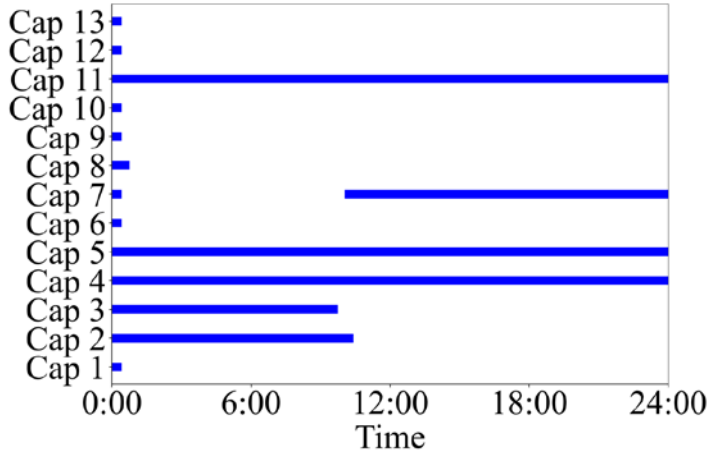
Bus voltages



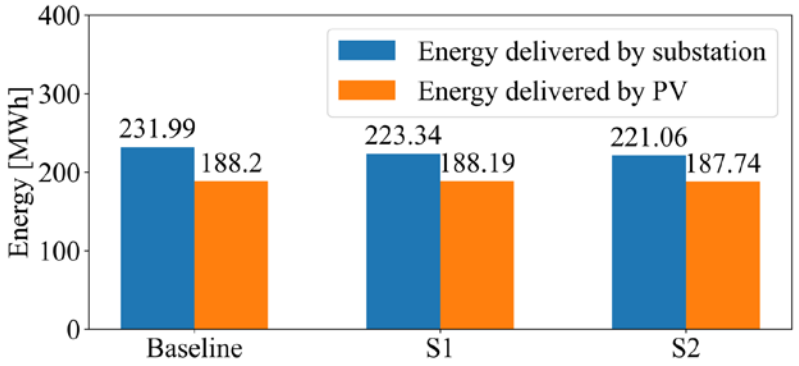
LTC set point and tap changes

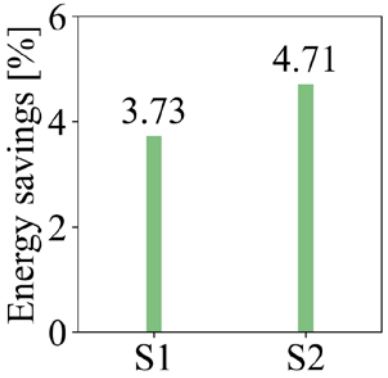


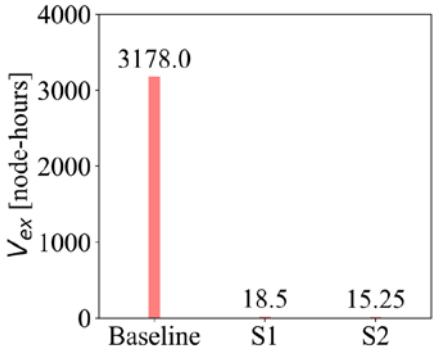
Total PV generation comparison



Capacitor bank statuses







Metrics: Energy delivered, energy savings, and voltage exceedances

Conclusions and Recommendations

- Evaluated coordinated operation of an ADMS and DERMS for CVR and voltage regulation
- ADMS lowers bus voltages by reducing feeder head voltages using LTC for CVR
- Uses capacitor banks and ENGO units for obtaining flat voltage profile
- DERMS complements ADMS in ensuring voltage regulation using smart PV inverters
- Energy savings of ~4.7% + significant voltage profile improvement obtained
- PV energy export curtailment is minimal ~0.25%
- Future work will consider cost-benefit analysis

Thank you

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