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Peak Load Management in Distribution Systems Using Legacy Utility Equipment and Distributed Energy Resources

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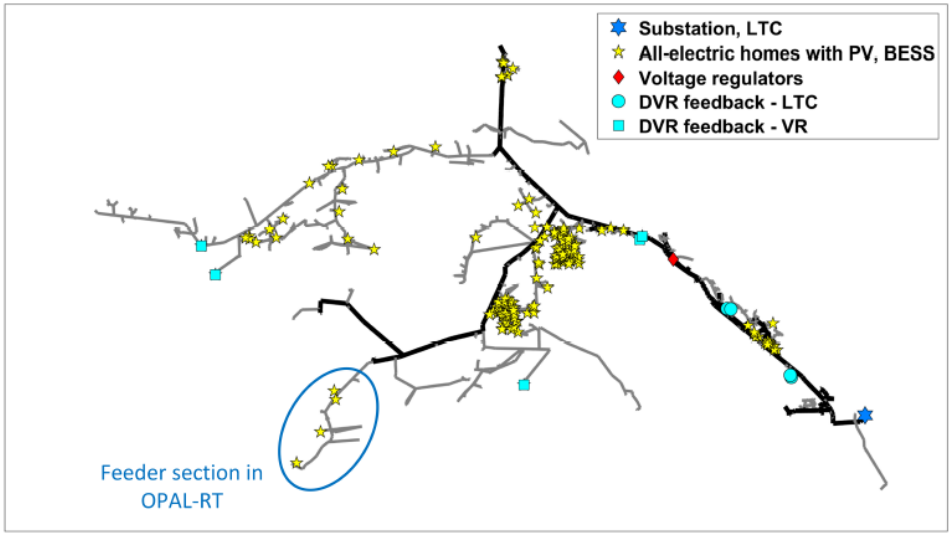
Background

- Peak load management (PLM) in distribution networks offers several benefits, including reduced demand charges and improved reliability, efficiency, and network utilization.
- Distribution utilities are increasingly deploying advanced distribution management system (ADMS) and distributed energy resource management system (DERMS) to optimize grid operations.
- In this paper, the coordinated operation of an ADMS and a DERMS in achieving PLM is demonstrated.

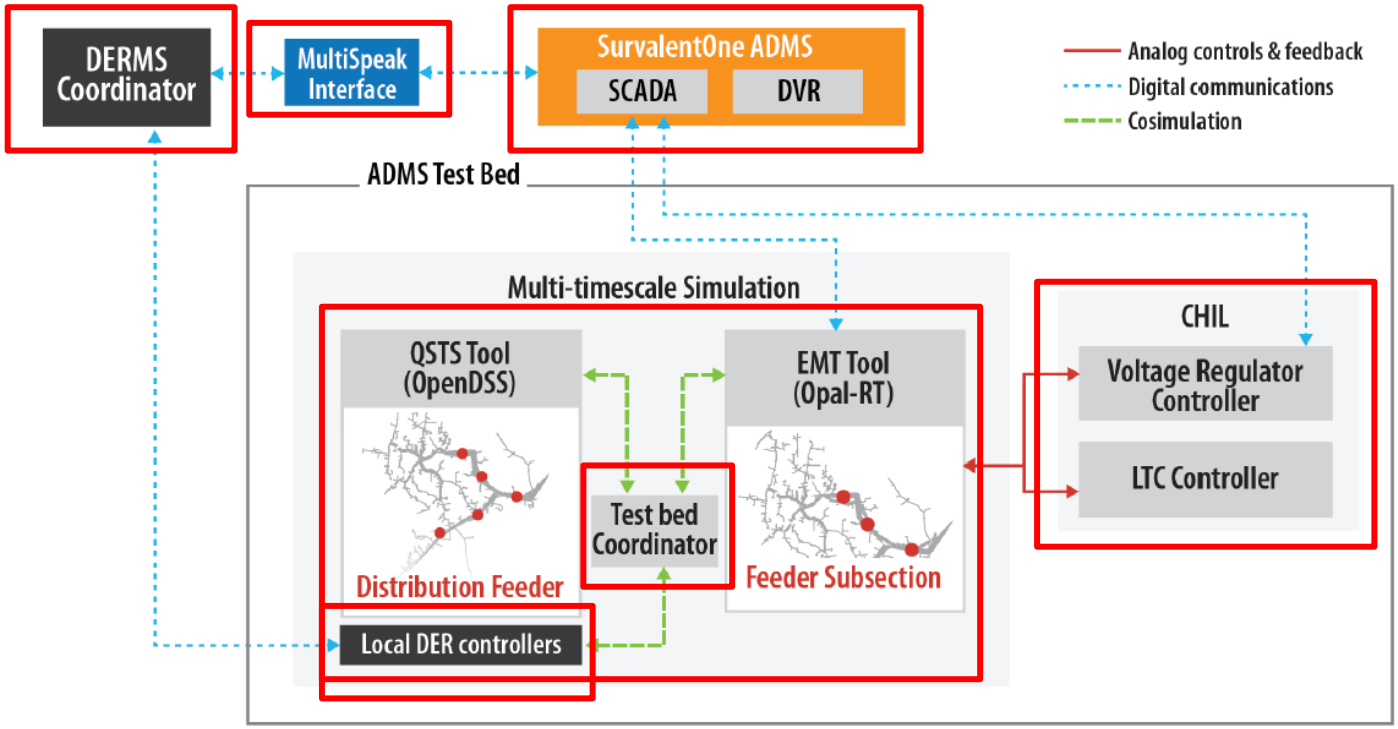
Distribution Feeder Details

- A 14.4-kV feeder with the following features:
  - Peak demand: ~11 MW
  - Load tap changer
  - Three 1-phase line voltage regulators
  - 163 homes have all-electric appliances.
  - Residential rooftop photovoltaic (PV) and battery energy storage are assumed in their premises.
  - Rated PV generation: 1,635 kW
  - Battery storage rating: 990 kW, 2,672 kWh.



Topology of the utility distribution feeder

ADMS Test Bed Setup



ADMS test bed experimental setup

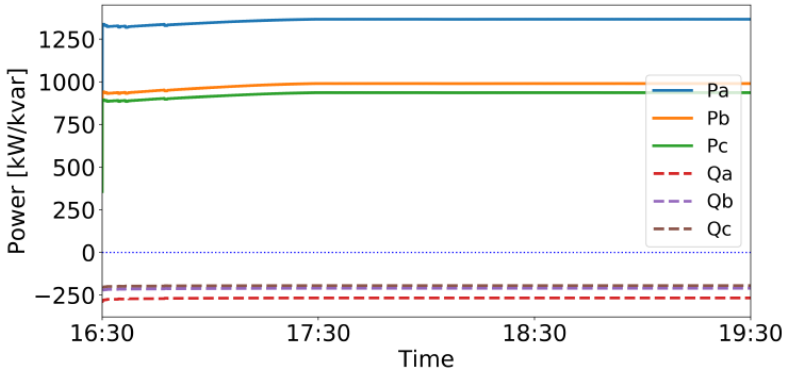
Experiment Scenarios

Scenario	ADMS DVR	DERMS
Baseline	Disabled	Disabled
DVR only	Enabled	Disabled
DERMS only	Disabled	Enabled
DVR + DERMS	Enabled	Enabled

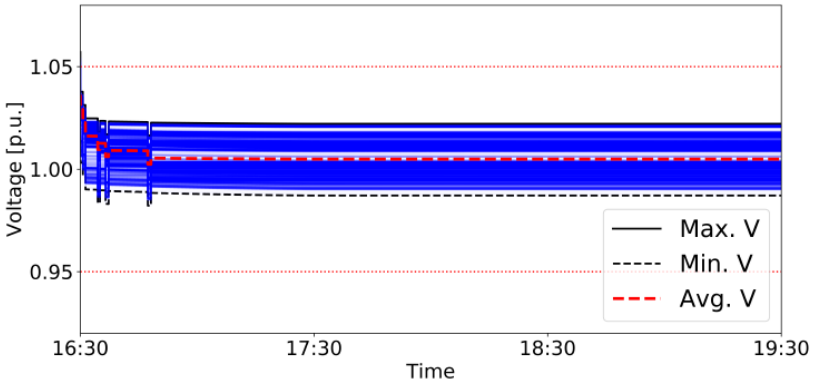
Baseline Results

- Active power consumption at the feeder head in phases A, B, and C is nearly 1,350 kW, 980 kW, and 930 kW, respectively.
- The bus voltages are within ANSI limits.
- Dynamics from the load tap changer (LTC) and voltage regulator tap changes are observed in the bus voltages during the initial simulation period.

Feeder head powers



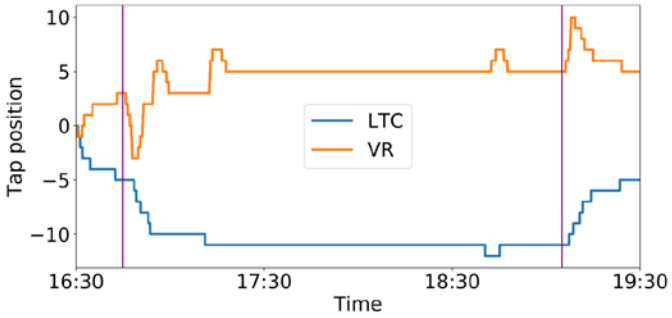
Bus voltages



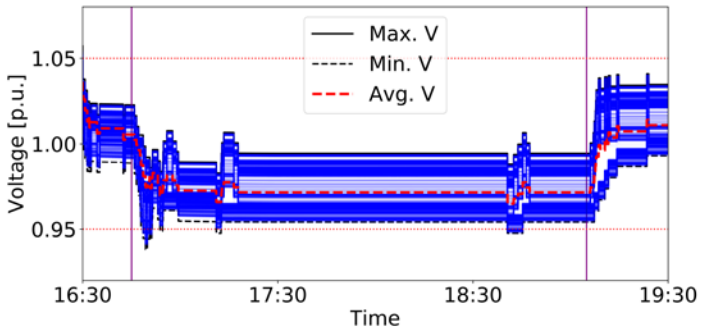
DVR-Only Results

- Nearly 90 kW demand is reduced by DVR via conservation voltage reduction.

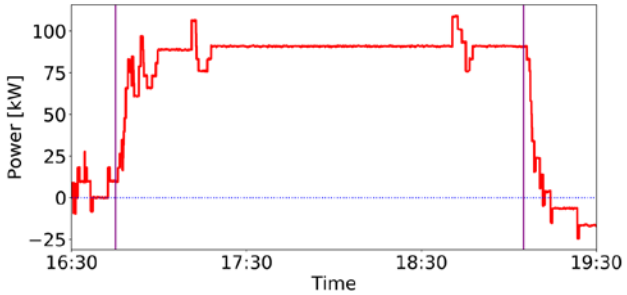
LTC and voltage regulator tap positions



Bus voltages



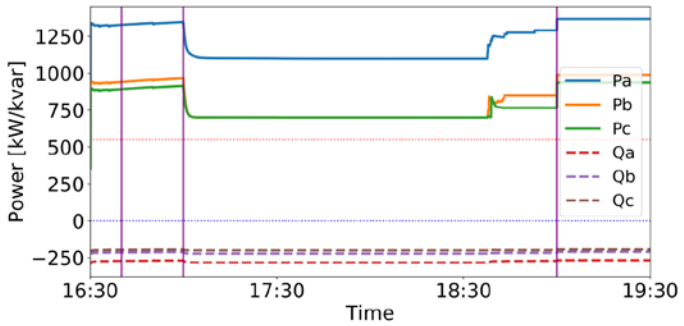
Substation demand deviation



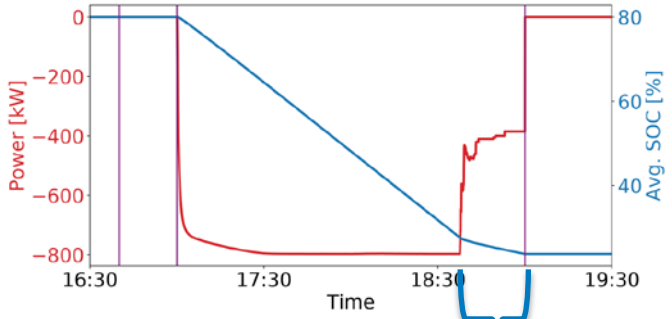
DERMS-Only Results

- The DERMS PLM reduced the feeder head powers to the target values of 1,100 kW, 700 kW, and 700 kW in phases A, B, and C, respectively, from time 17:00.

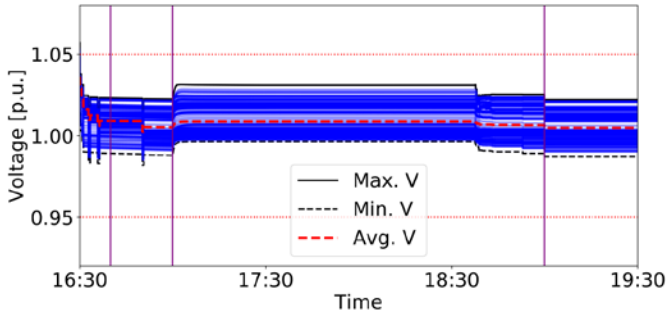
Feeder head powers



Battery energy storage output and SOC



Bus voltages

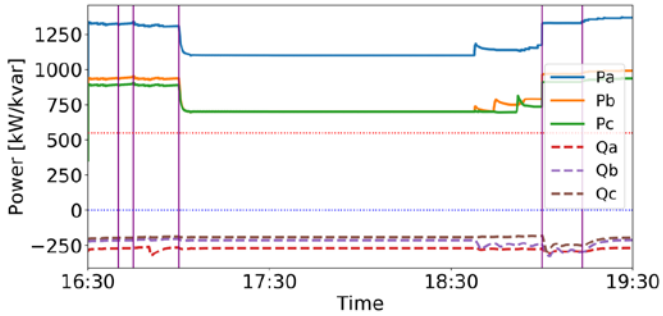


Some batteries reach minimum state of charge (SOC) and the DERMS can no longer regulate to target values.

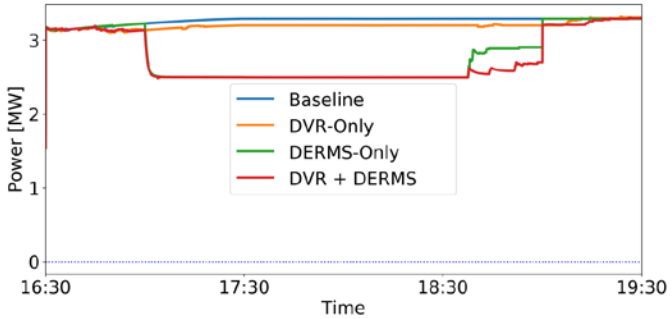
DVR + DERMS Results

- The PLM is observed to be longer than in the DERMS-only scenario because the DVR application reduced the demand to some extent already.

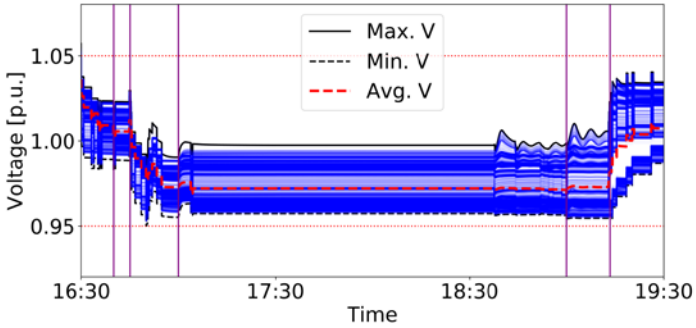
Feeder head powers



Substation demand



Bus voltages



Conclusions

- The coordinated operation of an ADMS controlling legacy equipment and a prototype DERMS in achieving PLM is demonstrated.
- The ADMS DVR application controls the LTC and voltage regulators to reduce the system voltages to reduce the substation demand through conservation voltage reduction.
- The DERMS controls the distributed battery energy storage to inject the required amount of active power to maintain the substation demand at power reference levels set by the ADMS.
- The PLM is achieved while maintaining voltages within ANSI limits.

Thank you

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