SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy

ENERGISE: Eco-Idea

Enhanced Control, Optimization, and Integration of Distributed Energy Applications

National Renewable Energy Laboratory

Challenges for Distribution Planning, Operational and Real-time Planning Analytics Workshop

May 16-17, 2019

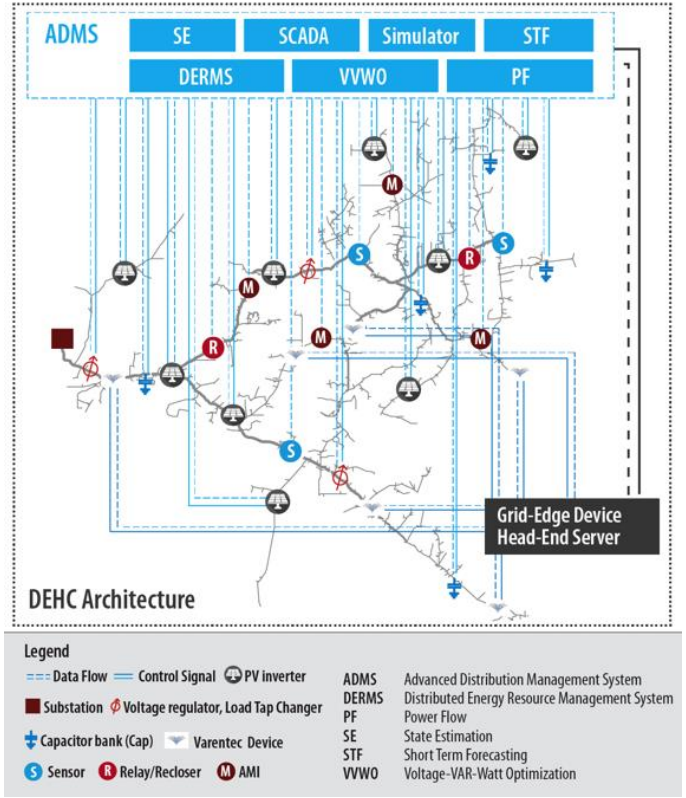
Principal Investigators: Murali Baggu and Santosh Veda, NREL Email: Santosh.Veda@nrel.gov
Partners: Varentec, Telvent/Schneider Electric, EPRI, Xcel Energy

Objective

- The project targets to develop and validate a novel ***Data-Enhanced Hierarchical Control (DEHC)*** architecture for distribution grids with high PV penetration.
- The DEHC architecture represents a hybrid approach of ADMS-based centralized controls, grid-edge controls and distributed controls for PV inverters.

DEHC features:

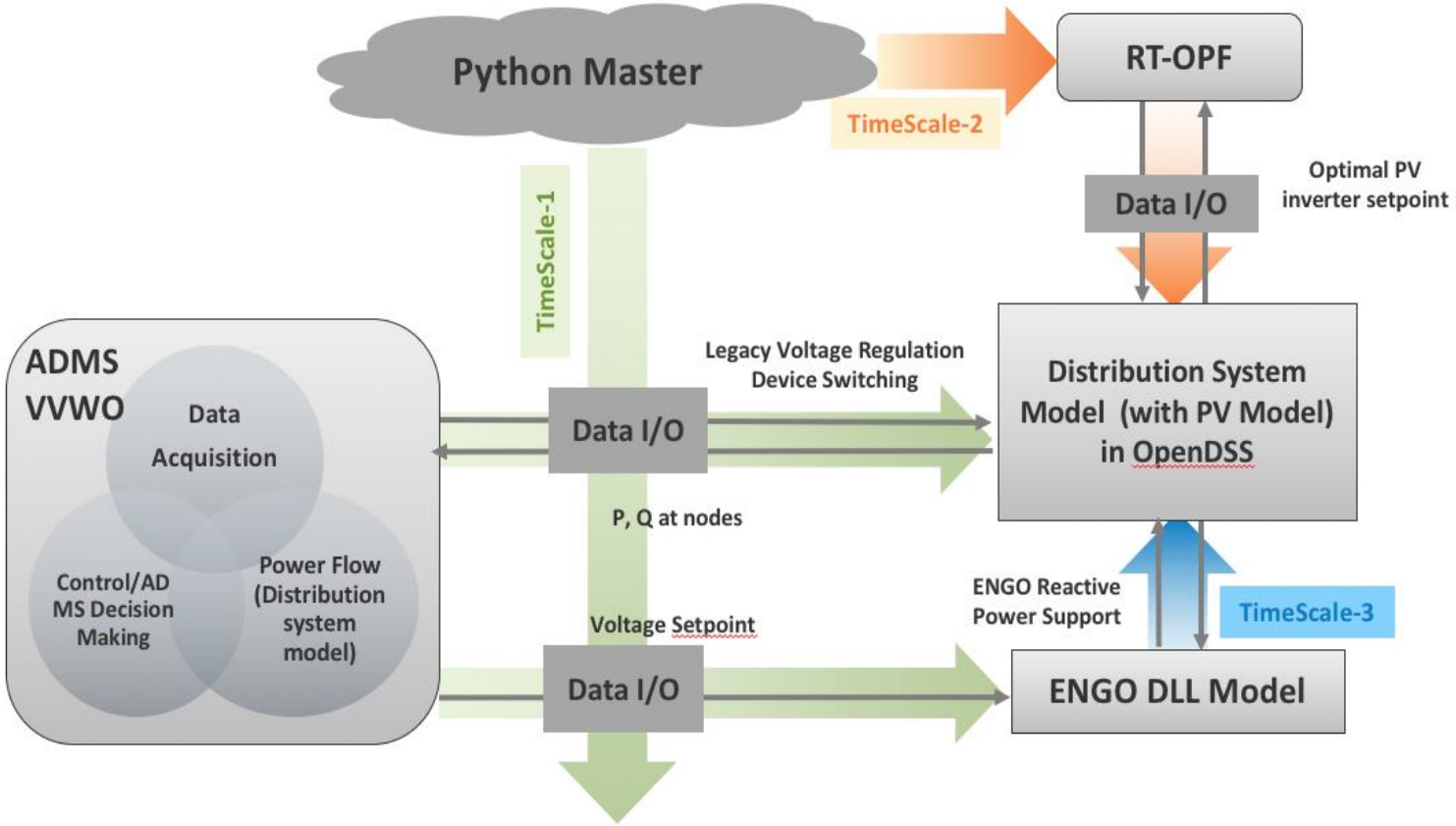
- ADMS-centered operations,
- Synergistic ADMS-grid edge operations,
- PV fast-regulation capabilities,
- Comprehensive situational awareness, cybersecured and interoperable.



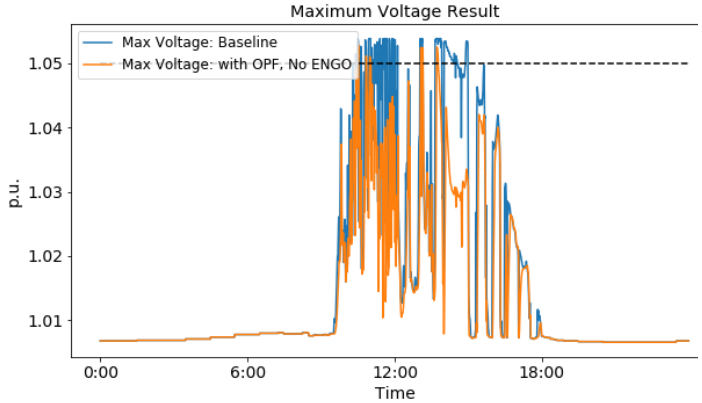
Key Activities

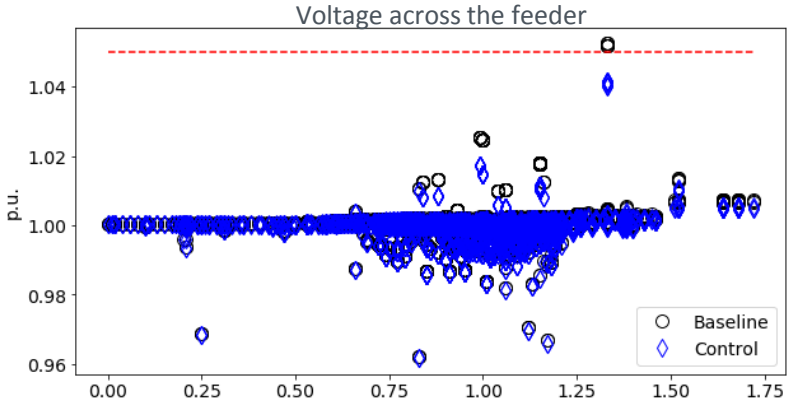
- Period 1: Development and validation of co-simulation framework of DEHC architecture.
- Period 2: Hardware-in the-loop validation of DEHC architecture in lab and real-time simulation environment
- Period 3: Field validation on selected distribution feeders with DEHC architecture components and control

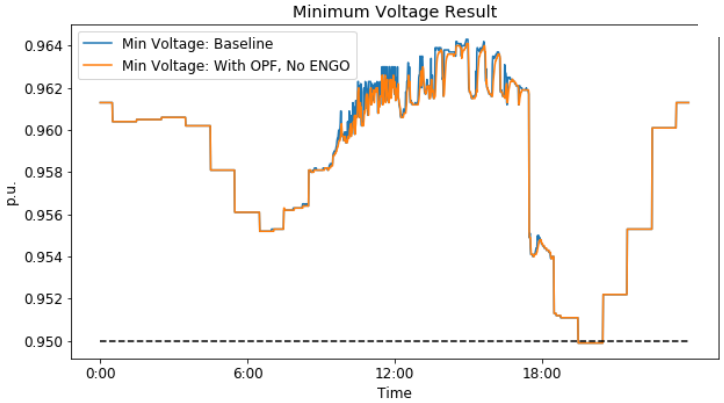
Co-simulation Framework for Developing and Evaluating the DEHC Architecture

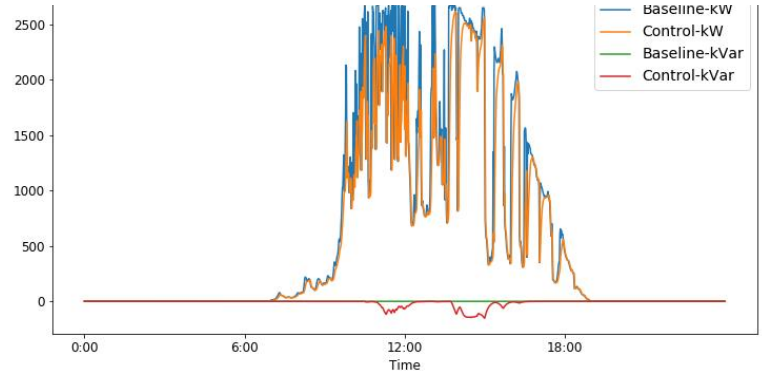


Feeder voltages with PV Regulation (RT-OPF)









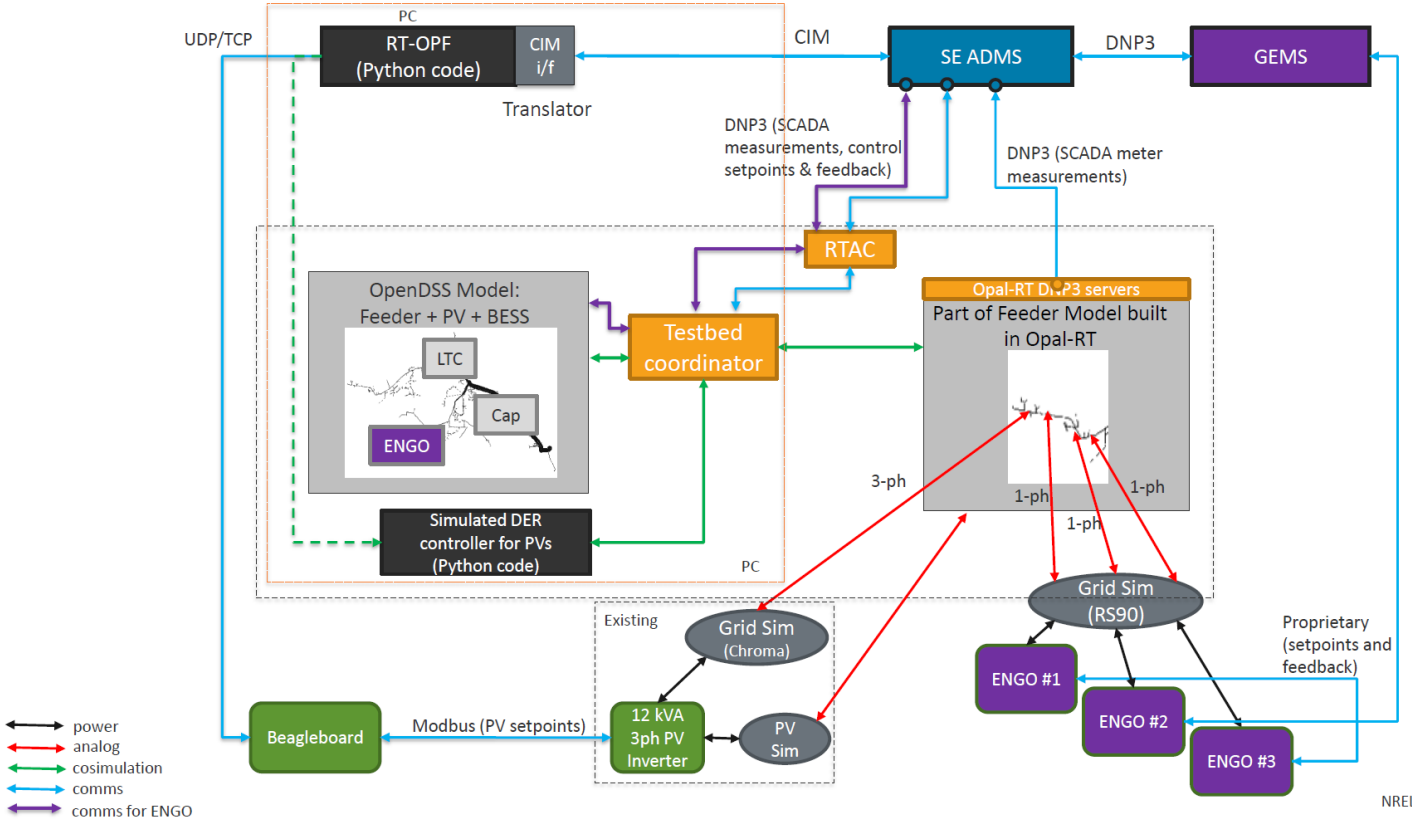
Scenarios for Simulation

- Following simulation scenarios are planned to be carried out

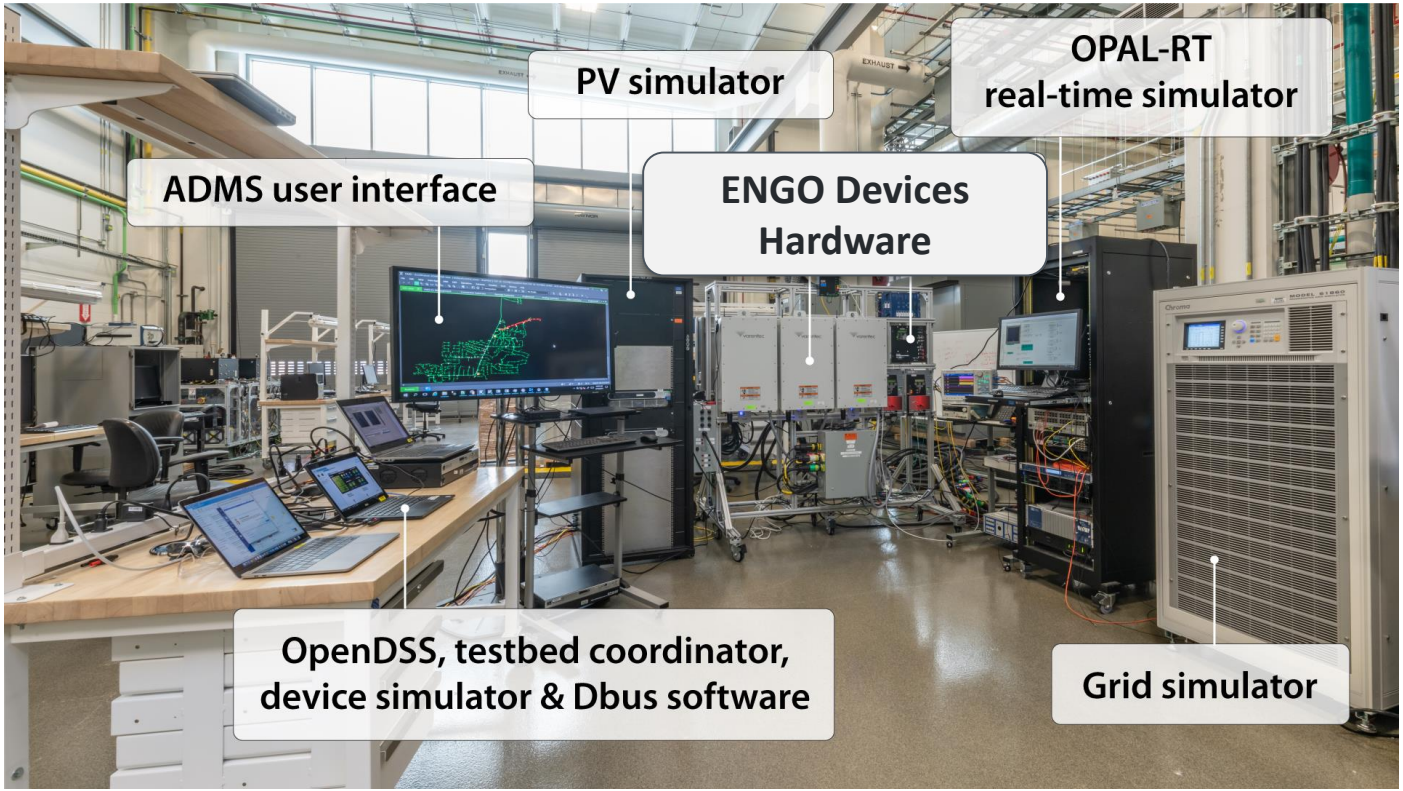
Category	Description	Planned Scenarios	RTAC+ADMS required?
Category 1: Evaluate the performance of ADMS and ENGO	Baseline, S1: No ENGOs, No RTOPF	4 (high PV scenario * 2 load profiles * 2 PV profiles)	No
	S2: ENGOs with fixed voltage setpoint in OpenDSS	4 (same as S1)	No
	S3: No ENGOs, No RTOPF, ADMS controls LTC only to do CVR	4 (same as S1)	**Yes**
	S4: Enable ENGOs	4 (same as S1)	**Yes**
Category 2: Evaluate the performance of RTOPF	S5: Enable RTOPF	12 (3 PV inverter control intervals * 4 scenarios as above)	No
Category 3: Evaluate the performance of ADMS, ENGO, and RTOPF	S6: Combine S4 + S5	4 (same as S1)	**Yes**

Note: **2 load profiles - Peak day, Min. load day**
2 PV profiles - Intermittent day, Moderate day
3 PV inverter control intervals - 1 sec, 5 sec, 10 sec

Hardware in the Loop Setup



HIL Test Setup



Lab infrastructure for ENERGISE ECO-IDEA Project (1)

HIL Test Setup

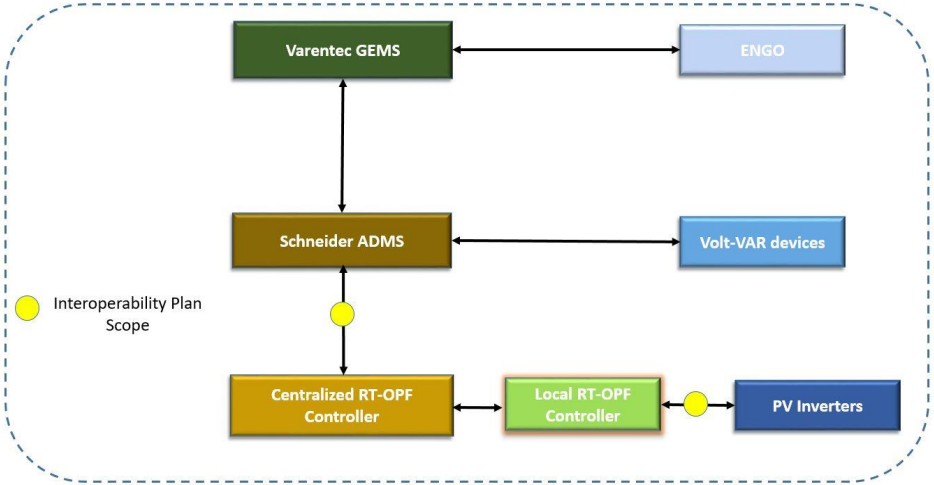
TI microcomputer
(Local controller)

RTOPF

Schneider
ADMS

Lab infrastructure for ENERGISE ECO-IDEA Project (2)

Interoperability Testing

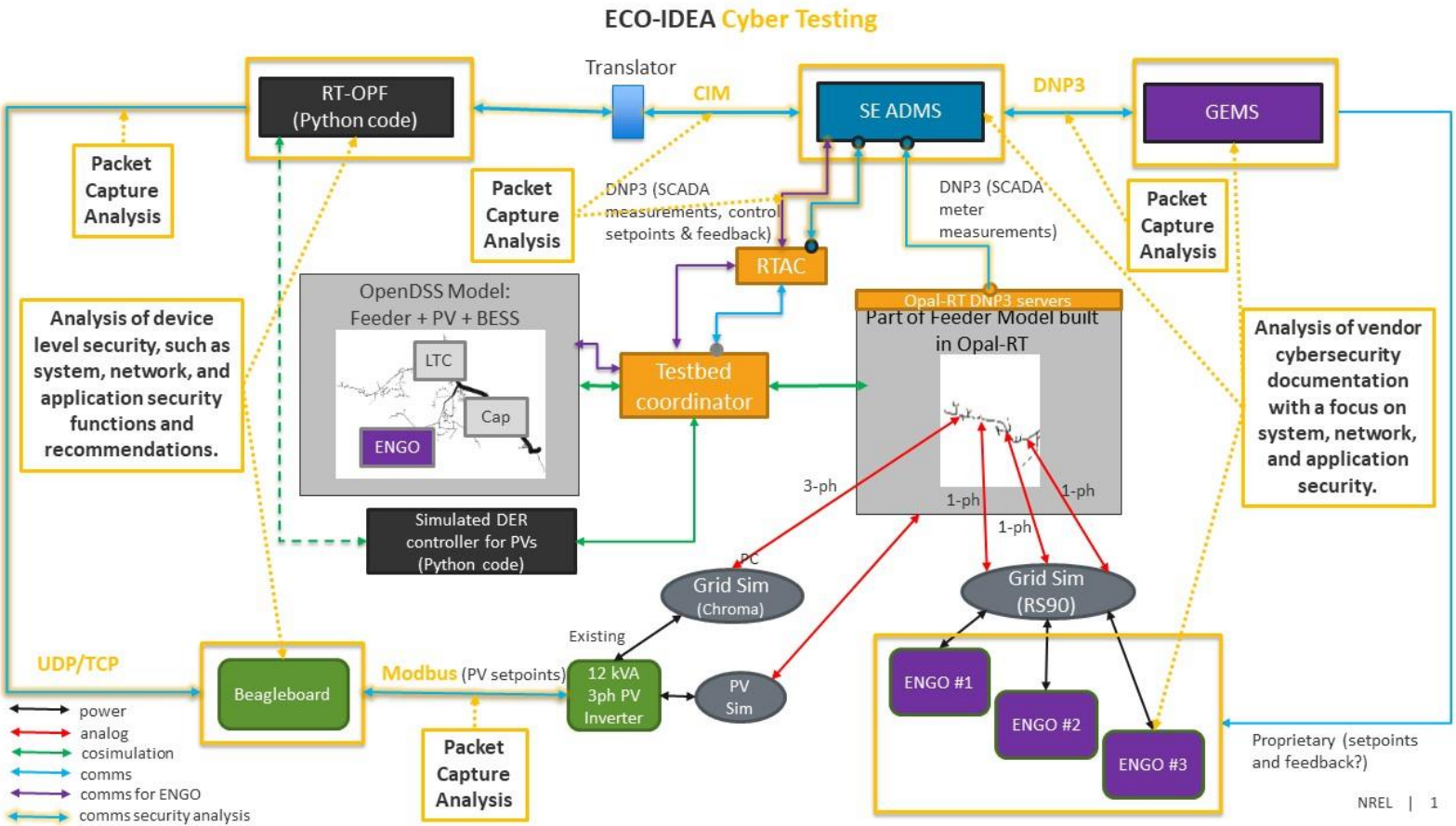


DEHC Architecture Interoperability Plan Scope

Interoperability testing in DEHC architecture:

- Local RT-OPF controller to PV Inverters
- SE ADMS to Centralized RT-OPF Controller

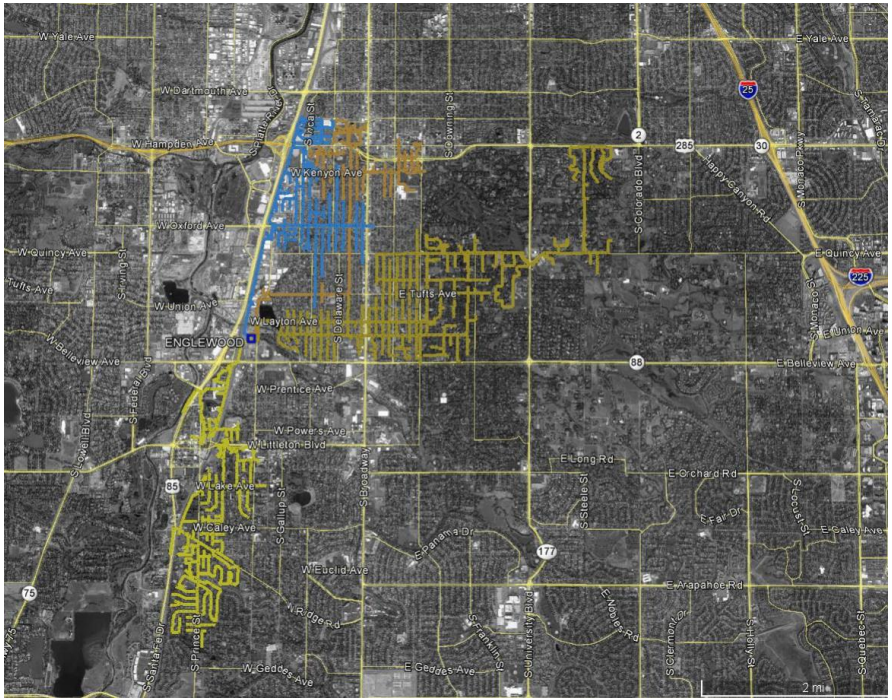
Cybersecurity Evaluation



Field Deployment – Xcel Energy

Englewood Bank 2

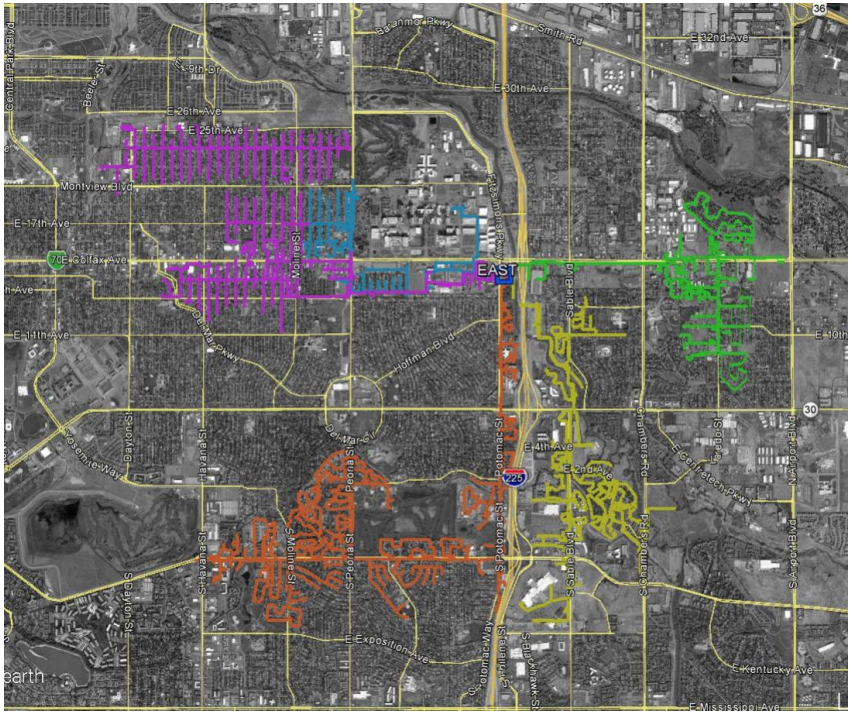
- All devices installed in preparation for IVVO except for the bellwether meters and small subset of ENGOs.
- Testing should be completed before the end of May and IVVO should begin running in closed loop at that time.
- Bellwether meters should be installed in November of 2019 but will have a limited scope and only be installed on residential and some commercial customers.
- Upgraded Load Tap Changer(LTC) control installed at substation transformer. SEL 2411 allows the ADMS to issue a set point which the LTC with regulate the secondary voltage to.
- 18 primary capacitor banks installed.
- 122 ENGOs installed – 22 additional ENGOs to be installed.
- WiMAX network installed and functional, WiSUN mesh network is planned for the coming months.



Field Deployment – Xcel Energy

East Bank 1

- Device installations should be completed in November 2019 and ADMS deployment there will follow in late Q2/early Q3 of Fiscal Year 2020 (March or April 2020).
- The bellwether deployment at EAST will likely not be in time for the Eco-Idea project as their deployment was pushed out to 2021.
- Upgraded LTC control to be installed in November 2019.
- 10 primary capacitor banks installed.
- 56 ENGOs planned for installation in coming months.
- WiMAX network installed and functional, WiSUN mesh network at East#1 is currently a little lower on the schedule, it will be ready for the ADMS enablement of that substation area in March/April 2020.



GEMS

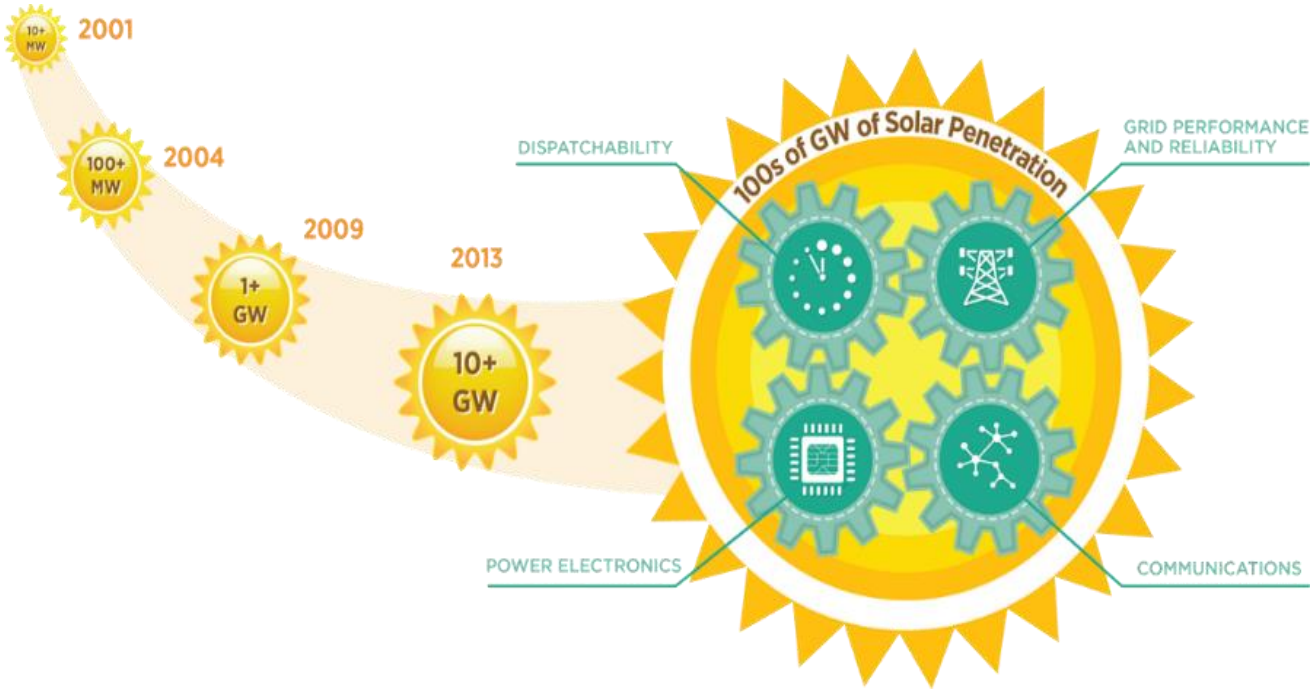
Xcel Energy's instance of GEMS will go live in September 2019. The deployed ENGOs will have set points issued remotely at that time.

In the next quarter, the team will also start developing the field test plan that will be executed in BP3.

Key Outcomes and Impacts

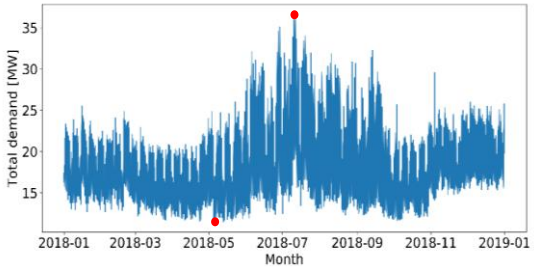
- Validated novel hybrid control architecture
- Reliable and secure grid operation for high PV grids
- Interoperable interfaces for integration of system-level controls on the Utility Enterprise Bus
- Laboratory and field validation of hierarchical controls

Questions?

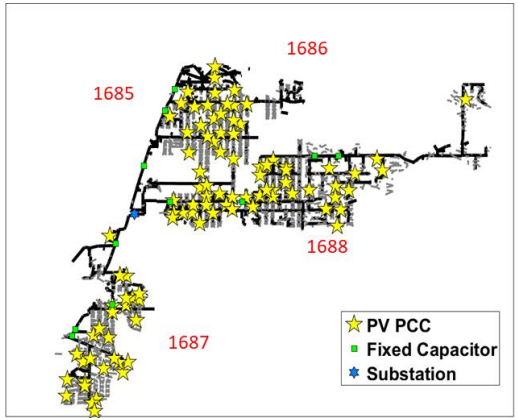

10+ MW
2001
100+ MW
2004
1+ GW
2009
10+ GW
2013
100s of GW of Solar Penetration
DISPATCHABILITY
GRID PERFORMANCE AND RELIABILITY
POWER ELECTRONICS
COMMUNICATIONS

Model Updates – Load Modeling

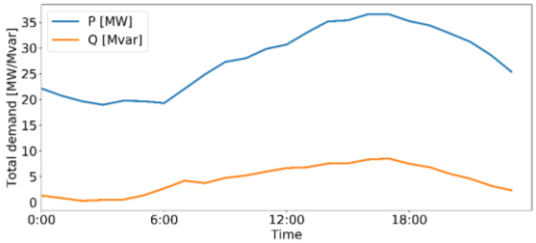
- Historical SCADA data was received from Xcel at 1-hour resolution
- Minimum load of 11.48 MW was observed at 15 hours on May 13, 2018
- Peak load of 36.6 MW was observed at 16 hours on July 10, 2018
- Voltage-dependent load model



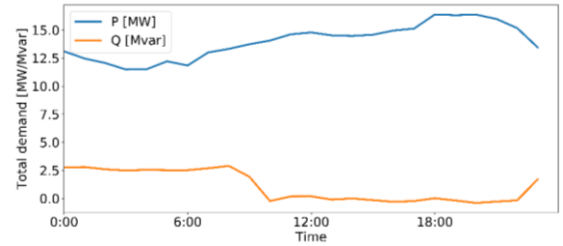
Yearly load profile



ENGL Feeders



Profile for Peak Load Day

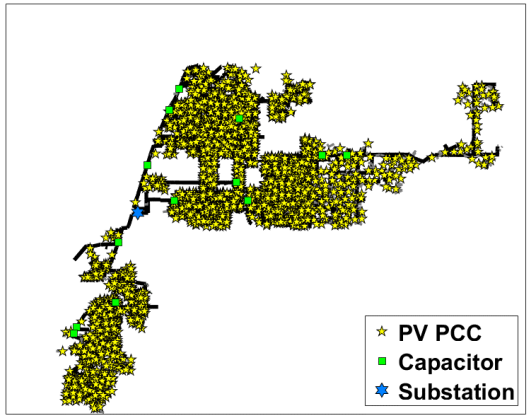


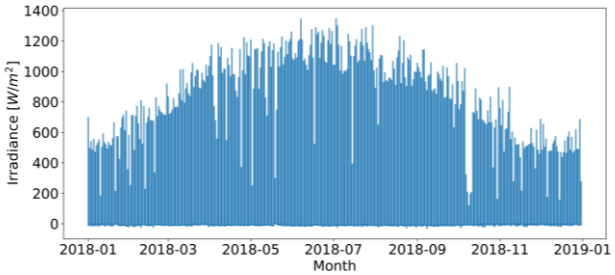
Profile for Min Load Day

Model Updates – High PV Scenario

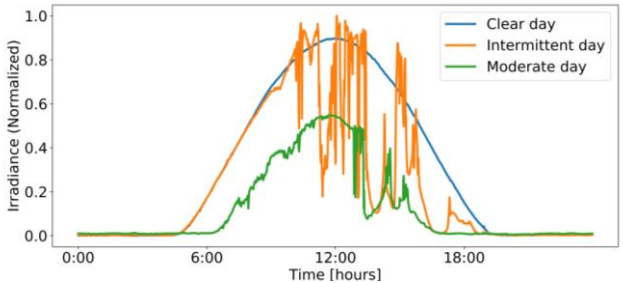
- New high-PV scenario is created with updated criteria

PV locations

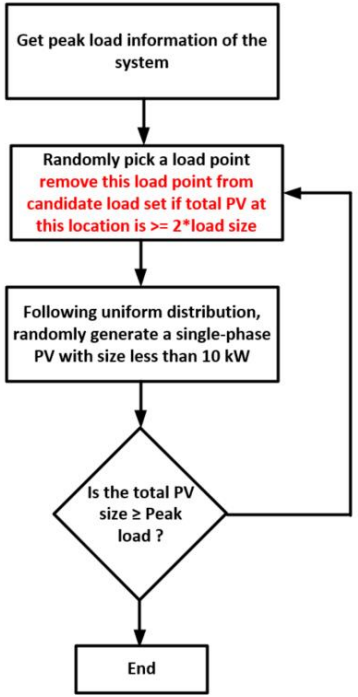




Yearly PV profile



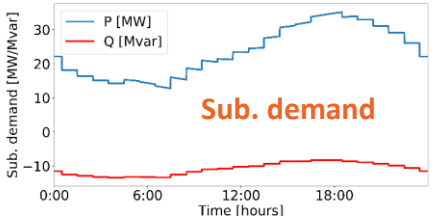
Selected PV profiles



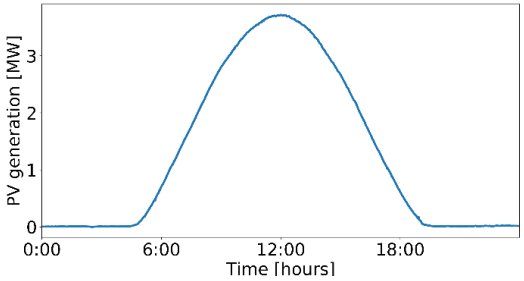
High-PV scenario criteria

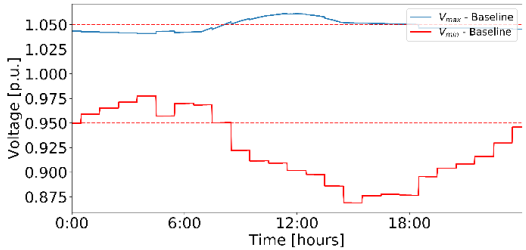
Scenario Results – S1, Baseline

- S1, Baseline: No ENGOs, No RTOPF
- Peak day, low-PV
- Impact of PV intermittencies are observed in max. voltage

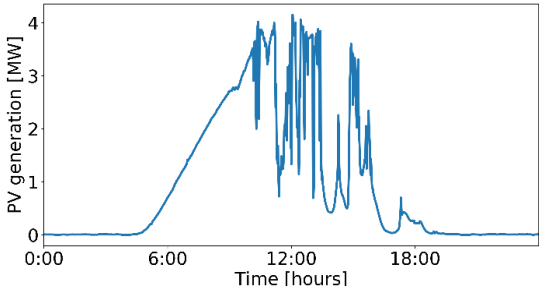


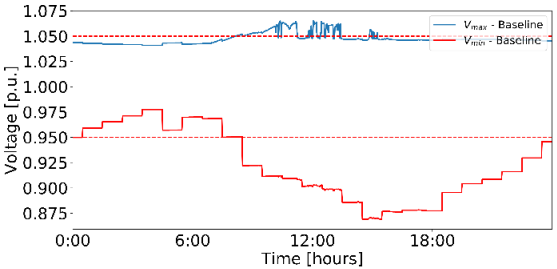
Clear



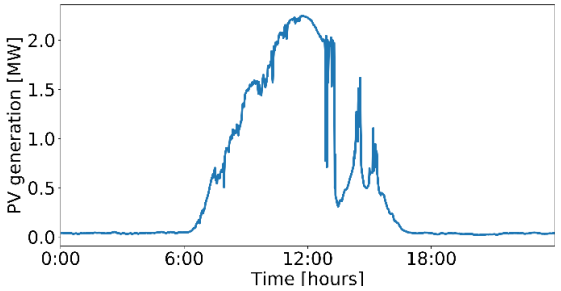


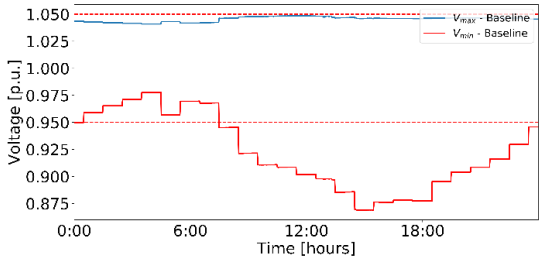
Intermittent





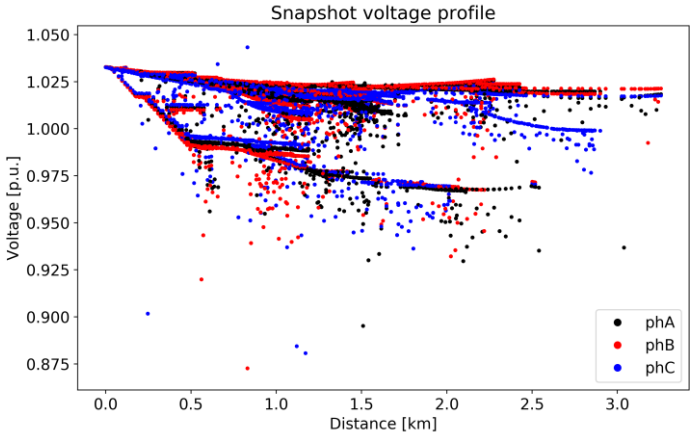
Moderate



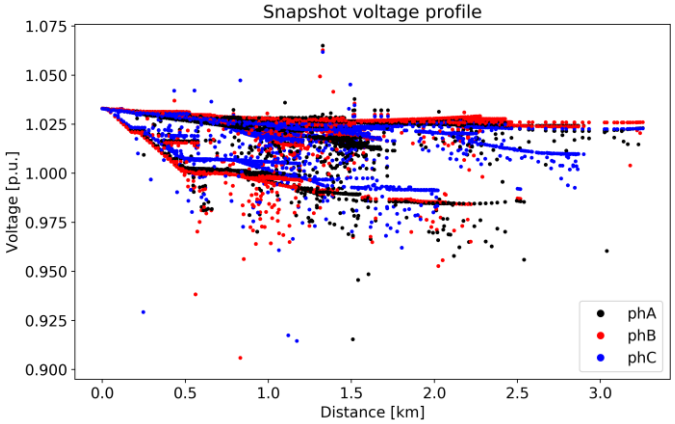


Scenario Results – S1, Baseline

- S1, Baseline: No ENGOs, No RTOPF
- Peak day, low-PV scenario, Intermittent load profile

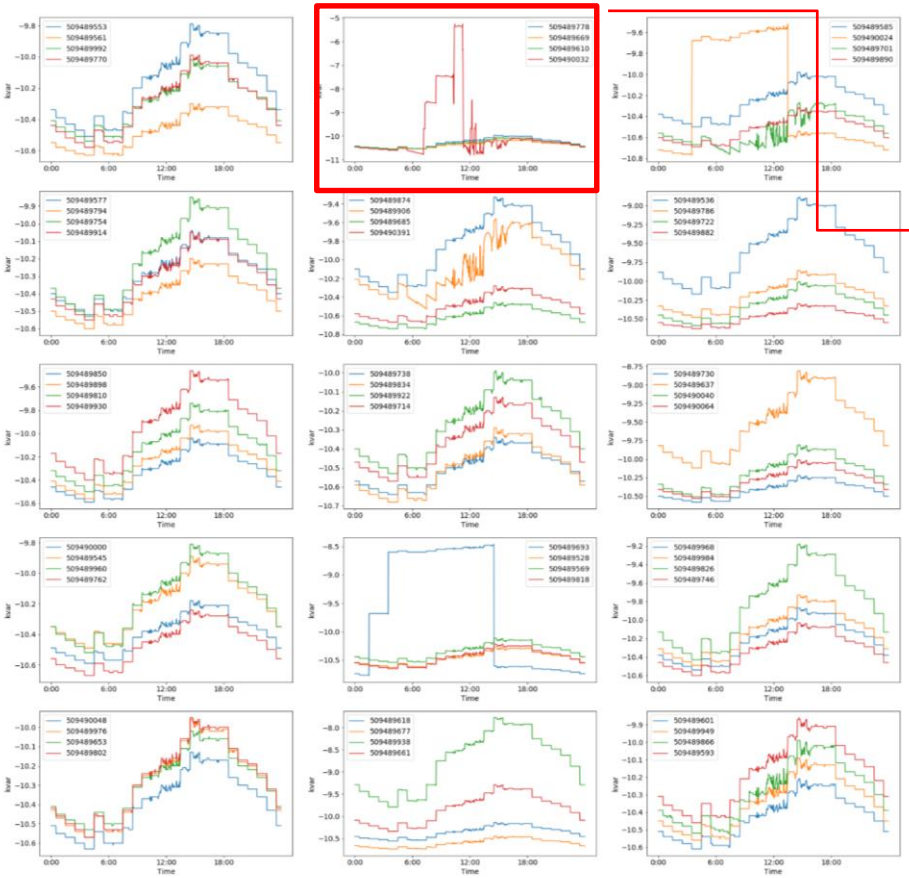


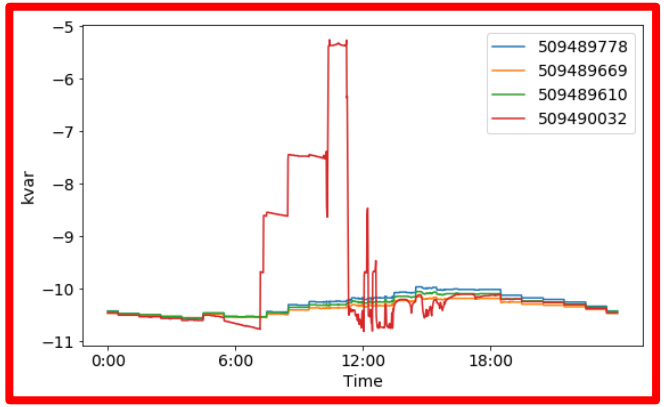
Voltage profile at min. voltage time step



Voltage profile at max. voltage time step

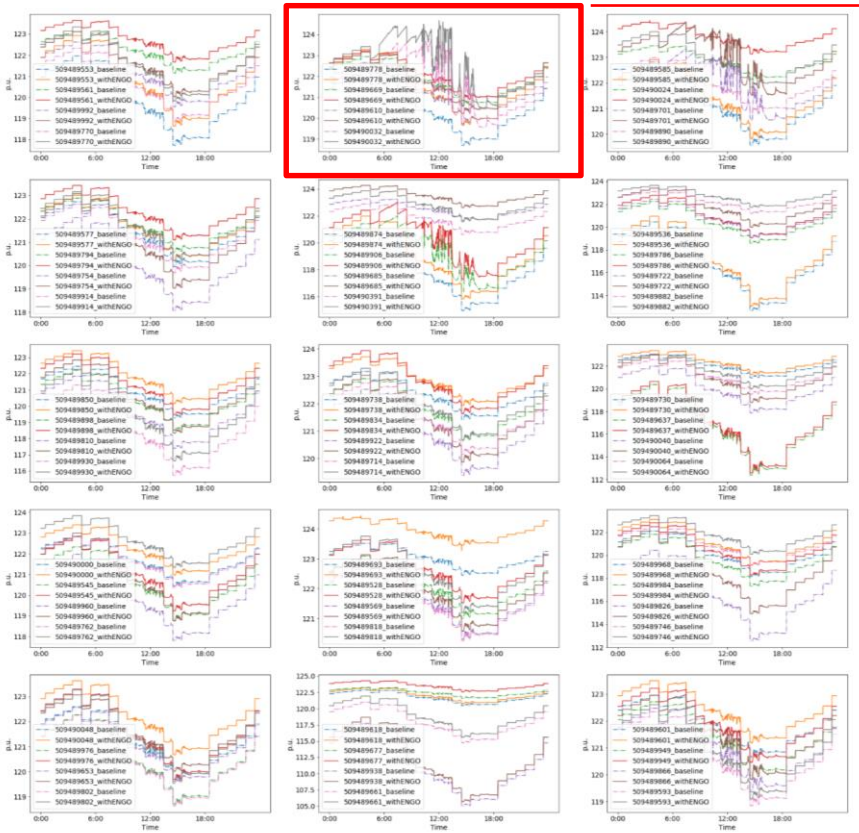
S2 – Individual ENGO Powers

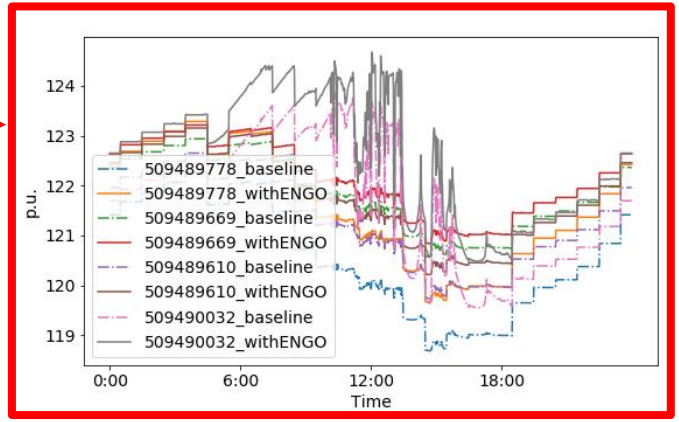




Peak load day, Intermittent PV profile

S2 – Individual ENGO Voltages





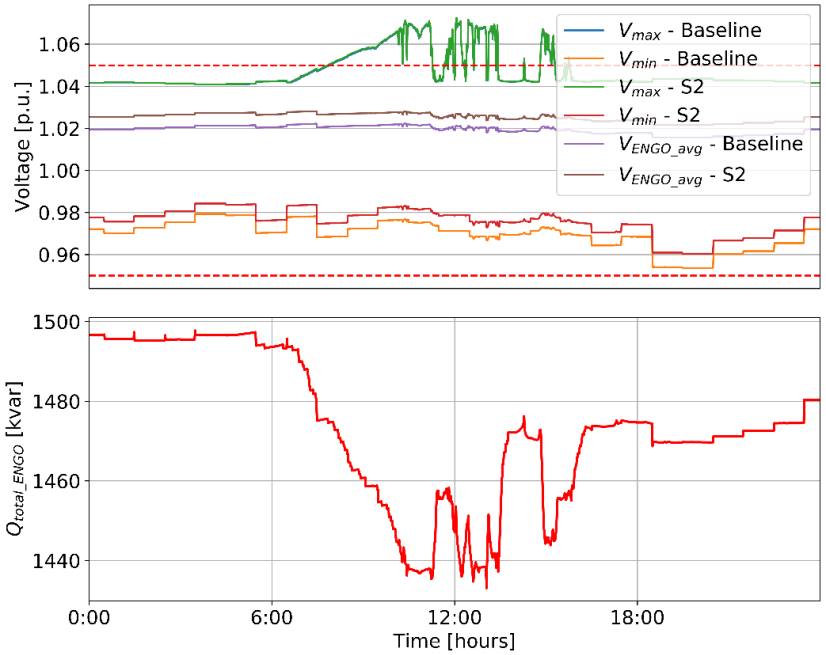
Peak load day, Intermittent PV profile

S2 – Individual ENGO Powers

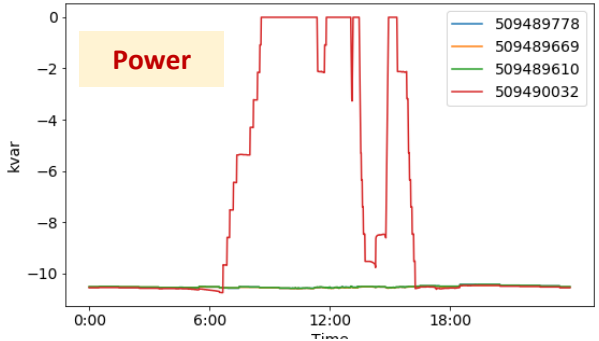
- Similar observations are made in this scenario as well
- That is, ENGOs provide voltage boost by injecting reactive power into the system

Min. load day, Intermittent PV profile

Extreme voltages & ENGO powers



Power



Voltage