



# **CAPER**

**Center for Advanced Power  
Engineering Research**

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# Project Summary

- Implement and evaluate battery storage schemes to maximize benefit to the circuit
  - Efficient battery locations for testing
  - Value Streams: Nodes outside bandwidth, line loss, tap changes

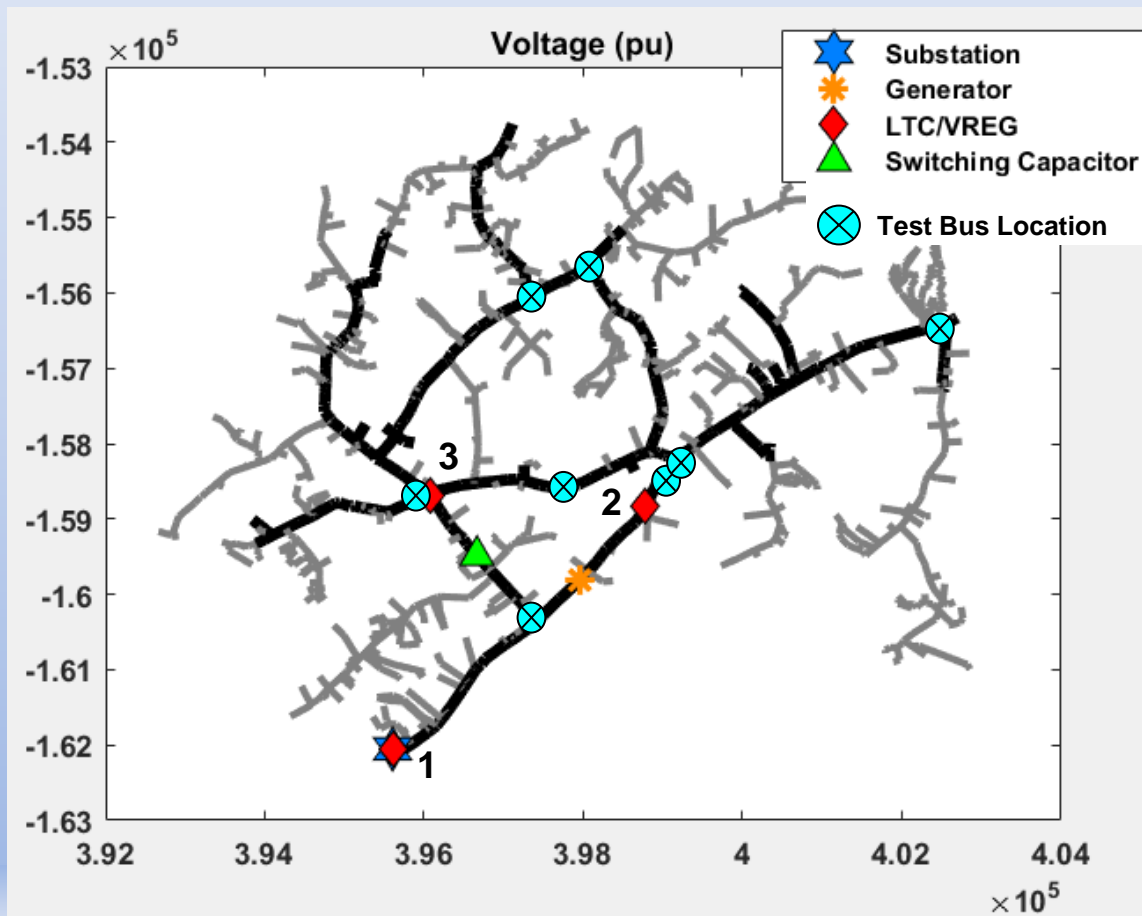
# Goals

- Evaluate BES implementation with the circuit and load profile in regard to energy arbitrage and PV firming
  - Consider this implementation and its effects at strategic circuit locations to maximize value
  - Consider this implementation at different seasons and PV profiles

# Introduction

- Targeted each side of an LTC and switch
- Analyzed sunny conditions and intermittently cloudy conditions in August
- Energy Arbitrage and PV Firming

# Circuit Test Locations



# PV Firming/Smoothing

- Results unclear
- Variations based off minute data will cause the battery to increase ramp rates by switching from load to generation each minute in an attempt to smooth the curve

# Energy Arbitrage

- A fixed approach
  - Constant charging and discharging based on solar day times
- In cloudy conditions, the battery has trouble fully charging and therefore has less effect when discharging
- Worst location
- Best Location

# Battery Parameters For Testing

Initial Charge Percentage: 20%

BES charge and discharge rate (kW) = 400

BES size (kwh) = 2000

BES hour charging begins: 8

BES hour and discharge begins: 16



# Nodes Outside Bandwidth

- Number of nodes daily outside of 0.95 - 1.05pu
- 1st priority

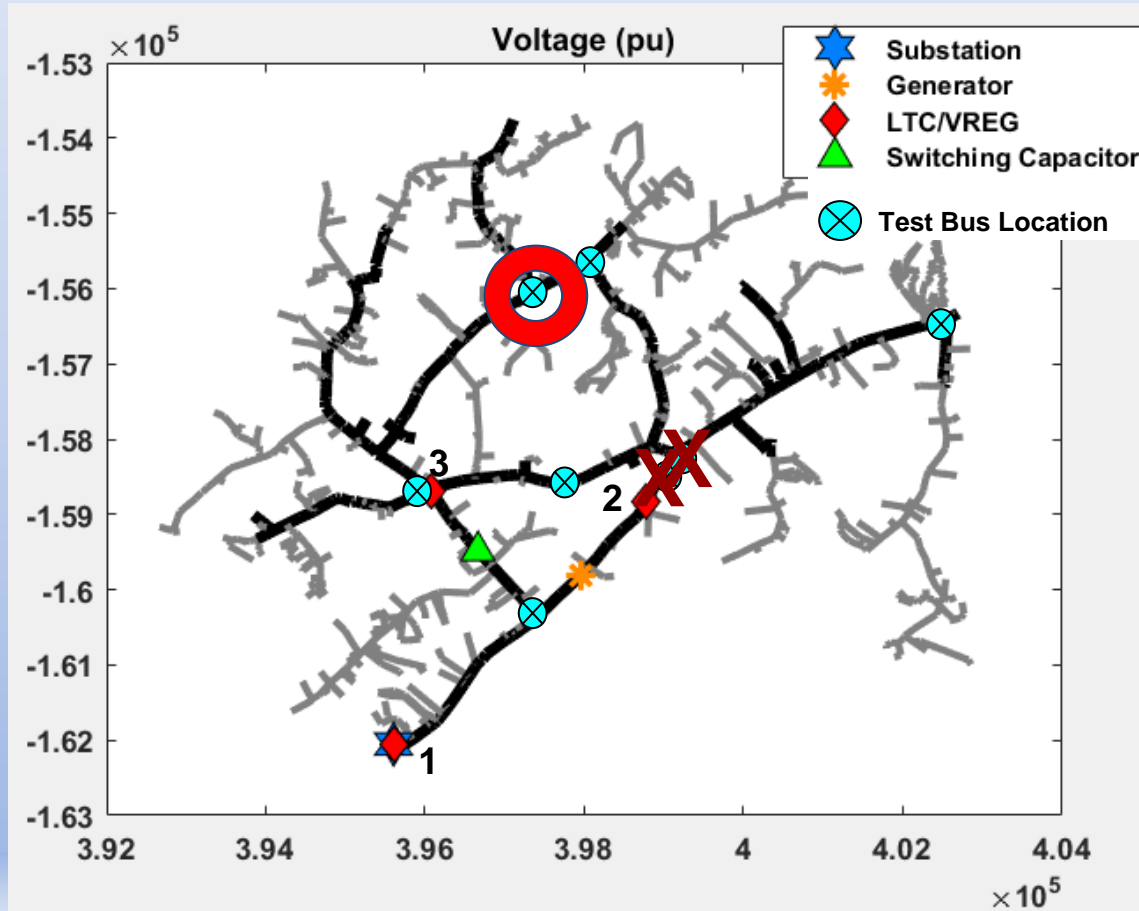
# Line Loss

- Line loss across the circuit
- 2nd priority

# Tap Operations

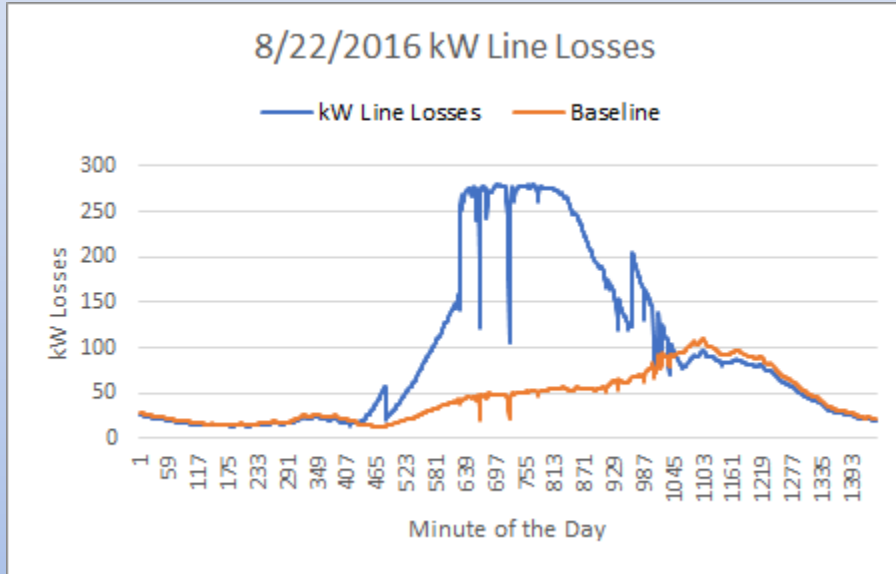
- Changes in the number of tap operations to keep voltages regulated
- 3rd priority

# Worst Bus Location



# Worst Location: Bus 256160759

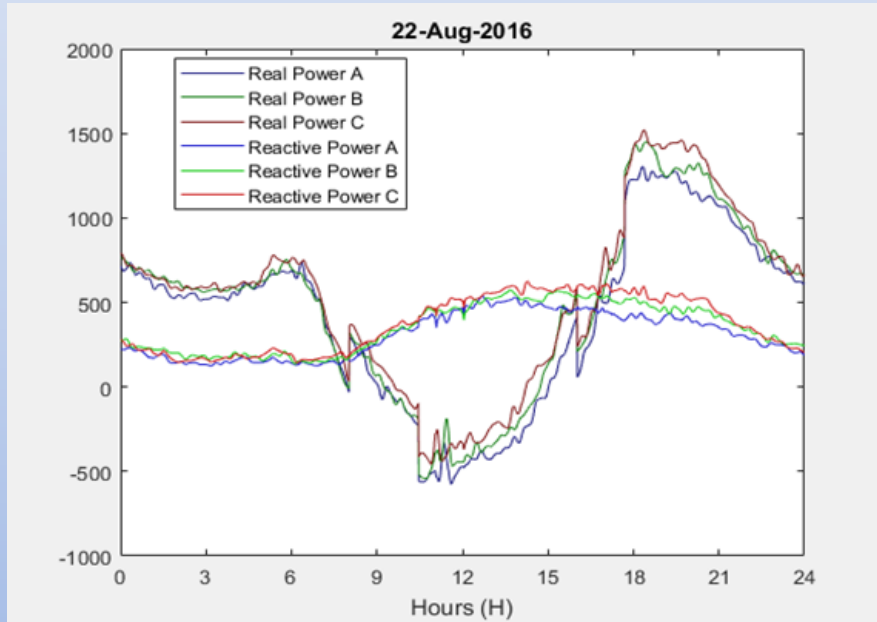
Clear, Summer



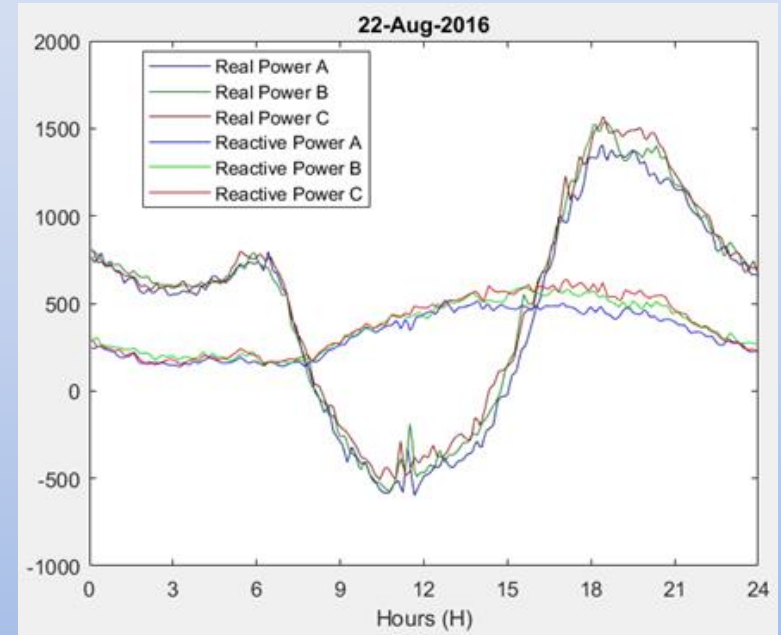
	Baseline	Energy Arbitrage	Number Change
OLTC1 Changes	1	0	-1
OLTC2 Changes	3	2	-1
OLTC3 Changes	4	1	-3
Nodes Outside Bandwidth	0	205627	205627

# Worst Location: Bus 256160759

Clear, Summer



Energy Arbitrage

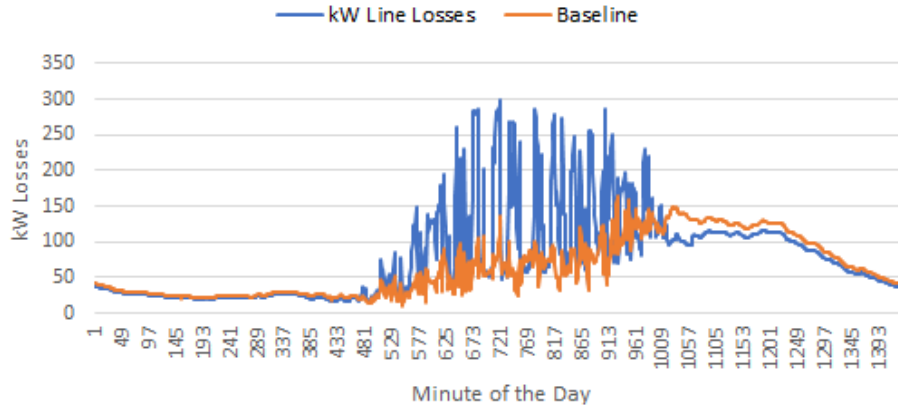


Baseline

# Worst Location: Bus 256160759

Cloudy, Summer

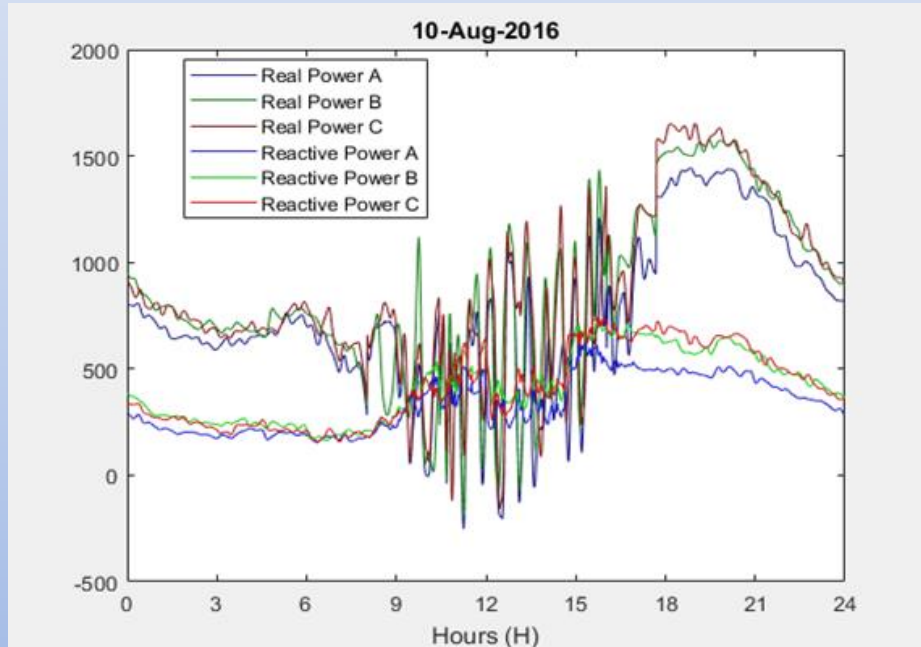
8/10/2016 kW Line Losses



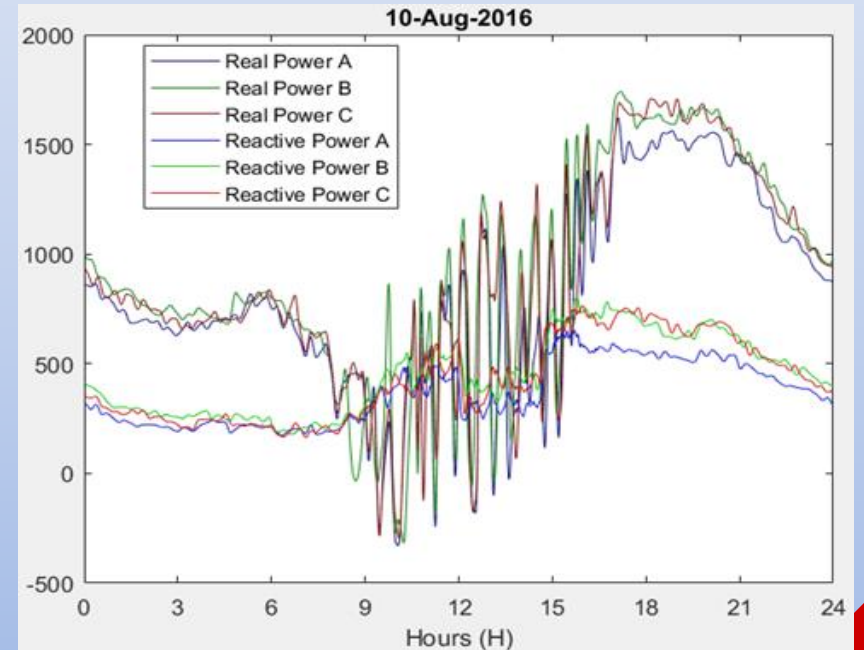
	Baseline	Energy Arbitrage	Number Change
OLTC1 Changes	2	2	0
OLTC2 Changes	17	10	-7
OLTC3 Changes	14	14	0
Nodes Outside Bandwidth	2409	87136	84727

# Worst Location: Bus 256160759

Cloudy, Summer



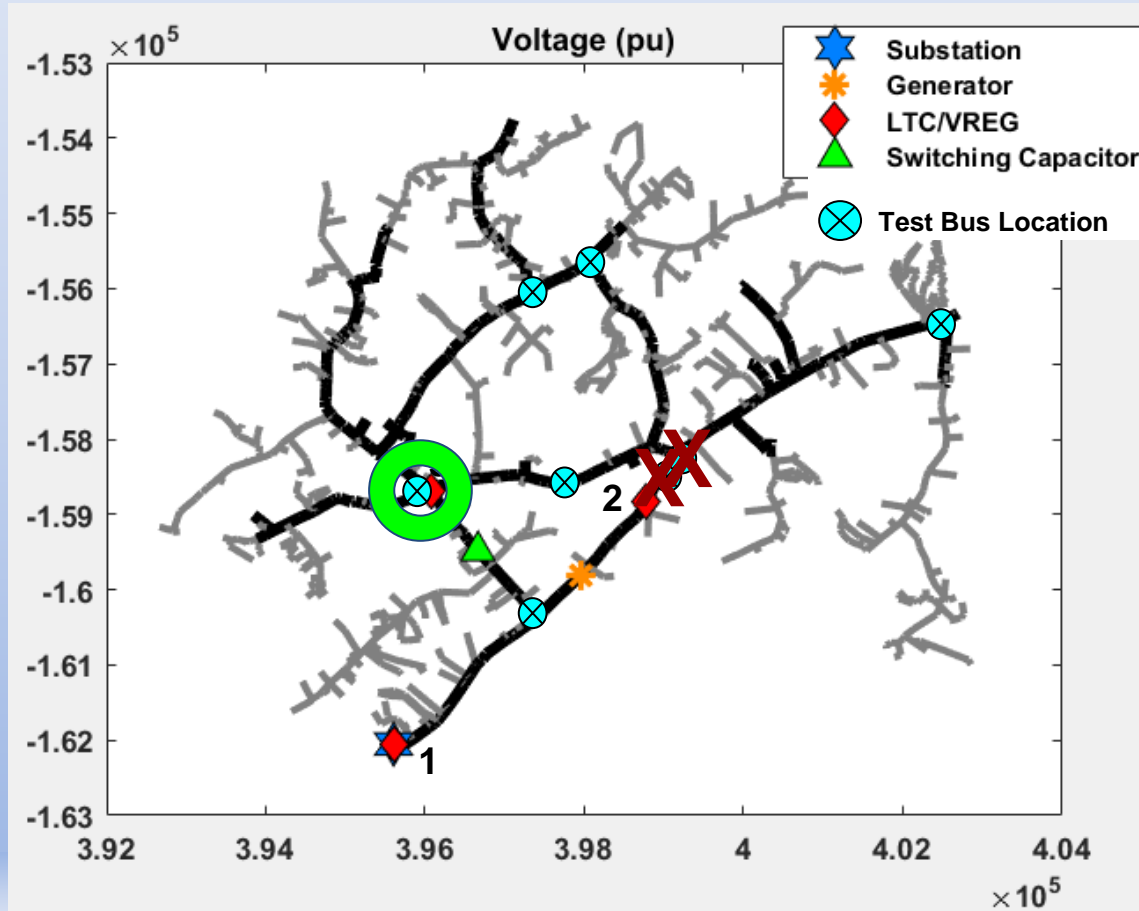
Energy Arbitrage



Baseline



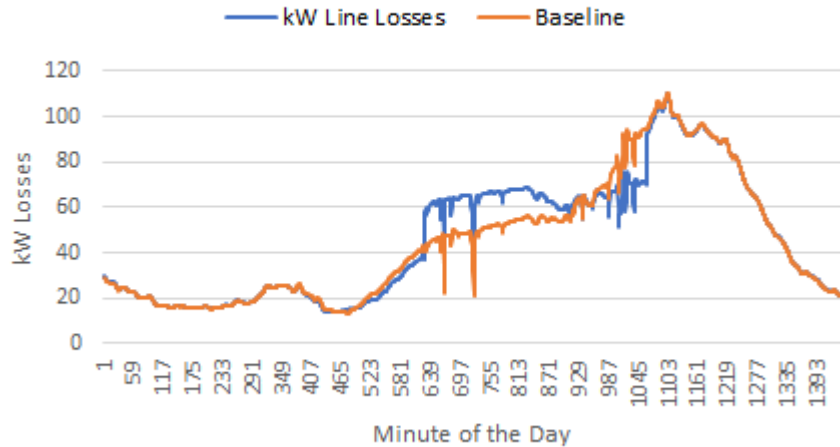
# Best Bus Location



# Best Location: Bus 256155986

Clear, Summer

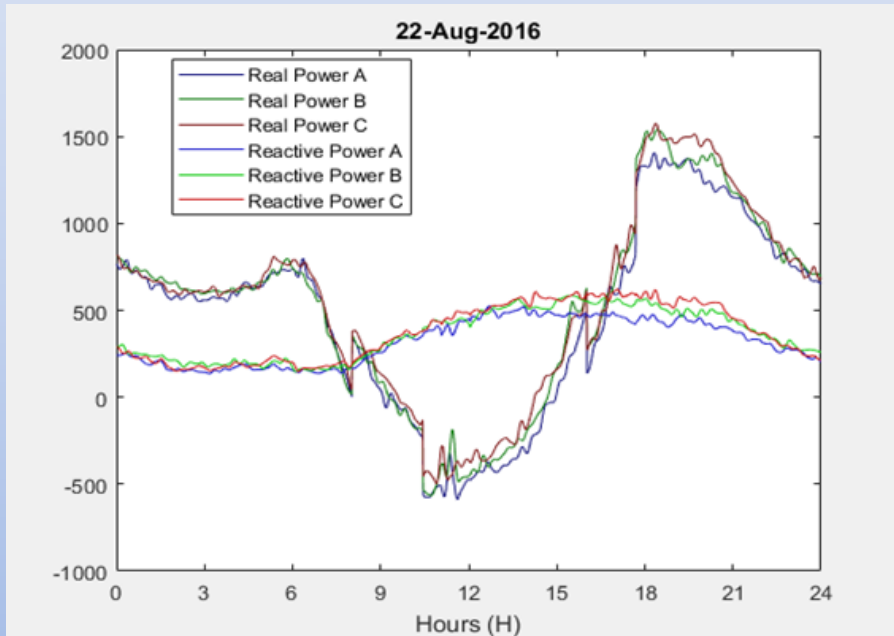
8/22/2016 kW Line Losses



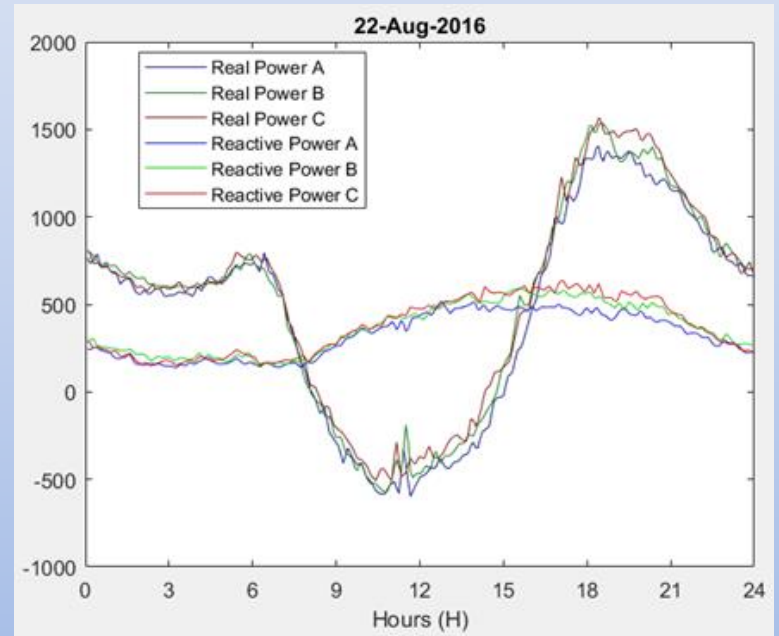
	Baseline	Energy Arbitrage	Number Change
OLTC1 Changes	1	1	0
OLTC2 Changes	3	5	2
OLTC3 Changes	4	7	3
Nodes Outside Bandwidth	0	0	0

# Best Location: Bus 256155986

Clear, Summer



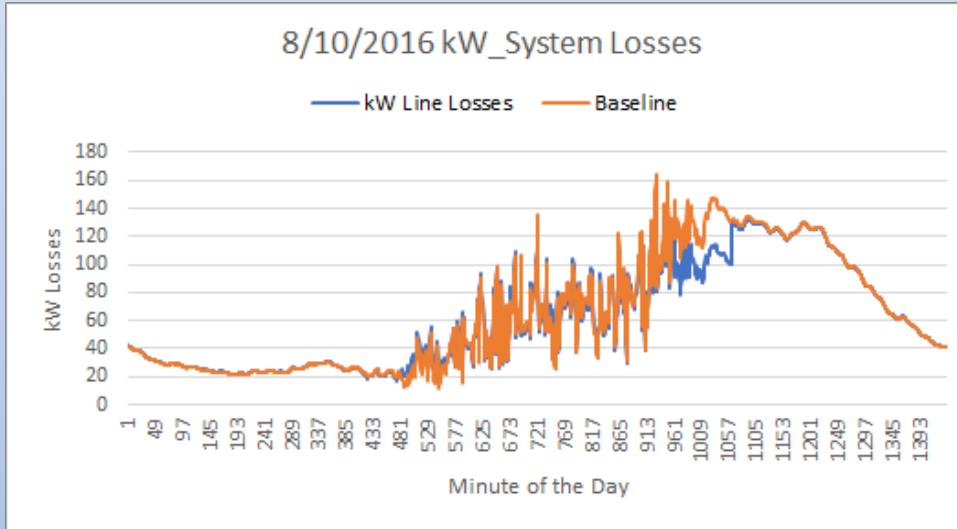
Energy Arbitrage



Baseline

# Best Location: Bus 256155986

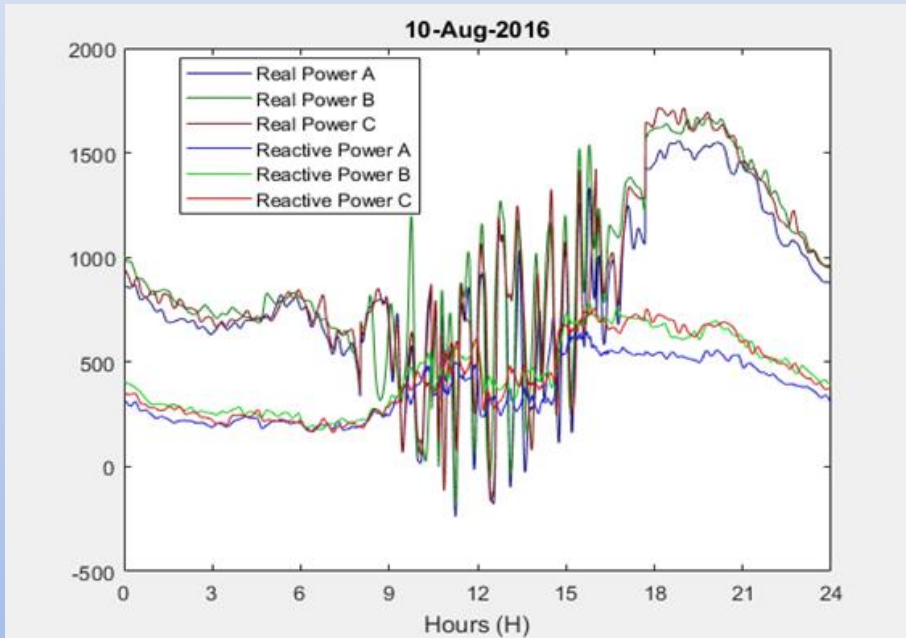
Cloudy, Summer



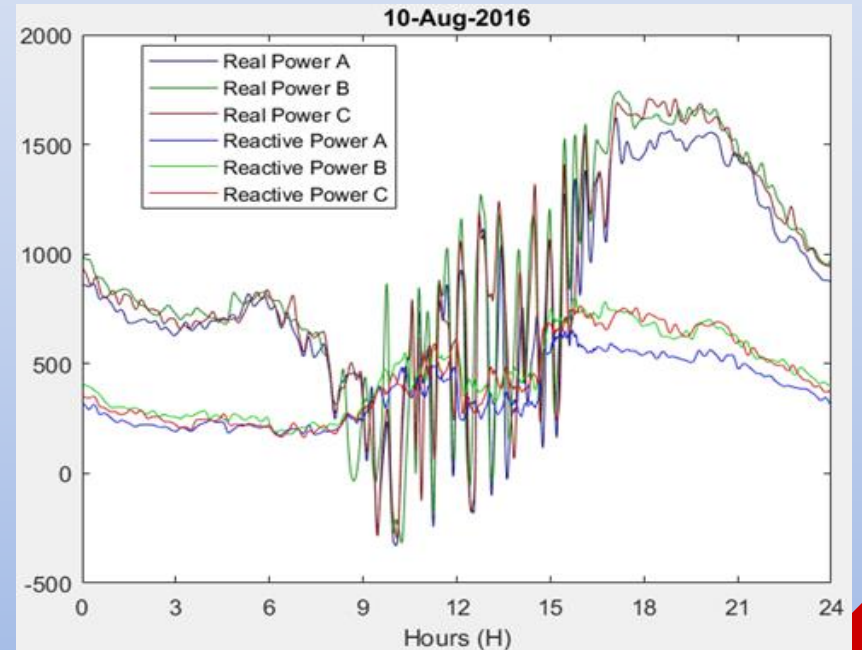
	Baseline	Energy Arbitrage	Number Change
OLTC1 Changes	2	2	0
OLTC2 Changes	17	13	-4
OLTC3 Changes	14	16	2
Nodes Outside Bandwidth	2409	745	-1664

# Best Location: Bus 256155986

Cloudy, Summer



Energy Arbitrage



Baseline

# Q&A



Thanks!

