RLC ENGINEERING

Modeling Dynamic CVR Schemes and DER Impacts

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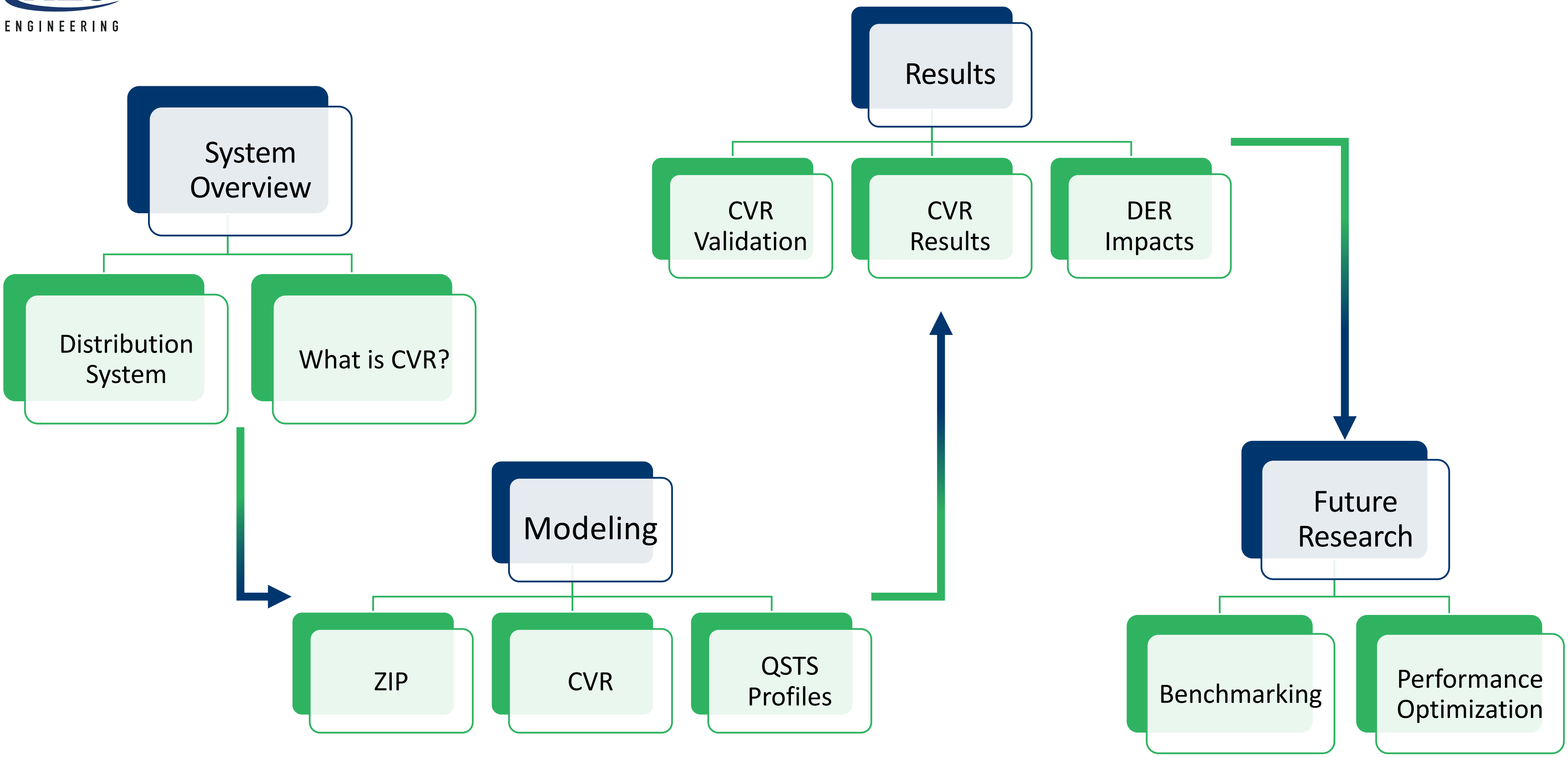
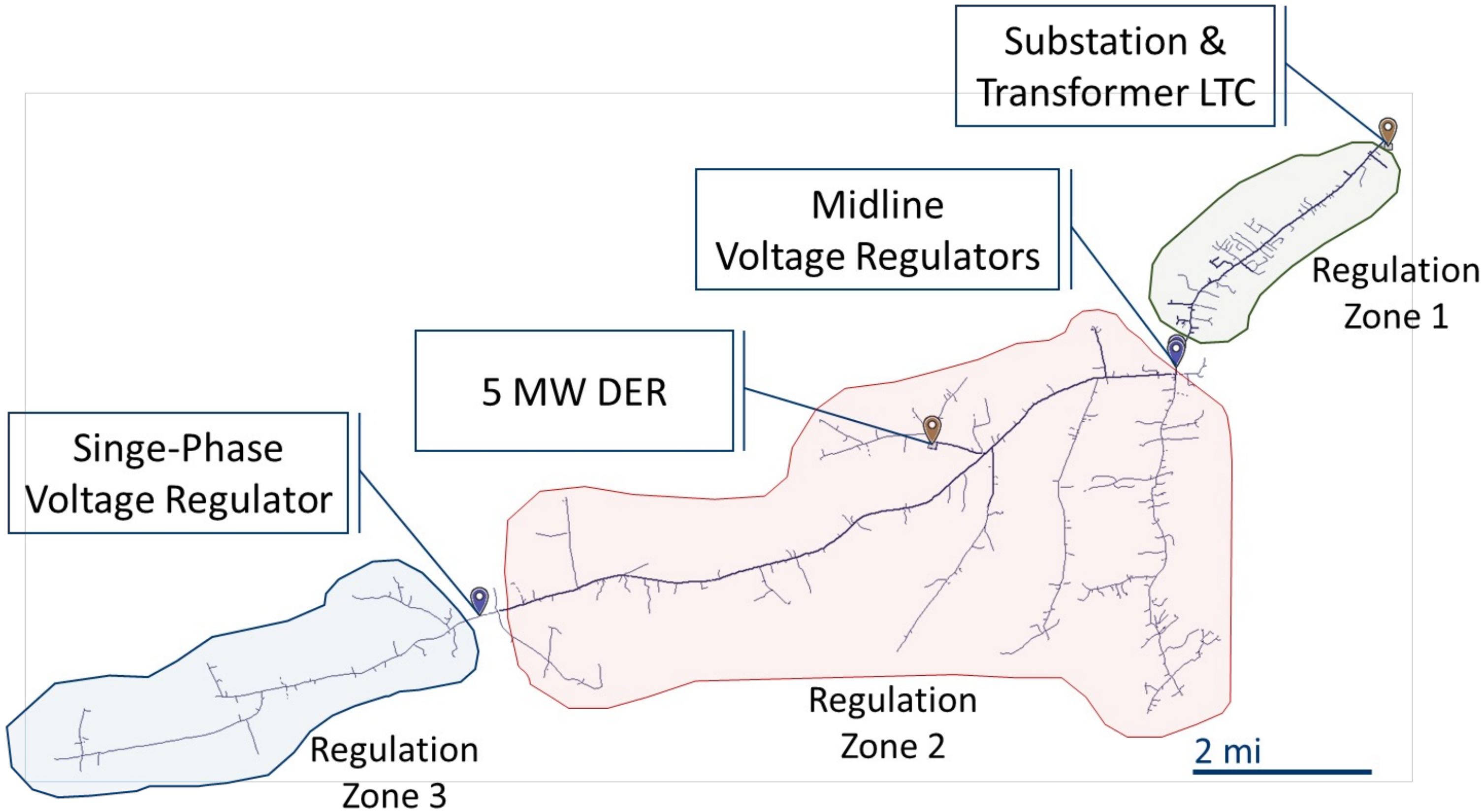
Genesis

- DER SIS requested on a dynamic CVR station:
  - Are the high voltages real?
  - Are the low voltages real?
  - Are we accurately capturing regulator tapping?
  - How will the DER Volt/Var scheme perform?
  - What happens if the CVR scheme is offline?
- We lacked visibility to easily answer these questions…
- This presentation outlines one approach to improve visibility


System Overview
Distribution System
What is CVR?
Modeling
ZIP
CVR
QSTS Profiles
Results
CVR Validation
CVR Results
DER Impacts
Future Research
Benchmarking
Performance Optimization

Distribution System (DS) Overview



What is CVR?

- Conservation Voltage Reduction (CVR)
- CVR is an energy and demand reduction technique
  - Operates customer voltages at the lower end of the acceptable ranges
  - Most effective for constant impedance (Z) and constant current (I) loads
- Why is a dynamic CVR scheme hard to model?
  - Requires custom control logic for all CVR devices
  - May requires customer voltage data (often not modeled)
  - Requires an accurate load representation

DS Load Representation

The utility data did not include an accurate ZIP load model. Typical values were selected based on other electric utility models.

Table 1: ZIP Representation by Customer Type

Customer Type	Z (%)	I (%)	P (%)
Residential	60	5	35
Commercial	20	10	70
Industrial	10	10	80

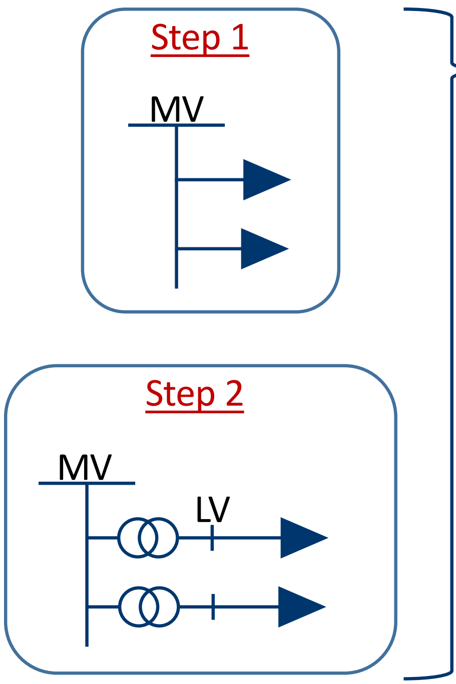
To properly scale the loads within the QSTS simulations, a uniform customer type had to be selected. A weighted ZIP breakdown was used based upon the percent of each customer type, and the new weighted ZIP was applied uniformly to all loads

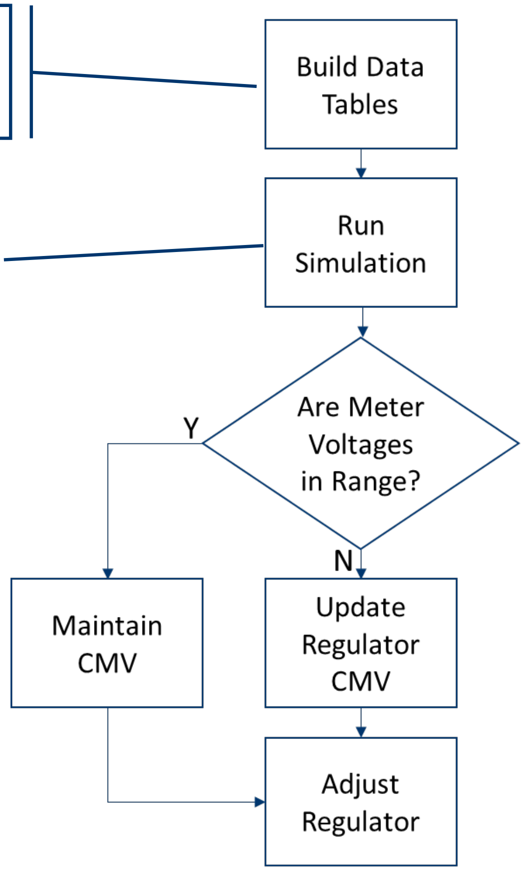
Table 1: ZIP Load Percentages by Feeder

Feeder	% of Total				ZIP Modeling		
	Residential	Commercial	Industrial	Other	Z (%)	I (%)	P (%)
Feeder A	18.25%	58.47%	23.18%	0.09%	**25.02**	**9.08**	**65.90**
Feeder B	86.52%	13.26%	0.00%	0.22%	**54.70**	**5.66**	**39.64**
Feeder C	54.91%	35.64%	9.13%	0.32%	**41.18**	**7.24**	**51.58**
Feeder D	77.74%	22.15%	0.00%	0.12%	**51.14**	**6.11**	**42.75**

CVR Model

Customer secondary system was **not** explicitly modeled





Build customer data tables for each regulator based upon exported GIS, including: transformer Z_{ohms}, cable Z_{ohms}, and secondary voltage calculations.

Perform unbalanced steady state load flow or QSTS simulation.

Apply CVR logic to the calculated meter voltages:

- $V_{Avg} < 97.5\%$ AND $\text{VMin} < 95.8\%$: Regulator CMV + 1 V
- $V_{Avg} < 98.8\%$: Regulator CMV − 1 V

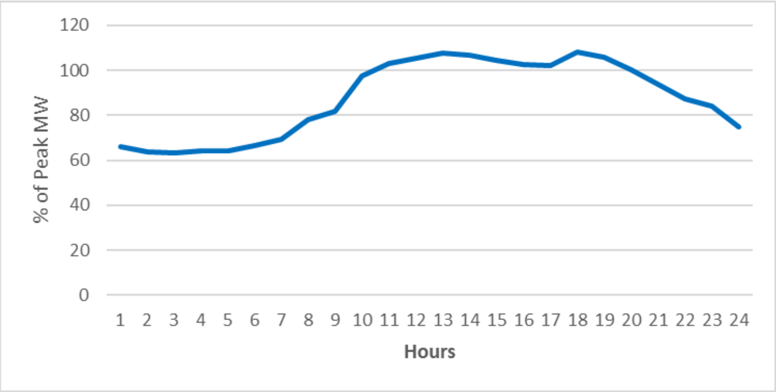
Where, V_{Avg} is the average of the 10 lowest meter voltages and V_{Min} is the lowest meter voltage.

Check whether a CMV change is required based on the CVR logic AND ensure ≤ 1 CMV change is made per hour and voltages are metered every 15 minutes

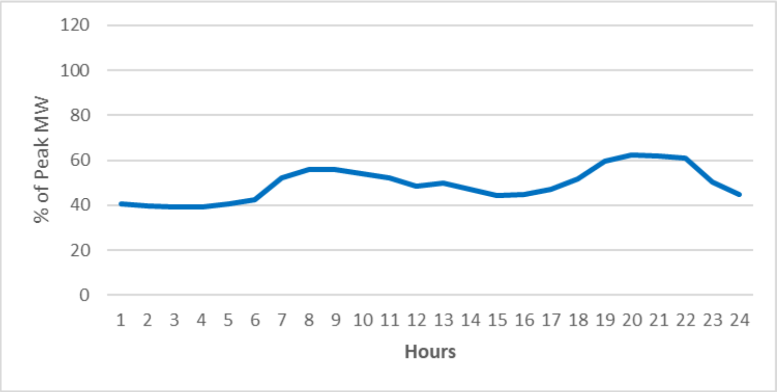
The regulators within this distribution system had a variable CMV controlled by the CVR scheme, a 2 V Bandwidth, and a 30 second tap change delay

QSTS Profiles

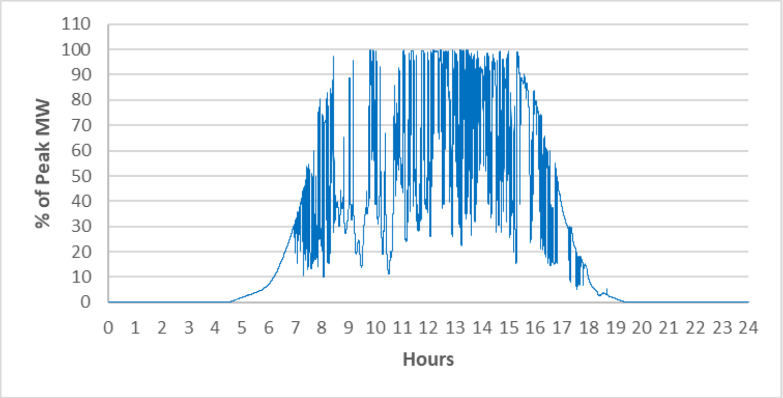
Feeder B, Peak Load, 24 Hr Profile



Feeder B, Light Load, 24 Hr Profile

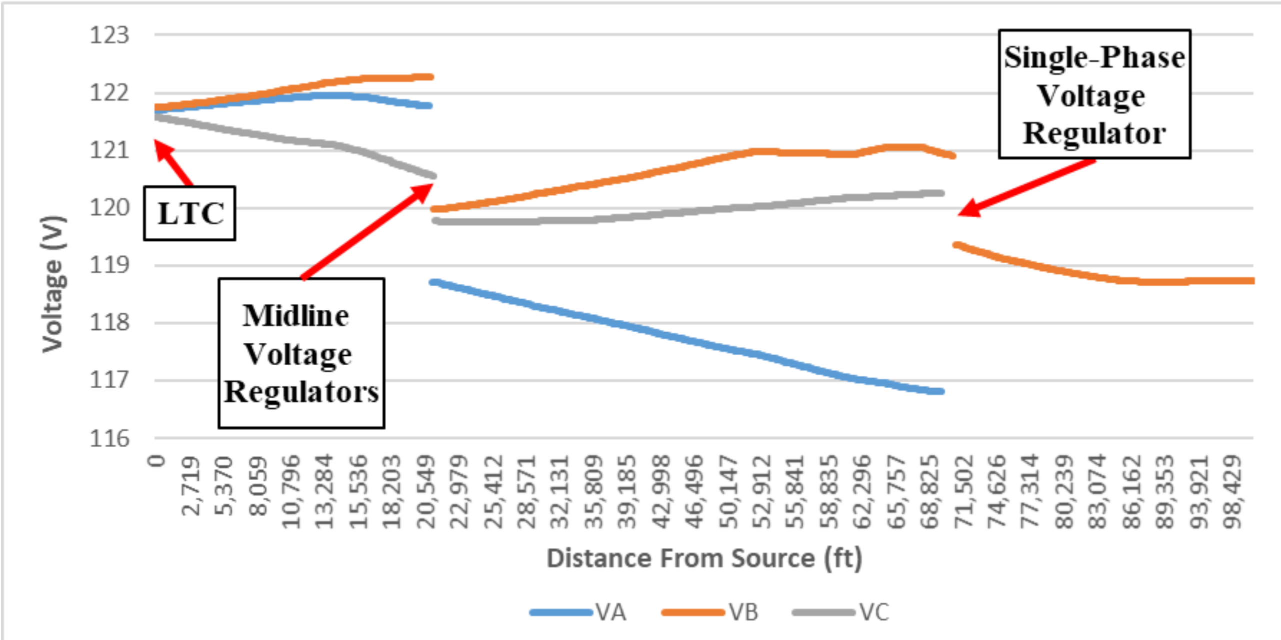


Feeder B, 5 MW DER, 24 Hr Volatile Profile



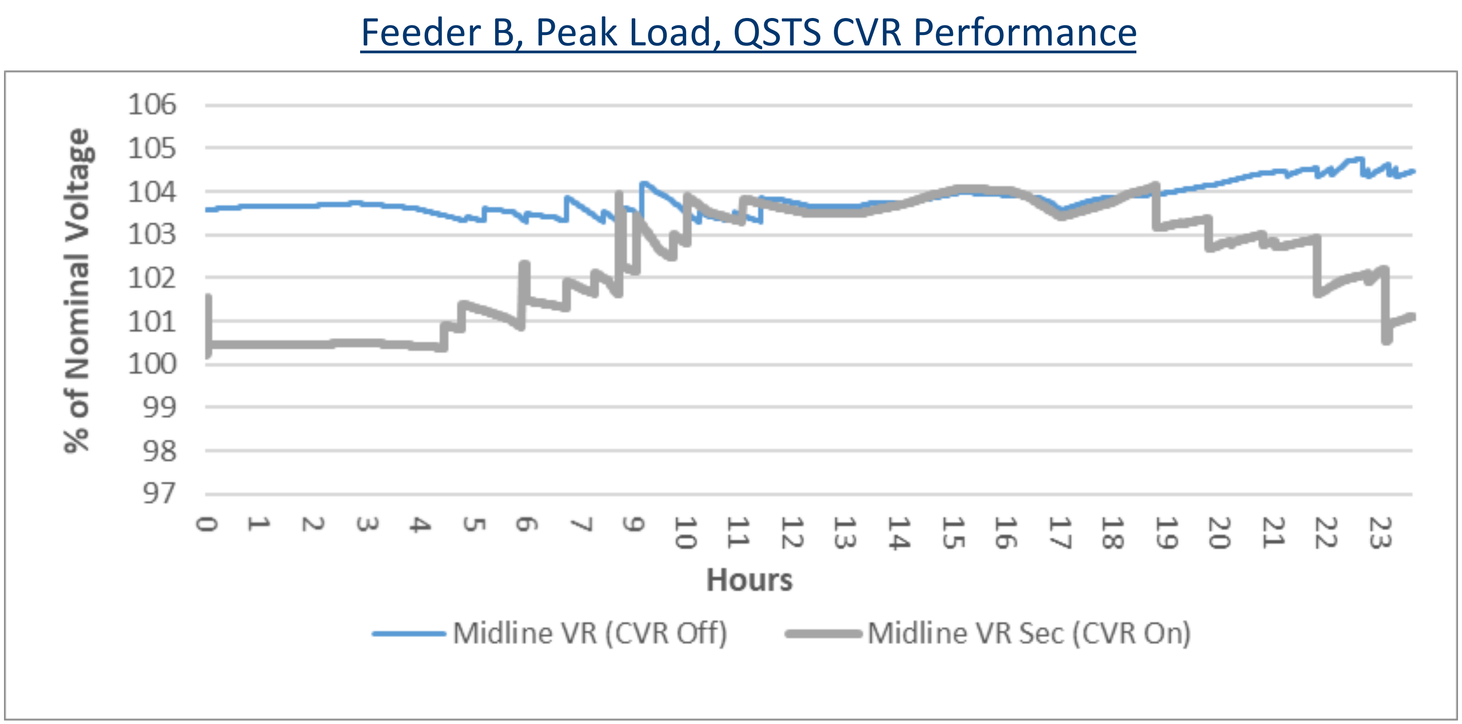
CVR Model Validation

Feeder B, Light Load, Circuit Voltage Plot



Note: Feeder B's nominal CMV setting is 125 V; therefore, this light load profile shows the reduction in CMV due to the CVR scheme

CVR Model Validation



This graph provides a comparison of the midline regulator terminal voltage with and without the CVR scheme enabled.

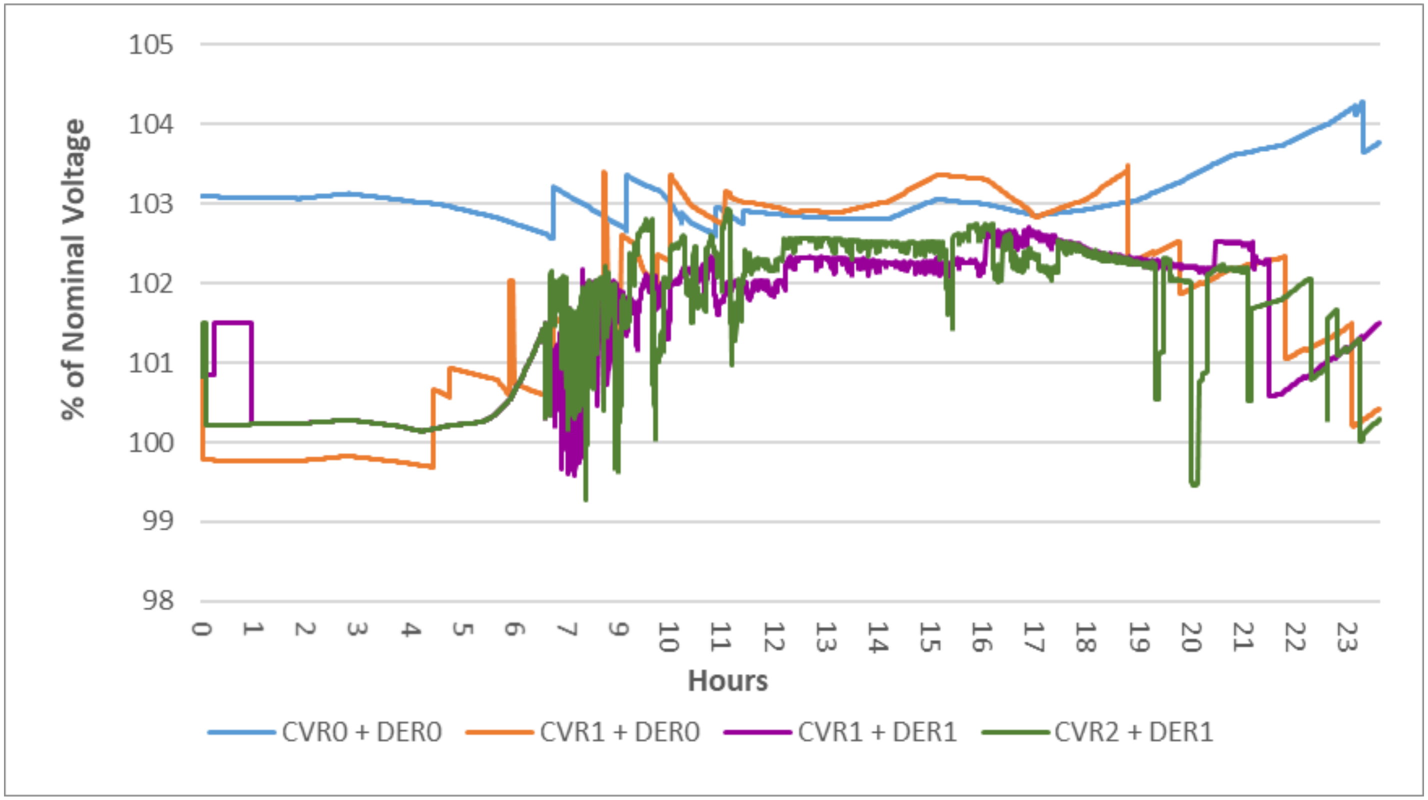
CVR Steady State Results

- CVR0 + DER0: CVR disabled and the 5 MW DER offline
- CVR1 + DER0: CVR enabled and the 5 MW DER offline
- CVR1 + DER1: CVR enabled and the 5 MW DER online
- CVR2 + DER1: CVR enabled with faster communication times and the 5 MW DER online
  - Note that the CVR2 evaluation, with faster communications, is only applicable to QSTS simulations, as the steady state CVR evaluations assumed the system had reached its final state.

Scenarios		Net kVA Flows				
Loading	**Label**	**Substation**	**Feeder A**	**Feeder B**	**Feeder C**	**Feeder D**
Peak	CVR0 + DER0	20,848	6,713	5,296	4,428	4,257
	CVR1 + DER0	20,813	6,713	**5,266**	4,428	**4,253**
	CVR1 + DER1	16,321	6,707	1,645	4,421	4,248
Light	CVR0 + DER0	5,590	1,977	1,437	1,066	1,323
	CVR1 + DER0	5,334	1,937	**1,335**	1,023	**1,241**
	CVR1 + DER1	717	1,928	3,388	1,013	1,231

CVR QSTS Voltage Results

Feeder B, Peak Load, DER Lateral (Near PCC), QSTS Voltage Plot



CVR QSTS Regulator Tapping Results

Scenarios		Tap Count		
Loading	**Label**	**LTC***	**Midline Regulators†**	**Single Phase Regulator**
Peak	CVR0 + DER0	1	25	14
	CVR1 + DER0	2	49	35
	CVR1 + DER1	2	36	35
	CVR2 + DER1	3	140	69
Light	CVR0 + DER0	0	10	8
	CVR1 + DER0	3	29	27
	CVR1 + DER1	2	117	149
	CVR2 + DER1	2	286	205

*The substation LTC is gang operated. Each tap count reflects a tap on all three phases.
†The midline regulators regulate individual phases. Tap counts across these phases are summed.

Future Research

- Add meters to the field for a benchmarking study (insufficient data currently exists)
- Optimize CVR scheme data retrieval intervals for DER scenarios
- Advanced CVR algorithms for handling DER volatility
- DER Volt/Var scheme optimization for better coordination with CVR

Conclusions

- CYME's custom device control scripts allow for dynamic CVR modeling
- The CVR model performed as expected from a qualitative analysis perspective and seemed to provide a better representation of how the system would actually respond
- The interconnection of DER within the dynamic CVR scheme resulted in increased regulator tapping with the Volt/Var scheme and settings that were tested
- The CVR scheme reduced system voltages with the DER online, creating additional headroom and reducing the reactive draw from the DER facility
- Many opportunities for additional optimization seem to exist and these results only show a first cut and demonstrate one viable route for modeling dynamic CVR schemes

Thank You