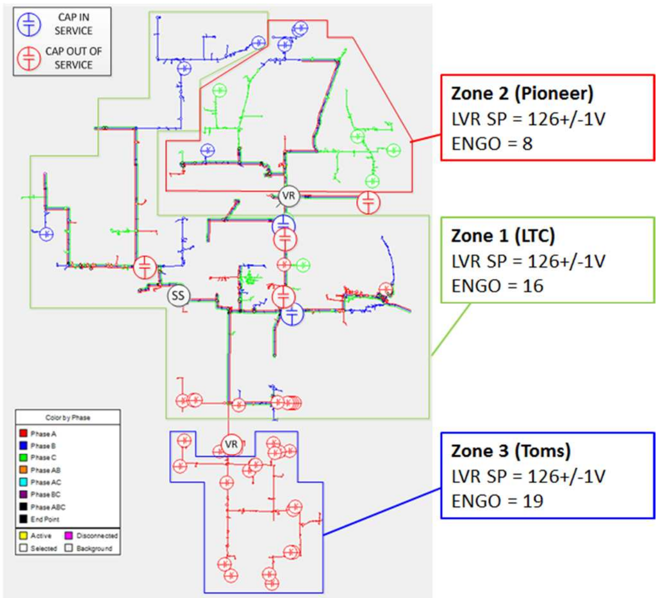

Figure 8: Switx City Voltage Regulating Zone

As shown in Figures 9 and 10, the voltage control margin per zone will vary as function of the loading condition during lightly and heavy loaded seasons. No peak demand reduction could be achieved in zone 1 (56.7% of the substation peak load) during heavy loaded condition.

A minimum weighted average voltage control margin of 1.1% was measured when ENGOs Off and of 3% when ENGOs On.

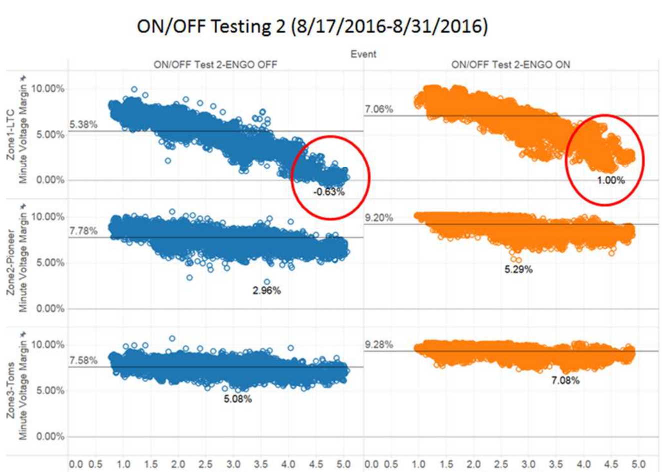

Figure 9: Voltage Margin During ON/OFF (Heavy Loaded)

In case of lightly loaded condition, a minimum weighted average voltage control margin of 4.9% was measured when ENGOs Off and of 7.0% when ENGOs On.

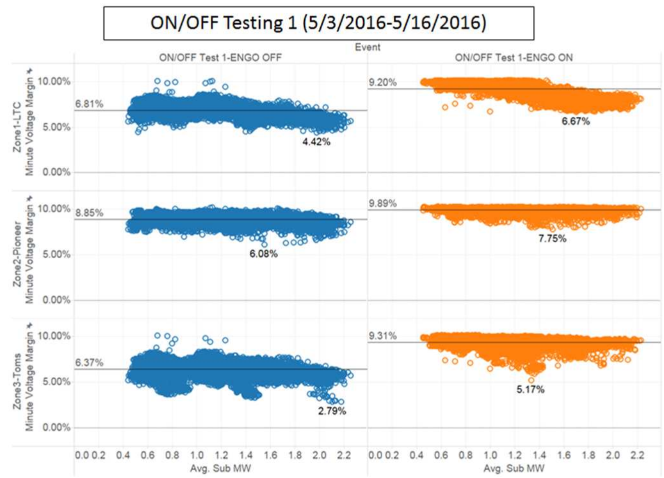

Figure 10: Voltage Margin During ON/OFF (Lightly Loaded)

Based on the field data, a grid edge solution could increment an additional voltage control margin by a minimum of 1.9% up to 2.4%.

As LVR's and LTC's were not automated, Voltage set point was set manually. It was decided to have weekly CVR event. The table 2 shows the different phases of the testing plan defined jointly between UDWI and [illegible] to capture the different value streams such as the available voltage control margin, the voltage variation reduction, the technical loss reduction and finally the CVR factor for Demand.

Event	Date	Zone	LTC/LVR SP	ENGO SP
ON/OFF Test 1-ENGO ON	5/3/2016-5/16/2016	Zone1-LTC	126	126
		Zone2-Pioneer	126	126
		Zone3-Toms	126	126
ON/OFF Test 1-ENGO OFF		Zone1-LTC	126	126
		Zone2-Pioneer	126	126
		Zone3-Toms	126	126
No CVR (Base Case)	6/1/2016-6/8/2016	Zone1-LTC	126	126
		Zone2-Pioneer	126	126
		Zone3-Toms	126	126
CVR Event 1	6/8/2016-6/15/2016	Zone1-LTC	122	122
		Zone2-Pioneer	122	122
		Zone3-Toms	122	123
No CVR (Base Case)	6/15/2016-6/22/2016	Zone1-LTC	126	126
		Zone2-Pioneer	126	126
		Zone3-Toms	126	126
CVR Event 2	6/22/2016-6/29/2016	Zone1-LTC	122	123
		Zone2-Pioneer	122	123
		Zone3-Toms	122	123
No CVR (Base Case)	6/29/2016-7/6/2016	Zone1-LTC	126	126
		Zone2-Pioneer	126	126
		Zone3-Toms	126	126
CVR Event 3	7/6/2016-7/13/2016	Zone1-LTC	122	126
		Zone2-Pioneer	122	126
		Zone3-Toms	122	126
No CVR (**Toms LVR Relocation)** **ENGO Relocation**	7/13/2016-7/20/2016	Zone1-LTC	126	126
		Zone2-Pioneer	126	126
		Zone3-Toms	126	126
CVR Event 4	7/20/2016-7/26/2016	Zone1-LTC	122	123
		Zone2-Pioneer	122	123
		Zone3-Toms	122	123
CVR Event 5	7/26/2016-8/3/2016	Zone1-LTC	121	122
		Zone2-Pioneer	121	122
		Zone3-Toms	121	122
CVR Event 6	8/3/2016-8/10/2016	Zone1-LTC	120.5	121
		Zone2-Pioneer	125	125
		Zone3-Toms	120.5	121
No CVR (Base Case)	8/10/2016-8/16/2016	Zone1-LTC	126	126
		Zone2-Pioneer	126	126
		Zone3-Toms	126	126
ON/OFF Test 2-ENGO OFF	8/17/2016-8/31/2016	Zone1-LTC	126	126
		Zone2-Pioneer	126	126
		Zone3-Toms	126	126
ON/OFF Test 2-ENGO ON		Zone1-LTC	126	126
		Zone2-Pioneer	126	126
		Zone3-Toms	126	126

Table 2: Testing Plan

Six CVR events have been conducted by reducing the LTC/LVR setpoint from 126V to a minimum of 120.5V (4.58%), 121V (4.17%) and 122V (3.33%). The series of weekly CVR events allowed computing the CVR factor for Demand using system entropy methodology (SEM) as shown in Figure 11.

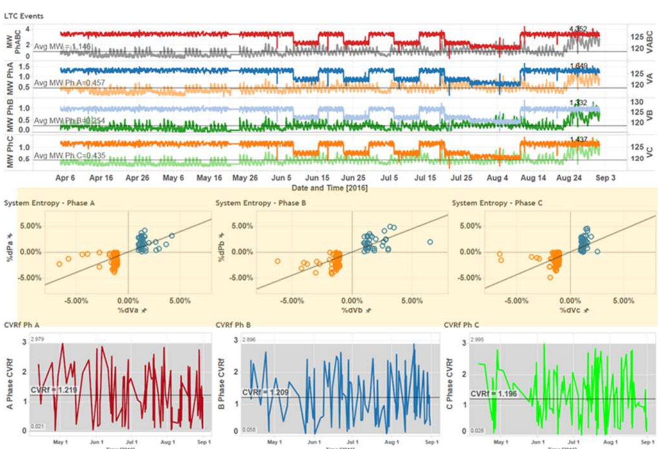

Figure 11: Computation of CVR Factor for Demand

AMI system was used (hourly AMI data) to monitor voltage at meter to ensure that all nodes stay within ANSI limits during peak demand reduction.

It should be noted that irrigation loads during peak load could be a limiting factor of a CVR program. Therefore it is recommended to control irrigation loads during periods of peak demand and implement an irrigation load program through a pay for performance agreement. Participating sites could be compensated for shutting off irrigation load for specific time periods determined by UDWI REMC, and would be provided day-ahead notice of dispatch events. By reducing the voltage by 4.58% allows to mitigate costs and economic losses by 5.54% (4.58% x 1.21) that are associated with serving peak demand by operating at the low end of the acceptable voltage supply without affecting consumer services.

It was also measured that technical losses have been reduced by 1.48%.

8. Conclusion

By applying grid edge solution to reduce peak demand on distribution feeders, utilities can mitigate the costs and economic losses that are associated with serving peak demand. The deployed solution brings real-time *grid edge visibility,* grid edge *control,* and *"LV protection shield". It* enables an enhanced VVO/CVR which enhance real time operations such as emergency and routine peak reduction.

The grid edge solution delivers an average control margin of ≈ 5% during Peak Condition (≈6% Peak MW Demand Reduction) and is suitable for future support to PV penetration.

The investment Benefit-Cost Ratio was is higher than 3 of savings per every dollar invested, and the Internal Rate of Return over 7 years higher than 29%.

The Sentient Energy solution is now a proven technology with over 2,100 units deployed since 2012. Full integration with existing assets used for voltage optimization and SCADA system is ease thanks to a scalable, easy to implement and fast roll-out.

ENGO deployment is based either on AMI field data or load flow analysis. Therefore the location and number of ENGO units is done easily and in a few hours as there is no need for other backend system or interfaces. GEMS is a hosted solution and all ENGO field data are collected in the cloud at the moment an ENGO device goes live. Conventional VVO techniques would require investment in reflecting and maintaining an accurate network model and topology.

ENGO units are maintenance free and have a 15 years lifetime. The technology can reduce peak demand by as much as 5 to 7%, as shown below, without affecting consumer services. Conventional CVR techniques, by comparison, reduce peak demand by just 1.5 to 2.5%.

References

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[3] D. Divan, R. Moghe, A. Prasai, "Power Electronics at the Grid Edge: The key to unlocking value from the smart grid" in IEEE Power Electronics Magazine, Dec. 2014.

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