Study Committee C6-PS2

ACTIVE DISTRIBUTION SYSTEMS AND DISTRIBUTED ENERGY RESOURCES

Paper ID - 10523

Volt-VAR Optimization and Benchmarking in a Pilot Project

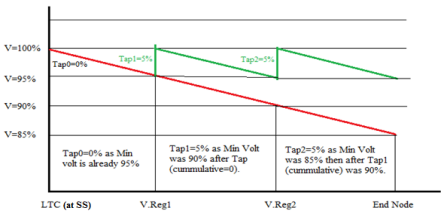
Ahmed SABER and Tanuj KHANDELWAL, ETAP, USA
Lo KIM and Calvin CHING, TNBR, Malaysia

Motivation

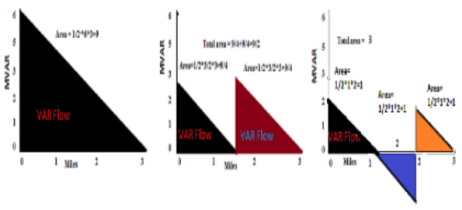
- Conservation voltage reduction (CVR) or peak demand reduction
- Efficient distribution grid
- Less CO_2 emission
- Investment deferral for network upgrade
- Part of ADMS

Control Variables

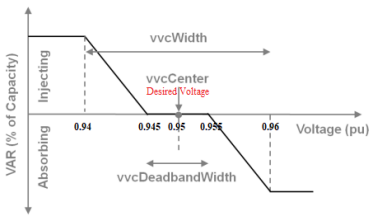
- Tap/LTC, Voltage Regulator
- Distribution Transformer (if poss.)



- Switch Capacitor



- Smart Inverter (PV, Battery)

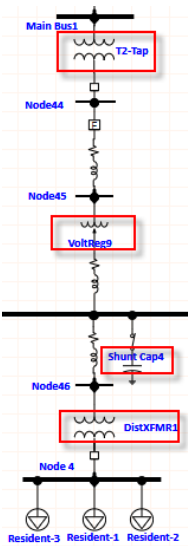


Constraints

- Voltage limit (e.g., ANSI C.84.2 ±5%)
- Thermal limit

Optimization

- Unbalanced optimization
- Heuristic optimization
- Steady state power flow
- Both Loop and radial system
- System with DERs



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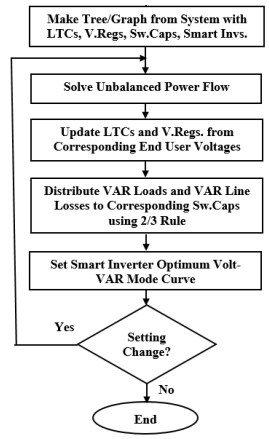

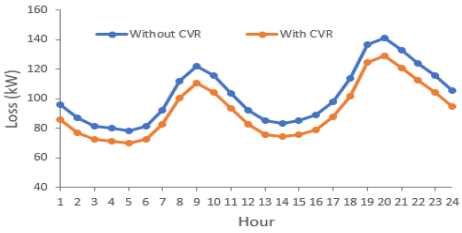

Fig. 1. Loss reduction in CVR

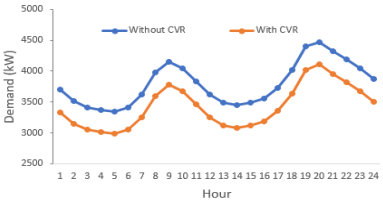

Fig. 2. Demand reduction in CVR

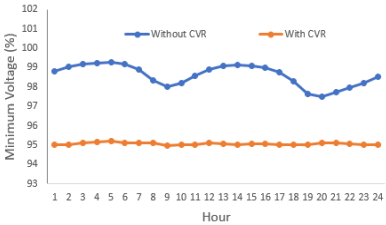

Fig. 3. Voltage profile with and without CVR

- **Around 5% to 10% demand reduction**
- **Around 1% to 2% CVR factor**

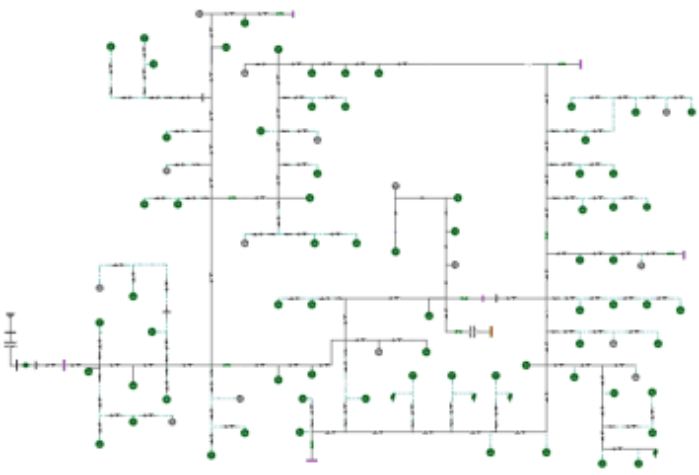

Fig. 4. IEEE 123-node test feeder in ETAP

Feeder	Initial Power (kW)	Final Power (kW)	Difference (kW)
IEEE123-Feeder	3660.82	3289.88	-370.94

Feeder	Initial Min. Volt (%)	Final Min. Volt (%)	Difference (%)
IEEE123-Feeder	97.53	95.02	-2.52

Device ID	Initial Tap (%)	Final Tap (%)	Change (%)
VoltReg1 - Phase A	4.38	0.00	-4.38
VoltReg1 - Phase B	4.38	0.00	-4.38
VoltReg1 - Phase C	4.38	0.00	-4.38
VoltReg2 - Phase A	-0.63	-1.88	-1.25
VoltReg3 - Phase A	0.00	-0.63	-0.63
VoltReg3 - Phase C	0.00	-0.63	-0.63
VoltReg4 - Phase A	5.00	1.25	-3.75
VoltReg4 - Phase B	5.00	1.25	-3.75
VoltReg4 - Phase C	5.00	1.25	-3.75

Capacitor ID	Initial kvar	Final kvar	Difference (kvar)
CAP1	-0.05	0.05	0.10
CAP2	-0.05	0.05	0.10
CAP3	-0.05	0.05	0.10
CAP4	-0.60	0.56	1.16

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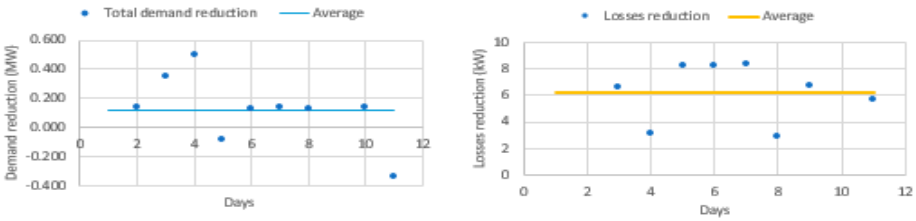
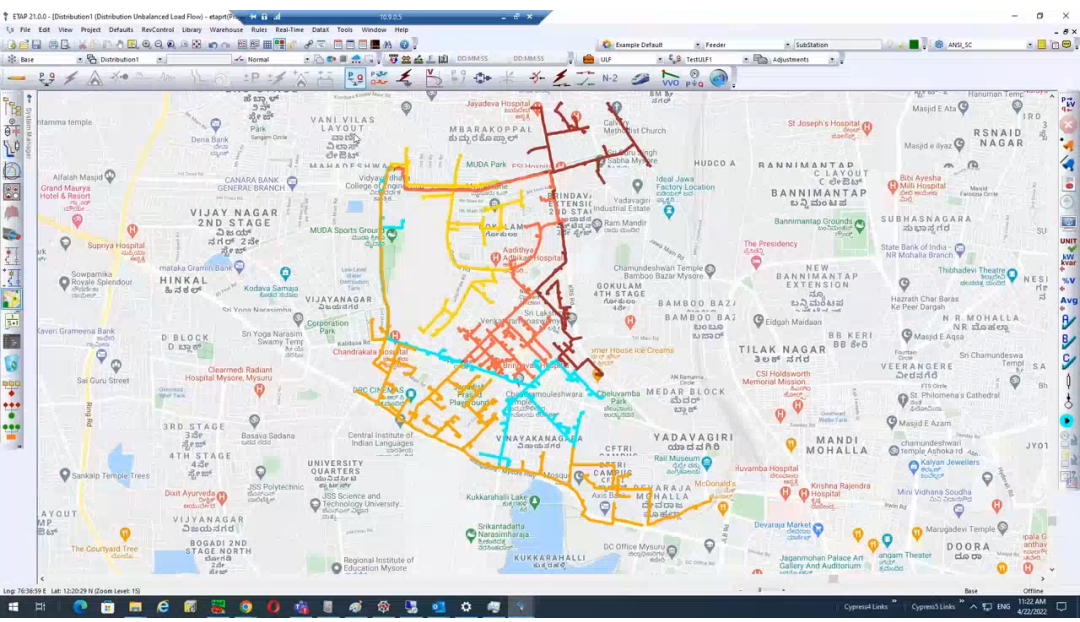


Fig. 5. Demand and loss reduction using CVR at a real-time pilot project in ETAP



Conclusion

- Save energy and cost
- Reduce CO_2 footprint
- Evaluate benefits for way forward
- Increase efficiency
- Reduce equipment cost
- Grid code compliant