Voltage Management on Low Voltage Busbars

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LV Network Solutions Project – Dissemination Event

Outline

- Project objectives
- Modelling of voltage control devices and LV networks
- Analysis of network site trial monitoring data
- Voltage regulation studies
- Network Capacity studies
- Conclusions

Project Objectives

- This project deployed a range of voltage management methods and techniques across several distribution substations within Electricity North West Limited.

- These technologies were assessed in terms of their ability to effectively regulate line voltage in real-time in a safe and economical manner.

- In addition, the ability of compensating devices to correct for power factor and feeder power quality was also assessed.

Options of voltage management in LV networks

- Voltage regulation devices
  - Two distribution transformers with on-load tap changers (OLTCs) (from MR)
  - Two voltage optimisers (from powerPerfector Plus)

- Voltage/Power quality
  - Two active harmonic filters (from ABB filters)

- Reactive compensation
  - LV capacitors (from ABB)

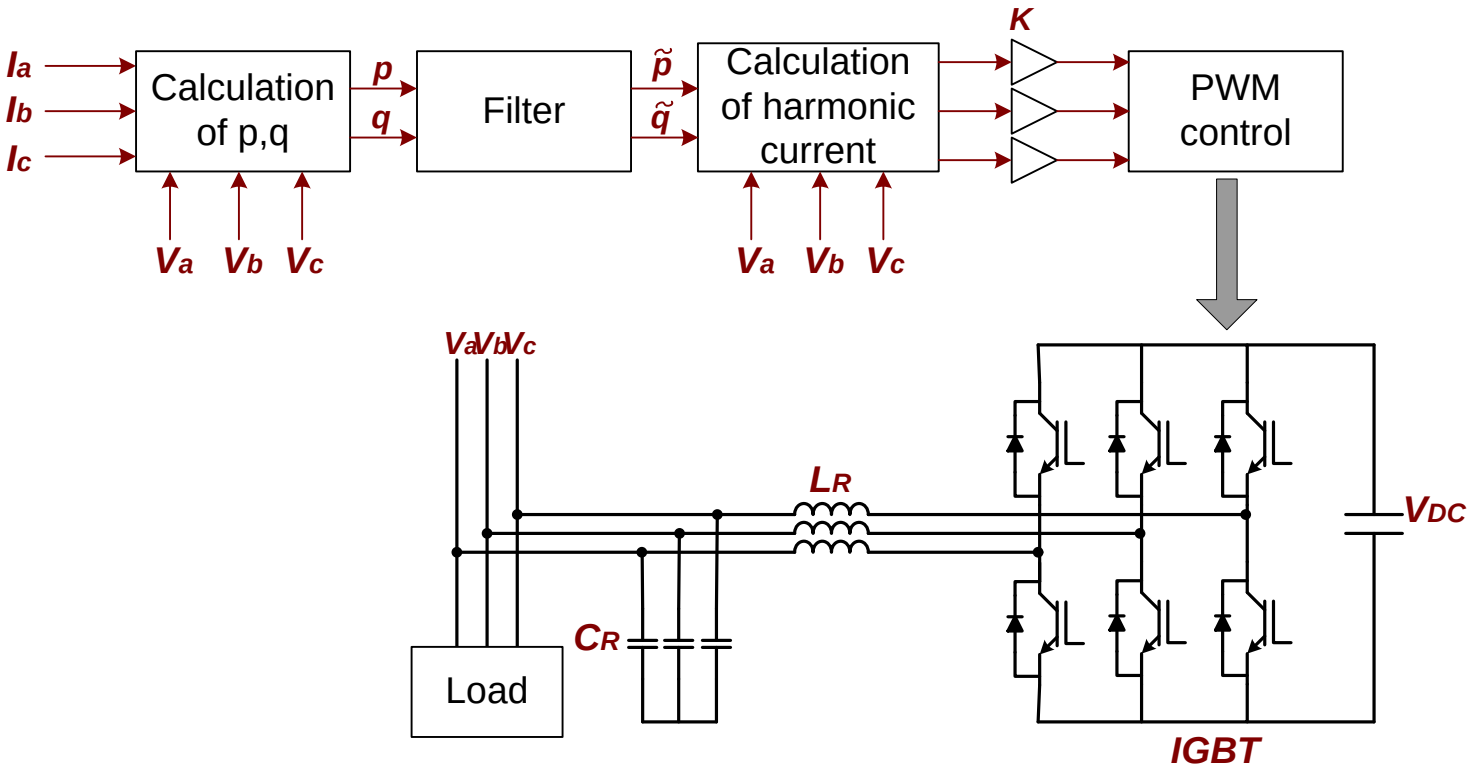
- Energy storage device (through simulations)

Modelling of Devices and Networks

- Active filter
- powerPerfector Plus unit
- Distribution transformer with OLTC
- LV network

Modelling of Active Filter

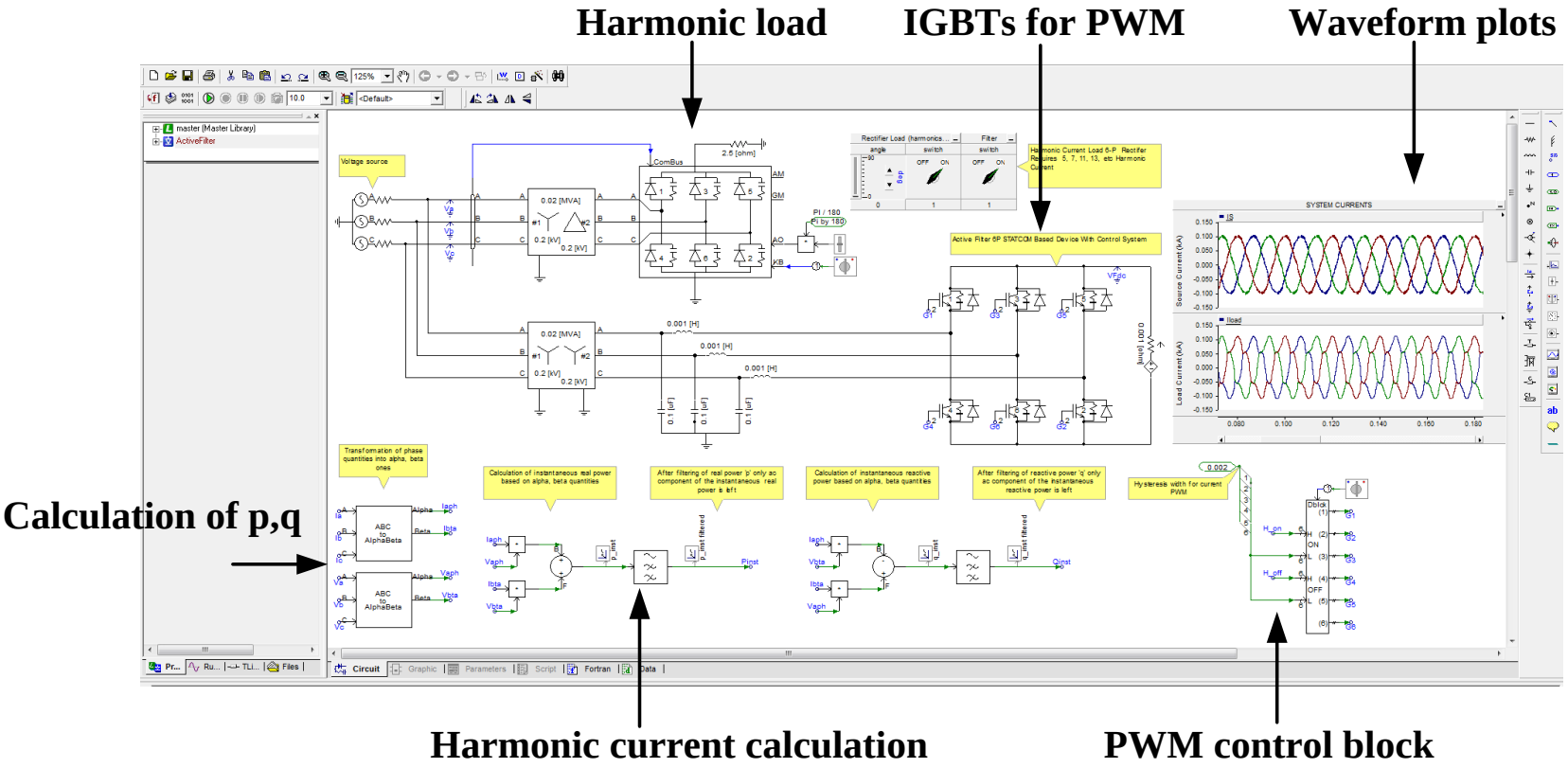
- Model was developed in PSCAD/EMTDC based on the control algorithm in [1]



[1] H. Fujita, and H. Akagi, "A practical approach to harmonic compensation in power systems - series connection of passive and active filters," *IEEE Transactions On Industry Applications*, VOL. 21, NO. 6, 1991.

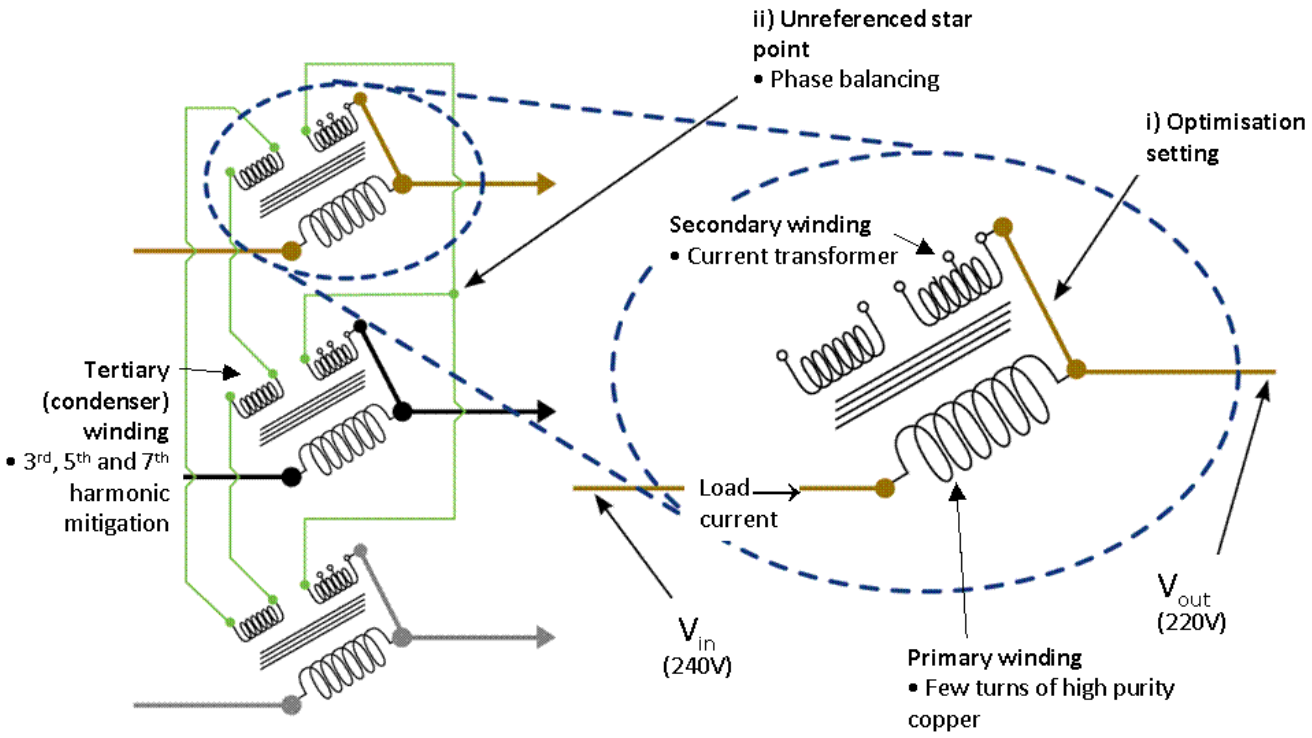
Modelling of Active Filter (*cont.*)

- Active filter in PSCAD



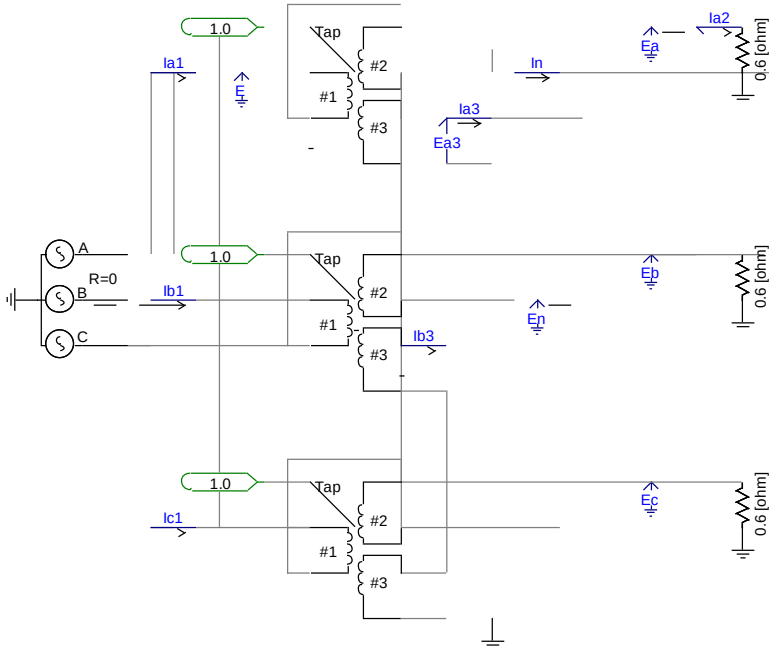
Modelling of powerPerfector Unit

- The unit was connected at the distribution transformer LV side to regulate the voltage on one LV feeder.

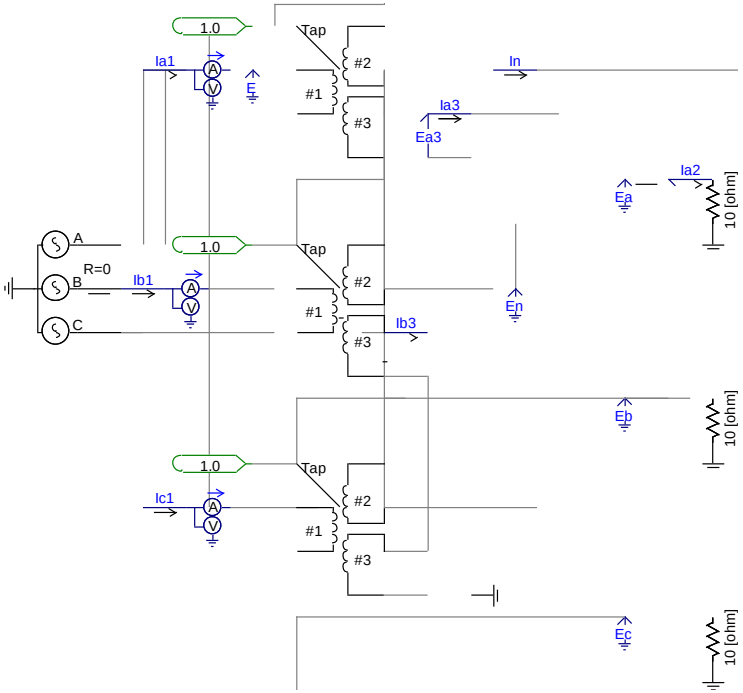


Modelling of powerPerfector Unit (*cont.*)

- Model in PSCAD



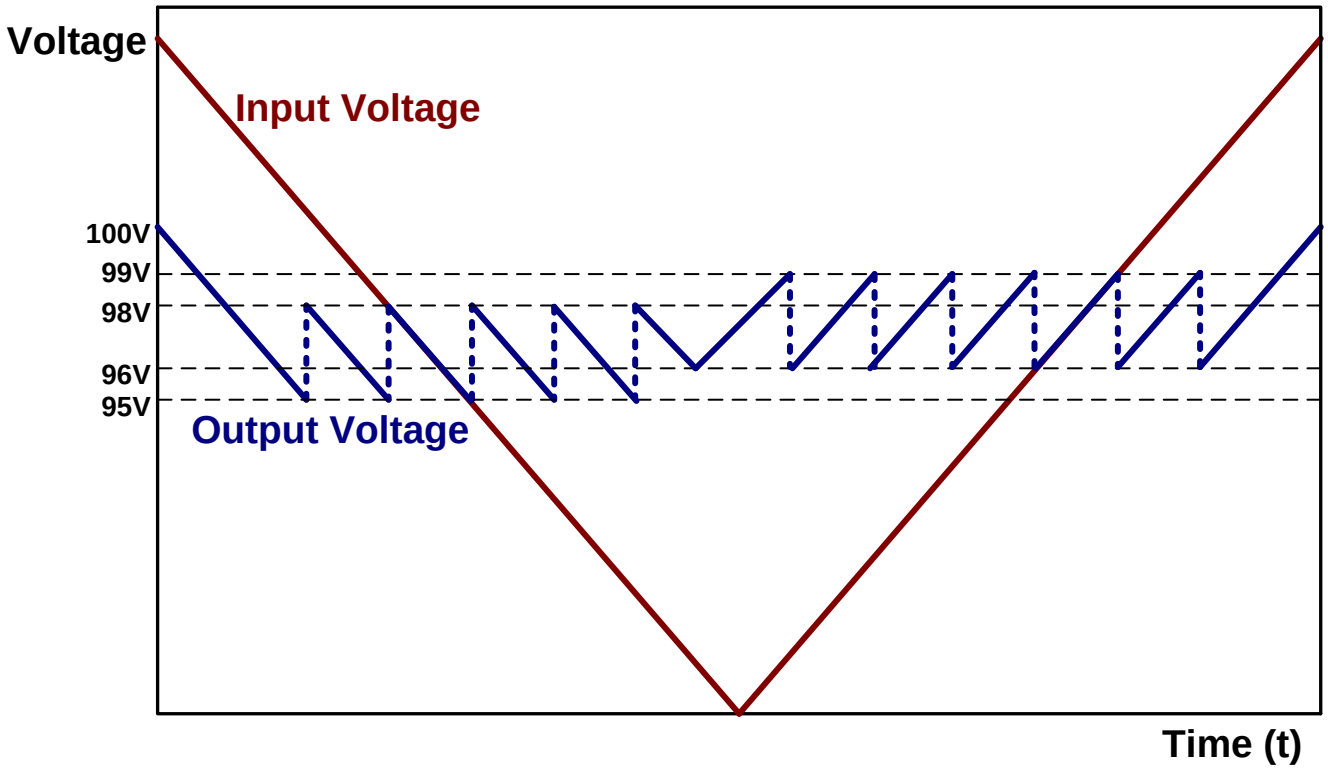
(a) Step down function



(b) Boost function

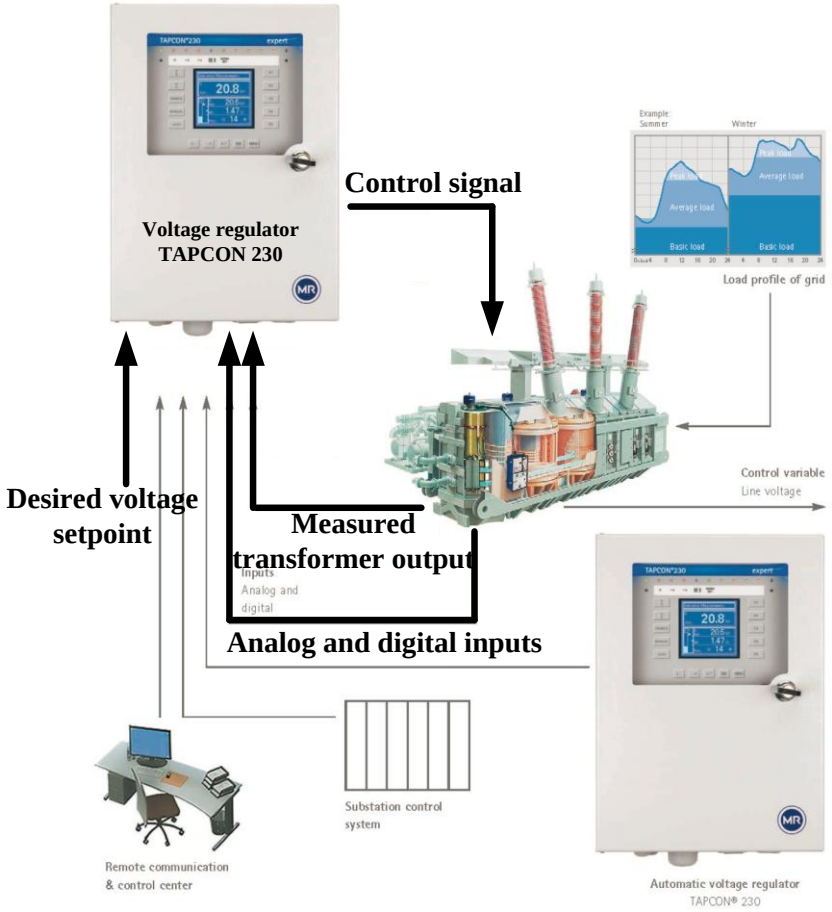
Modelling of powerPerfector Unit (*cont.*)

- The powerPerfector Plus unit is designed to maintain a stabilised output voltage for the load.



Modelling of Distribution Transformer with OLTC

- MR voltage regulator TAPCON 230 pro was installed to control OLTC.



Modelling of LV Networks

- Simulate six LV networks

Dunton Green

Edge Green Lane

Greenside Lane

Howard St

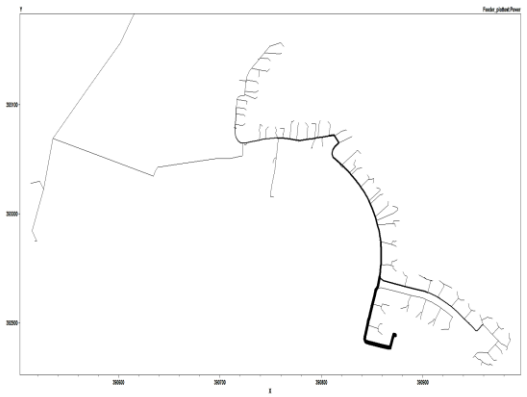
Leicester Ave

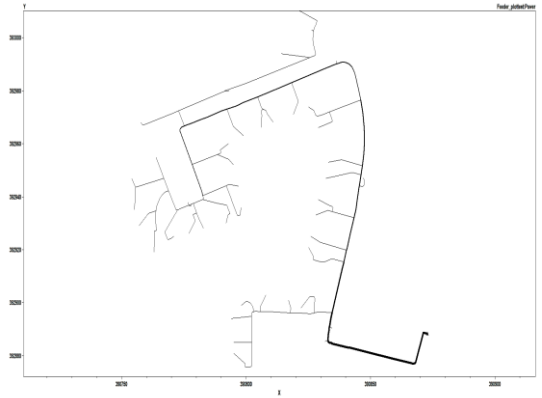
Landgate

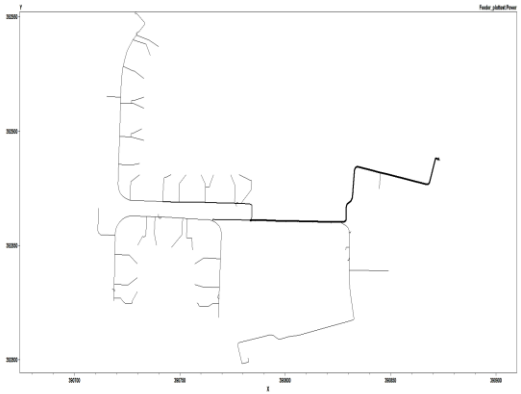
Modelling of LV Networks (*cont.*)

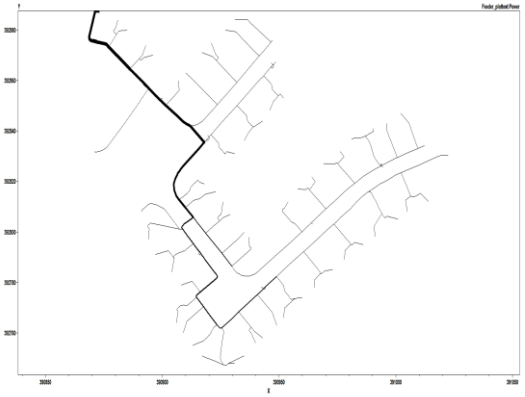
- Each network consists of several LV feeders.

Dunton Green



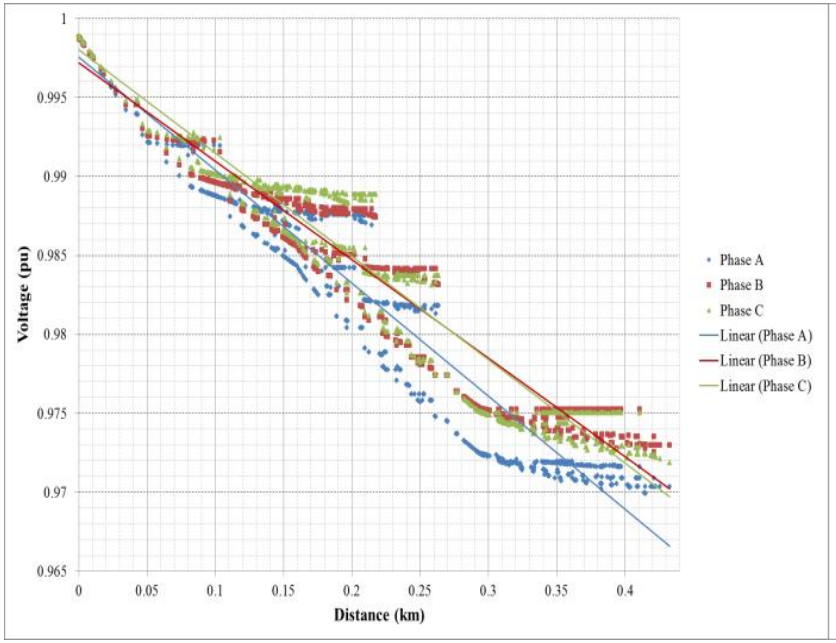




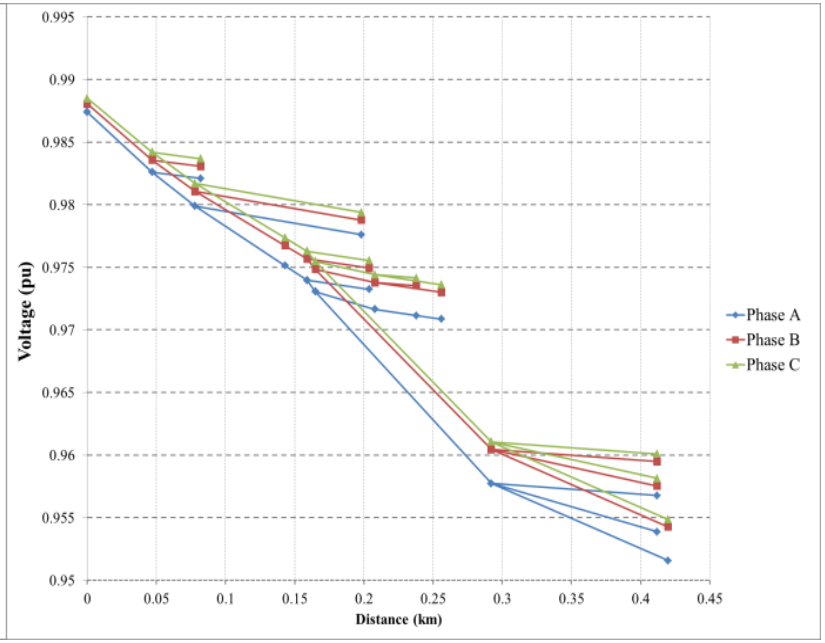


Modelling of LV Networks (*cont.*)

- To study the performance of voltage management devices, each LV feeder has been simplified and modelled in PSCAD.



Voltage profile of Leicester feeder (in OpenDSS)



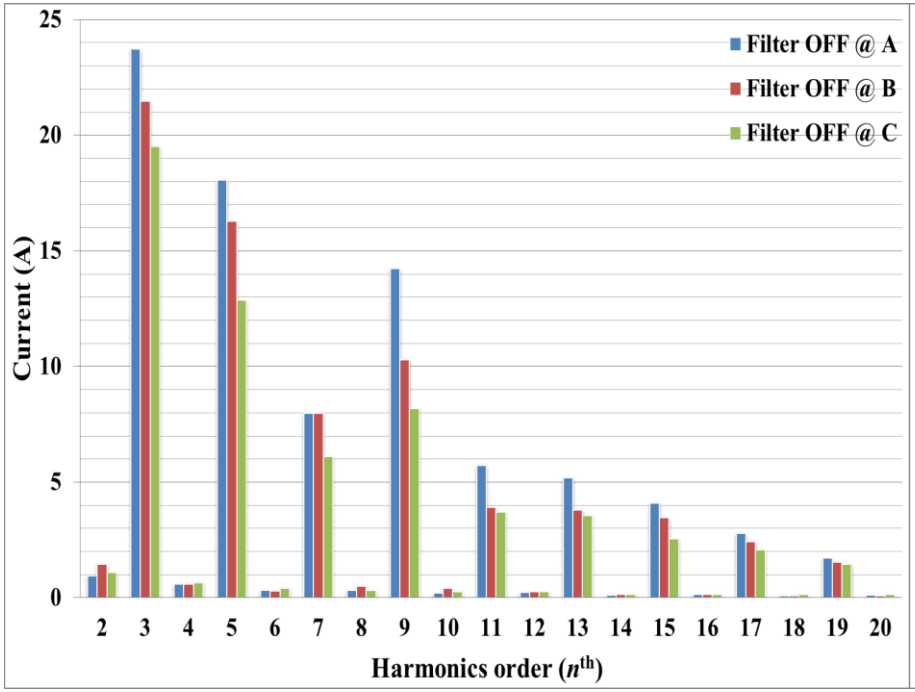
Voltage profile of Leicester feeder (in PSCAD)

Network Site Trial Monitoring Data

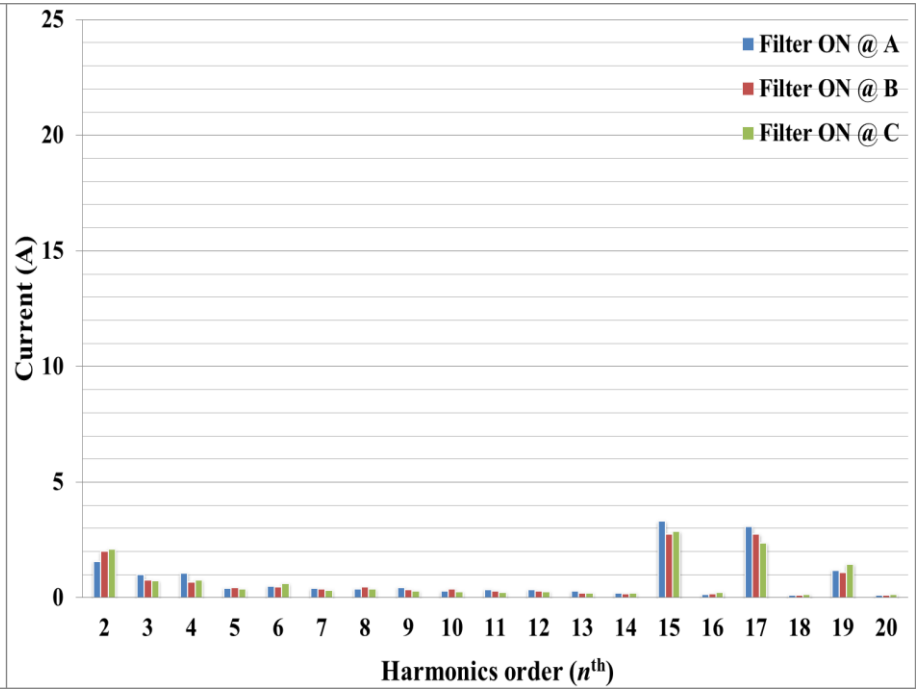
- Active filter site trial
  - Dunton Green substation
  - Howard Street substation
- powerPerfector (pP) site trial
  - Greenside Lane substation
  - Edge Green Lane substation
- Distribution transformer with OLTC site trial
  - Landgate substation
  - Leicester Avenue substation

Active Filter Site Trial

- Investigate the ability to filter out network harmonic currents



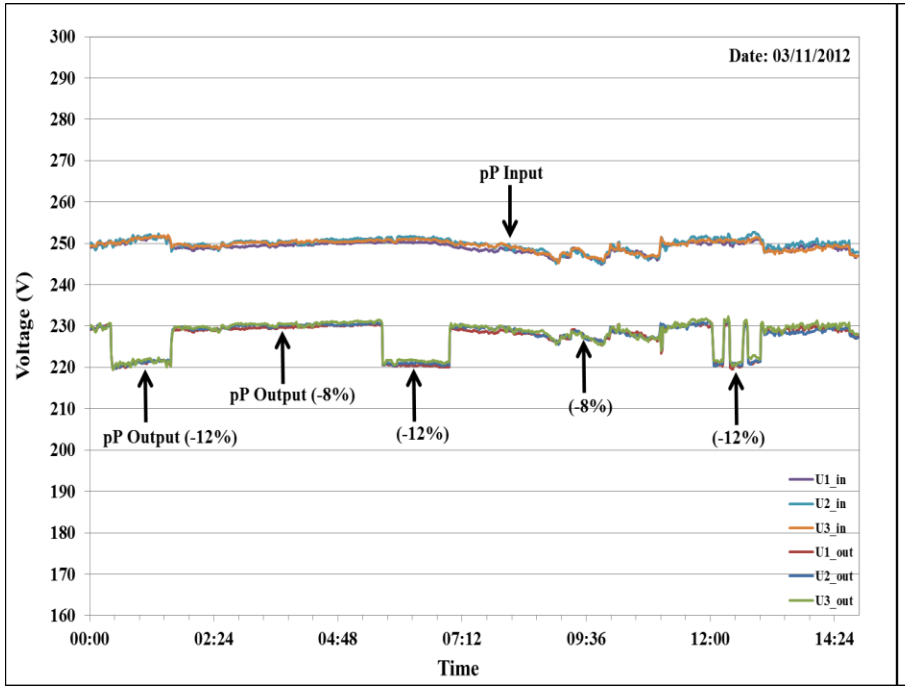
Filter switched off



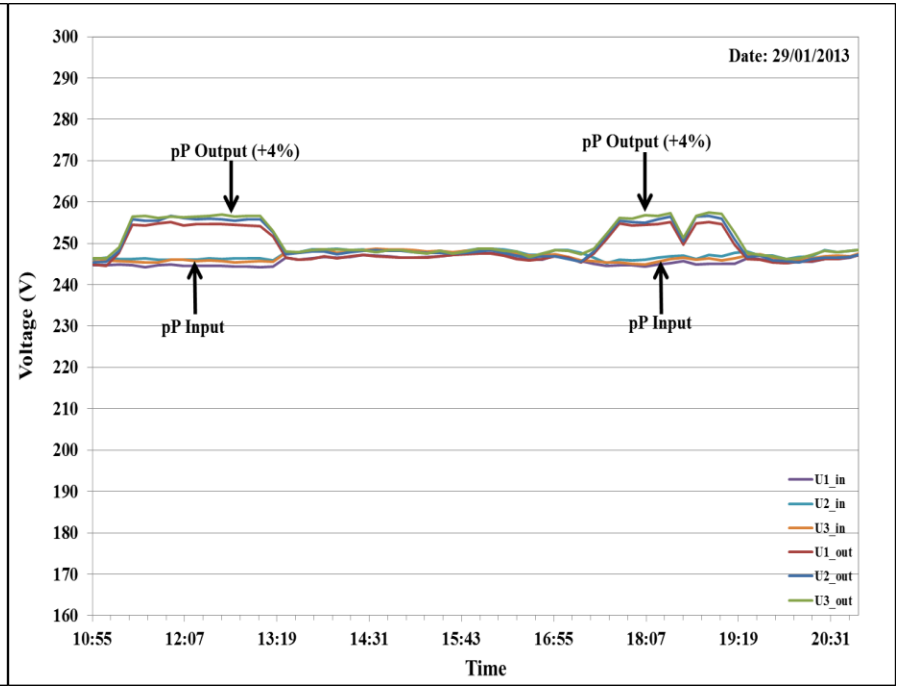
Filter switched on

powerPerfector Site Trial

- Assess the ability to decrease/increase feeder voltage



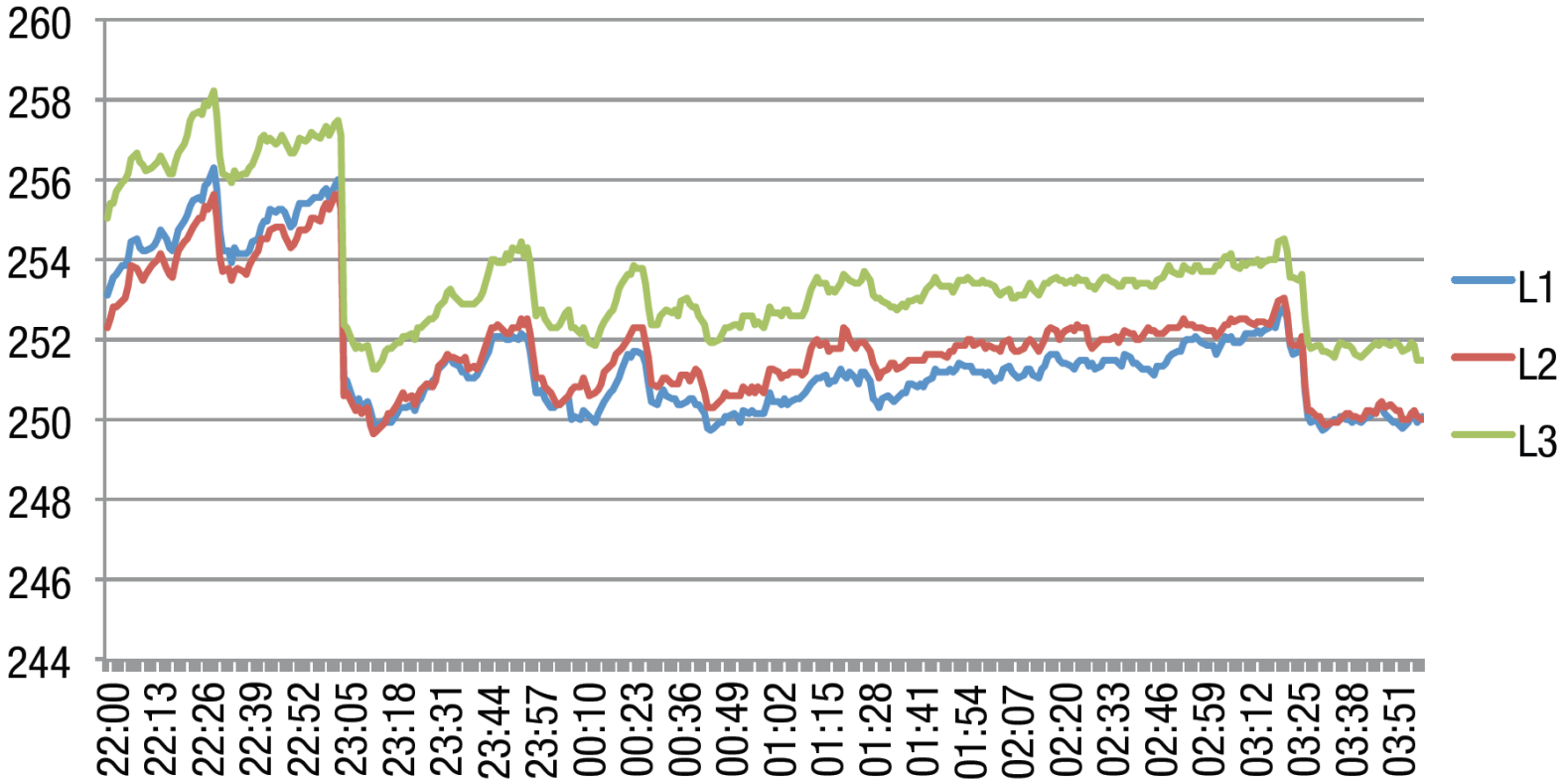
Step Down Mode



Boost Mode

Distribution transformer with OLTC Site Trial

- OLTC had performed approximately 80 times in a 3 month period



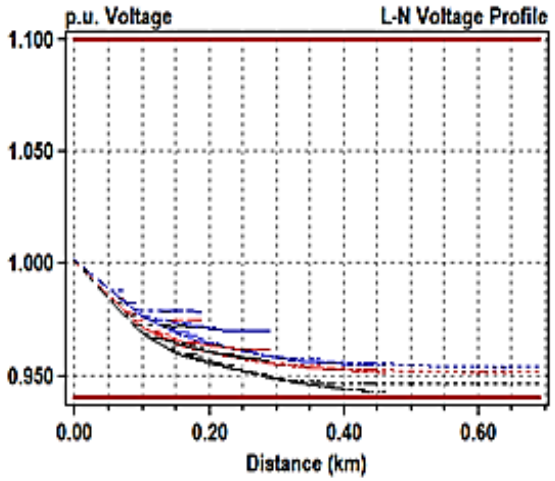
Voltage Regulation Studies

- Assess the effectiveness of control devices on regulating voltage
  - Distribution transformer with OLTC
  - LV capacitor
  - Energy storage device

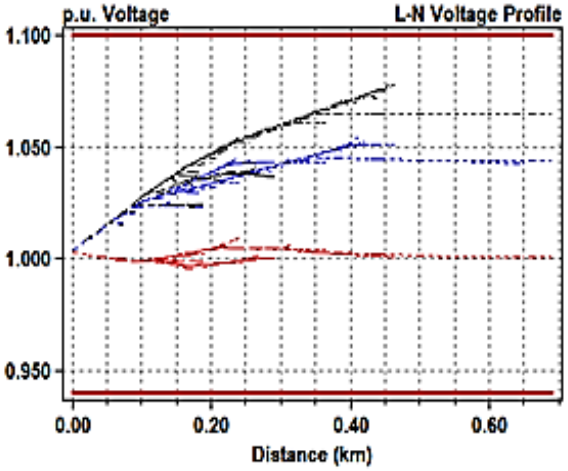
- Investigate the LV feeders with different load levels and photovoltaic generator (PV) penetration

Distribution Transformer with OLTC

- With large PV penetration, employ OLTC transformer to reduce the voltage at the substation so that the voltages along the feeder could be maintained within the limits.

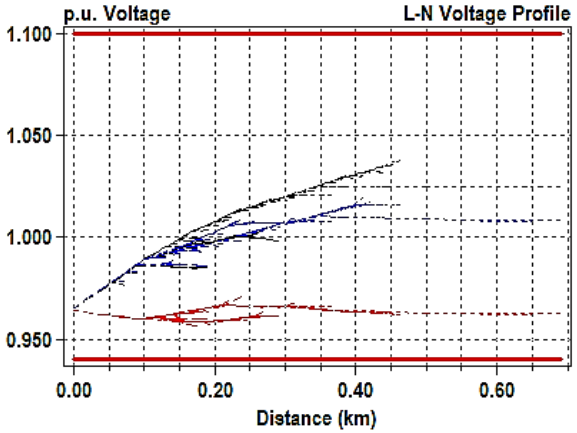


without PV penetration



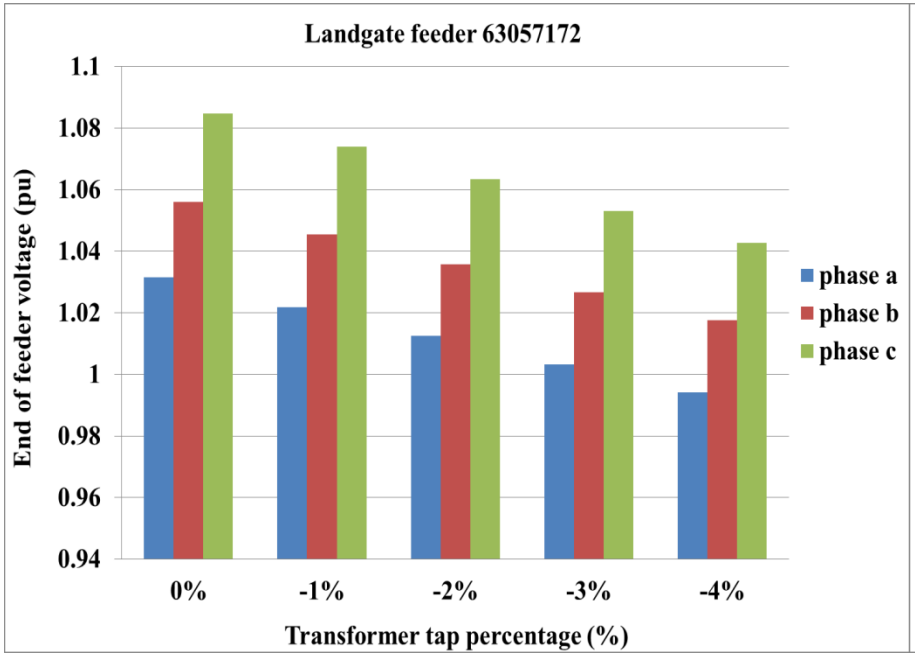
with PV penetration

-4% tap position

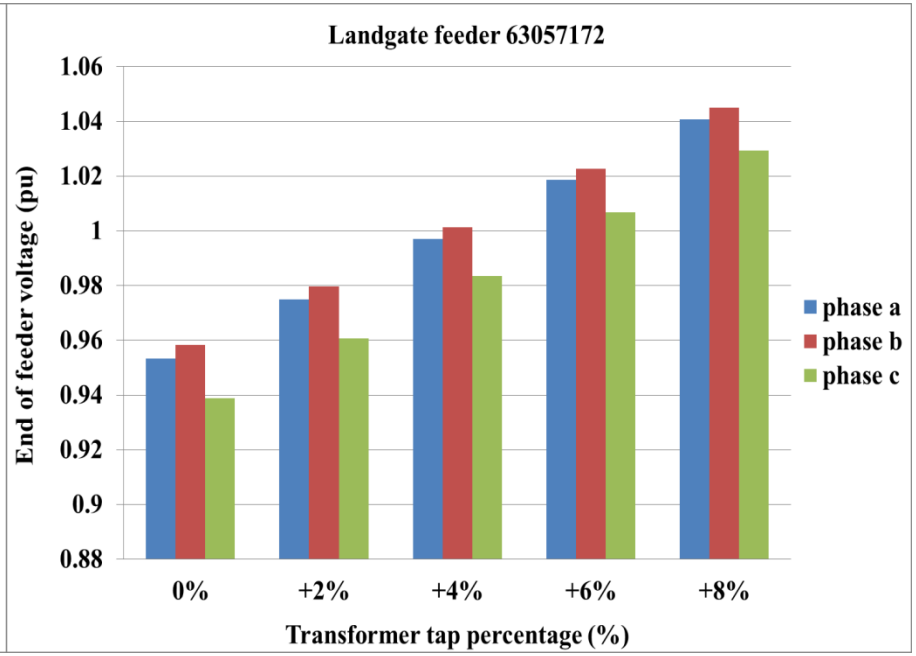


Distribution Transformer with OLTC (*cont.*)

- The OLTC transformer is able to reduce or increase the substation voltage under different network conditions.



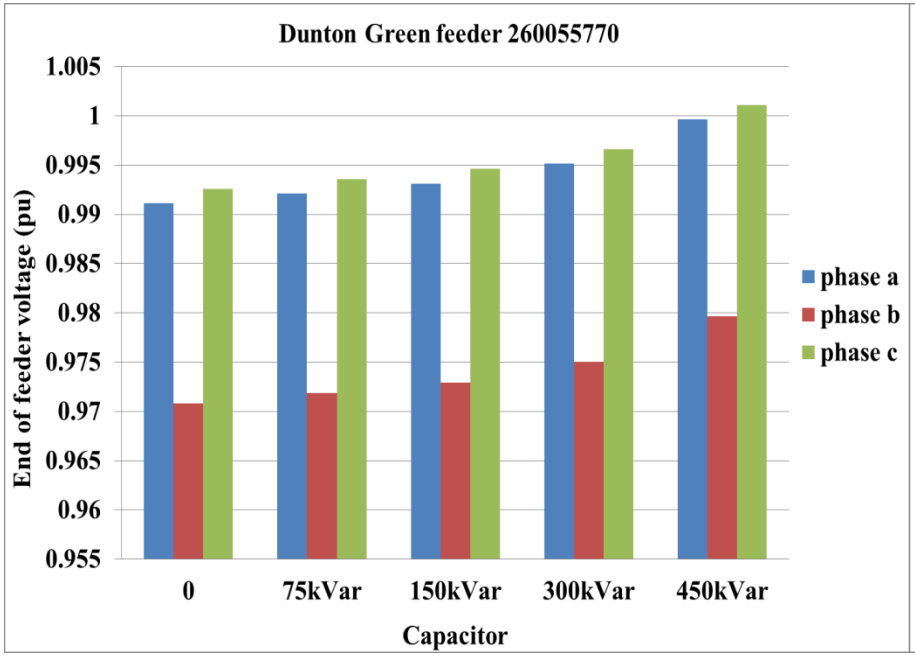
at high PV outputs



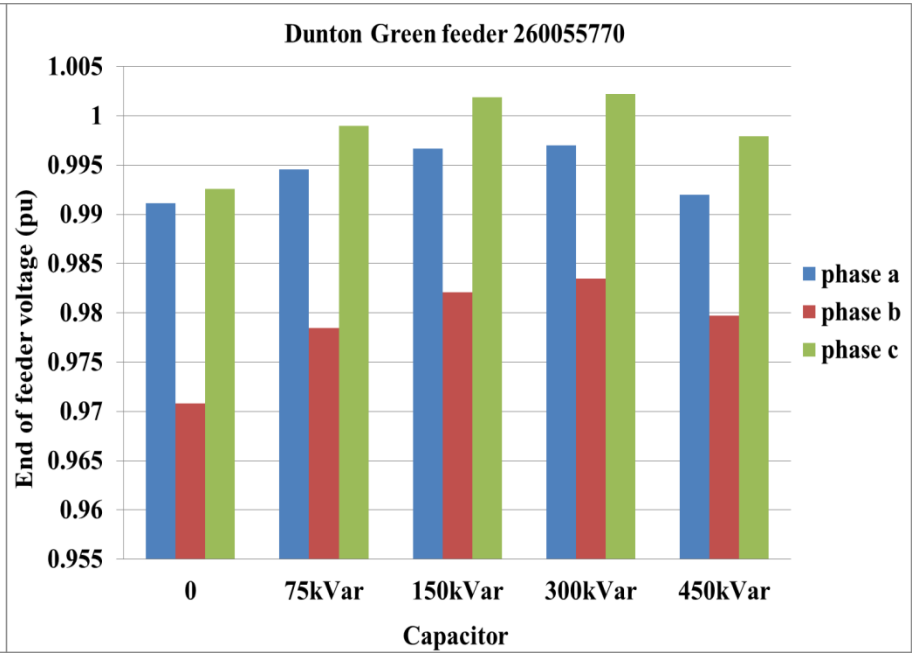
at reduced PV outputs

LV Capacitor

- The installation of capacitor banks on the feeder could produce reactive power to compensate the voltage drops.



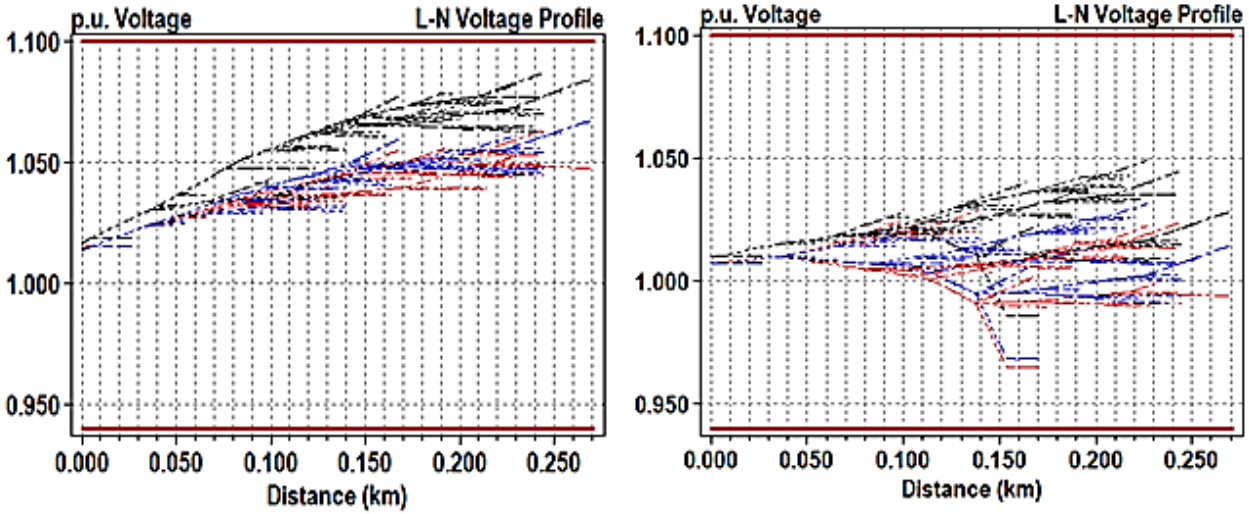
Installed at substation



Installed at feeder mid-point

Energy Storage Device

- When the PV generation is high while demand is low, the energy storage devices could be charged to absorb the excess power.



(a)

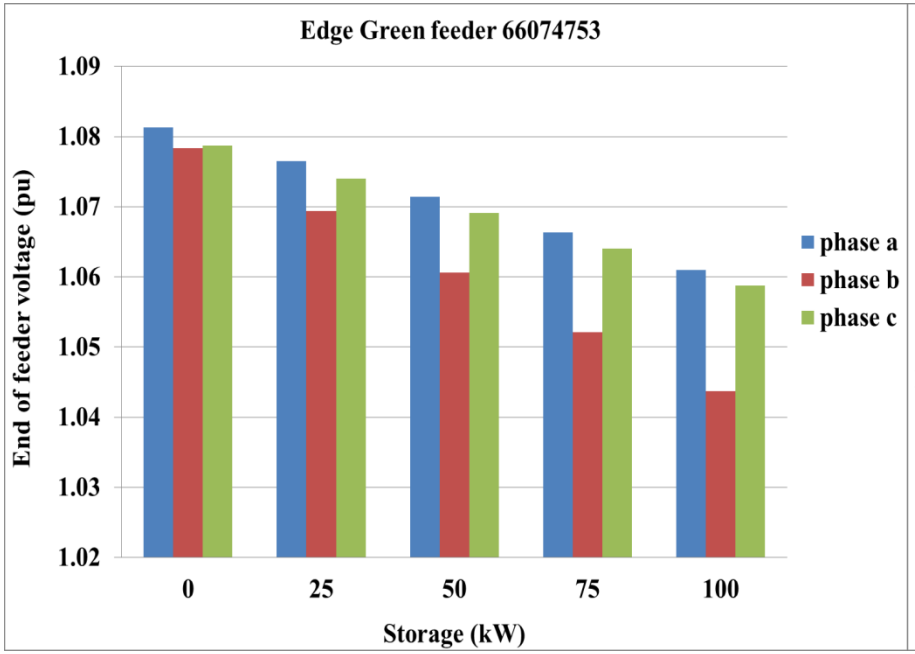
without storage

(b)

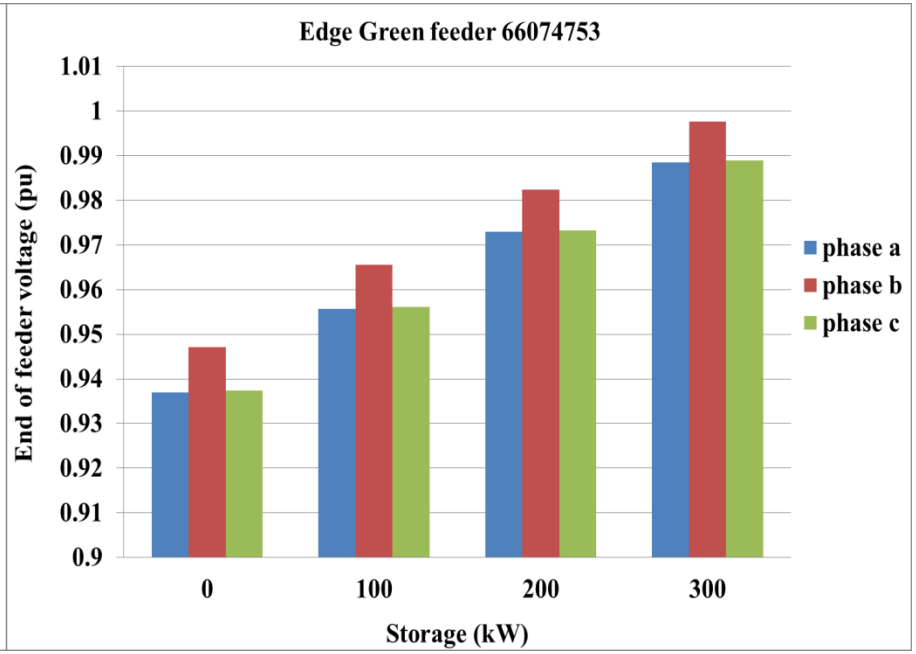
with storage installed at mid-point

Energy Storage Device (*cont.*)

- The storage unit can be configured to absorb the excess power generated by PVs and release the power during periods of peak demand.



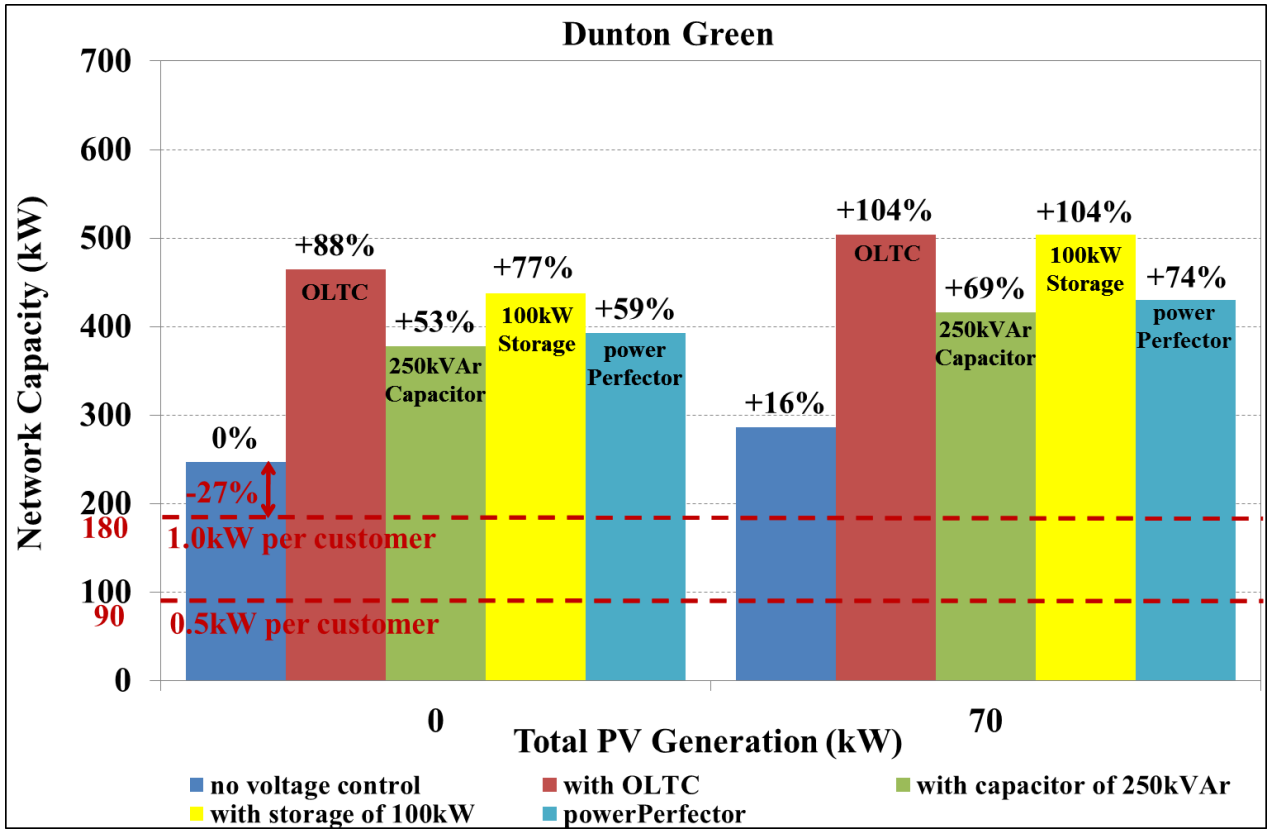
Charge mode



Discharge mode

Network Capacity Studies

- Investigate which solution increases more network capacity while maintaining the voltage level within the statutory limits.



Conclusions

- Establish learning on a range of alternative techniques for management of voltages on low voltage networks
- Deployment of new technology on the network for improved voltage regulation and measurement of the effect on voltage profiles in response to changes in demand
- Assessment of voltage management device effectiveness
- Investigate the changes in network capacity with different voltage management techniques

Thanks for your time