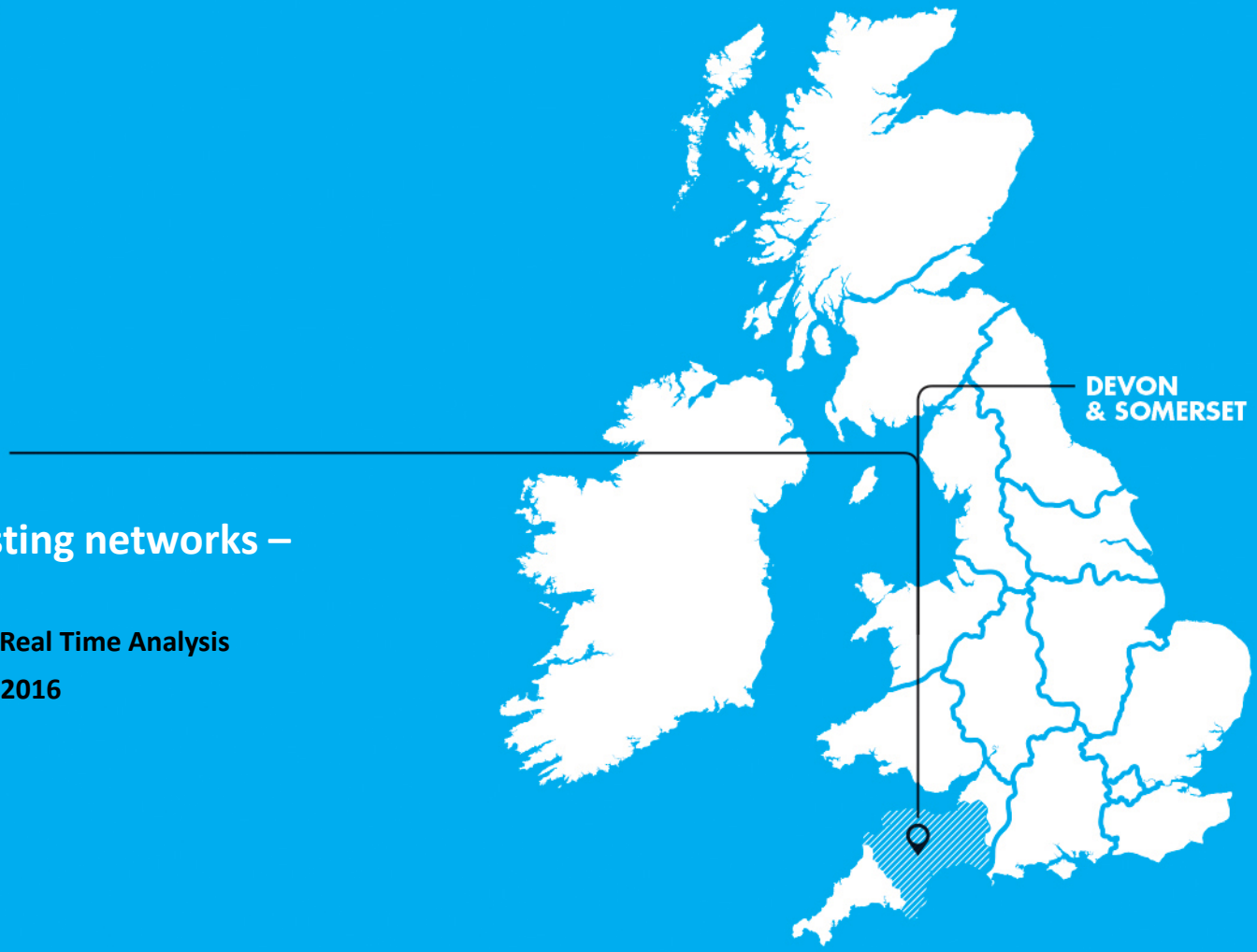
WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND



Making best use of existing networks – Network Equilibrium

5.2 Future Networks Planning and Real Time Analysis

LCNI 2016, Thursday 13th October 2016

Yiango Mavrocostanti

Innovation and Low Carbon Networks Engineer

LCN Fund
Low Carbon Networks

Outline

- WPD Innovation – Introduction
- What is the problem?
- Network Equilibrium overview
- The project's techniques
- Progress and next steps
- Summary

WESTERN POWER DISTRIBUTION
NETWORK EQUILIBRIUM

Future Networks Programme

WESTERN POWER DISTRIBUTION PROTEUS NEW

WESTERN POWER DISTRIBUTION FLEXDGRID

WESTERN POWER DISTRIBUTION PLUGS AND SOCKETS

WESTERN POWER DISTRIBUTION SOLA BRISTOL

WESTERN POWER DISTRIBUTION LOW CARBON HUB

WESTERN POWER DISTRIBUTION OPEN LV NEW

WESTERN POWER DISTRIBUTION NETWORK EQUILIBRIUM

WESTERN POWER DISTRIBUTION SMART ENERGY ISLES

WESTERN POWER DISTRIBUTION NETWORK TEMPLATES

WESTERN POWER DISTRIBUTION FALCON

Assets

- Telemetry
- Decision support
- Improved assets
- New assets
- Flexibility
- Automation
- Incident response

Customers

- New connections
- Upgrades
- Information
- Self Serve
- Products/Service
- Tariffs
- Communities

Operations

- Reliability
- Forecasting
- DSO
- DSR
- GBSO Interface
- Efficiency
- SHE and Security

Network and Customer Data

- Airborne Inspections
- AIRSTART[1]
- Telecoms Analysis
- Superconducting Cable
- SF6 Alternatives
- MVDC Test Lab
- Smart Energy Laboratory
- Statistical Ratings
- Primary Network Power Quality Analysis
- Hybrid Heat Pump Demonstration
- Hydrogen Heat & Fleet
- Carbon Tracing
- HV Voltage Control
- Solar Storage
- LV Connect and Manage
- Sunshine Tariff
- CarConnect
- Industrial & Commercial Storage
- DSO/SO Shared Services
- Project SYNC
- Project ENTIRE
- Smart Meter data for Network Operations
- Distribution Operability Framework
- Times Series Data Quality
- Voltage Reduction Analysis
- LV Connectivity
- Smart Systems and Heat[2]

Note: 1 – Funded by Aerospace Technology Institution; Note 2 – Funded by the Energy Systems Catapult

What is the problem?

- **Current electricity infrastructure is passive.**
- **Designed and planned for demand dominated networks.**
- **Power flows from centralised generation to demand down in the network.**

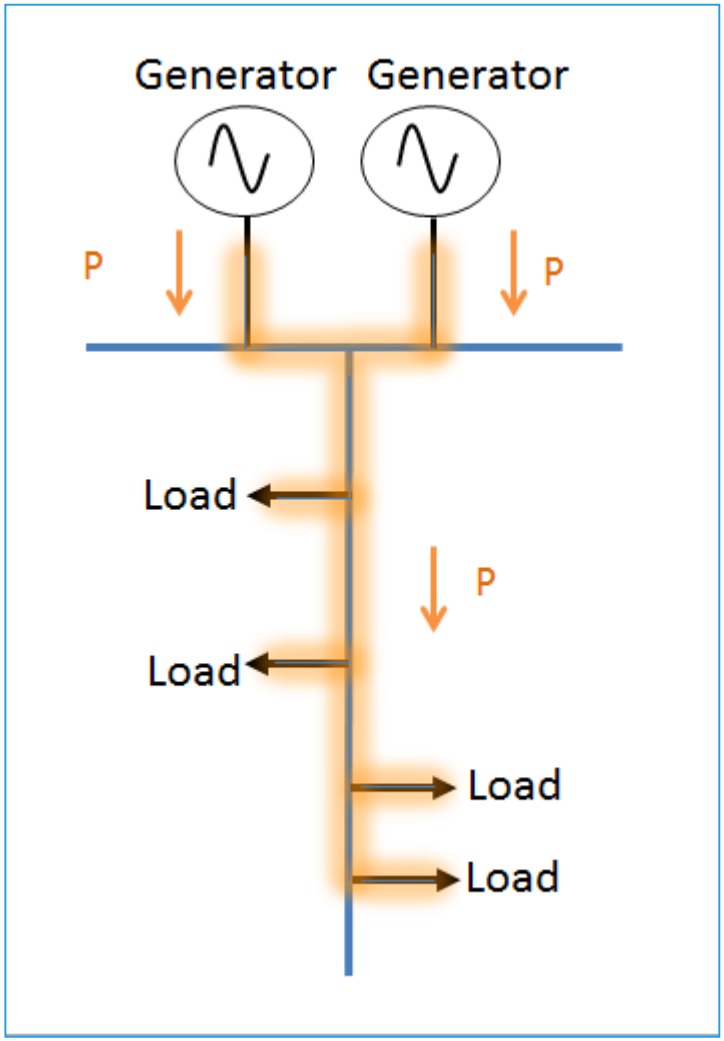


Figure 1 – Traditional network flows

What is the problem?

Networks no longer demand dominated.

Complex, bi-directional power flows.

Network conditions change significantly in real time.

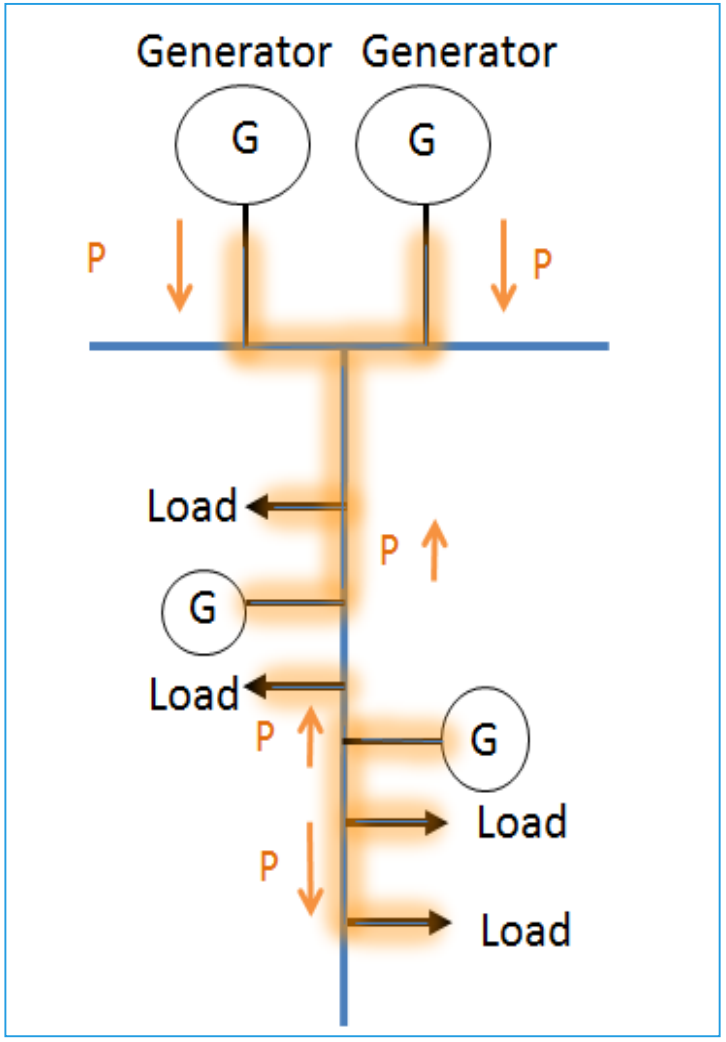


Figure 2 – New network flows

What is the problem?

We need to

- Find ways of controlling these complex power flows.
- Make the most of existing network capacity and assets.
- Change the ways we plan and design our networks.

Network Equilibrium – An Overview

- £13 million Tier 2 project
- Project area: Part of WPD's South West Network.
- Started in March 2015, finishes June 2019.

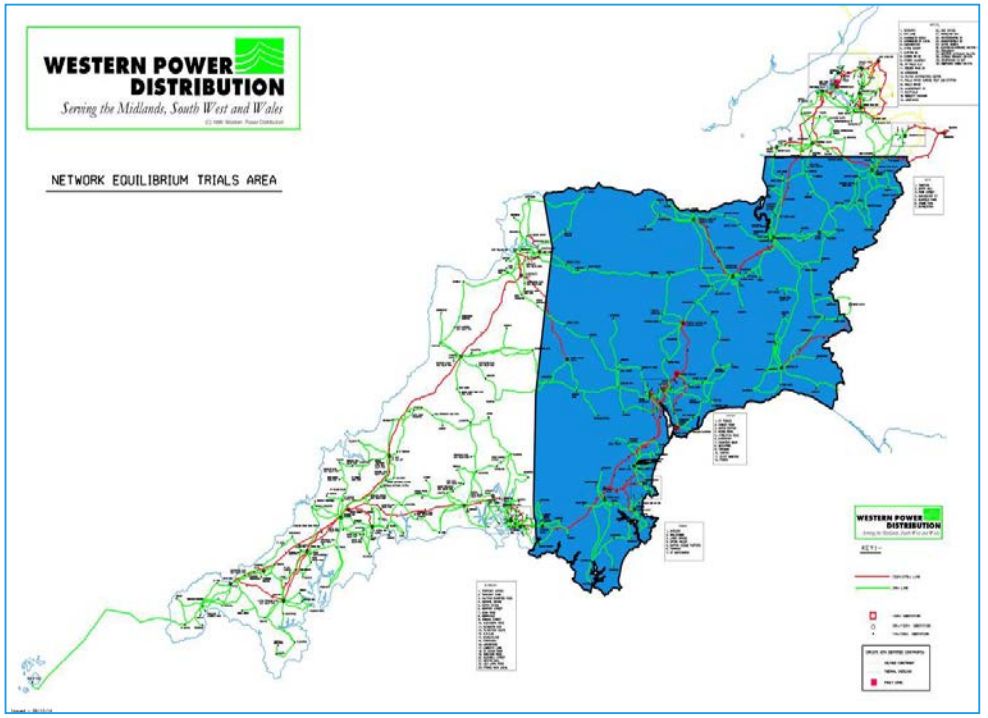
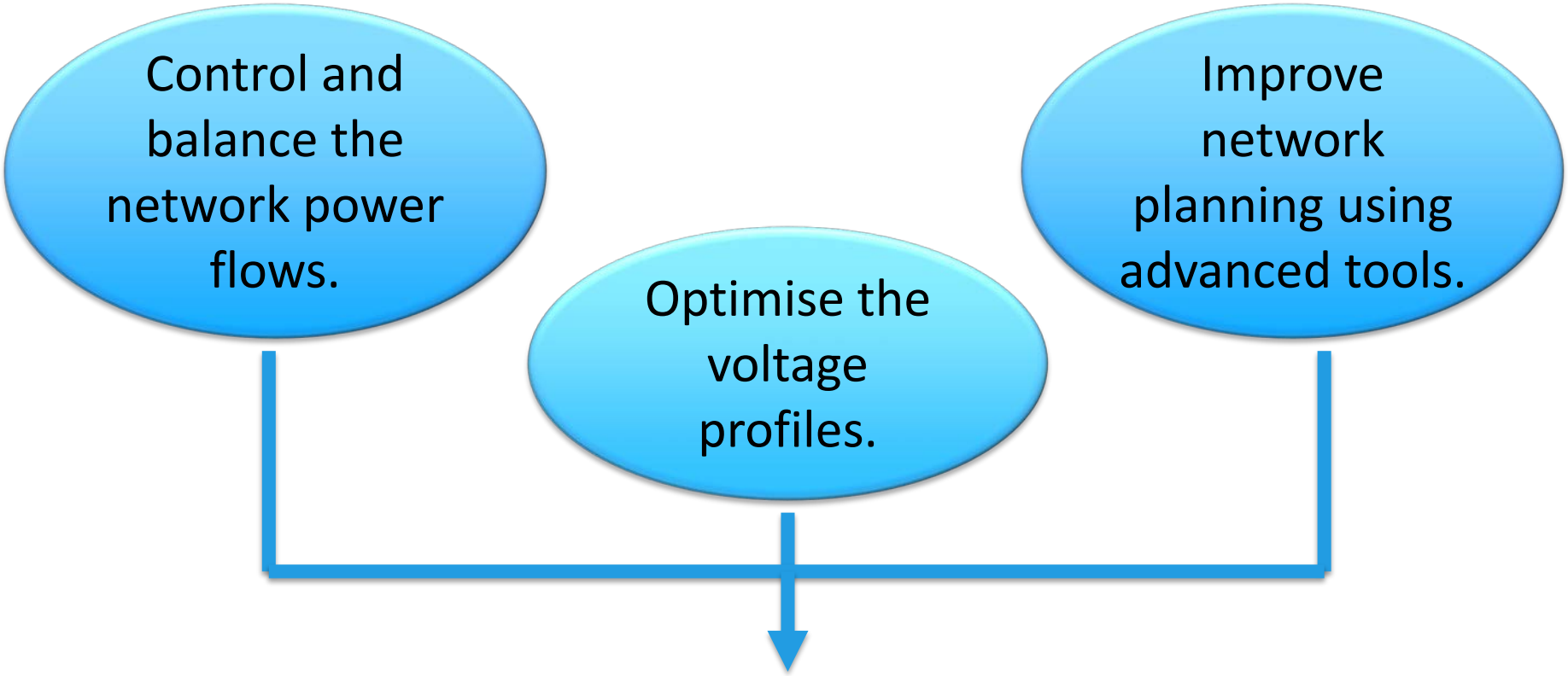


Figure 3: Network Equilibrium Project area

Network Equilibrium – Project Objectives



To release network capacity and allow more Low Carbon Technologies to connect

Network Equilibrium – The Techniques

1. EVA

Enhanced Voltage Assessment

- **Part 1:** Advanced Planning Tool – better network planning.
- **Part 2:** Investigation into potential amendment of statutory voltage limits.

2. SVO

System Voltage Optimisation

- Centralised, real-time Voltage Control system in 33kV and 11kV networks.

3. FPL

Flexible Power Link

- Back-to-back voltage source converter installed between two previously unconnected Bulk Supply Points.

Network Equilibrium – Enhanced Voltage Assessment

PART 1: Advanced Planning Tool (APT)

What is the problem we want to solve?

- Current planning procedures based on worst case scenarios.

  ➡ These might never occur – Underestimated network capacity!

- Different tools used for the 11kV network and different tools for the upper voltage levels.

  ➡ Unable to see operation of entire network.

Network Equilibrium – Enhanced Voltage Assessment

PART 1: Advanced Planning Tool (APT)

- Better visibility of all voltage levels.
- Analysis using:
  1. Historic time-series SCADA data.
  2. Typical profiles.
  3. 48-hour forecast profiles.
- Users: Design Engineers, Control Engineers, Outage planners.

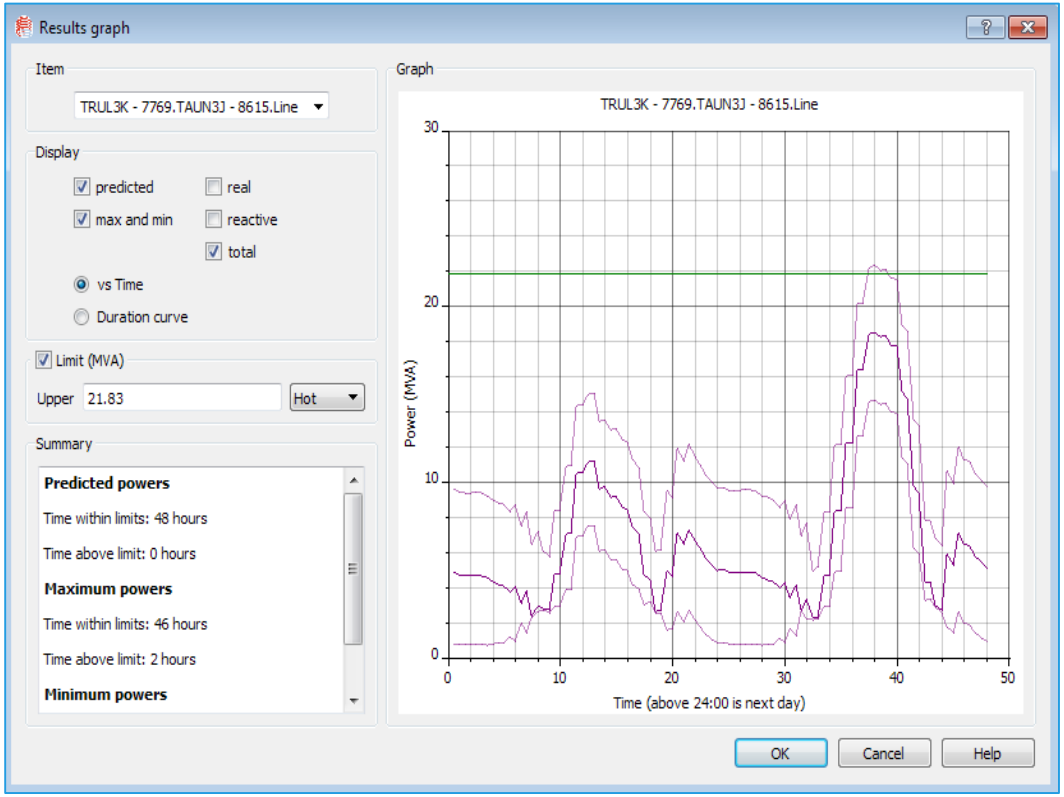


Figure 4: APT Screenshot

Network Equilibrium – Enhanced Voltage Assessment

PART 1: Advanced Planning Tool (APT)

- Evaluation of network capacity.
- Easy identification of constrained parts of the network and historic patterns.
- Modelling of SVO and FPL.

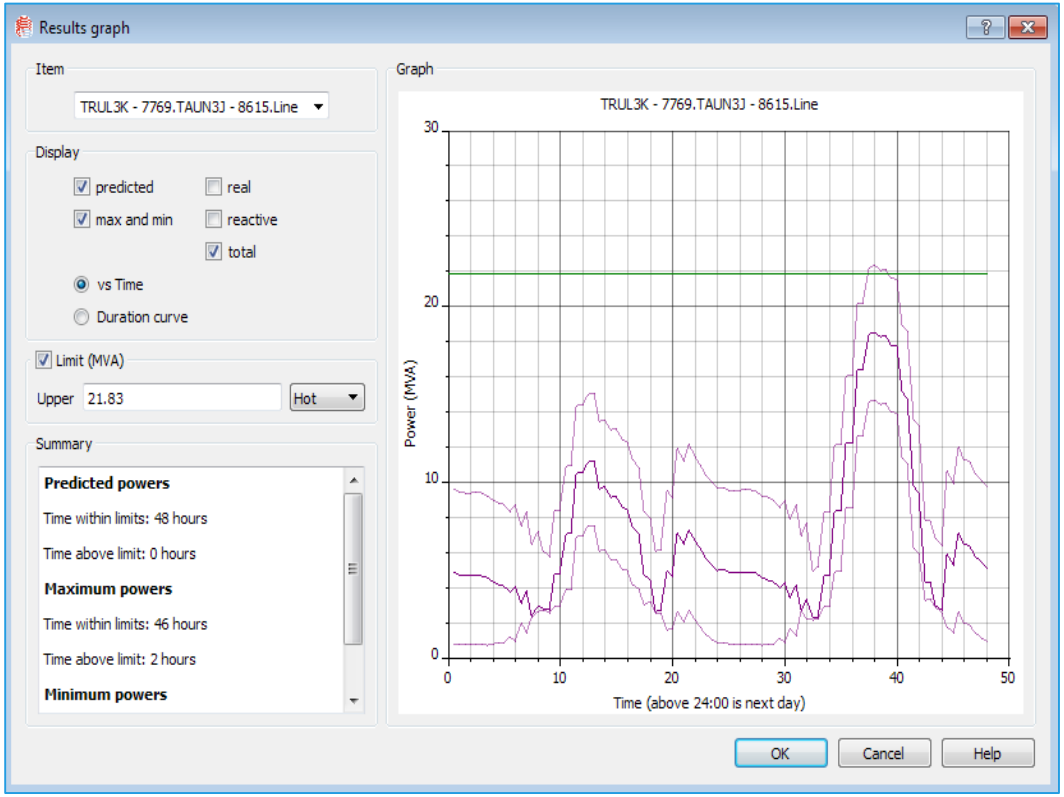


Figure 4: APT Screenshot

Further work on understanding network behaviour – Losses Project

- Installation of monitoring on HV and LV feeders.
- Develop methodology to accurately predict losses.
- Improve understanding of network losses.
- Update losses strategy.

Network Equilibrium – Enhanced Voltage Assessment

PART 1: Advanced Planning Tool (APT)

What we have done so far

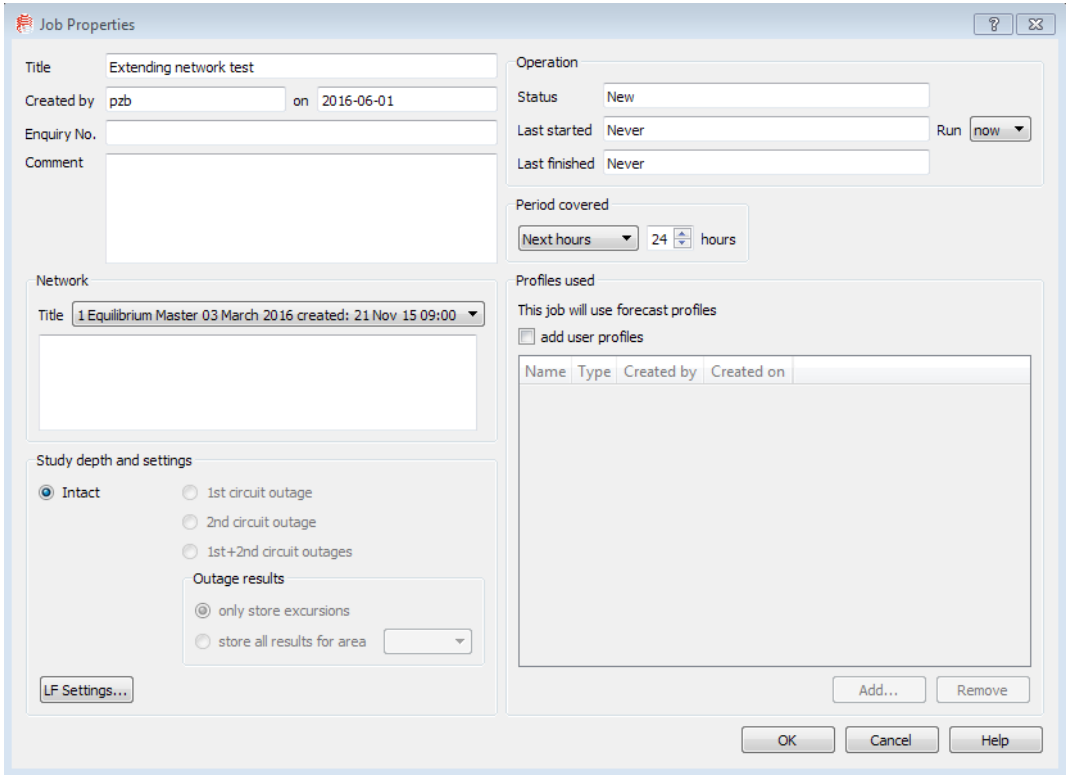


Figure 5: APT Screenshot

- Tool under development.
- Forecasting and typical models created.
- SVO and FPL plugins under test.
- FTP link established with Met-Office. forecast profiles have been generated since January 2016.

Network Equilibrium – Enhanced Voltage Assessment

PART 1: Advanced Planning Tool (APT)

Next Steps

- Finish tool development: Q1 2017.
- Testing of tool: Q1 2017.
- Training and trial: Q3 2017.

Network Equilibrium – Enhanced Voltage Assessment

PART 2- Voltage Limits Assessment

What is the problem we want to solve?

- Statutory voltage limits set at +/- 6% in 11kV and 33kV networks.

  → Capacity for new connections depends on headroom available before upper voltage limit is reached.

  → Rationale behind existing limits unknown.

Network Equilibrium – Enhanced Voltage Assessment

PART 2- Voltage Limits Assessment (VLA)

Theoretical investigation

Could the 11kV and 33kV statutory voltage limits be widened to release network capacity?

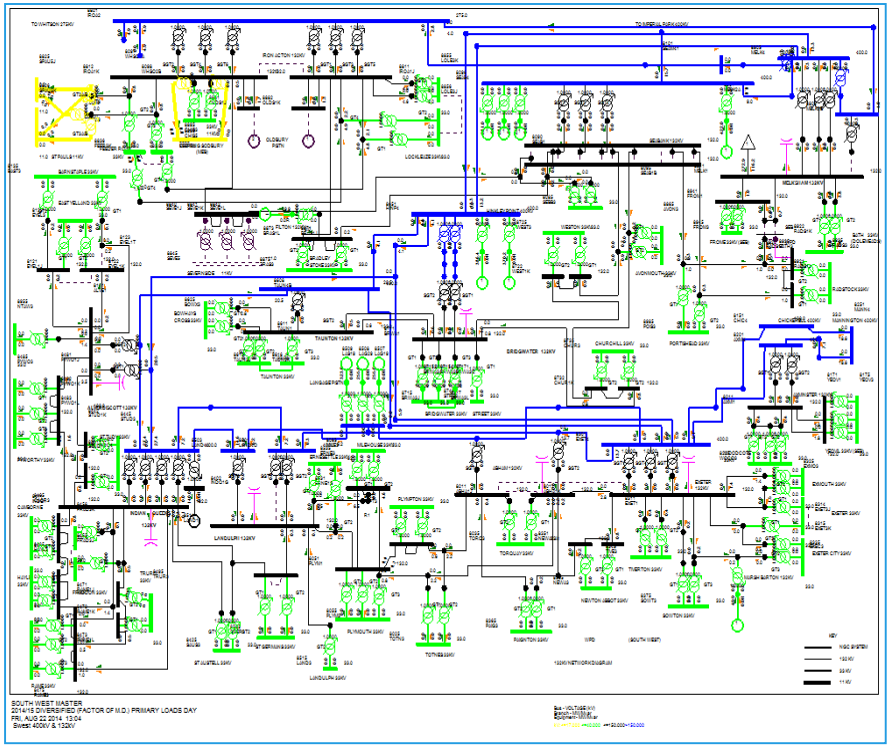


Figure 6: South West Network Single Line Diagram

Network Equilibrium – Enhanced Voltage Assessment

PART 2- Voltage Limits Assessment (VLA)

- Study completed by Parsons Brinckerhoff.

- Included literature reviews, stakeholder engagement, equipment specification investigations and system studies.

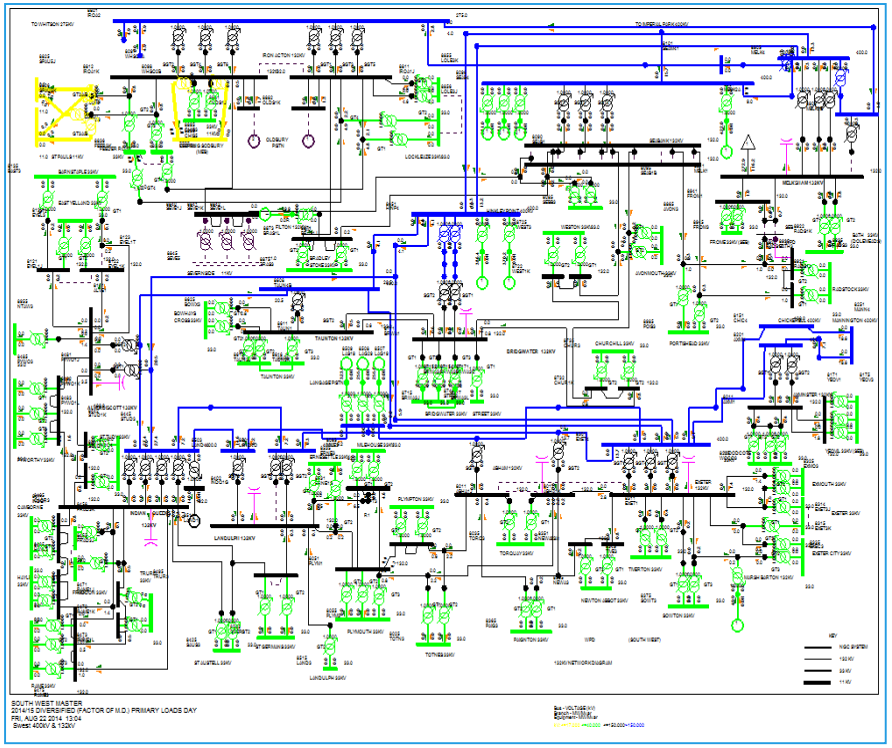


Figure 6: South West Network Single Line Diagram

WESTERN POWER DISTRIBUTION
NETWORK EQUILIBRIUM

Network Equilibrium – Enhanced Voltage Assessment

PART 2: Voltage Limits Assessment (VLA)

Study completed – Main Outputs

- Industry supportive of investigations.
- A new voltage range of +-10% was considered.
- Majority of 11kV and 33kV connected equipment would not need replacement.
- This range advisable for 33kV but tighter range for 11kV is suggested due to voltage regulation issues.

WESTERN POWER DISTRIBUTION
NETWORK EQUILIBRIUM

Network Equilibrium – Enhanced Voltage Assessment

PART 2: Voltage Limits Assessment (VLA)

Study completed – Main Outputs

- Step change limits to be maintained.
- Study and outputs forwarded to industry.
- Further consultation – voltage limit working groups.
- Consultation with customers, UK and EU regulators and studies on other parts of the UK network are suggested.

Network Equilibrium – System Voltage Optimisation

What is the problem we want to solve?

Traditional Voltage Control philosophy

- Relays at substations Control On Load Tap Changers.
- Keep voltage at substation close to pre-determined value.
- This target voltage value historically set high.
- Suitable for demand dominated networks.

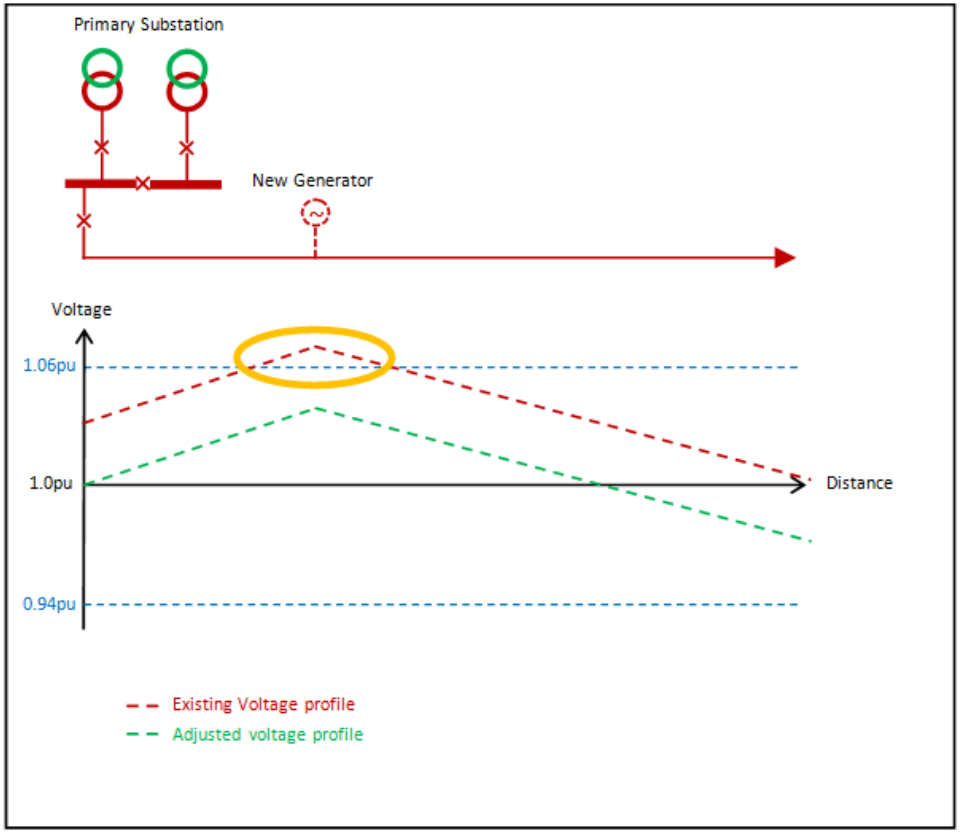


Figure 7: Traditional and amended voltage profiles

Network Equilibrium – System Voltage Optimisation

What is the problem we want to solve?

Traditional Voltage Control philosophy

- Restrictive in modern networks.

Limits available network capacity!

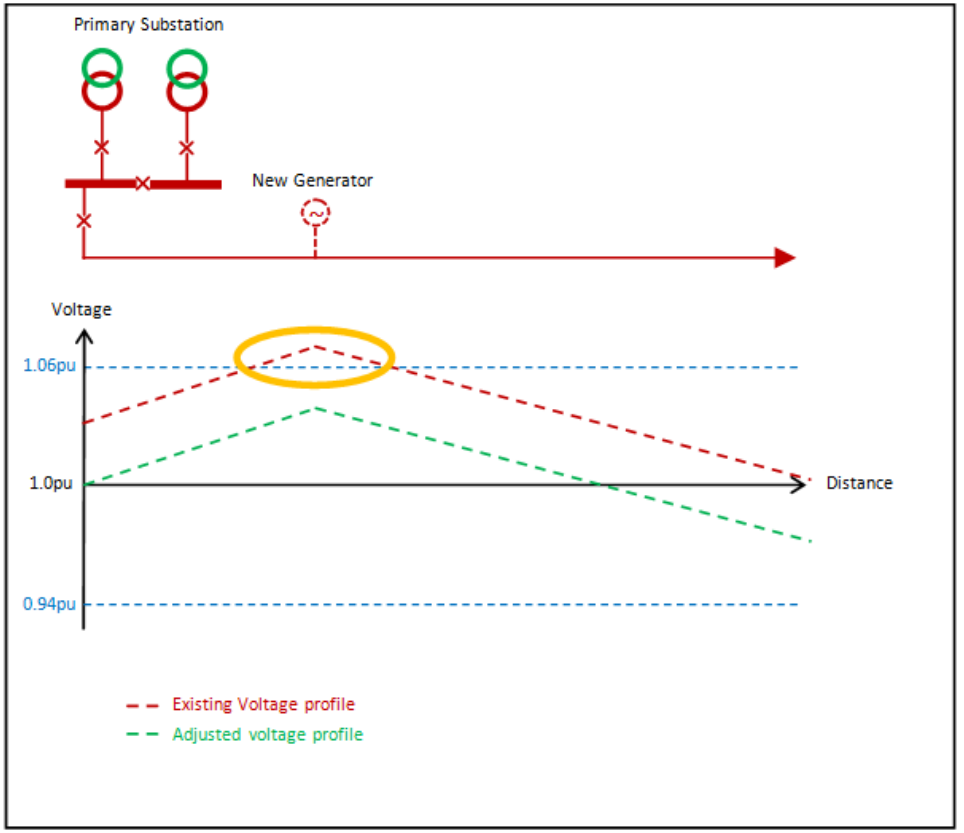


Figure 7: Traditional and amended voltage profiles

Network Equilibrium – System Voltage Optimisation

Dynamically adjust the previously static target voltage at the substation based on real-time operating conditions.

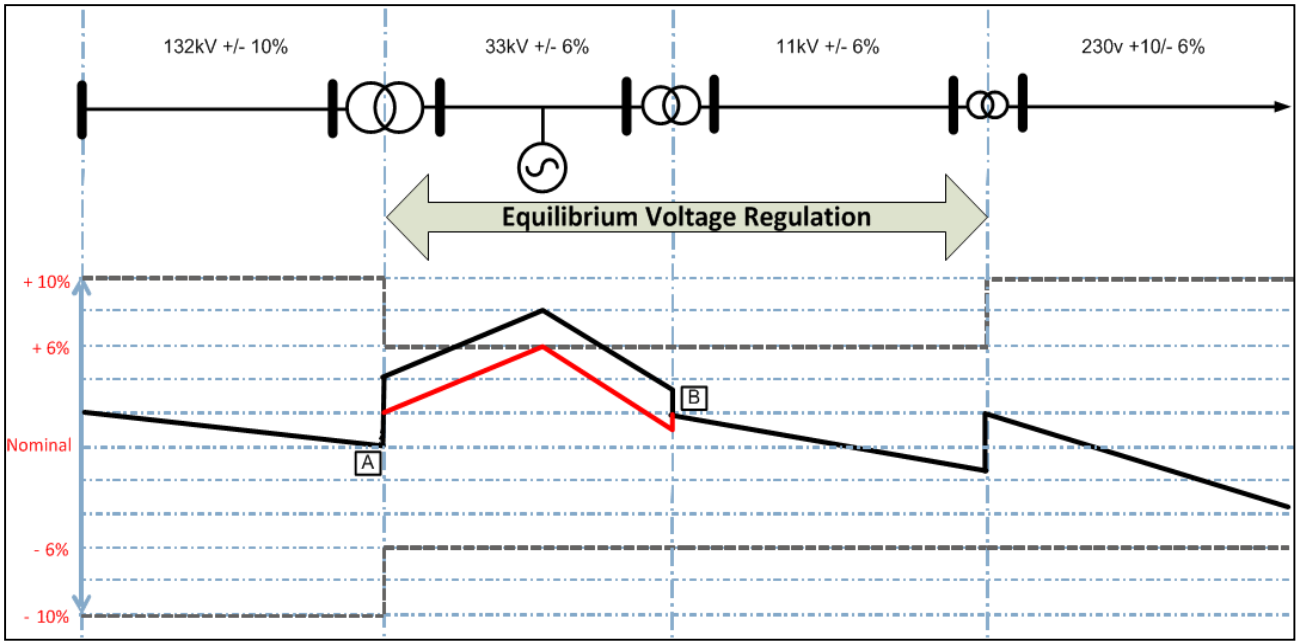


Figure 8: System Voltage Optimisation operation

Network Equilibrium – System Voltage Optimisation

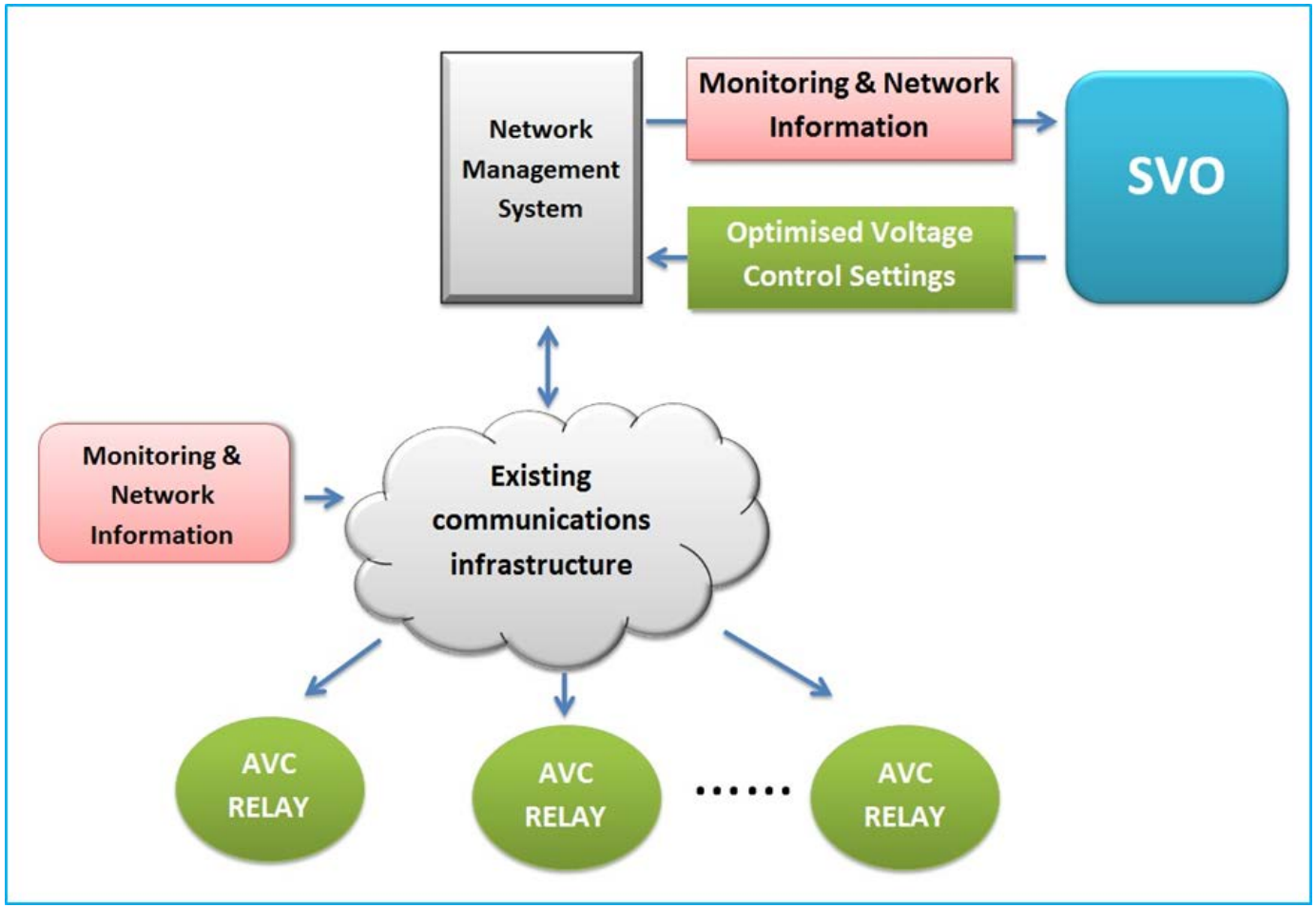


Figure 9: System Voltage Optimisation Architecture

Network Equilibrium – System Voltage Optimisation

What we have done so far

- Selected the 16 substations.
- Identified required relay replacements.
- WPD'S IT, PowerOn and Engineering Design teams involved in design process.
- Produced extract of ICCP Bilateral Table linking SVO model to monitoring information to be received.

Network Equilibrium – System Voltage Optimisation

Next Steps

- System Design Complete by Q3 2016.
- Preparation for testing Q1 2017.
- Site works complete by Q3 2017.
- Testing and commissioning of system complete by Q3 2017.
- System live Q3/Q4 2017.
- Trials commence Q4 2017.

Network Equilibrium – Flexible Power Link

What is the problem we want to solve?

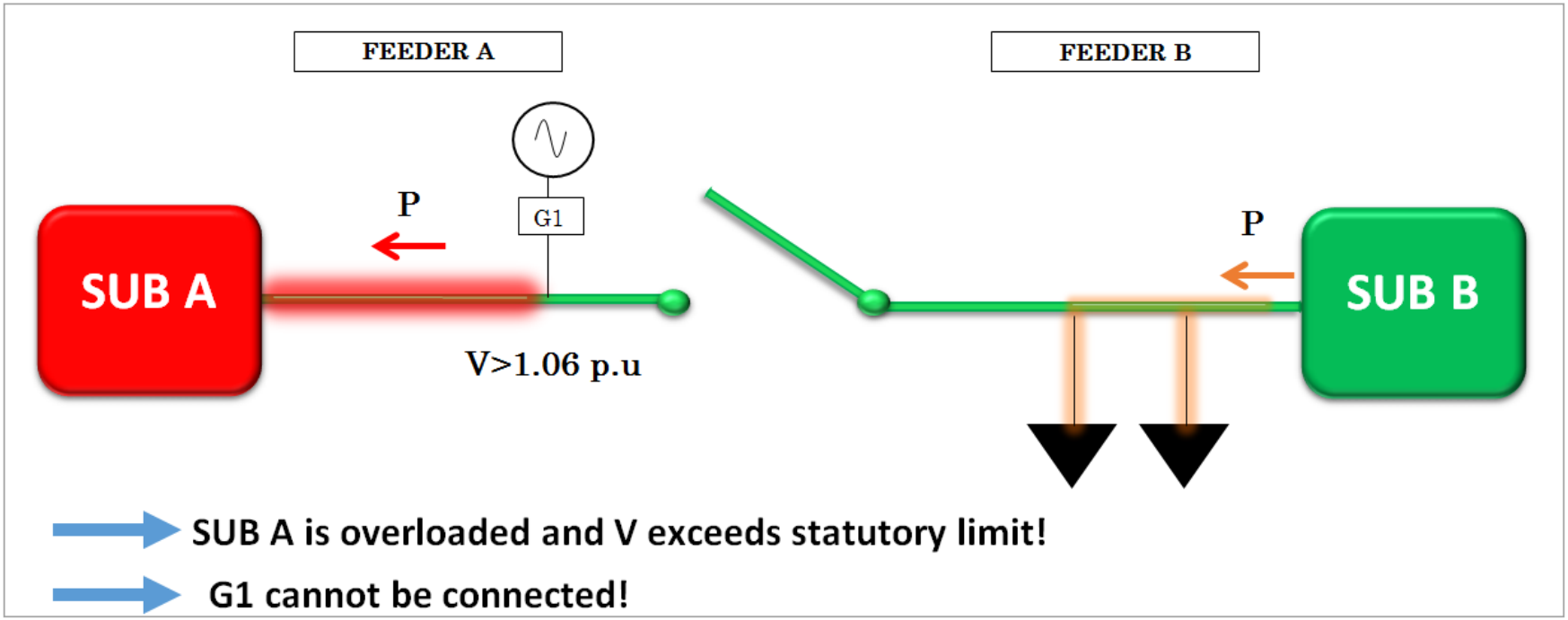


Figure 10: Thermal and voltage constraints preventing network connections.

Network Equilibrium – Flexible Power Link

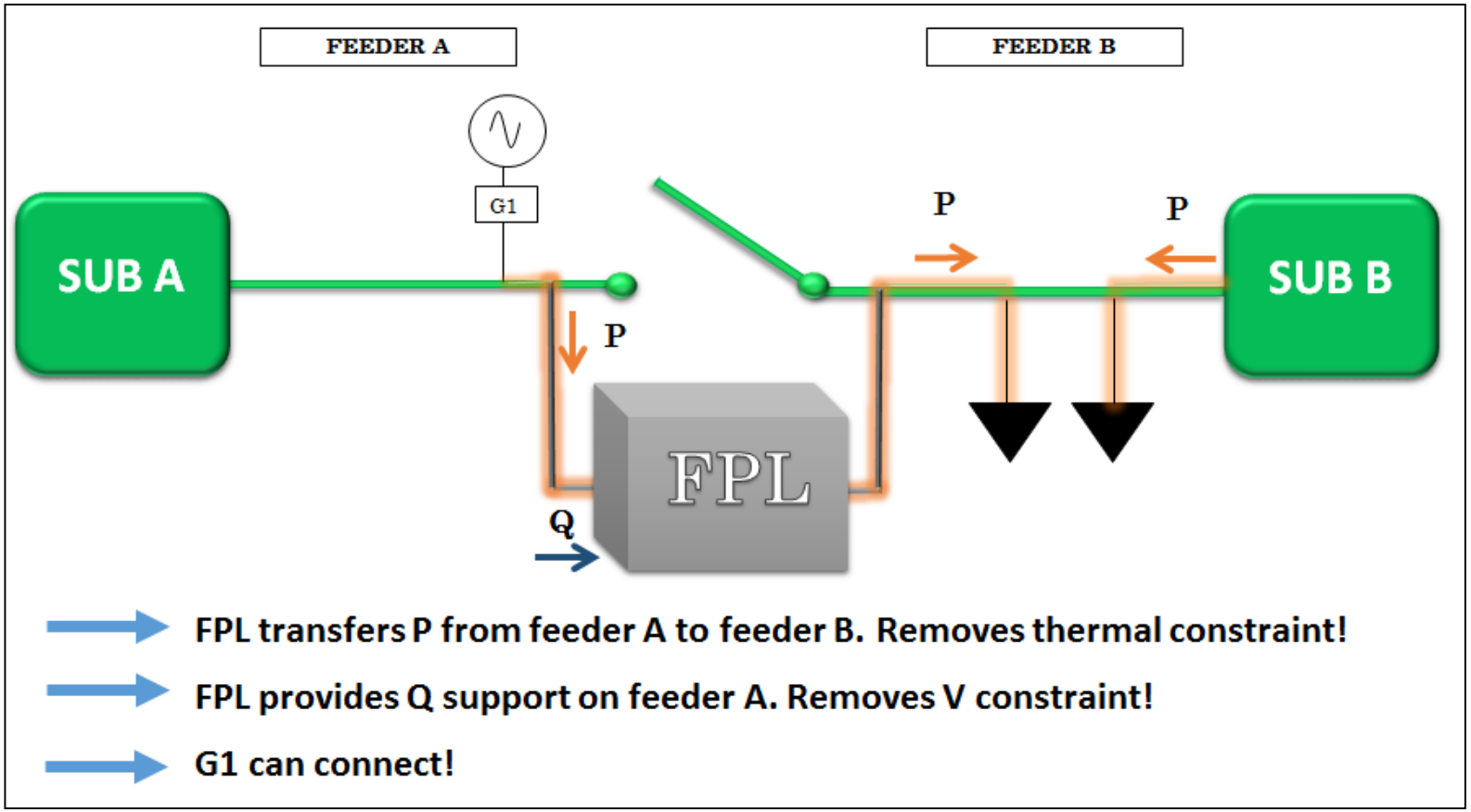


Figure 11: Thermal and voltage constraints removed by FPL.

Network Equilibrium – Flexible Power Link

- Back-to-back voltage source converter manufactured by ABB.
- Interconnecting two different Grid Groups.
- Connected across a 33 kV Normal Open Point.

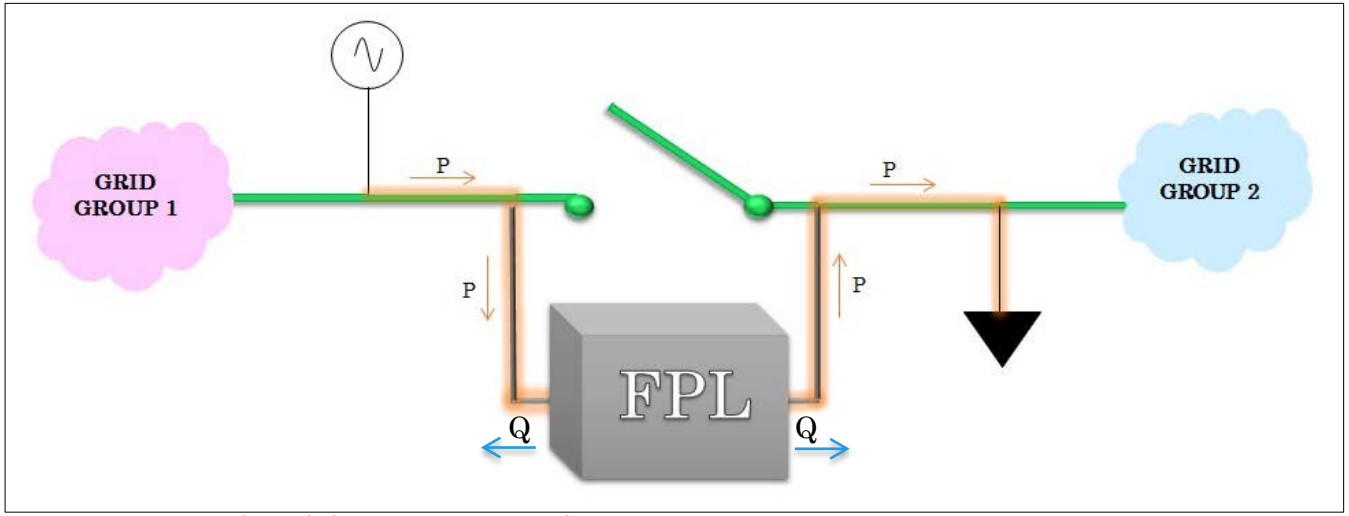


Figure 12: Flexible Power Link operation

Network Equilibrium – Flexible Power Link

- External Control System developed independently.

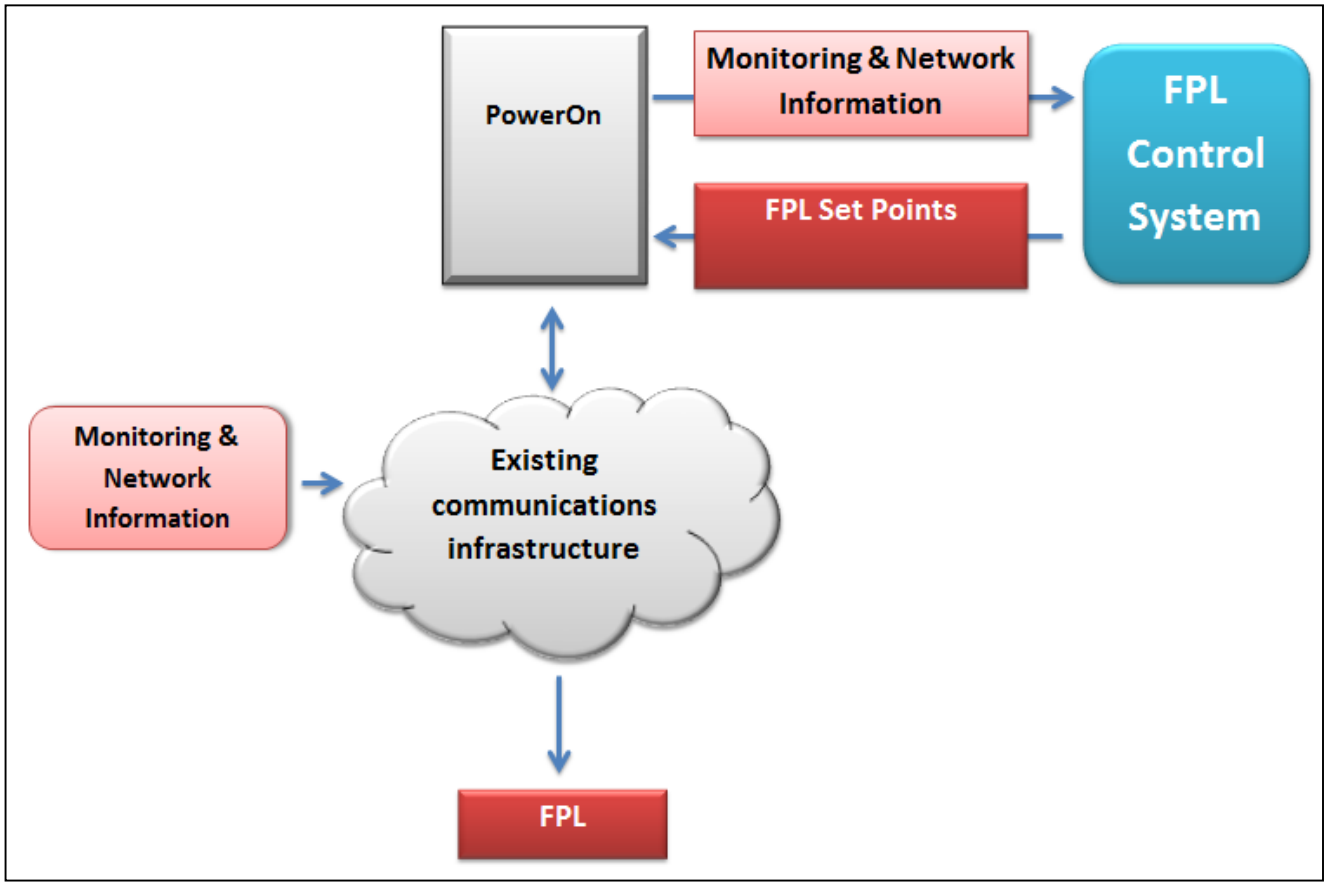


Figure 13: FPL Control System Architecture

Network Equilibrium – Flexible Power Link

What we have done so far

- Selected the site.
- Now in detailed design phase.
- Working with WPD's Engineering Design and Primary System Design and Projects teams on system integration design work.
- Contract negotiations for FPL Control System.

Network Equilibrium – Flexible Power Link

Next Steps

- Design complete by Q4 2016.
- Testing preparations complete by Q2 2017.
- FPL delivered on site Q3 2017.
- FPL commissioned and energised by Q1 2018.
- FPL Control System delivered by Q3 2017.

Summary

- Networks are now very different than what they have been designed for.

- We need to change the ways we control, design and manage our electricity distribution networks.

- That's why we have an Innovation Strategy, which includes among other projects Network Equilibrium.

Summary

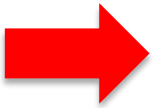
- Network Equilibrium – Aims to improve network power flows, voltage profiles and develop new planning tools.

To facilitate the integration of more LCTs in our network.

- The project consists of 3 techniques.

Summary

- VLA – Could we widen the voltage limits to release network capacity?



No knowledge on rationale behind existing limits.
Statutory voltage limits constrain network capacity.

Study complete. Suggestions provided for statutory voltage and step change limit amendments in 33kV and 11kV networks. Further consultation to consider other parts of the UK and regulatory aspects.

Summary

- APT – Planning tool with advanced functionalities.

Existing planning tools only consider very conservative scenarios.

APT will provide better understanding of real network operation and will support:

1. Analysis using historic time-series information.
2. Analysis using typical demand and generation profiles.
3. Short-term forecasting of demand and generation using weather data.
4. Modelling and planning of SVO and FPL.
5. Evaluation of network capacity.

Summary

- APT – Planning tool with advanced functionalities.

→ Development of the tool is in progress.

→ Current version includes plugin modelling and analysis using typical and forecasted demand and generation.

→ Trial of the tool to commence in Q3 2017.

Summary

- SVO – Real time, dynamic voltage control.

Existing voltage control systems not suitable for modern networks and limit available network capacity.

SVO will adjust the target voltages at 8 BSPs and 8 Primaries in real time, based on the operating conditions.

It will communicate with WPD's NMS to receive network monitoring information and send the optimised target voltage settings.

Summary

- SVO – Real time, dynamic voltage control.

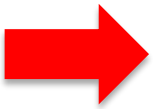

Sites selected and site work identified and planned.


Design work in progress.


System to go live by Q4 2017.

Summary

- FPL – Converter for voltage support and power flow control, connecting two independent networks.



New connections limited by both voltage and thermal constraints.

FPL will remove network constraints by providing voltage support and transferring power to neighbouring network with spare capacity.

It will be controlled by an external system that has view of the network in real time.

Summary

- FPL – Converter for voltage support and power flow control, connecting two independent networks.


Site selected.


Detailed design of FPL in progress.


Contract negotiations for FPL Control System.


FPL commissioned and energised by Q1 2018.


FPL Control System delivered by Q3 2017.

Network Equilibrium

Improve the network voltages.

Control the network power flows.

Understand and plan networks better.

To make the most of existing network and enable more Low Carbon Technologies to connect.

THANKS FOR LISTENING

WESTERN POWER DISTRIBUTION

Serving the Midlands, South West and Wales

Yiango Mavrocostanti

Western Power Distribution

Innovation and Low Carbon Networks Engineer

01332827445

ymavrocostanti@westernpower.co.uk

wpdinnovation@westernpower.co.uk

www.westernpowerinnovation.co.uk