Power Networks and Flexibility to Accommodate Changing Usage Patterns

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Overview

- Introduction to PSC
- Challenges Facing the Distribution and Transmission Networks
- Network Innovation Projects
  - Electricity Flexibility and Forecasting System (EFFS)
  - Virtual Statcom
- Next Steps

PSC at a Glance

197
Subject matter experts

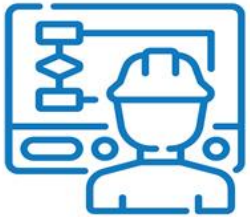
25+
Countries served

>20
Offices in North America, Europe & Asia Pacific

25
Years in business

200+
Clients

PSC Solution Areas – Operational Technologies



Operational Technologies

Generation, energy and distribution management systems

Project and program management

Project development and integration

System upgrade, migration and training

Substation and generation automation

Smart grid

Data analytics

DERMS

IT, telecommunications, networks and security

Market Systems

Market system analysis, design, audit and training

Program and project management

Custom software development and testing

Technology refresh roadmaps

Market clearing engine expertise

Simulation and analysis tools

Market trading applications

Distributed Energy Resources

Generation: solar (PV), wind, fuel cell, co-gen, diesel

Energy storage and efficiency

Electric vehicles

Demand response

Load management

Micro grids

PSC Solution Areas – Power Networks

Power Networks

Power system transmission and distribution planning

Power system studies

Generator testing

System operator support

Aerial Laser Survey

Asset management

O&M advisory

Transmission lines

NERC

HVDC

HVDC technology reviews

System and engineering studies

Feasibility and conceptual design

Control and runback systems

Construction cost estimation

EPC spec preparation and FEED

Procurement, construction and commissioning support

Strategic Advisory

Strategies for power networks, systems and operations

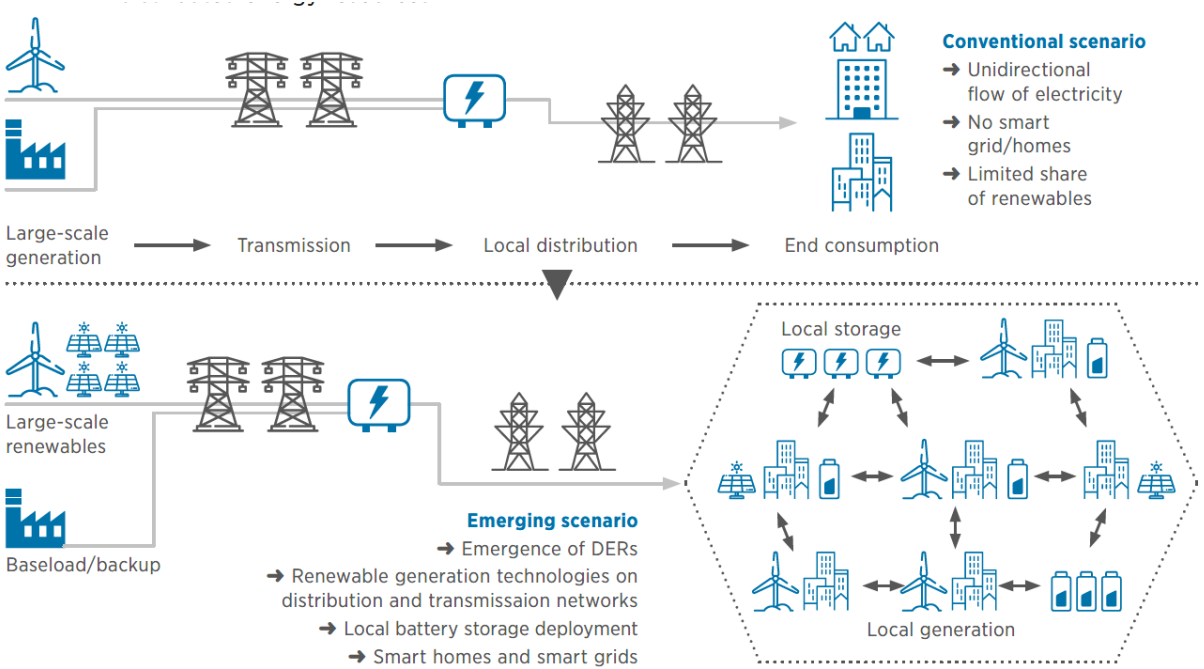
Asset strategies

Independent advice, project and business reviews

Electricity market and policy

Challenges Facing the Power System

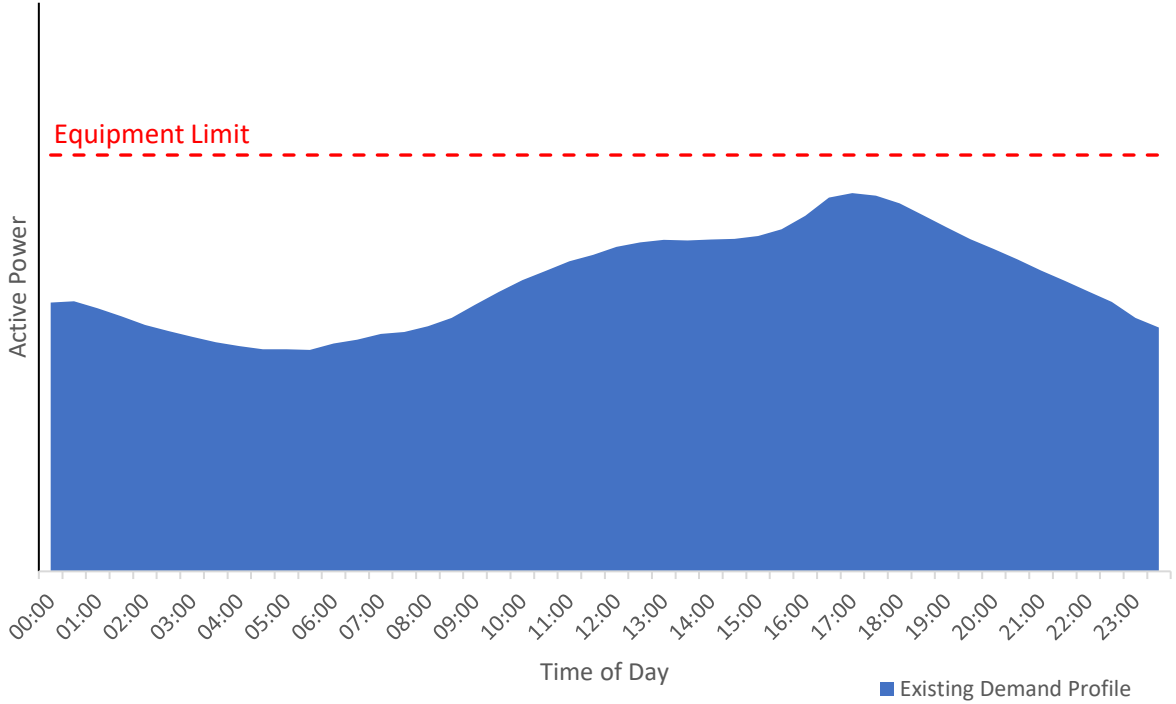
The Changing Electricity System



Source: International Renewable Energy Agency, "Future Role of Distribution System Operators – Innovation Landscape Brief", 2020

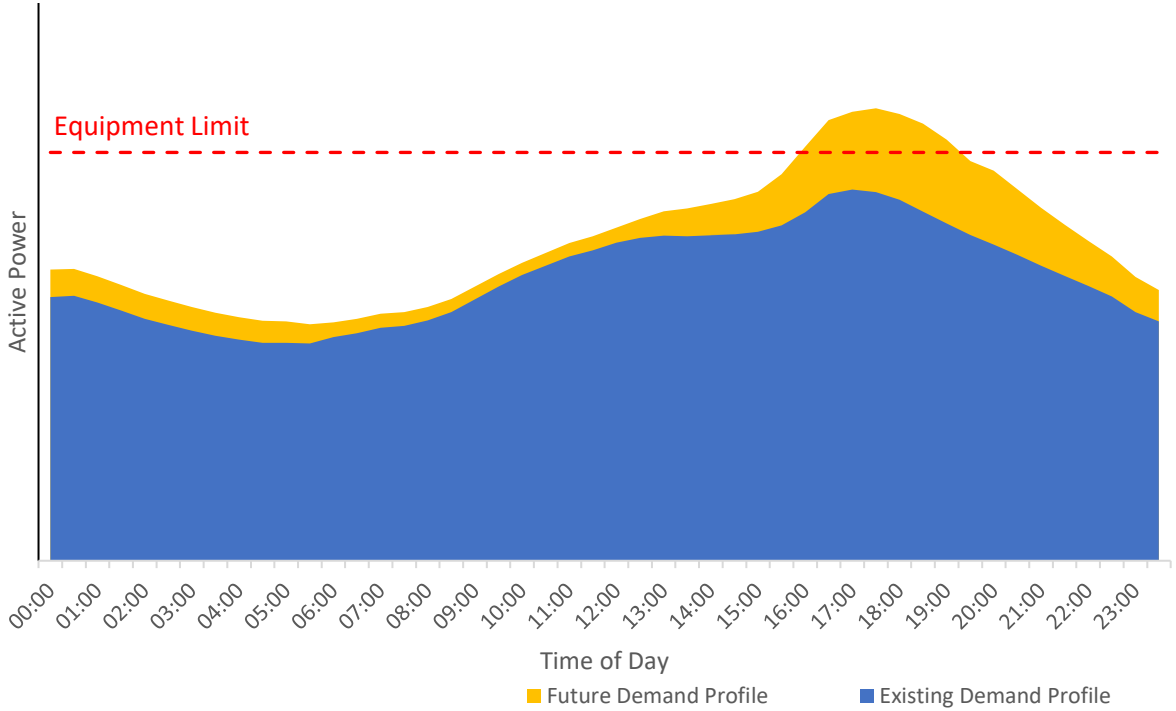
Changing Generation and Demand Mix

- Existing System
- Predictable pattern
- Operates within equipment limits



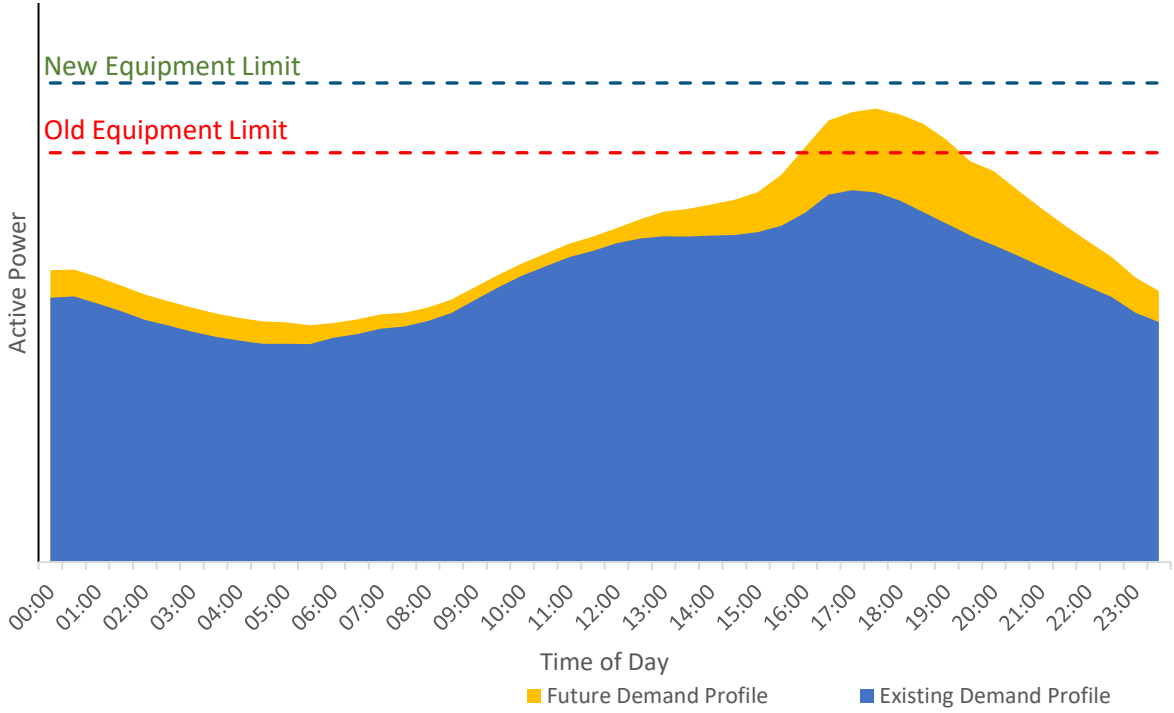
Changing Generation and Demand Mix

- Demand Increases
  - Electric Vehicles
  - Heat Pumps
  - Electrification of Transport
- Embedded Generation
  - Solar, Wind
  - Tidal



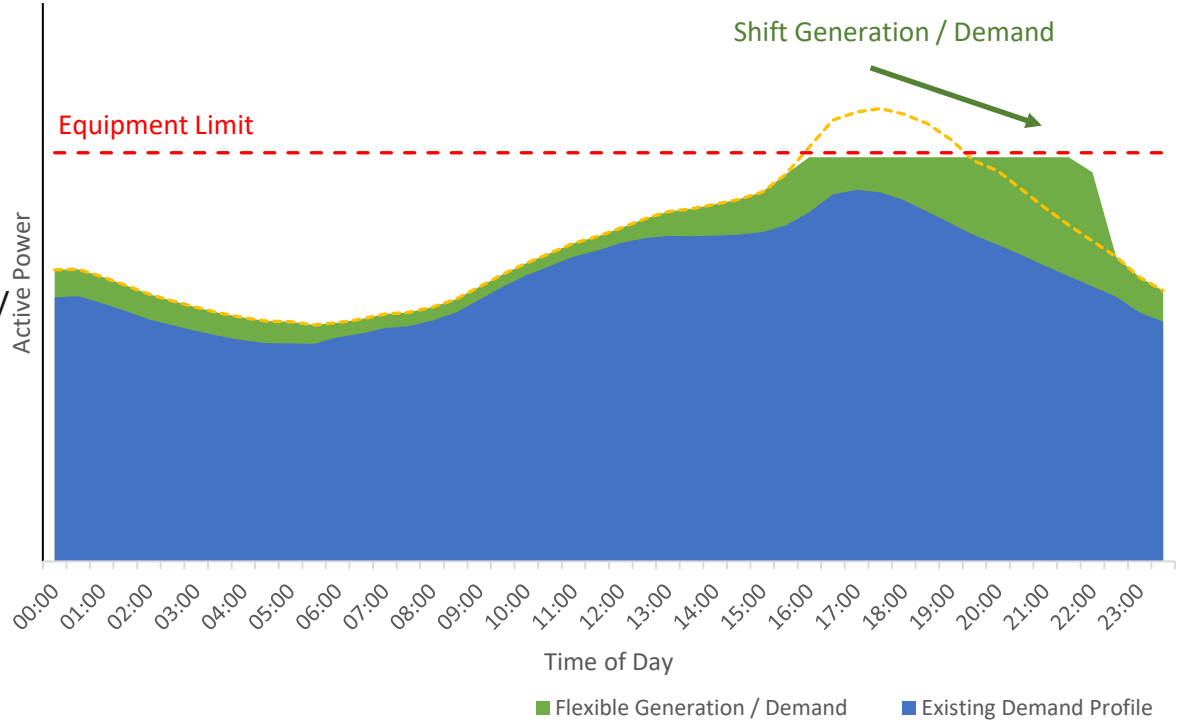
Changing Generation and Demand Mix

- Traditional Approach
  - New Circuits
  - New Transformers
  - Long Duration to Build
  - Long Duration to Repay
  - Disruptive
- What happens if the forecast is wrong:
  - COVID?



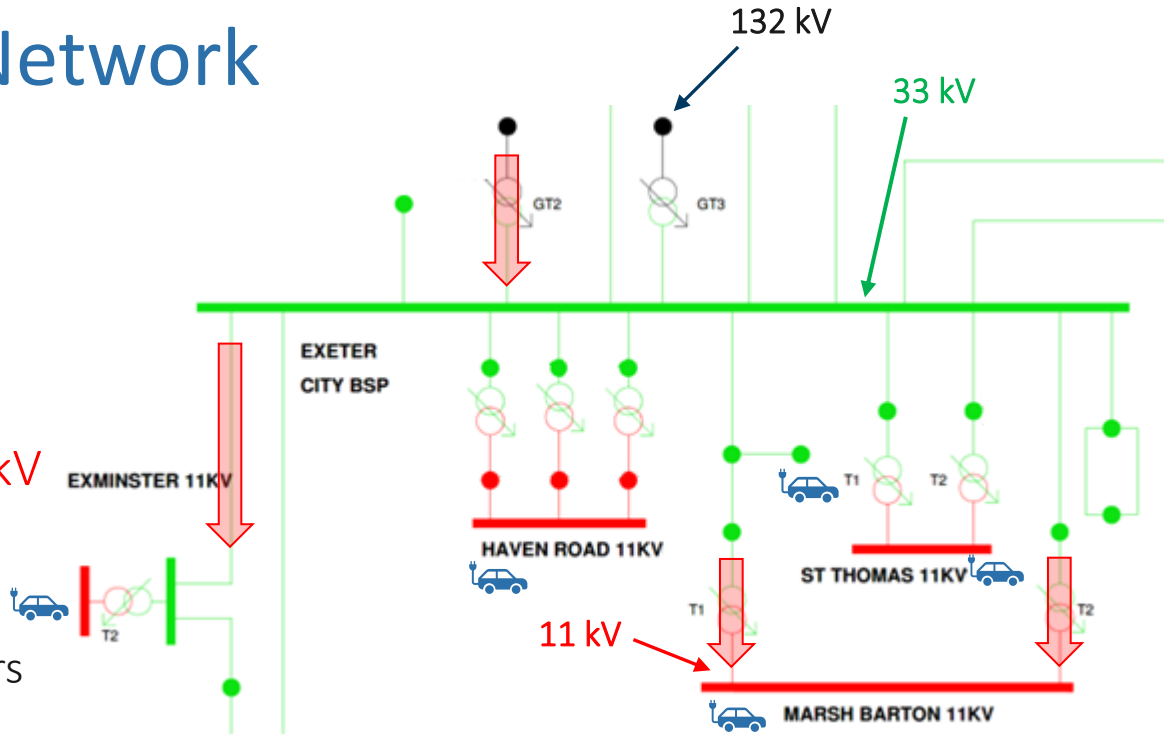
Changing Generation and Demand Mix

- Alternative Options
  - Better utilise existing equipment
- Will you charge your EV later?
- Energy storage
- Flexible generation
- Flexibility markets



The Distribution Network

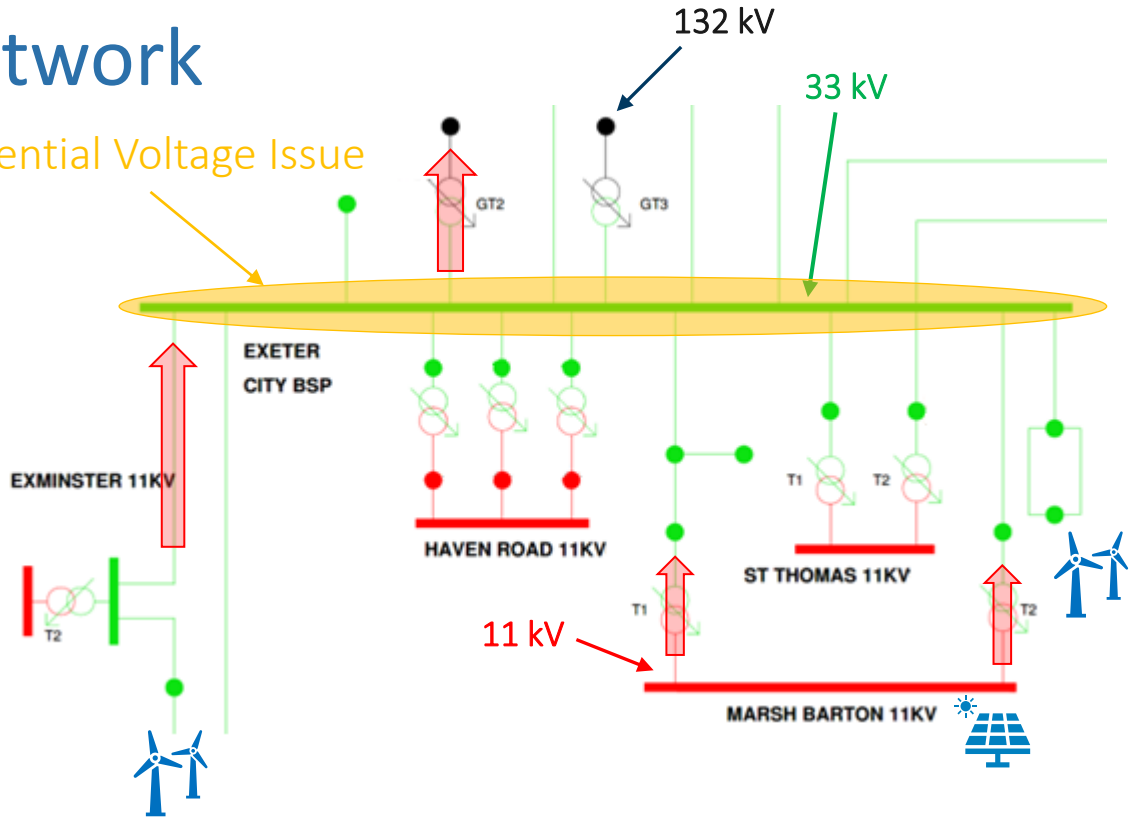
- Example Distribution Network
- Traditionally designed to flow 132kV -> 33kV -> 11kV
- Increasing demand
  - Circuits and transformers overloaded
  - Only during peak



Source: Western Power Distribution, Long Term Development Statement South West, 2019

The Distribution Network

- Example Distribution Network
- Traditionally designed to flow 132kV -> 33kV -> 11kV
- Embedded generation
  - Thermal overloads
- Voltage issues?



Source: Western Power Distribution, Long Term Development Statement South West, 2019

Overview of Projects

Innovation Funding and Projects

- Ofgem Network Innovation
  - “Essential backing to innovative projects which aim to make the energy networks smarter, accelerate the development of a low carbon energy sector as well as deliver financial benefits to consumers”

- Projects to demonstrate innovative approaches to operating the system and saving consumers money, but are unproven and therefore carry some risk in their implementation.

- PSC Projects:
  - Electricity Flexibility and Forecasting System (EFFS) – Ongoing NIC project
  - Virtual Statcom – Completed NIA project

PSC Innovation Projects

Electricity Flexibility and Forecasting System (EFFS)

PSC Project Manager: Michail Bitos

Further Info: www.pscconsulting.com/success-story/electricity-flexibility-and-forecasting-systems-tool-for-wpd/

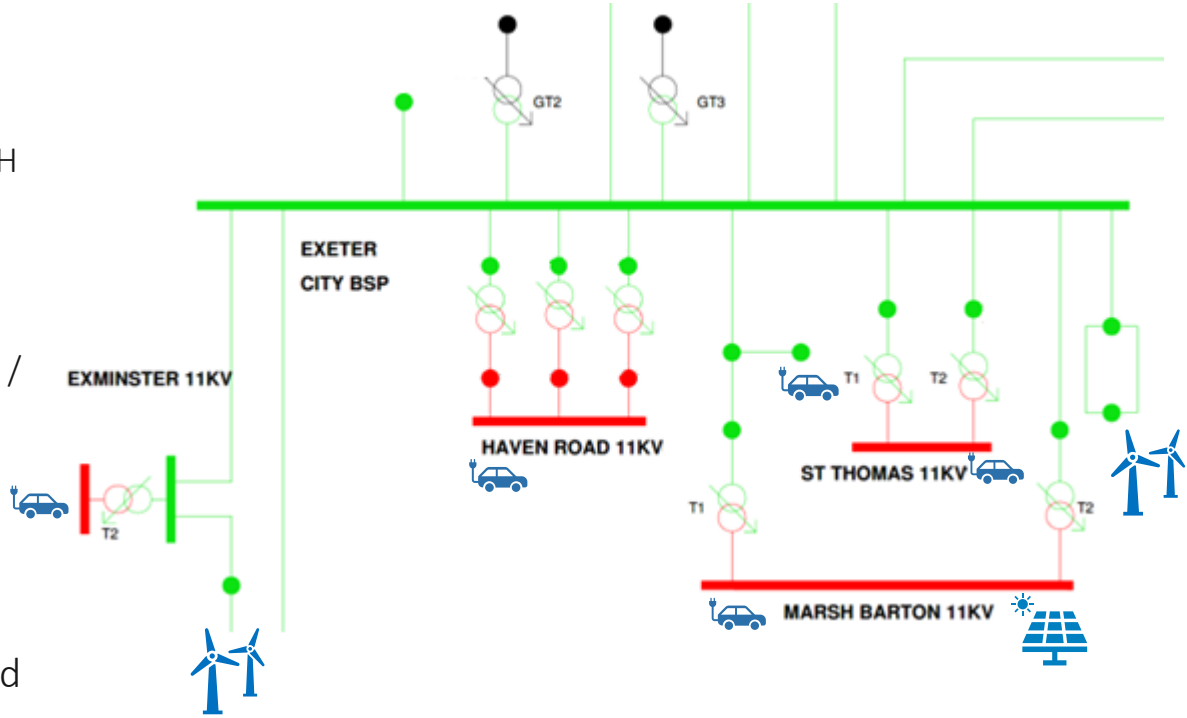
Project Background

- Project Requirement
  - Distribution Network Operators -> Distribution System Operators
  - Flexibility services to operate a more dynamic network

- Project Solution
  - Develop and demonstrate a solution to forecast, determine and optimize flexibility requirements.

Automated Constraint Analysis

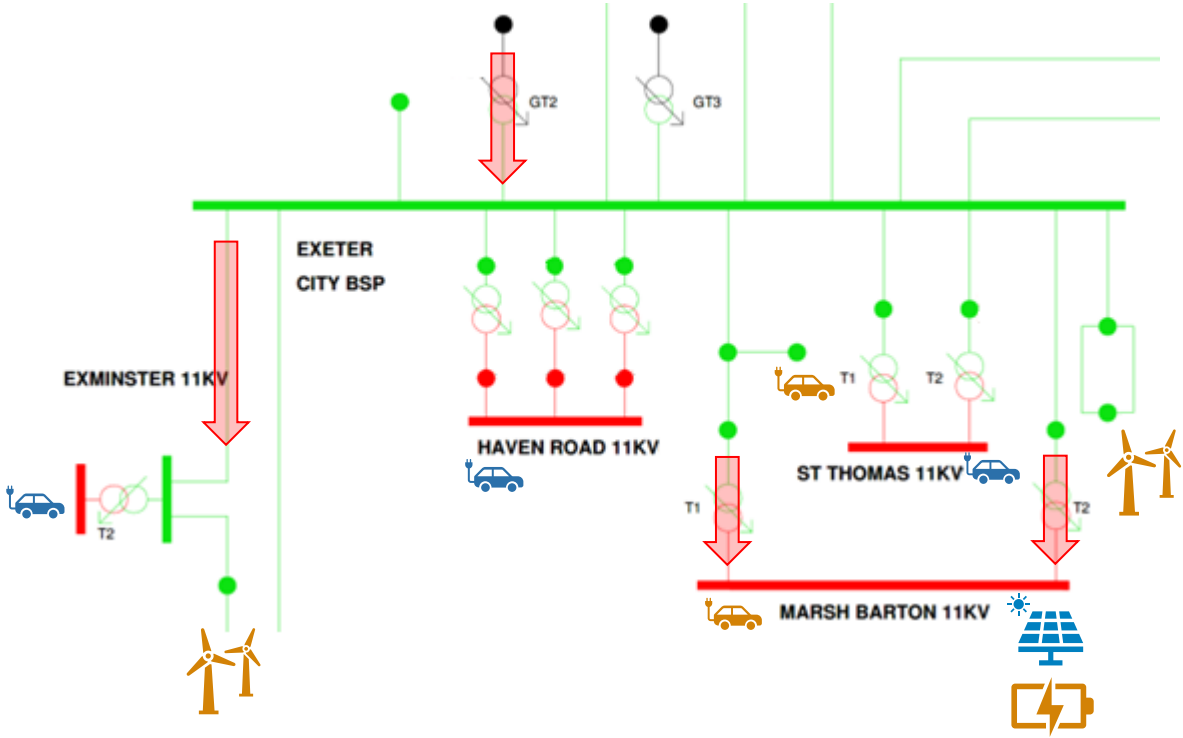
- Week ahead forecasts
  - Demand / generation for every HH
- Automated analysis
  - Python engine to drive PSS®E
  - Consider outages on every circuit / transformer
  - Study every HH period
- Identify times and contingencies when circuits risk being overloaded



Source: Western Power Distribution, Long Term Development Statement South West, 2019

Flexibility Service Requirements and Optimal Solution

- Identify flexibility services
  - Contribute to each constraint
  - Avoid creating new constraints
- Requests go to market
- Available services reviewed to determine optimal solution
  - Overall cost to consumer
  - Partially or fully resolve constraint



Source: Western Power Distribution, Long Term Development Statement South West, 2019

Results and Real System Trials - Ongoing

- Forecasting weekly demand and generation trial zones:
  - Plymouth 33kV BSP
  - Exeter City 33kV BSP
- Running automatic constraint analysis and determining flexibility services
  - System isn't at limit so artificially generating constraints for trials
- Market participants providing responses and confirmation that constraints resolved.
- Next Steps:
  - Confirm the dispatch requests and service response is received
  - Ongoing trials over next 6 months to stress test systems
  - Concept testing for different types of services (vehicle 2 grid, battery storage, etc.)

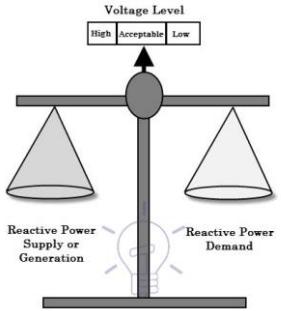
Virtual Statcom

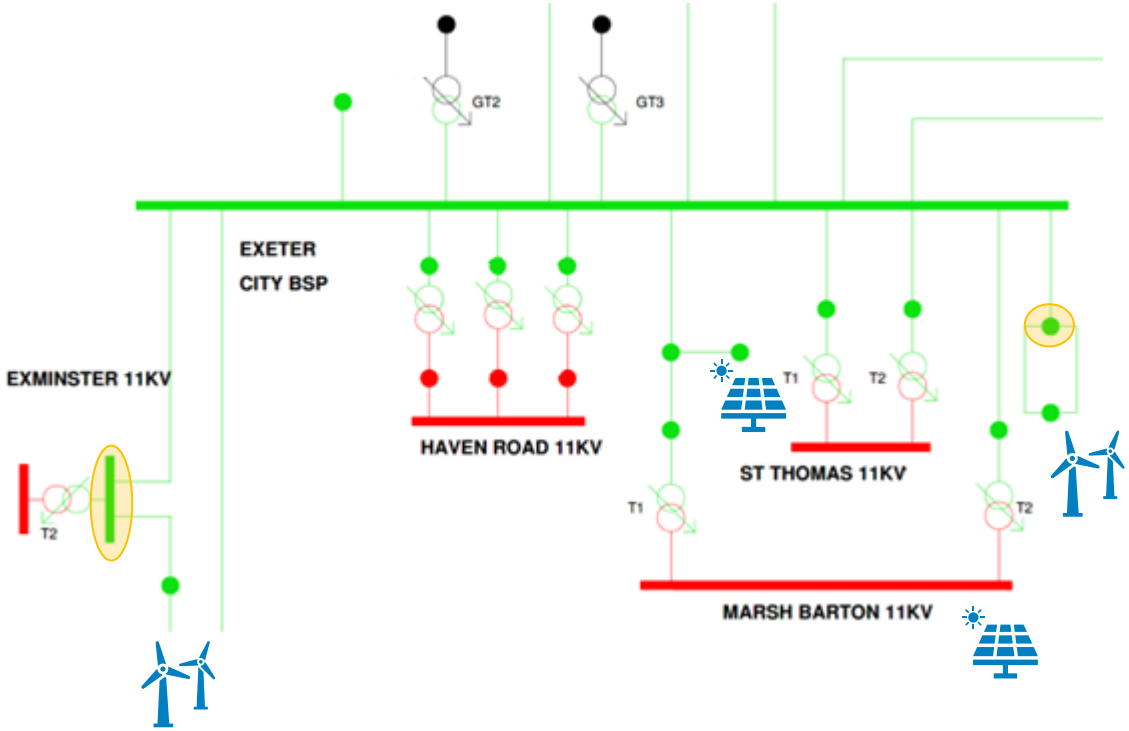
PSC Project Manager: Grant McCormick

Further Info: www.pscconsulting.com/virtual-statcom-innovation-project/

Challenges with Reactive Power

- Active Power – Useful part for motors, heating, lighting, etc.
- Reactive Power – Essential for regulating voltage to get active power through the system





Virtual Statcom NIA project concept

- Existing Distributed Generators (DGs) in DNO networks operate at a fixed power factor -> this may not be appropriate for all network conditions.

- The Virtual Statcom project assumed that instead of operating with fixed power factor:
  - The DGs can operate across a power factor range
  - The DGs can be set to target different power factors

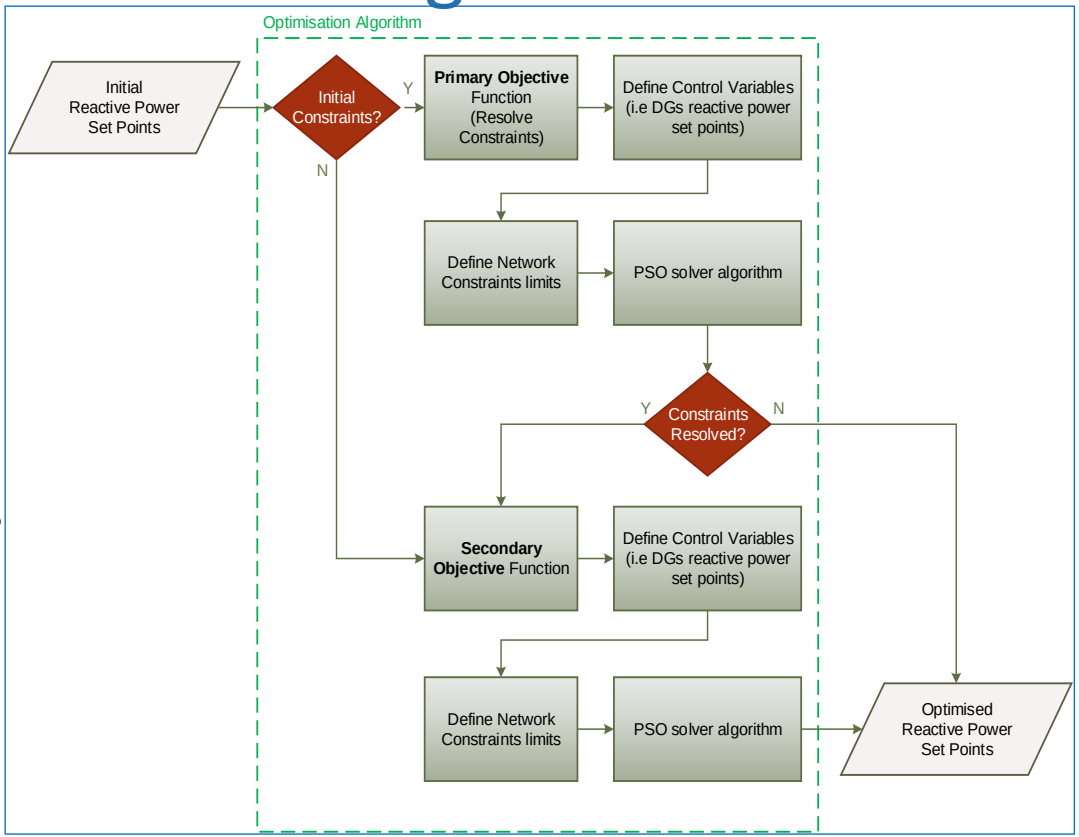
- By optimising the reactive power output of DGs in a network for different conditions there is a potential to increase the hosting capacity for both load and generation LCTs.

Study Zone Selection & Data Validation

- Three 33 kV Bulk Supply Points (BSPs) and one 11 kV Primary network selected.
- Networks were selected with different characteristics to test the applicability of the Virtual Statcom project methodology.
- Historical data for each network was validated.

Virtual Statcom Optimisation Algorithm

- Automated analysis
- Particle swarm optimisation algorithm
- Objective function:
  - Resolve system constraints
  - Optimise for system losses



Virtual Statcom NIA Project Key Results

- Demonstrated the ability to resolve or reduce constraints in networks through optimised reactive power dispatch
  - this has the potential to reduce the amount of active power curtailment required to manage network constraints.
- Released load capacity through optimising the reactive power output of existing generators
  - average hosting capacity released across the three BSP networks is equivalent to the connection of 10,000 domestic EV chargers.
- Released generation capacity by avoiding curtailment of active power for existing generators

Next Steps

Real System Trial

- The trial project concept is to build on the algorithm developed in the Virtual Statcom NIA project to operate/control reactive power devices connected to the distribution system in a new way.

- A control system is proposed that:
  - Uses reactive power to manage network constraints, reducing the amount of active power curtailment in networks required.
  - When no constraints are present on a network, uses reactive power management to reduce network losses.

- A market mechanism to incentivise asset owners to provide reactive power to the control system.

Just Generators?

- The Virtual Statcom NIA project only considered distributed generators to be able to offer controllable reactive power.

- The Re-Act NIC project looks to expand on this and take advantage of all devices that can offer controllable reactive power.
  - Distributed generators
  - Loads
    - EV chargers
    - Heat Pumps
    - Industrial loads
  - Batteries
  - Capacitors
  - STATCOMs/SVCs
  - Synchronous Condensers
  - MVDC links

Do you have a controllable asset?

OUR MISSION

We deliver expertise and solutions to utilities and energy companies around the world, empowering them to innovate and thrive in a rapidly changing industry.

Credit

EFFS - Michail Bitos
Virtual Statcom – Grant McCormick

Questions

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www.pscconsulting.com/news-insights/

OUR VISION

We want to be regarded globally as electricity experts, working with the energy industry to sustainable deliver power and improve the quality of human lives.

Thank You!


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