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Energy storage, an integrated approach

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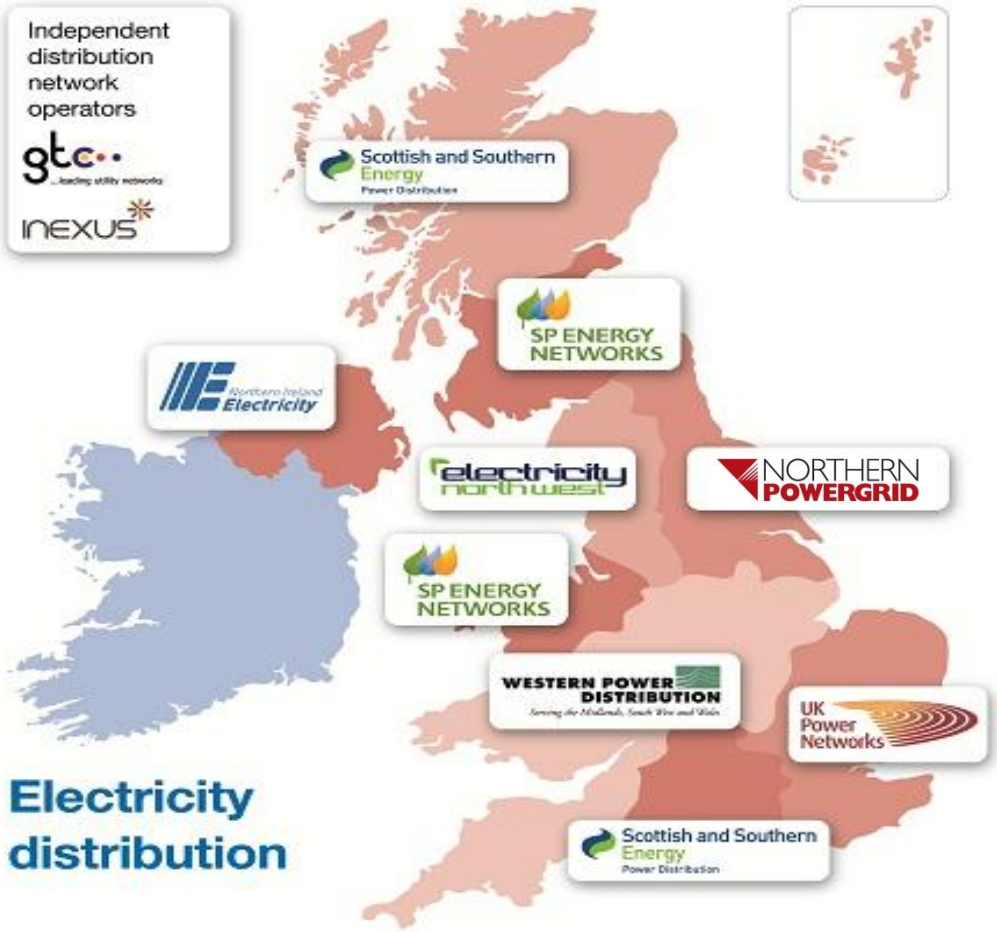
Customer-Led Network Revolution

NORTHERN POWERGRID

Northern Powergrid



All data at March 2011	Licences	Customers	Revenues	RAV
		million	*£m*	*£m*
WPD	4	7.7	1,107	4,936
UKPN	3	8.0	939	4,523
N. Powergrid	2	3.9	518	2,138
SSE	2	3.7	683	2,754
SP	2	3.5	663	2,637
ENW	1	2.4	329	1,347

- Regulated distribution network operator
- Covering Northeast & Yorkshire
- 31,000 substations
- 33,000 km of overhead line
- 66,800 km of underground cable
- 2,500 employees
- Annual capital investment £280 m
- Annual operating expenditure £180 m

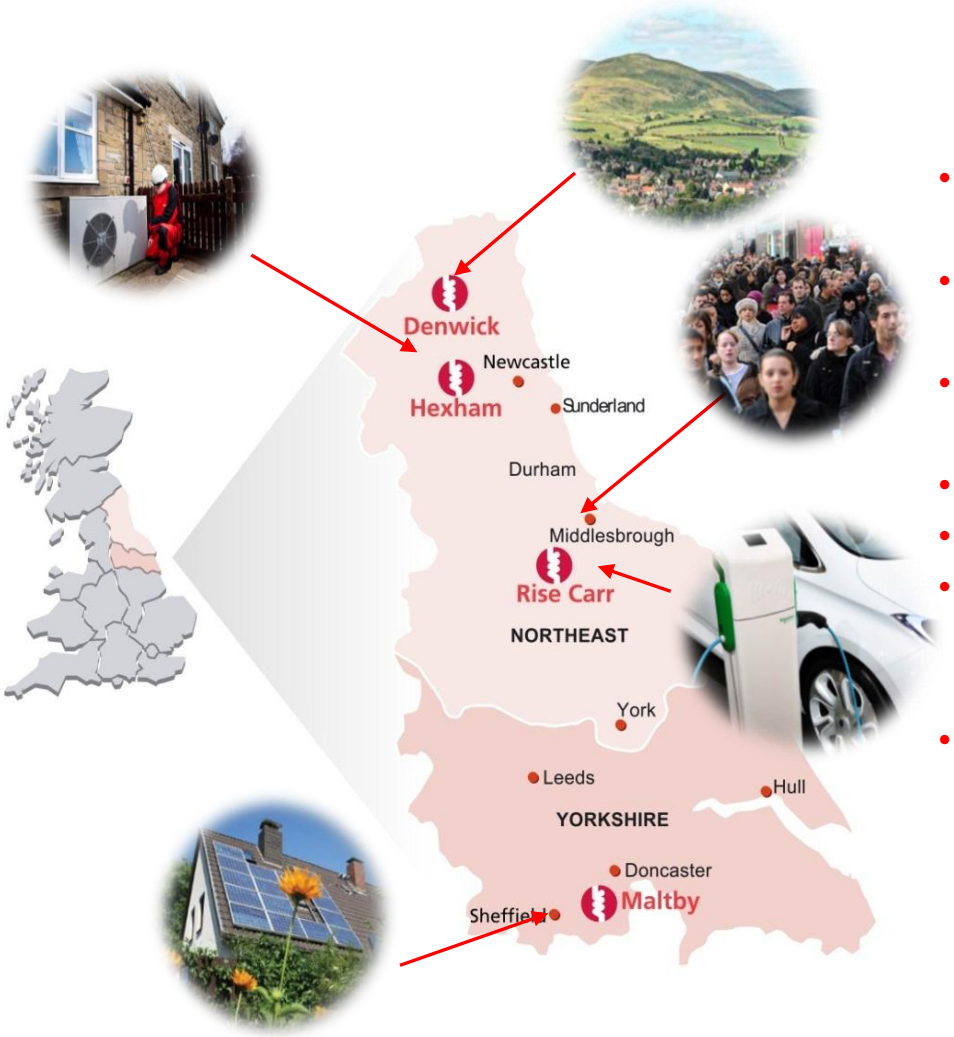
The project has five main learning outcomes:

Monitoring	What are the current, emerging and possible future customer load & generation characteristics?
Customer Flexibility	To what extent are customers flexible in their load and generation, and what is the cost of this flexibility?
Network Flexibility	To what extent is the network flexible and what is the cost of this flexibility?
Optimum Solutions	What are the optimum solutions to resolve network constraints driven by the transition to a low-carbon economy?
Effective Delivery	What are the most effective means to deliver optimal solutions between customer, supplier and distributor?

Customer and network technology solutions

Active customer participation to minimise electricity costs through flexibility

National smart meter data



Focussed, integrated network technology solutions installed on four trial networks:

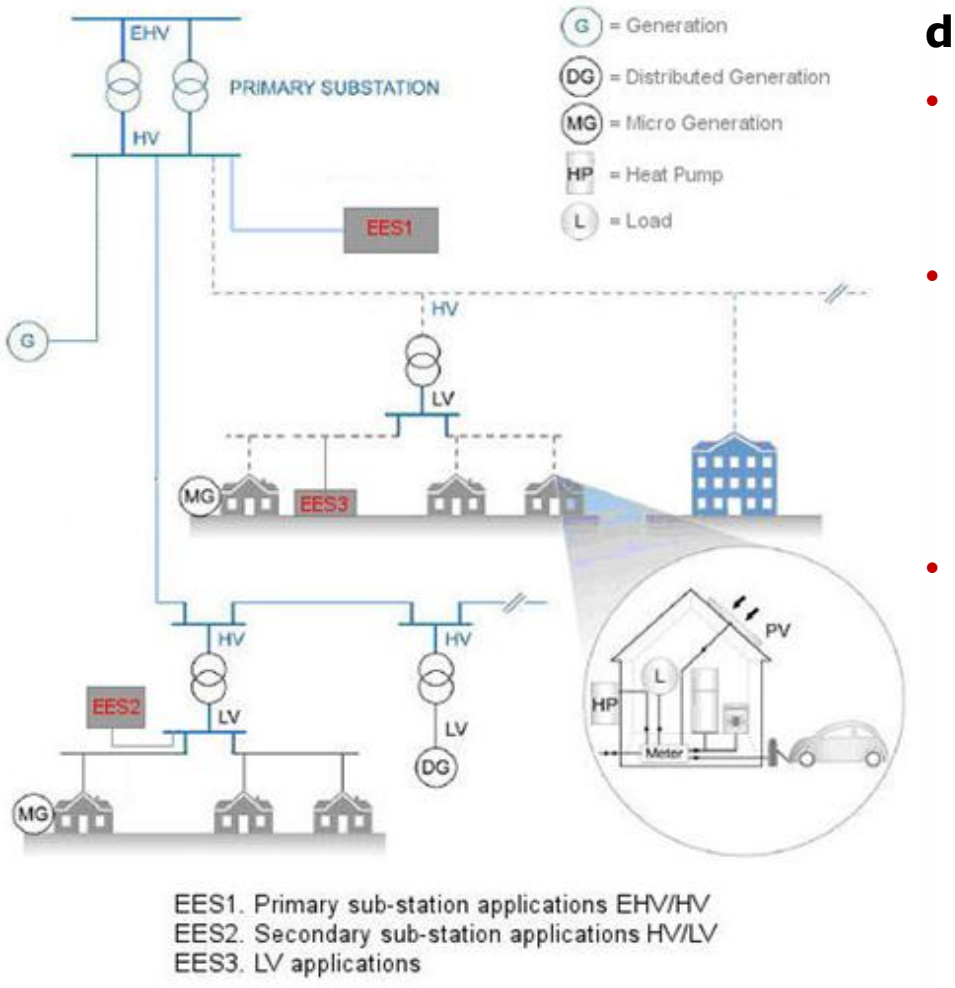
- Real-time Thermal Rating (RTTR)
- Enhanced Automatic Voltage Control (EAVC)
- Electrical Energy Storage (EES)
- Network Monitoring
- Demand response
- Trials at all voltage levels 400V, 6kV, 11kV, 20kV, 33kV and 66kV
- Representative of 80% of the UK's distributed network.

CLNR: A smart grid in a box

Specifications developed during CLNR

• EES1 Electrical Energy Storage System (nominal 2.5MVA/5MWh)	• Enhanced Automatic Voltage Control using HV in-line regulators (EAVC 3)
• EES2 Electrical Energy Storage System (nominal 100kVA/200kWh)	• Enhanced Automatic Voltage Control of a ground mounted HV switched capacitor bank (EAVC 4)
• EES3 Electrical Energy Storage System (nominal 50kVA/100kWh)	• Enhanced Automatic Voltage Control of LV feeders (EAVC 5)
• Overhead Line Real-time Thermal Rating System	• Network monitoring of Primary substations
• Primary Transformer Real-Time Thermal Rating system	• Monitoring of HV feeders
• Secondary Transformer Real-time Thermal Rating system	• HV Industrial & commercial customer monitoring equipment
• Real Time Thermal Rating of underground cables	• Network monitoring of secondary substations
• Enhanced Automatic Voltage Control of a primary transformer (EAVC 1)	• LV Feeder monitoring equipment
• LV In-line regulator Enhanced Automatic Voltage Control (EAVC 2)	• Grand Unified Scheme (GUS) • CLNR Data Warehouse • Demand Response

Electrical Energy Storage (EES)



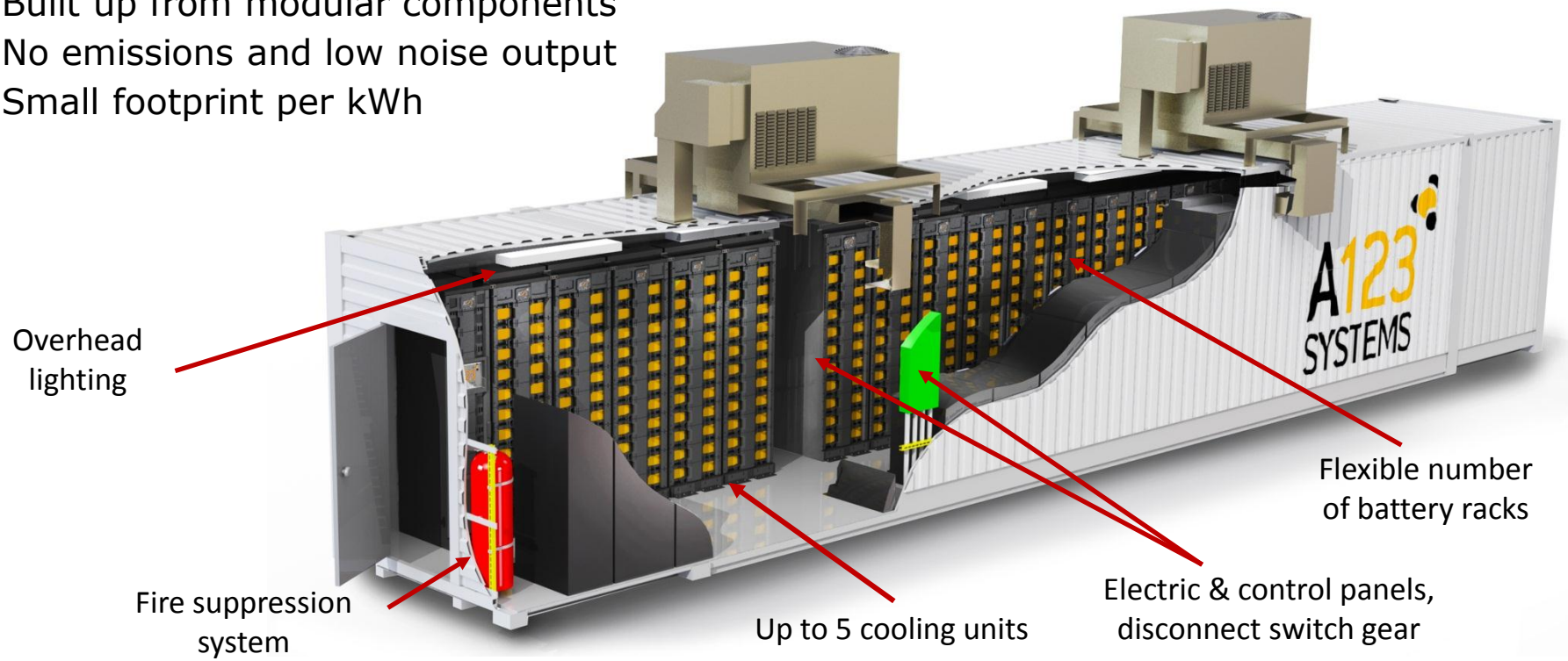
EES1. Primary sub-station applications EHV/HV
EES2. Secondary sub-station applications HV/LV
EES3. LV applications

Installed and commissioned six EES devices in 2013

- One 2.5MVA / 5MWh unit connected at HV to demonstrate voltage control and peak shifting of network loads
- Two 100kVA / 200kWh units connected at the LV
  bars of a distribution substation, to support the local transformer and the HV network
- Three 50kVA / 100kWh units connected deeper into
  the network on an LV distributor, supporting the LV mains cable, local transformer and HV network back to the primary substation

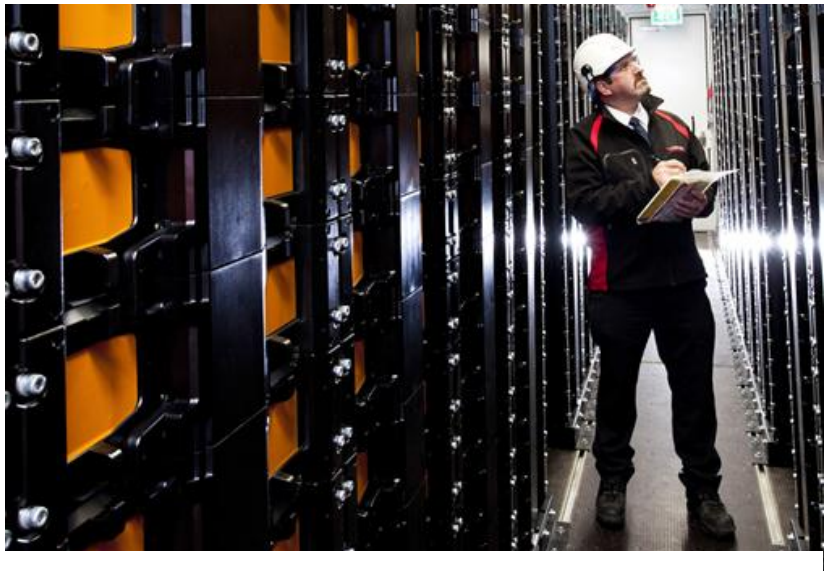
Rise Carr: 2.5 MVA / 5MWh device

- Containerised for flexibility and future mobility
- Operates as an individual device; plus integrates within the wider smart grid controller
- Stable lithium-ion nano-phosphate chemistry
- Safe system by design
- Built up from modular components
- No emissions and low noise output
- Small footprint per kWh

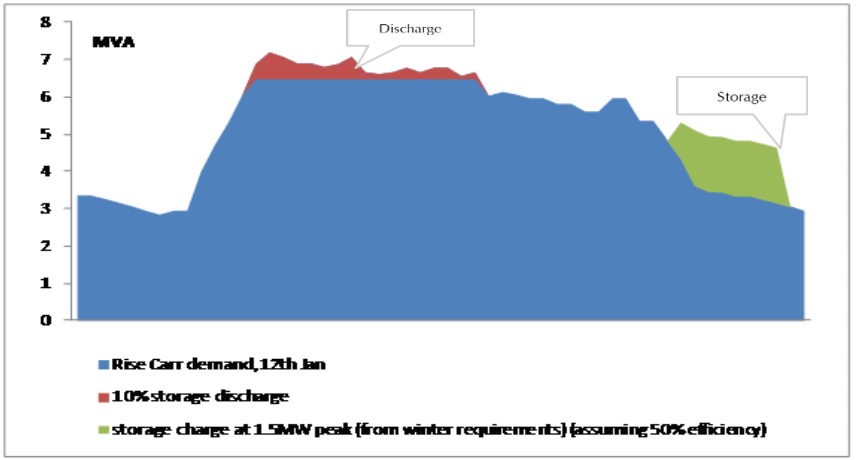


Installation of our 5MWh battery

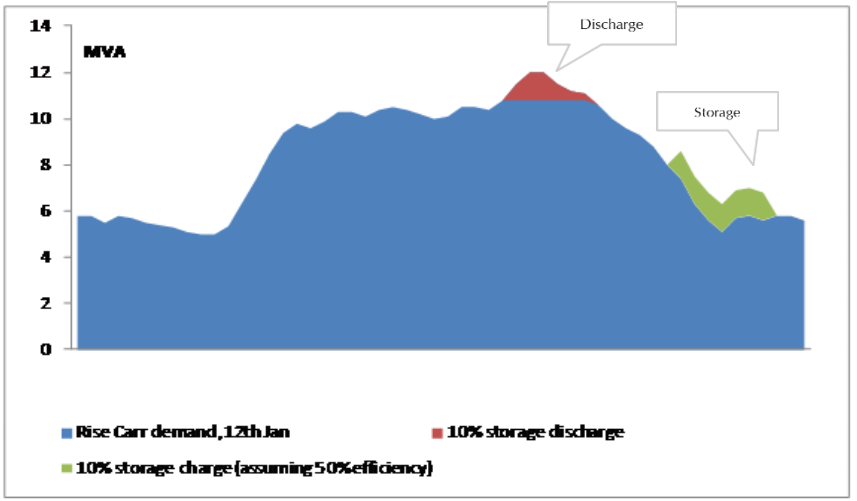
Electrical Energy Storage (EES)



Summer Forecast - Rise Carr - Peak shifting

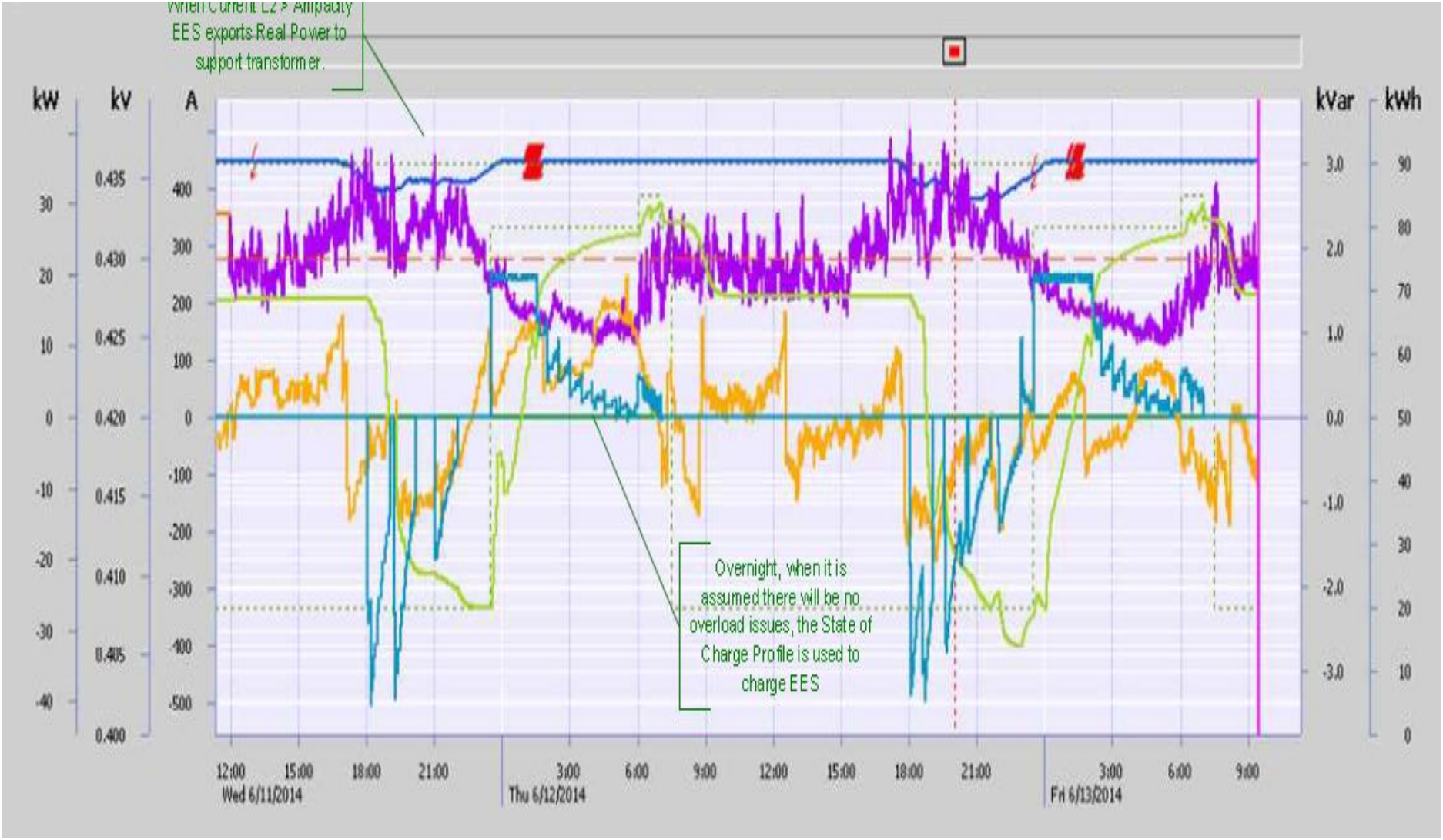


Winter Forecast - Rise Carr - Peak shifting



Trial results

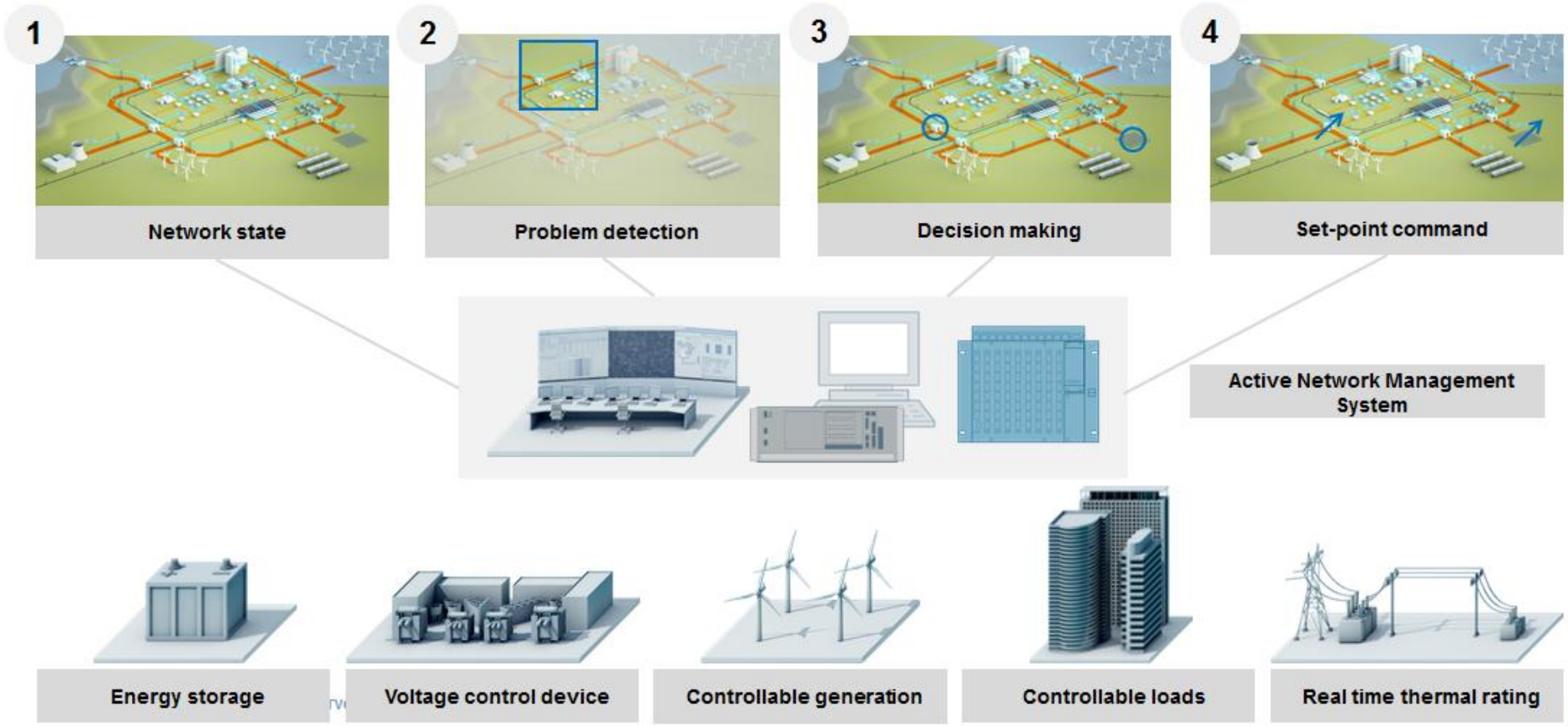
Harrowgate Hill - EES support for thermal issue on Transformer



Grand Unified Scheme (GUS)

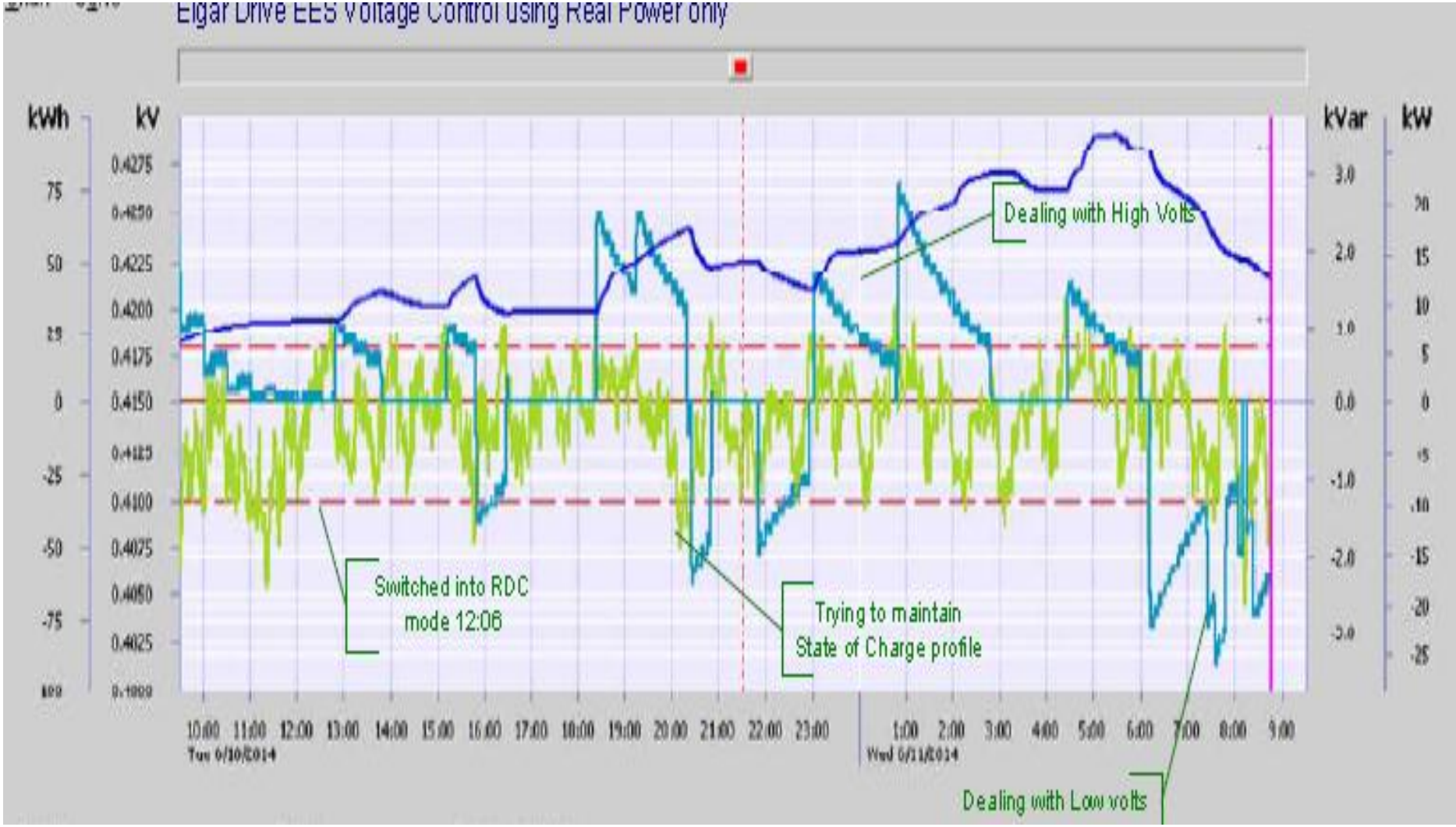
- Active control system to manage the enhanced devices via state estimation and volt-var control
- Network devices can operate independently but combining the technologies could give greater benefits
- Complex algorithms in central and distributed control will define the optimum set point for each device and manage each constraint to release network headroom

Grand Unified Scheme (GUS)



Trial Results

Elgar Drive - GUS utilising EES for real power voltage control



Trial Results

Harrowgate Hill - Real power thermal and reactive power voltage control

Lessons learnt from our network trials

Customer-Led Network Revolution

- Systems and communications integration is complex
- Expect the unexpected to happen
- Real-time monitoring = a lot of data
- Appropriate technical experts are much in demand
- Non-standard challenges call for agile solutions
- DNO's rules its safety systems better than external consultants and you can't go wrong with a belt and braces approach
- When it goes well and it all the equipment works in harmony, it feels good!

Want to know more?

Website

www.networkrevolution.co.uk

YouTube channel

www.youtube.com/CLNRUK