Innovation Learning Event

Wednesday 4 July 2018

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Introduction

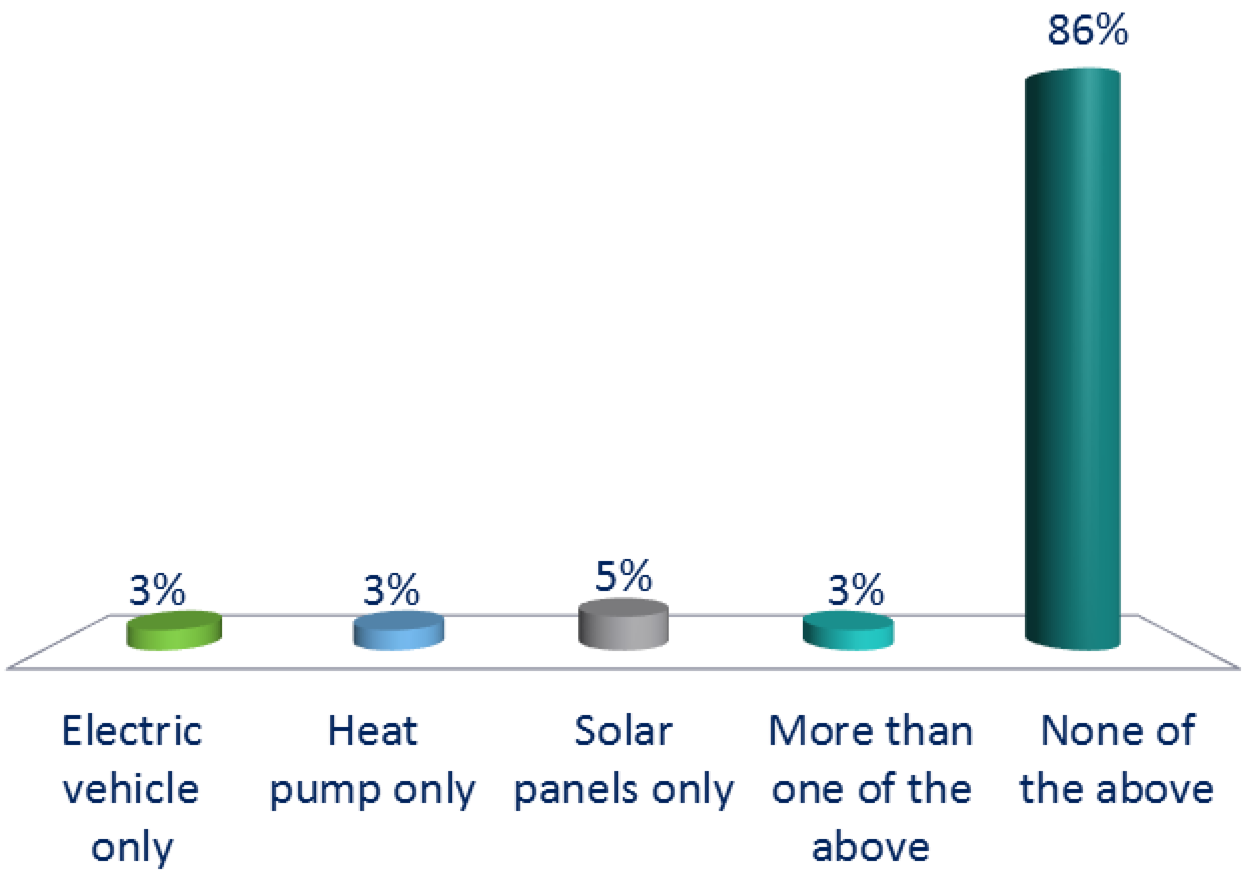
Paul Turner
Innovation Manager

Agenda

Introduction 10.00 – 10:15am				
Respond 10.15 – 10.45am	Smart Street 10.45 – 11.15am	Break 11.15 – 11.35am	Celsius 11.35 – 12.05am	DSO 12.05am – 12.35pm
Lunch/networking 12.35 – 1.30pm				
Breakout session 1 1.30 – 2.00pm	Breakout session 2 2.00 – 2.30pm	Break 2.30 – 2.50pm	Breakout session 3 2.50 – 3.20pm	Q&A & close 3.20 – 3.30pm

Do you use any of the follow low carbon technologies?

A. Electric vehicle only
B. Heat pump only
C. Solar panels only
D. More than one of the above
E. None of the above



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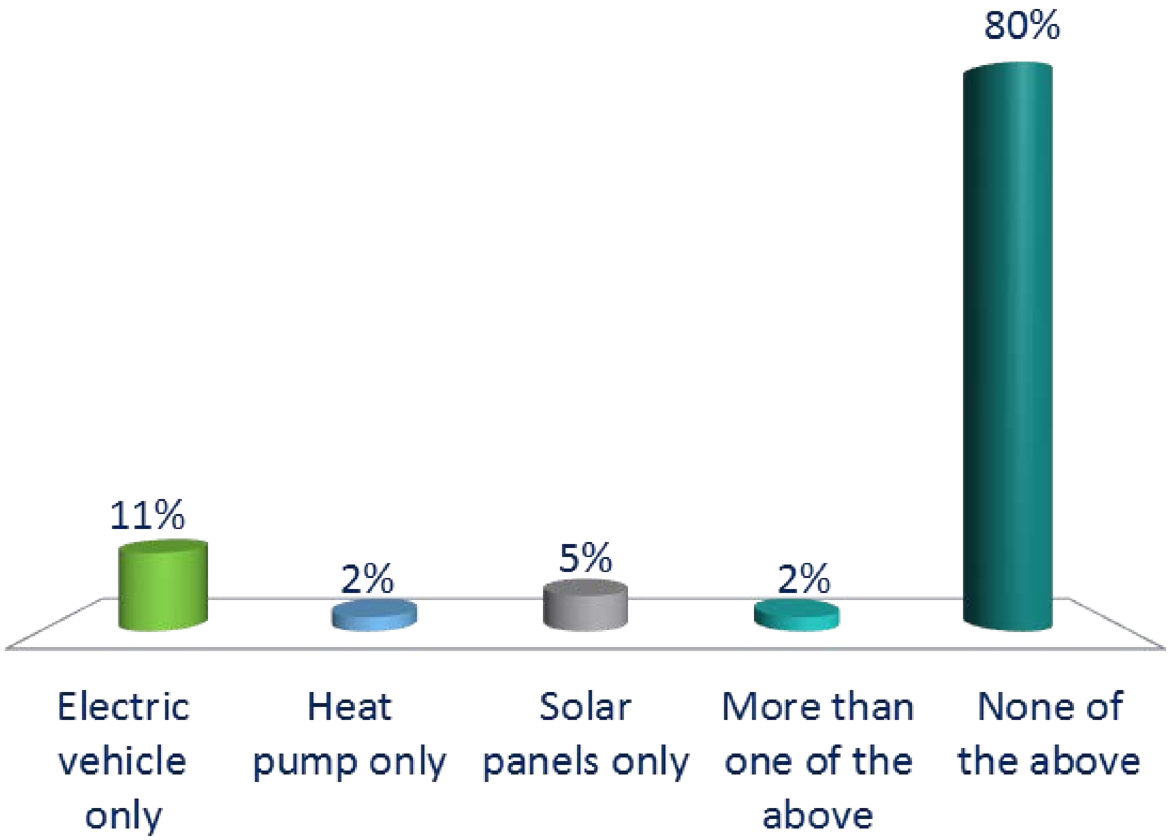
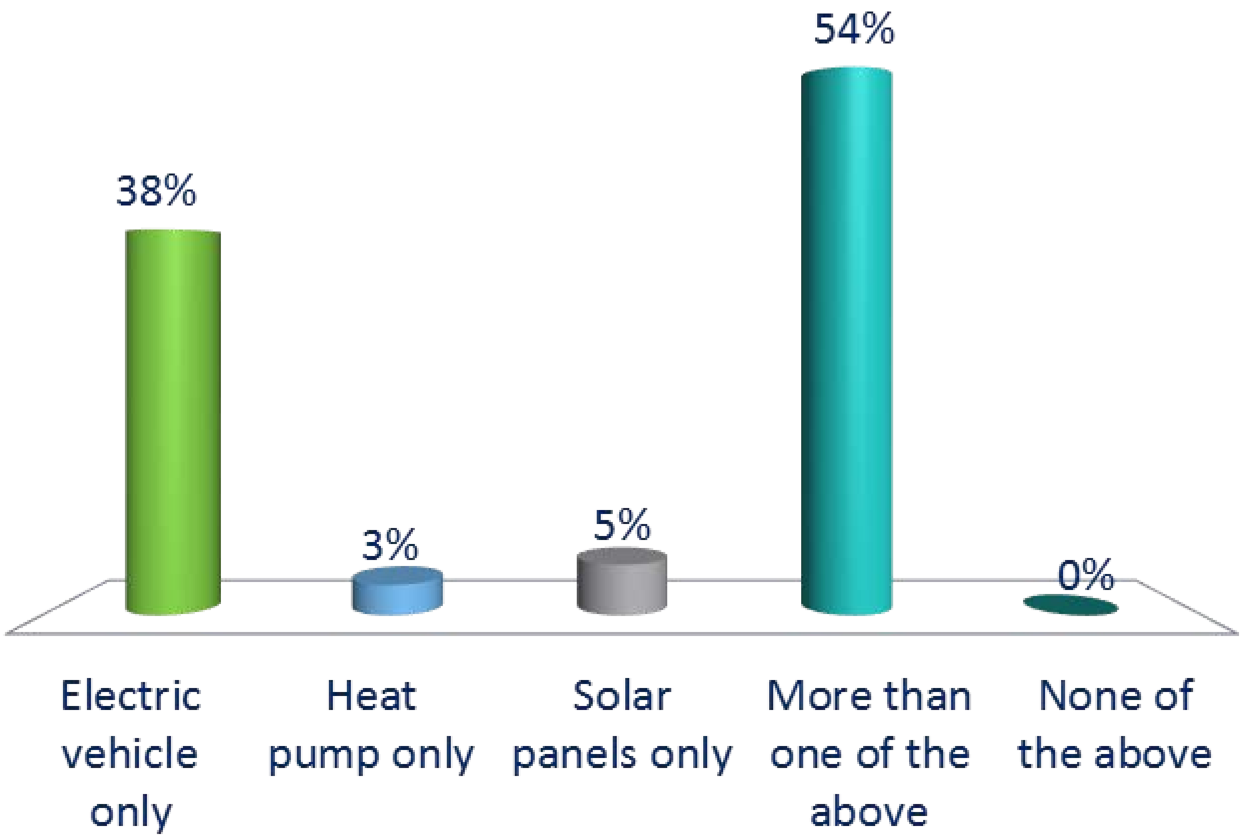


July 2017

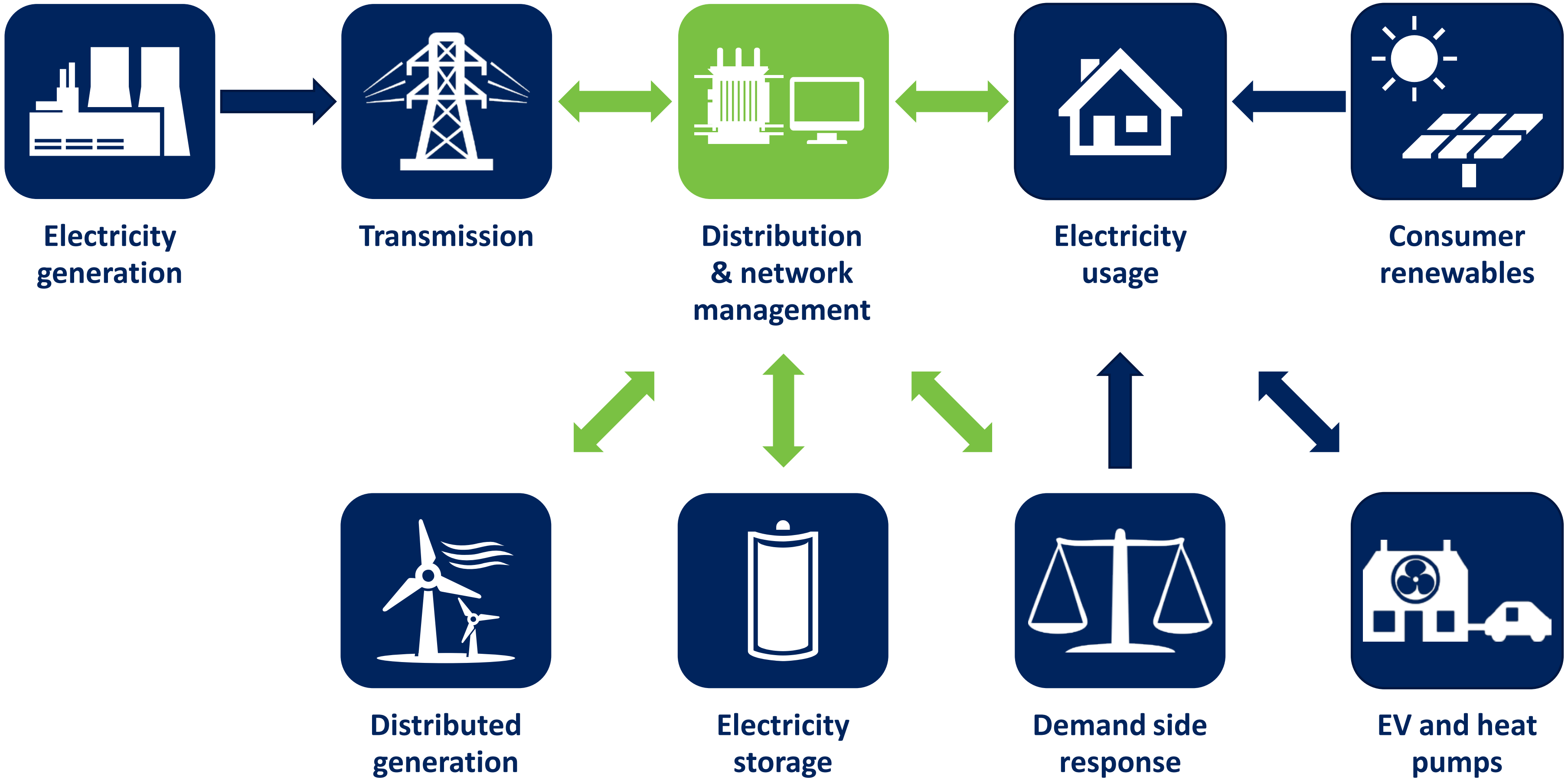
Which if any do you think you will have by 2030?

A. Electric vehicle only
B. Heat pump only
C. Solar panels only
D. More than one of the above
E. None of the above



Electricity networks – the challenge

The electricity networks are facing unprecedented change as a result of decarbonisation, digitisation and decentralisation



Industry trends

Shifting power-generating sources	Customer choice and changing energy demands	Evolving policy landscape	The smart, flexible energy system and the DSO transition	Uncertainty and choices for the electricity network companies

Developing a national innovation strategy

Objectives

Identify opportunities for the continuous improvement of our networks and deliver improved value to our customers

Find new ways to make our service more reliable, more affordable, more accessible, cleaner and safer

Provide us the flexibility to better respond to the changing requirements of our customers, both today and tomorrow

energynetworks association

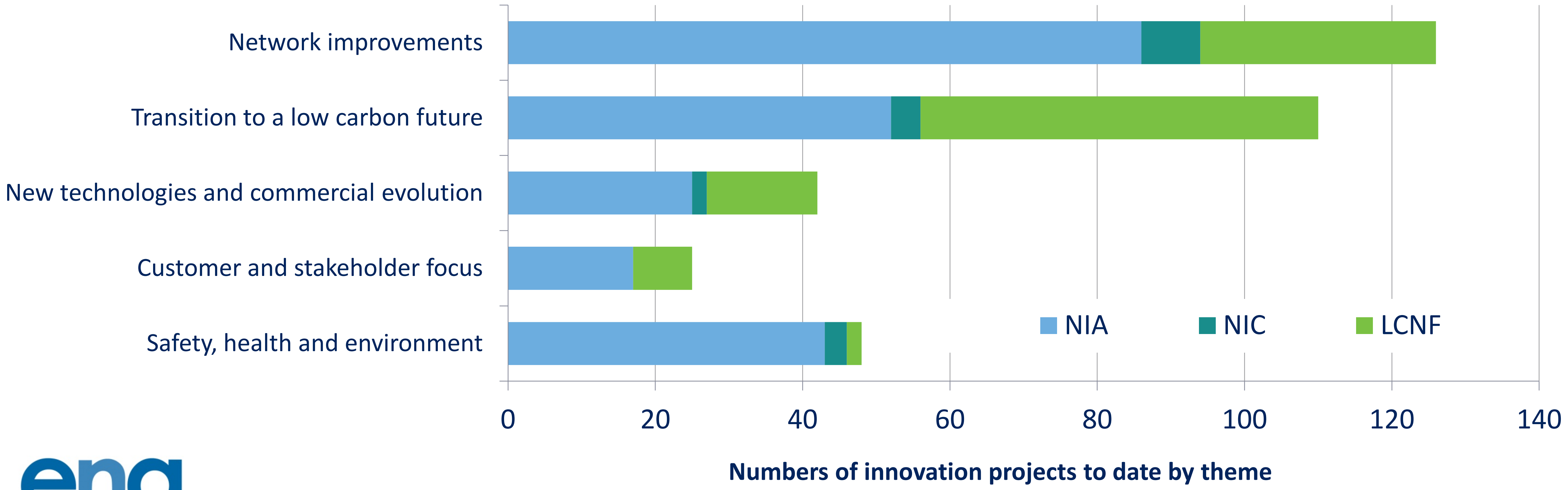
Innovation themes

Network improvements and system operability	Transition to a low carbon future	New technologies and commercial evolution	Customer and stakeholder focus	Safety, health and environment

energynetworks association

Current level of innovation

The electricity networks have already undertaken a range of projects across the various themes but some areas have received more attention than others



energynetworks association

Our innovation themes – aligned to ENA themes

Safety & environment	Network resilience	Capacity	Efficiency	Customer service	Commercial evolution
Strive to continuously improve safety and reduce impact on the environment	Improve network performance and reduce risk	Maximise the use of existing assets to increase demand and generation capacity	Provide our existing services at lower cost	Improve customer experience, offer new services and more choice	Change our role from network operator to system operator

Our completed projects

Project	Safety & environment	Network resilience	Capacity	Efficiency	Customer service	Commercial	Status
Capacity to Customers		✓	✓		✓	✓	Business as usual
CLASS		✓	✓	✓		✓	Business as usual
Smart Street		✓	✓	✓	✓		Complete
Oil Regeneration				✓			Business as usual
The Bidoyng Smart Fuse	✓	✓		✓	✓		Business as usual
Load Allocation		✓	✓		✓		Business as usual
Next Generation LV Board Design	✓	✓		✓	✓		Business as usual
Fault Support Centre	✓	✓		✓	✓		Business as usual
Changing Standards			✓	✓	✓		Complete
Power Saver Challenge			✓	✓	✓		Complete
Demand Scenarios with Electric Heat & Commercial Capacity Options		✓	✓	✓		✓	Complete
Distribution Asset Thermal Modelling			✓	✓			Complete
Asset Risk Optimisation	✓	✓		✓			Business as usual
P2/6 Rewrite		✓					Complete
Reliable Low Cost Earth Fault Detection for Radial OHL Systems	✓	✓		✓	✓		Complete
Investigation of Switchgear Ratings	✓	✓	✓	✓			Complete
Future Network Modelling Functions			✓	✓			Complete

Our in flight projects

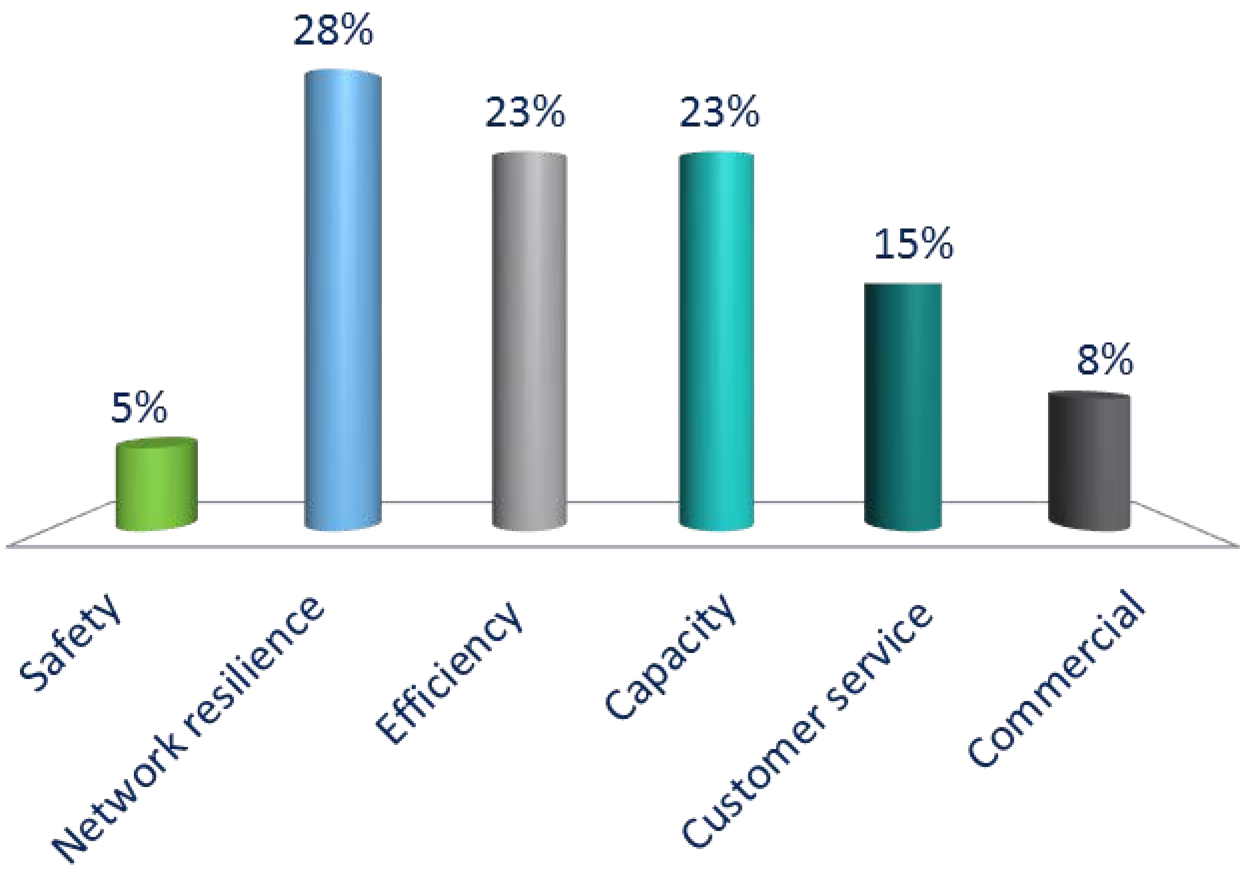
Project	Safety & environment	Network resilience	Capacity	Efficiency	Customer service	Commercial	Timescales											
							2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Respond	✓	✓		✓	✓	✓				■	■	■	■					
Celsius			✓	✓							■	■	■	■	■			
Combined Online Transformer Monitoring				✓					■	■	■	■	■	■				
Sentinel	✓	✓		✓	✓					■	■	■	■	■				
ATLAS		✓	✓	✓						■	■	■	■					
Cable Health Assessment – Low Voltage	✓	✓		✓						■	■	■	■					
Value of Lost Load				✓	✓					■	■	■	■					
Enhanced Voltage Control		✓		✓	✓					■	■	■	■					
Detection of Islands	✓			✓	✓						■	■	■					
Optimisation of Oil Regeneration				✓	✓						■	■	■	■	■	■	■	
Tapchanger Monitoring	✓			✓							■	■	■	■	■			
Smart Metering		✓	✓	✓	✓	✓					■	■	■	■	■			
Electricity and Heat			✓	✓	✓						■	■	■					
Avatar				✓	✓						■	■	■	■				

Areas for future investigation

Project	Safety & environment	Network resilience	Capacity	Efficiency	Customer service	Commercial	Timescales											
							2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Cutouts	✓	✓		✓									■	■				
Tree Cutting	✓	✓		✓									■	■				
Creosote	✓												■	■				
Losses	✓		✓	✓									■	■				
Condition Measurements	✓	✓		✓									■	■				
Condition Models	✓	✓		✓									■	■	■			
Network Models		✓	✓	✓	✓								■	■	■			
Network Reliability	✓	✓		✓	✓									■	■	■	■	
Cost Benefit Analysis	✓	✓	✓	✓	✓	✓								■	■	■	■	
Customer Service Improvement					✓	✓								■	■	■	■	■
Control Room Automation	✓	✓		✓	✓	✓								■	■	■	■	■
Connections			✓	✓	✓										■	■	■	■

On which strategy area would you like to see more focus

A. Safety
B. Network resilience
C. Efficiency
D. Capacity
E. Customer service
F. Commercial



RESPOND

Innovative Active Fault Management

Paul Marshall
Innovation Project Manager

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Agenda

Introduction	Project overview	Respond techniques
Trials & analysis	Customer	Next steps

Respond overview

Respond is the first UK demonstration of an active fault level management solution that avoids traditional network reinforcement

LCN Fund
Low Carbon Networks

Competitive competition
Funded by GB customers
Learning, dissemination & governance
Fourth of our five successful Tier 2 / NIC projects

£

Investment

£5.5 million

- Project Starts **Jan 2015**
- Site selection **May 2015**
- Design **Nov 2015**
- System installation & Go Live **May 2016**
- Post fault analysis **Apr 2018**
- Purchase FCL customer **Apr 2018**
- Safety case **Sep 2018**
- Closedown **Oct 2018**

Project partners

KELVATEK, WSP, ENER-G, ABB, Impact Research, United Utilities, ade

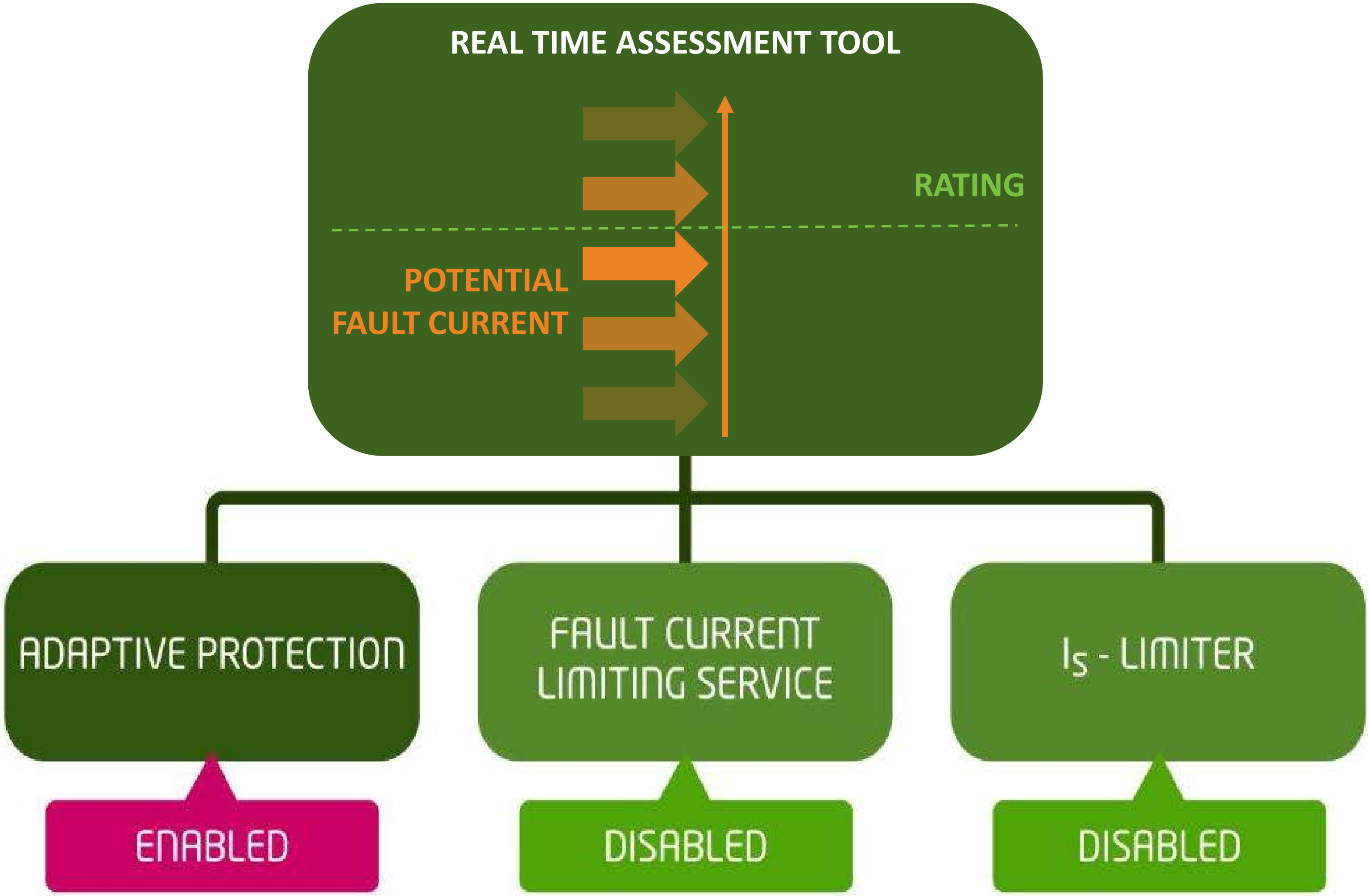
Financial benefits

Up to £2.3bn to GB by 2050

Respond project hypotheses

Faster and cheaper to apply than traditional reinforcement	Will deliver a buy order of fault level mitigation solutions based on a cost benefit analysis	Facilitates active management of fault current, using retrofit technologies and commercial services
Enables a market for the provision of an FCL service	Uses existing assets with no detriment to asset health	Reduces bills to customers through reduced network reinforcement costs

Real time mitigation techniques



● Real time fault current assessment ● Safe network operation ●

Adaptive protection at seven sites

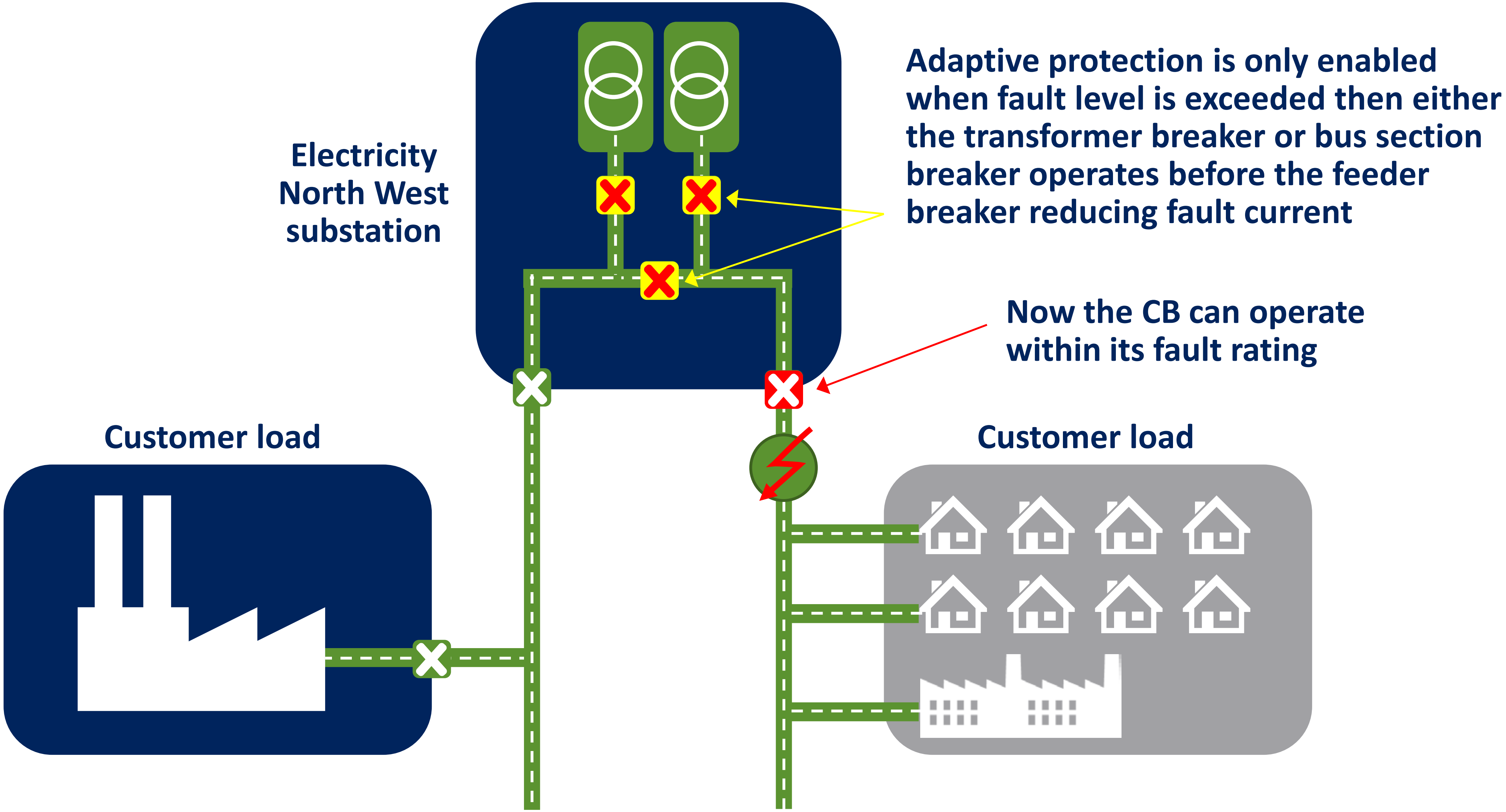
Network already designed to break fault current

Adaptive protection changes the order in which circuit breakers operate to safely disconnect the fault

Using redundancy in the network ensures no other customers go off supply

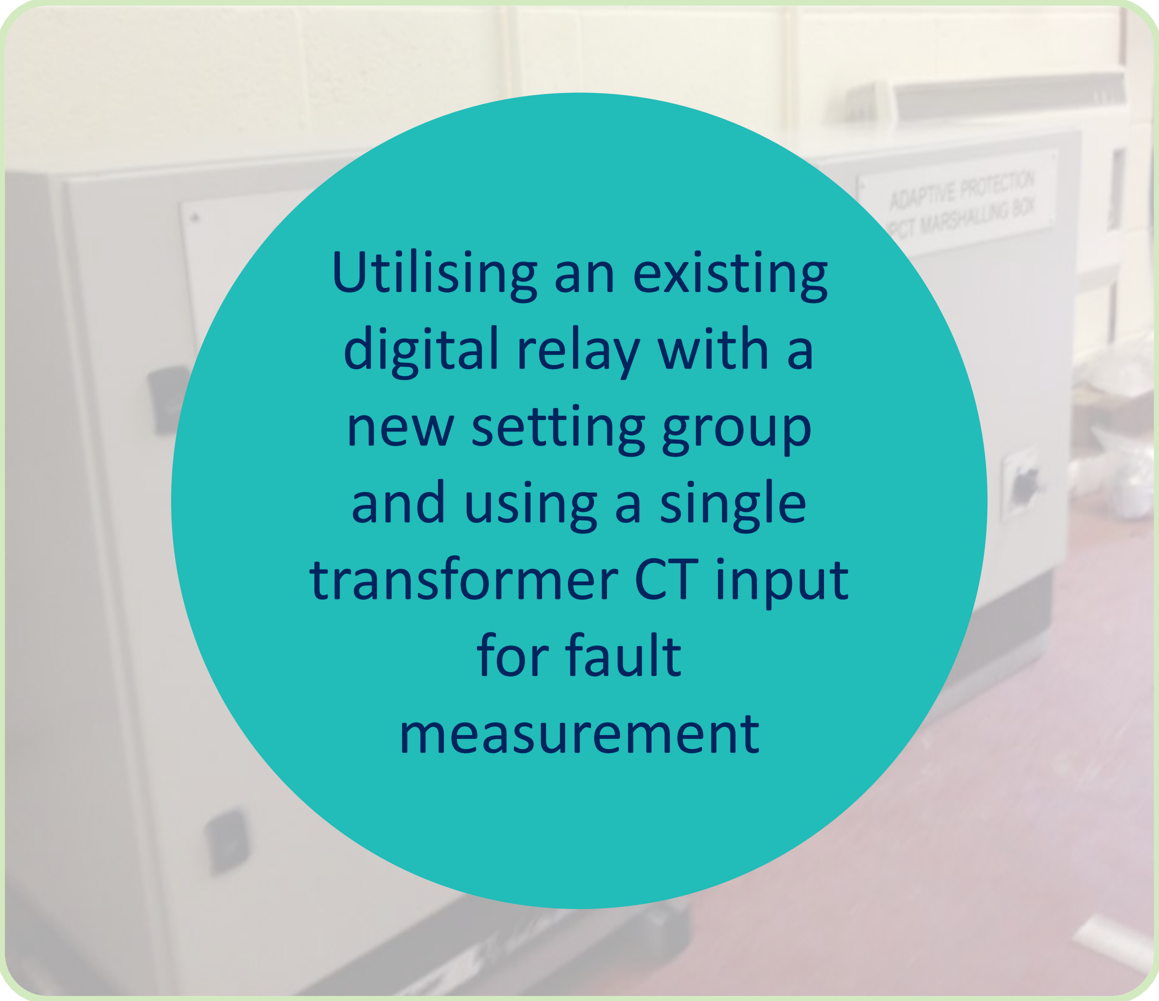
Adaptive protection

Adaptive protection



Simplified BAU design

Alternative installation methods have been designed and installed to demonstrate that Adaptive Protection can be implemented by:



Utilising an existing digital relay with a new setting group and using a single transformer CT input for fault measurement

Installing a new digital relay to replace an existing electro-mechanical relay and using a transformer CT input for fault measurement

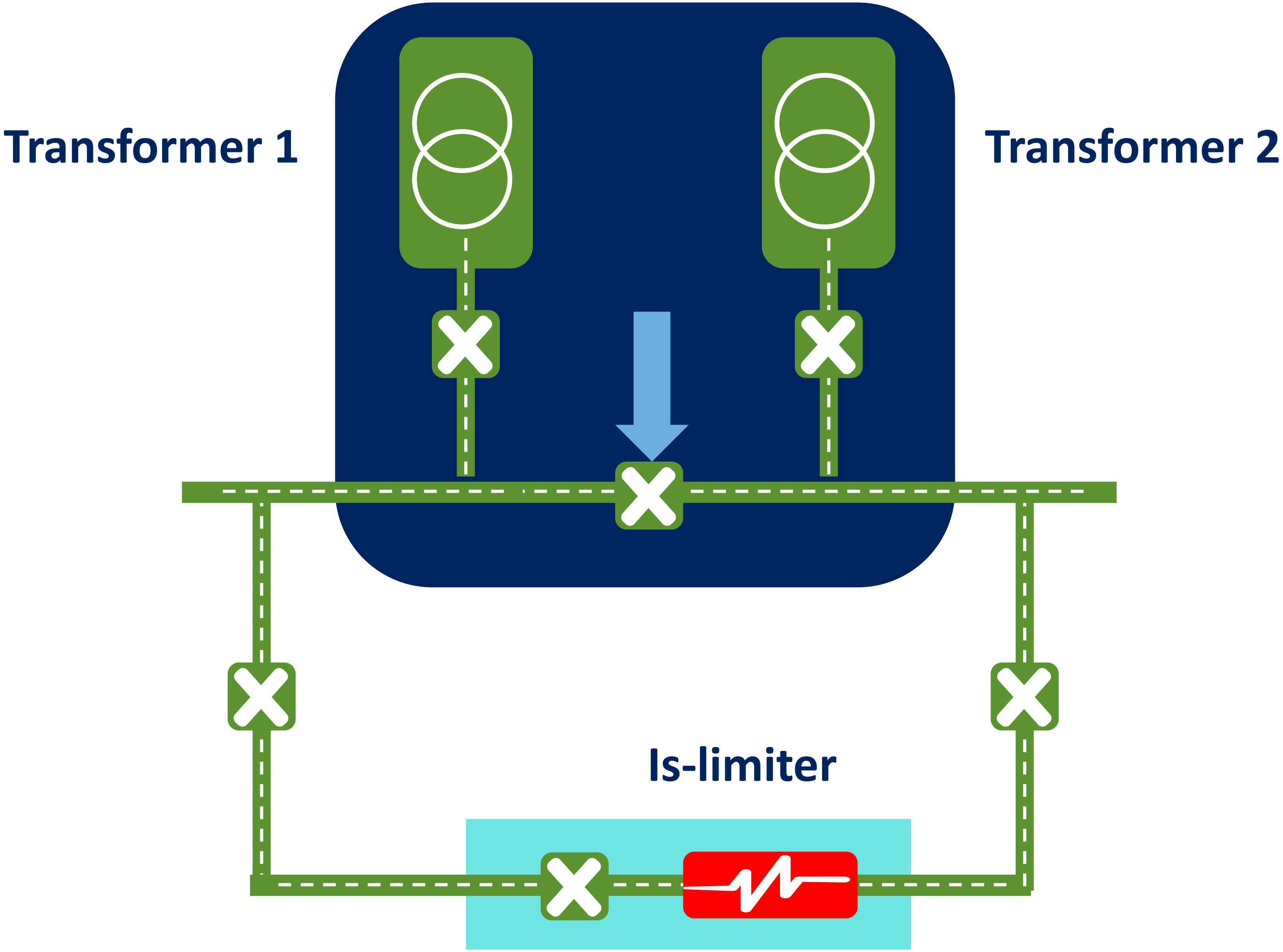
I_S-limiters – two sites and five sensing sites

Operates within
5 milliseconds or
1/200th of a second

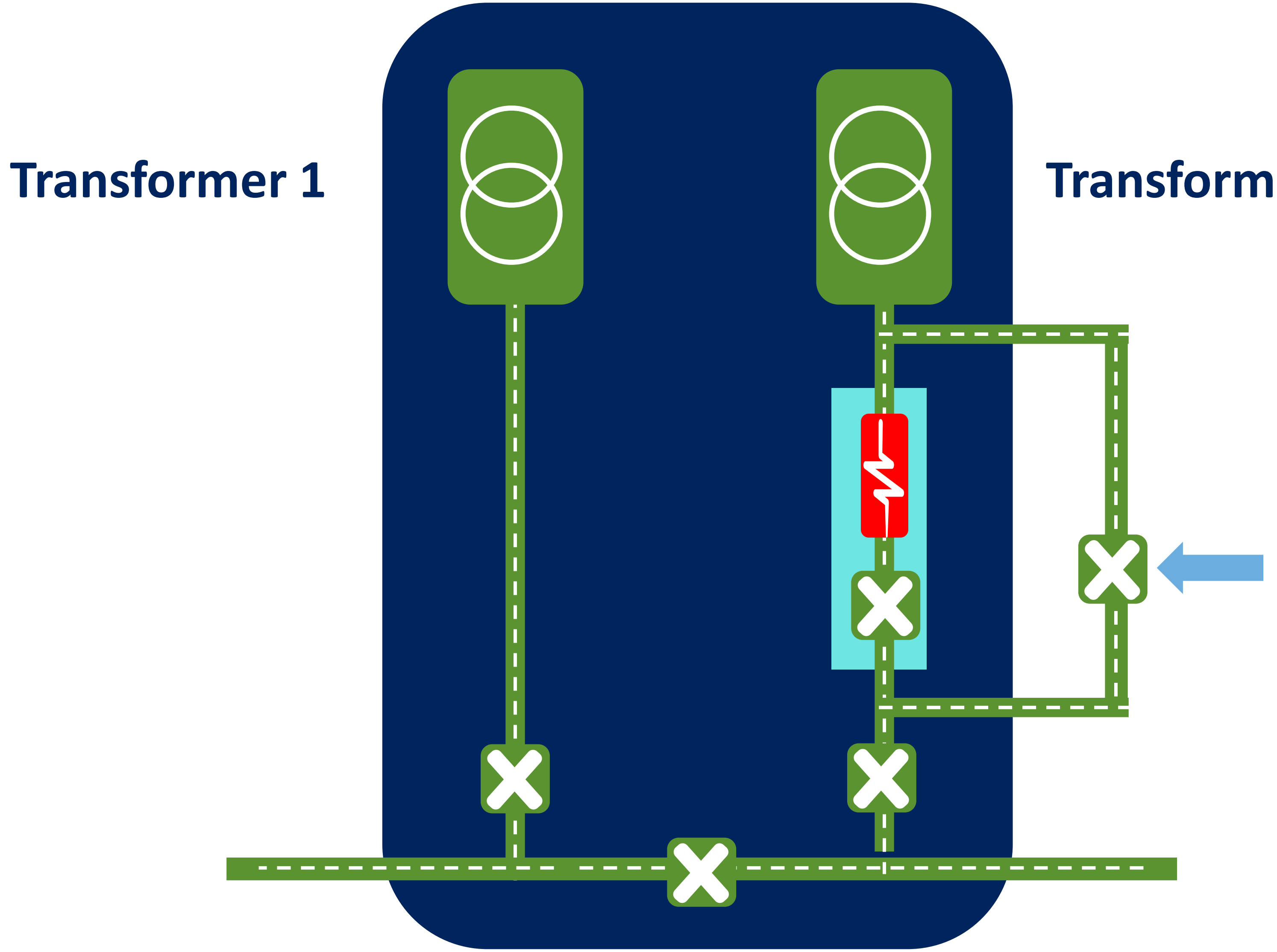
Detects rapid rise in current when a fault occurs and responds to break the current

Respond will prove the technology, review safety case and deploy at two sites

I_S -limiter – Bamber Bridge



I_S -limiter – Broadheath



I_S-limiter sites

I_S-limiter

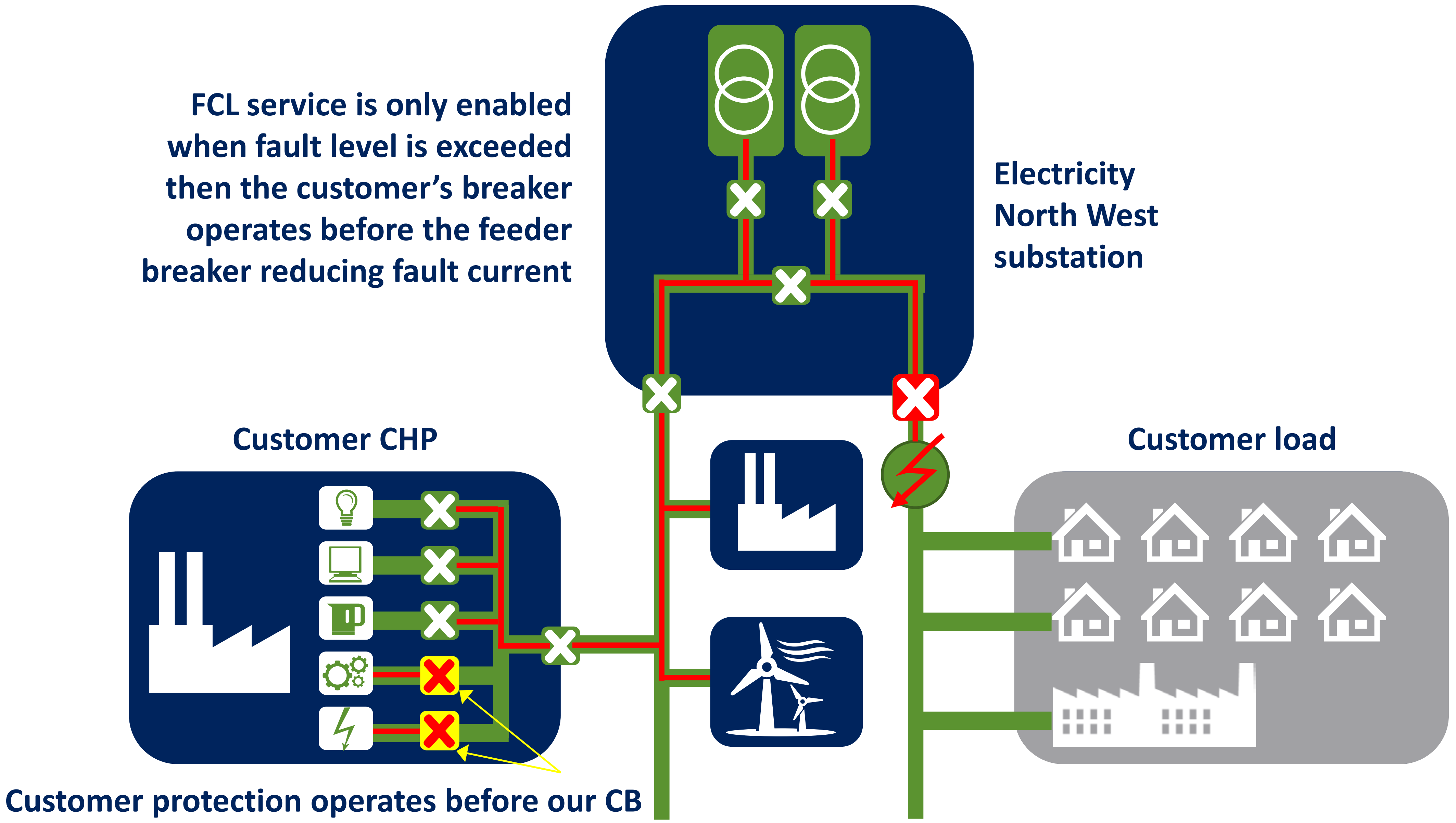
Fault Current Limiting (FCL) service
Two UU sites & three external sites

Fault current generated by customers can be disconnected using new technology

Financial benefits to customers taking part and long term to all customers

Challenge is to identify customers to take part in a trial of the FCL service

Fault Current Limiting service



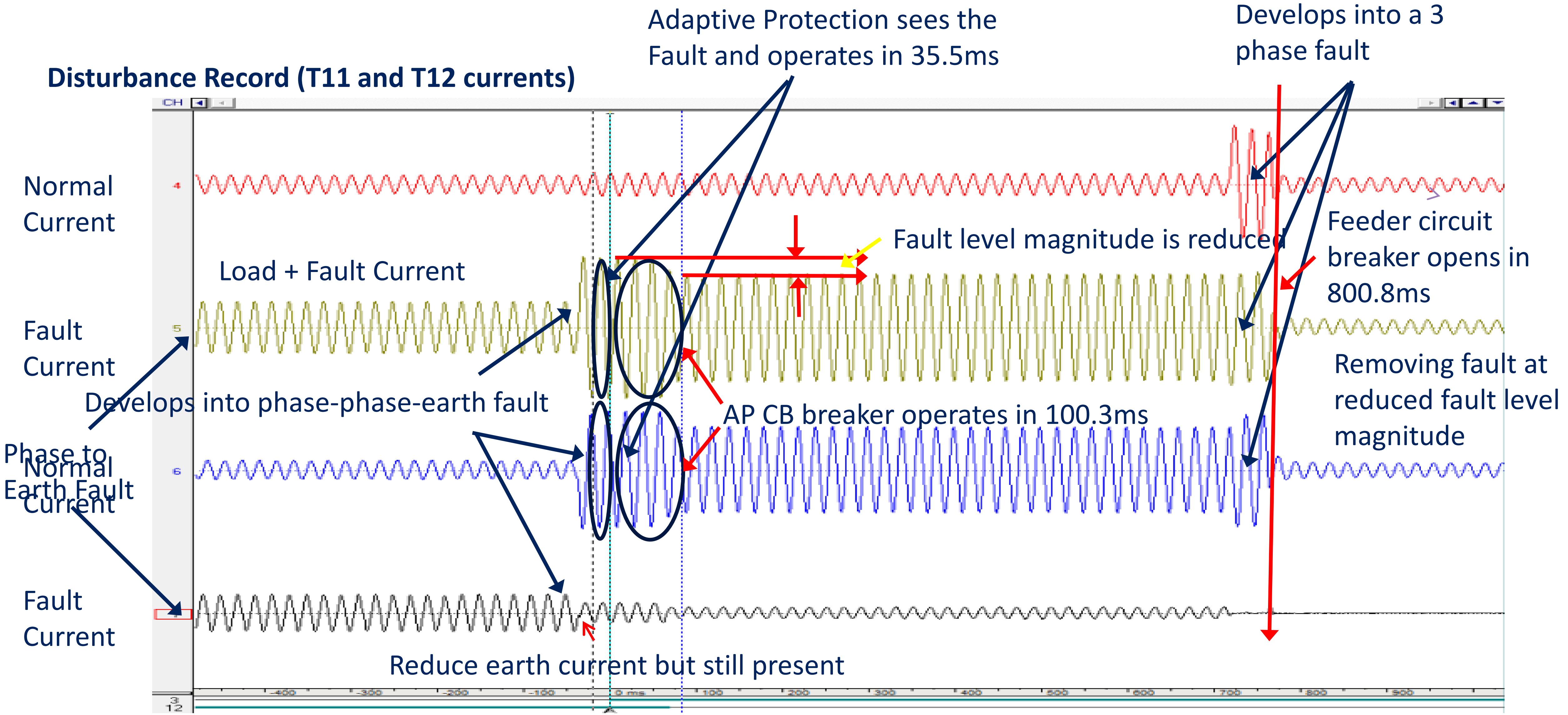
Trials and analysis phase

Respond techniques

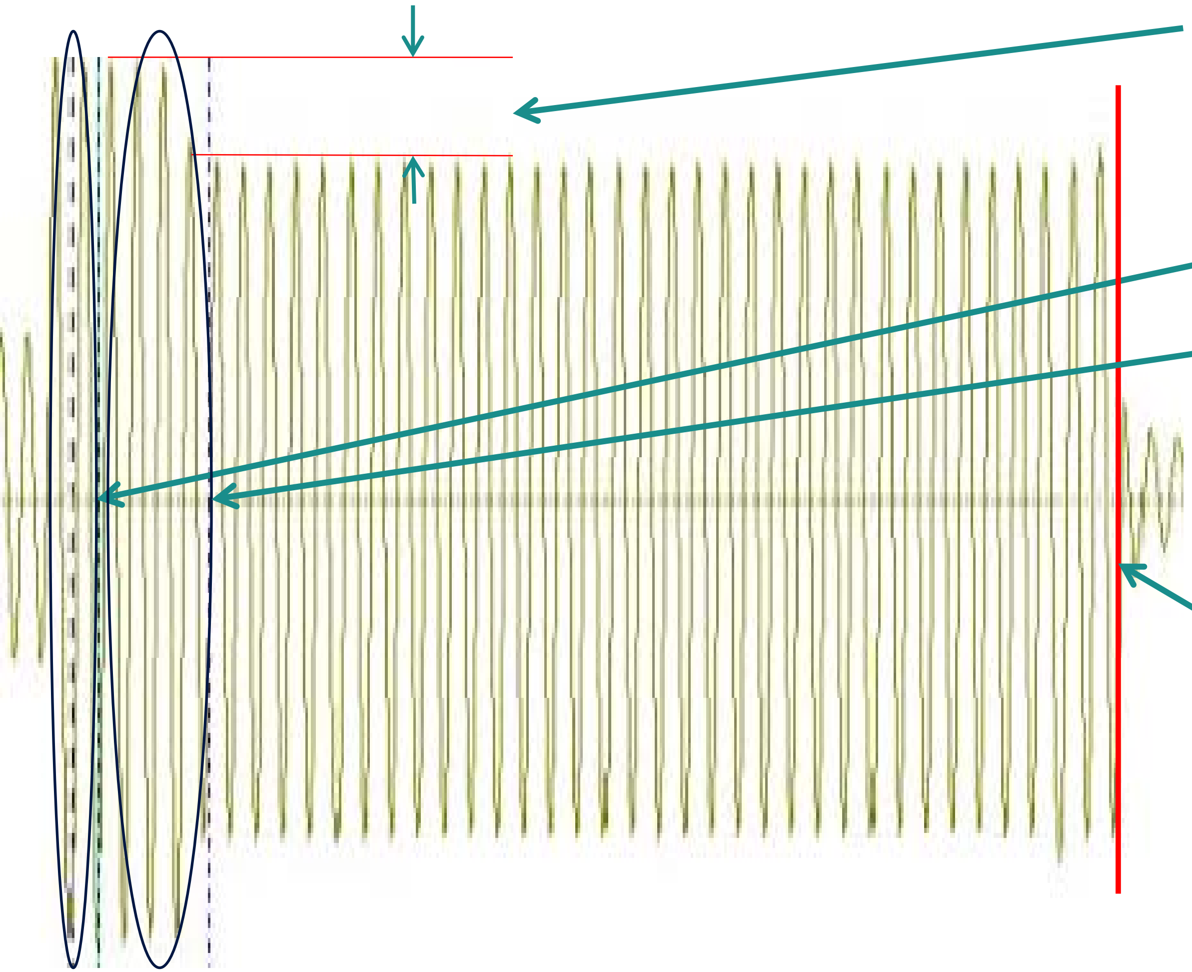
- 166 faults occurred across 14 Respond sites
- 11 successful operations of the Respond techniques
- Eight adaptive protection operations at four different sites
- Two I_S-limiter operations at Bamber Bridge and one I_S-sensing site
- All techniques operated correctly as designed
- No false operations or failures to trigger occurred
- Supports the reliability of the techniques for the safety case

Atherton Town Centre – Collier brook 11kV cct
29 July 2016 @ 22:39

Disturbance Record (T11 and T12 currents)



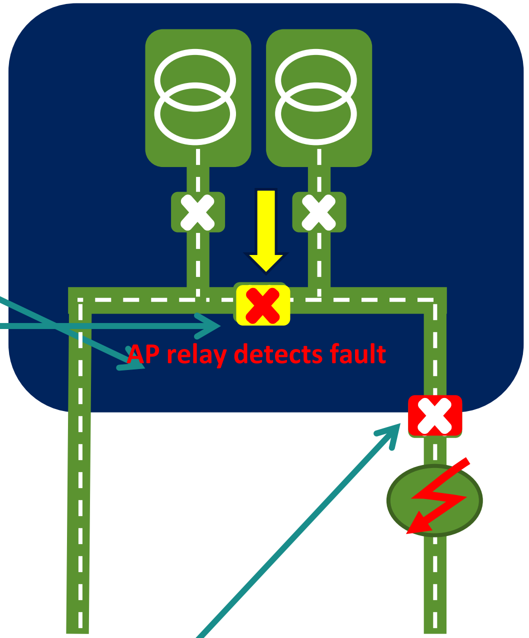
Waveform vs Sequence



Fault level magnitude is reduced

Adaptive Protection relay sees the fault and operates in 35.5ms

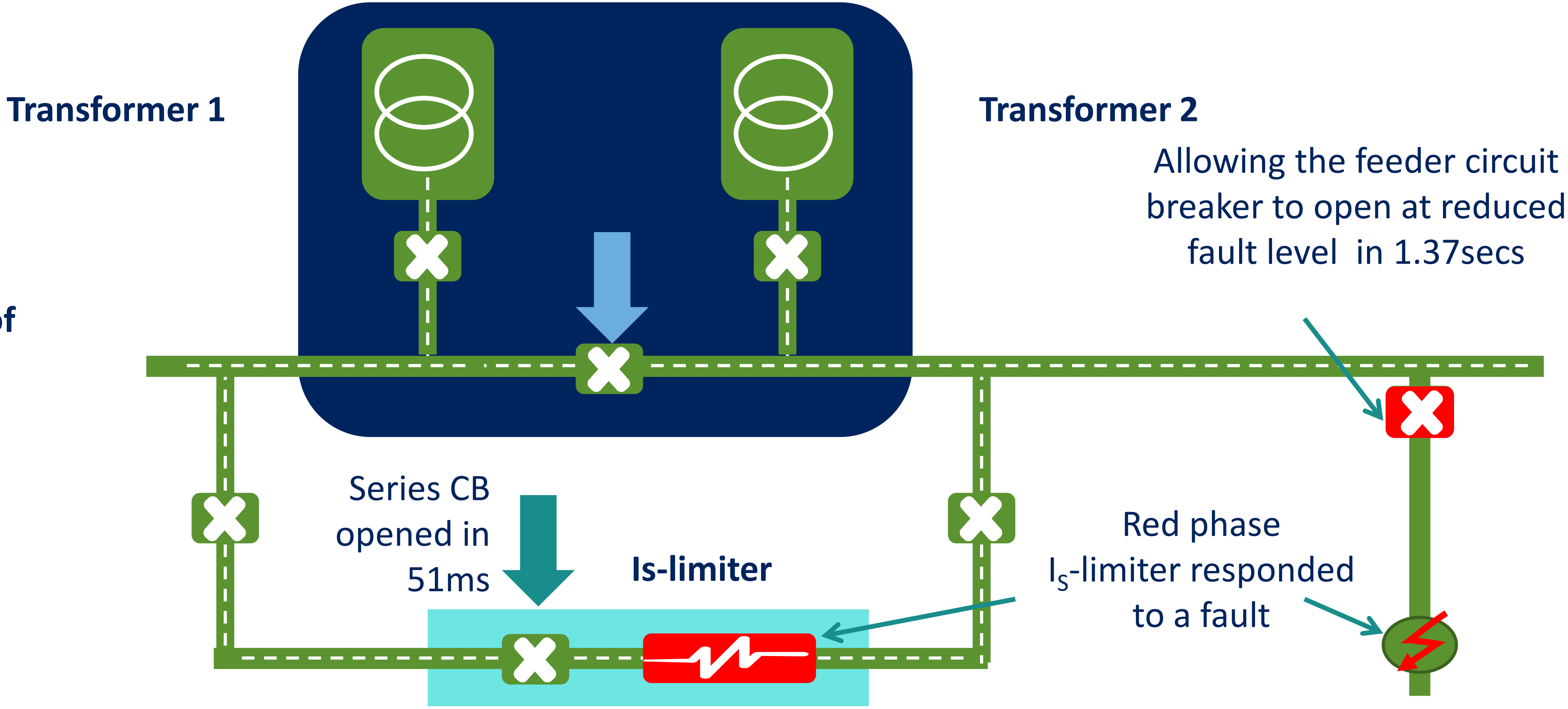
AP CB breaker operates in 100.3ms, opening the bus-section breaker



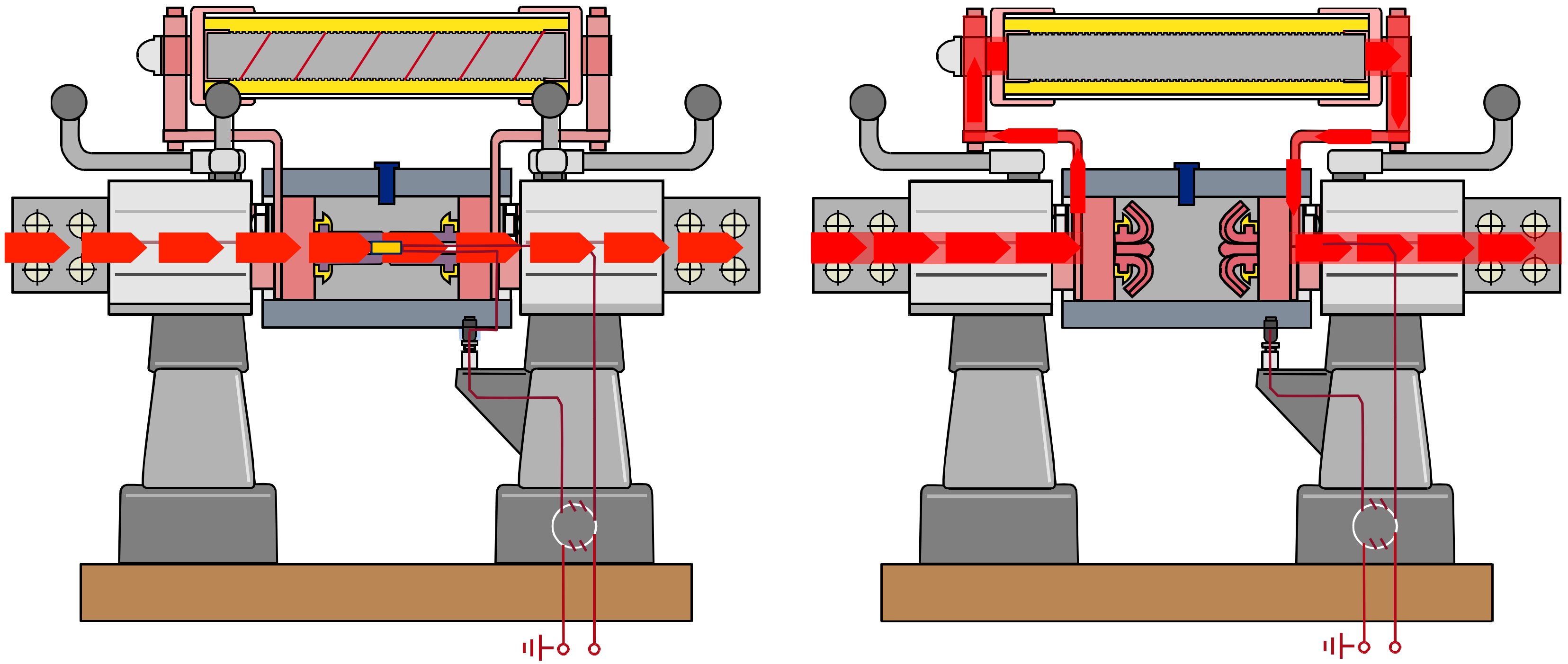
Allowing the feeder circuit breaker to open at reduced fault level in 800ms

I_S–limiter Bamber Bridge 22 May 2017

No waveforms are available due to the speed of operation of the I_S-limiter



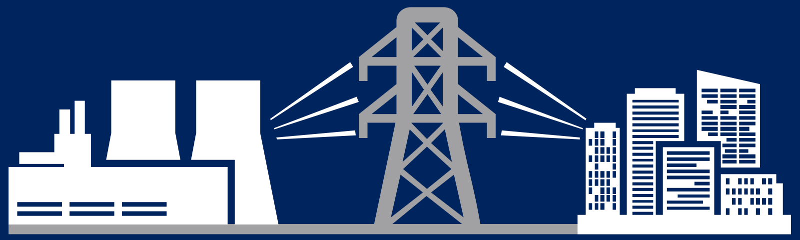
Function: Insert-holder with insert



Bamber Bridge red phase fuse

Bamber Bridge yellow phase fuse

Fault Current Limiting service

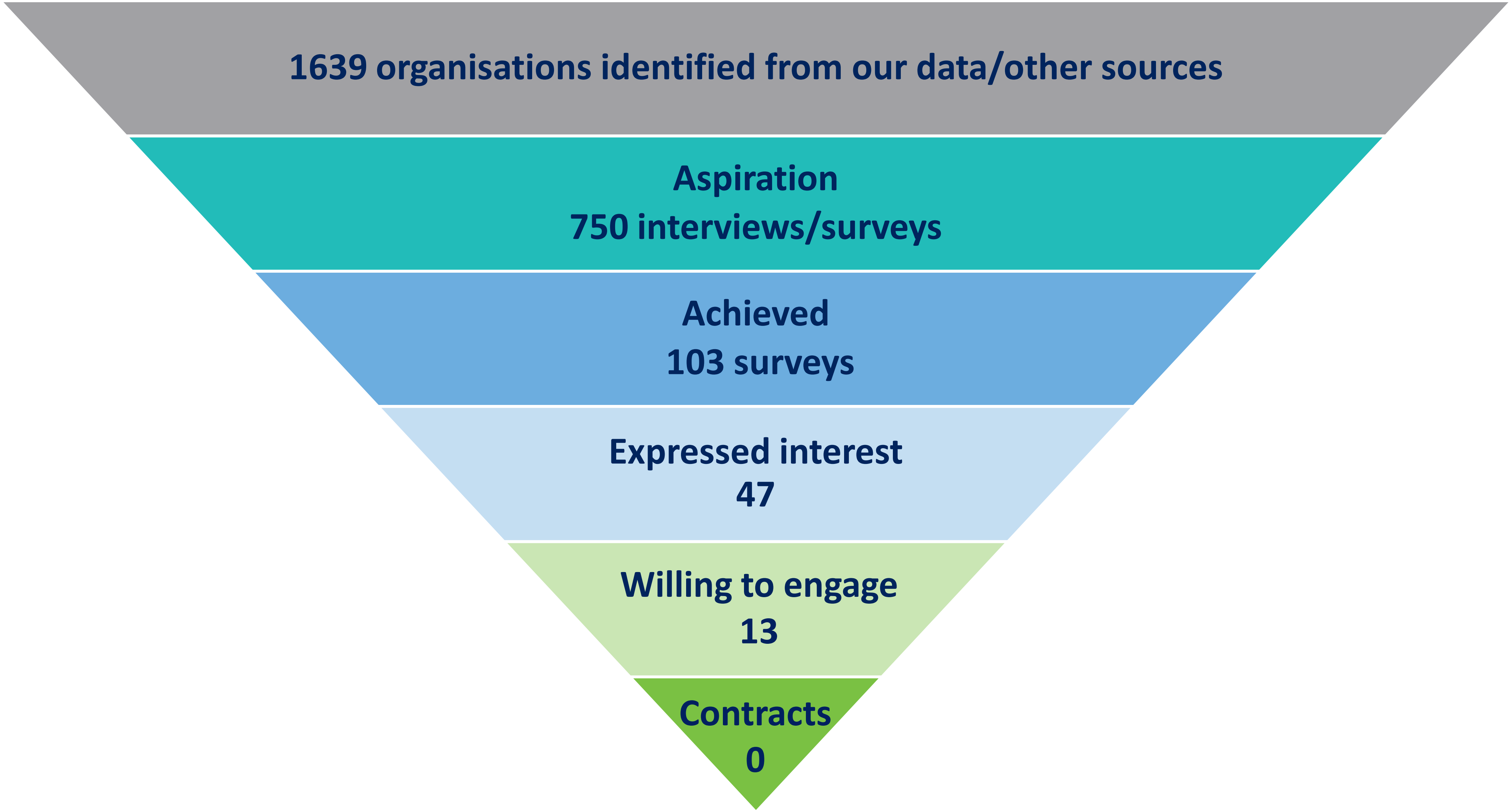


Survey analysis
‘appeared to prove’
the hypothesis that the

Respond method enables a market for an FCL service

A target market was identified of customers from **non-manufacturing industries** and those
‘able to constrain their motor or generator’
for up to 10 minutes, without significant impact

The reality – challenges of engaging with customers



Risks - barriers to transitioning from interest to agreeing terms

Essential to have electricity available 24/7 or a 10 minute constraint would have significant impact
Connection not within project timescale or not connected in parallel

Nervousness about the number of constraints
Long and short term impact on equipment / increased maintenance

Impact on operation of their business & loss of export ability
Breach of service level agreements (Triad & capacity market) & reputation

Unease at relinquishing control of equipment
Arrangements for re-closure / having staff on standby

Financial incentive = key driver for target market
But only if sufficient to offset all risks AND the revenue from other commercial arrangements

Prototype built to demonstrate a FCL service modules

External view of the RTU and AP panel used to communicate and control with the FCL service installation

Internal view of the RTU

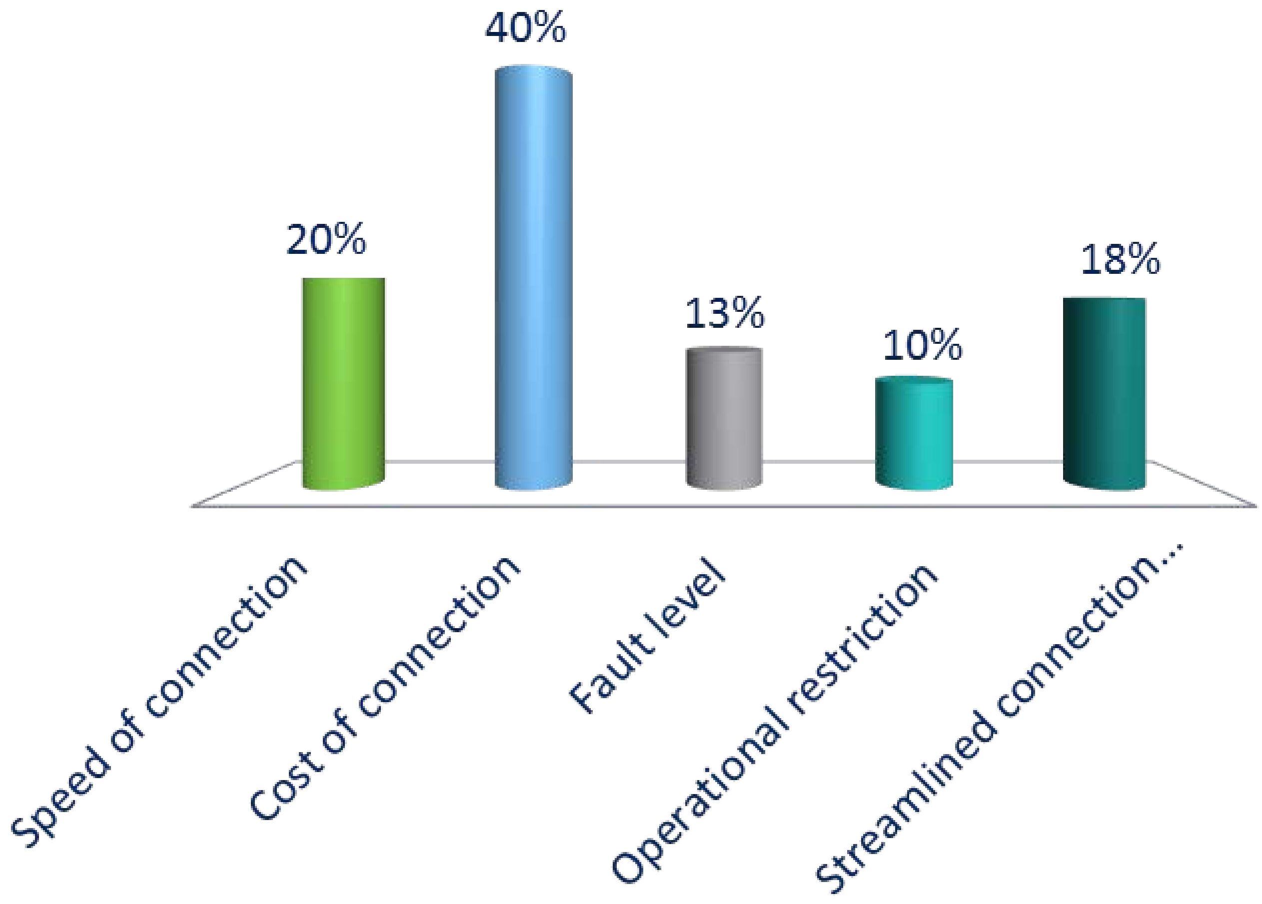
Internal view of the FCL service protection Adaptive Protection panel

Next steps

Decommission the Respond assets	Health study review based on condition monitoring analysis	Carbon impact study on Respond vs traditional approaches
Complete and peer review the safety cases for each of the Respond techniques	Update our policy and procedures to use the Respond techniques	Closedown report

Which challenge do you feel is the most important for a new connection?

A. Speed of connection
B. Cost of connection
C. Fault level
D. Operational restriction
E. Streamlined connection procedure



SMART STREET

Project update

Ben Ingham
Innovation Engineer

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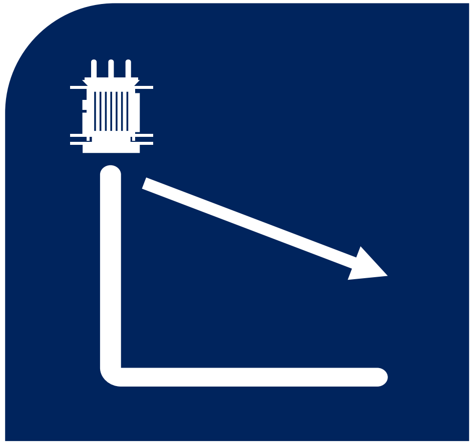
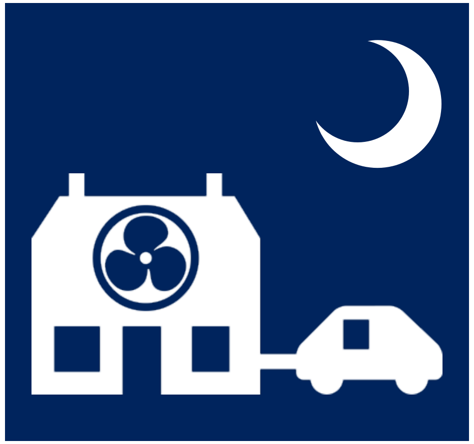
Background

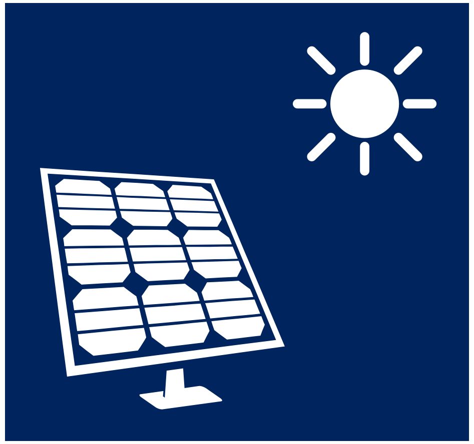


Historic networks have no active voltage regulation

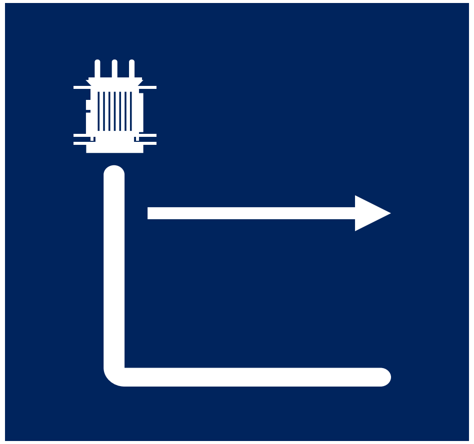


LCTs create network issues

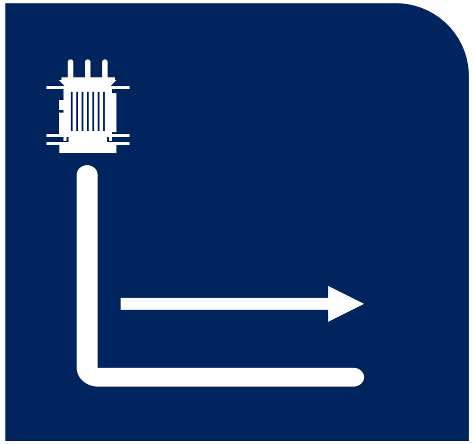
Customer demand could cause voltage to dip below statutory limits



Customer generation could cause voltage to exceed statutory voltage limits



Smart Street stabilises voltage across the load range and optimises power flows



Conservation voltage reduction

Stabilised voltage can be lowered making our network and customers' appliances more efficient

Project overview

£11.5m, four-year innovation project	Started in Jan 2014 and finished in Apr 2018	Quicker connection of LCTs Lower energy bills Improved supply reliability	Trials period Jan 2016 – Dec 2017	Extensive customer engagement programme throughout project

Trial overview

Six primary substations
67,000 customers
11 HV circuits – five closable HV rings

Three pole-mounted HV capacitors
Three ground-mounted HV capacitors

38 distribution substations
Five OLTC transformers

Five substation capacitors
79 LV circuit capacitors

Overview of research workstream

Quantified the voltage optimisation and loss reduction techniques used in Smart Street	Proved the benefits of meshed networks and the effects on power quality	Quantified the cost benefits and carbon impact related to the Smart Street solution	TNEI provided research support and consultation for the duration of the trials

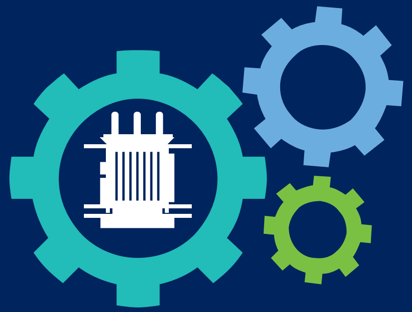
MANCHESTER 1824

TyndallManchester Climate Change Research

tnei enterprise with energy

High level conclusions

Network benefits



Alleviate network issues

Facilitate energy savings

Reduce network losses

Benefits from reduced losses and deferred reinforcement if ...

Smart Street investment costs low

Demand growth and LCT uptake uncertain

Customer benefits

Economic benefits per customer independent on network type

High level conclusions

Optimisation benefits (energy)	Optimisation benefits (losses)	Trade off between loss and energy consumption reduction	Carbon benefits
6-8% voltage reduction 5.5 – 8.5% energy reduction All networks similar energy reduction	Up to 15% loss reduction Rural network has highest loss reduction	Does exist but depends on load composition Energy consumption dominates Total energy reduction independent of weightings applied	Electricity system emissions reductions of 7% to 10% may be possible with a full application of Smart Street

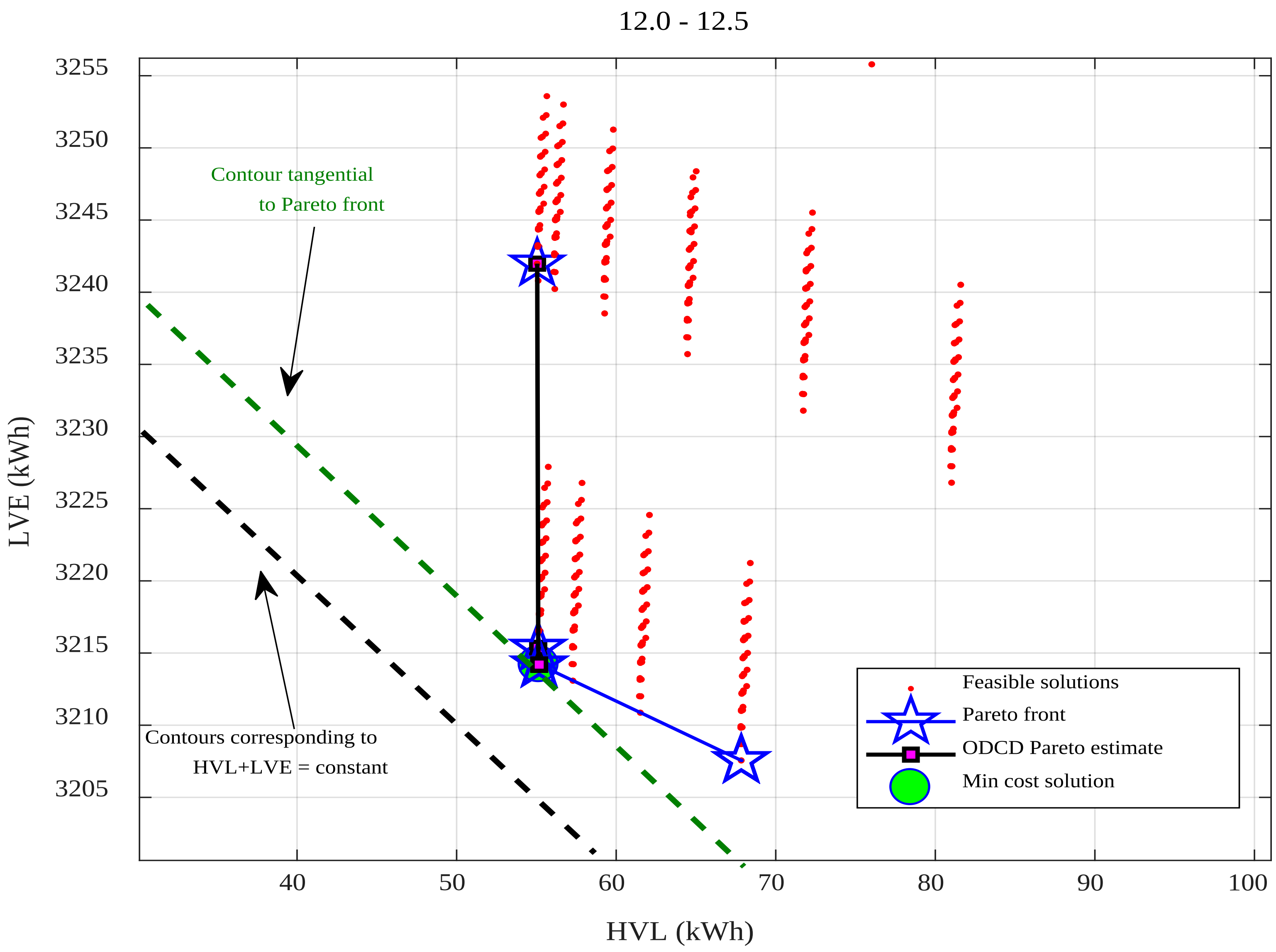
Overall impact of Smart Street trials

Perception of power quality	Experience of SDIs	Fault data	Smart Street benefits	The hypothesis
Perceptions driven by exposure to power cuts Minimal differences re frequency and/or duration On balance positive changes	Not spontaneously associated with a reduction in power quality Do not negatively impact customers' power quality perceptions	SDIs were generally linked to network faults unassociated with the trials or with equipment installation	Generally customers perceived the Smart Street project to have positive or at least neutral implications	Customers in the trial area have not perceived any changes in their electricity supply when the Smart Street method is applied

Outcomes

Monitored and actively optimised LV network	Proven that techniques save energy	Potential deferment of reinforcement	Associated carbon equivalent savings

Losses vs energy savings



Meshing

Reduces voltage issues

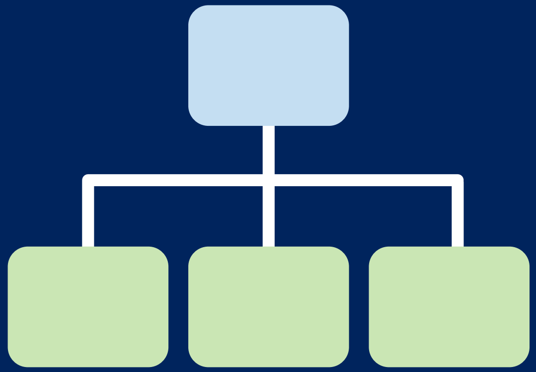
Improves asset utilisation

Reduces losses

Increases fault levels

No benefit to permanent connection – only mesh at beneficial times

Learning points – system



System architecture

Integration with existing SCADA system

Use of single line diagram

Learning points

Communications

Water ingress

Cabinet design and location

Enclosure size

Carbon impact

Reduction of approx 5% at HV level

Reduction of 7 – 10 % at LV level (network dependent)

Significant merit in reducing UK carbon emissions, particularly through reducing network losses and customer energy use

Lessons learned

- Comms reliability
- OLTC ‘safe’ setpoint
- Capacitor banks too large
- Capacitor banks better suited to rural networks
- BAU solution would need a four wire model
- LV volt drop not as expected
- Consider OLTC option in ENA technical specifications

Policy changes

LV Design	OLTC	Connections	Monitoring
Voltage drop not as severe as expected	Electricity North West specification modified to allow for use of OLTCs	Update connection process for LCTs	Fit monitoring to identify clusters

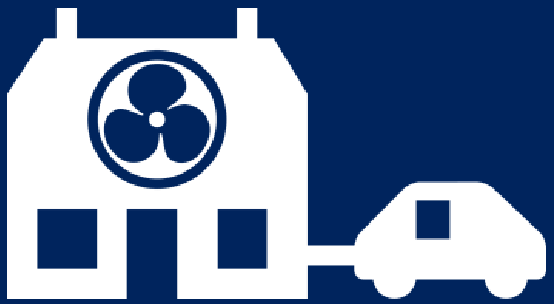
Technology

Lynx housing to be redesigned

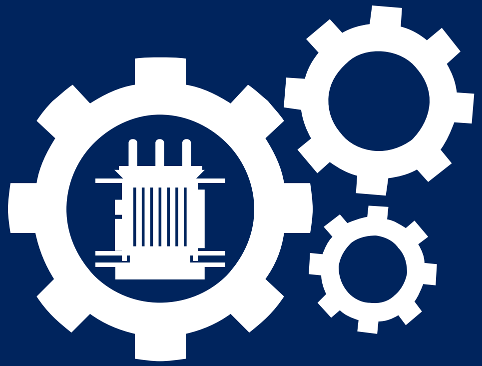
Monitored network being retained

Integration with new NMS

Further developments



Capacitors potentially useful if loads increase



Full network optimisation

Celsius

Project update

Geraldine Paterson
Innovation Engineer

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Celsius

Awarded: 9th December 2015

- Go live
- Monitoring installation Mar 2017
- Monitoring trial Mar 2018
- Retrofit cooling installation Jun 2018
- Thermal ratings tool stage 1 Oct 2018
- Cooling trial Jun 2019
- Thermal ratings tool stage 2 Jan 2020
- Closedown Mar 2020

Investment

£5.5 million

Up to £583m across GB by 2050

Financial benefits

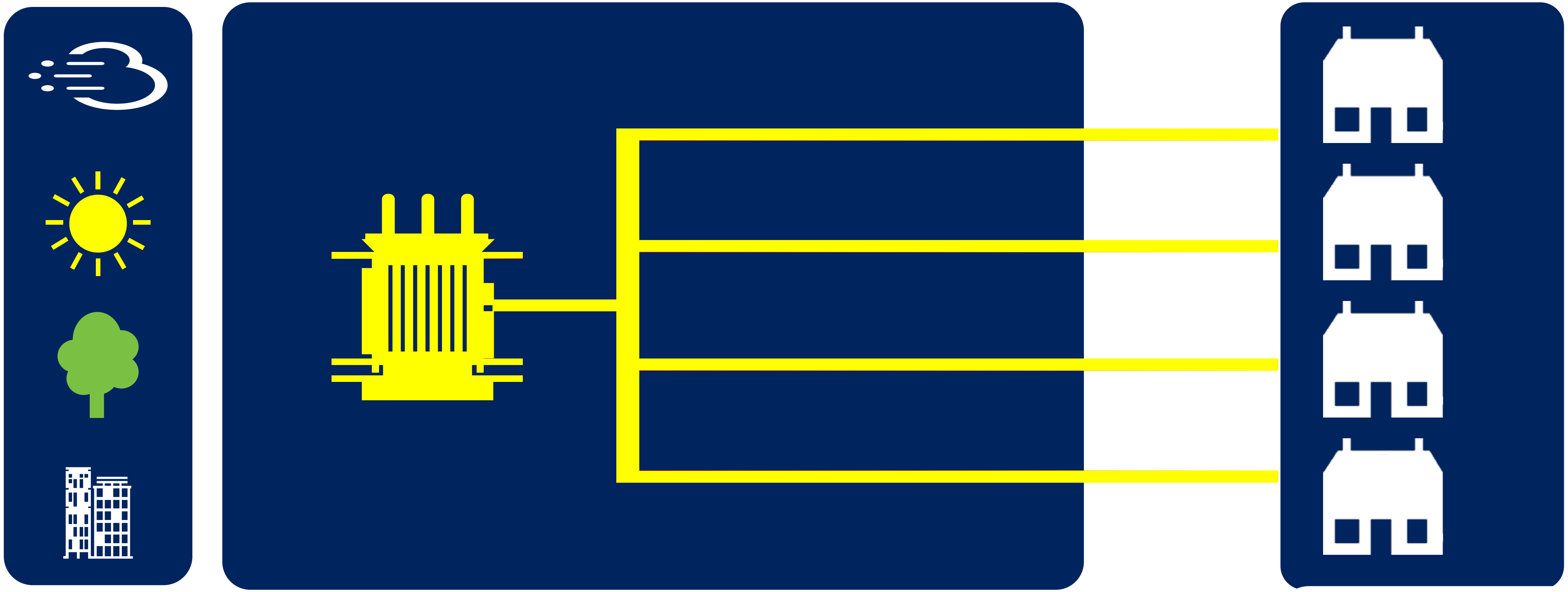
RICARDO-AEA

ASH ▪ CREATIVE WIRELESS ELECTRONICS ▪

Impact Research

UK Power Networks Delivering your electricity

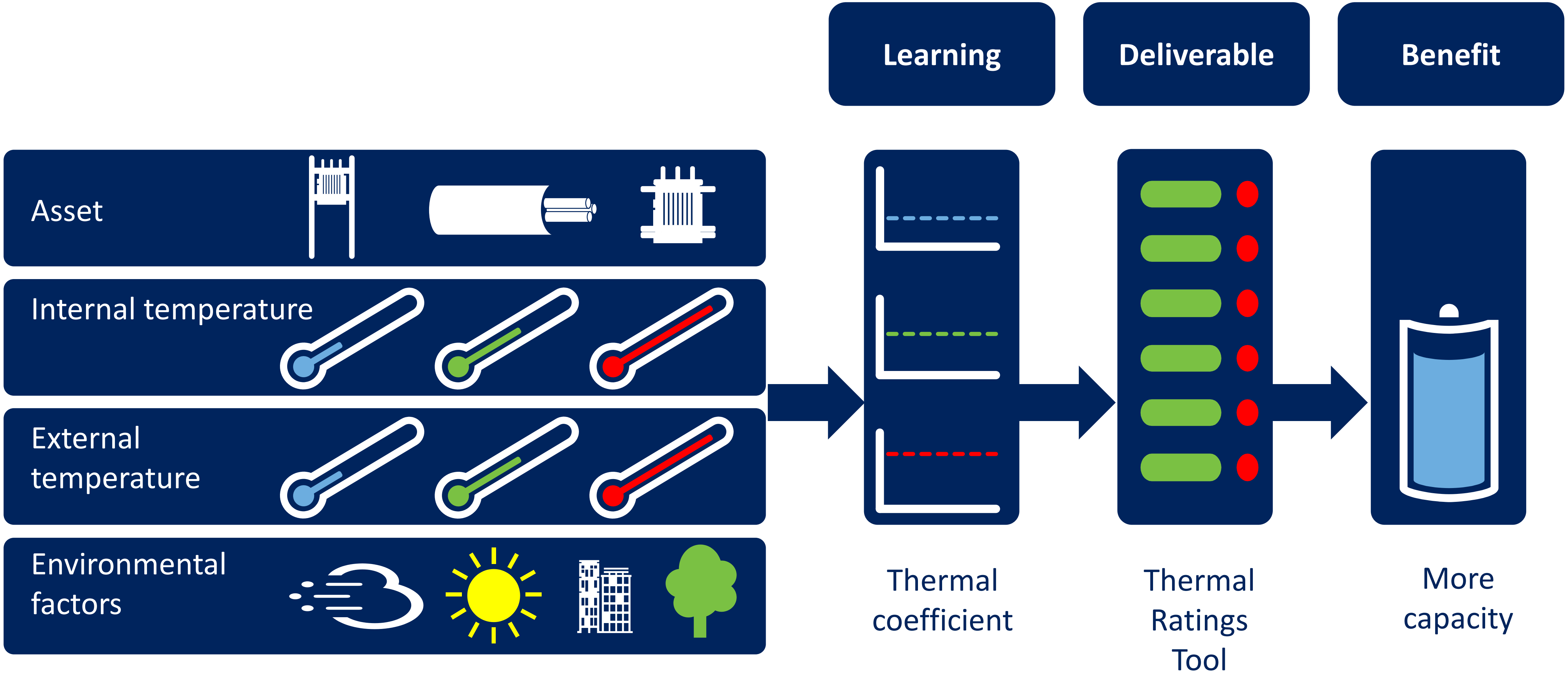
The problem



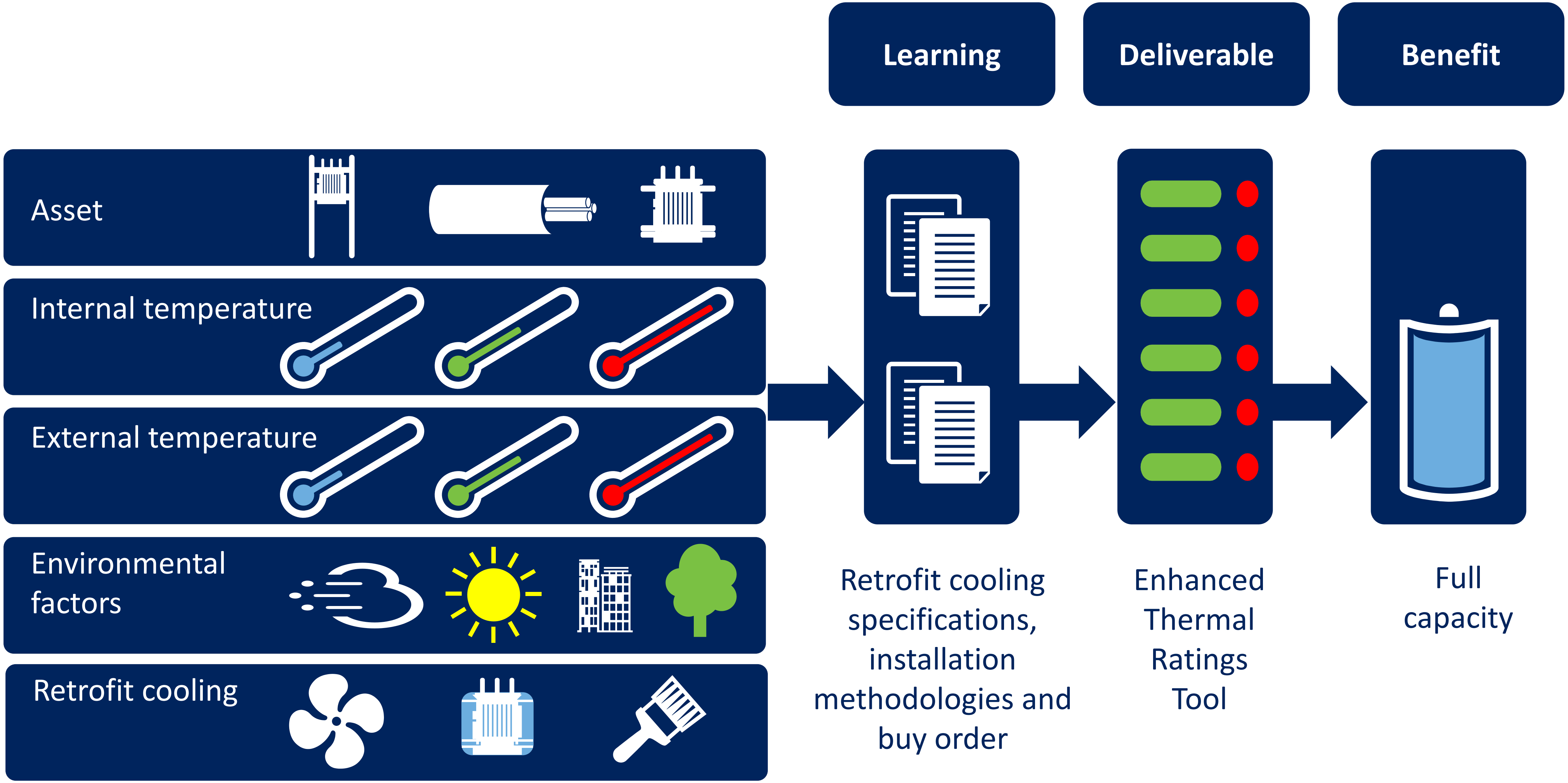
Distribution substation

Customers' LCTs

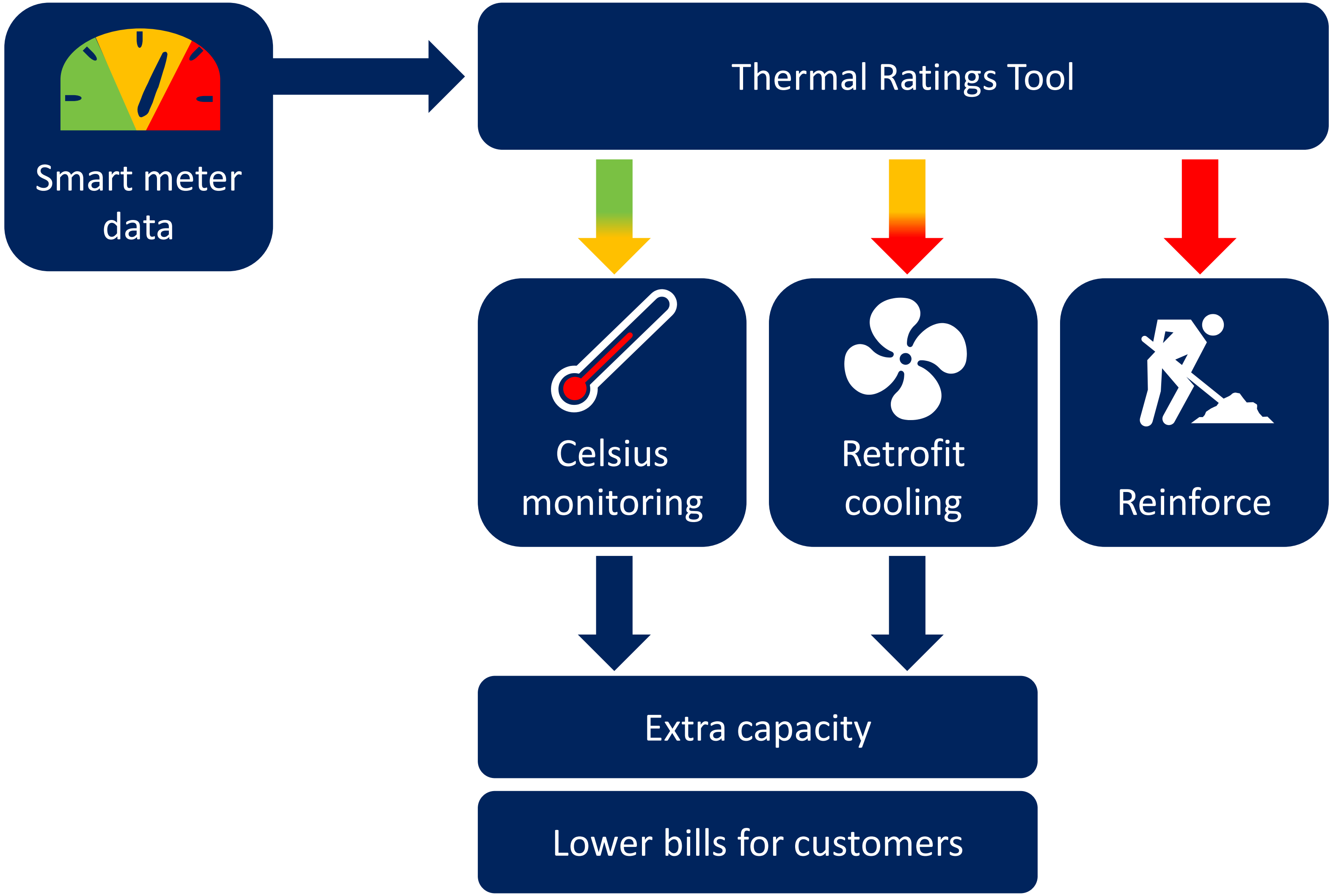
Step 1: Fit thermal monitoring



Step 2: Retrofit cooling



Celsius as part of the smart future



Case studies

Thermal analysis	q_{core} Internal asset temperature = Thermal coefficient × $q_{external}$ External asset temperature
Thermal flow study	Research into heat and air flows for optimal substation design
Asset health study	Examines effects of increased load and cooling techniques on assets

System health dashboard

Allows tracking of installation progress and data quality across all sites, including overview, site summaries, and issue tracking

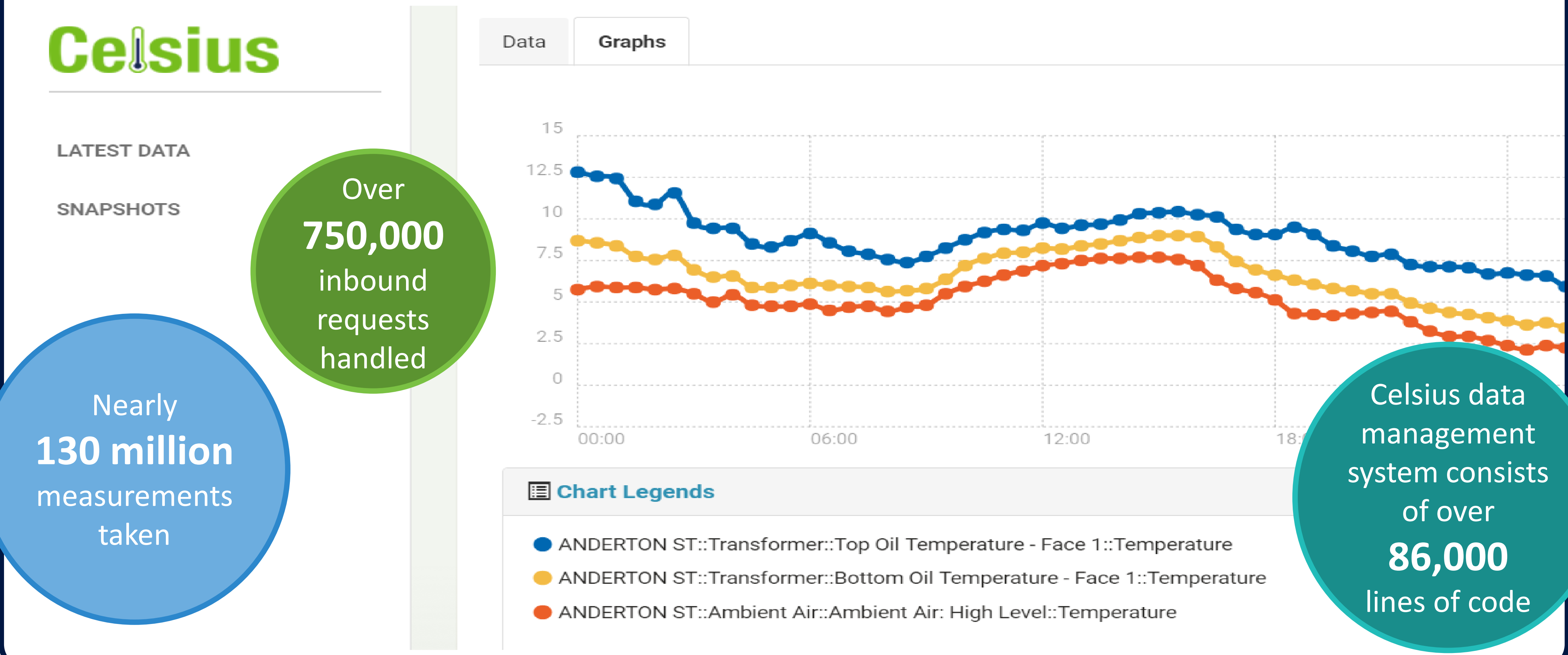
Celsius

- SITES
- ALERTS
- HUBS

Site	Code	Type	Status	Hubs	Sensor Positions	Measurements
ALBRIGHTON EST	415402	2	OK	C3E4B5B7319		85 % coverage
ALBRIGHTON RD	415599	2	OK	2045AC6E8B60		100 % coverage
ALDER AVE	212304	2	OK	10172469DA63		100 % coverage
ALEXANDRA RD S	171051	2	OK	2218AF88E894		98 % coverage
ALLITHWAITE	618166	1	OK	1E0882561604		100 % coverage
ALTRINCHAM FOOTBALL	171011	2	OK	14165694CF3F		100 % coverage

Data dashboard

Allows visualisation and download of retrofit monitoring data across any site, sensor position and timescale



Over **750,000** inbound requests handled

Nearly **130 million** measurements taken

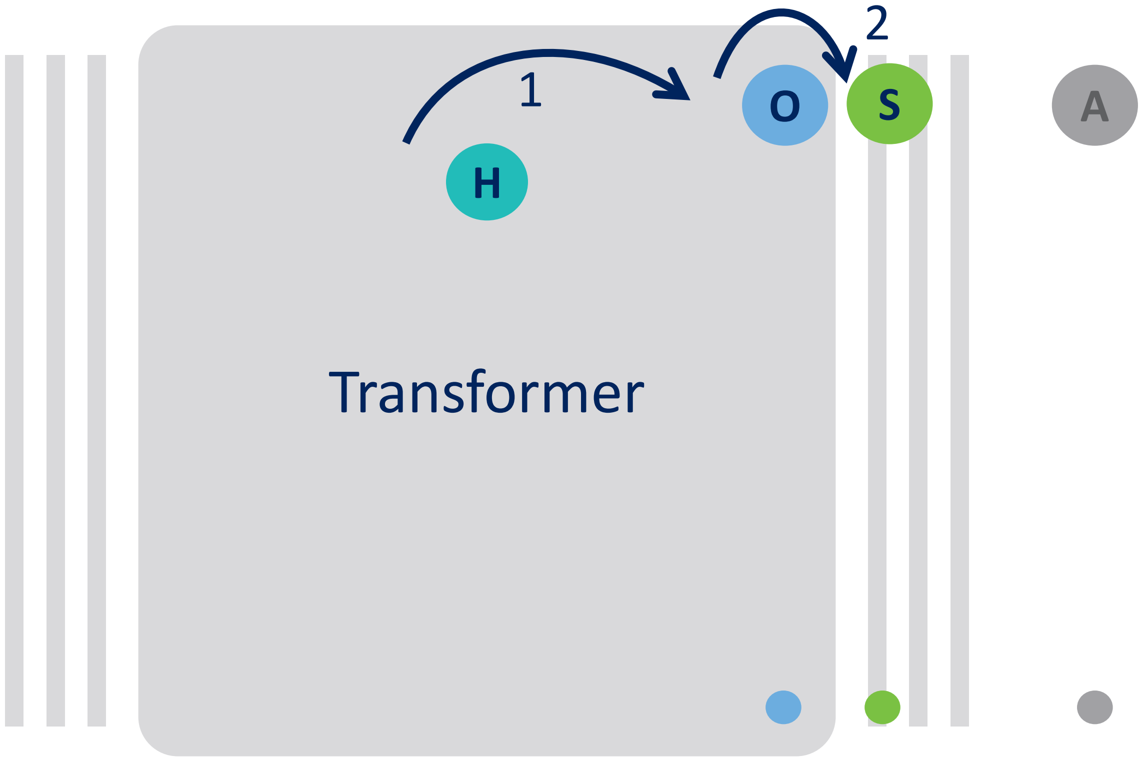
Celsius data management system consists of over **86,000** lines of code

Transformer hotspot assessment

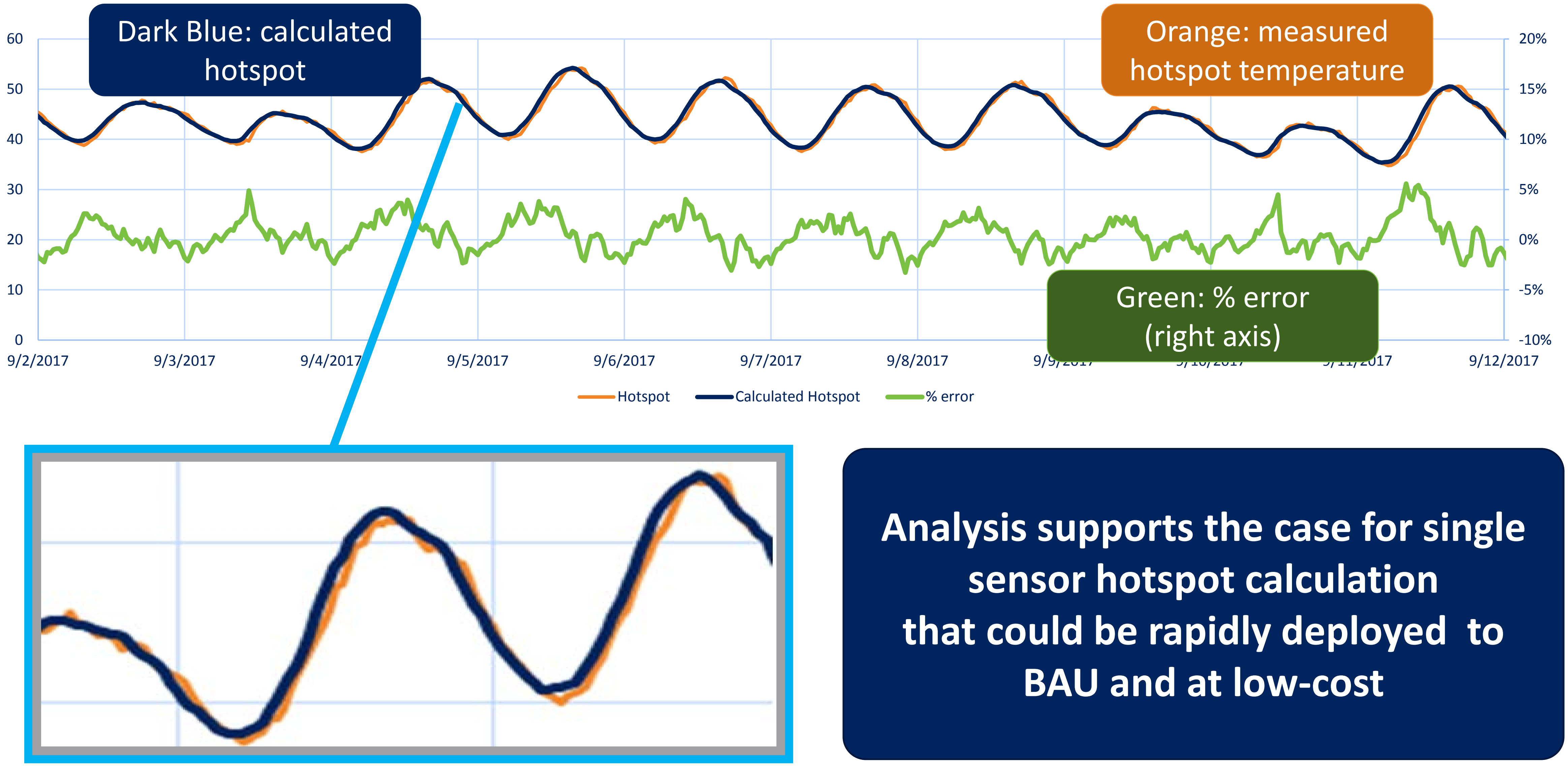
Goal: To know the hotspot temperature from one external sensor

1	**Use 'Smart' transformer data** to understand link between hotspot and internal oil
2	**Use oil measurements** to link between internal oil and surface measurements
3	**Develop a method to use surface measurements to estimate hotspot**

Taking into account ambient conditions and characteristics of the transformer



Transformer hotspot calculation



Analysis supports the case for single sensor hotspot calculation that could be rapidly deployed to BAU and at low-cost

Thermal flow study

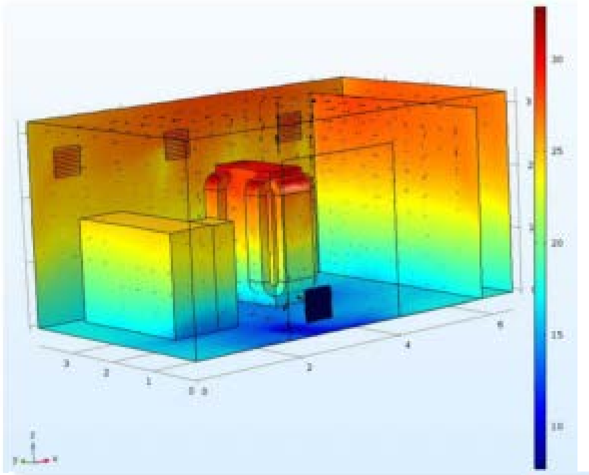
National Physical Laboratory

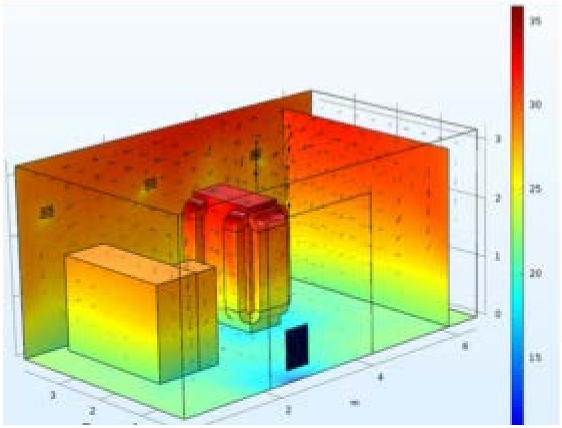
Six trial substations modelled

Validated with monitoring data

Changes to ENW Substation Policy

Application of cooling to models underway





Cooling site selection

Subset of monitored sites (100 out of 520)

Appropriate mix of outdoor, GRP, brick building, etc

Operating temperatures at the site from monitoring data

Physical requirements of the cooling technology

Active cooling

Powered technologies which can be used to push or pull the hot air from the building

Ekkosense

Uses a fan to pull air over the transformer, and expel it through the top vent

Air is directed by using screens to create negative pressure inside the building

Warm air is directed through trunking to an exit vent

Active cooling

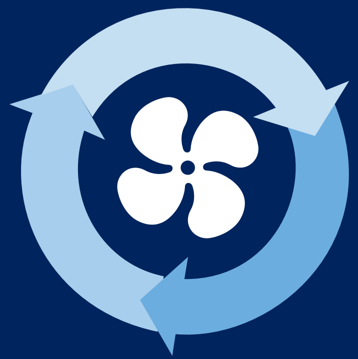
Powered technologies which can be used to push or pull the hot air from the building

Passcomm

Uses equipment to force air from outside through the lower vent, which creates positive pressure inside which expels through a high exit vent

Passive cooling

Improving ventilation

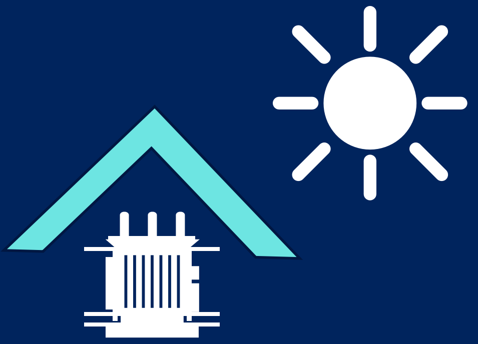


Supported by the Thermal Flow Study results, which will provide guidance about the best ventilation arrangements

Painting outdoor transformers

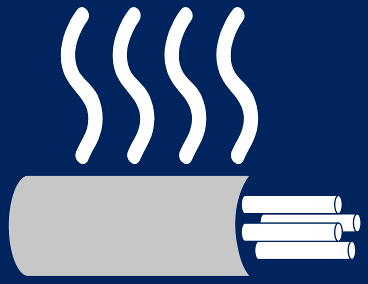
White paint will be used to reflect solar heating of the asset

Shading outdoor transformers



To protect from solar radiation

Cable backfill



Backfilling cable ducts with a material with beneficial thermal properties, to allow heat to escape from cables more effectively

Customer engagement

Customers in the Celsius trial areas will find the implementation of innovative retrofit cooling techniques as acceptable as traditional reinforcement

Customers who are educated as to the need for and benefits of Celsius are significantly more likely to find it acceptable

Perception and acceptability of cooling techniques

600 baseline surveys

Prior to installation of cooling techniques

April 2018

300 uneducated about Celsius

300 educated

Test

- Awareness of Electricity North West
- Satisfaction with Electricity North West
- General perception of substations
- Awareness of existing asset location, appearance, size, noise level etc

600 test surveys

Following installation of cooling techniques

Winter 2018

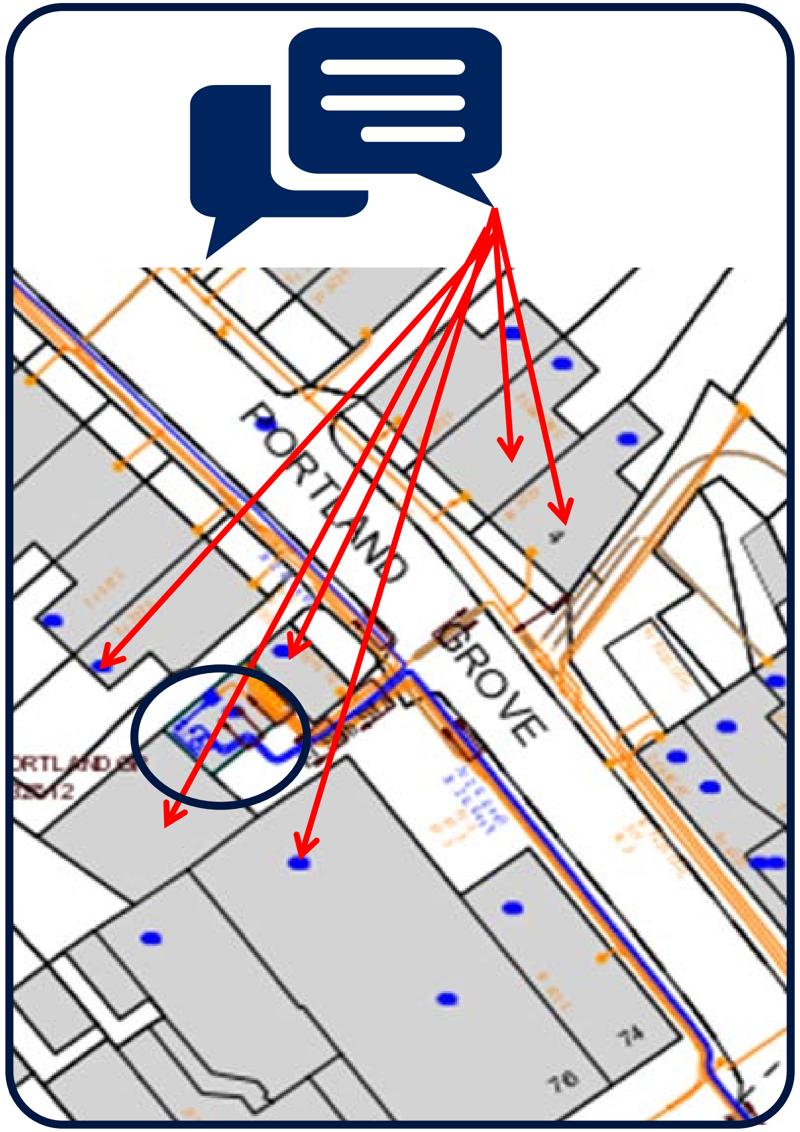
150 previously educated

450 new no prior education about Celsius

Test

- Changes in overall satisfaction
- Notice of any changes
- Attitude/acceptance of any change in asset location, appearance, size, noise level
- Design features/barriers

Assessing customer impact



Surveys of those nearest substation and most likely to be impacted

Survey carried out on doorstep

Repeat visits to interview customers neighbouring substations

Cash incentive for completing baseline

Dissatisfaction from customers not surveyed because no payment

Progress so far

Customers educated about the need and benefits of Celsius are more likely to find it acceptable

- Engaged customer panel to develop comms materials
- Project leaflet for all educated survey participants
- Survey developed
- Baseline survey complete
- Embedded process to capture complaints / enquiries
- Feedback via customer contact centre, website and SMS
- Materials and findings published on project website


Important information from your electricity network operator

electricity north west

Bringing energy to your door

Celsius

Good news. We are improving the electricity network that supplies your street as part of our Celsius project.

Who is Electricity North West?

We operate the local electricity network and distribute electricity to all 2.4 million homes and businesses in the North West.

What are we doing?

We are looking at smarter ways of managing high temperatures at substations, by trialling a range of cooling techniques. These could be modifications to equipment fitted inside our substations, or small changes to a substation's structure which will cool it down. This will help to reduce costs for all electricity customers. The project is called Celsius.

Why are we doing this?

To help protect the environment we need to use fewer fossil fuels like gas and oil and use cleaner sources of power. This means that in the future we will need more electricity for running electric cars and heating systems. The more electricity that flows through our network, the hotter the equipment in our substations becomes.

How will I benefit?

By cooling our existing substation equipment we can make it last longer which helps us operate the network more efficiently. This will help us to meet the increased demand for electricity, without increasing customers' bills.

Assessing customer impact

Embedded complaints process to capture/manage customer issues arising from installation

3 noise complaints from 19 sites

High density urban substations close to domestic dwellings

Settings reduced to lower noise emissions

Reduction on cooling potential

Technical solution may be viable but need to consider customer impact in some environments

Progress and next steps

January – June 2018	July – December 2018	January – June 2019	July – December 2019
Baseline customer survey	Asset temperature behaviour report	Cooling trial	Thermal Ratings Tool step 2
Thermal flow study part 2	Asset health study report	Trial customer survey	Monitoring specification
Cooling technology installation	Thermal Ratings Tool step 1		Customer survey report

Knowledge sharing and dissemination

Distribution System Operator (DSO) Update

Steve Shaw
DSO Transition Manager

electricity north west
Bringing energy to your door

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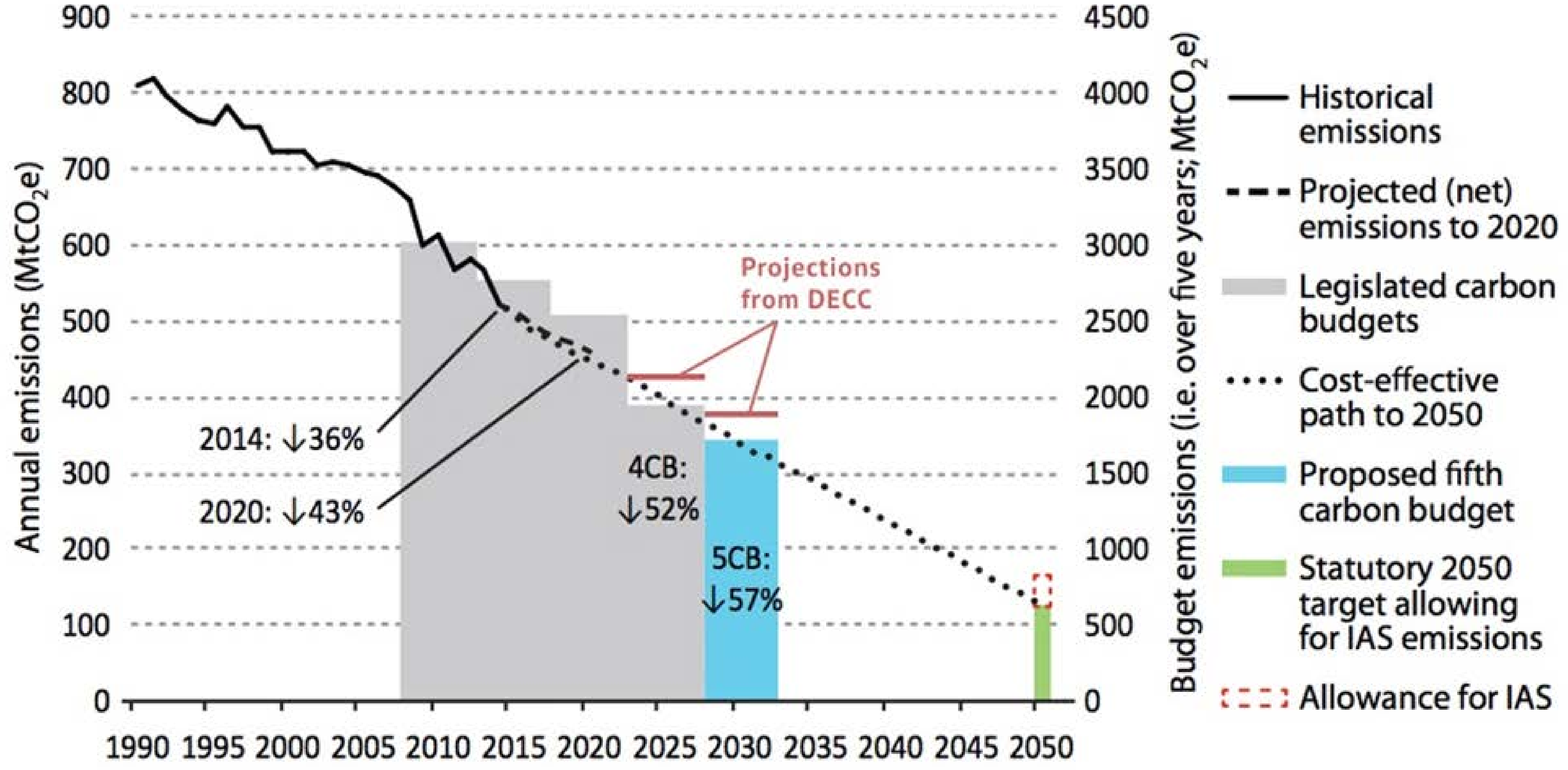
Key driver - UK climate change targets



The challenges

2010

Energy Mix

1/3 Gas
1/3 Electricity
1/3 Oil

2016 /17

30% of energy from renewable technology

42% reduction in CO_2 from 1990 baseline

Generation mix is radically ‘overhauled’

First ‘non-coal day’ in 130 years (April 2017)

2030

60% reduction in CO_2

Electricity demand increases, driven by electric vehicles & heat pumps

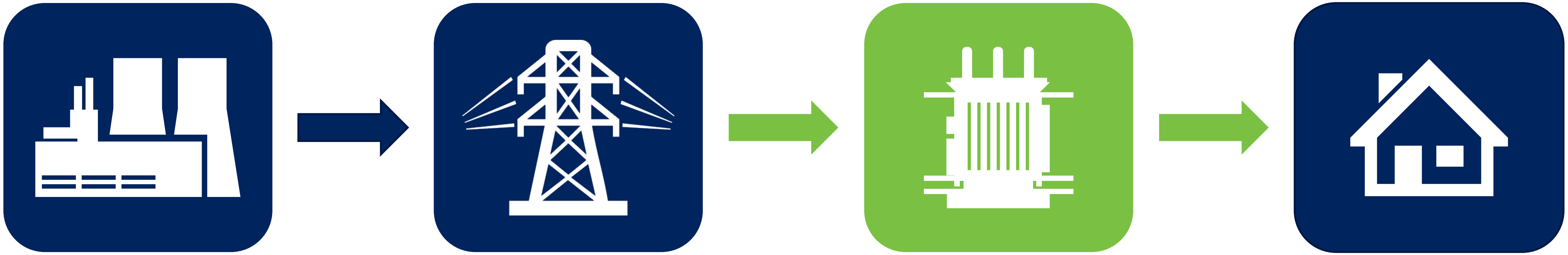
Distribution network capacity needs to significantly increase

2050

80% CO_2 reduction

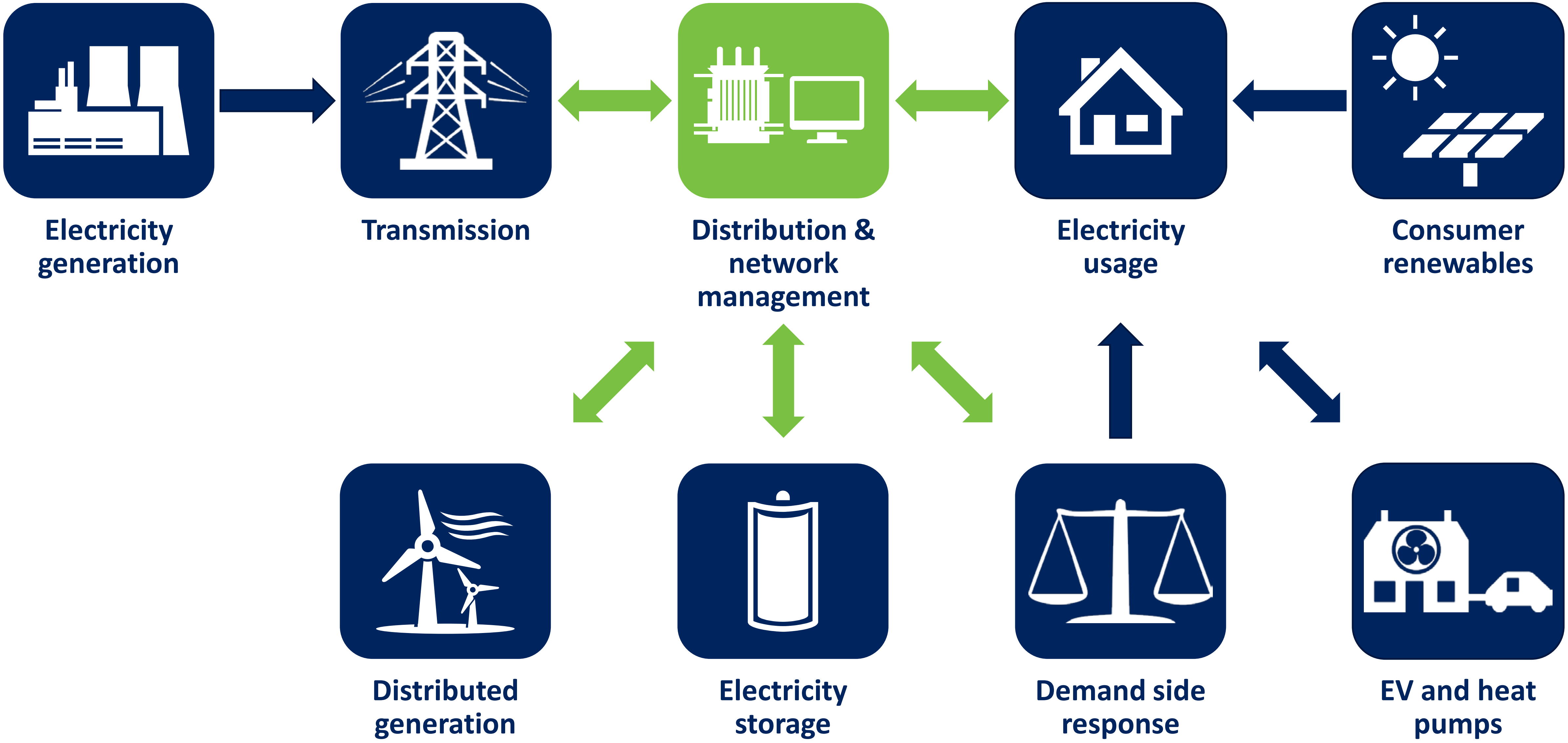
Significant increase in electricity demand

What used to be relatively simple



Electricity generation | **Transmission** | **Distribution** | **Electricity usage**

Is now becoming far more complex



From DNO to DSO

Old distribution network operator model

Low numbers of connections

Relatively easy to connect more demand

Limited customer engagement

Reactive management

Network sized to cope with peak winter demand

Very little renewable generation

New distribution system operator model

Energy flows in multiple directions

Huge increase in number of renewable connections

Increasingly complex to manage supply and demand

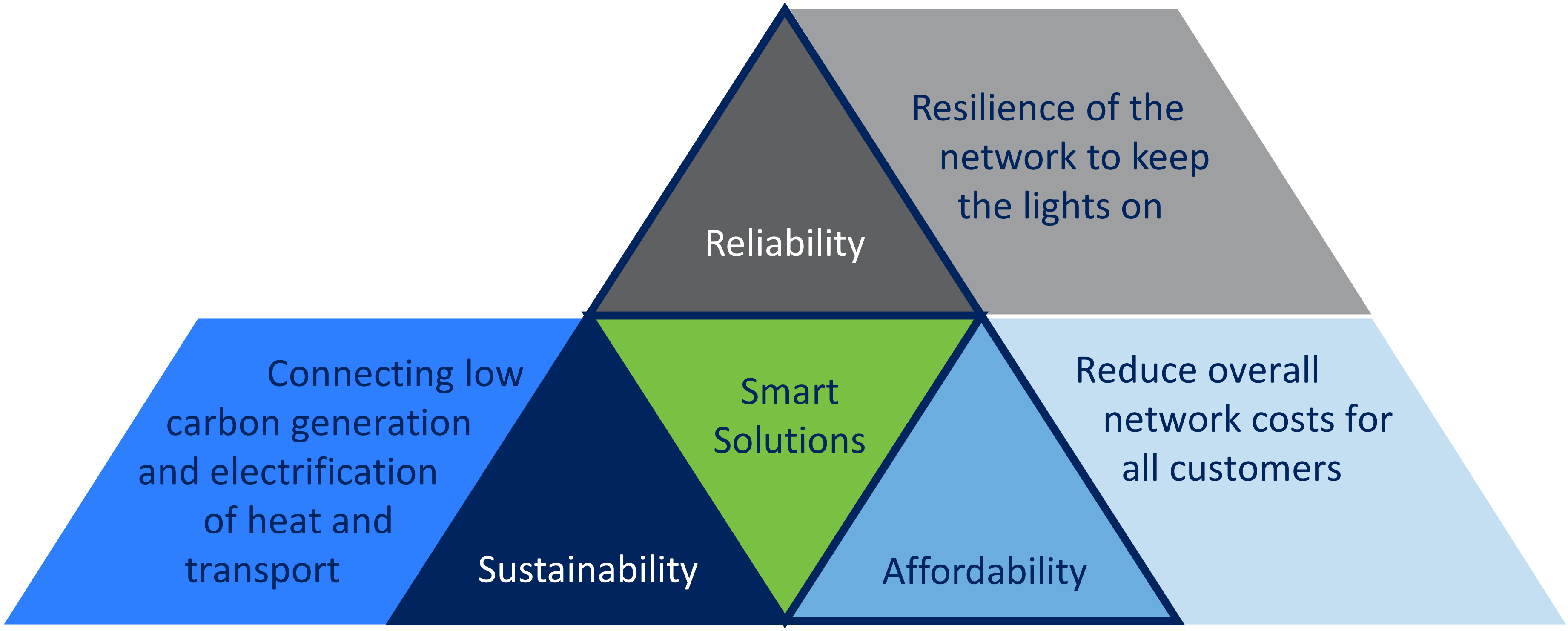
Need to build relationships, and facilitate competition and innovation

Much higher use of electricity for electric vehicles and heat

Electricity distributors will need to play a more sophisticated role

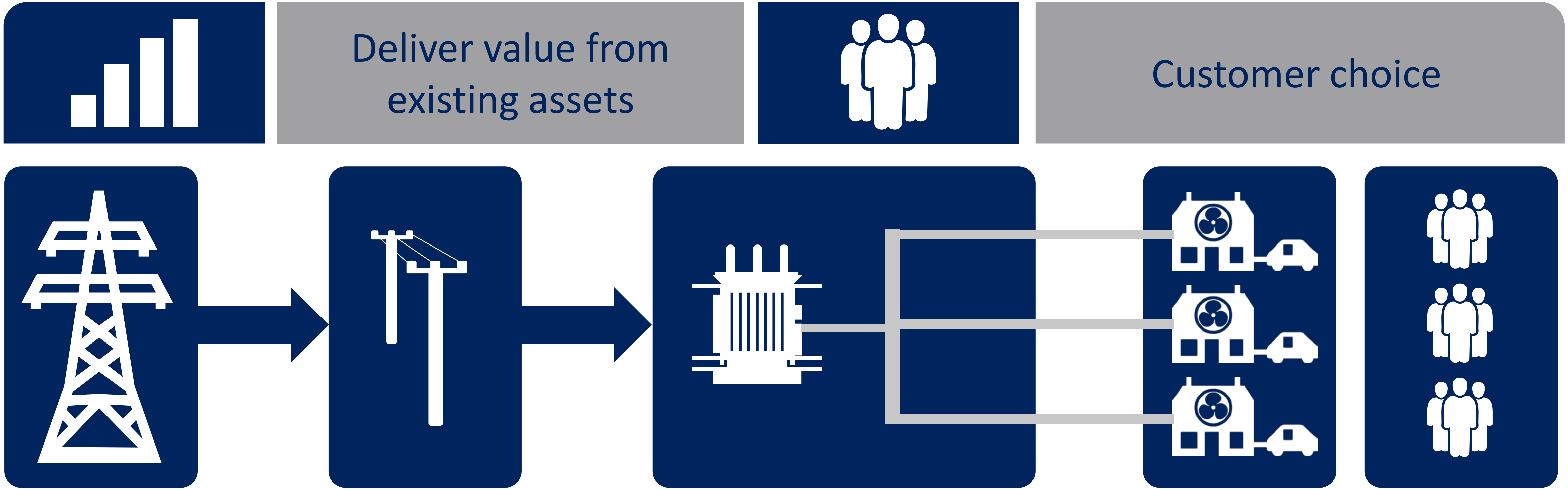
Network operator challenges

● The network operator 'Trilemma' ●



● Customers can help us deliver ●

Managing these challenges – our Smart Grid strategy



Extra high voltage network

High voltage network

Distribution substation

Customers’ LCTs

Customer behaviour

Respond
EHV and HV fault level

C_2C
HV network meshing

CLASS
Voltage at HV substations

Celsius
Cooling at distribution substations

Smart Street
CVR
LV network meshing

Opportunity for significant savings ‘beyond the meter’

DSO: Open networks definition and exclusions

"A Distribution System Operator (DSO) securely operates and develops an active distribution system comprising networks, demand, generation and other flexible distributed energy resources (DER). As a neutral facilitator of an open and accessible market it will enable competitive access to markets and the optimal use of DER on distribution networks to deliver security, sustainability

The DSO is not necessarily the owner of the network(s) that it operates, for example independent DNOs or private networks connected to the licensed DNO's network or indeed multiple licence areas

The DSO is not necessarily limited to one licence area or indeed one group boundary. It is conversely likely that within a given network area the DSO will encompass all emerged networks eg IDNO

The DSO should not normally own permanent generation, storage or other DERs unless it does so as the owner of last resort (and in such circumstances subject to the guidance in the EU package)

From DNO to DSO: Our road map

Fundamental role remains unchanged: The provision of network capacity

Key challenge: provide all capacity network users require, without expensive additional infrastructure

DSOs required to actively balance capacity, on a minute-by-minute basis, using real time data and automated technology

Achieved by establishing local markets where providers of flexibility services can sell this flexibility

The DSO will create this market and buy flexibility

To enable this transition DSO must become trusted facilitator and advisor

ENA open networks project

Whole system investment and operational processes and data flows

WS1
T-D Processes

WS2
Customer Experience

Open Networks Project

DNO to DSO Transition
WS3

Charging
WS4

Customer journey maps for connections and updated connections agreements

DSO transition roadmap, functional requirements and model for DSO, market model options

Identify problems with current charging arrangements, recommend smart tariffs, flexible connections and ancillary service pricing and a longer term whole system pricing review

Phase 1
Definition of T-D processes, customer experience, DNO to DSO transition and charging

End 2017

Phase 2
Impact assessment of options, trials and preferred designs

Phase 3
Regulatory enactment

Phase 4
Design, build and test

DSO worlds under consideration

World A – DSO coordinates
A world where the DSO acts as the coordinating party for all DER and provides services on a regional or location basis to the ESO

World B – Joint DSO – ESO procurement
A world where DSO and ESO work together to efficiently manage networks

World C – Price driven flexibility
A world where changes developed through Ofgem's Charging Futures have improved access arrangements and forward looking signals

World D – ESO coordinates
A world where the ESO is the coordinating party for all DER with DSO's informing the ESO of their requirements

World E – Flexibility coordinators
A world where a national (or potentially regional) third party acts as the coordinating party for DER providing services to the ESO and/or DSO

Open networks project DSO functions

System Coordination	Operate local and regional areas and coordinate energy and power transfers with other Networks and systems toenable whole system planning, operation and optimisation across different timescales.
Network Operations	Operate the electricity distribution network to maintain a safe and secure system. Ensure that network power flows remain within limits and that the network operates within acceptable voltage limits. Ensure that the network remains secure against credible events such as circuit trips and generation loss. Identify and manage current and future risks.
Investment Planning	Identify capacity requirements on the distribution network and secure the most efficient means of capacity provision to customers. Coordinate with the NETSO and TOs to identify whole system options. These would include commercial DER options as well as distribution network investment.
Connections & Connections Rights	Provide fair and cost effective distribution network access that includes a range of connection options that meet customer requirements and system needs efficiently.
System Defence & Restoration	Enhance whole system security through the provision of local and regional flexible services. Provide system resilience to very low probability but high consequence events using risk based approaches. Provide the means to re-establish the wider synchronous area in the event of widespread disruption.
Services / Market Facilitation	Interface with the GBSO and other network operators to enable the development of distribution capacity products, the creation and operation of local network service markets and to enable DER access/participation in wider services for whole system optimisation.
Service Optimisation	Ensure system needs can be efficiently met across all timescales by identifying network requirements, understanding the limitations of network assets and providing network access for additional flexibility services from smart solutions and DER services. Ensure whole system optimisation and resilience thro ugh the optimal selection of flexibility services.
Charging	Sets Distribution Use of System prices for local network. Determines Point of Connection. Determines connections charges and informs of transmission reinforcement charges (if applicable). Consideration to exit charging (dependent on size, variations and apportionment).

DSO essential components

- Network capacity provision
- Network capacity market facilitation
- Network access management and forecasting
- Capacity-based charging
- Market driven collaboration with Transmission System Operator to provide Whole System participation

Network capacity provision

Our responsibility:

To enable customers connected to our networks the freedom to buy and sell their energy safely, securely and at lowest cost

Requires new service model for network management and design

Provision of flexible network capacity through local and regional balancing

DSO will need to determine:

- Point of Connection and operating terms
- Any new capacity required
- Quality of supply
- Security and Resilience standards
- Electrical losses optimisation

Network capacity market facilitation

Maximising utilisation of all existing network capacity ensures efficiency

Provision of capacity **for** customers **from** other customers is often lowest cost, first option

DSOs must facilitate local markets for flexible capacity

Direct customer access ● Access through aggregators

Exchange of information and enhanced transparency necessary to avoid inefficient network over-stress and maintain security of supply

Network access management

Dynamic network management becomes a 24/7 function to balance security, cost and access

- Commercial solutions
- Managing essential outage plans
- Engineering solutions

New service metrics and mechanisms required

- Generation Indices
- Constraint Indices

Forecasting capacity

Enhanced forecasting abilities required

Day ahead	Year ahead	Long-term forecasting
...24	**...365**	**--2030--**

Service definition and charging

Structure of network charging will require fundamental review

Charging arrangements must reflect service customers require

Capacity based charging structure

Potentially enhanced by recognition of requirements for services such as:

- Security of connection
- Power quality
- Voltage stability
- Fault Level
- Reactive power and inertia

Summary

Climate change imperative drives increasing urgency to deliver DSO capability

Energy trilemma constrains acceptable solutions

Multi-sector innovation is currently demonstrating what can be done

Ease of deployment and market access must not constrain growth

Further thinking and innovation still needed on the shape and scope of network activities to make this happen

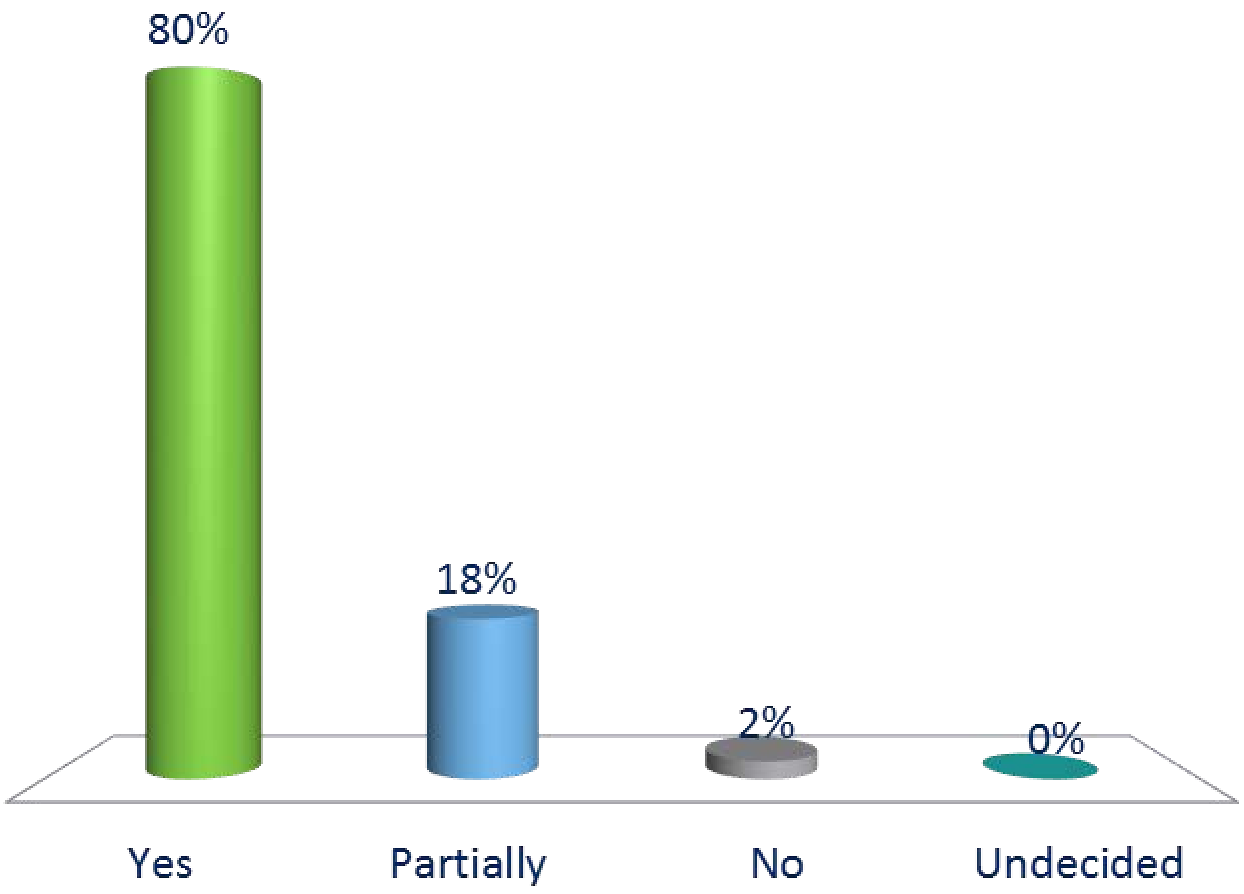
Development of new RIIO outputs needed eg capacity incentive?

DNOs to DSOs facilitating wide participation in new markets

DSOs could play increased role in energy efficiency roll-out

Do you think that DSO will support flexibility and innovation?

A. Yes
B. Partially
C. No
D. Undecided

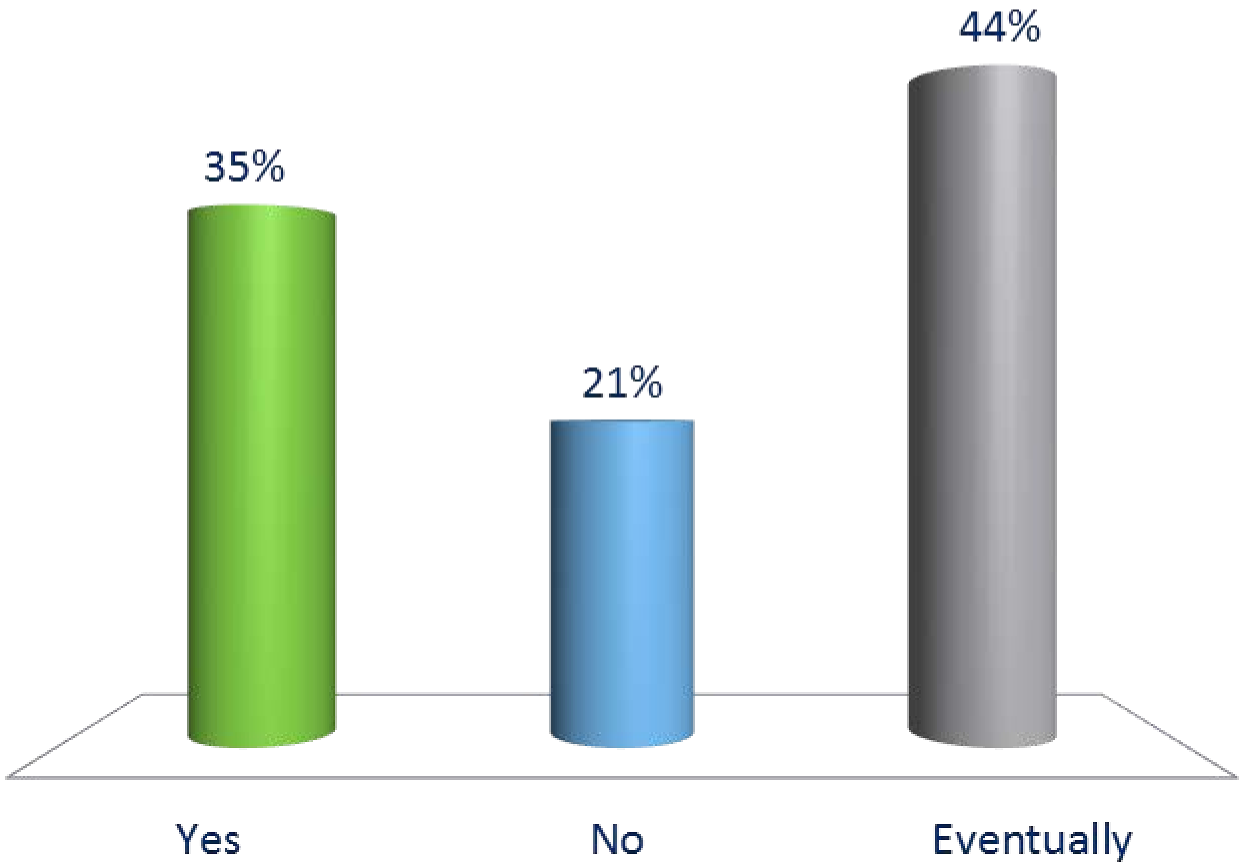


Should the DSO encompass all energy options eg gas, heat

A. Yes

B. No

C. Eventually



The ATLAS project
(Architecture of Tools for Load Scenarios)

Dr Christos Kaloudas
Forecasting Manager

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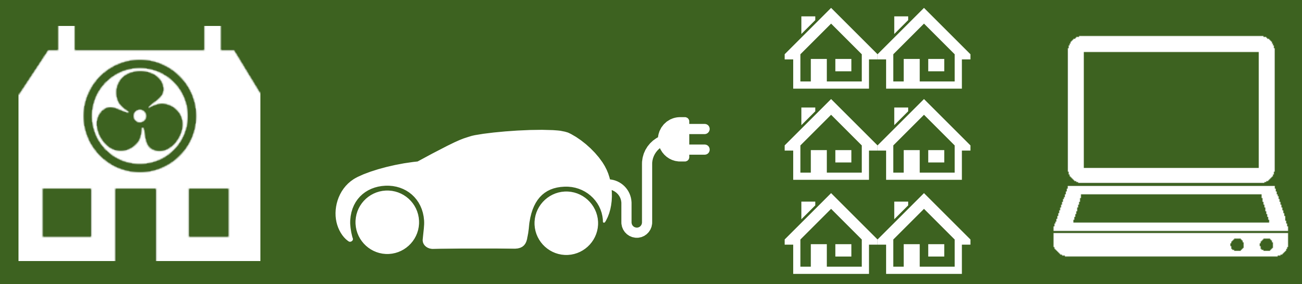
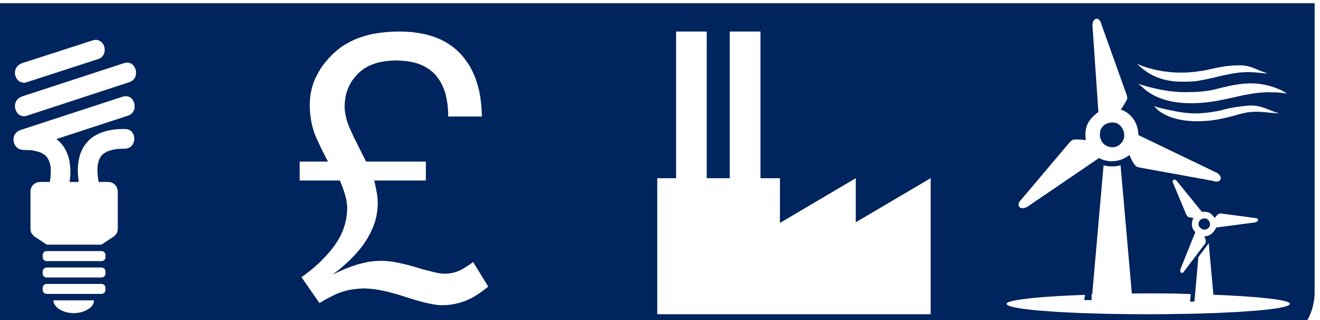
Future demand is uncertain

Load may rise...



... and it may fall



Why do we need forecasts?

Credible demand and generation scenarios, reflecting uncertainty.

Tailored to our region, assets and data

Support well-justified strategic planning of network capacity

Enabling good decisions about solutions to capacity problems, and informed dialogue with National Grid and other stakeholders

This presentation

Overview of the ATLAS project

New approach to MW (P) forecasting

New approach to MVAr (Q) forecasting

After ATLAS

Two NIA projects on load scenarios

Demand Scenarios with Electric Heat and Commercial Capacity Options	**ATLAS (Architecture of Tools for Load Scenarios)**
Winter / summer peak load	Half-hourly (hh) through year
Heat pumps & air con	Demand & generation
The Real Options CBA model	P (MW) & Q (MVAr)
April 2015 - October 2016	Nov 2015 – December 2017

ATLAS scope

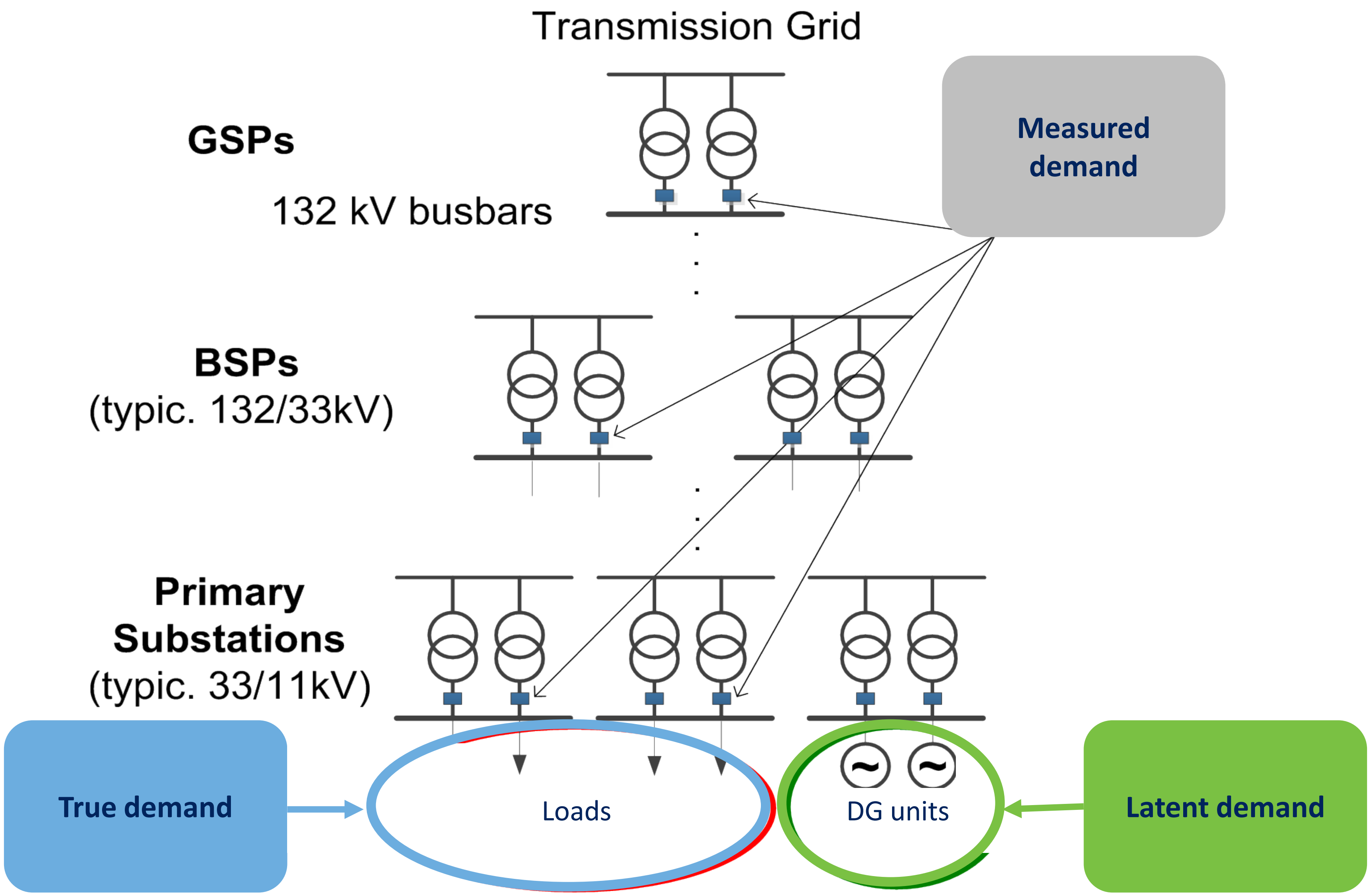
Full half-hourly view of ***true*** MW demand

MW forecast
learning from the Demand Scenarios NIA, *with more customer detail*

MVAr forecast
learning from REACT NIA, *for whole DNO network*

Prototype tools for GSP, BSP and Primary scenarios

ATLAS – demand definitions



ATLAS – true demand

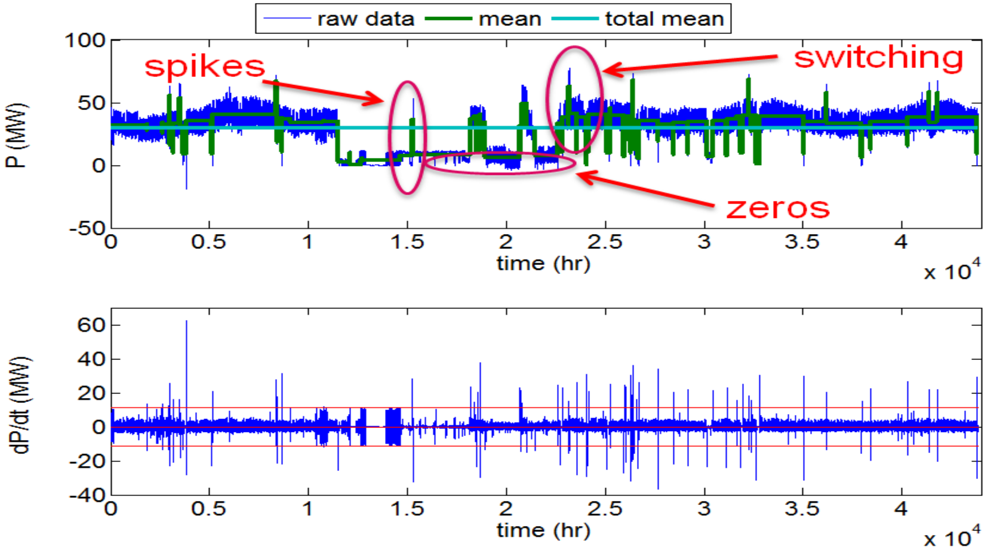
True demand = Measured demand + Monitored DG exports + Effects of DG on reducing customer demand + Non-monitored DG

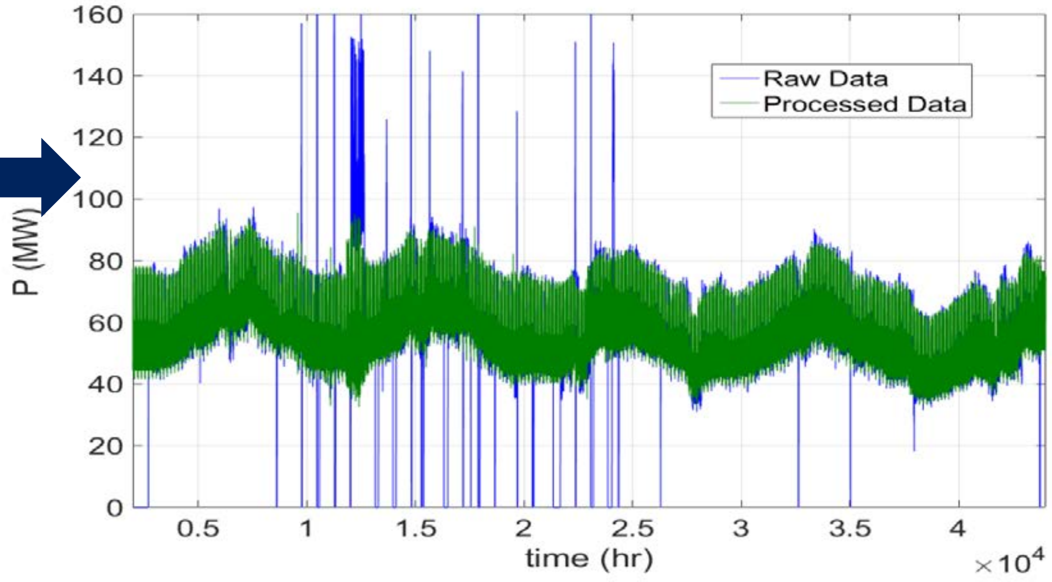
Measured demand + Monitored DG exports: Monitored component of true demand

Monitored DG exports + Effects of DG on reducing customer demand + Non-monitored DG: Latent demand

Historical Demand – data processing

Identification of data problems → Data corrections (half-hourly & daily analyses)

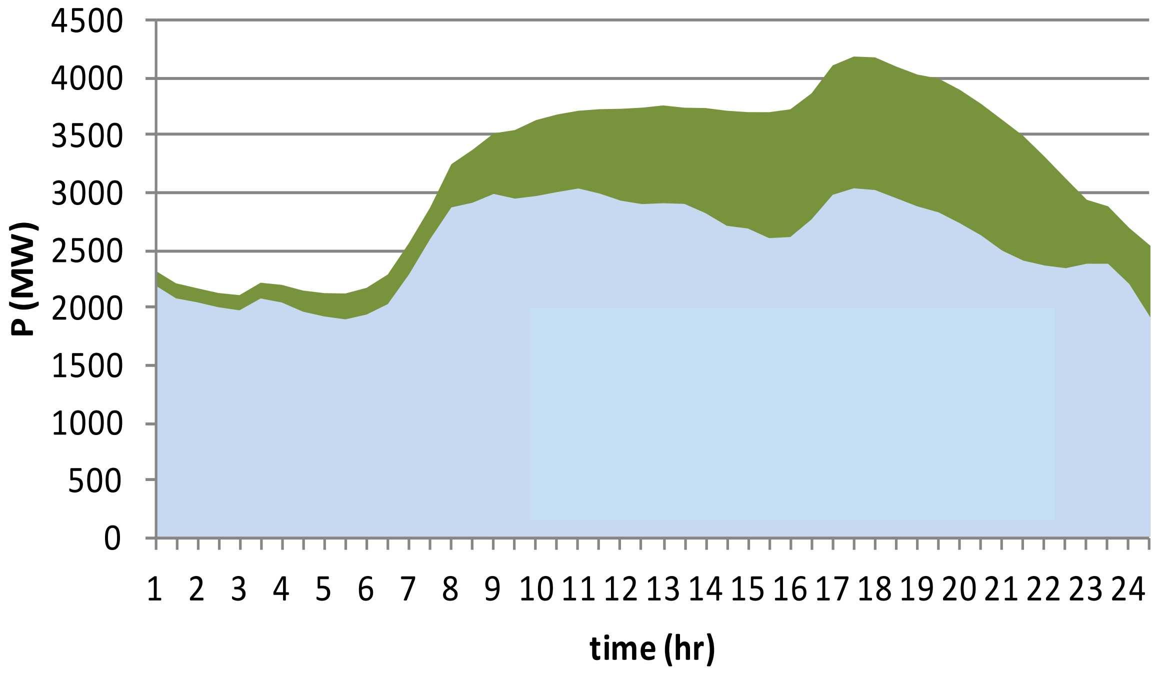




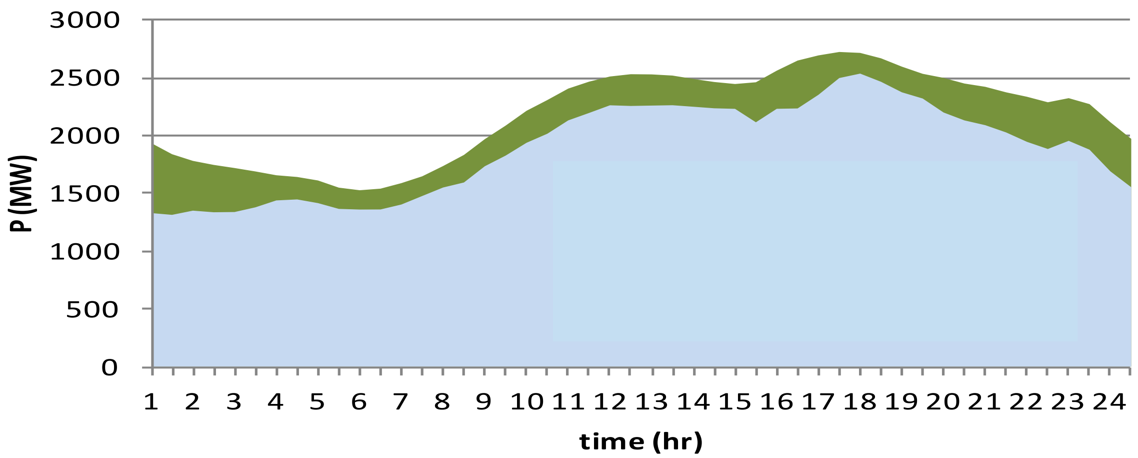
See detailed methodology at www.enwl.co.uk/atlas

Historical demand – effects from DG

Peak true demand (23/11/2016)



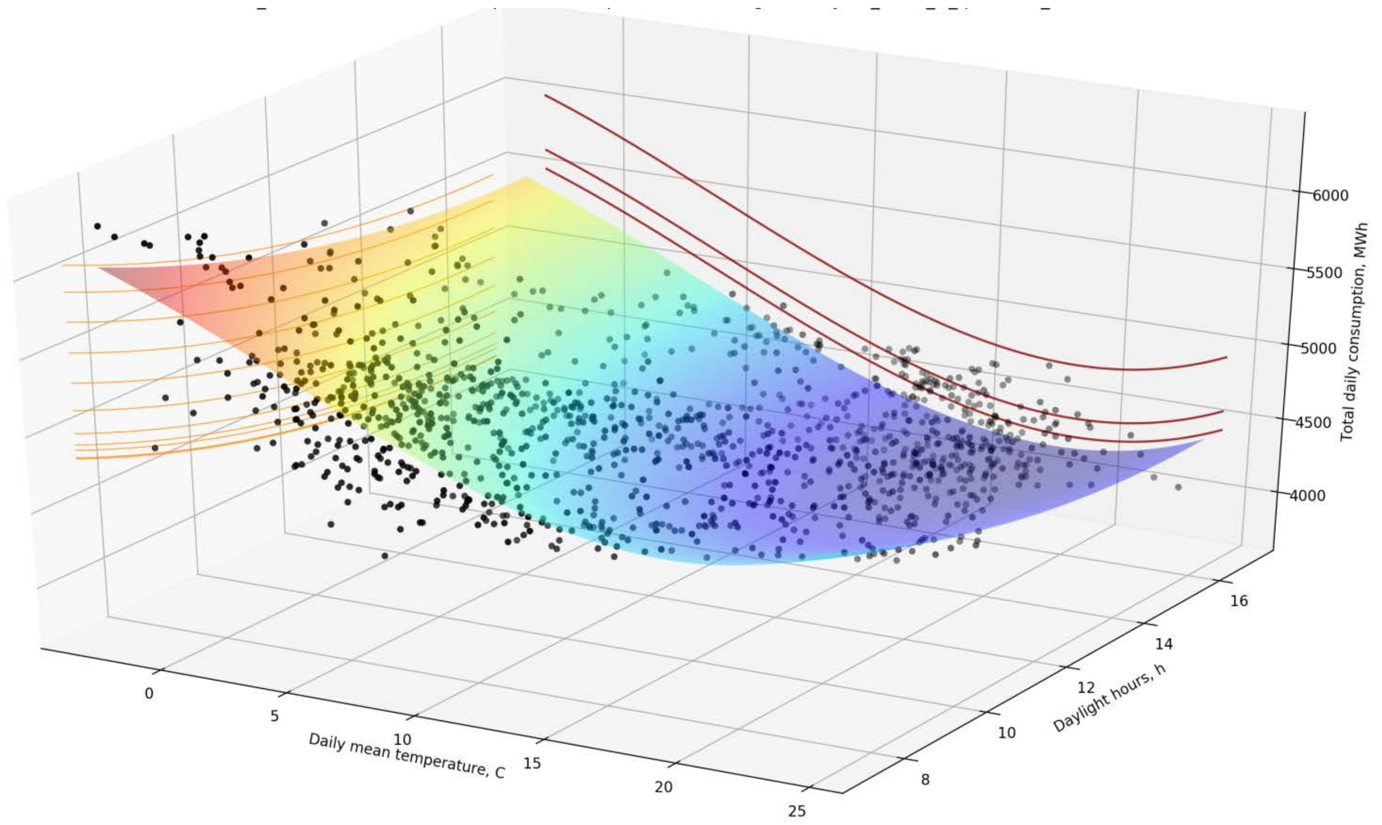
Min true demand (05/07/2016)



Latent demand varies over time

Substation-specific weather correction

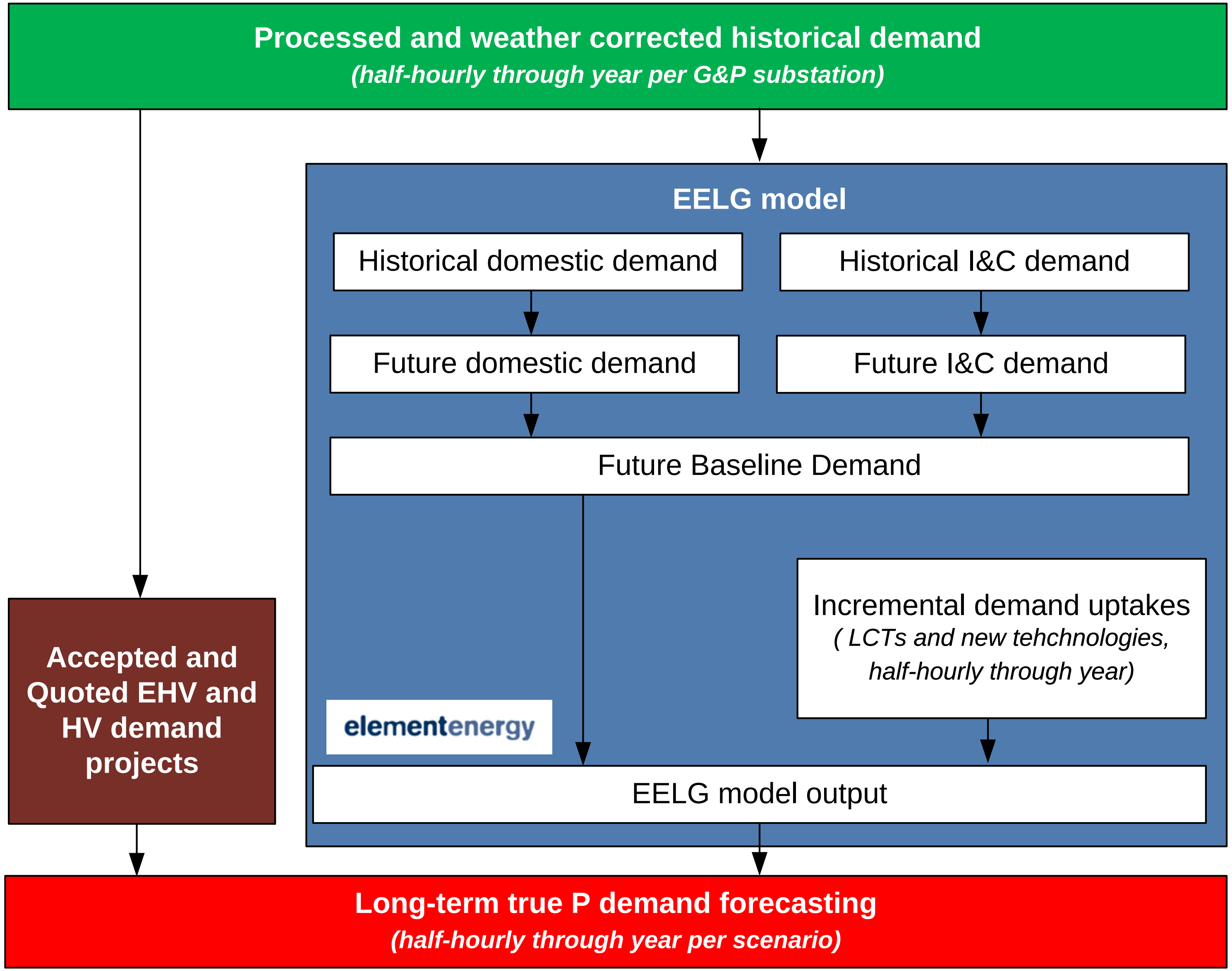
Correlate daily weekday demand over five years, with temperature and daylight hours



Scale half-hourly demand to the historic temperature range of that month

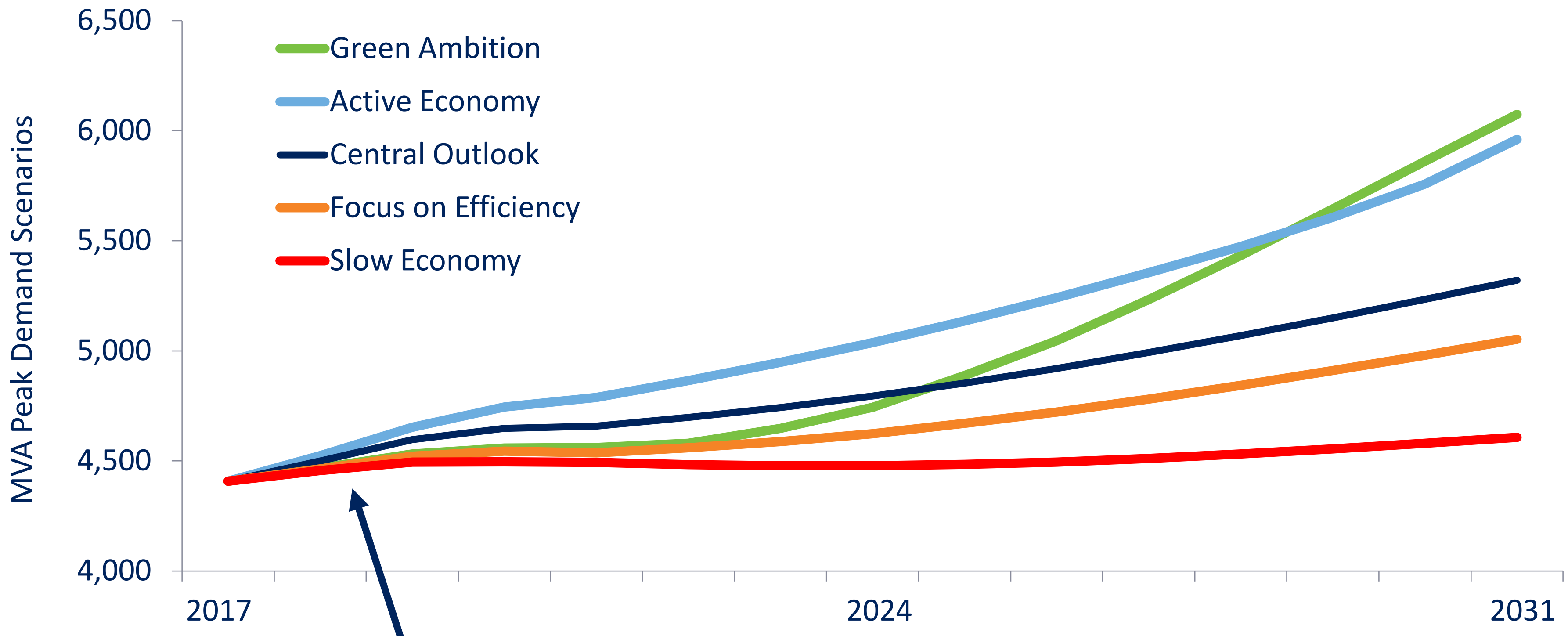
elementenergy

Assessment of Future P Demand



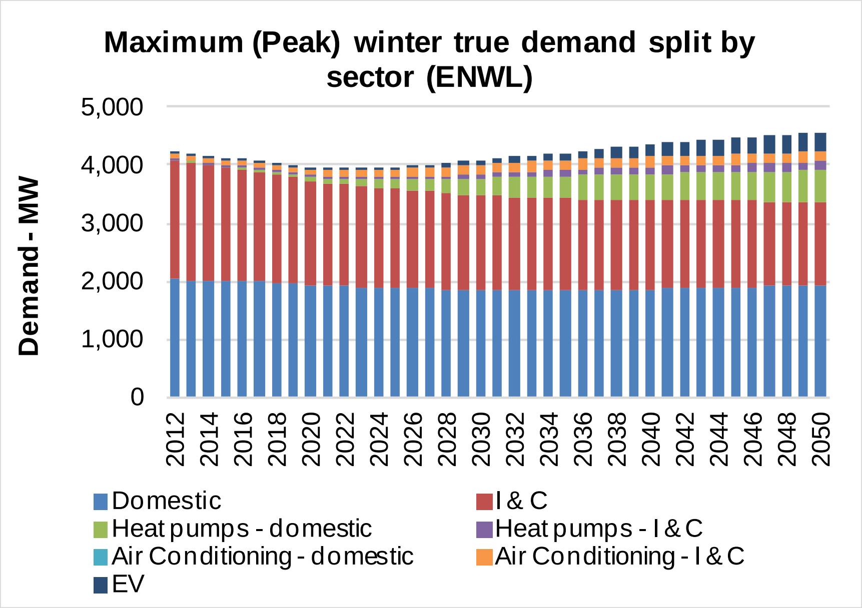
2017 peak true demand scenarios

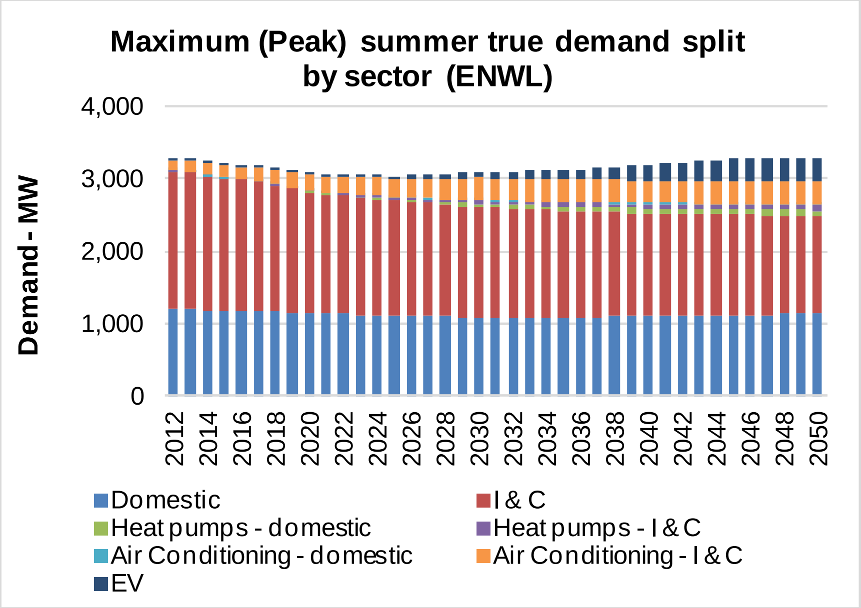
Using the ATLAS prototype approach

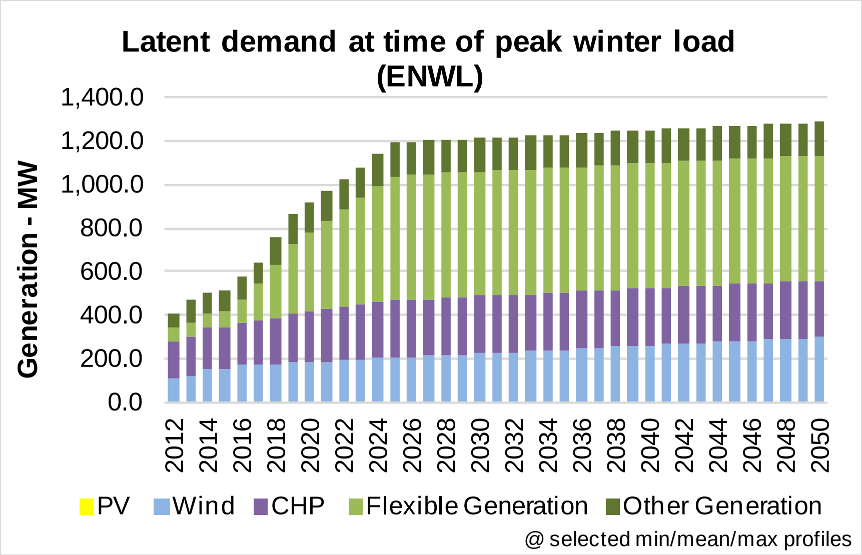


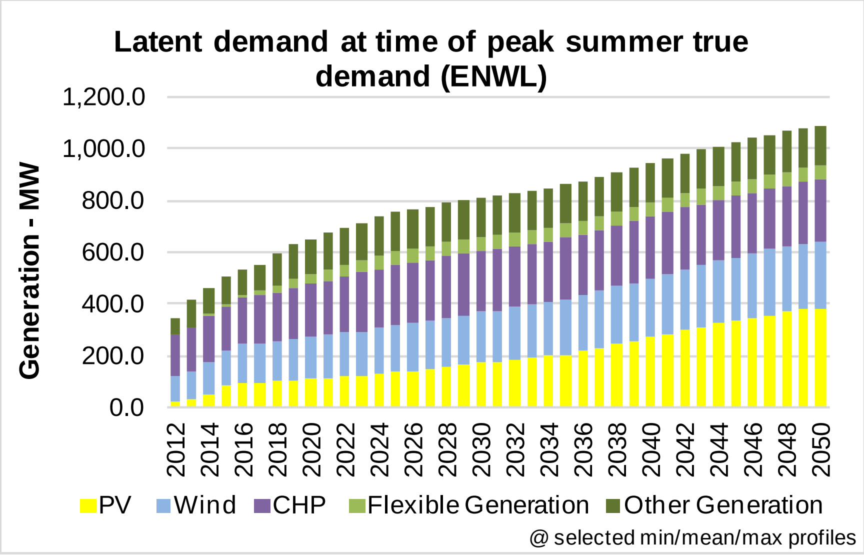
Long-term scenario adjusted for known major demand projects

Decomposition of demand and DG

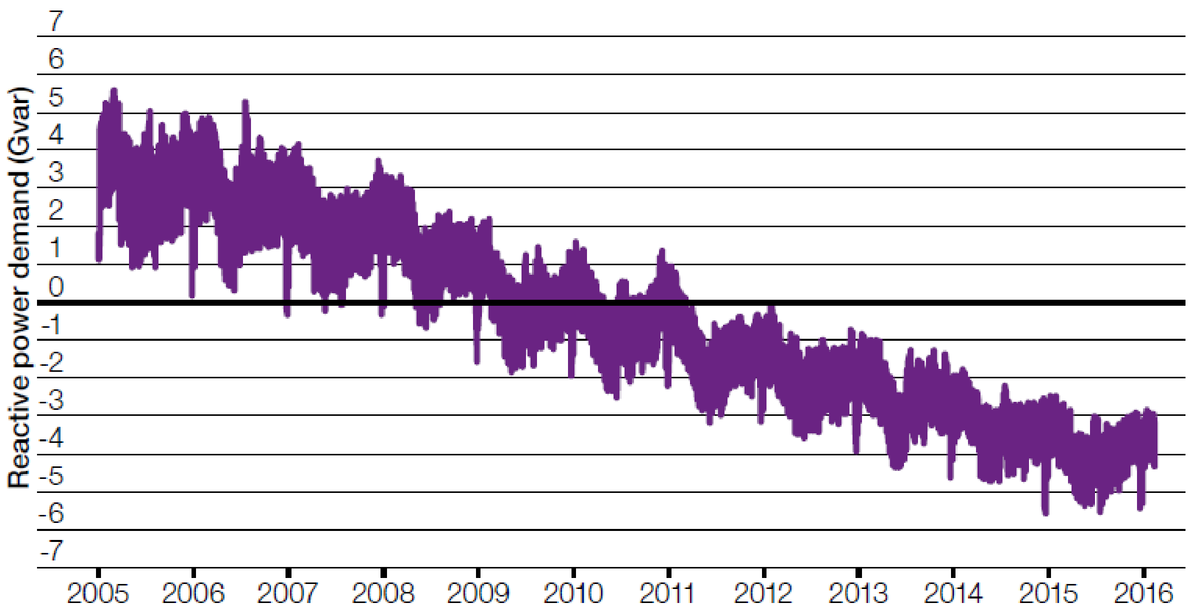








Why forecast reactive power?



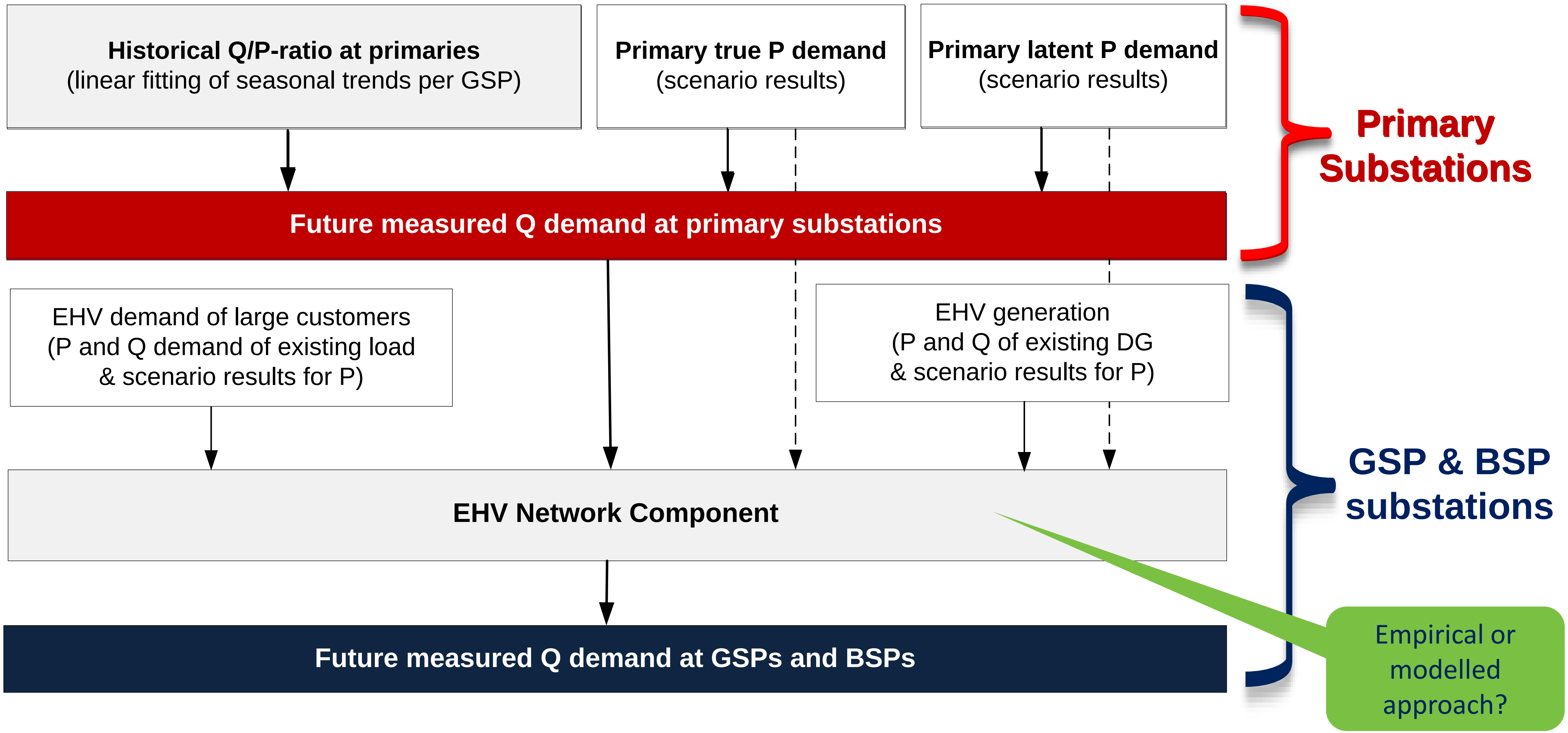
Source: NG SOF 2016

Declining minimum Q (MVAr) demand from distribution

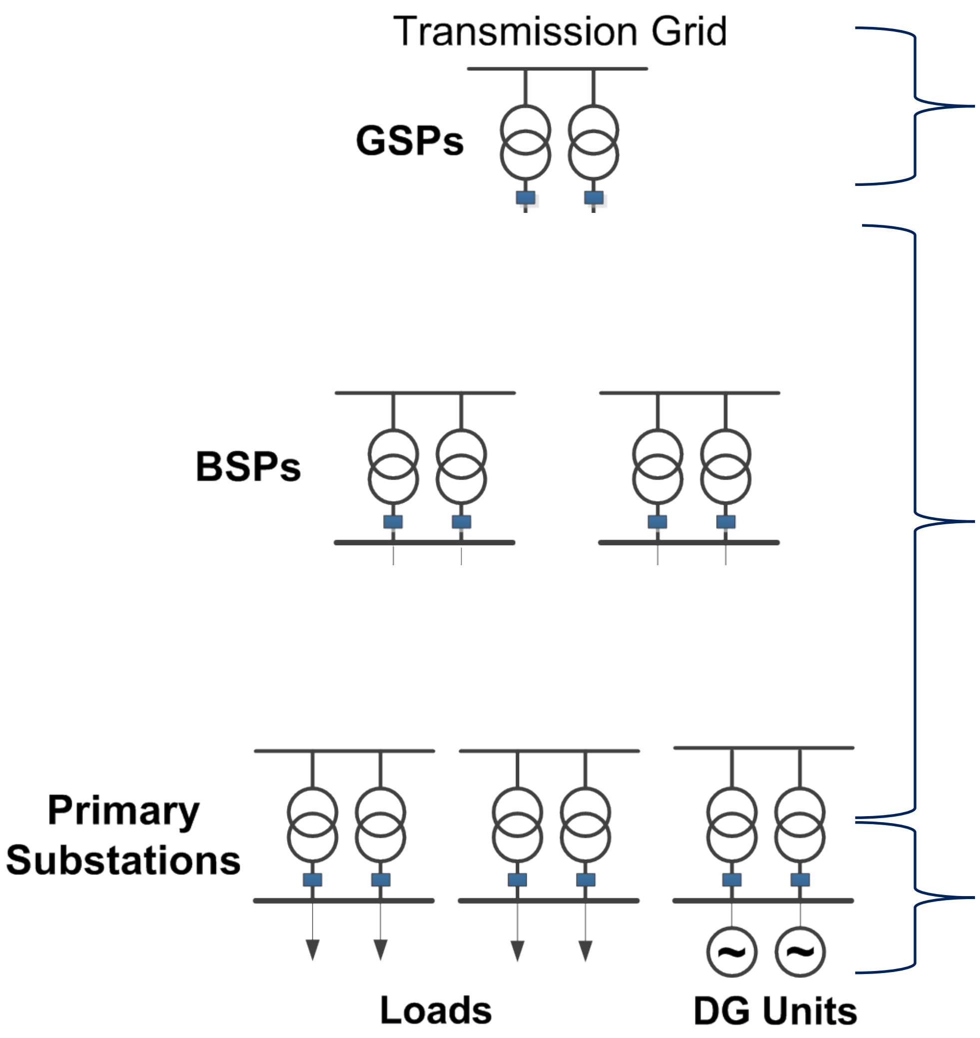
→ High voltage problem on transmission network

Develop ATLAS method to put scale on future Q exports to transmission

ATLAS Q Forecasting method



Simplified view of MVAr (Q) flows



Empirical Rule:

$Q_{GSP} = Q_{primaries} + Q_{EHV\text{-}absorbed} - Q_{EHV\text{-}gains}$

$= Q_{EHV\text{-}absorbed} - Q_{EHV\text{-}gains}$

I^2X $V^2C'\ell\omega$

$Q_{primaries}$

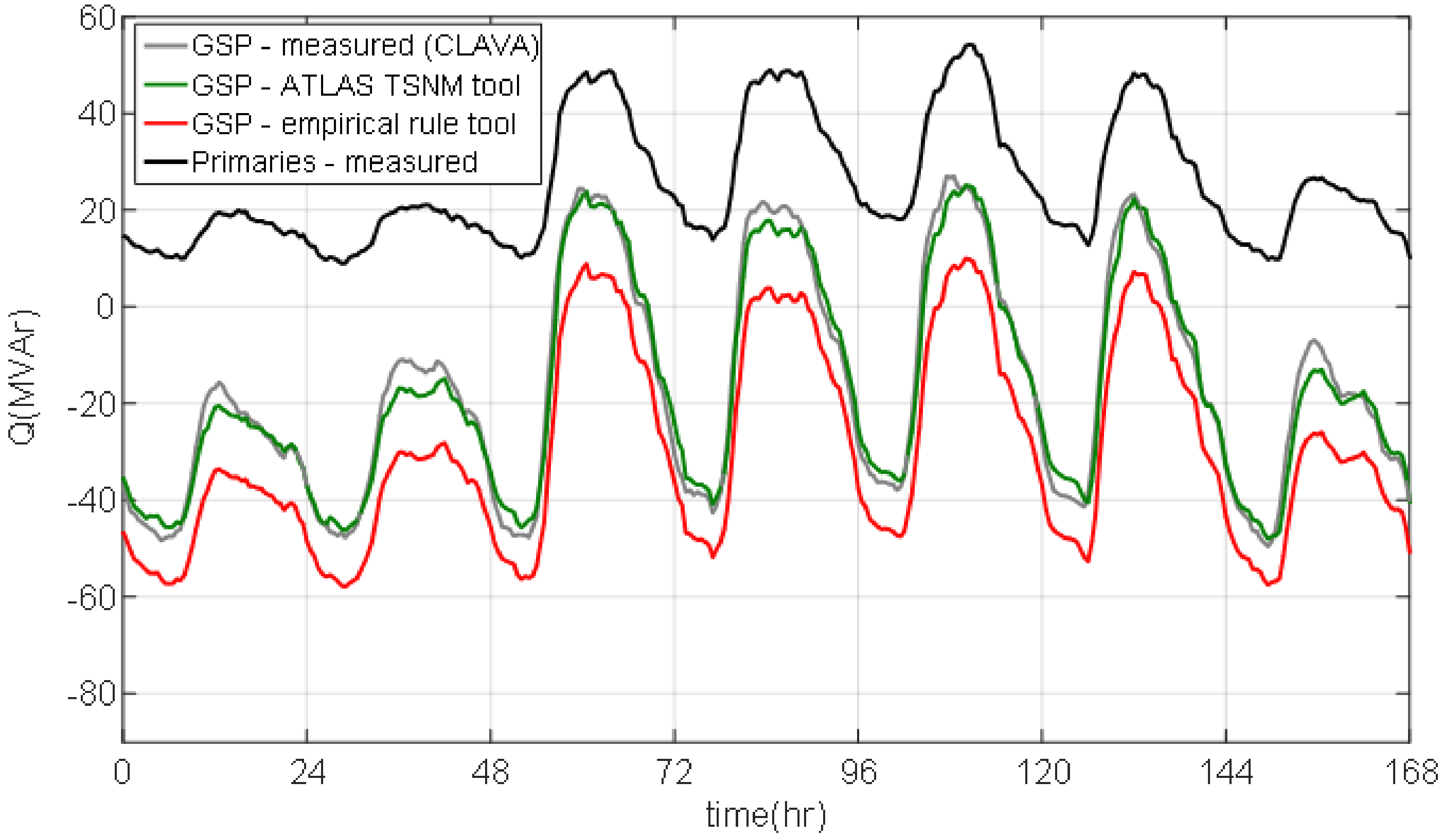
Q forecasting – network modelling

Network Modelling

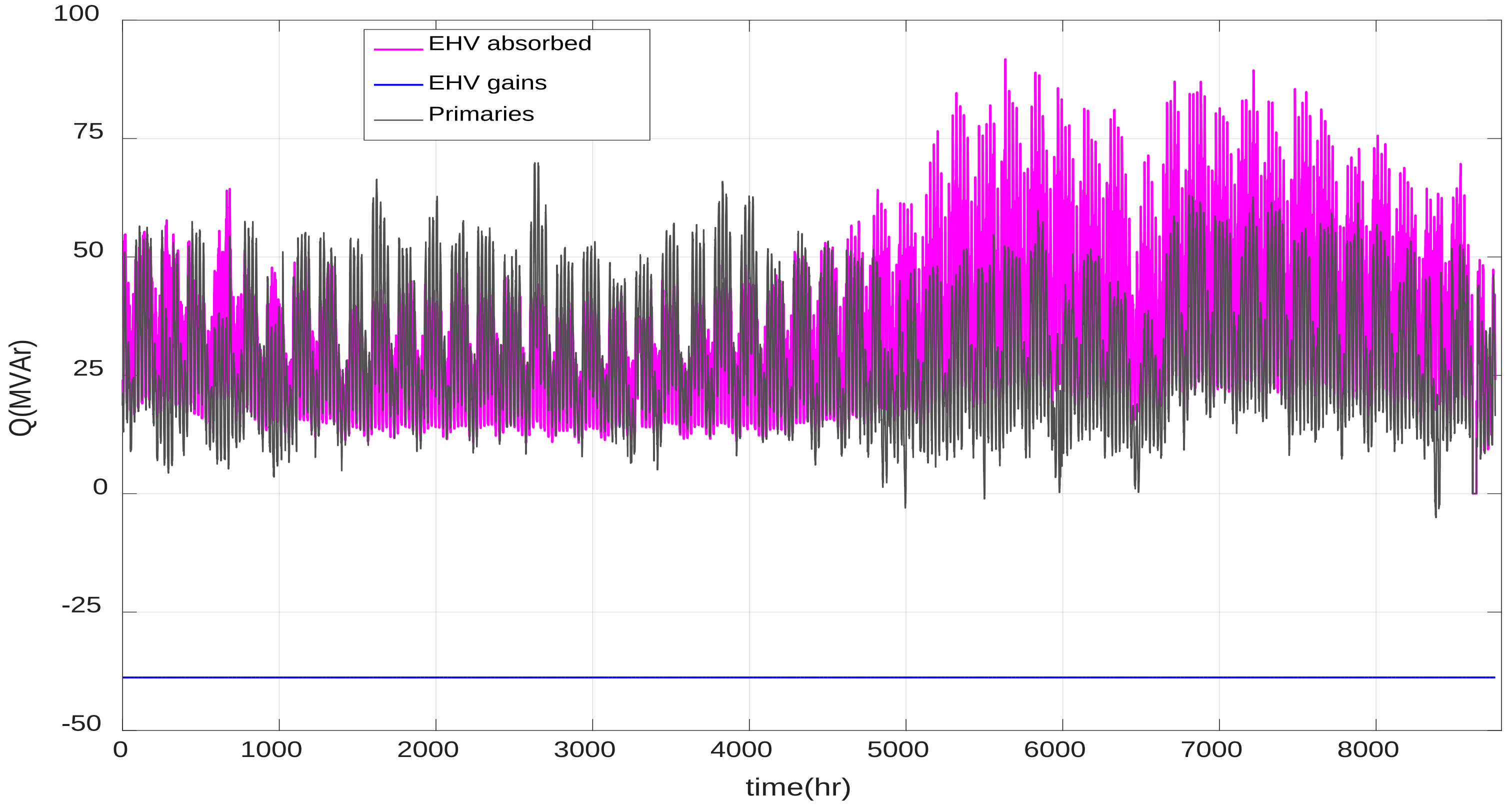
Time-series analyses (ie daily simulation using operational aspects)

REACT approach... but with enhanced inputs

P and Q profiles at primaries (and BSPs for large customers)



Q forecasting – empirical rule

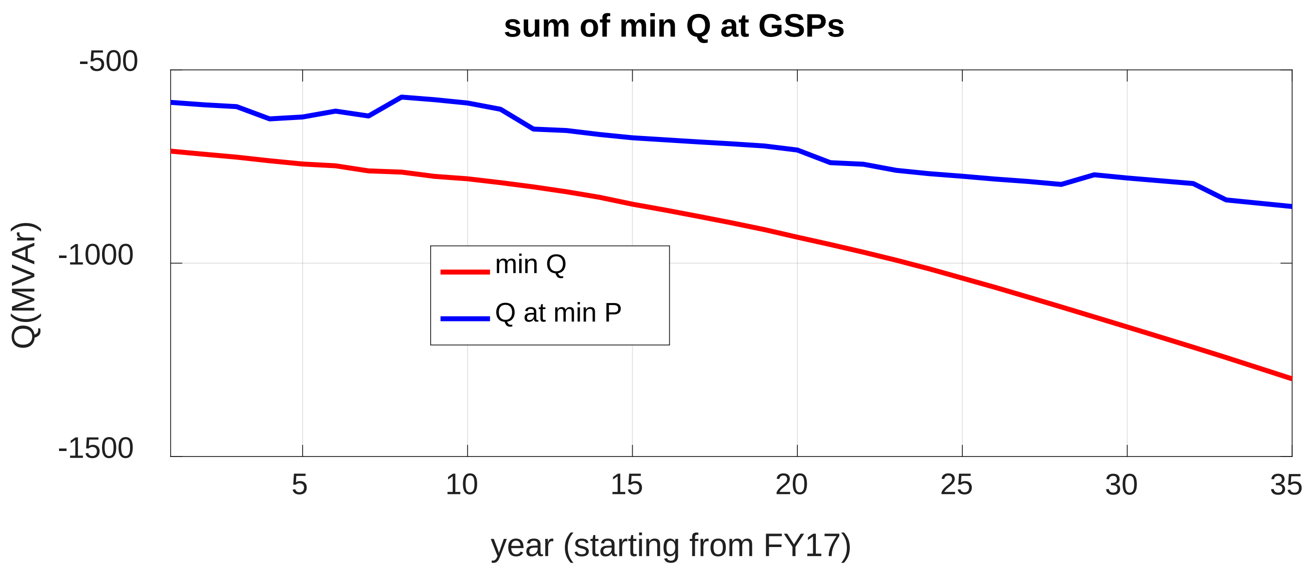


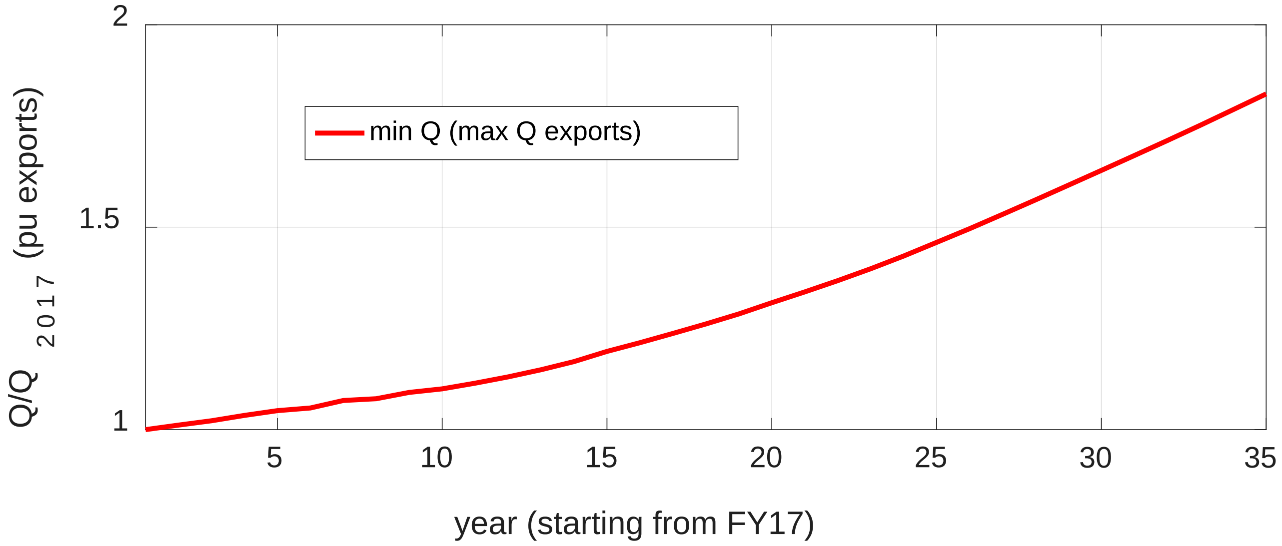
Q absorption → reduced for more lightly loaded EHV, but not for reverse flows

Q gains → increased when more cables or higher voltage targets are used

Q at primaries → more capacitive primaries (declining Q/P trends)

Central Outlook scenario, avg DG output , minimum Q demand = max Q exports





Q exports in this scenario:
+5% in 5 years
+11% in 10 years
+83% in 35 years

But... in reality max Q exports could be even higher in different scenario and with different generation output

After ATLAS

Transition G&P approach to BAU, but keep under review

Use of demand and generation forecasts in regional development plans

In FY18 compare Q exports with expected NG limits at GSPs. By 2020 create high level intervention programme for ED2

Value of Lost Load (VoLL)

Tracey Kennelly
Customer Delivery Innovation Lead

Dawn Mulvey
Head of Utilities, Impact Research

Michael Brainch
Managing Director, Impact Research

David Pearmain
Director of Advanced Methods, Impact Research

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What is the value of lost load (VoLL)?

The **social** cost of supply interruptions to customers in £ per MWh

VoLL has existed since 1990
2013 - London Economics **~£17k/MWh**
average value (excluding I&C)

VoLL varies considerably across domestic and SME customer segments

A single average figure is used to provide an overall value for a given asset / decision

Ofgem used a figure of ~£16k/MWh for RIIO ED1

Quantify VoLL by customer segment now and in the future

What is the impact on customers of lost load?

What is the value of this impact, expressed as the financial and social cost to customers in £ per kWh?

How does this vary by customer type?

How does this vary by supply interruption components?

How can DNOs mitigate the cost of lost load?

How will this vary with LCT adoption?

Deliverables

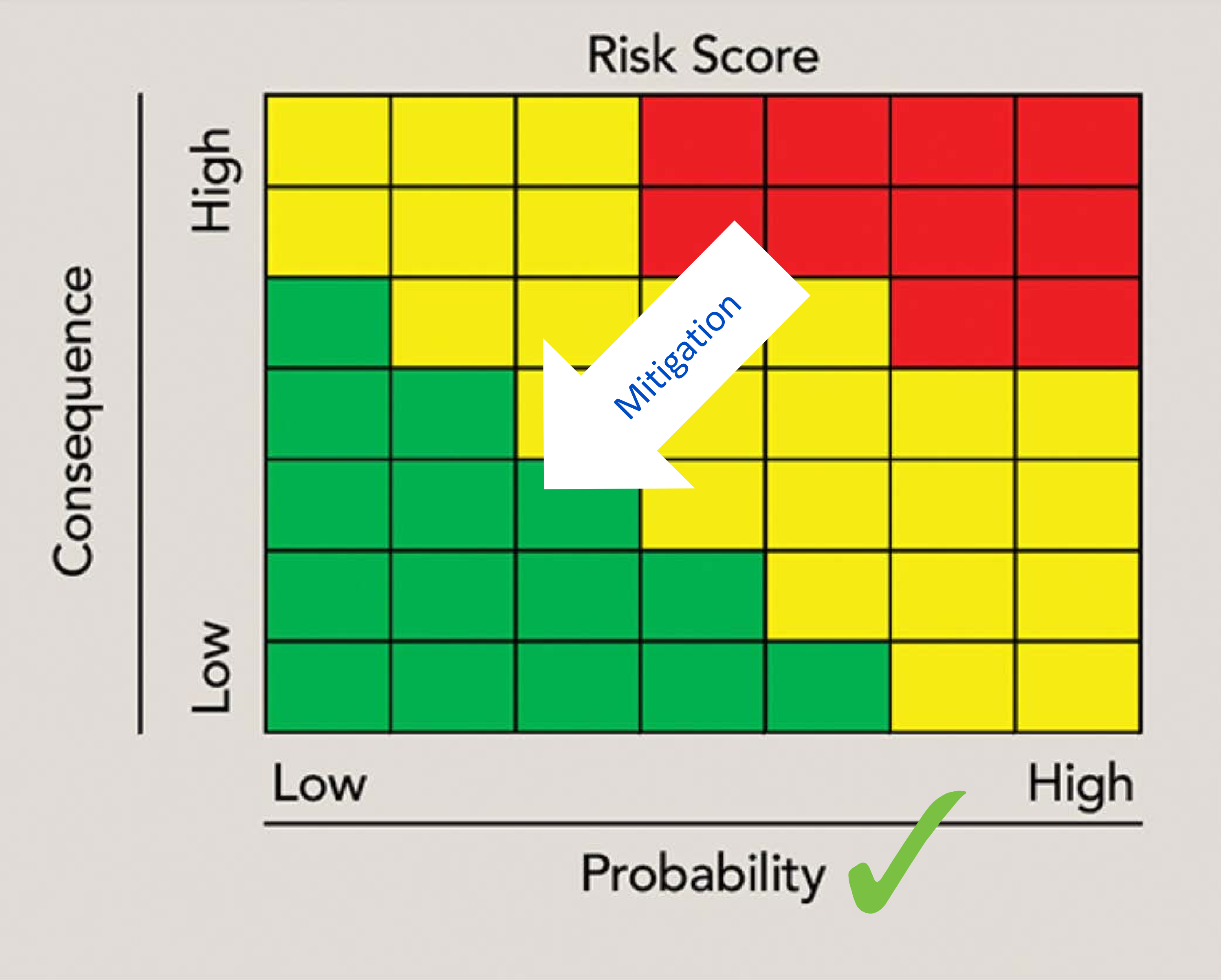
Understanding customer impact: how value is defined and how this might be influenced

Credible segmentation and future VoLL model by key customer groups

A demonstration of how these values would help DNOs better plan network investment strategies

Guidance on customer compensation strategies

VoLL is a key component of measuring the consequence of asset failure



When DNOs invest to mitigate the risk of service failures they can quantify the probability of an asset failure but…

One of the key factors in the *consequence* to customers is the number of customers affected by the failure

The current single VoLL gives **no differentiation between customer types**

Objectives of our project

Outcome: Future decisions directly guided by customer needs

for example comparative need of vulnerable and non vulnerable customers

So ... we need an accurate and representative VoLL covering a range of customer groups to create a bespoke investment value per decision

Demonstrate how segmented VoLL model will help DNOs improve planning models and guide investment strategies

Our challenge was to establish VoLL across the full spectrum of customers using data readily accessible to DNOs

How we structured our research

Interviews with key stakeholders to guide research approach

ECP panels of domestic and SME customers

Depth interviews

6,000 interviews across GB with domestic and SME customers

New VoLL model

Suitable for use by DNOs

Statistically robust & representative research
to establish VoLL by key customer segments now and in the future

Who did we speak to?

Domestic

Interviews were conducted with a wide range of customers across all of GB in winter and summer

2446

2510

Domestic customer data was weighted to reflect the national profile

- Gender
- Age
- Socio-economic
- Vulnerable
- Fuel poor
- Electric heating
- Electric vehicle
- PV

Who did we speak to?

SME

Interviews were conducted with a wide range of customers across all of GB

561

480

SME customer data was weighted according to:

- Industry sector
- Company size
- Public vs private

Companies over 250 employees were outside the project scope

Using our results to replicate LE's value

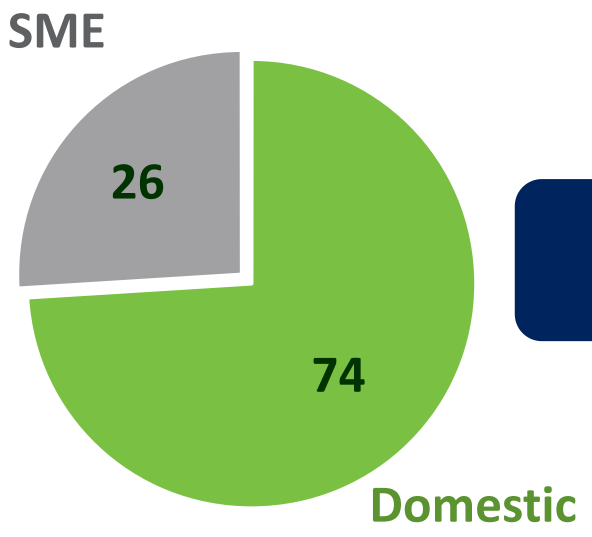
Combining our values to reconstruct 'vanilla' VoLL

Rural £20,970
Urban £16,071

£17,481

Rural £63,107
Urban £42,366

£47,560

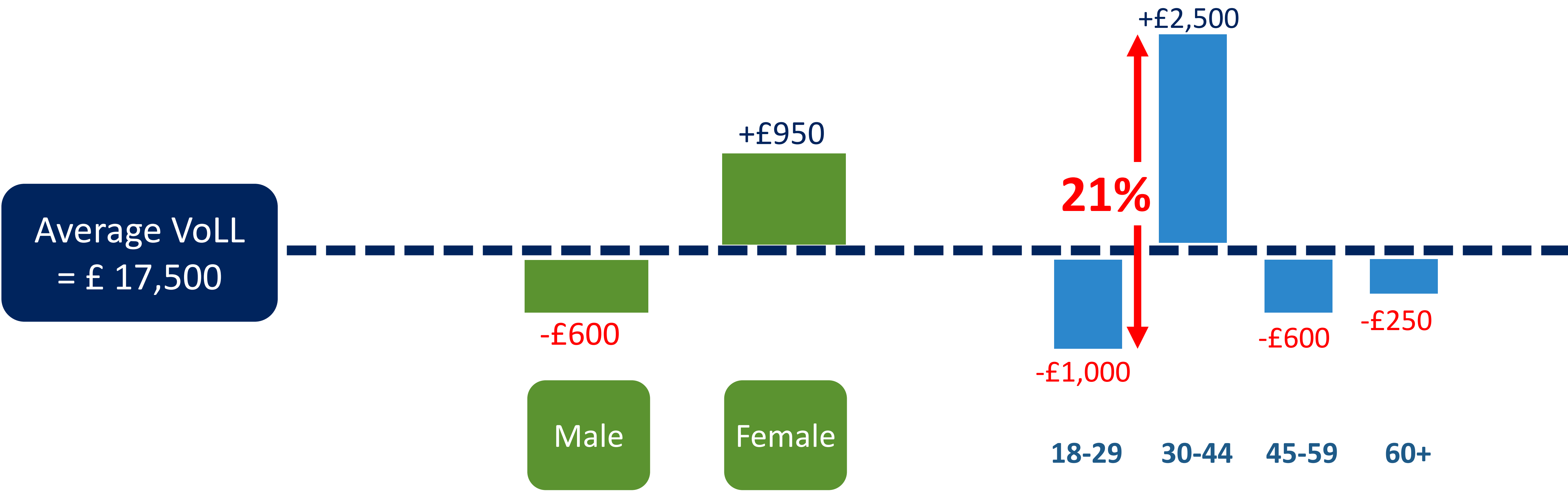


£25,301

LE value = £16,940

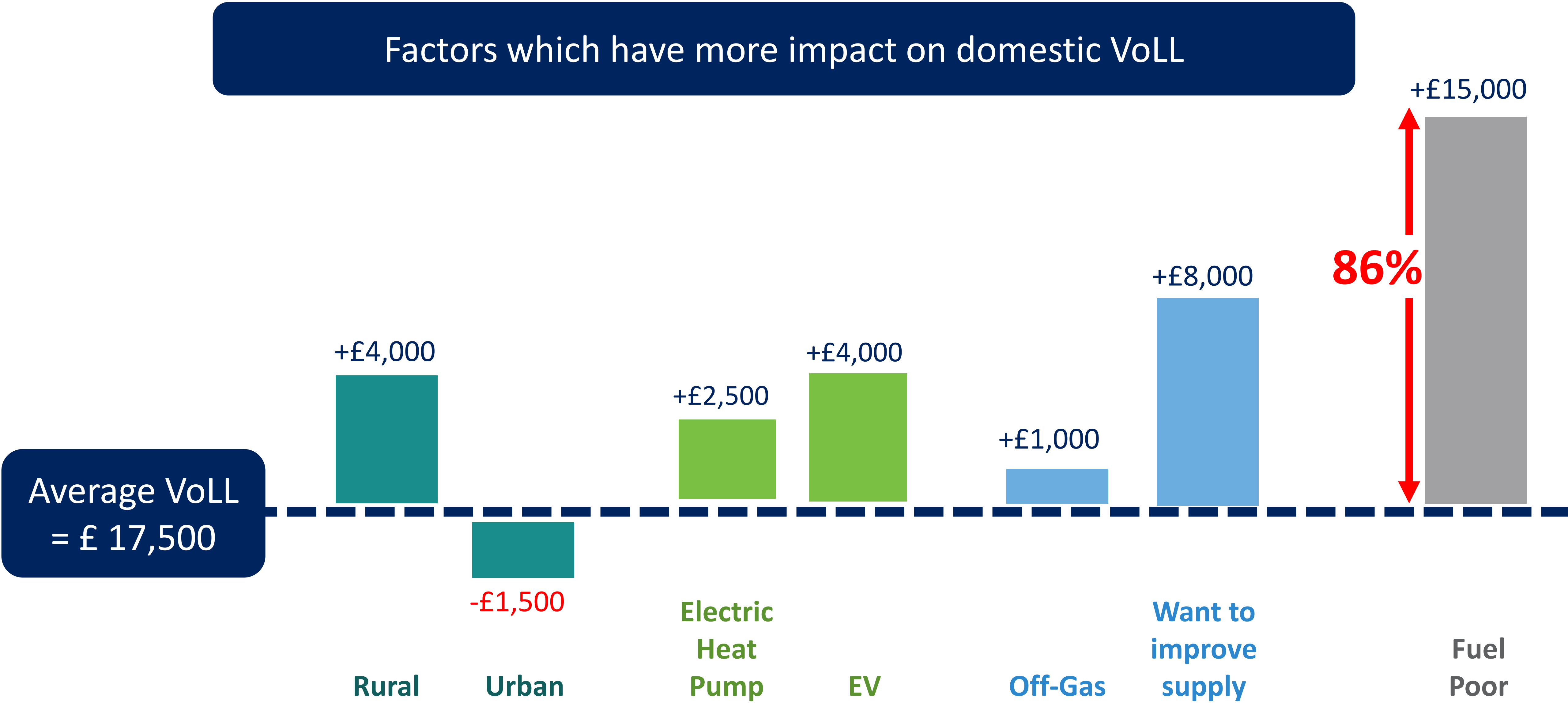
How does domestic VoLL vary?

Customer demographics: impact on domestic VoLL



per MWh

How does domestic VoLL vary?



Current estimation of VoLL

10 hour LV feeder fault occurring once every five years, over a period of 40 years

Two LV feeders, both supplying 50 homes

Old VoLL

X 35

X 15

£ 72,000

X 15

X 20

X 15

£ 72,000

VoLL currently calculated by multiplying the number of homes x standard figure

New estimation of VoLL

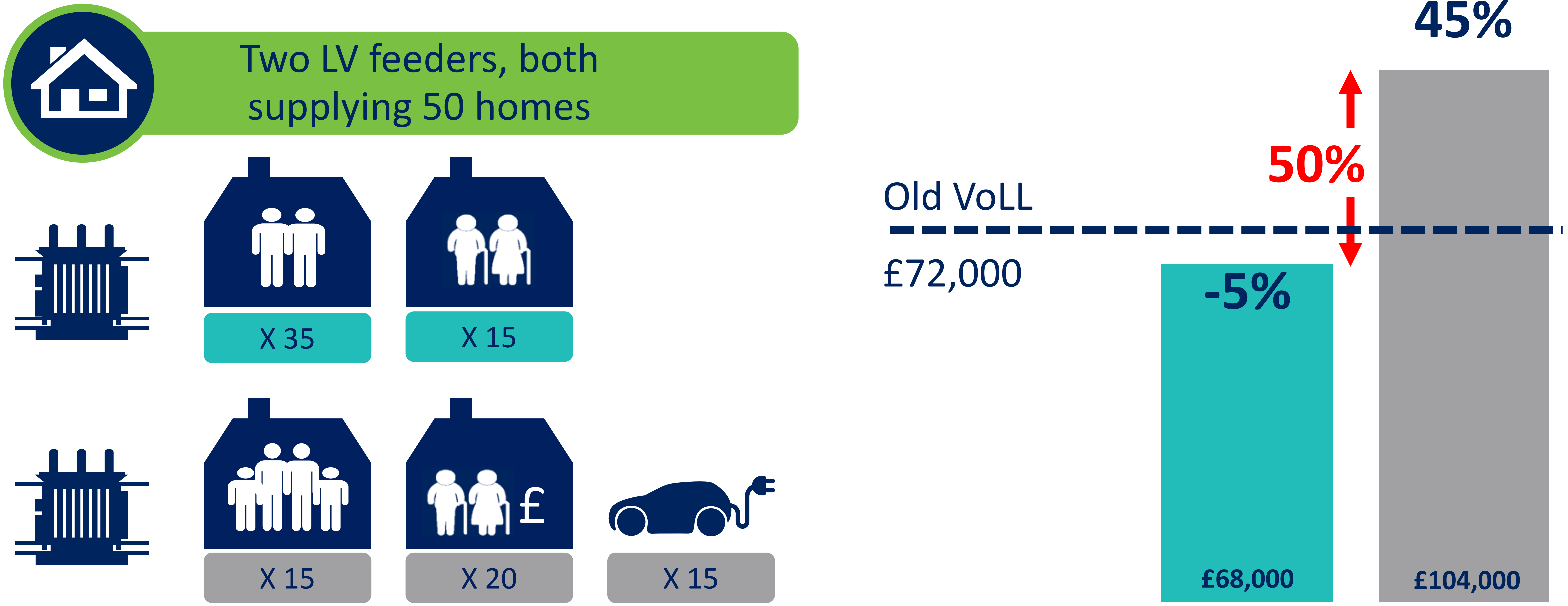
10 hour LV feeder fault occurring once every five years, over a period of 40 years

Two LV feeders, both supplying 50 homes	Old VoLL	New VoLL
X 35, X 15	£ 72,000	£ 68,000
X 15, X 20, X 15	£ 72,000	£ 104,000

VoLL calculated for each household by applying a weighted combination of values for each household characteristic

New estimation of VoLL

10 hour LV feeder fault occurring once every five years, over a period of 40 years

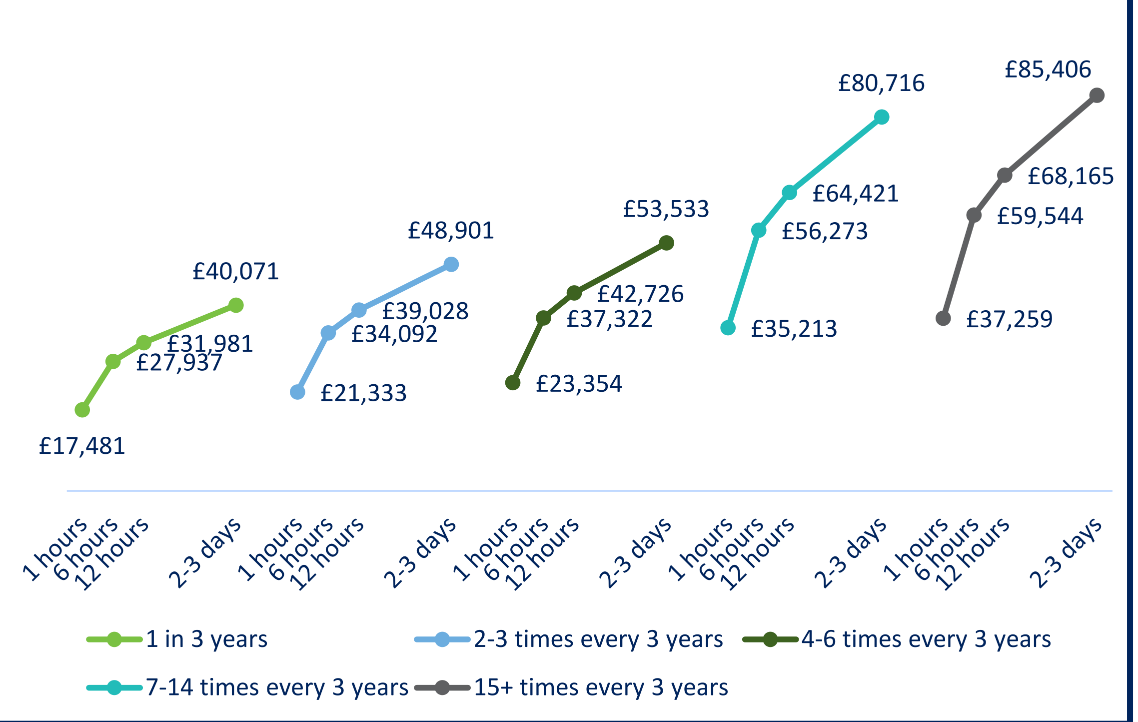


VoLL calculated for each household by applying a weighted combination of values for each household characteristic

A VoLL timeline – domestic customers

Tested:	1 hour	6 hours	12 hours	2 to 3 days

***Domestic** VoLL in MW/h by frequency and duration of outage - **unplanned**)*



***Domestic** VoLL in MW/h by frequency and duration of outage (**planned**)*

For an outage over 6 hours (occurring 7-14 times every 3 years) VoLL falls from **£64,500** (*unplanned*) to **£48,000** (*planned*)

Summary

Existing approach undervalues the needs of certain customers

Not reflective of those dependent on LCTs

Fuel poor are hugely under represented

Others are over represented potentially driving inefficient investments

VoLL model to be published that will provide an effective tool that all DNOs can use without the need for new data flows

Segmentation model enables DNOs to make decisions more reflective of actual customer needs

Q&A panel

David Pearmain

Director of Advanced Methods

Impact Research

Michael Brainch

Managing Director

Impact Research

Dawn Mulvey

Head of Utilities

Impact Research

Tracey Kennelly

Customer Delivery Innovation Lead

Electricity North West

Impact Utilities
Pursue, Discover, Act

Sentinel

Kieran Bailey and Brian McGregor

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Agenda

What's the problem?

Storm lifecycle

Sentinel – progress to date

KELVATEK

Product development & Technology review

The problem

Faults on rural OHL networks can be difficult to detect and locate
Transient/emerging
Broken Conductor
Low Clearance

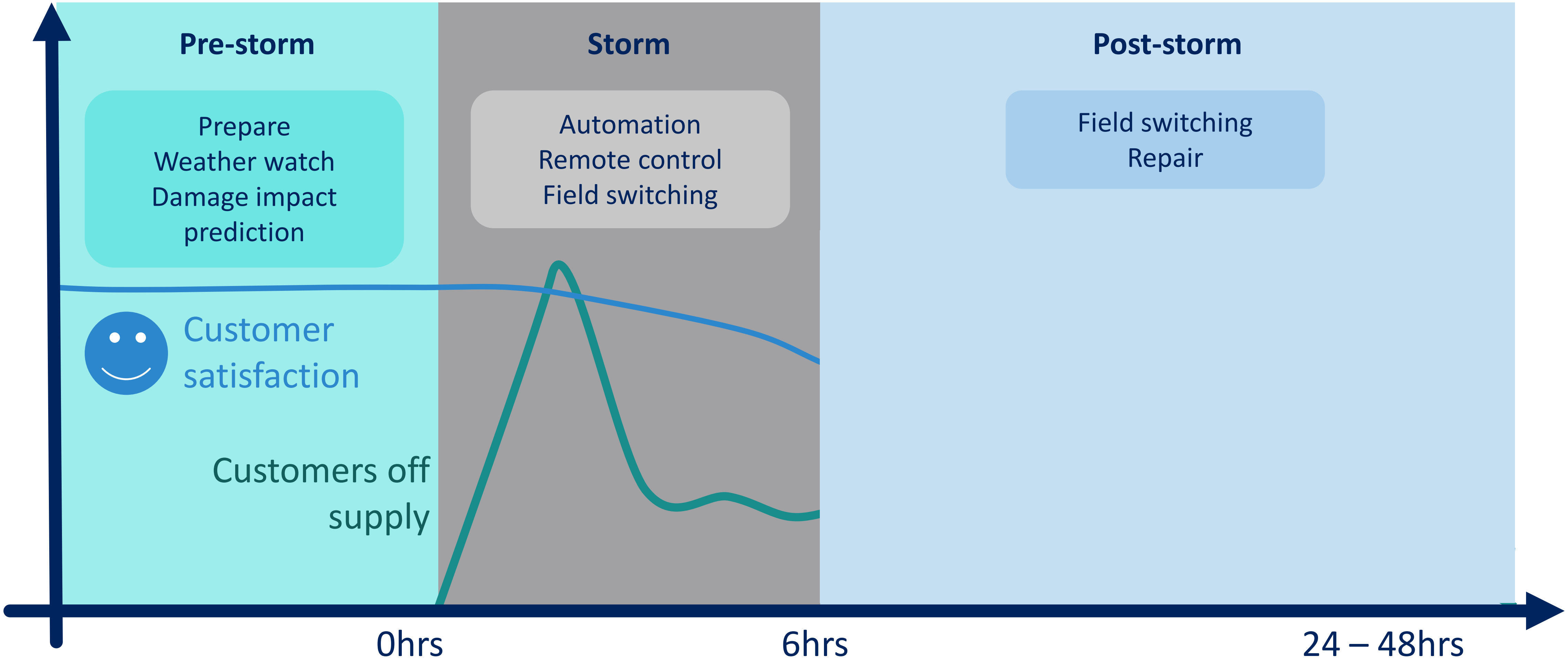
In storm situations there can be multiple faults on single circuits

Traditional location techniques are time consuming, dangerous and lead to poor customer experience

Some faults, if left undetected, can present a serious danger to life

What does it look like?

Timeline



How do you minimise time to repair?

Sentinel

Objective

Find damage in real time

Optimise deployment of repair teams

Output

Fault location system

Location within 500m for high current faults

1km for low current/low lines (worst case)

Right teams to right location

Reduces safety risk

Maximising productivity of repair teams

Faster restoration

Customer Satisfaction

Location techniques

Uses a combination of different location techniques

Impedance

Voltage gradient

TW and TDR

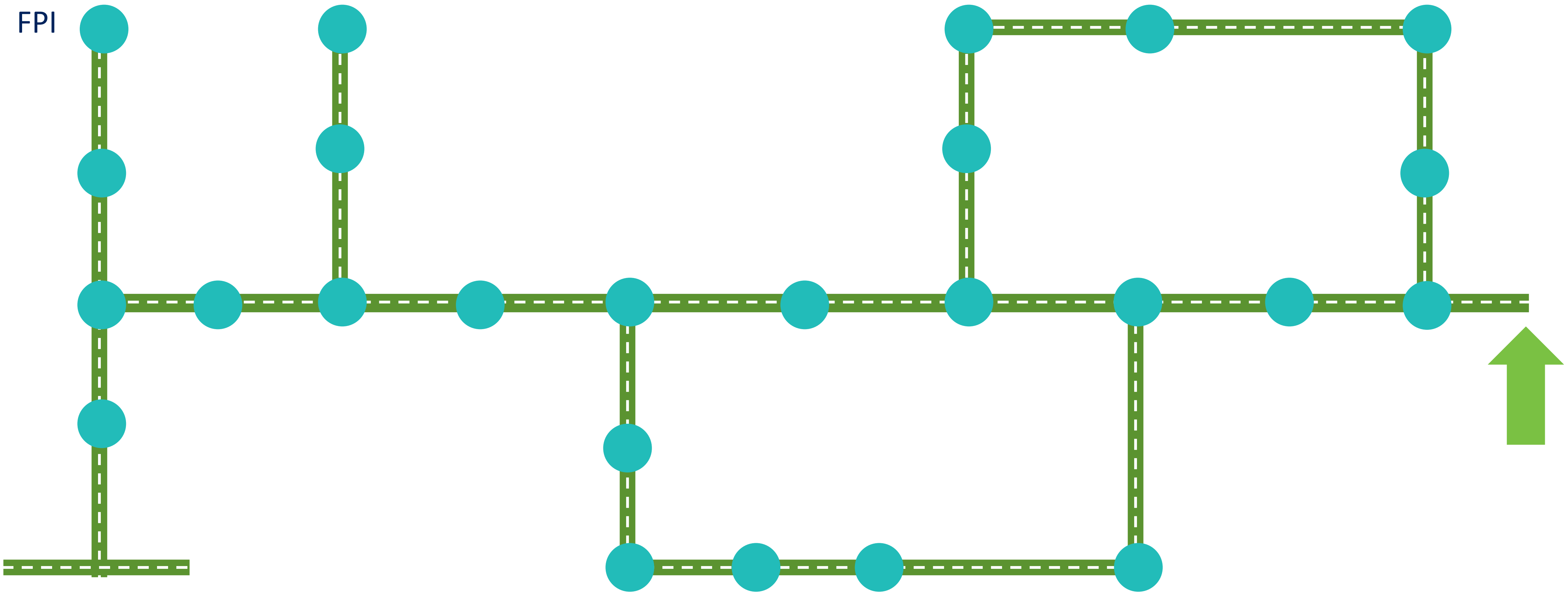
Integrate with real time systems

Responds to changes in network configuration

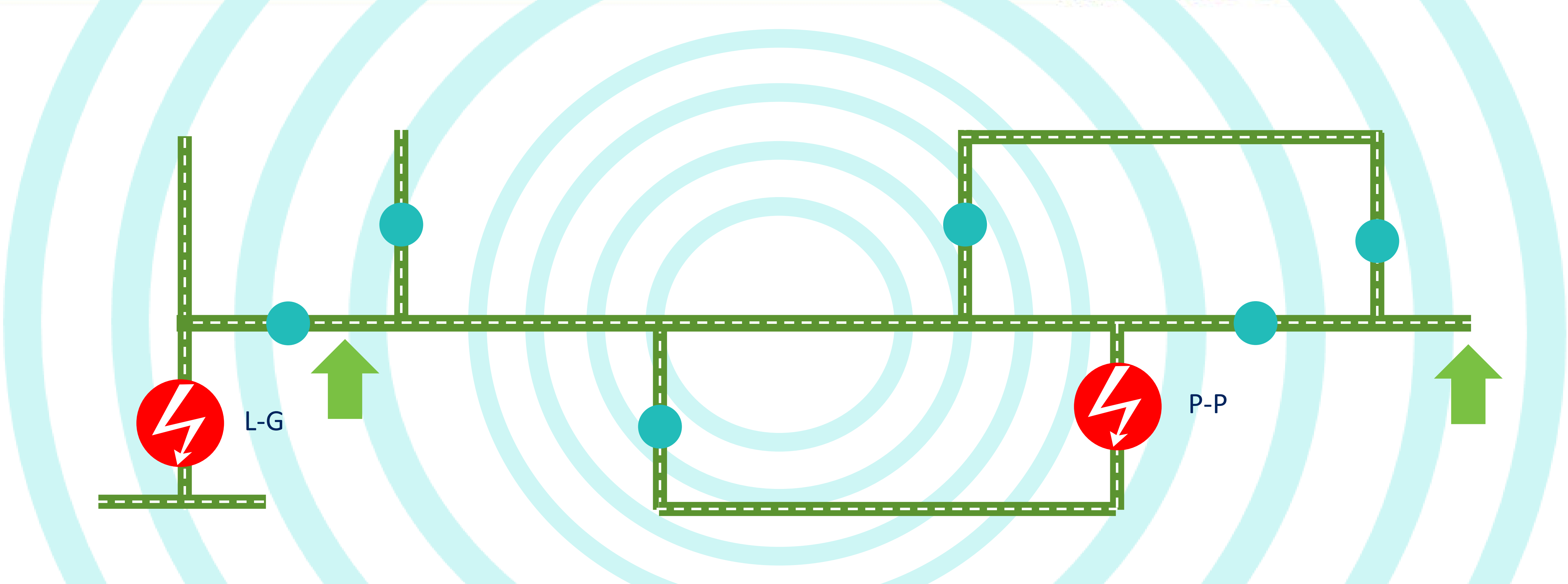
Why Sentinel?

Nafirs data 2007 - 2017		Total	Phase to Phase	Line to Ground	Sensitive Earth Fault
Storms	Damage	51%	21%	27%	3%
	Transient	49%	34.5%	9%	0.5%
			High current	Reduced current	High impedance

Why Sentinel?



Why Sentinel?



Finds multiple faults of multiple types
on a rapidly reconfiguring network in near real time

Benefits of Sentinel

Customer		Safety		Financial	
Fault location within 500m for high current faults and 1km for low current faults	Detect and locate emerging faults on network	Detect and locate high impedance fault eg broken conductor	Engineers not patrolling in extreme weather	Reduce guaranteed standard liability	Real time condition monitoring Target replacement programme

Progress

Built OHL test facility	Product development	Sentinel System	Trial install August 2018
Indoor 11kV system OHL built to ENW specifications (dead) for signal injection testing	Electronics bench tested, PCB layout finalised and in production New current transducer Construction of steelwork for voltage sensor & HF coupler Control cubicle designed	All equipment design complete System GA completed Operational procedures in progress Training	Trial install on dead system June 2018 First single pole live install August 2018 Data gathering for algorithm optimisation and refine trigger Optimisation Calibration

Technology update

Brian McGregor

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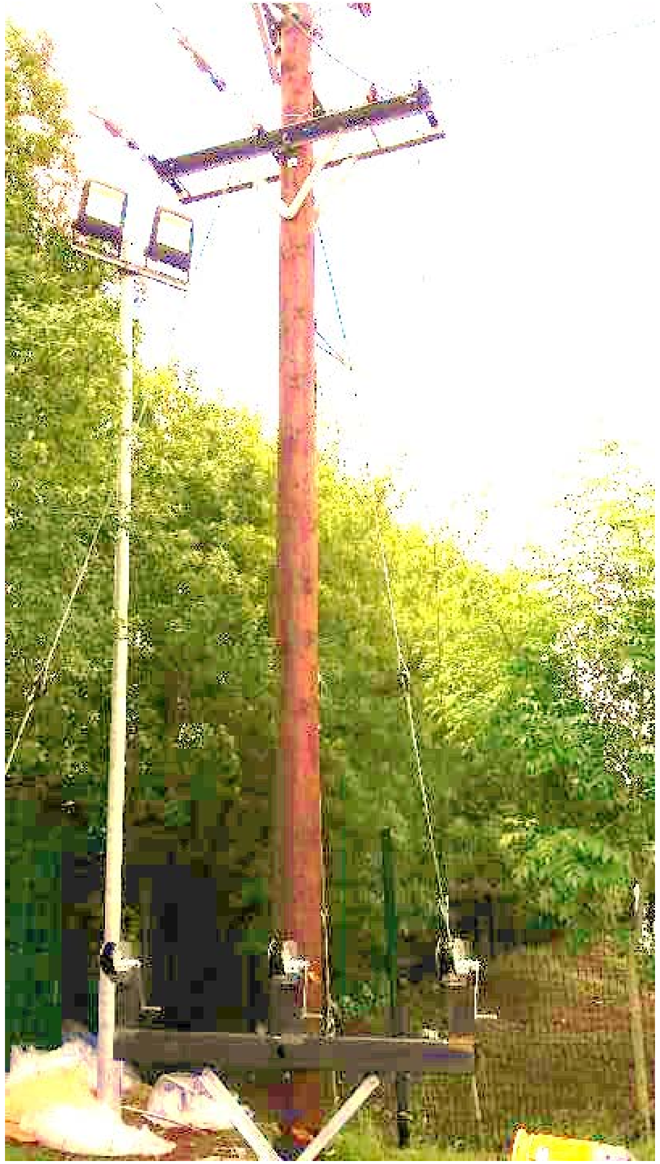
Test facilities



Test facilities

Current sensor

Coil holder

High temperature materials

Mould tools

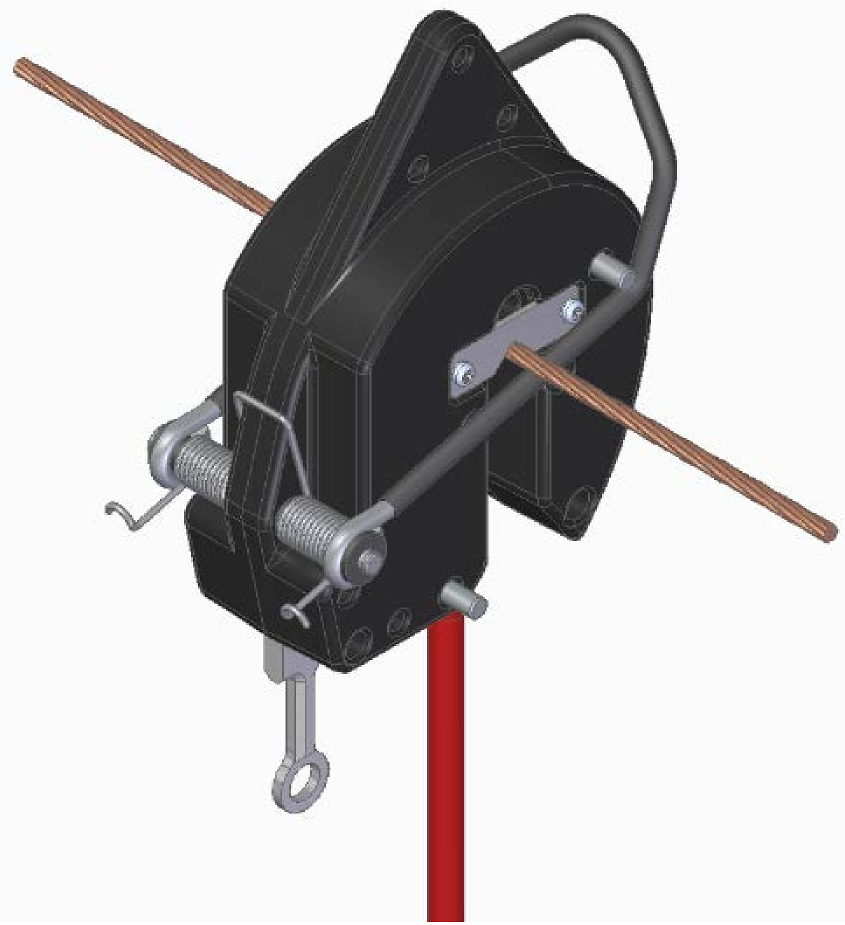
Coil winding

Winding tools

Coil over moulding

HV materials

Mould tools



Outer case

Environmental materials

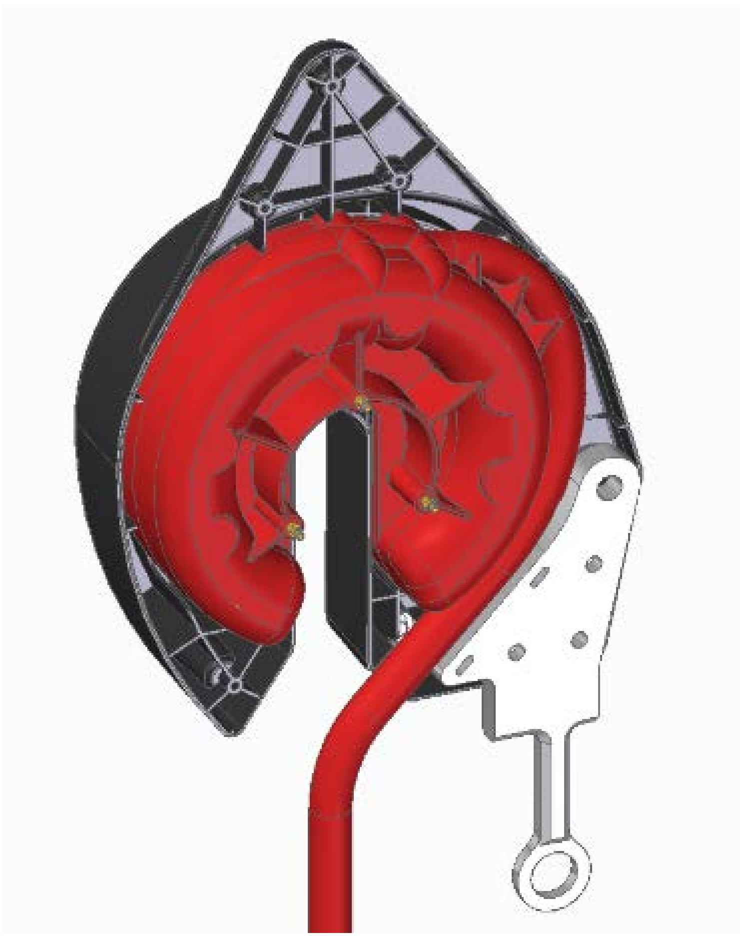
Mould tools

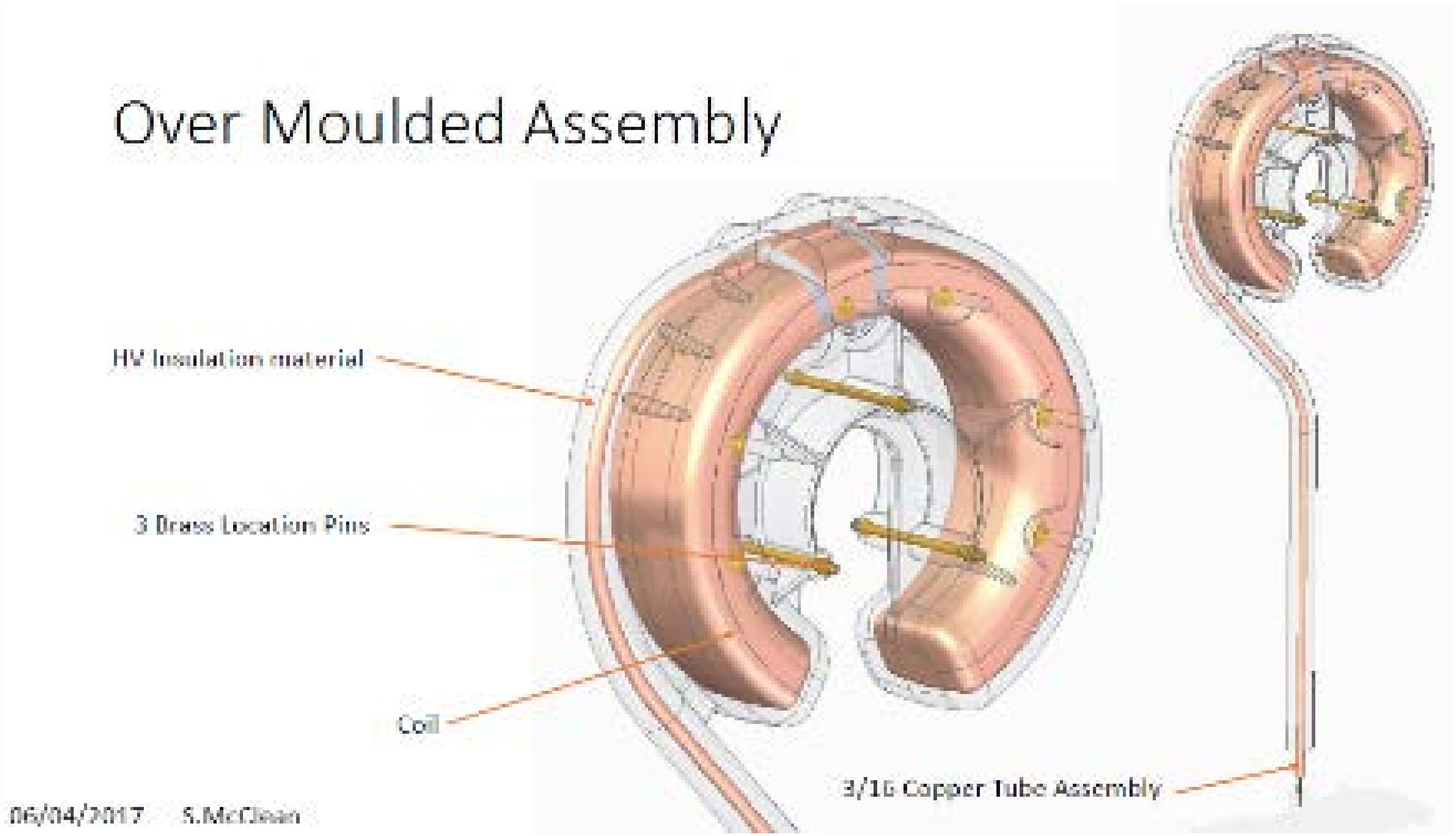
Cable clamp

Customer spring and clamp parts

Approvals

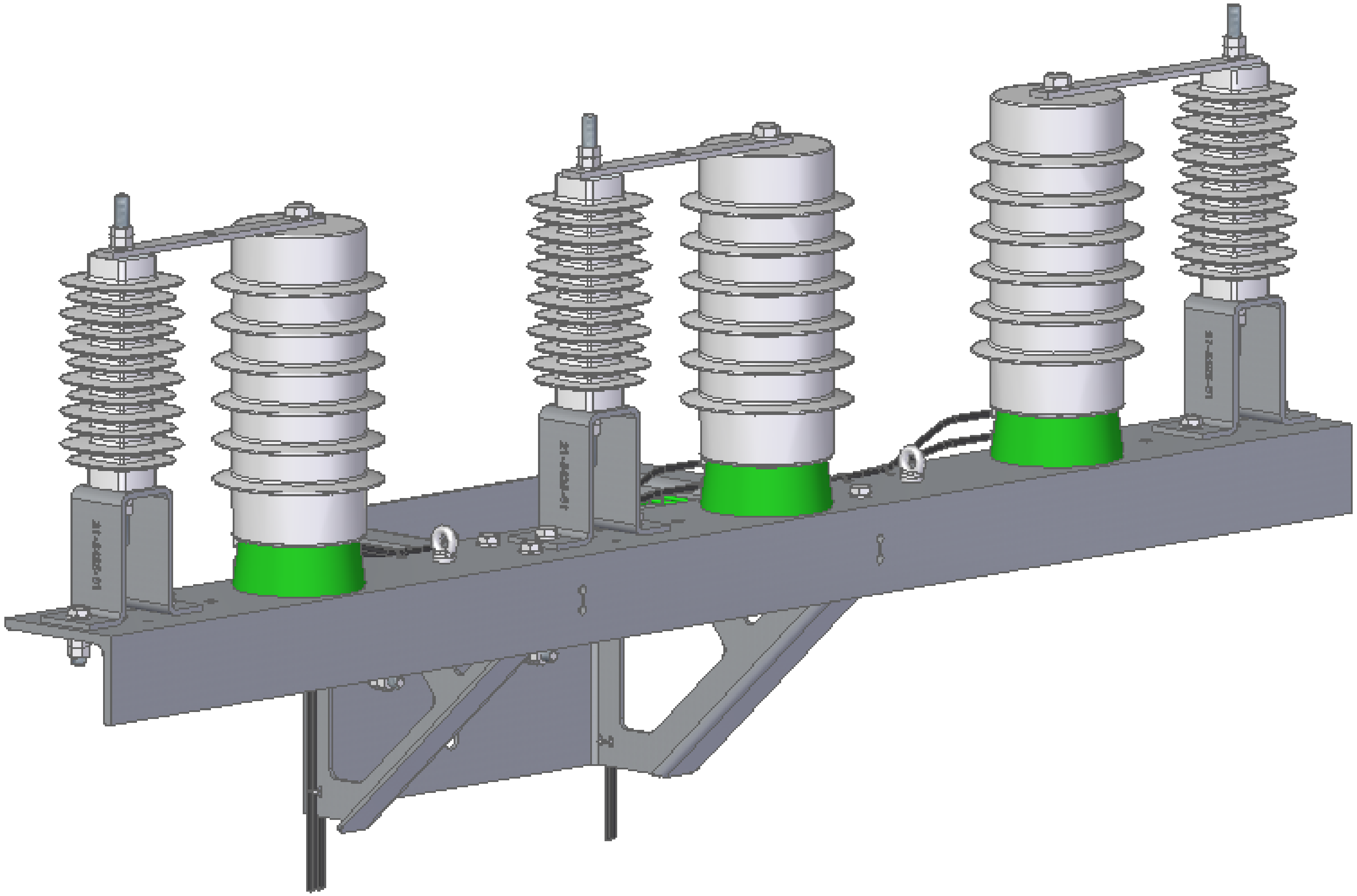
Current sensor



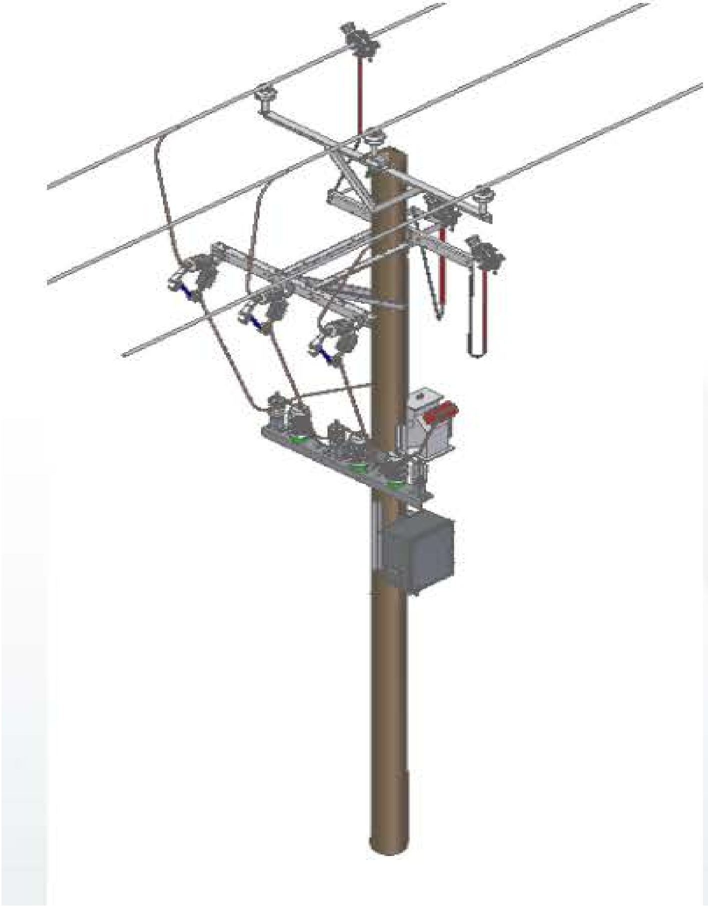


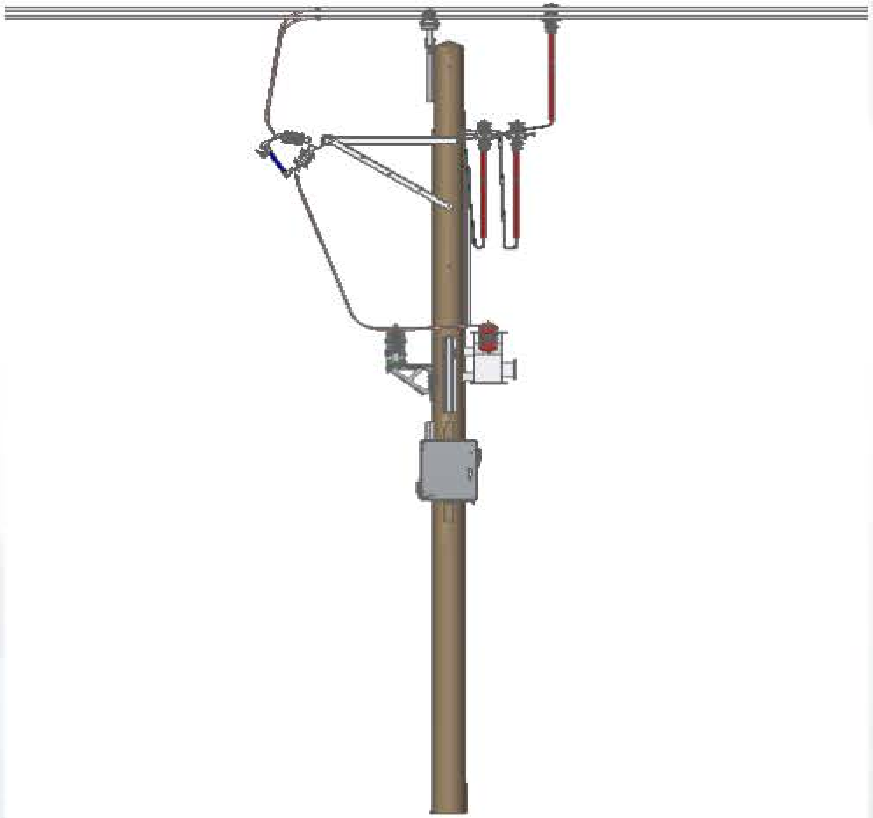
Control box

Voltage sensor crossbar (VSC)



Sentinel system 3D model





Technology

Concept development	Preliminary network modelling	Feasibility testing of algorithms
Measure/analyse voltage and current Send/receive TDR	Explore range of target networks	Network penetration limitations Resolution/penetration trade offs

Technology

Three technologies, four methods being trialled

Mains frequency V&I

Travelling wave

Active TDR, faults and lowered lines

Different techniques have strengths in different situations – system shall collate and present results

Detection of lowered lines

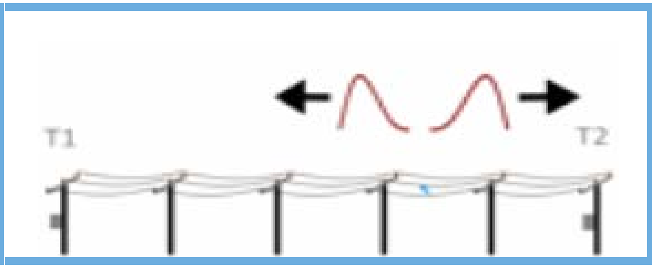
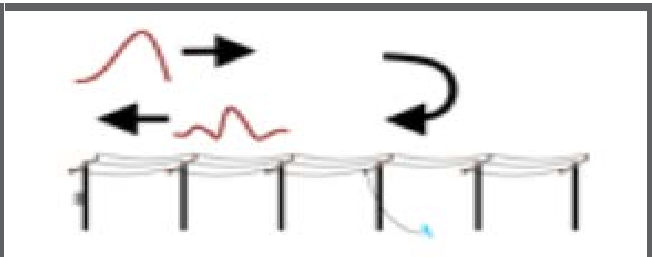
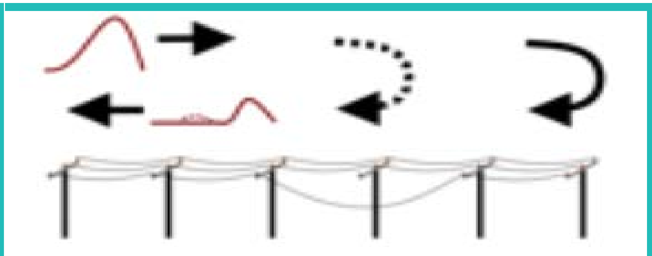
Challenges prove MELF on OHLs

Develop TDR for use on OHL

Development of current sensor or OHLs with MELF

Algorithm development has been supported by simulation and test network investigations

Technology

Multiple ended location of faults (MELF)		**LF** 0-12.8kHz	Accurate voltage and current transducers
Travelling wave Location of faults (TW)		**HF** 50kHz-5MHz	Low accuracy voltage transducer
Time domain Reflectometry Location of faults (TDR)		**HF** 50kHz-5MHz	Low accuracy voltage transducer
Time domain Reflectometry Lowered line Detection (TDR)		**HF** 50kHz-5MHz	Low accuracy voltage transducer

Next steps

- Live trials to commence in August 2018
- Collate live trial data until Nov 2019
- Post fault/ detection closed loop system
- Implement a method of "nudging" to simulate phase to earth faults to test algorithms/ triggers
- System performance
  - Sensors
  - Optimisation of devices
  - Calibration of device against GIS mapping location
- Integration into NMS system

Summary

Challenge

- Response to storms
- Exact fault location

Solution

- Sentinel – fault ‘radar’ system

What’s next?

- Watch out for further updates as project progresses

Benefits

- Customer
- Safety
- Financial

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Our community and local energy strategy

Helen Seagrave
Community energy manager

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Agenda

What is community and local energy?

Stakeholder-led strategy development

Our strategy

Keep in touch

What is community and local energy?

To us community energy means community-led projects or initiatives to reduce, manage, generate or purchase energy. Community energy projects focus on engagement and benefits to their local area and communities.

Local energy encompasses community energy projects and also includes activities by a wider set of local partners such as local authorities, housing associations, intermediary or advisory organisations and local businesses. Local energy projects may have a commercial aspect to their delivery but are also likely to benefit their local area and community.

Community and local energy in our region

MORE Morecambe Bay Community Renewables

Stockport Hydro

Lancaster Cohousing

torrshydro NEW MILLS
Generating clean, green electricity since 2008

CarbonCo-op

COMMUNITY ENERGY CUMBRIA

CAfS Cumbria Action for Sustainability
Towards Zero Carbon Cumbria

GREATER MANCHESTER COMMUNITY RENEWABLES

HALTON LUNE HYDRO
COMMUNITY HYDRO PROJECT

GMCA GREATER MANCHESTER COMBINED AUTHORITY

BAYWIND ENERGY
Co-operative Limited

Oldham Council

OLDHAM COMMUNITY POWER

St John's Sunshine

Whalley Community Hydro
A Community Renewable Energy Scheme

Stakeholder led process

“Build relationships and enhance service to customers”

Eight interviews with community and local energy stakeholders	Two independently facilitated engagement events	Online call for evidence Dec 17 – Feb 18	Further engagement through our stakeholder panels and external events

Where should we take action?

Access to ENWL

Early engagement
More face-to-face time; Dedicated point of contact
Collaboration
Help with understanding where connections could be easier

Finance

Financial support
Help to develop viable business models

Regulation

Regulatory regime doesn't suit community and local energy
Current solutions such as virtual private wires are a "work around" and not a long-term solution

91% of responses agreed or strongly agreed we have understood the main challenges faced by community and local energy groups

Our approach

Electricity North West wants to work closely with community and local energy groups, organisations and developers to support the development of their projects.

We understand that community and local energy projects can be volunteer led and complex and therefore need more time support to engage with Electricity North West services.

We would like to engage early with community and local energy groups to support them with the process of connecting to the network.

We would like to develop our relationships with the communities we support to explore other ways to work together such as on innovation projects and what role they may play in the future.

.

95% of responses to our online consultation strongly agreed or agreed with our approach

Our Community and Local Energy Strategy

Forging links with community and local energy organisations

We will be responsive to customers' needs and deliver a stakeholder engagement plan that enables us to develop those relationships

We will create new mechanisms for community and local energy groups to engage with us

We will search for locations on our network where community and local energy can be deployed for the benefit of the network

Stakeholder engagement plan

Reach

New stakeholders and raise the profile of C&L energy

Inform

About our activities and deliver regular communications

Listen

And provide opportunities for feedback

Engage

In an interactive, collaborate way to develop relationships

Collaborate

To deliver mutual benefit

We will create new mechanisms for engagement

Network – led approach for multiple benefits

Reliability

Avoiding network reinforcement

Resilience

Reducing fuel poverty

Keep up to date

Sign up for our newsletter and view previous editions on our website.

Visit the community and local energy section of our website.

www.enwl.co.uk/communityandlocalenergy

Get in touch

If you have any comments on this strategy or how we should develop our actions please get in touch.

If you are developing a community or local energy project please get in touch to discuss your plans.

Contact details

Helen Seagrave, Community Energy Manager,
Communityandlocalenergy@enwl.co.uk

12

Quiz

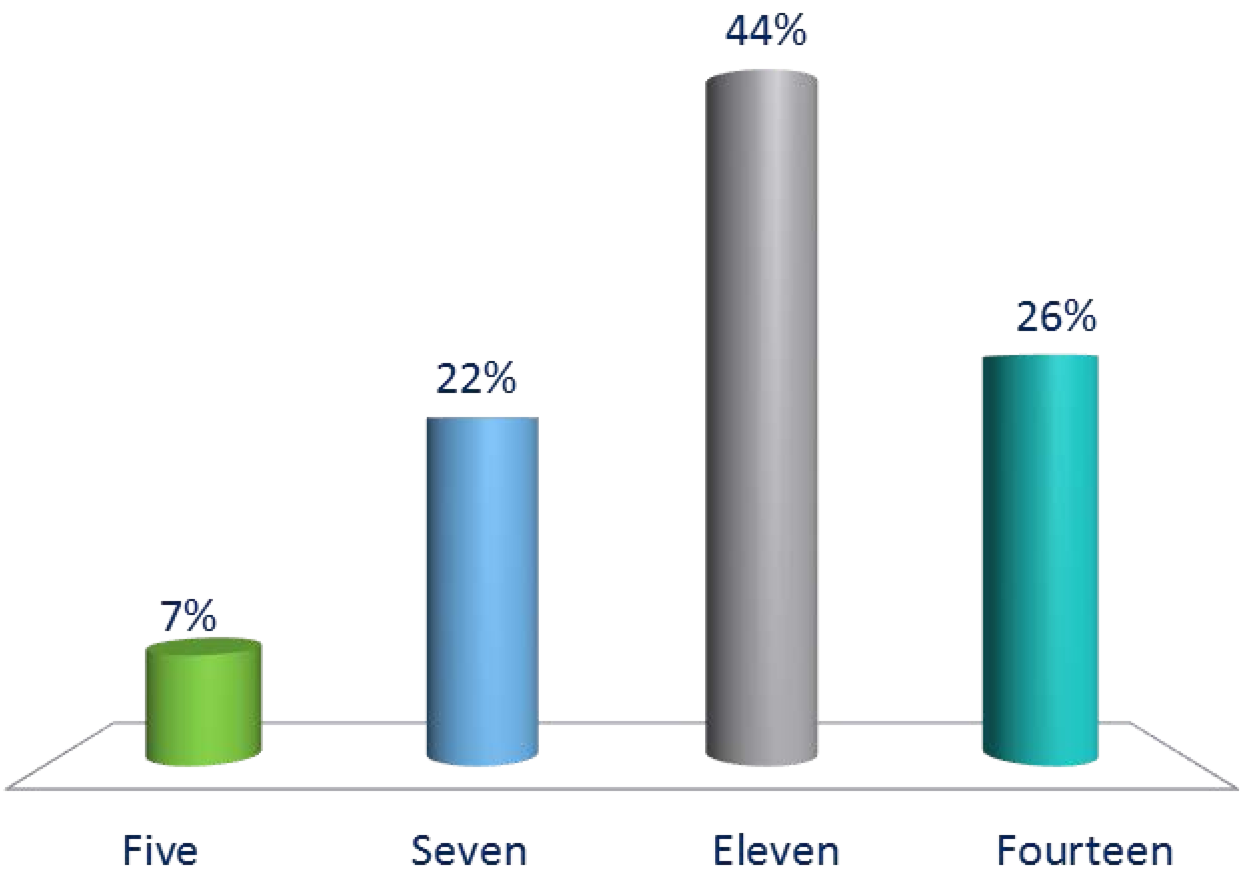
How many successful operations of the Respond techniques have we experienced?

A. Five

B. Seven

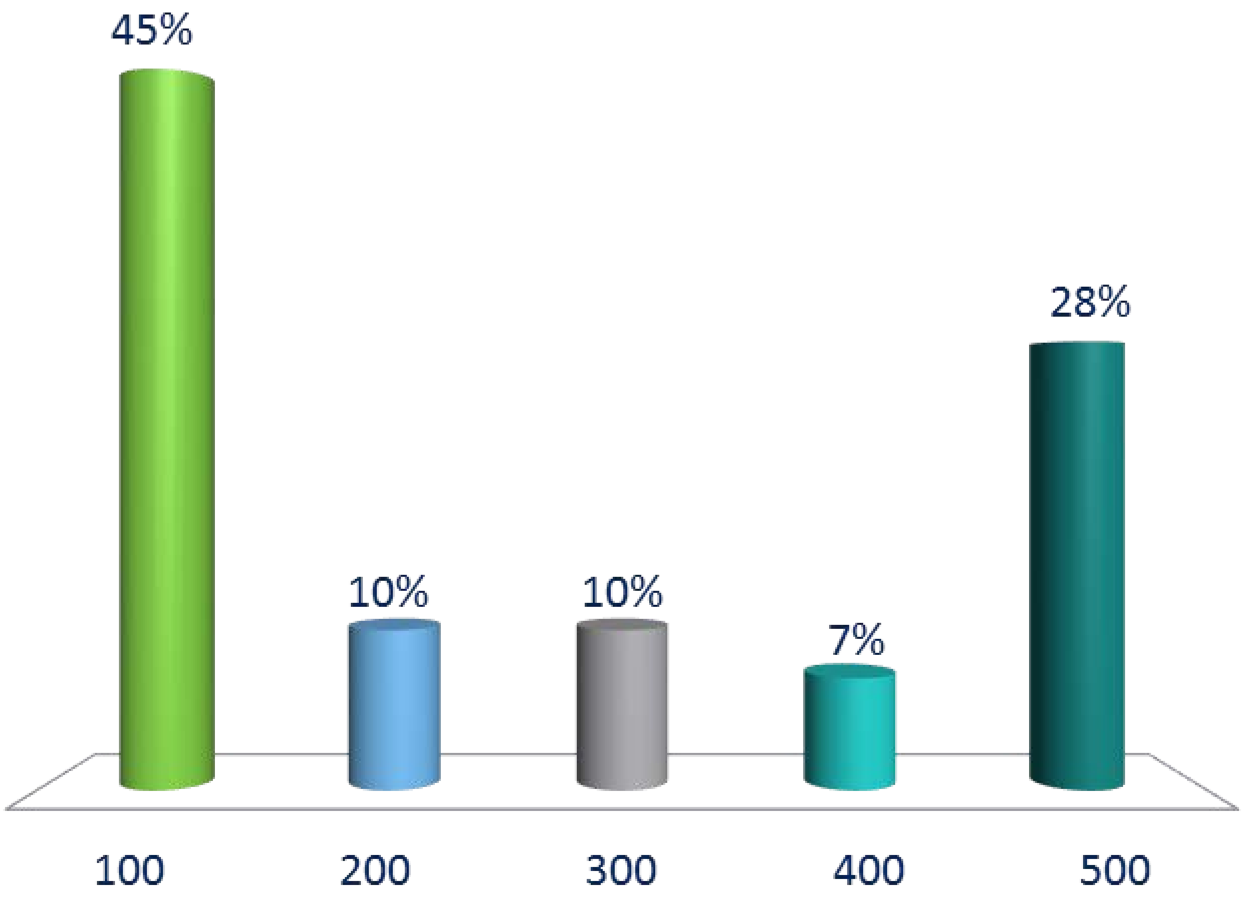
C. Eleven

D. Fourteen



How many Celsius sites are being used to test cooling techniques?

A. 100
B. 200
C. 300
D. 400
E. 500



What's the maximum possible LV electricity system carbon emissions reduction with a full application of Smart Street?

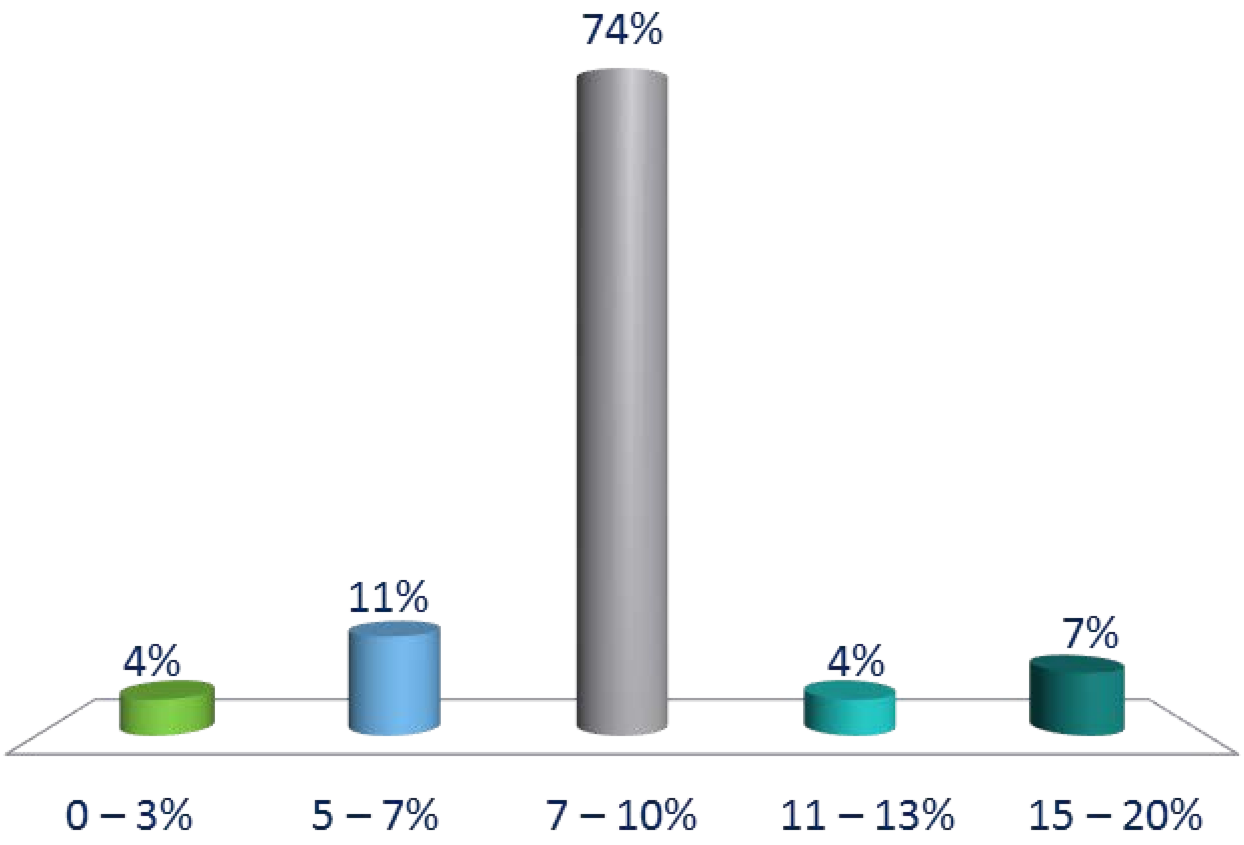
A. 0 – 3%

B. 5 – 7%

C. 7 – 10%

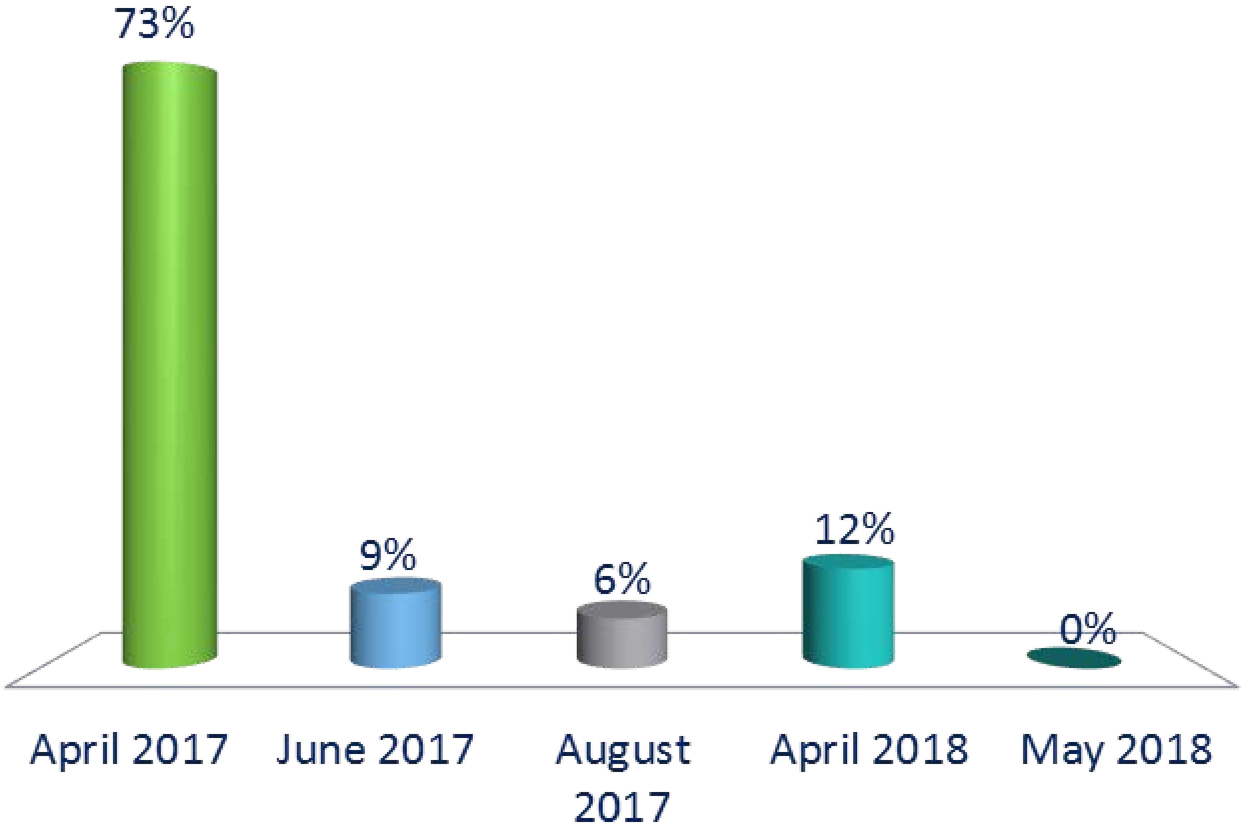
D. 11 – 13%

E. 15 – 20%



When was the first 'non-coal day' for 130 years in GB?

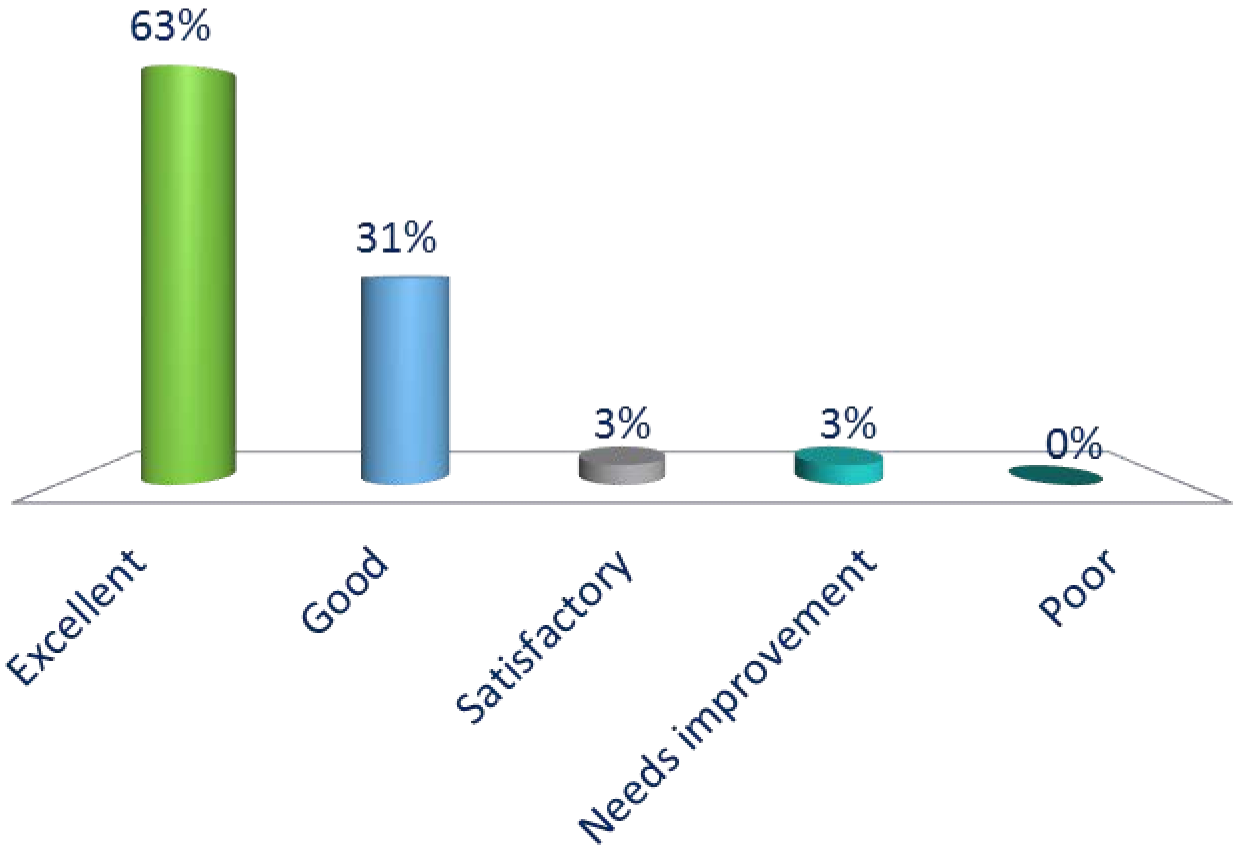
A. April 2017
B. June 2017
C. August 2017
D. April 2018
E. May 2018



Feedback

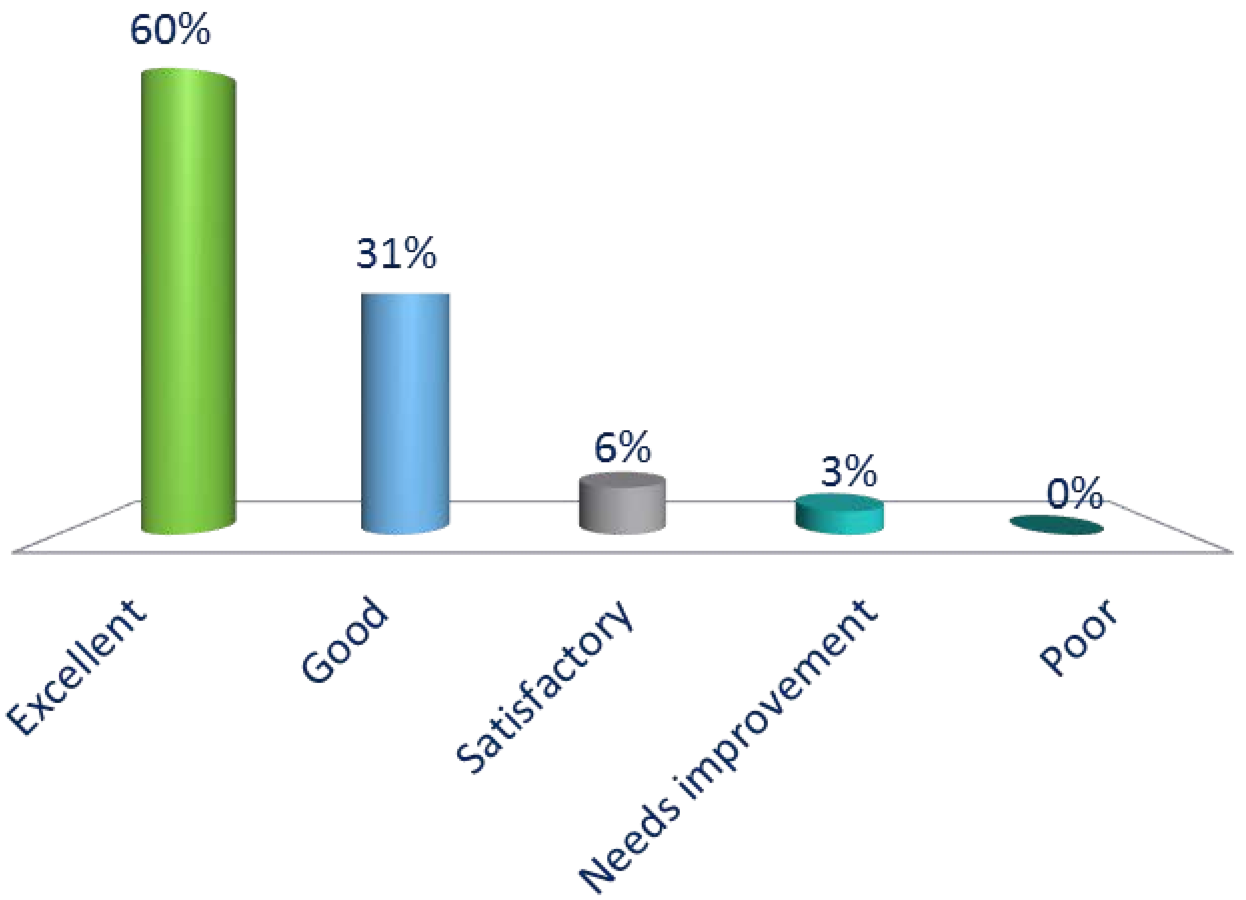
How do you rate the event for content?

A. Excellent
B. Good
C. Satisfactory
D. Needs improvement
E. Poor



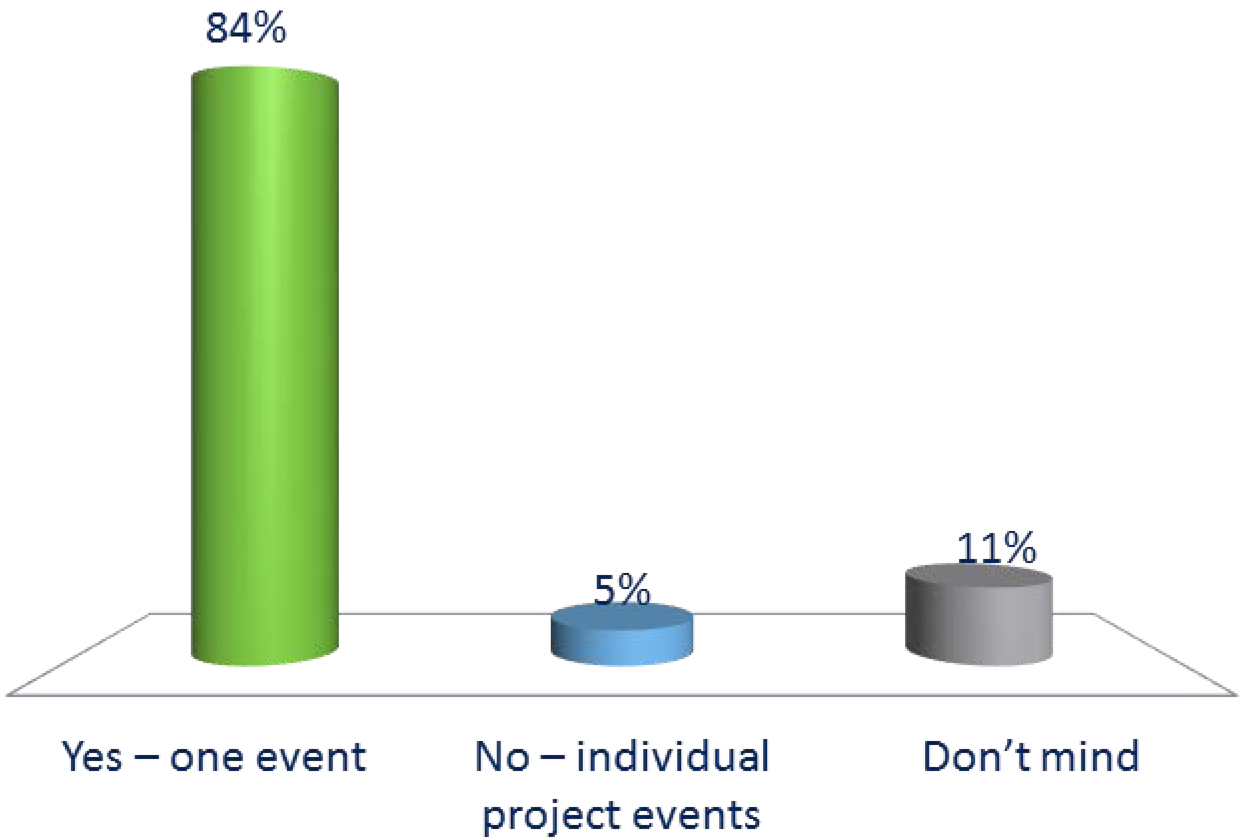
How do you rate the event 's format ie large presentations, breakout sessions and networking opportunities?

A. Excellent
B. Good
C. Satisfactory
D. Needs improvement
E. Poor



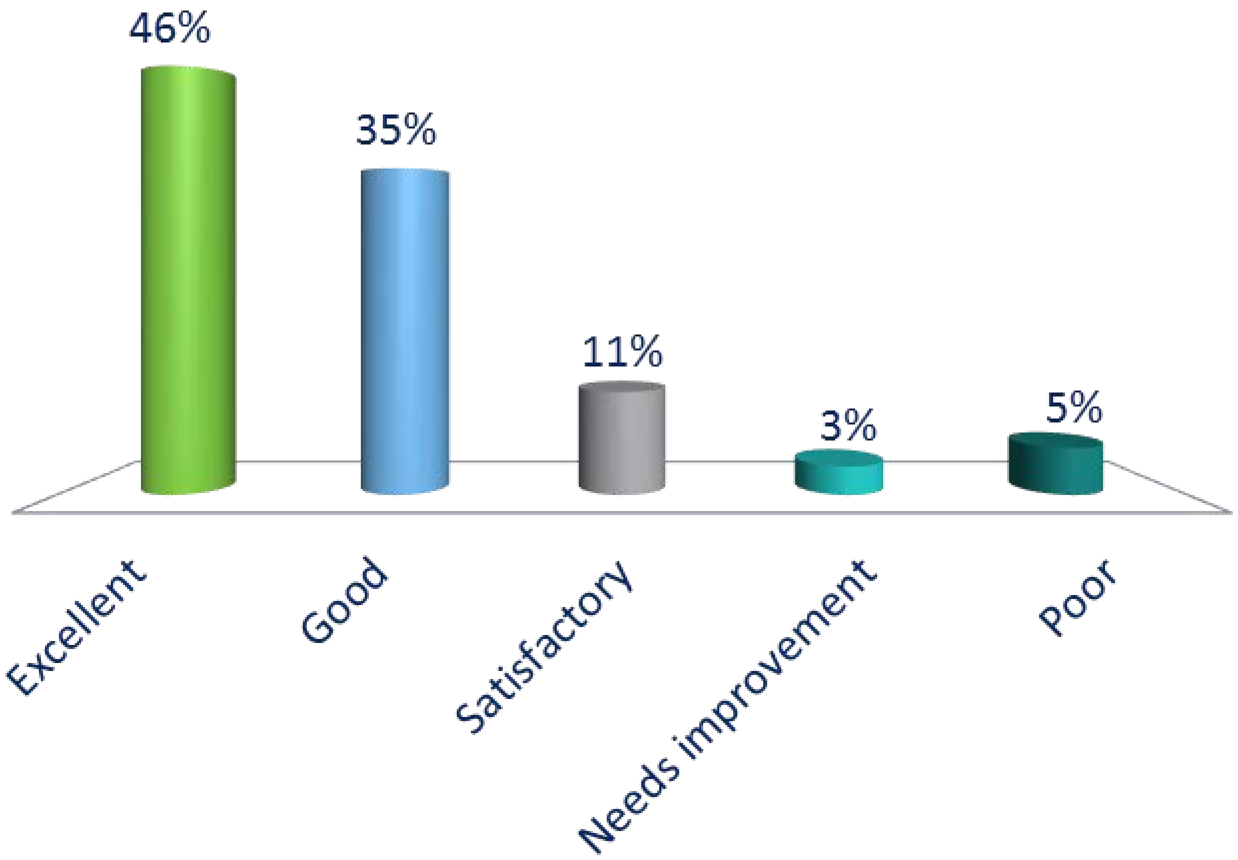
Do you prefer to have one annual learning event rather than several project-focused events?

A. Yes – one event
B. No – individual project events
C. Don't mind



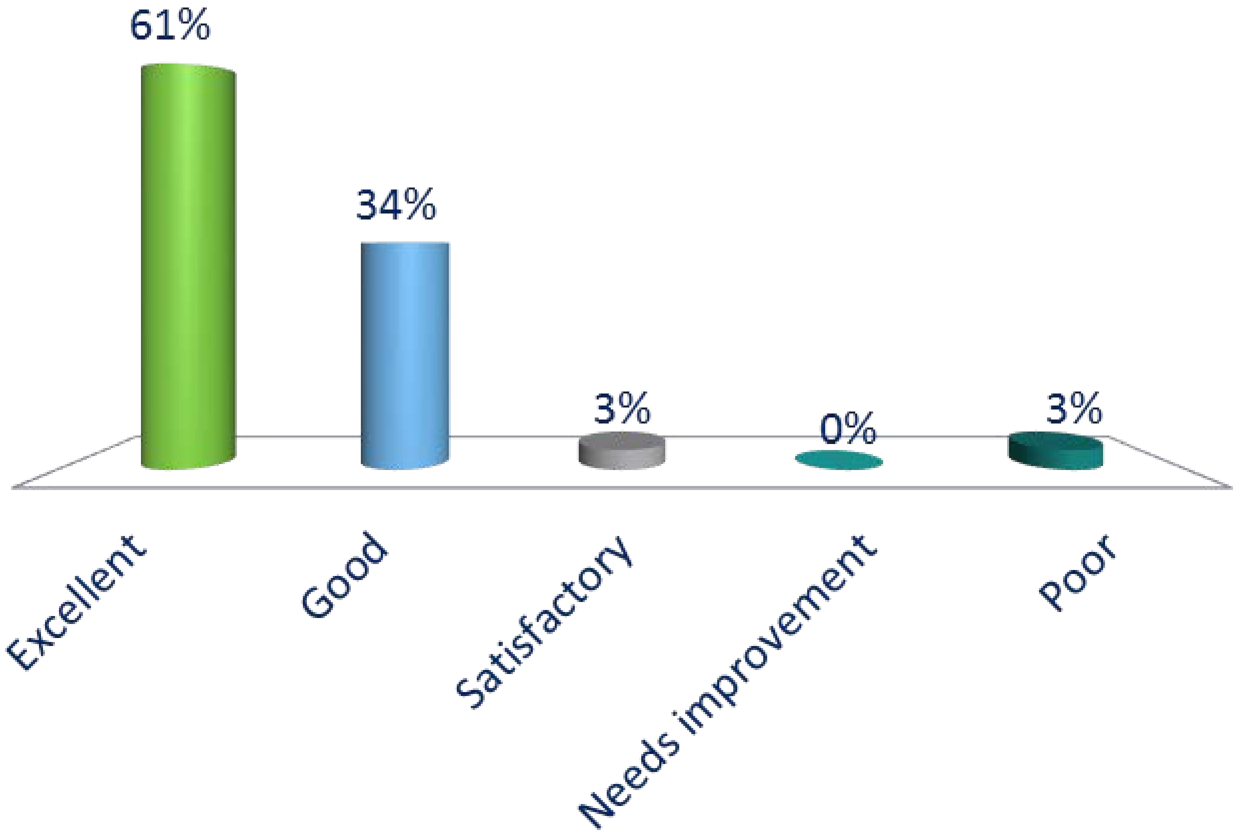
How do you rate the event for questions and networking opportunities?

A. Excellent
B. Good
C. Satisfactory
D. Needs improvement
E. Poor



How do you rate the overall experience of the event?

A. Excellent
B. Good
C. Satisfactory
D. Needs improvement
E. Poor



For more information

	innovation@enwl.co.uk
	www.enwl.co.uk/innovation
	0800 195 4141
	@ElecNW_News
	linkedin.com/company/electricity-north-west
	facebook.com/ElectricityNorthWest
	youtube.com/ElectricityNorthWest

Thank you for your time and attention