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SMART STREET

Closedown Event

Wednesday 28 February 2018

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Introduction

Paul Marshall
Innovation Project Manager

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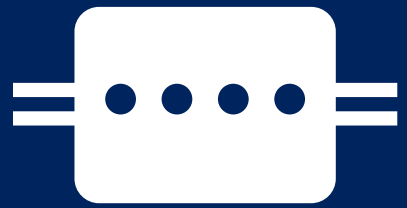
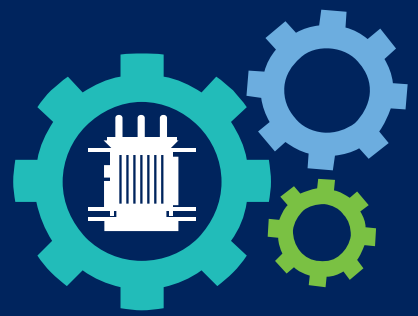
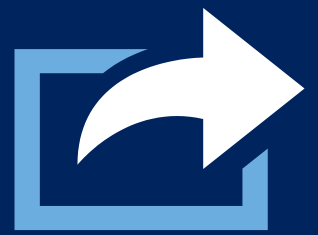
Housekeeping

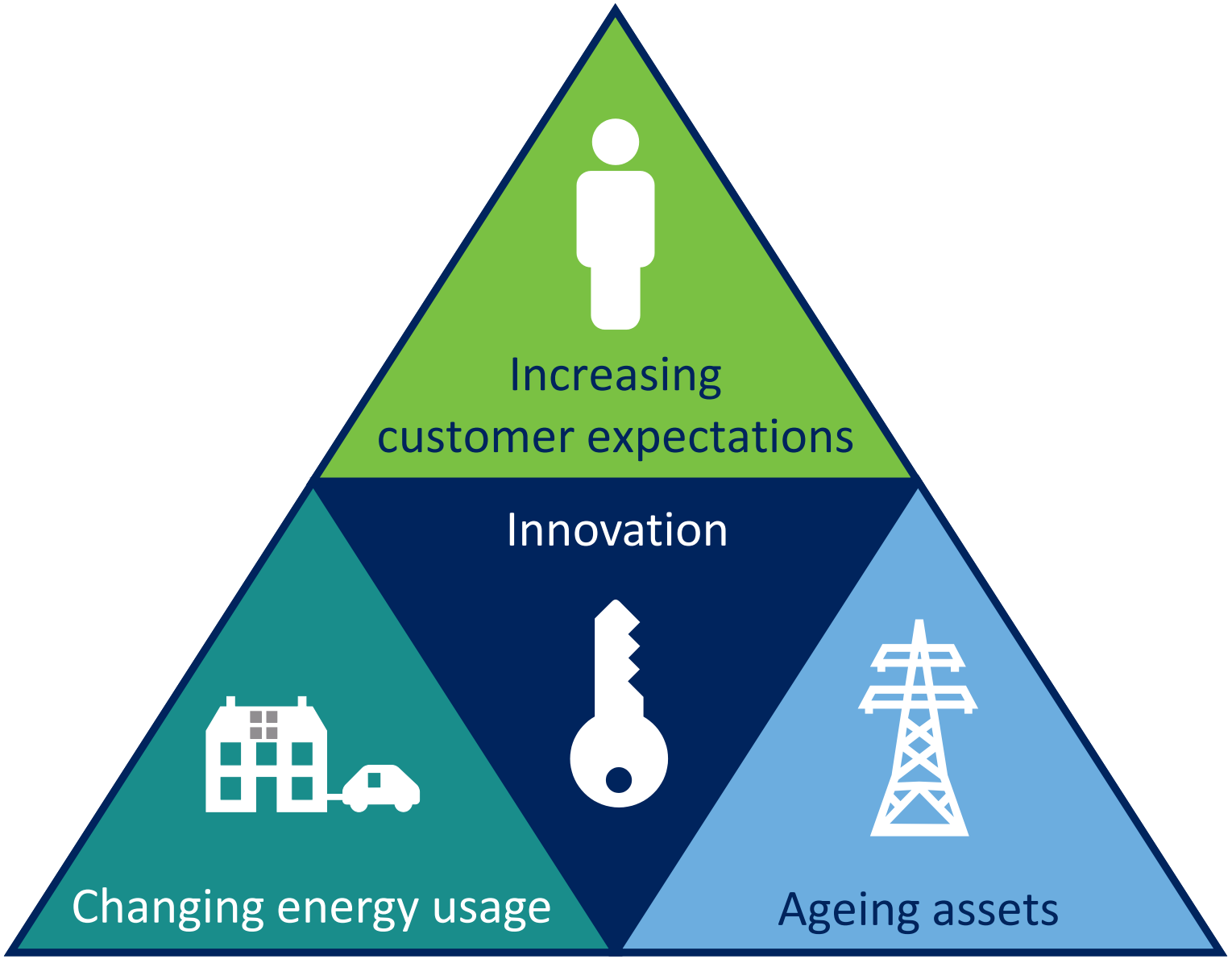
Mobile phones	Breaks	Fire alarms	Main Q&A at end of day

Agenda

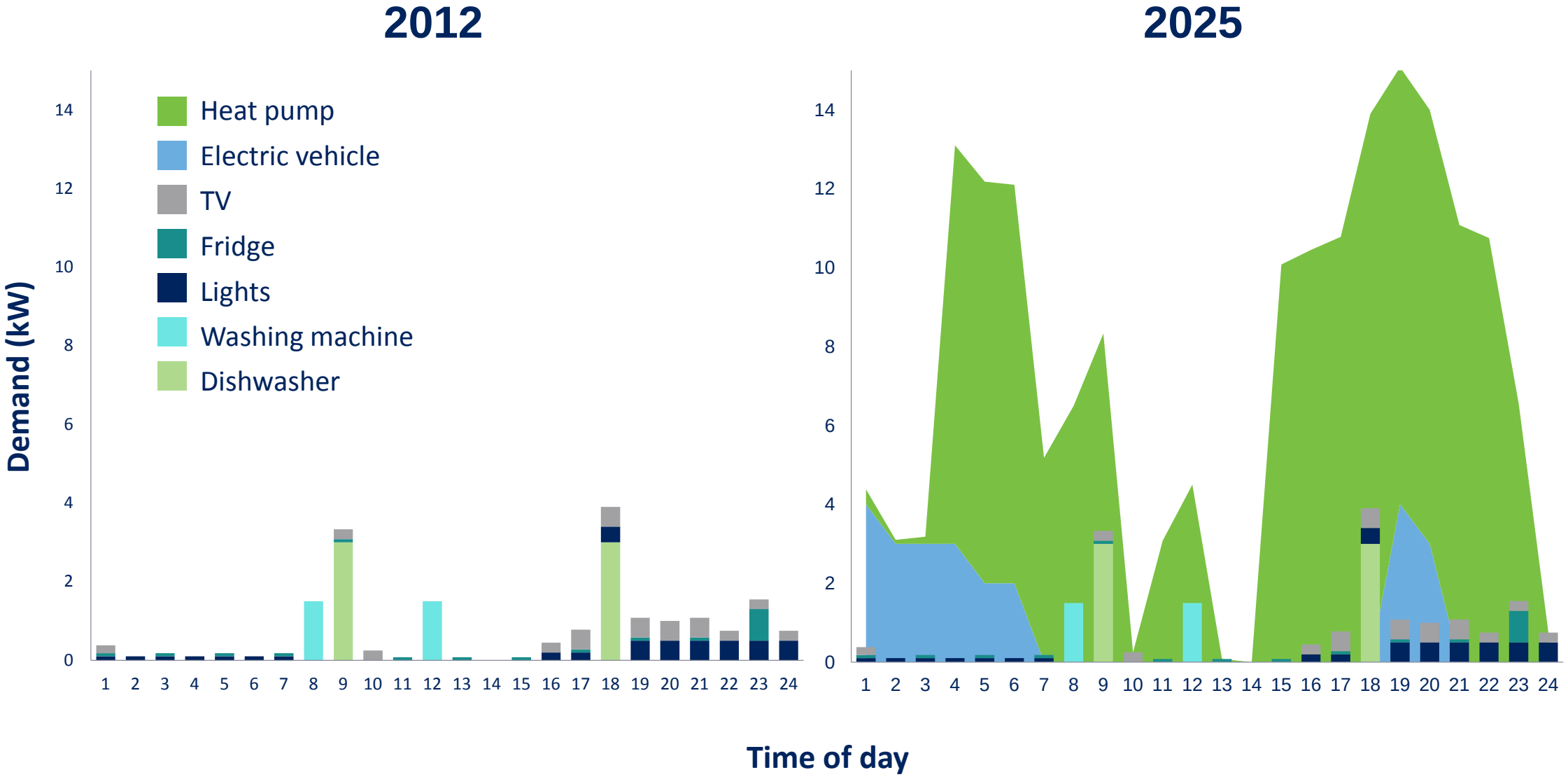
SMART STREET			
Introduction 10.00 – 10:15am	Project overview 10.15 – 10.45am	Technology 10.45 – 11.15am	Break 11.15am – 11.45am
			
Trials 11.45am – 12.15pm	Customer engagement 12.15pm – 12.45pm	Summary & next steps 12.45 – 12.50pm	Q&A 12.50 – 1.00pm

Lunch & close

Our challenges

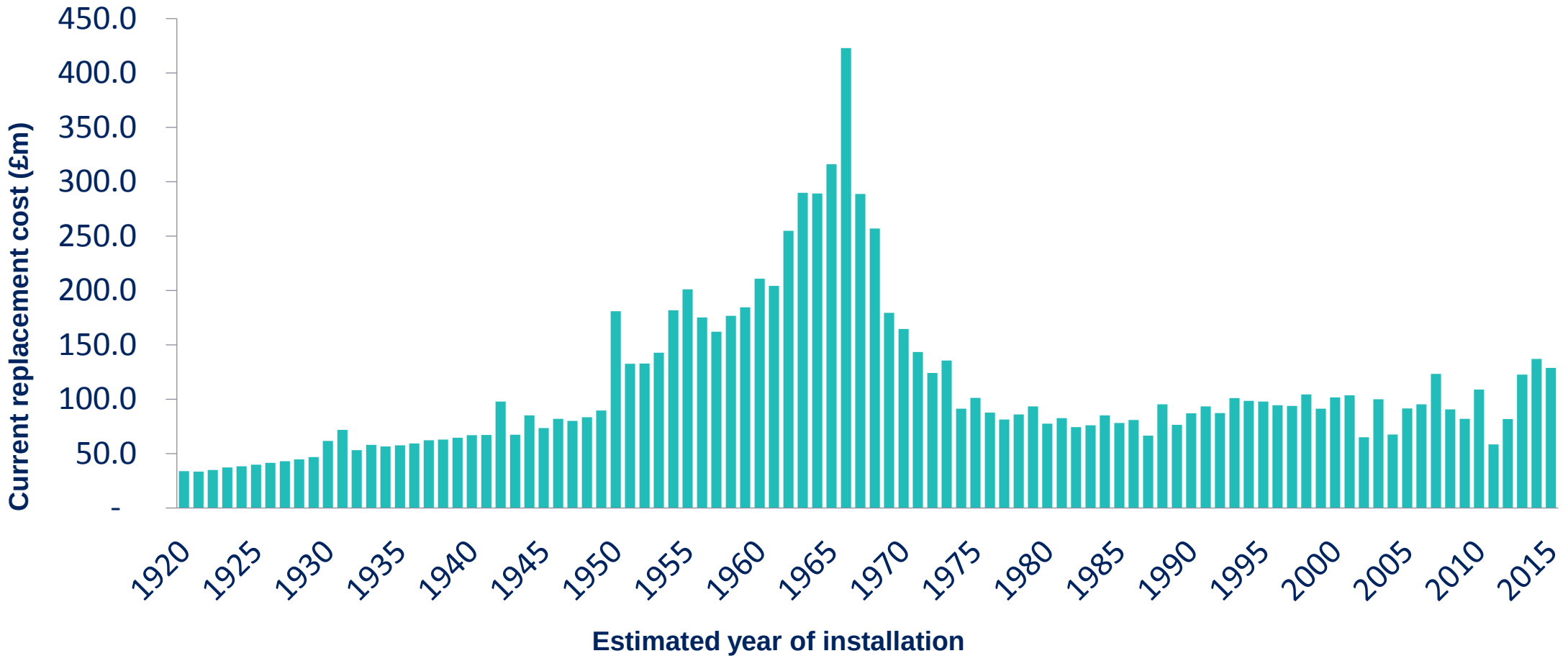


Demand changes



Ageing assets

Age profile of assets



Opportunities

New technology

Automation

Weezap

Smart meters

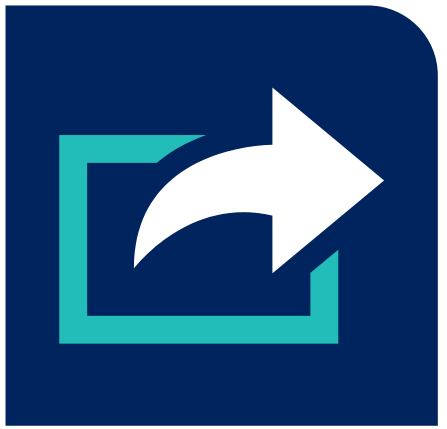
Access to more data

New markets

Demand side response

More open regulation

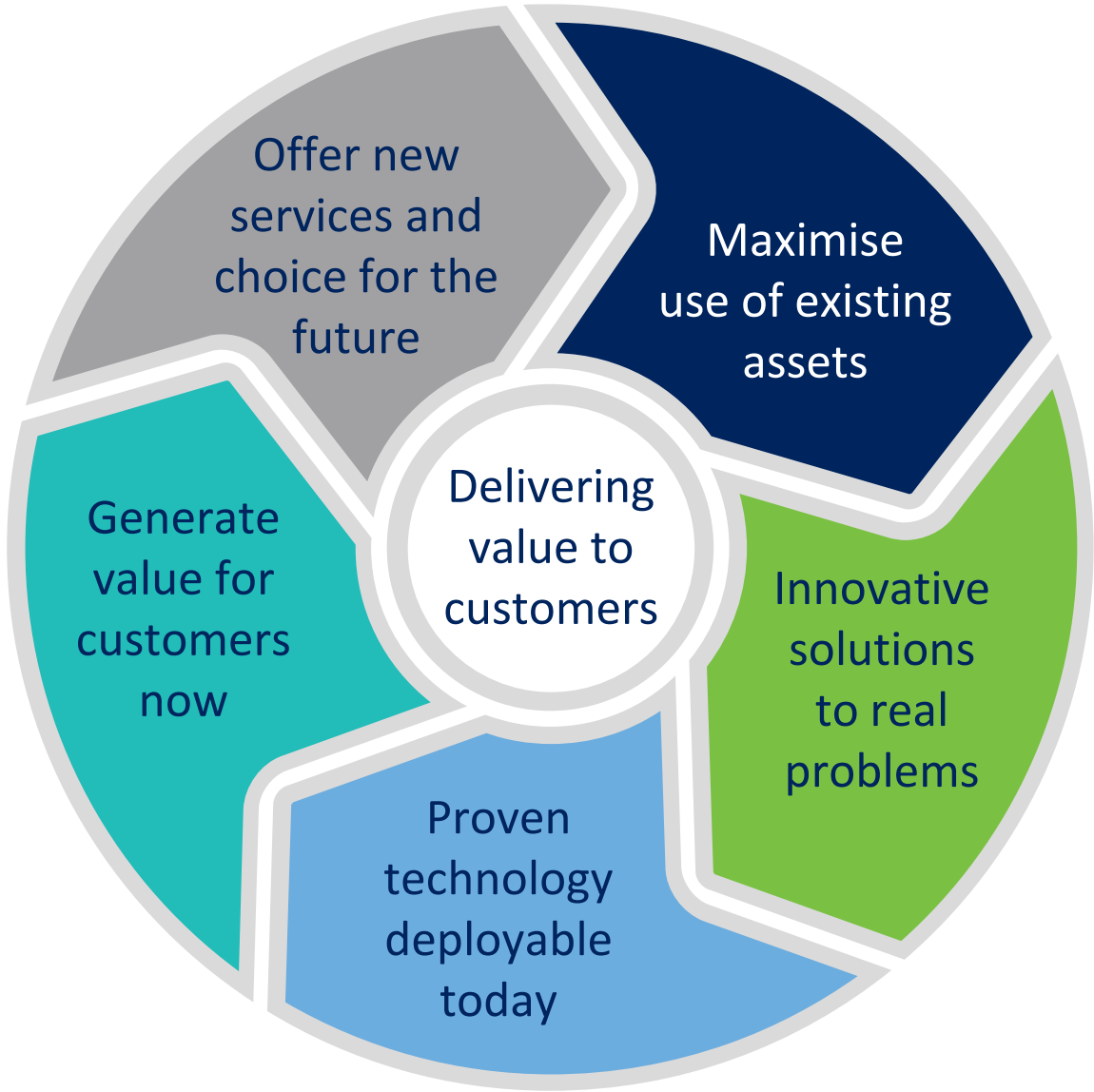
Incentives



Storage

Provision of response services

Our strategy



Innovation 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

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Project Overview

Ben Ingham

Innovation Engineer

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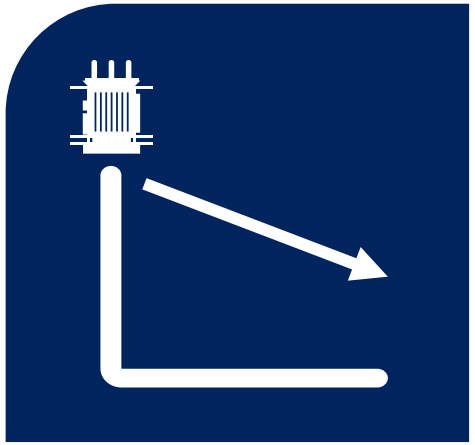
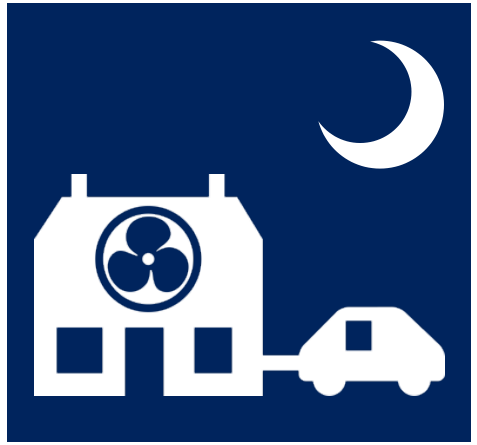
Background

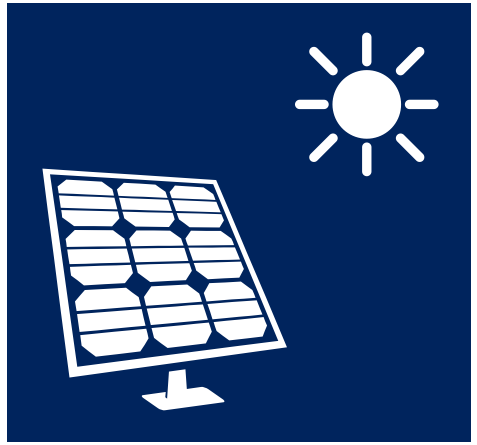


Historic networks have no active voltage regulation

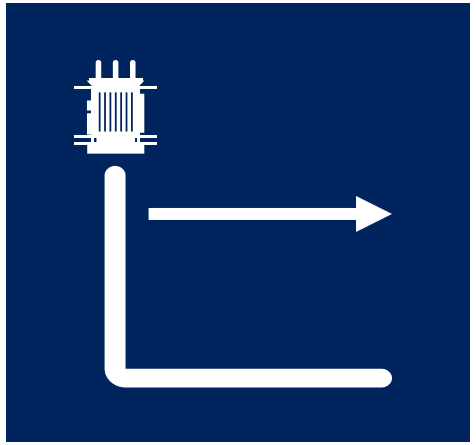


LCTs create network issues

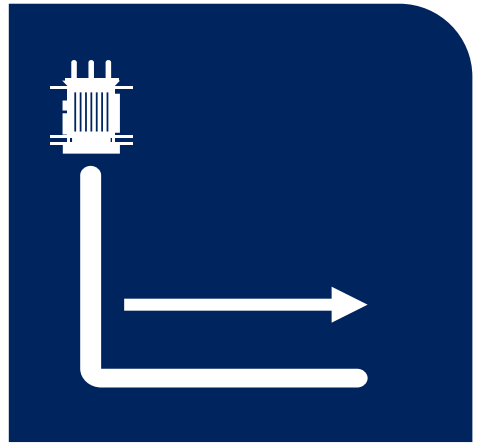
Customer demand could cause voltage to dip below statutory limits



Customer generation could cause voltage to exceed statutory voltage limits



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



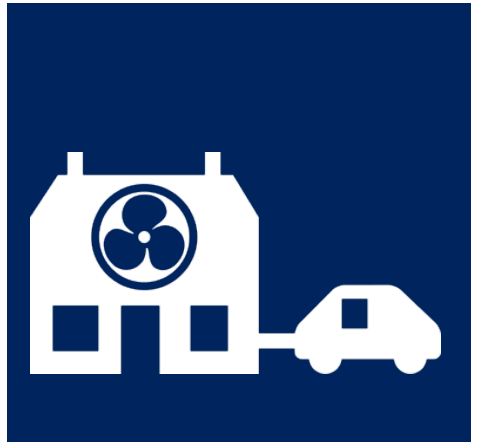
Conservation voltage reduction

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 finishes 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

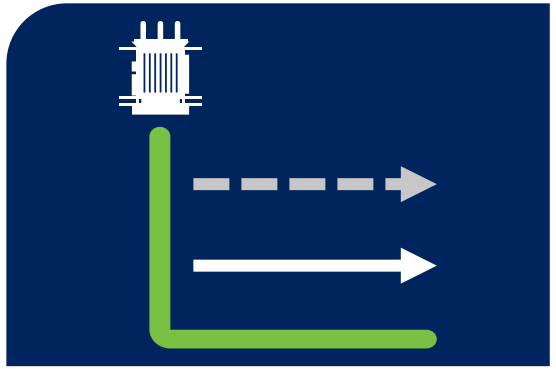
Project review

Four-month extension granted to project due to equipment safety modifications

Will still be delivered within budget

All Successful Delivery Reward Criteria met

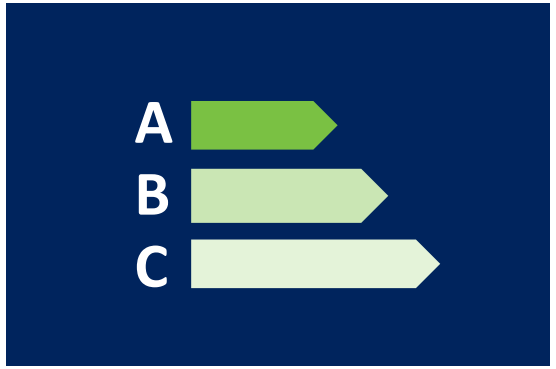
Outcomes



Monitored and actively optimised

LV network

First in the UK



Proven that techniques save energy

Potential deferment of reinforcement

Associated carbon equivalent savings

Project partners

KELVATEK

SIEMENS

TyndallManchester
Climate Change Research

tnei
enterprise with energy

MANCHESTER 1824
The University of Manchester

Impact Research

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Technology

Damien Coyle
Innovation Technical Engineer

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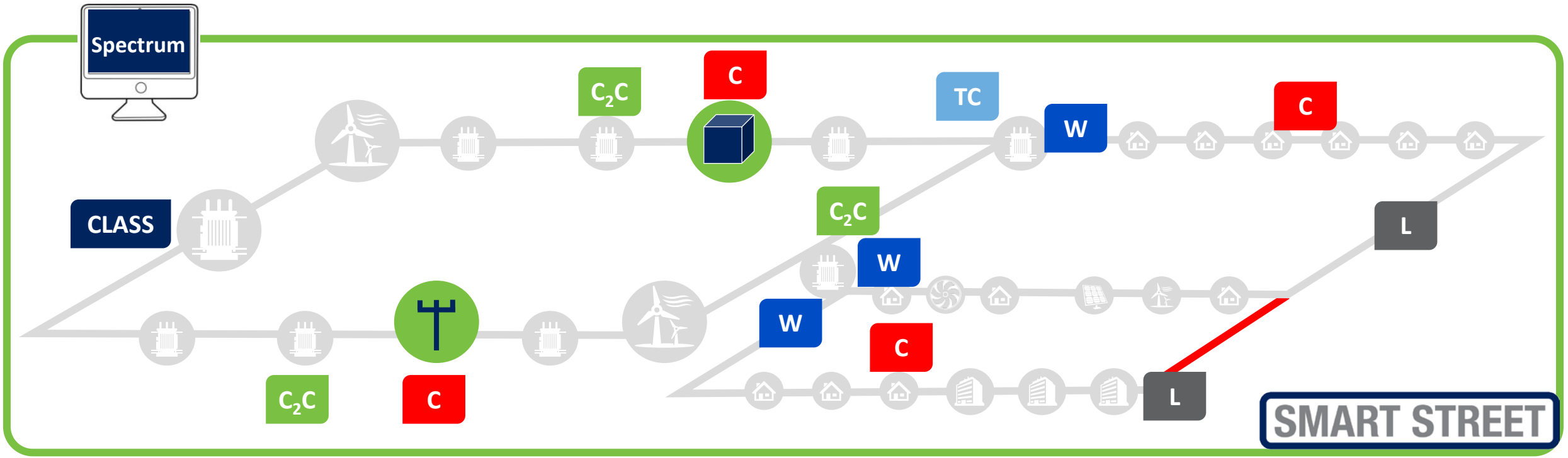
Network overview



C2C Capacity to Customers

C Capacitor

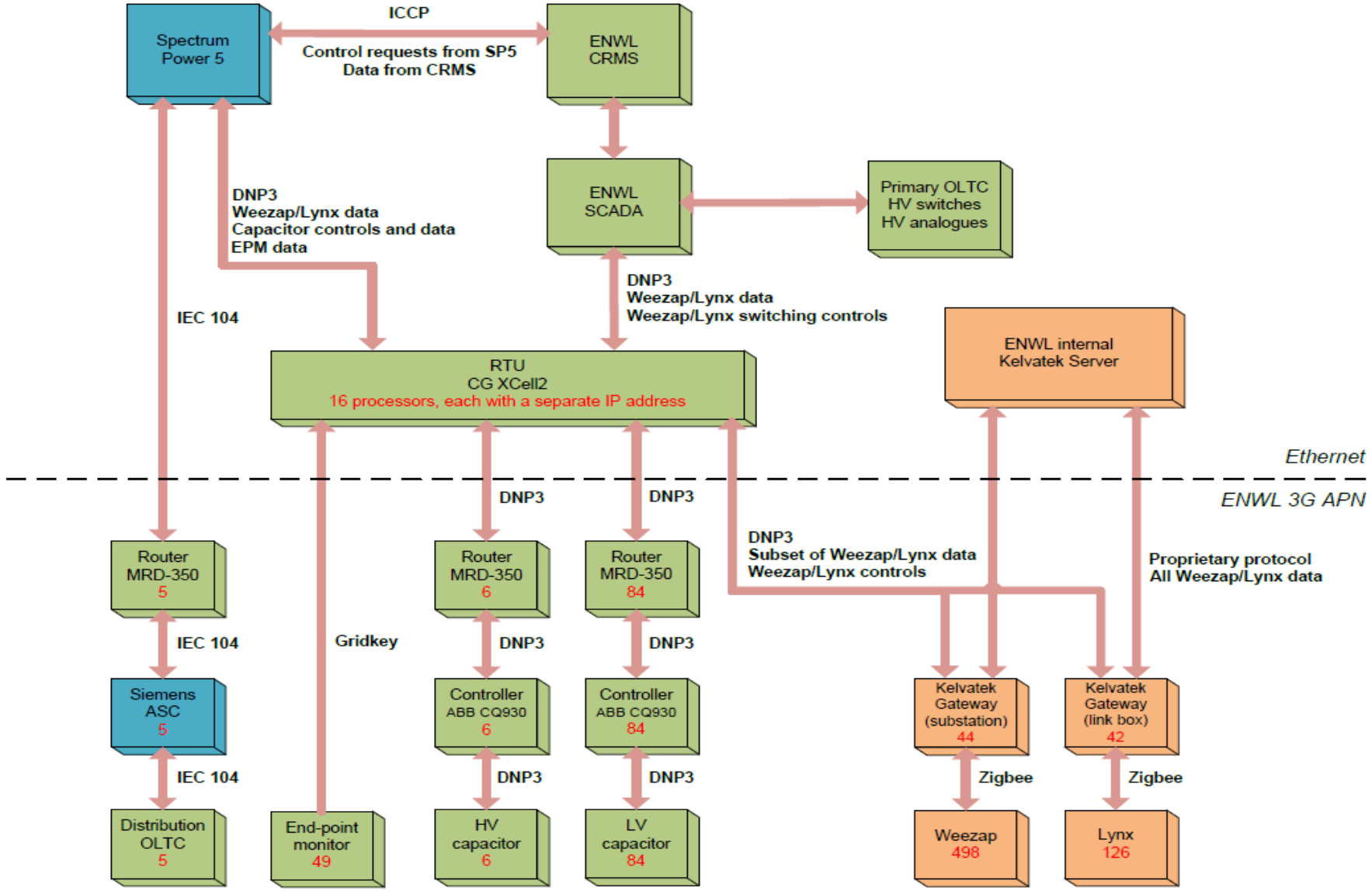
W WEEZAP

L LYNX

TC On-load tap changer

Builds on C2C and CLASS ● Storage compatible ● Transferable solutions

System architecture



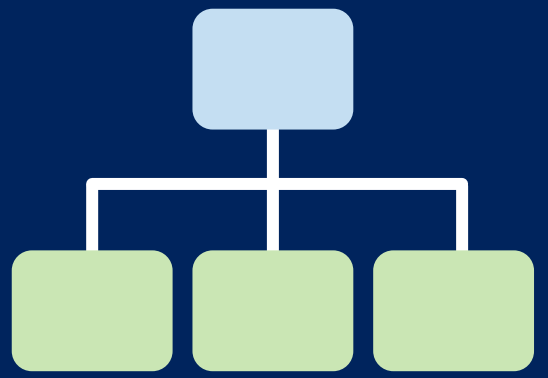
Spectrum Power 5

Siemens network management system

Optimisation module – DSSE/ VVC

Linked to CRMS via ICCP link

Learning points – system



System architecture

Integration with existing SCADA system

Use of single line diagram

Smart Street technology overview

Spectrum 5 (NMS)

Lynx and Weezap

LV retrofit vacuum devices

Telemetered back to central monitoring point

Water Ingress issues with Lynx

Comms issues

Capacitors

Used for voltage control only

Issues with enclosure design

System loadings not currently suitable for deployment

On load tap changers (OLTCs)

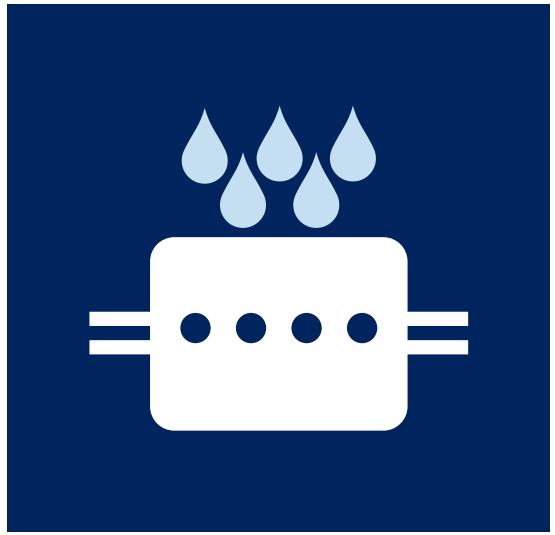
Nine tap positions with 2% per step

Reset to nominal on comms blips

Operated reliably throughout

Learning points – general

Communications



Water ingress

Cabinet design and location

Enclosure size

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QUESTIONS & ANSWERS

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Break

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Trials

Dr Geraldine Paterson
Innovation Strategy & Transition Engineer

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Smart Street site selection

Stage 1		Stage 2		Stage 3	
Initial circuit screening		Circuit classification		Circuit simulation and refined circuit selection	
Use of existing CLASS and C_2C assets	Avoided areas scheduled for asset replacement works	Circuit types & customer types Low carbon technology uptake	Physical & electrical constraints LV inter-connection	HV network modelling in IPSA / DINIS	Identification of any thermal, voltage or fault level issues

Smart Street site selection

Stage 4				Stage 5	
Network design methodology				Final site selection	
Detailed combined HV & LV network modelling	Applied a range of meshing scenarios	Varied capacitor sizes and locations Altered transformer tap settings	Modified the demand profile Developed rules based methodology based on results	Final circuits selected	Rules based design methodology applied

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

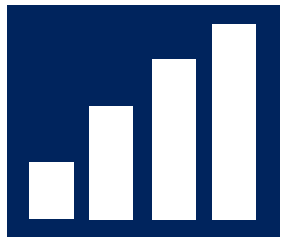
Five substation capacitors
79 LV circuit capacitors

Trials overview

Smart Street trial	Test regime
LV voltage control	1. On-load tap changing distribution transformer only
	2. On-load tap changing distribution transformer and capacitor(s) on LV circuits
	3. Capacitors at distribution substation only
	4. Capacitors at distribution substation and on LV circuits
	5. Capacitor(s) on LV circuits only
LV network management & interconnection	1. LV radial circuits
	2. LV interconnected circuits
HV voltage control	1. Voltage controllers at primary substation only
	2. Voltage controllers at primary substation and capacitor(s) on HV circuits
HV network management & interconnection	1. HV radial circuits
	2. HV interconnected circuits
Network configuration & voltage optimisation	1. Losses reduction
	2. Energy consumption reduction

Initial trial design

Two years
Two weeks on
Two weeks off



One year's worth of Smart Street data

To be designed to avoid placebo affect

Five trial regimes to test full effects

Five trial techniques
LV voltage control
LV network management and interconnection
HV voltage control
HV network management and interconnection
Network configuration and voltage optimisation

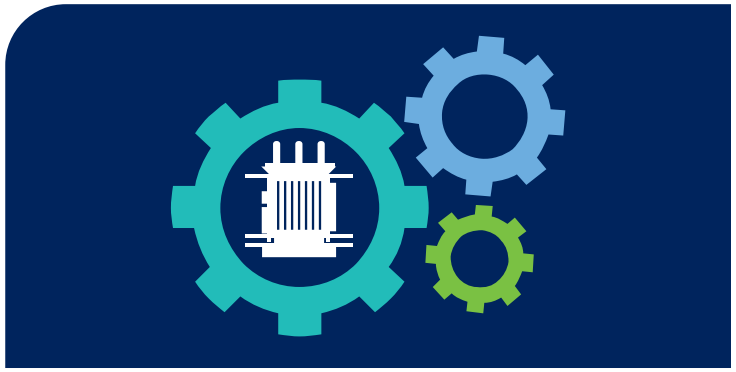
Aims of trials

Quantification of benefits

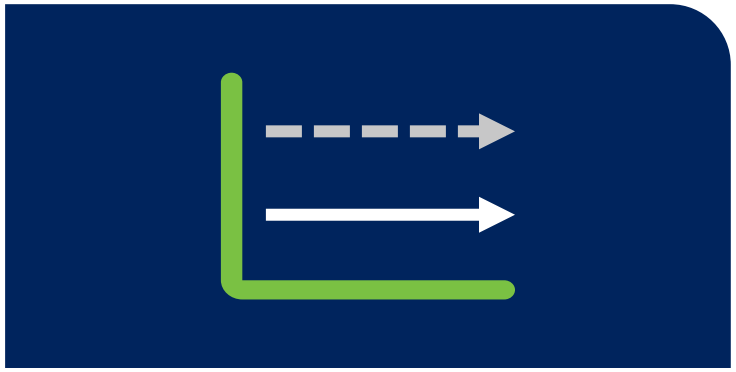
Validation of optimisation techniques

Identify potential power quality and customer side impacts

Issues with initial trials



Due to installation problems all devices enabled when optimisation on



Modified trial regime showed CVR working

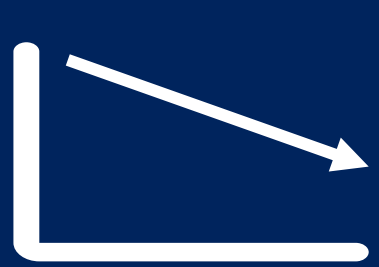
Software issues led to a change in parameters

Further amendments to trial to get best out of learning

Trial design

Week	Trial Areas										
	Denton East		Egremont		Green Street		Hindley Green		Longsight		Wigton
	NLTC	OLTC	NLTC	OLTC	NLTC	OLTC	NLTC	OLTC	NLTC	OLTC	
30	All devices	All devices	All devices	All devices	All devices	All devices	All devices	All devices	All devices	All devices	
31	Caps HV Meshing	OLTC HV Meshing	Caps HV Meshing	OLTC HV Meshing	Caps+Lynx	OLTC	Caps	OLTC	Caps+Lynx HV Meshing	OLTC+Caps+Lynx HV Meshing	
32	Caps+Lynx HV Meshing	OLTC+Caps HV Meshing	Caps HV Meshing	OLTC+Caps HV Meshing	Caps+Lynx	OLTC+Caps+Lynx	Caps	OLTC	Caps+Lynx HV Meshing	OLTC+Caps+Lynx HV Meshing	
33	Caps HV Meshing	OLTC HV Meshing	Caps HV Meshing	OLTC HV Meshing	Caps+Lynx	OLTC	Caps	OLTC	Caps+Lynx HV Meshing	OLTC+Caps+Lynx HV Meshing	
34	Caps+Lynx HV Meshing	OLTC+Caps HV Meshing	Caps HV Meshing	OLTC+Caps HV Meshing	Caps+Lynx	OLTC+Caps+Lynx	Caps	OLTC	Caps+Lynx HV Meshing	OLTC+Caps+Lynx HV Meshing	
35		OLTC		OLTC		OLTC		OLTC		OLTC	No CVR
36	Caps+Lynx HV Meshing	OLTC+Caps HV Meshing	Caps HV Meshing	OLTC+Caps HV Meshing	Caps+Lynx	OLTC+Caps+Lynx	Caps	OLTC	Caps+Lynx HV Meshing	OLTC+Caps+Lynx HV Meshing	
37	Caps HV Meshing	OLTC HV Meshing	Caps HV Meshing	OLTC HV Meshing	Caps+Lynx	OLTC	Caps	OLTC	Caps+Lynx HV Meshing	OLTC+Caps+Lynx HV Meshing	
38	Caps+Lynx HV Meshing	OLTC+Caps HV Meshing	Caps HV Meshing	OLTC+Caps HV Meshing	Caps+Lynx	OLTC+Caps+Lynx	Caps	OLTC	Caps+Lynx HV Meshing	OLTC+Caps+Lynx HV Meshing	
39	Caps HV Meshing	OLTC HV Meshing	Caps HV Meshing	OLTC HV Meshing	Caps+Lynx	OLTC	Caps	OLTC	Caps+Lynx HV Meshing	OLTC+Caps+Lynx HV Meshing	
40	Caps+Lynx HV Meshing	OLTC+Caps HV Meshing	Caps HV Meshing	OLTC+Caps HV Meshing	Caps+Lynx	OLTC+Caps+Lynx	Caps	OLTC	Caps+Lynx HV Meshing	OLTC+Caps+Lynx HV Meshing	

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

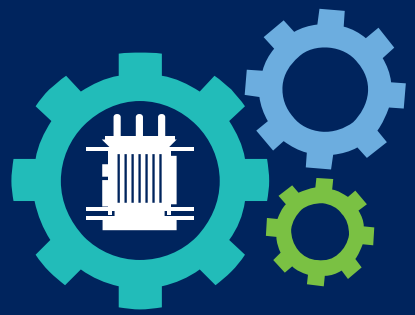
Models and scenarios

Universities created models of network – used measured data to validate

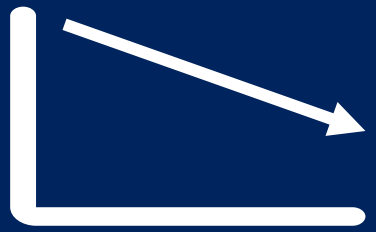
Modelled 54 scenarios

Three networks	Three optimisation modes	Two day types	Three years
Dense urban	Mode 1 – OLTCs	Winter weekday	2017
Urban	Mode 2 – OLTCs and capacitors	Summer weekday	2035
Rural	Mode 3 – OLTCs, capacitors and meshing		2050

High level conclusions

Network benefits	Benefits from reduced losses and deferred reinforcement if ...	Customer benefits
		
Alleviate network issues Facilitate energy savings Reduce network losses	Smart Street investment costs low Demand growth and LCT uptake uncertain	Economic benefits per customer independent on network type

High level conclusions

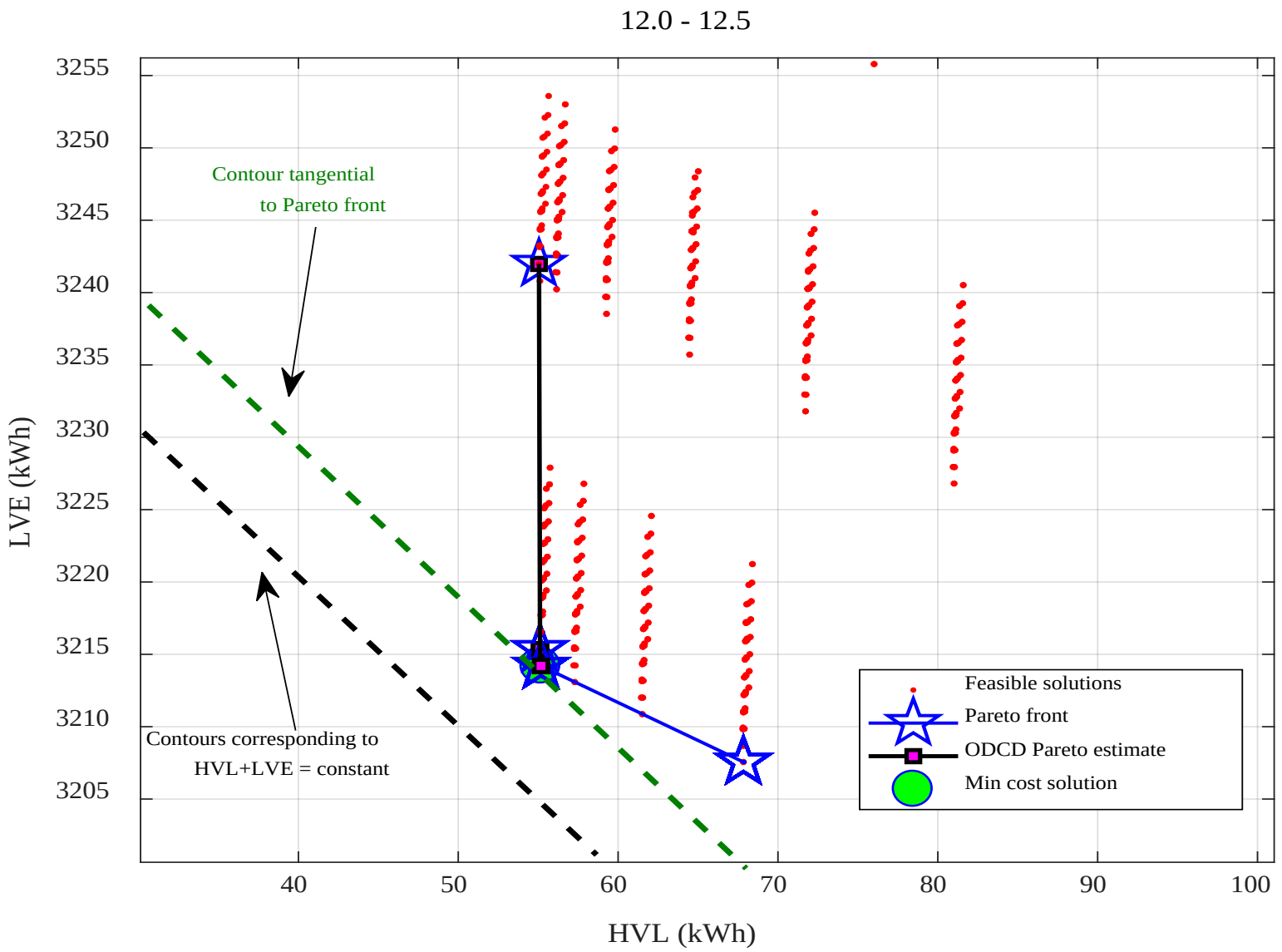
Optimisation benefits (energy)	Optimisation benefits (losses)	Trade off between loss and energy consumption reduction	Carbon benefits
			
6-8% voltage reduction 5.5 – 8.5% energy reduction All networks similar energy reduction	Up to 15% loss reduction Rural network has highest loss reduction	Does exist 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

Consumption and loss reduction

		Energy Consumption Reduction (%)							Losses Reduction (%)			
		Unoptimised NLTC				Optimised NLTC						
		2017	2035	2050		2017	2035	2050		2017	2035	2050
Dense Urban	Summer	2.9	3.4	3.7	Summer	6.4	6.9	7.2	Summer	8.1	10.3	7.0
	Winter	2.3	2.1	1.8	Winter	6.5	7.0	7.1	Winter	8.7	11.0	3.7
Urban	Summer	2.0	2.3	2.7	Summer	7.2	7.8	7.1	Summer	8.7	10.4	2.3
	Winter	1.3	1.1	1.0	Winter	7.8	8.5	8.1	Winter	9.8	12.2	7.1
Rural	Summer	2.3	2.4	2.9	Summer	6.4	7.0	7.0	Summer	10.8	11.6	5.0
	Winter	1.4	1.2	1.0	Winter	6.7	7.3	7.2	Winter	13.0	15.0	11.5

From analysis of the actual trial results 6 - 8% energy consumption reduction was observed

Losses vs energy savings



Meshing

Reduces voltage issues

Improves asset utilisation

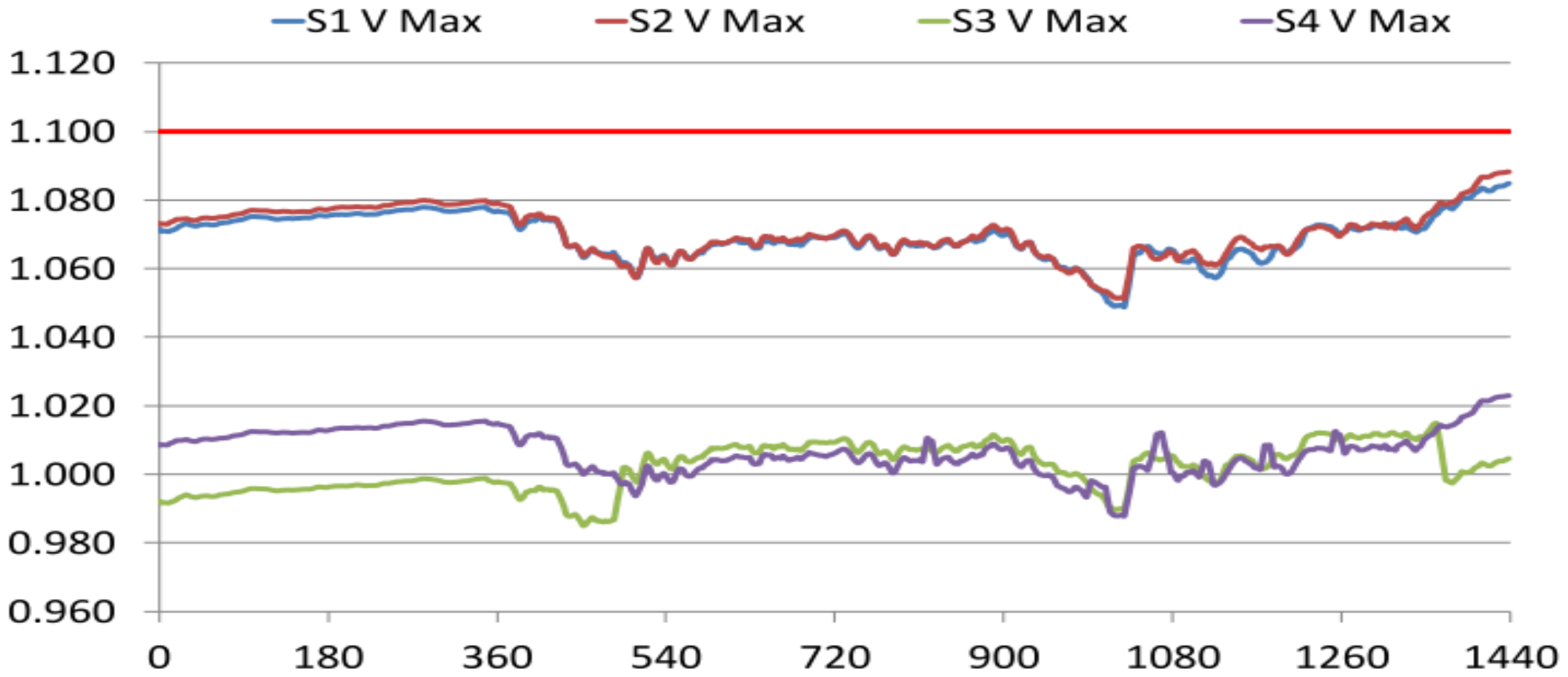
Reduces losses

Increases fault levels

No benefit to permanent connection – only mesh at beneficial times

Voltage impacts – LV

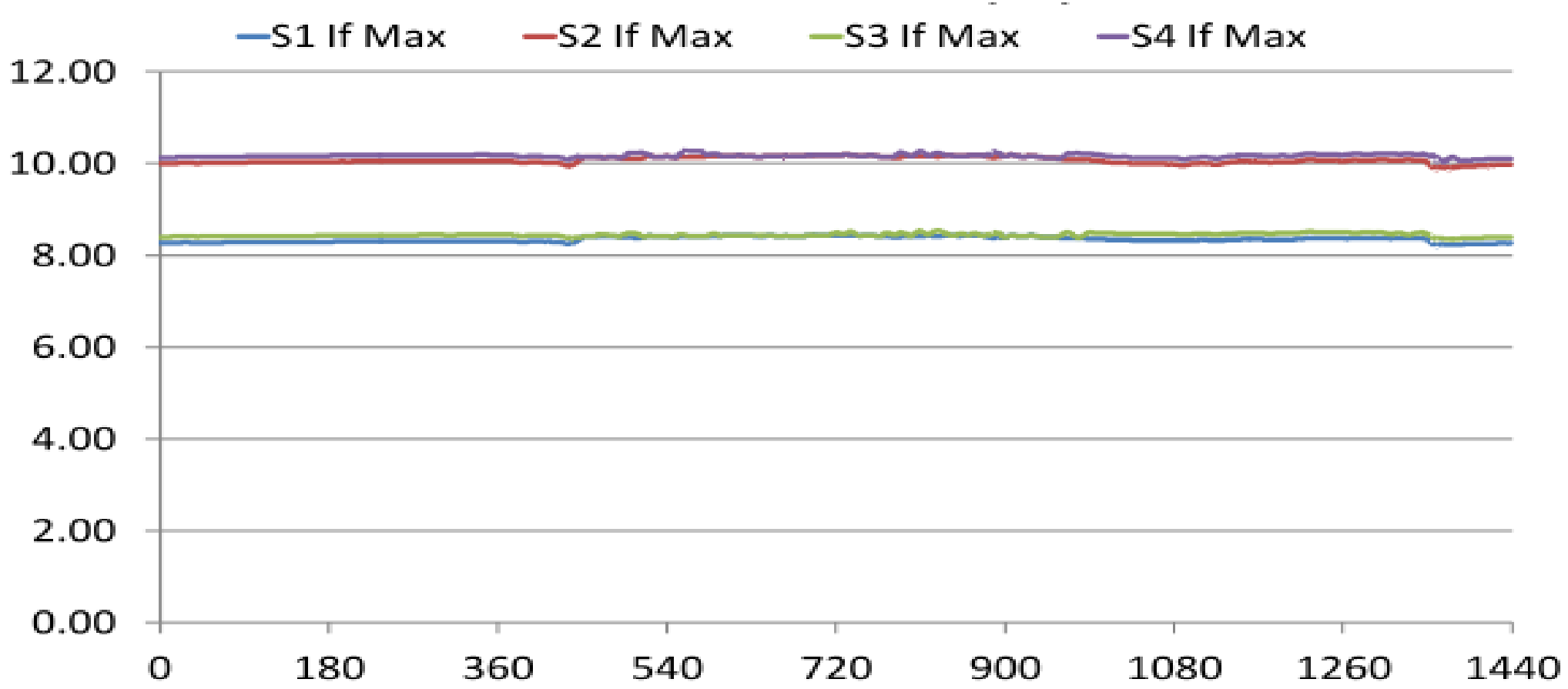
Voltage at distribution substation



1 pu = 230v

Fault level impacts

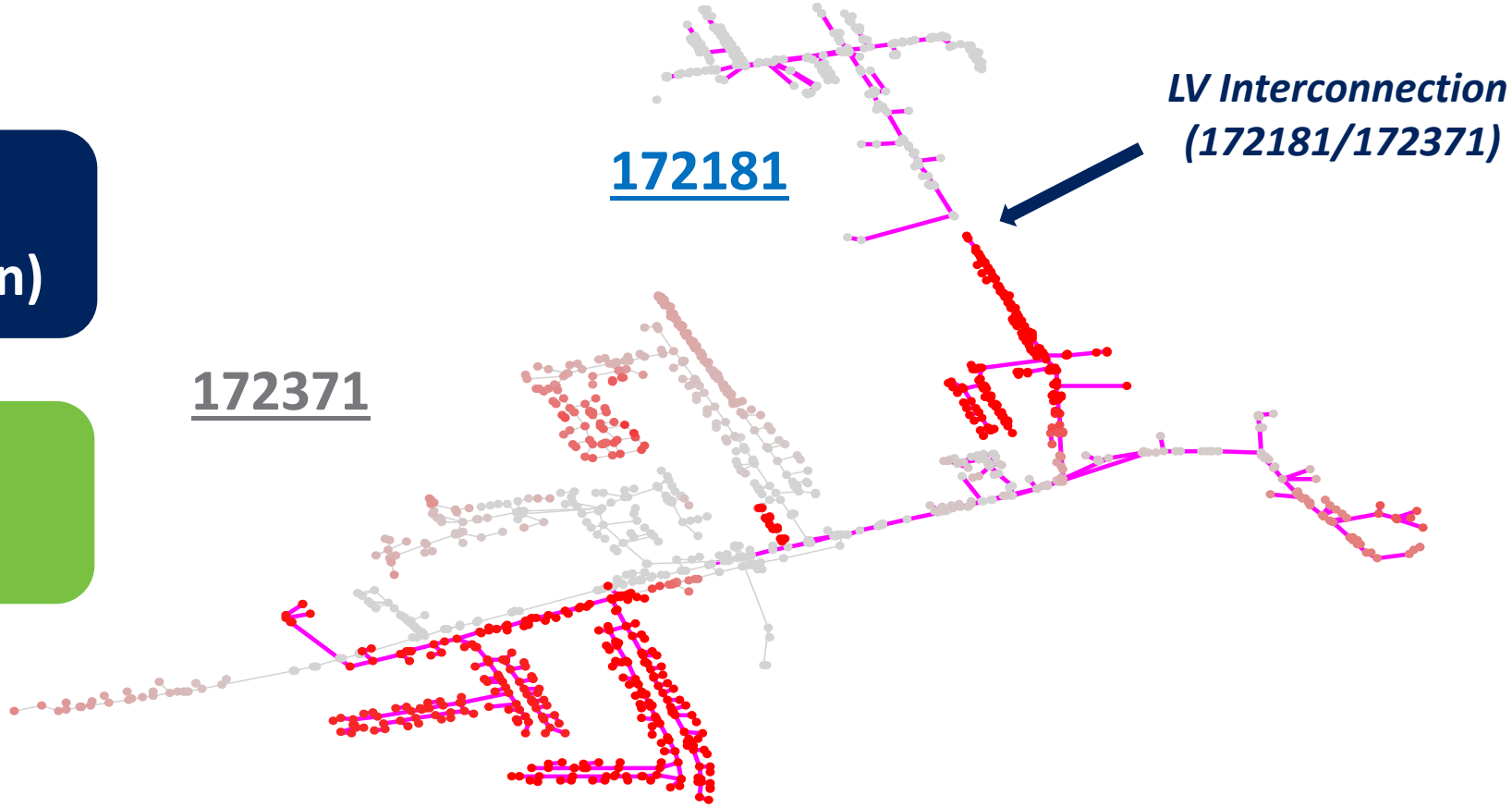
Fault levels at Denton East



Voltage unbalance factor

Summer 2050
(40% PV penetration)

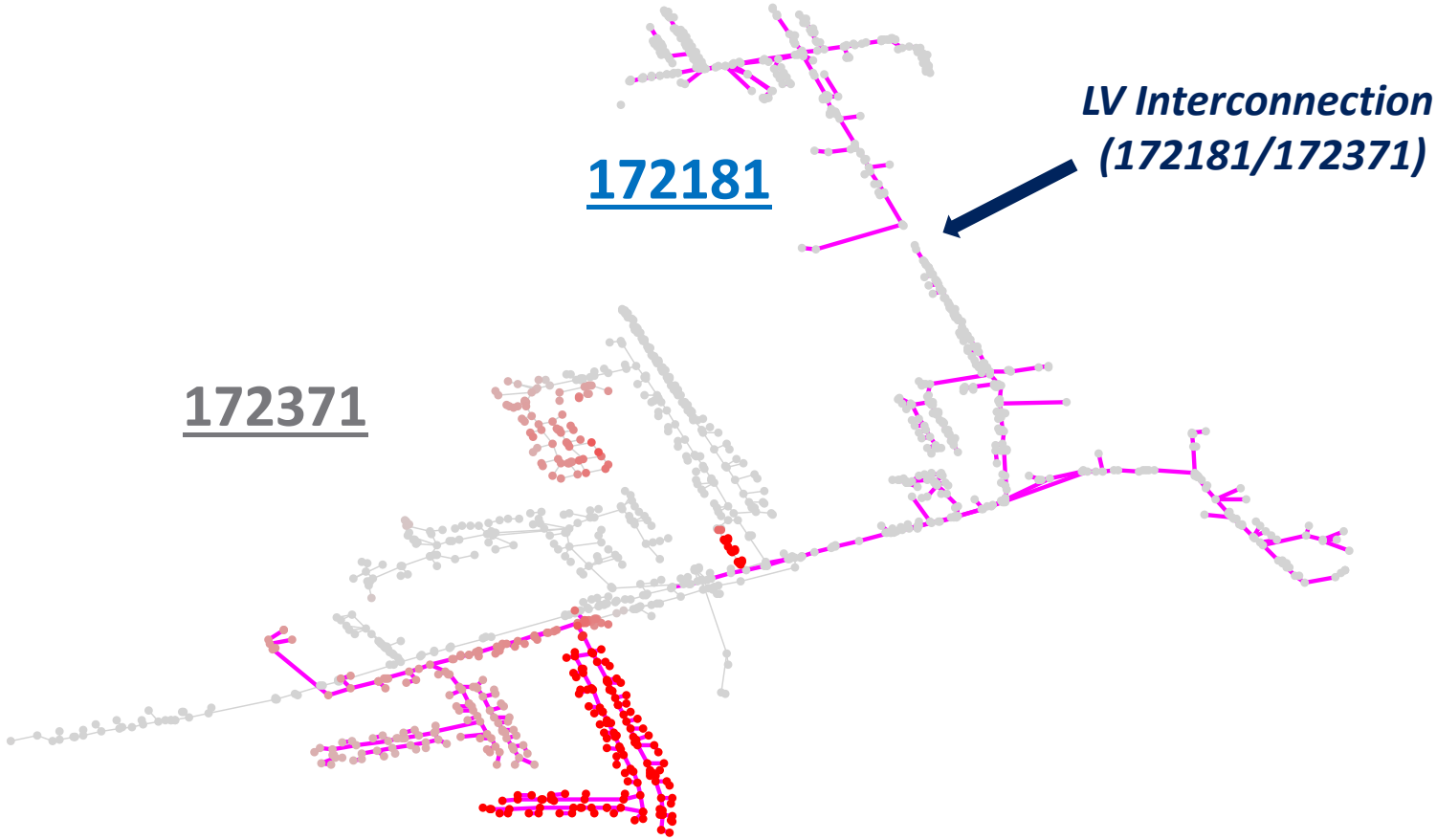
No meshing,
CVR enacted



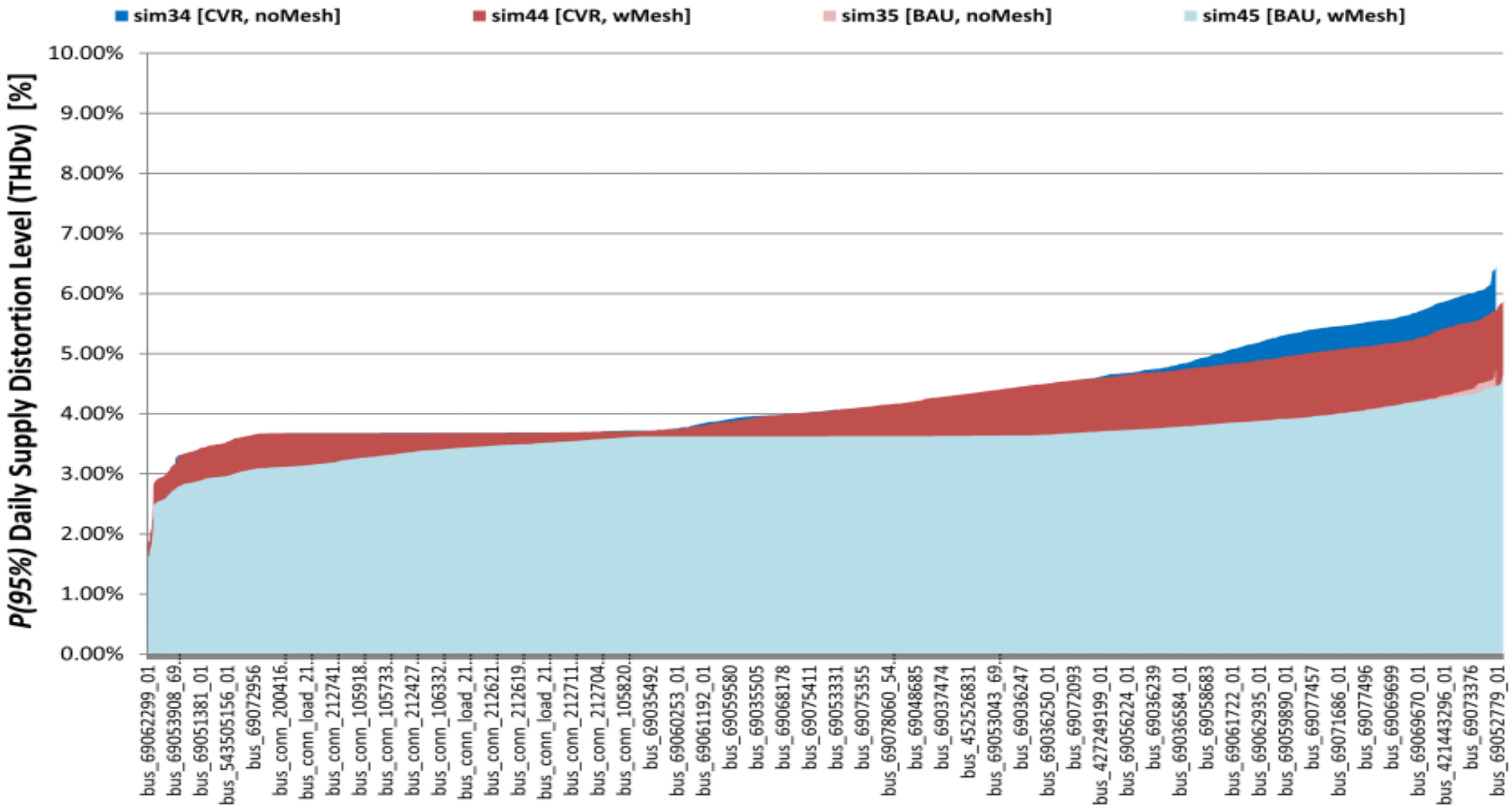
Voltage unbalance factor

Summer 2050
(40% PV penetration)

Meshing applied



Harmonic distortion



IET consultation

Reports issued to IET wiring regs working group

Issued by IET for public consultation

Workshop to discuss

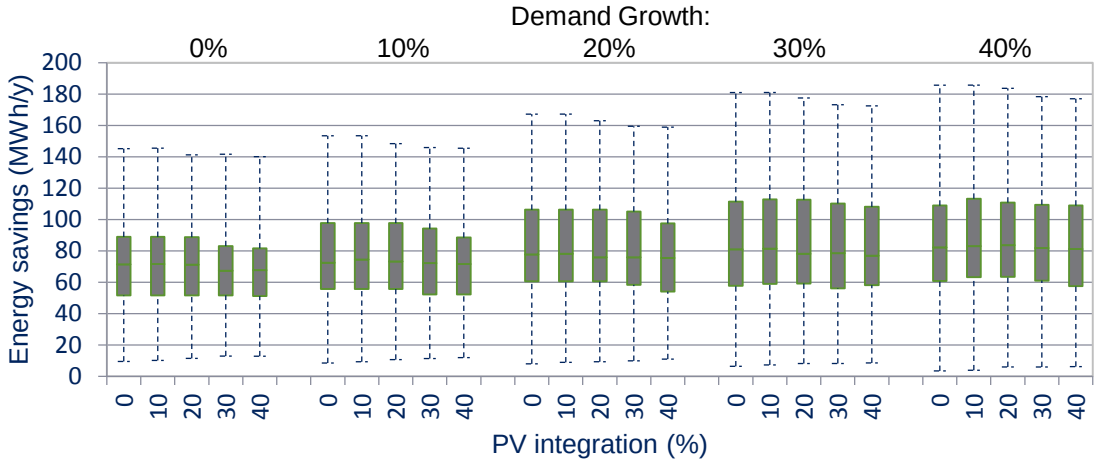
No issues for customer premises

Techno-economic results

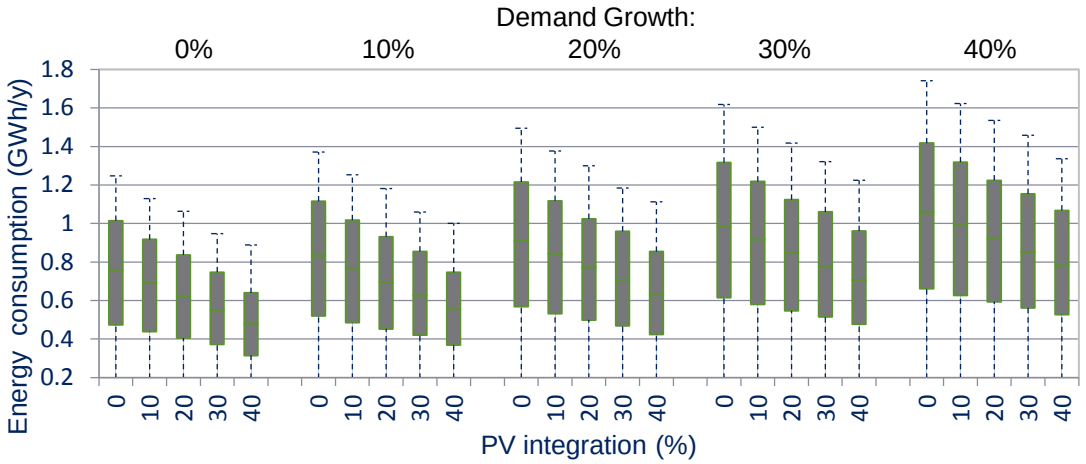
Energy savings

Net energy savings increase with net demand, while the savings percentage decreases

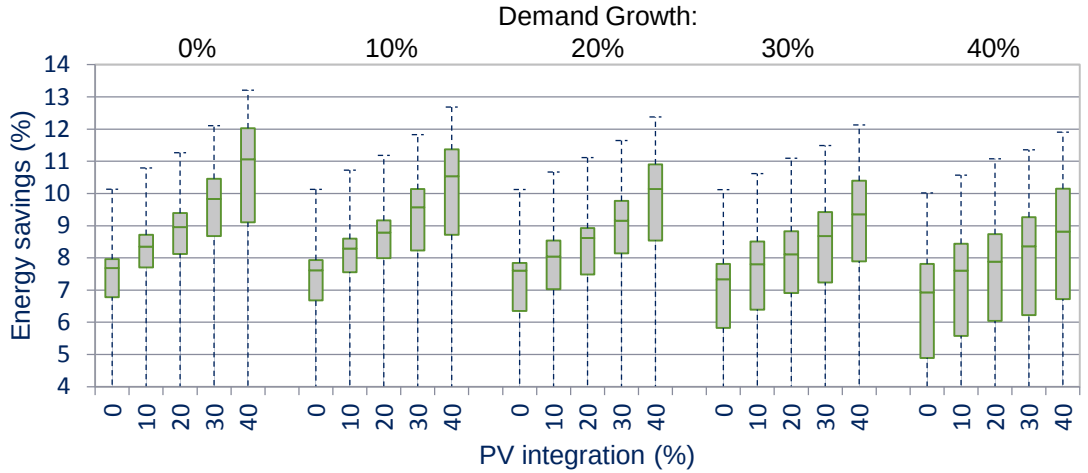
Most benefits can be attributed to OLTCs



OLTC+Cap+Mesh: Net energy savings



Baseline annual energy consumption

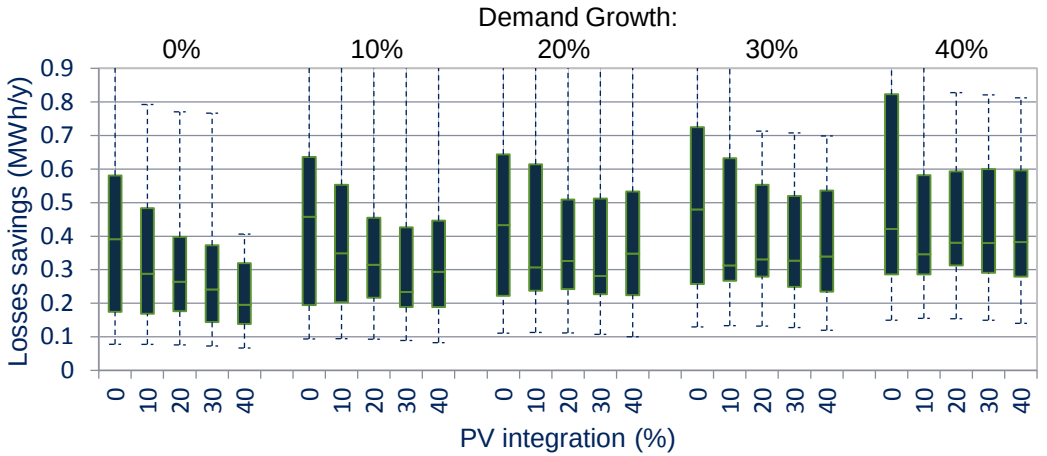


OLTC+Cap+Mesh: Energy savings

Techno-economic results

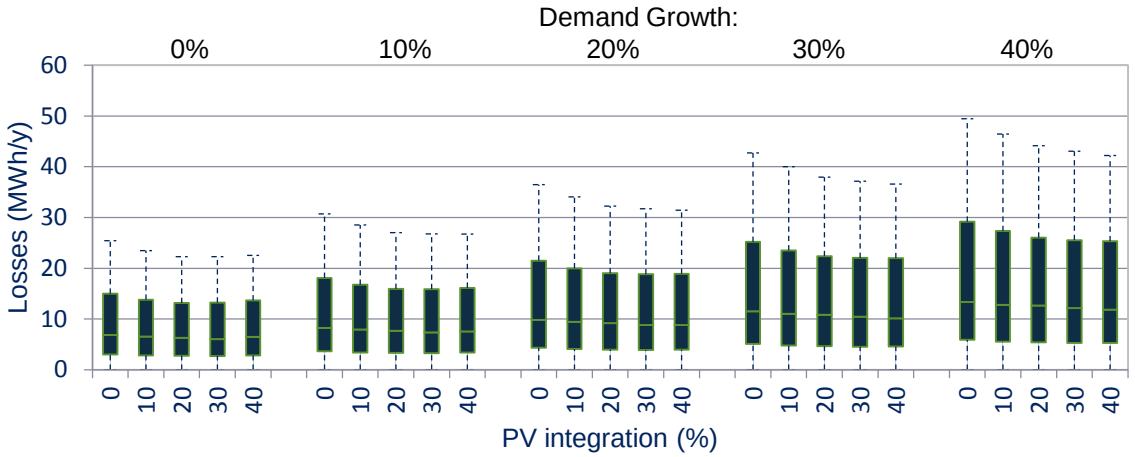
Losses savings (LV)

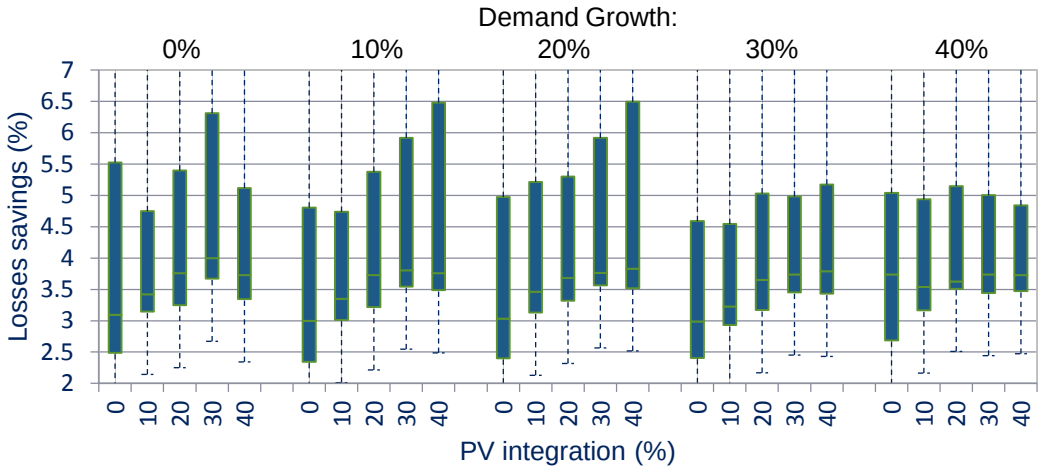
Losses are reduced due to lower demand or redistribution of flows (meshing)



OLTC+Cap+Mesh: Net losses savings

Baseline annual losses





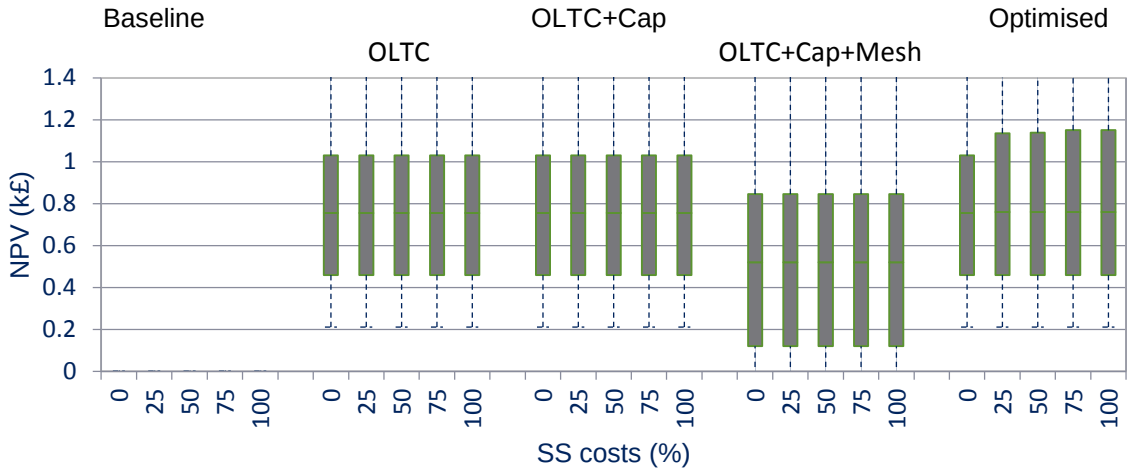
OLTC+Cap+Mesh: Losses savings

Business case results

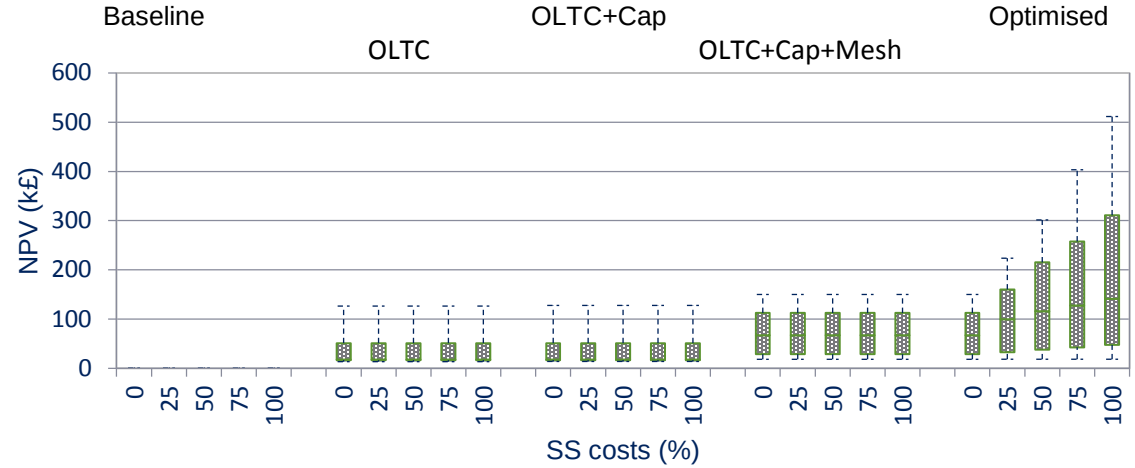
Uncertainty

Only the optimised strategy is set to respond to uncertainty

The potential to defer reinforcement under uncertain LCT uptake can make Smart Street more attractive



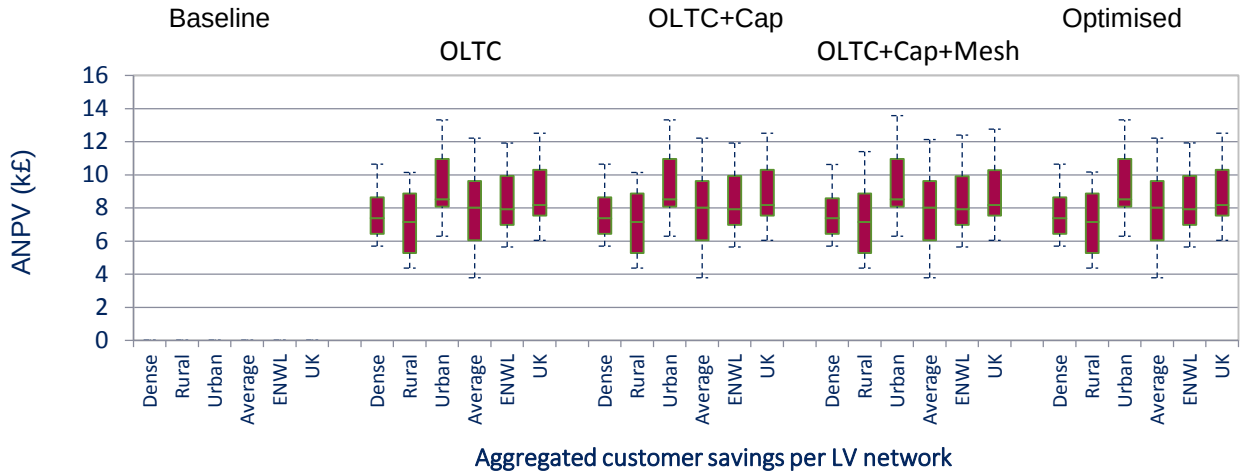
NPV associated with the LV networks



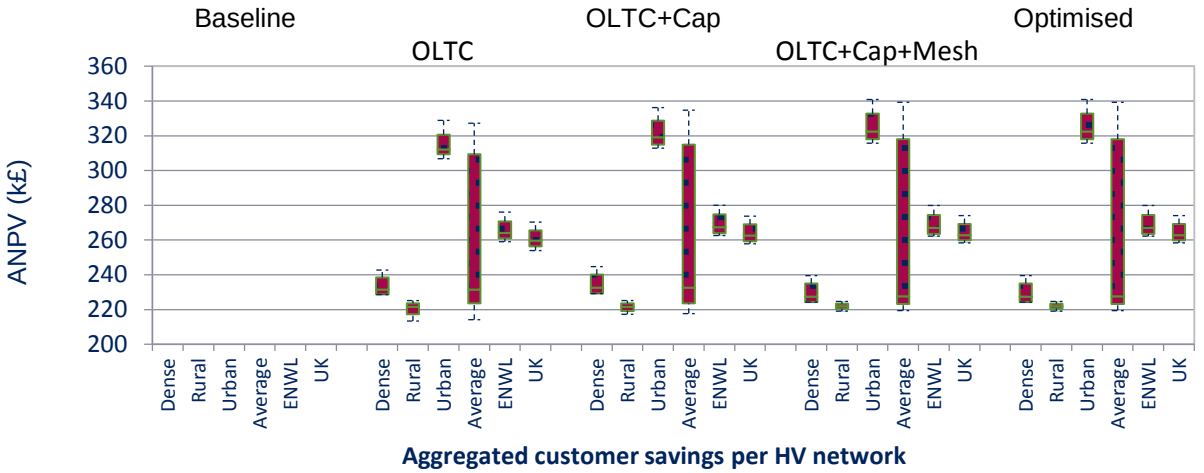
NPV associated with the HV networks

Cost benefit analysis results

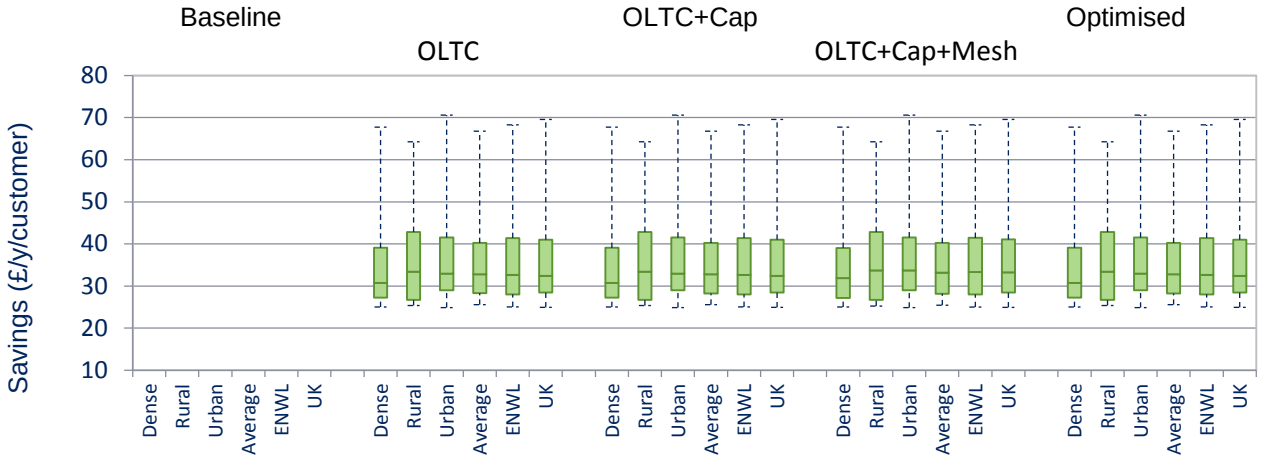
Customers: Energy savings



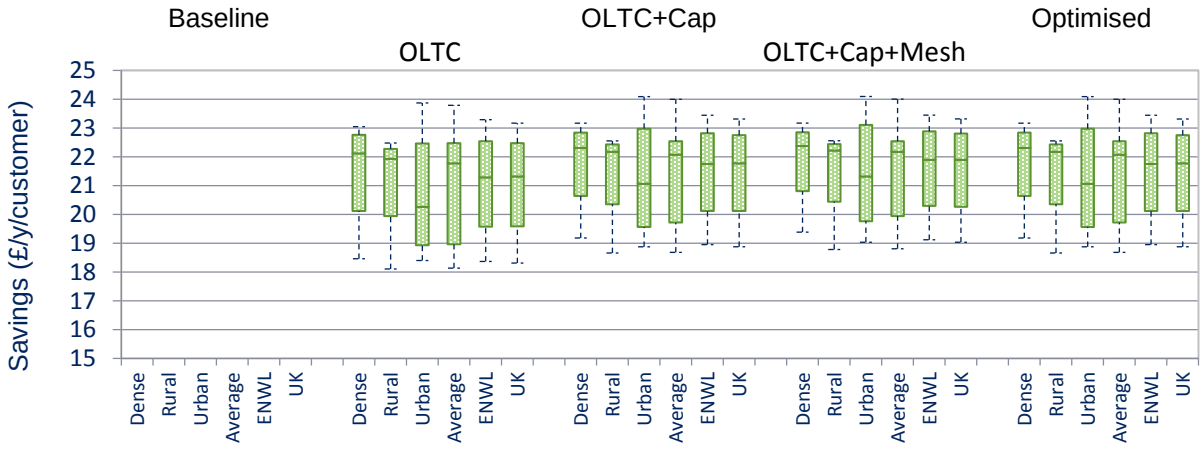
Aggregated customer savings per LV network



Aggregated customer savings per HV network



Average savings per customer connected to the LV network



Average savings per customer connected to the HV network

Electricity North West rollout

Greenhouse gas emissions ($MtCO_2e$) potential – Rollout over Electricity North West area 2016 - 2060				
Scenario		**HV**	**LV Low**	**LV High**
Two Degrees	OLTC	5.13	7.24	10.84
	OLTC + Cap	5.11	7.07	10.81
	OLTC + Cap + Mesh	5.11	7.13	10.78
Slow Progress	OLTC	6.3	8.91	13.33
	OLTC + Cap	6.28	8.74	13.26
	OLTC + Cap + Mesh	6.28	8.79	13.26
Steady State	OLTC	15.14	21.45	32.06
	OLTC + Cap	15.11	21.28	31.99
	OLTC + Cap + Mesh	15.11	21.3	31.93
Consumer Power	OLTC	8.09	11.43	17.12
	OLTC + Cap	8.08	11.28	17.05
	OLTC + Cap + Mesh	8.08	11.31	17.05

Great Britain rollout

Greenhouse gas emissions ($MtCO_2e$) potential – Rollout across Great Britain 2016 - 2060				
Scenario		**HV**	**LV Low**	**LV High**
Two Degrees	OLTC	64.17	90.51	135.54
	OLTC + Cap	63.94	88.42	135.13
	OLTC + Cap + Mesh	63.94	89.15	134.73
Slow Progress	OLTC	78.81	111.39	166.63
	OLTC + Cap	78.52	109.26	165.8
	OLTC + Cap + Mesh	78.52	109.93	165.8
Steady State	OLTC	189.2	268.15	400.73
	OLTC + Cap	188.84	266	399.93
	OLTC + Cap + Mesh	188.84	266.27	399.13
Consumer Power	OLTC	101.15	142.92	214.02
	OLTC + Cap	100.95	141.05	213.16
	OLTC + Cap + Mesh	100.95	141.34	213.16

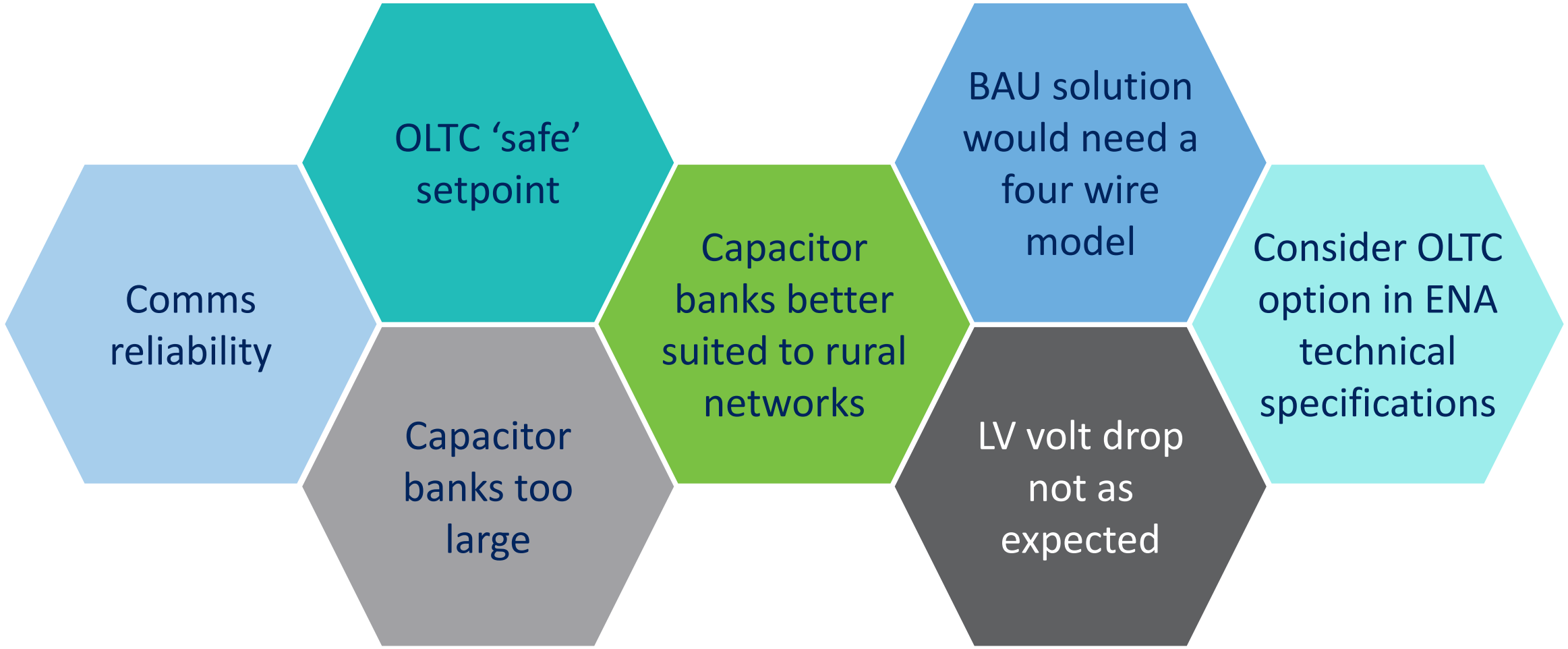
Carbon impact

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



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Customer Engagement

Tracey Kennelly
Innovation Customer Delivery Lead

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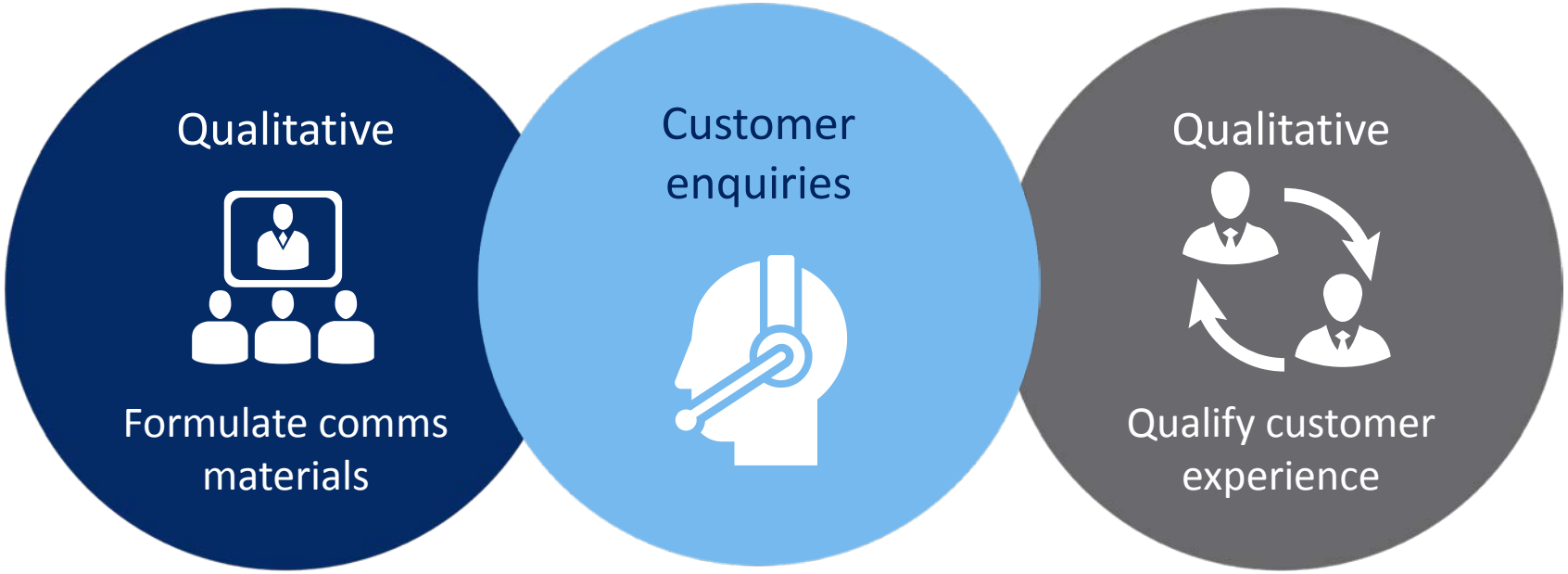
Customer research methodology

"Customers in the trial area will not perceive any changes in their electricity supply when the Smart Street method is applied"



Potential customer impacts

Installation of street cabinets
A relatively higher number of faults of a shorter duration
Planned supply interruptions due to equipment installation
Possible change in voltage

Customer impact and objectives

Pre-trial		During/post-trial	
			
Customers have seen increased activity while equipment is installed	Occasional planned supply interruptions due to equipment installation	Higher number of faults of shorter duration during trial period	Possible change in voltage
Objective: To engage with customers and explain impact of Smart Street trial		Objective: To prove that customers will not perceive a change to their electricity supply	

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The impact of the Smart Street technique on customers

Susie Smyth
Research Director Impact Research Ltd

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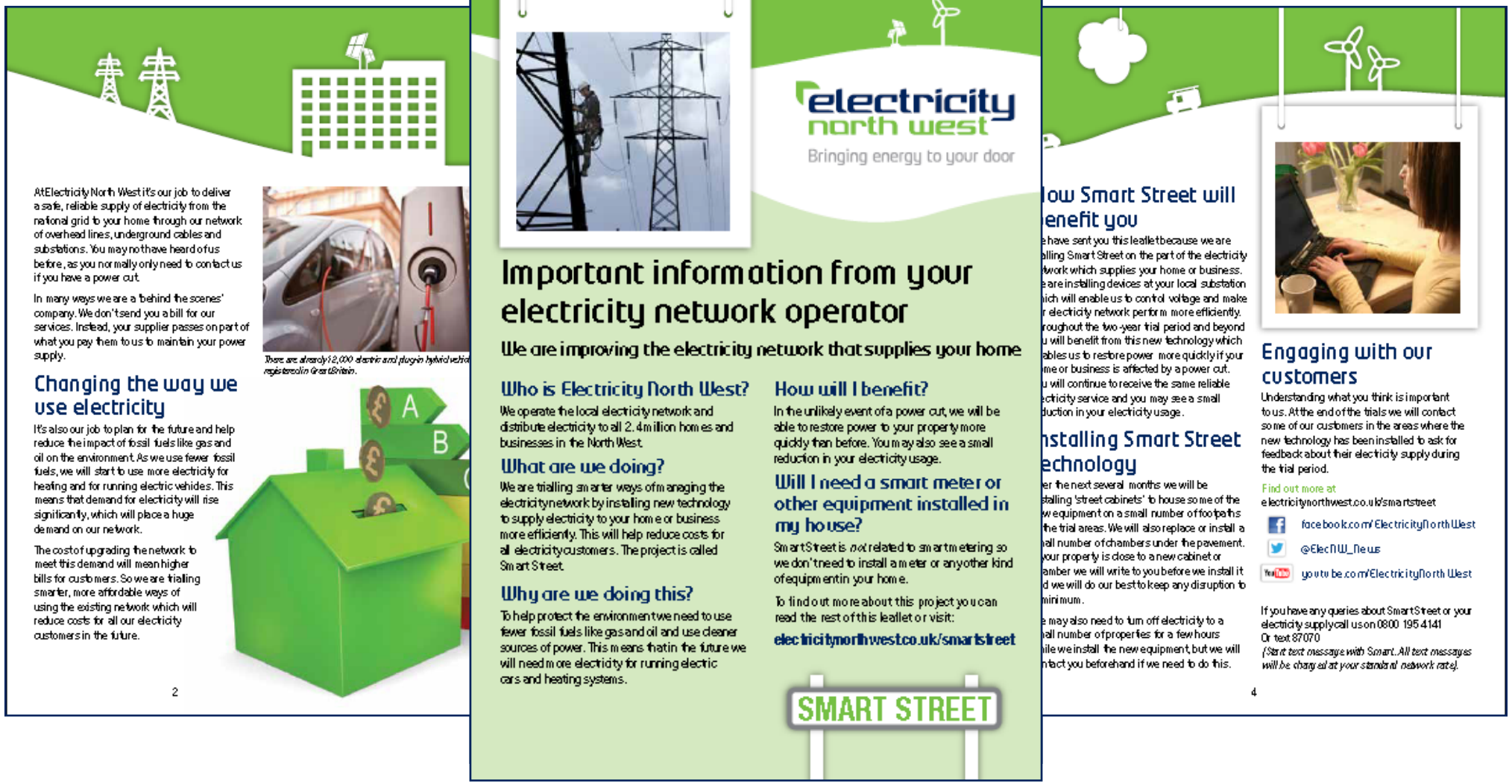
ECP recommendations – customer leaflet



At Electricity North West it's our job to deliver a safe, reliable supply of electricity from the national grid to your home through our network of overhead lines, underground cables and substations. You may not have heard of us before, as you normally only need to contact us if you have a power cut.

In many ways we are a 'behind the scenes' company. We don't send you a bill for our services. Instead, your supplier passes on part of what you pay them to us to maintain your power supply.

Changing the way we use electricity

It's also our job to plan for the future and help reduce the impact of fossil fuels like gas and oil on the environment. As we use fewer fossil fuels, we will start to use more electricity for heating and for running electric vehicles. This means that demand for electricity will rise significantly, which will place a huge demand on our network.

The cost of upgrading the network to meet this demand will mean higher bills for customers. So we are trialling smarter, more affordable ways of using the existing network which will reduce costs for all our electricity customers in the future.

There are already 12,000 electric and plug-in hybrid vehicles registered in Great Britain.

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Important information from your electricity network operator

We are improving the electricity network that supplies your home

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 trialling smarter ways of managing the electricity network by installing new technology to supply electricity to your home or business more efficiently. This will help reduce costs for all electricity customers. The project is called Smart Street.

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.

How will I benefit?

In the unlikely event of a power cut, we will be able to restore power to your property more quickly than before. You may also see a small reduction in your electricity usage.

Will I need a smart meter or other equipment installed in my house?

Smart Street is *not* related to smart metering so we don't need to install a meter or any other kind of equipment in your home.

To find out more about this project you can read the rest of this leaflet or visit:

electricitynorthwest.co.uk/smartstreet

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ow Smart Street will enefit you

e have sent you this leaflet because we are alling Smart Street on the part of the electricity twork which supplies your home or business. e are installing devices at your local substation ich will enable us to control voltage and make r electricity network perform more efficiently. roughout the two-year trial period and beyond u will benefit from this new technology which ables us to restore power more quickly if your me or business is affected by a power cut. u will continue to receive the same reliable ctricity service and you may see a small duction in your electricity usage.

nstalling Smart Street echnology

er the next several months we will be talling 'street cabinets' to house some of the w equipment on a small number of footpaths the trial areas. We will also replace or install a all number of chambers under the pavement. our property is close to a new cabinet or amber we will write to you before we install it d we will do our best to keep any disruption to minimum.

e may also need to turn off electricity to a all number of properties for a few hours ile we install the new equipment, but we will ntact you beforehand if we need to do this.

Engaging with our customers

Understanding what you think is important to us. At the end of the trials we will contact some of our customers in the areas where the new technology has been installed to ask for feedback about their electricity supply during the trial period.

Find out more at
electricitynorthwest.co.uk/smartstreet

facebook.com/ElectricityNorthWest

@ElectNW_News

youtube.com/ElectricityNorthWest

If you have any queries about Smart Street or your electricity supply call us on 0800 195 4141
Or text 87070
(Start text messages with Smart. All text messages will be charged at your standard network rate).

4

Engaged customer panel methodology

Wigton/Egremont (rural)

Wigan (urban)

Manchester (dense urban)

Cross-section of customers

Two meetings x three areas = six focus groups

30 customers recruited across three groups

Trial research

Five key questions

1. Power quality prior to the trials
2. Power quality perceptions during the trials
3. Power quality perceptions at the end of the trial
4. Experience of short duration interruptions (SDIs)
5. Expectation of future power quality

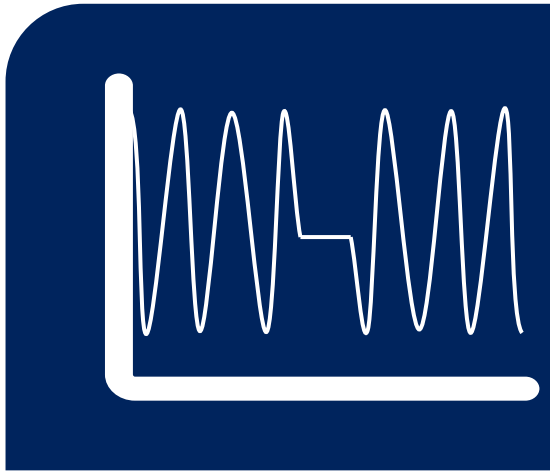
Perception of power quality

Customers rated their power quality as extremely high

They struggled to recall significant variations in supply with either consistency or reliability

Power quality concerns raised were often before the Smart Street trials started

Changes to perception when sensitised

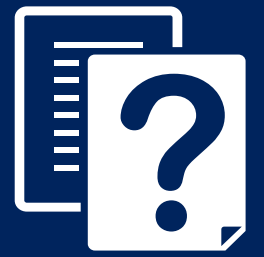


Smart Street method may increase occurrence of short duration interruptions (less than three minutes) - SDIs

The ECP were educated about a potential increase in SDIs

Only then were they able to recall any changes in power quality

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

Did customers notice Smart Street?

Hypothesis

Customers in the trial area will not perceive any changes in their electricity supply when the Smart Street method is applied

No complaints about power quality

67,000 customers in trial areas

= 0

No voltage complaints or enquiries about power quality likely to have been caused by Smart Street trials

Customer sensitivity to new street furniture

Anticipate regional/demographic sensitivity

Design and location key to mitigate impact

Notify customers to negate resistance and costs

Robust customer strategy to maintaining customer relationships

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Summary and next steps

Ben Ingham

Innovation Engineer

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Summary

- OLTCs provide benefits
- Operation of devices proven
- Software needs refinement

Technology

Trials

- Energy savings of up to 8.5%
- Loss reduction of up to 15%
- Active interconnection benefits quantified

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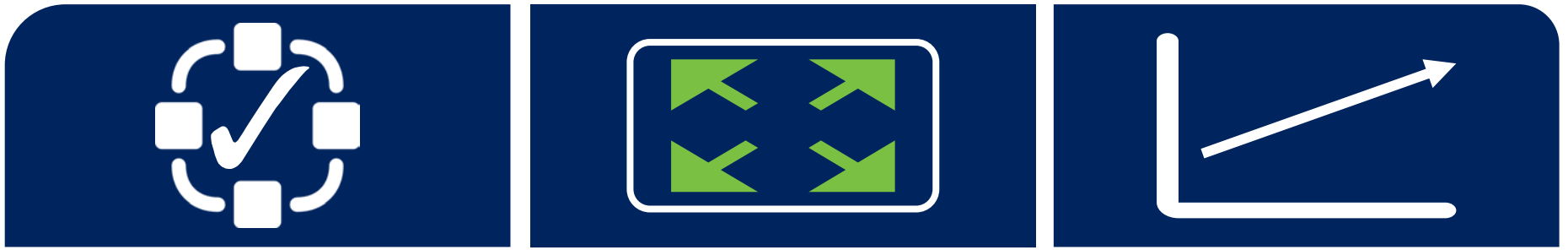
Carbon Footprint

- Faster LCT adoption
- Carbon emissions reduced by up to 19%
- Re-usable technology

Customer Benefits

- Lower energy bills
- More reliable supply
- Reinforcement savings
- No impact on supply

Going forward



Maintain the monitored LV network

Lynx housing being redesigned

Potential for capacitors as loads increase

Integrating devices into new Electricity North West network management system

OLTCs now included in technical specifications as an option

Planning policies updated to allow use of all techniques as required

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	**0800 195 4141**
	**@ElecNW_News**
	**linkedin.com/company/electricity-north-west**
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	**youtube.com/ElectricityNorthWest**

Thank you for your time and attention

Post event survey results

	Poor	Needs improvement	Satisfactory	Good	Excellent
Content			1 (4%)	13 (57%)	9 (39%)
Format			1 (4%)	14 (61%)	8 (35%)
Opportunity for questions			1 (4%)	7 (30%)	15 (65%)
Networking		1 (4%)	1 (4%)	15 (65%)	6 (26%)
Overall experience				16 (69%)	7 (31%)
Administration			2 (9%)	10 (43%)	11 (48%)
Venue facilities			1 (4%)	14 (61%)	8 (35%)
Refreshments			4 (18%)	11 (50%)	7 (32%)

Please provide any further comments you have about today's event.

- Very informative
- Good session overall
- Would like more time, maybe a little more detail in the presentations, but good to get it from discussions