Smart Street

Second Tier Reward Application

1 August 2022

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Executive summary

Low Carbon Technology (LCT) uptake is expected to increase further as we move through RIIO-ED2 and, without intervention, would have a dramatic effect on our network by causing voltages to fall outside of statutory limits, negatively affecting customer supply and the performance of appliances. By combining innovative technology with existing assets, Smart Street makes networks and customers' assets perform more efficiently and facilitates the adoption of LCTs onto the electricity distribution network.

This award-winning project, originally submitted to the Low Carbon Network Fund (LCNF) under the name "eta", was **the first demonstration of a fully centralised, low voltage network management and automation system** in Great Britain (GB). It enables LCTs to be connected to networks more easily and releases capacity more quickly and cheaply than traditional methods, enabling the development of a low carbon electricity system. Smart Street also drives direct reductions in carbon emissions by reducing losses and lowering energy consumption.

This Second Tier Reward (STR) application illustrates the exceptional performance of Smart Street in addition to the exceptional effort we have undertaken in delivery of this ground-breaking project, including the below key points:

- Customer energy savings have extended significantly beyond expectations, with a **reduction in energy usage by 5% to 8%** and a reduction in High Voltage (HV) **losses of up to 15%**, as detailed in the closedown report, pages 21 and 3, respectively. This produces a significant carbon savings benefit where Smart Street is implemented, with cumulative GB-wide **savings to 2060 of up to 400MtCO_2e** – equal to around 11 months of total UK emissions[1] – as per Figure 4.8 on page 24 of the closedown report.
- Smart Street has **fundamentally changed industry thinking** on how voltage management can facilitate the operation of a low carbon electricity system, notably proving that Conservation Voltage Reduction (CVR) does not impact customer supplies. Smart Street was designed to enable rollout across GB, with outcomes focused on sharing, with other DNOs, deployment methodologies and optimisation and engagement strategies. As a result, a number of DNOs have now committed to rolling out similar technology, or elements of the Smart Street system, in their business plans, including SSEN, NPG, SPEN and NIEN.
- In October 2019 Ofgem backed an initial, targeted rollout of the technology by granting an £18m adjustment to our RIIO-ED1 allowance under the Innovation Rollout Mechanism (IRM). Ofgem recognised the value in Smart Street, stating that the technology provides "substantial benefits in the mid to longer term" for customers.
- Following this, Ofgem showed further support for the project by granting us £76m to roll the project out across our network in RIIO-ED2 in its draft determination, issued 30 June 2022.

Smart Street was delivered under-budget and will bring **benefits that far exceed the investment**, representing good value for money for customers. The project methodology also **put customers first**, proactively engaging with customers and using feedback to shape the future of the project. This led to our decision to prioritise areas with high levels of fuel poverty for the IRM and RIIO-ED2 rollouts.

Ofgem recently published its Smart Systems and Flexibility Plan (2021), which highlighted the need for DNOs to manage networks to enable LCTs and flexibility on page 30. Smart Street has enabled DNOs to meet the emerging challenge presented by our customers' increasing uptake of LCTs and enable our transition to a low carbon economy.

[1] Calculated using 2021 UK greenhouse gas emissions, provisional figures – provisional figure for 2021 of 424.5 MtCO2e. 424.5/12 = 35.4 per month. 400/35.4 = 11.3 months, round to 11.

Project details

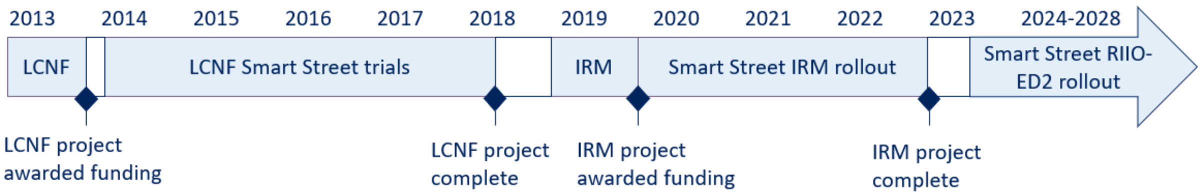
Figure 1: Summary of Smart Street Tier 2 project

Tier 2 project name	Project Summary (2 sentences)	Second Tier funding £k*	Licensee compulsory contribution £k*	Other contributions £k*	Link to closedown report £k*
Smart Street (eta)	A system that uses innovative voltage control techniques to enable network and appliances to perform more efficiently, delivering significant financial and environmental benefits.	8,438	955	1,926	Closedown report

**nominal prices*

Background

By combining innovative technology with existing assets, Smart Street makes networks and customers' assets perform more efficiently and facilitates the adoption of LCTs onto the electricity distribution network. Smart Street uses On-Load Tap Changing (OLTC) transformers and controllable switching devices (Weezaps and Lynx units) integrated into our Network Management System (NMS) to stabilise network voltage and prevent it falling outside of statutory limits.



Smart Street was originally submitted to the LCNF in July 2013 under the name "eta". This original, £11.5m project ran from January 2014 to April 2018 and, in conjunction with our project partners, trialled innovative technology to optimise voltages on our network. Despite a slight project extension, the LCNF project was delivered £851,000 under budget. After proving the benefits of Smart Street during the trials, we made an application in 2019 for an adjustment to our RIIO-ED1 allowance under the IRM to fund an initial, targeted rollout. We were granted £18m to fund the rollout of Smart Street to 180 sites within RIIO-ED1, which is currently underway and expected to complete in March 2023.

The next step for Smart Street at Electricity North West is to continue our rollout of the technology through RIIO-ED2, and following the submission of our business plan Ofgem has announced its "minded to" position to award a further £76m to facilitate the wider rollout of Smart Street across our network from 2023 in its draft determination, page 31.

LCNF project objectives

The LCNF project was able to prove the following key hypotheses as a result of the project trials and customer engagement, see Figure 2.

Figure 2: Key hypotheses summary table

Hypothesis	Proven
The Method will deliver a reduction in customers' energy consumption.	✓
Customers within the Trial area will not perceive any changes in their electricity supply.	✓
The Method will have no adverse effects on customers' internal installation or appliances.	✓
The Method is faster to apply than traditional reinforcement, supports accelerated LCT connection and reduces network reinforcement costs.	✓
The Method facilitates the prioritisation of the range of solutions across differing LCT adoption scenarios based on a cost benefit analysis to accommodate customers' uptake of LCTs.	✓
The Method will deliver a reduction in overall losses through network configuration and voltage optimisation.	✓
The Method facilitates real time control of a portfolio of Low Voltage (LV) network solutions, using retrofit technologies with application combined or in isolation.	✓

Trials

The project explored five trials, each involving a series of test regimes to ensure an understanding of how the different technologies impact each trial and to maximise learning. These were identified based on the limited number of test circuits available and recommendations by our academic partner. The five trials are listed below:

- Trial 1 – LV voltage control
- Trial 2 – LV network management and interconnection
- Trial 3 – HV voltage control
- Trial 4 – HV network management and interconnection
- Trial 5 – Network configuration and voltage optimisation

Trials 1 and 3 reduced network losses or energy consumption via a combination of CVR and voltage optimisation techniques. They tested the voltage control equipment in isolation and in combination to fully assess the benefits of these techniques. Trials 2 and 4 compared the benefits of radial and interconnected circuits across the LV and HV trial areas. Trial 5 assessed the reduction in losses and energy consumption achieved by the optimisation software.

Further detail on the results of the trials can be found in the project closedown report, pages 6-10, and the full trial design is detailed in the network design methodology report, from page 6.

Customer engagement

To prove our hypothesis that customers will not perceive any changes in their electricity supply, we undertook significant and robust customer engagement activities alongside the trials. This included continuing our use of Engaged Customer Panels (ECPs) as initially trialled in the CLASS project and active engagement with customers to raise awareness of the project, the problem it addresses and the challenges involved.

In addition, we made exceptional effort to engage proactively with customers in relation to our installation of street furniture. This strategy ensured that the project team was able to manage customer enquiries on a case-by-case basis and resolve each one amicably in advance of the installation work. Further detail can be found in the closedown report, pages 39-40.

Evidence of critical outcomes

Reward criterion A: exceptional performance against one or more of the Detailed Criteria

A1 Facilitating the carbon plan: the trials proved energy consumption is reduced by 5-8%, more than the 3.5% anticipated in the LCNF submission, with cumulative GB savings of up to 400MtCO_2 – equivalent to ~11 months of total UK emissions – enabling cheaper, faster LCT connection.

A2 Releasing network capacity: the trials proved we could get a greater energy consumption reduction than that predicted in the LCNF submission, which results in a greater capacity release than we originally estimated.

A3 Delivering financial benefits: lowering energy consumption by 5-8% will reduce customer bills by up to £54 per year without affecting supply, and this increased energy saving will in turn increase the deferred reinforcement saving to up to £500m across GB.

A4 Rollout across system/GB: the technology is designed to enable rollout – Ofgem supported our initial IRM rollout to 180 sites in addition to our further £76m rollout in RIIO-ED2, delivering NPV of £456m to customers.

A5 Value for money to customers: the project used best practice risk management alongside strong governance to ensure that all outputs were effective, and was delivered £851k under budget despite an unavoidable delay.

A6 Relevance and timing: project findings have been adopted as the Government strategy for moving towards a flexible and smart system is launched, as LCT uptake requires innovation to release network capacity and to manage the grid, and as the cost of living increases – our rollouts are focusing on areas with high levels of fuel poverty.

A7 Methodology robustness and project readiness: the project pioneered new applications of Social Return On Investment (SROI) techniques which put the customer first, and the customer engagement methodology has led to new findings for DNO communications strategies whilst also making innovative use of existing techniques.

A8 Other: the project has changed industry attitudes towards CVR, now an accepted technique, resulting in a fundamental change to the approach of other DNOs in RIIO-ED2.

Reward criterion B: investment of the DNO's own money for successful delivery

We have not invested any additional contribution and therefore offer no evidence against this criterion.

Reward criterion C: exceptional effort to ensure Smart Street exceeds the expected delivery outcomes and the learning is maximised for the good of all DNO customers

C1 Delivered more learning than expected: there were several pieces of additional learning during the project – the technology produces additional customer energy savings, energy reduction is not dependent on network type, and the LV network is more robust than originally believed.

C2 Additional learning due to exceptional effort: proactive engagement with customers in relation to the street furniture installation proved critical in achieving customer acceptance, saving time and cost.

C3 Exceptional capture and dissemination to maximise value for customers: the project contributed towards improvement of Schneider Electric's (SE) core NMS product, available to all DNOs; learning was available to academics, who published numerous papers based on it; and other DNOs have committed to the rollout of Smart Street, or elements of the system, including SSEN, NPG, SPEN and NIEN.

Reward criterion A

A1 – Aspects of the Carbon Plan that have been facilitated

Smart Street is the first demonstration of a fully centralised, low voltage network management and automation system in GB. It enables LCTs to be connected to networks more easily and releases capacity more quickly and more cheaply than traditional methods, enabling the development of a low-carbon energy system. Smart Street also drives direct reductions in carbon emissions by reducing losses and lowering energy consumption.

Smart Street combines innovative voltage control technology with existing assets to make networks and customers' assets perform more efficiently, thus reducing carbon emissions and facilitating the adoption of LCTs onto the electricity distribution network. Both objectives, reduced carbon emissions and scaling of LCTs, are salient features of the Sixth Carbon Budget and the Clean Growth Strategy. The former states on page 5 that "low carbon investment must scale up to £50 billion each year to deliver Net Zero", while the Clean Growth Strategy's approach is for the UK to "nurture low carbon technologies, processes and systems that are as cheap as possible", page 10.

Smart Street also aligns with other, more recent Government carbon reduction strategies including:

Net Zero Strategy 2021: states that by 2035, all our electricity will come from low carbon sources. It also prioritises critical system enablers, stating on page 100, "Crucially, a whole system approach puts more emphasis on addressing critical system enablers. These measures will integrate different low carbon technologies into a coherent, single entity and optimise the system most efficiently and cost-effectively, in the interest of consumers." Smart Street is precisely one of these efficient, low cost LCT enablers, which provides direct carbon and energy savings to the customer.

The Prime Minister's Ten Point Plan: in November 2020 the government announced its intention to end the sale of new petrol and diesel cars and vans in the UK from 2030, and National Grid's Future Energy Scenarios (FES) estimates 15 million electric vehicles will be on the road by 2030 on page 102. This will increase electricity demand, and the Smart System and Flexibility Plan 2021 states:

- "This increase in demand will need to be managed by the system operator and local networks." (Page 30)
- "By March 2023, the Electricity System Operator will develop and publish a plan, to implement regular, dependable, bankable markets for solutions to stability, voltage and thermal constraints." (Page 44)

Smart Street is relevant in that it offers DNOs a solution to managing their networks as well as a solution to inform the Electricity System Operator's 2023 obligations, particularly around voltage constraints.

Ofgem's 2022 – 2023 Forward Work Programme: states in Point 4, "Through our 'Low Carbon Infrastructure' Strategic Change Programme, we will ensure that the necessary enablers are in place to facilitate a more co-ordinated approach to the transition of GB's network infrastructure to meet net zero and protect energy security." Smart Street's solution is one such enabler. Smart Street uses On-Load Tap Changing (OLTC) transformers and controllable switching devices (Weezaps and Lynx units) integrated into our NMS to stabilise network voltage and prevent it falling outside of statutory limits. This reduces carbon emissions through lowering energy consumption and reducing losses. Smart Street also allows more LCTs to connect to the grid.

Government's British Energy Security Strategy (April 2022): states that increasing on and off-shore renewable generation is a priority. Specifically, "By the end of 2023 we are set to increase our capacity by a further 15%" and "Our ambition is to deliver up to 50GW by 2030, including up to 5GW of innovative floating wind."

As GB moves towards the low carbon future envisioned through these Government strategies, electricity demand and the level of renewable and low carbon distributed generation is expected to increase. This will introduce voltage challenges for GB electricity network operators, and Smart Street offers centralised voltage management at both the LV and HV levels of the distribution network. While electric vehicles and heat pumps could cause voltages to fall below statutory limits, new generation technology from photovoltaics exporting electricity onto the network will have the opposite effect. If voltage levels fall outside statutory limits, the performance of customers' appliances will be affected.

Traditionally HV networks have minimal or no voltage regulation and active management, and LV networks have no voltage regulation or active management at all. This is known as passive network management, and it does not allow the kind of network voltage configuration needed to efficiently adapt circuit load resulting from LCT integration whilst also protecting the grid.

This raises the following network issues:

Barriers to a low-carbon system: LCTs on LV networks significantly change the traditional LV voltage profile, meaning that with passive management, network reinforcement would traditionally be required to enable networks to stay within statutory voltage limits.

Barriers to a more efficient energy system: Passive network management also means that LV and HV networks experience higher losses than would be expected under an actively managed network.

- Losses associated with transporting energy across distribution networks are 5-8% of distributed energy.
- Our 2011-12 Carbon Footprint Report showed network losses of 1230GWh (5.3% of energy distributed) which represented 670,540tCO_2e, of which 70% occurred on HV and LV networks (23% HV and 46% LV), see page 6.

Aspects of the Carbon Plan facilitated: vulnerable customers

The Carbon Plan lays out five principles to addressing climate change and maintaining energy security on page 5. One of the principles is that "Costs must be distributed fairly. The Government will continue to focus on the distributional impacts of the low carbon transition."

The IRM rollout has been designed so that vulnerable and low-income customers can be prioritised. These customers can save energy with little to no intervention, which is particularly important in the current cost of living crisis. Taking on board feedback and encouragement from customers and representatives of vulnerable customers, we took the decision to prioritise areas of high fuel poverty for the initial IRM rollout in RIIO-ED1. This means that those impacted the most by rising energy prices will benefit from the Smart Street deployments that began in 2020.

Reducing customer electricity use without impacting quality of supply delivers important energy savings. This requires no behaviour change from customers and means that those energy savings are more likely to be realised. The amount of energy saved using Smart Street is significant; equivalent to boiling 750-1,200 full kettles of water[2] a year for a typical customer. Smart Street bypasses the need for customer action, which is, in part, why other consumer-end energy saving innovations have struggled to deliver predicted

[2] This figure is based on 5-8% energy savings and BEIS subnational energy stats for mean domestic electricity consumption (2020) – 2 litre 3kW kettles.

savings: BEIS's analysis of the Smart Meter roll-out found that Smart Meters deliver 3% savings in electricity use (page 36), compared with predictions of up to 15%. Smart Street demonstrates how the technology can deliver savings without impacting the customer.

Aspects of the Carbon Plan and Clean Growth Strategy facilitated: carbon reduction

Smart Street reduces carbon emissions by reducing energy consumption, reducing losses and by deferring embedded emissions in assets used for network reinforcement. The LCNF project demonstrated that:

- It could reduce customer energy consumption by up to 8%, leading to a direct reduction in CO_2 emissions.
- A total loss reduction of up to 15%, consisting of reductions from meshing feeders and reduced energy consumption from CVR.
- Avoided network reinforcement will release additional capacity on the existing network, leading to carbon savings by reducing the embedded carbon emissions from traditional reinforcement. It could release up to 220MW in additional capacity for LCTs (on our network) based on our peak demand of 4.3GW.

Figure 3 shows a comparison between the projected carbon savings and the trial findings.

Figure 3: Projected Smart Street Carbon Savings from a GB-wide Rollout to 2060

	LCNF project submission	Smart Street trial findings
GB scale	9.8MtCO_2e	153MtCO_2e to 400MtCO2e
ENWL scale	0.8MtCO_2e	12.2MtCO_2e to 47.0MtCO_2e

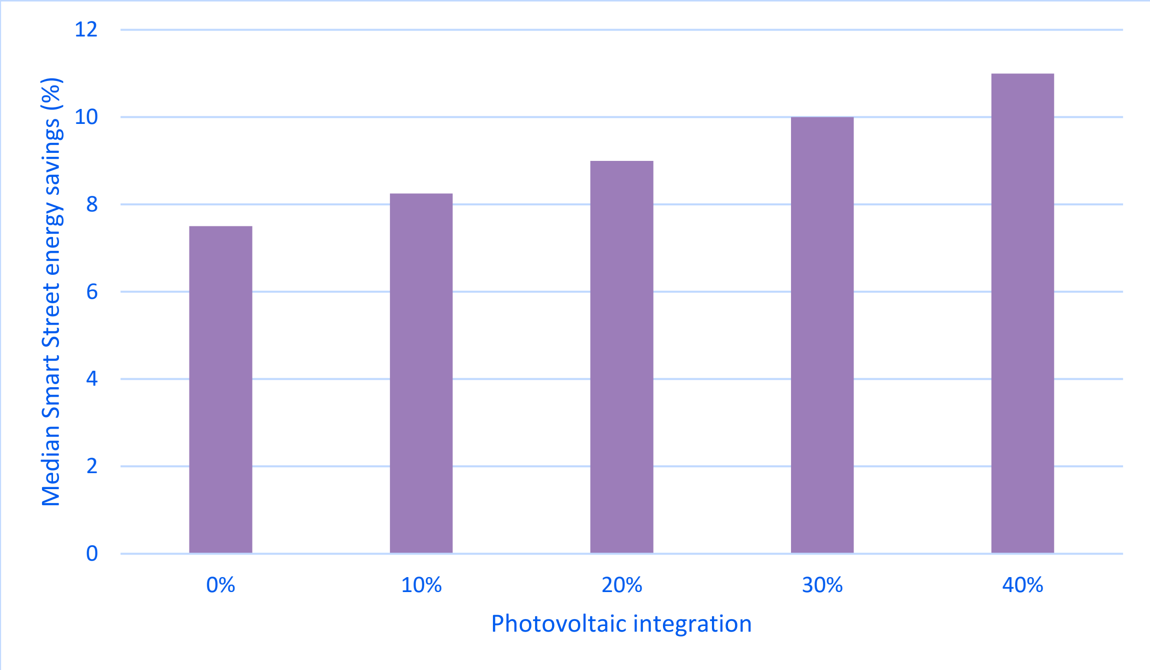
The LCNF project demonstrated that Smart Street's impact on carbon emissions through reducing electricity consumption and reducing losses are much greater than those from simply deferring and avoiding traditional network reinforcement (around 84% of the total). The carbon savings projections for a GB-wide Smart Street rollout show up to 400MtCO_2e savings, the equivalent of up to 11 months of total UK emissions, based on BEIS National Statistics 2020 UK Greenhouse Gas Emissions.

The LCNF project found that customer energy usage reductions are primarily driven by the use of OLTCs. The trials demonstrated Smart Street's ability to reduce energy consumption by up to 8%, without affecting perceived supply quality. This performance is above and beyond expectation, as the estimate in section 1.3 of the LCNF submission was up to 3.5% energy consumption reduction, (although this was not included in our projections of potential carbon emissions savings).

The LCNF project also demonstrated that interconnection meshing plays an important role in losses savings by redistributing power flows. The trials demonstrated up to a 15% reduction of losses on the HV network. This has led to new potential research areas in understanding the redistribution of power flows due to meshing and its potential value to customers, the energy system and society.

Notably, net annual energy savings from Smart Street, and the associated carbon savings, increase with higher power demand growth and with high solar panel integration. Smart Street also increases the capacity of the networks and is most economical in areas with high uptake of LCTs, such as solar panels and heat pumps. Figure 4 shows energy savings on the LV network under different solar panel adoption scenarios.

Figure 4: Energy savings through the Smart Street trial LV networks under different photovoltaic adoption scenarios[3]



Depending on the network type and energy scenario, the LCNF trials delivered emissions reductions at HV level by between 4% and 5% and at LV level by between 7% and 11%. As a result, the trials found that Smart Street can deliver carbon savings of up to 400MtCO_2e across the GB networks to 2060, compared to the 9.8MtCO_2e originally estimated (which did not capture the carbon benefits from end-use energy consumption reduction), as per page 24 of the closedown report.

Successful trials led to rollout across Electricity North West network

The success of the LCNF project led us to apply to Ofgem's IRM. Ofgem subsequently approved £18m in funding to introduce Smart Street to 180 distribution substations before the end of RIIO-ED1. When complete, this rollout will cover 45,000 customers, and save 144,000tCO_2e up to 2050, as per page 61 of the IRM submission. This is equivalent to taking 2,570 cars off our roads every year. In RIIO-ED2 we will begin another roll-out, this time to 250,000 customers, saving 359,000tCO_2e up to 2050, as per our RIIO-ED2 CBA calculations.

Figure 5 shows the carbon savings associated with the confirmed rollouts across our network. The cumulative carbon savings may appear disproportionate at first glance, but they take into account the decarbonisation of GB through adoption of LCTs; as LCT uptake increases, carbon savings from reduced energy consumption will reduce.

Figure 5: Carbon savings of confirmed Smart Street rollouts across our network

	IRM roll-out	ED2 roll-out
Deployment years	2019 to 2023	2023 to 2028

[3] Figure 4 is based on Figure 3.2 on page 8 of the Smart Street Final Cost Benefit Assessment Study.

	IRM roll-out	ED2 roll-out
Number of customers	45,000	250,000
Cumulative carbon savings up to 2050	144,000tCO2e	359,000tCO2e

December 2021 trial

In December 2021, we undertook another Smart Street trial at Ofgem's request. This formed part of the due diligence needed for Smart Street rollout funding to be extended into RIIO-ED2. Data from this trial further confirmed the voltage-demand relationship driving CO_2e reduction projections.

A2 – Releasing network capacity

The LCNF trials demonstrated that Smart Street technologies not only release firm capacity on local networks, but also perform particularly strongly compared to traditional reinforcement where LCT uptake is increasing. Capacity is released through avoided losses and active voltage management. More specifically, Smart Street is well-suited to releasing network capacity for LCTs by minimising their impact on voltage on the LV and HV networks.

Smart Street's active voltage control management has the cascading effect of speeding up LCT connections by increasing headroom capacity. Smart Street voltage control techniques reduce the impacts of LCT rollout on the LV network in particular, protecting the grid. This means that Smart Street can help the low carbon transition by releasing network capacity while also creating more resilient LV networks for customers.

Context

Current forecasts from BEIS show that there may be up to a 60% increase in total electricity demand between 2030 and 2050. Small-scale embedded generation such as photovoltaic panels on domestic properties are expected to increase from 26.5MW in 2015 to 18,700MW by 2040, according to National Grid's FES, page 87, Figure CV.24. An increase in new electricity loads from customer adoption of LCTs, combined with new, intermittent generation, will introduce thermal and voltage-related challenges associated with the management of local HV and LV networks.

Currently, for an estate of domestic premises with gas heating, LV networks are scaled to supply a diversified peak demand of less than 2kW per property. Electrifying heating could add 6kW per property, and a family EV car could add a further 3.5-7kW, on average. Different LCTs could also add to thermal, harmonic and voltage issues. Traditionally there has been limited voltage regulation on HV networks and none on LV networks.

UoM analysis

The University of Manchester (UoM) analysed the techno-economic results of Smart Street on firm capacity by comparing Smart Street configurations to the baseline of no Smart Street technologies applied and instead traditional reinforcement and network management are leveraged. They did this under different scenarios and combinations of PV uptake, and demand growth (e.g. from electric vehicles and heat pump adoption) varied between 0% and 40%.

UoM found that all Smart Street solutions can increase the firm capacity of networks and do so by alleviating voltage and thermal issues in the existing infrastructure. Specifically, intelligent use of OLTCs and capacitors at distribution substations can alleviate significant voltage problems in 20%, 30%, and 40% demand growth scenarios, thus releasing network capacity. Although capacitors are only required to alleviate problems at the highest growth scenario.

Smart Street highlighted that meshing (aka interconnection) is an attractive option to increase firm capacity on the LV network, particularly under high demand growth conditions. This is due to meshing alleviating both thermal and voltage issues. Quantifying the potential of meshing to increase capacity on the HV network is challenging, due to the large number of network configurations that should be modelled to account for the relevant security standards.

On average, Smart Street allowed for 2.45% more LCT integration from the baseline (and up to 8.67% with greater demand scenarios), and the result showed how a combination of different technologies, as trialled in Smart Street, provide the most potential to increase firm capacity.

As GB decarbonises through the adoption of LCTs, carbon savings from reduced energy consumption will also reduce. UoM carried out a study on the carbon impact of Smart Street. They found that in scenarios with lower LCT uptake, Smart Street would deliver potential savings of up to 32.1MtCO_2e across our LV network, but even in scenarios with high LCT adoption, Smart Street methods provide significant climate change mitigation savings of at least 7.1MtCO_2e across our LV network.

Network cost savings

UoM found that Smart Street can save £44m across our network and £519m across GB through the deferral of reinforcement, as per the closedown report (pages 32 and 37).

Costs were compared to typical costs of traditional reinforcement based on Ofgem reported values, and UoM found that the median NPV per network from using Smart Street strategies is +£800 for LV networks[4] and +£25,000 for HV networks. Smart Street's economic benefits over traditional reinforcement increase as LCT uptake accelerates, which is forecast to happen from the 2020s.

The results show Smart Street can provide valuable flexibility through voltage management and meshing to postpone, and even avoid, network reinforcement at LV and HV level. Smart Street has the ability to support LCT loads on distribution networks through optimising voltage within statutory levels. Smart Street reduces costs compared to traditional reinforcement under uncertainty, as the solutions can adapt to different future scenarios.

Latest forecasts

Our IRM submission stated on page 32 that Smart Street would reduce the need for traditional network reinforcement, and through deferred reinforcement alone was expected to save approximately £45,350 in 2012/13 prices for each deployment of Smart Street, once the capital cost of the equipment is subtracted. This saving does not take into account the significant additional customer benefits associated with reduced network losses and customer consumption. Over RIIO-ED1, DNOs' combined reinforcement and other load-related expenditure is forecast to cost £2.31bn, according to the RIIO-ED1 Network Performance Summary 2020-2021. We also estimated in our submission that

[4] Financial benefits before taking account of reduced charges.

Smart Street could release up to 220MW in additional capacity for LCTs (on our network) based on our peak demand of 4.3GW – equivalent to 31,000 EV charges[5].

A3 - Delivering financial benefits

The LCNF trials demonstrated that Smart Street technology delivers significant customer energy savings, beyond what was first anticipated. The savings result in direct bill reductions for customers on LV networks, with no perceived change in the quality of electricity supply. These savings arise from deferred reinforcement and reduced losses, which lower Distribution Use of System (DUoS) charges, in addition to reduced energy consumption, which has a direct kWh reduction to customer bills.

Stakeholder engagement highlighted support from communities to deploy Smart Street to benefit lower income and vulnerable customers, and the unique consumer-end savings resulted in the development of new social impact benefits assessments used in RIIO-ED2 called Social Value Measurement (SVM). The SVM is a method to assess wider benefits to society beyond the direct financial benefits to DNOs.

The LCNF trials demonstrated exceptional financial benefits, including direct savings to customer bills, which exceeded expectations. As the first trial of CVR on LV networks in GB, Smart Street demonstrated the significant financial benefits for customers that active management technologies can unlock:

- The trial proved that customers benefit from reduced energy consumption of 5% to 8% without any perceived changes to the quality of their electricity supply, page 21 of the closedown report. This results in direct bill savings for customers as well as wider savings from market imports, balancing services, transmission and distribution charges, and taxes. Prior to Smart Street, the level of impact on energy consumption in GB networks was not fully understood and savings of 3.5% were assumed in the LCNF submission, section 1.3.
- Smart Street's financial benefits are consistent across the network. The trials were carried out across a range of network geographies: rural, urban, and dense urban networks. UoM's research found that financial benefits to customers from Smart Street are significant across geographies and future growth scenarios.
- Smart Street reduced losses on HV networks by up to 15% through meshing and OLTC technologies, page 30 of the closedown report. Initial estimates were that Smart Street might reduce losses associated with transporting energy across distribution networks by up to 2%, as per the LCNF submission (section 1.3).
- The trials showed that Smart Street generates cost savings by deferring or avoiding the need for traditional reinforcement. Additionally, analysis by UoM demonstrates that Smart Street becomes more financially desirable as LCT rollout increases, as is anticipated over the coming decades.

Bill impacts

Smart Street was demonstrated to produce a reduction in customers' energy consumption of between 5% and 8%. As part of the LCNF project and the IRM rollout, analysis was carried out to understand the potential benefits to customers from a GB-wide rollout.

Analysis described on page 37 of the closedown report estimated a bill saving of £70 per customer, per annum, based on this saving. This was recalculated as part of our work for the IRM rollout, using Typical Domestic Consumption Values and the published average unit cost for electricity in the UK, and showed a range based on Elexon's Profile Classes.

[5] 220MW = 220,000kW and the average home charger in UK is 7kW: 220,000/7 = 31,429 EV charges.

These values were used to calculate the Social Value Measurement for Smart Street in RIIO-ED2, published on page 10 of Annex 19 of our business plan.

The most recent analysis work for the RIIO-ED2 rollout of Smart Street updated this saving again to include Ofgem's latest price cap cost figures, giving a net annual saving of up to £54 per annum for medium consumption Profile Class 1 customers, and bill savings equivalent to eliminating up to a third of electricity green levy costs.

This analysis work takes account of both the direct savings from reduced energy consumption and the wider impacts of Smart Street on the non-wholesale elements of customers' electricity bills. The updated analysis including the latest customer bill data from Ofgem's April 2022 Price Cap can be found in Figure 6.

Figure 6: Annual Smart Street customer bill savings in £ (before tax)

Net energy consumption reduction	**Profile Class 1**			**Profile Class 2**		
	Low (1,900 kWh)	Medium (3,100 kWh)	High (4,600 kWh)	Low (2,500 kWh)	Medium (4,200 kWh)	High (7,100 kWh)
5%	21	34	50	28	46	76
6%	25	41	60	33	55	91
7%	29	47	69	38	63	106
8%	34	54	79	44	72	121

Savings from deferred reinforcement

UoM carried out financial analysis of the LCNF trials using the Ofgem CBA as a basis for its methodology. The trials demonstrated potential GB-wide savings of £519m out to 2060 through avoided reinforcement, and financial savings of £44m for Electricity North West, as referenced in the project closedown report, section 7.2, page 37.

Benefits calculated in RIIO-ED2

Due to the significant financial benefits for customers through reduced bills, we are rolling out Smart Street to an additional 250,000 customers in RIIO-ED2. The customer-driven financial benefits mean that a SVM is used to capture consumer value beyond the financial benefits to Electricity North West. A total societal benefit of a rollout on Electricity North West's network would provide benefits of £456m over its lifetime (out to 2076) as identified in our RIIO-ED2 analysis, see page 13 of Annex 15a of our RIIO-ED2 business plan. The total financial benefits of the rollout can be found in Figure 7.

Figure 7: Total financial benefits RIIO-ED2 Electricity North West rollout

	Total benefits (£)				
	10 years	**20 years**	**30 years**	**45 years**	**Whole Life**
£m NPV (20/21 prices)	90	210	295	387	456

A4 - Rollout across the DNO's system and across GB

Smart Street learning has far-reaching impact across Electricity North West, GB and broader stakeholders

After a successful four-year LCNF trial, Ofgem supported Smart Street further by granting an £18m adjustment to Electricity North West's funding allowance via the IRM, recognising that the technology provides "substantial benefits in the mid to longer term" for customers in its decision. This is funding the rollout of Smart Street to 180 distribution substations, benefitting approximately 45,000 customers and saving approximately 144,860tCO_2e to the end of 2050 – the equivalent of removing 2,570 polluting cars from our roads every year – as per page 29 of the IRM submission. This initial rollout is due to be completed by March 2023 and demonstrates Electricity North West's commitment to bringing benefits to customers as soon as possible, even where there is little benefit to the DNO in the short term.

The significant societal benefits of Smart Street when compared to the direct financial benefits to the DNO also led us to use SROI to inform our decision to rollout Smart Street to benefit customers. The SROI demonstrated the value of social welfare measures compared to traditional CBA methods in investment appraisals as regulated networks adapt to new and innovative customer solutions. To ensure these benefits reach customers in greatest need, when selecting sites for the IRM rollout we filtered first by applicable site, then by LCT penetration (real or predicted) and finally by areas with high levels of customers experiencing fuel poverty. After the LCNF project pioneered this used of SROI, Smart Street was used as a base case to develop a standard, Ofgem-endorsed, common methodology for assessing CVP value for DNOs, now used across the industry.

Before Smart Street, CVR was not accepted in the UK or across Europe at distribution level (although it was possible to purchase an optimiser for private customers). Smart Street is the first project that is now BAU and takes advantage of this concept at grid scale. As a result of the trials, industry thought processes are changing and these techniques are now accepted. This has resulted in a fundamental change to the approach taken by other DNOs to managing the operation of a low carbon electricity system in RIIO-ED2. The IRM is the first step in our ambitious and ground-breaking rollout of Smart Street.

Following this initial rollout within RIIO-ED1, Ofgem has awarded us funding as part of our baseline allowance for RIIO-ED2 to continue the rollout. Smart Street will therefore extend to a further 250,000 customers over RIIO-ED2 as part of this £76m investment, as detailed in our RIIO-ED2 business plan, page 78, section 4.6. Over RIIO-ED2, deployment will focus on areas with the highest levels of fuel poverty to maximise Smart Street's social impact, followed by areas with LCT clusters.

Information dissemination design from the start

As the first demonstration of a fully centralised, voltage network management and automation system in GB, Smart Street transformed industry acceptance of the use of the technology. A salient and unique feature of Smart Street resides in its design methodology. The project was created with a primary focus toward producing information that would be beneficial to other DNOs and learning that would be adaptable for the potential rollout of the technology. These design choices included:

- Trial sites - rural, urban, and dense urban - were selected to give insight into Smart Street effectiveness across a range of distribution network categories.
- The LCNF project trialled different combinations of its component technologies. This meant that the learning was not limited to Smart Street as a single package, and this enabled us and other DNOs to understand which components would be most effective to rollout on their own networks.
- The LCNF project published reports on equipment specifications, installation, network design, and optimisation strategy. This ensures that all learning from the project can easily be considered in future rollouts and provides a ready-made foundation for future rollout projects.
- The LCNF project focused on off-the-shelf and retrofitting technologies and methods to best enable wider rollout.

Across other DNOs, Smart Street has provided valuable learning

Learning was disseminated across four areas, as detailed in Appendix A (from page 46) of the closedown report:

- Customer engagement
- Technology implementation and effectiveness
- Smart Street trial data and methodology
- Evaluation of Smart Street benefits

Other DNOs, including SSEN, UKPN and SPEN, engaged positively with Smart Street learning dissemination events which included the following:

- Webinars - July 2014 and April 2015
- Learning event - October 2015
- Innovation event - July 2017
- LCNI conferences - 2014, 2015, 2016, 2017
- Workshop - February 2017 (in conjunction with the Institution of Engineering and Technology (IET) and published on IET.tv)
- Closedown event - February 2018

Across these categories and engagement sessions, we shared a wealth of information. We have updated internal specifications to include the equipment used in Smart Street so it can be rolled out across our network and have made proposals to modify the national standard documentation. This and other information shared include the following:

1. Installation methodologies: we have published a detailed methodology for retrofitting network management and voltage regulation equipment.

2. NMS configuration: we have published functional specifications for LV network management and automation and the new interface arrangements with the optimisation software.
3. Transforming LV radial networks: we have developed a methodology for interconnecting LV networks, including design considerations, selection and deployment of voltage regulation equipment and protection arrangements required for safe interconnected operation, particularly for fault scenarios and cold load pick up.
4. Change proposals for design and operational standards submitted to ENA: Smart Street has resulted in proposed changes to existing industry standards, such as ENA ER P5-6 (and was issued in March 2017) and ACE Reports Nos 3, 49 and 105, on Design and Operation of LV distribution networks, including optimal number of interconnection points.
5. Safe working practices: we have implemented changes required to our existing engineering policy documents, codes of practice and authorisation procedures facilitating LV network management.
6. HV and LV voltage control: we have delivered results of the study on co-ordinated optimisation of voltage across HV and LV networks using OLTC capabilities and capacitors.
7. Network configuration and voltage optimisation: we have published the functional specifications, settings and configuration parameters required to optimise operation of the distribution networks to deliver a range of specified outcomes such as carbon, losses and energy reduction.
8. Customer engagement and feedback: we have described a method for attracting and engaging customers in trials and detail their feedback, testing hypotheses that customers will not perceive any changes in their electricity supply. Our customer engagement strategy quality has helped establish best practice for DNOs implementing voltage control technologies.

DNOs have picked up Smart Street

Smart Street is a faster, cheaper, widely applicable alternative to traditional reinforcement. As part of the LCNF business case preparation, TNEI found that Smart Street is transferable to 54% of our network and 72% of the GB network. In addition, Ofgem describes Smart Street as a non-traditional reinforcement alternative. While other non-traditional reinforcement alternatives, including dynamic smart meter control and other methods of voltage reduction, may in some cases deliver effective short-term results with little capital investment, Ofgem recognises in page 14 of its IRM decision document that Smart Street is able to deliver a larger-scale of benefits over a mid to long term, thus offering demonstrated, lasting and scalable benefits for network capacity and efficiency. As GB begins its long-term transition to a net zero energy system, the larger-scale benefits Smart Street can deliver over the mid- to long-term means it’s more likely to be adopted than similar solutions.

Smart Street represents a low intervention, yet high acceptability method that can be rolled out across distribution networks. It has been a successful proof of concept regarding customer energy consumption reduction with no perception of change in power quality. Some DNOs have said they will rollout similar technology or parts of Smart Street.

SSEN indicated in its RIIO-ED2 Business Plan that it would like to integrate a 'light' version of Smart Street, detailed on p.83. On page 130 of Annex 10.2, SSEN proposed developing the capability to operate and manage the LV network in real-time, by rolling out real-time monitoring infrastructure and LV automation technologies across their LV network.

All the technologies SSEN referenced, on page 46 of Annex 12 its, as "Innovations which have influenced our load-related expenditure proposal" were Smart Street technologies including:

- OLTC at lower voltages: SSEN proposes approx. 130 deployments
- LV Meshing

NPG adopted Smart Street as a proof of concept enabling its own project trial called BEET, see pages 15-18. Smart Street learning around reducing energy consumption, customer research, and methodology fed into the BEET trial, and in particular, by proving the CVR hypotheses and demonstrating that voltage reduction can be implemented without affecting customer quality of supply. NPG is proposing to invest £7.9m to further deploy the BEET trial project and potentially roll it out across the whole of its network, see page 76 of NPG's RIIO-ED2 business plan.

SPEN is installing OLTCs in HV/LV substations at 19 sites, as per page 19 of its RIIO-ED2 business plan, and increasing automation at LV over 122 locations, as per page A19 of Annex 4A.1 of their RIIO-ED2 business plan.

NIEN has discussed Smart Street with us and is investigating integrating the techniques based on the LV active network management component of Smart Street as part of its next price control in 2024. They refer to this as DRVC and LVANM.

How Smart Street's outcomes have been taken on board by external stakeholders

Customer engagement: Electricity North West's Plugged-in Public Panel members were pleased to see how Smart Street's Customer Advisory Panels supported the Smart Street trial. The concept was so successful that Customer Advisory Panels have become a permanent feature of the way we work.

Smart Street won the 'Innovation Project of the Year – Electricity' at the Utility Week Network Awards in 2020. Judges found that Smart Street had the most quantifiable benefits for the environment, customers, and stakeholders; the potential to create significant future benefits across the industry and beyond; and was a genuine business change that has been embedded into BAU.

Stakeholders who provided feedback on our RIIO-ED2 submission felt that there was substantive evidence that Smart Street has a very positive social benefit, in addition to network benefits such as reduced losses and deferral of traditional reinforcement:

> *"It's a no brainer - it'll help customers to save a lot of money: £1 cost per person = £60 saving for impacted customers"- Plugged-In Public Panel member*

RIIO-ED2 stakeholders support the wider rollout of Smart Street, with domestic customers even telling us that they would be willing to pay slightly higher bills to fund faster investment in Smart Street's deployment and ensure that a further 250,000 customers benefit – this is the fastest rate of rollout we proposed for RIIO-ED2.

A5 - Value for money to customers

The LCNF project has successfully delivered an ambitious programme of work and has produced significant learning for all stakeholders, detailed in section A4. The combined output from the project has more than fulfilled the commitments made. The project maximised the use of strong partnership organisations, using their insights and feedback to make the most of efficiencies and learning.

In the sections below, we have provided evidence on the three areas covered under the criteria for delivering value for money for customers: minimising costs, the efficient use of funds, and the effective use of funds.

- Minimised costs: the LCNF project was delivered 9% under budget: for £8.7m instead of the expected £9.5m. It also had exceptional support from project partners who contributed £1.9m – or 17% – to bring total the project funding to £11.5m.
- Efficient: robust governance processes and leverage of existing assets and knowledge.
- Effective: all project hypotheses were proven.

Minimising Cost

The LCNF project was delivered below budget. The funding was made up of £8.6m from Ofgem (£8,438k in funding plus interest) and £955,000 from Electricity North West, totalling £9.5m. The final project was completed 9% below budget, for £8.7m, saving £851,000. This is all despite an approximate 3-month extension due to a delay in delivery of the HV capacitors, and the associated cost impact. The project cost variance is detailed in the closedown report, page 35-36, Figure 6.1. In addition, project partners showed their commitment and minimised costs to customers by funding a further £1.9m for a total project funding of £11.5m. This funding level from partners is exceptional as it represents 17% of the total project funding, which is the highest partnership contribution for an innovation project we have seen and is over double the average contribution as a proportion of total funding.

As a result of cost-effective risk management, only 6% of the contingency was used. Our risk management tactics included engineering out delivery risks, as far as feasible, through effective partnerships and detailed project planning.

An essential part of our approach to Smart Street was to remove delivery risk prior to the bid submission stage. At the bid development stage, a strong consortium of project partners with proven delivery credentials was assembled. The LCNF project partners were identified through an open competitive process and were selected based on their prior experience, value for money to customers, and their commitment to Electricity North West, the LCNF project and the dissemination of knowledge and learning. All project partners were engaged on a fixed-price contractual basis with the scope of the work and the price pre-agreed. This approach provided the foundation for delivering the project for the lowest possible cost whilst minimising risk through collaboration with market-leading experts in their relevant fields.

Efficient use of funding

The project capitalised on potential cost savings as they were identified, such as making use of more internal labour and adopting efficiencies in the peer review processes. The approach was to leverage, as well as build on, previous innovation and existing, appropriate assets.

- By incorporating Capacity to Customers (C2C) rings (assets from the C2C LCNF trial that enable customers to make more use of HV capacity) in the Smart Street LCNF trial, we realised benefits and efficiencies. These included a reduction in planning time and savings in equipment costs as the technologies required were already installed.
- Data preparation: tests carried out identified that the Siemens Spectrum Power 5 (SP5) system used in the LCNF project could manage the project's data storage

requirements, so a separate system was not needed. This saved £81k or 29% of the data preparation budget.

- Contractor: we were able to make more use of our internal labour force for network configuration and voltage optimisation, reducing the need for contractors and saving £25k or 7% of the network configuration and voltage optimisation budget.
- Peer reviews: we adapted the peer review aspect of the project based on feedback from a partnering organisation, delivering the peer reviews, support and customer research for 19% less, a saving of £27k.

We used a robust project management framework based on PRINCE2 principles. We established a strong governance regime with each output reviewed internally at least once as a minimum. We established a Project Steering Group to provide ongoing oversight and our internal Future Networks Steering Group provided additional oversight.

Effective use of funding

The LCNF project was structured to ensure that it met its delivery criteria by using a strong governance structure to achieve milestones effectively. This included the following:

- A designated Smart Street delivery team was established and given project ownership with weekly operational meetings.
- A Smart Street project steering group with executive-level sponsorship provided oversight through quarterly meetings to provide direction, monitor finances, monitor deliverables, monitor risks, and raise concerns.
- Our Future Networks Steering Group carried out programme progress reviews of Smart Street, overseeing programme management, resources, and costs, and brought in learning from other Electricity North West projects.
- Key deliverables were subject to peer review and sign-off by other DNOs to bring in external feedback, to ensure Smart Street's learning was effective for use by other DNOs and stakeholders, and to promote effective knowledge dissemination.

All the above measures ensured that all project objectives were met. Figure 8 summarises the hypotheses stated in the Smart Street submission and the way that these have been proven as a result of the project.

Figure 8: Summary of Smart Street LCNF project hypotheses

Hypothesis	Proven finding	Outcome
The Smart Street method will deliver a reduction in customers' energy consumption	Analysis of the data generated during the Smart Street trials indicated that a reduction in energy consumption of up to 8% could be expected.	Exceeded
Customers within the Smart Street trial area will not perceive any changes in their electricity supply	Following extensive engagement with customers in the trial areas over the course of the project, there were no reports of any issues relating to the implementation of the Smart Street techniques.	Met

Hypothesis	Proven finding	Outcome
The Smart Street method will have no adverse effects on customers' internal installations or appliances	A consultation was held in conjunction with the Institute of Engineering and Technology (IET) to explore the possible effect of the techniques on customer installations. The outcome was that while there was a small, albeit within design limits, increase in fault level, the reduction in earth loop impedance would lead to faster fault clearances. The consultation found no adverse impacts on customer installations as a result of implementing Smart Street.	Met
The Smart Street method is faster to apply than traditional reinforcement, supports accelerated LCT connection and reduces network reinforcement costs	The Weezap and Lynx devices are both retrofit solutions and as such can be installed much faster than any reinforcement work. Installation of the LV capacitors is more involved but again is still easier than a full cable overlay or distribution transformer replacement. The installation of OLTCs requires the transformer to be replaced, however some benefits can be achieved by adjusting the off-load tap changer to a more suitable position.	Met
The Smart Street method facilitates the prioritisation of the range of solutions across differing LCT adoption scenarios based on a cost benefit analysis to accommodate customers' uptake of LCTs	From the outcomes of the analysis of the data it has been possible for us to create a set of scenarios and understand the optimum combination of equipment to provide the most benefit. From the data it is apparent that the benefits of OLTCs and interconnection are universal across the network conditions encountered.	Met/ Exceeded
The Smart Street method will deliver a reduction in overall losses through network configuration and voltage optimisation	The data generated by the project has shown that even when the system is optimising the network to reduce the energy consumption of the LV network there is a concurrent reduction in HV losses of up to 15%.	Exceeded
The Smart Street method facilitates real time control of a portfolio of LV network solutions, using retrofit technologies with application combined or in isolation	All the devices installed as part of the project were linked into the Siemens SP5 system, a centralised control system linked to our Control Room Management System, and were shown to be controllable from this point.	Met

Rollout post-LCNF project

We have been innovative in how we have developed Smart Street forward, always seeking the best value for customers to ensure that important benefits are carried through into BAU. We have tailored both the IRM and RIIO-ED2 rollout plans to the project, ensuring that wherever possible those customers in vulnerable circumstances are the ones to see the benefit of this technology.

A6 - Relevance and timing of project

The LCNF project was initiated in 2014 when LCT adoption on the distribution networks was minimal. Since then, the role of customer-end transformation in Net Zero has become widely recognised, as has the need for a smarter grid to accommodate LCTs. Three years after the LCNF trial findings were published the Prime Minister announced his [Ten Point Plan], which included ending the sale of new petrol and diesel cars and vans from 2030. In July 2021 Ofgem and BEIS jointly published their Smart Systems and Flexibility Plan, which highlighted the need for DNOs to progress effective outcomes for more active distribution systems. And more recently, the government has issued its British Energy Security Strategy calling for "Accelerating our domestic supply of clean and affordable electricity" and "encouraging all forms of flexibility". The LCNF trials were also completed in time to inform the decision to rollout Smart Street across our network in our RIIO-ED2 business plan, setting the stage for GB-wide adoption of the technologies.

LCTs place an additional burden on the electricity grid. In an estate of domestic properties where gas heating is swapped for electric alternatives and each address makes use of an electric vehicle, the total load on the network could be over six times the peak demand that the network was originally designed for. This scenario would result in the network going below its statutory voltage limits and above its thermal limits. Domestic generation such as solar PV could result in the network going above its statutory voltage limits. If the grid goes above or below its statutory limits, customer appliances might not work as designed.

LCT adoption is expected to skyrocket over the next ten years. According to National Grid's FES, the number of battery-electric cars on the roads in GB is expected to increase from approximately 50,000 in 2017 to up to 13 million in 2030. Low carbon generation on our distribution networks is expected to follow a similar trend. Domestic Solar PV capacity is forecast to increase from approximately 2,500MW in 2017 to up to 9,300MW in 2030. See Figures 9 and 10 for projections from National Grid's FES 2021 and, in particular, the Leading the Way projections – pages 102 and 87, respectively.

Figure 9: FES 2021 Number of Electric Cars on the road

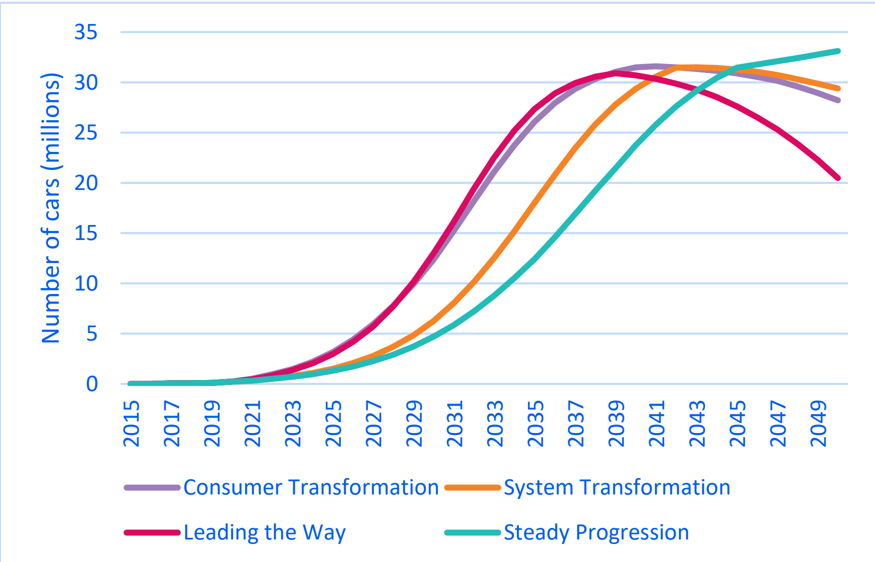
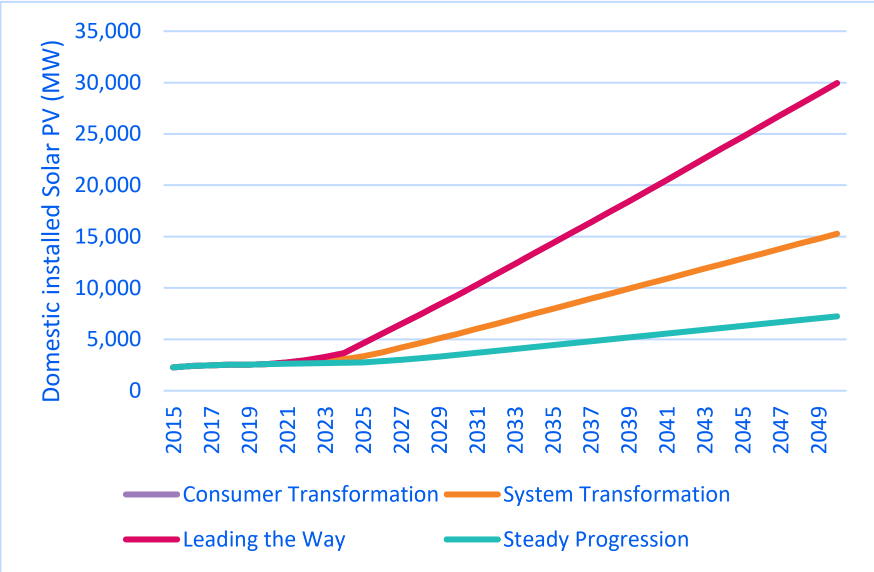


Figure 10: FES 2021 Capacity of domestic Solar PV



> *"As electrification of the economy increases across all scenarios, flexibility becomes increasingly important to help manage peak electricity demands and reduce the need for additional electricity generation capacity." – FES 2022, National Grid ESO*

The LCNF trials demonstrated that Smart Street can optimise the voltage levels on distribution networks to increase the available network capacity for the connection of LCTs, and the timing of the project means that Smart Street technology can be rolled out to the grid just as LCTs are expected to take off in GB. The LCNF project's outputs have led to the rollout of more active distribution networks over the 2020s, coinciding with the significant expected uptake of LCTs. In the North West, we will deploy Smart Street to a further 250,000 customers up to 2028, on top of the 51,250 customers who are already on a Smart Street network as a result of the LCNF project and the IRM rollout. We have been able to focus on areas where LCT uptake over the next decade is expected to cause greater peaks in demand and supply, and cause voltage levels to rise or fall below statutory levels without intervention.

Smart Street is being rolled out to households living in fuel poverty, delivering energy usage savings of up to 8% that will reduce their energy bills without customers having to make any changes. This comes at a crucial time of increasing energy prices and costs of living.

Stakeholders have said that the bill savings as a result of Smart Street have a very positive social impact, and encouragement from customers and representatives of vulnerable customers led to areas of high fuel poverty being prioritised for Smart Street installation in RIIO-ED2. This means that those impacted the most by rising energy prices following the rise in global gas prices and the 54% increase in the energy price cap will benefit from the Smart Street deployments that began in 2020. The price cap is expected to increase again in October 2022, according to a report by the BBC, by as much as 42%. Smart Street, as a non-invasive, easy option for energy savings, is more relevant than ever in the face of the cost of living crisis. This also comes at a time when awareness of consumer vulnerability and addressing fuel poverty is high on all industry agendas.

A7 - Methodology robustness and project readiness

The LCNF project's approach not only delivered robust findings from the trial but also built-in best practice in information dissemination and customer engagement from the beginning of the project. Expert partners, including academic partners from UoM and Queen's University Belfast, ensured the trial and its findings were robust and provided insights across the range of deployment options available from Smart Street. The LCNF project's exceptional customer engagement approach, centred around ECPs, not only reinforced our research into customer impact, but also helped shape the project through feedback and set the foundation for continuous engagement on Smart Street beyond the trial, to the present day.

Information dissemination

Information dissemination was at the heart of the trials, with methodology publications for implementing and optimising Smart Street on GB networks being a key objective of the project. In addition to a range of dissemination activities, such as conferences, webinars, and engagement sessions, the research outputs of the LCNF project were curated to maximise learning for stakeholders. Key learning documents designed to disseminate learning beyond the project progress and closedown reports included:

Technology

- Equipment specification and installation report: a review of the specifications, installation, and configuration of the technologies deployed.
- Commissioning and installation report: a description of how the Siemens Spectrum Power 5 system trialled in the LCNF project can interface with existing control room management systems.

Trial methodology

- Network design: a report outlining the methodology used for designing the LCNF trial circuits.
- Site selection, trial and test regimes and trial overview documents: detailed reports on the LCNF project's trial methodology, including site selection, test regimes, and an overview of results.

Research

- Final voltage and configuration optimisation: a description of the methodology, simulation work, and analysis of trial data to quantify the effects of conservation voltage reduction.
- Final design of interconnected LV networks: a description of the methodology and simulation work for assessing the interconnection of LV networks.
- Final cost benefit assessment and Final report on carbon accounting: methodologies and findings for the cost benefits and potential carbon savings of Smart Street.
- Optimisation implementation strategy: a description of the means by which a communication networks (required to run Smart Street) can be established, and the settings used in the trial

Customer engagement

- ECP reports: lessons learned and findings reports from the engaged customer panels.

IRM rollout

In October 2019, Ofgem awarded Electricity North West £18m in additional funding following the conclusion of the first trial to rollout the Smart Street project to a further 180 distribution substations. The decision by Ofgem recognised the benefits identified in the research carried out in the first trial.

Customer engagement

There is a dedicated page on our website detailing our customer engagement plan and all associated findings.

ECPs representing key demographics were convened to embed continuous customer engagement from customers on the LCNF trial networks. Consultations with the ECP provided important proactive customer research for Smart Street, including discussions focused on both developing and testing engagement plans and materials. In the first stage of customer research, three 90-minute discussions were held with 27 customers from across the trial regions of Cumbria, Lancashire, and Manchester to test awareness materials and share information.

We adapted our customer engagement plan organically in response to feedback from our customers. In one instance, customers told us our plan to advise everyone in the trial locations about theoretical increases in short duration interruptions were confusing and unnecessary. Because of this, we were able to improve our messaging by omitting the confusing material from our communications. This case demonstrated the benefits to the LCNF project's methodology of listening to customers in planning engagements.

We launched a targeted awareness campaign to publicise Smart Street to ensure that as many of the 67,000 customers as possible in the trial area understood the project. The awareness campaign was informed by the LCNF project's ECPs, which worked with us to develop the most effective communication methods. A leaflet providing project information, contact details, and reassurance of expected impacts to customers was distributed. Quantitative research was carried out to evaluate the effectiveness of the leaflet to deliver learning for the project going forward.

Smart Street's exceptional customer engagement continued beyond the LCNF trials and has shaped the Smart Street proposals in our RIIO-ED2 business plan. Customer feedback, for example, through our Consumer Vulnerability Stakeholder Advisory Panel, contributed to our RIIO-ED2 rollout of Smart Street targeting areas where there is a greater concentration of fuel poverty. Customers felt that Smart Street has a very positive social benefit which should focus on fuel-poor customers.

Customer research

Cutting edge customer research was carried out to evaluate the impact that Smart Street has on customers. The findings of this research have provided confidence that customers do not perceive degradation in power quality while benefitting from Smart Street technologies. The confidence in these findings has helped support the wider rollout of Smart Street to customers and fed into other projects and deployments interested in applying conservation voltage reduction to customer supplies.

As well as feeding back into the design of the LCNF project trials, the ECPs enabled us to understand the effects of Smart Street on customers. Two phases of evaluative research were carried out with the ECPs: the first in January 2017 during the trial and the second in January 2018 after the trial had ended to understand whether they had any perceived changes, interruptions, and their overall perception of Smart Street.

The LCNF project also applied data analysis to existing customer engagement systems to support the evaluation of whether Smart Street would affect customers' perceived quality of electricity supply. Before the trial, a process was embedded into our customer query and complaints process to capture all customer communications related to Smart Street. The process identified all 37 enquiries made through the customer contact centre and enabled us to carry out investigations which confirmed that none were related to power quality issues. This research, making use of existing systems and data analysis, has contributed to the confidence in the LCNF project's findings that CVR does not affect customers' perception of electricity supply.

Customer research into the effects of Smart Street has continued beyond the original trial period, adding to confidence in the LCNF project's findings and benefits. In December 2021, we conducted an evaluation of customers perceived impact from the Smart Street IRM rollout by interviewing customers in test and control areas. This research confirmed the findings from the LCNF project.

Social Value Measurement

Studies into the LCNF trials highlighted how traditional cost-benefit analysis is unlikely to measure the full benefits of Smart Street to customers and society. This led to Smart Street being a leading case study in developing a Social Value Measurement framework by Sia Partners and Economic Insight for RIIO-ED2, which helps industry, customers, and Ofgem to better understand the value of investments with hard-to-quantify benefits. Traditional cost benefit analysis focuses on strictly financial costs and benefits to networks, whereas Social Value Measurement monetises outcomes to society, including environmental benefits and financial benefits for customers.

A8 - Other benefits

The LCNF project has brought about several other important benefits.

Significantly, the LCNF project has changed industry attitudes towards CVR. Before the LCNF project, CVR was not accepted in the UK or across Europe at distribution level (although it was possible to purchase an optimiser for private customers). The Smart Street LCNF project is the first project that is now BAU and takes advantage of this concept at grid scale. As a result of the trials, industry thought processes are changing and these techniques are now accepted. This has resulted in a fundamental change to the approach taken by other DNOs to managing the operation of a low carbon electricity system in RIIO-ED2.

Capacitors were included in the trials to provide a boost for the assumed voltage drop along the feeders. The trials found that capacitors were not as useful as we originally believed as this voltage drop was almost negligible, which meant the capacitors were rarely required to provide the voltage boost, as outlined in the closedown report, page 23. This may change as LCT uptake increases, but for the IRM and RIIO-ED2 rollouts we were able to use this learning to ensure that we are only rolling out the most beneficial apparatus.

One aspect of the trials was to test applicability and suitability of LV interconnection. Analysis by our project partners showed that interconnection in particular can have a positive effect on the majority of power quality metrics, outlined in the closedown report on page 32. There can be a negative effect on fault level, but it is not shown to increase beyond design levels. This should be monitored as the demand and generation change on the network.

Reward criterion B

B1 - Details and significance of DNO additional contribution

We have not invested any additional contribution and therefore offer no evidence against this criterion.

B2 - Issues that justified additional contribution

We have not invested any additional contribution and therefore offer no evidence against this criterion.

B3 - Demonstrable benefits to customers

We have not invested any additional contribution and therefore offer no evidence against this criterion.

Reward criterion C

C1 - Demonstrate where the project has delivered more learning than was expected

There are a number of areas where learning from the LCNF project exceeded what was originally anticipated.

Additional customer energy savings

The LCNF trials demonstrated that Smart Street technologies deliver significant customer energy savings, beyond what was first anticipated. For the LCNF submission TNEI calculated a saving of £18 per customer. The LCNF project proved that we could achieve a higher energy consumption reduction, leading to an increased benefit of £54, which is a direct bill reduction for customers on LV networks.

Once it became apparent that the project could achieve further benefits than originally anticipated, the project team demonstrated an appetite to push the envelope and achieve these benefits for customers, rather than stopping once the anticipated benefits had been realised.

This customer saving was the main driver behind our decision to apply for an adjustment under the IRM to fund a BAU rollout of Smart Street within RIIO-ED1. Due to the nature of the way these benefits present within the energy system a rollout within this price control would provide little benefit to Electricity North West, as they mainly accrue to the customer.

Hardware resilience

During the trials, a number of sites had trouble maintaining communications due to the signal strength of the 3G network. As part of the trials, we installed high gain aerials with some success. However, the closedown report recommended on page 34 that for a BAU approach, other solutions such as roaming SIMs or NarrowBand-Internet of Things should be considered to maximise the availability of the Smart Street technology for voltage optimisation. This additional learning was then applied in practice and, as a result, the business is now using roaming SIMs as standard for all mobile communications.

Another incremental piece of learning was that the LV network is more robust than originally anticipated. Monitoring and analysis showed that headroom does already exist to cater for the adoption of some LCTs, but as adoption increases, the use of voltage control and interconnection can provide even more headroom and thereby defer reinforcement.

Network type

We also aimed to understand the differing effect of the technology on a full range of network types found in the UK. The trials found that, in practice, energy consumption reduction is not dependent on network type, and the learning demonstrated that every customer can expect to get the same reduction of 5-8%.

Current / voltage relationship

The learning from the relationship between current and voltage identified in the Smart Street (and CLASS) LCNF project has given rise to another evolution of the project through our QUEST project. Reducing system voltages reduces demand on the network, which can result in a reduction in peak loads at critical sites and therefore release latent thermal capacity, allowing deferral or mitigation of the need for reinforcement. QUEST will build upon the learning from the LCNF project to co-ordinate this technique with other methods for creating capacity, i.e. CLASS and Active Network Management, enhancing the benefits associated with Smart Street.

C2 - Additional learning as a result of exceptional effort of the DNO

During the trials, we put in additional effort to engage proactively with customers in relation to our installation of street furniture. This strategy ensured that the project team was able to manage customer enquiries on a case-by-case basis and resolve each one amicably in advance of the installation work.

We took exceptional effort to tailor solutions in response to customer concerns. We received a number of the enquiries as a result of engagement related to the positioning of the metal cabinets designed to house LV capacitors and end-point monitors. The majority of these were resolved by agreeing to relocate them to a more acceptable position or by committing to removing the cabinets at the end of the trial. However, there were three complaints related to the flat lids on the cabinets – customers were concerned these lids would provide a seating area that would encourage anti-social behaviour or provide a climbing aid. After discussion, we came to an amicable resolution by constructing and retro-fitting the cabinets concerned with sloping lids, which made climbing or sitting impossible, thus resolving the perceived issue quickly.

This early, proactive engagement proved critical in achieving customer acceptance of the required street furniture. This helped to mitigate the risk of customer complaints at a later point in time. It also allowed sufficient time to facilitate technical redesign in advance of the installation work, thereby negating costly post-construction relocation costs. This additional learning, particularly in relation to the sloping lids, will be taken forward and applied to future projects, and has been translated to other specifications for street furniture. Further detail can be found on p.39-40 of the closedown report.

C3 - Exceptional capture and dissemination of learning in a way that maximises value for all customers

We deployed a variety of information dissemination techniques during and after project conclusion to ensure that all learning was captured and disseminated to reach as many stakeholders as possible and to maximise value for customers. These techniques included online publication of academic papers written by our project partners and in-person dissemination of learning at multiple industry conferences, such as partner events, webinars, and learning events, in addition to the requirement for participation at the annual Low Carbon Networks & Innovation (LCNI) conference.

More recently, in January 2021, we also facilitated a DNO-only event run by the innovation team to share ongoing learning from the RIIO-ED1 rollout and plans for further rollout during RIIO-ED2. Attendees included representatives from SPEN, SSEN and UKPN, and the aim was to assist in their preparations around implementing Smart Street techniques in RIIO-ED2.

Schneider Electric's core product

The optimisation software was provided by Siemens in the LCNF project. Since the conclusion of the LCNF project we have contracted with Schneider Electric (SE) to provide our NMS.

Smart Street contributed towards improving SE's core NMS product so that it can efficiently accommodate Smart Street technology, allowing us and other DNOs to maximise savings for customers where Smart Street is deployed. Project learning helped to enable this by demonstrating that the optimisation solution used in the trials was not ideal for BAU. As a result, SE developed the optimisation software module, which can be added to our NMS – it is this module that we use in our BAU operation of Smart Street.

Other DNOs can now purchase SE's NMS including the optional "add-on" optimisation module, should they choose to adopt voltage optimisation onto their networks to maximise value for their customers. Alternatively, they can also use the functional requirements published on our website to produce the optimisation module in their own NMS.

Modelling and data sharing

We recognised the importance of understanding the benefits not only to the network as configured at the time of the trials, but also to the electricity networks of the future, and thus produced 54 comprehensive modelling scenarios in an attempt to cover most eventualities. These scenarios considered factors such as the network type (dense urban, urban and rural), different optimisation modes (OLTCs only, OLTCs and capacitors, and OLTCs, capacitors and meshing), type of day (summer or winter) and year (2017, 2035 and 2050).

Monthly data was transferred to the academic project partners to enable the creation and validation of these models and to allow them to conduct a direct assessment of the benefits of optimisation. Other academic institutions have since requested this data to assist in their own research.

The following academic papers, on modelling as well as other areas, are an example of what is available online in relation to the LCNF project and provides interested stakeholders with access to this element of the project learning:

- Smart Street project – key findings from final deliverables – University of Manchester (2018)
- Report on the carbon impact implications of the Smart Street Method at Electricity North West and Great Britain scale – University of Manchester (2018)
- Smart Street: A real UK Smart Grid project and its applicability to the Chilean context – University of Manchester (2017)
- Final Interim Report on Power Quality Impacts of CVR – Queen's University Belfast (2017)
- Report on the performance trade-off or otherwise between loss reduction of HV and LV CVR – Queen's University Belfast (2017)
- Interim report on the performance of the adopted methods, potential improvements and potential new approaches – Queen's University Belfast (2017)
- Impacts of CVR on customer power quality in future networks – Queen's University Belfast (2016)

Awards and recognition

The LCNF project was recognised as 'Innovation Project of the Year – Electricity' in 2020 by Utility Week through the Network Awards. The Network Awards recognise individuals and organisations who demonstrate exceptional performance in the energy networks space, and Smart Street was selected as the winner despite tough competition from innovation projects submitted by National Grid, UKPN, WPD and NPG.

The project has also been featured in a number of online publications, including the Guardian, Energy Live News, Network and Current News.

Adoption by other DNOs

The project found that Smart Street is transferable to 54% of our network and 72% of the GB network, and represents a low intervention, high acceptability method that can achieve significant benefits including being rolled out without impacting customers' perception of their quality of supply.

Some DNOs have said they will rollout similar technology, or parts of the Smart Street system, thus maximising value to customers.

SSEN indicated in its RIIO-ED2 Business Plan that it would like to integrate a 'light' version of Smart Street, detailed on p.83. On page 130 of Annex 10.2, SSEN proposed developing the capability to operate and manage the LV network in real-time, by rolling out real-time monitoring infrastructure and LV automation technologies across their LV network.

All the technologies SSEN referenced, on page 46 of Annex 12 its, as "Innovations which have influenced our load-related expenditure proposal" were Smart Street technologies including:

- OLTC at lower voltages: SSEN proposes approx. 130 deployments
- LV Meshing

NPG adopted Smart Street as a proof of concept enabling its own project trial called BEET, see pages 15-18. Smart Street learning around reducing energy consumption, customer research, and methodology fed into the BEET trial, and in particular, by proving the CVR hypotheses and demonstrating that voltage reduction can be implemented without affecting customer quality of supply. NPG is proposing to invest £7.9m to further deploy the BEET trial project and potentially roll it out across the whole of its network, see page 76 of NPG's RIIO-ED2 business plan.

SPEN is installing OLTCs in HV/LV substations at 19 sites, as per page 19 of its RIIO-ED2 business plan, and increasing automation at LV over 122 locations, as per page A19 of Annex 4A.1 of their RIIO-ED2 business plan.

NIEN has discussed Smart Street with us and is investigating integrating the techniques based on the LV active network management component of Smart Street as part of its next price control in 2024. They refer to this as DRVC and LVANM.