CLASS

Second Tier Reward Application

1st August 2022

Contents

Executive summary

Welcome to the Second Tier Reward application for our award-winning Customer Load Active System Services (CLASS) project. Through the exceptional efforts of Electricity North West and our project partners, CLASS delivered significant learning that resulted in Electricity North West becoming the **first DNO to provide balancing services** to National Grid Electricity System Operator (the ESO), improving competition in the market. It has led to changes in the regulatory framework and delivers significant benefits for customers.

CLASS has **fundamentally shifted industry attitudes** regarding the utility and deployment of the voltage/demand relationship. The robustness of the methodology developed for CLASS and our significant efforts provided Ofgem with the confidence to change the regulatory framework, bringing to the market a ground-breaking, highly competitive balancing services product. CLASS has **delivered £5.22m of savings** for our customers up to June 2022 and is expected to provide net savings of between £0.9bn and £1.2bn over the next 30 years by displacing more expensive technology under a central scenario, see page 29 of the Ofgem Impact Assessment.

In October 2021, the Government brought forward the commitment for a net zero electricity system from 2050 to 2035. Scaling intermittent generation and connecting Low Carbon Technologies (LCTs) drives urgency for more balancing services, which CLASS is positioned to provide. A GB-wide rollout across all Distribution Network Operators (DNOs) would mean a contribution of up to 2.8GW of capacity for balancing services, see page 27 of the closedown report.

Unlike other balancing services on the market today, the operation of CLASS does not generate carbon emissions – the carbon savings alone from displacing alternative, carbon intensive balancing services are sufficient to justify investment in CLASS. CLASS has **delivered carbon emissions reductions of 28,760tCO_2e** in the reserve balancing market from 2019 to 2021, a significant increase on the 2,288tCO_2e per year anticipated on page 20 of the Low Carbon Network Fund (LCNF) submission.

CLASS demonstrated that more capacity could be released than originally anticipated in the LCNF submission. It can be implemented cheaper and faster than traditional reinforcement; a 5% voltage reduction would **create 3.3GW of capacity**, resulting in deferred reinforcement costs of £78m, see page 37 of the closedown report.

To gain additional learning we increased the level of testing, producing a larger and richer data set for analysis. To further assure our learning, we discussed follow-on research and funding with Ofgem to investigate the balancing services market, who accepted our proposal, enabling our delivery of the CLASS extension project.

We took exceptional efforts to engage our customers to ensure that they did not perceive any changes to the quality of their electricity supply, including using an innovative, but highly effective, method for developing and refining the customer engagement documents through the use of an Engaged Customer Panel (ECP).

CLASS is now **fully embedded as Business as Usual** (BAU) across our area, delivering balancing services multiple times each day. Other DNOs are considering deployment in RIIO-ED2 pending a decision from Ofgem on its regulatory treatment. It has cross-fertilised learning among technology providers leading to companies, such as Fundamentals and Schneider Electric, investing to upgrade their off-the-shelf products to provide the CLASS functionality.

Leveraging robust governance processes and existing assets and knowledge ensured that CLASS spending was efficient, with the project being delivered significantly under budget.

Project details

Figure 1: Summary of CLASS Second Tier LCNF project

Tier 2 project name	Project Summary	Second Tier funding £k*	Licensee compulsory contribution £k*	Other contributions £k*	Link to closedown report
Customer Load Active System Services (CLASS)	An innovative solution that manages electricity demand by controlling voltage to cut energy bills and carbon, and provide balancing services to the ESO.	7,174	810	911	Closedown report

**nominal prices*

CLASS was submitted to the Second Tier LCNF to investigate whether the application of innovative voltage management technologies could be used to reduce peak demand and defer network reinforcement. The trials revealed that CLASS could deliver greater benefits by providing a demand response service to the ESO as part of the balancing services market.

CLASS ran for 2 years and 9 months, was delivered on time and under budget, as detailed in the response to Criterion A5, and proved five hypotheses through four distinct trials.

Figure 2: CLASS hypotheses

Hypothesis	Proven
The CLASS Method creates a demand response and reactive absorption capability through the application of innovative voltage regulation techniques.	✓
Customers within the CLASS trial area do not notice any impact on their power quality when the innovative techniques are applied.	✓
The CLASS Method shows that a small change in voltage can deliver a meaningful demand response, thereby engaging all customers in demand response.	✓
The CLASS Method defers network reinforcement and saves carbon, by the application of demand decrement at times of system peak.	✓
The CLASS Method uses existing assets with no detriment to their health.	✓

CLASS LCNF project

Trial 1: load modelling – using data from network tests, our project partner, University of Manchester (UoM) developed an innovative 365-day, 24-hour voltage/demand relationship matrix which, using substation characterisation, was applied to each primary substation enabling a real-time estimation of the demand response available.

Trial 2: peak demand reduction – using the CLASS dashboard, developed during the project, we tested manual and automatic voltage reductions to reduce peak demand and demonstrated that a voltage reduction of 5% could yield up to a 6.5% demand reduction, without any impact on customers' supply, and therefore defer the capital replacement of primary transformers.

Trial 3: frequency response by demand management – we tested primary (automatic disconnection of one of a pair of primary transformers) and secondary (tapping down both primary transformers) frequency responses, which proved that CLASS could provide a primary response in less than 500ms and a secondary response in 20-120s, within existing frequency market timeframes. This learning allowed us to apply for a project extension to investigate how a DNO could participate in the balancing services market, delivering both significant financial and carbon benefits for customers.

Trial 4: reactive power absorption – demonstrated that DNOs could deliver reactive power absorption using the tap staggering technique on a pair of primary transformers. The trial showed that there is potential to provide reactive power services to the ESO, should it require them, resulting in significant benefits. This service could be used to defer the need to replace existing assets or potentially remove the need for new installations. The tap staggering method offers a flexible, dynamic, cost-effective and low carbon solution to existing voltage management techniques applied by the ESO on the transmission network.

Customer engagement – in parallel with the trials we conducted significant and robust customer engagement, which included distributing leaflets to all 485,000 customers on the trial networks, conducting focused surveys and convening ECPs. This research showed that implementation of CLASS has no detriment to power quality and is indiscernible to customers.

CLASS extension project

Following the learning gained from the frequency response trials we sought permission from Ofgem to extend CLASS in terms of scope and timescales, using the funding remaining from the LCNF project budget to demonstrate how the technology can be deployed commercially by DNOs into the GB electricity market.

This research proved that there was significant potential for this technology to reduce customer costs, and the use of CLASS could result in material reductions in CO_2 emissions associated with holding and using plant for balancing services. The overall effect of delivering more dependable voltage control is a net positive for the security of the system.

CLASS rollout

Following the successful delivery of CLASS and the exceptional learning around the use of voltage reductions to elicit a demand response, we successfully rolled out the BAU solution to 257 (78%) of our applicable primary substations, and the core technology is now our standard solution for voltage control at primary and grid substations.

The LCNF submission benefits were based on the release of capacity for our network, but the project proved there is greater value to GB customers through our participation in balancing services. Therefore, since 2019 we have been actively participating in the balancing services market, which is an unprecedented step for a DNO. Using Directly Remunerated Service (DRS) 8 we share the benefits of this participation with our customers and have returned £5.22m to customers up to June 2022.

CLASS has resulted in a change in industry attitudes and the ESO has verified that it meets the performance requirements for the relevant balancing services and increases competition in the market. This change in industry attitudes is also reflected in the RIIO-ED2 business plan guidance, where Ofgem specifically asked DNOs to articulate how they would use CLASS, and by the recently-issued Ofgem consultation on the treatment of CLASS in RIIO-ED2. In the consultation Ofgem is “minded to” allow DNOs to continue to participate in the balancing services market using DRS8 to share the benefits with customers, thereby endorsing and supporting the use of this exceptional innovation.

Evidence of critical outcomes

Reward criterion A – exceptional performance against one or more of the detailed criteria

A1 Facilitating the carbon plan: CLASS has already delivered carbon emissions reductions of 28,760tCO_2e through its use in the balancing market, substantially higher than the 2,288tCO_2e per year anticipated in our LCNF submission.

A2 Releasing network capacity: the CLASS trials showed that a voltage reduction of 5% with a corresponding demand reduction of 6.5% was achievable, rather than the anticipated 1.5% voltage reduction and 1.5% demand reduction.

A3 Delivering financial benefits: revenues generated by CLASS are shared between the DNO and its customers and to June 2022 CLASS returned £5.22m to customers. An independent review by Baringa identified additional savings of £1.2bn due to the displacement of more expensive balancing services. When used for peak demand reduction, CLASS could create 3.3GW of capacity and defer reinforcement costs of £78m.

A4 Rollout across system/GB: CLASS has seen the unprecedented use of a DNO network to provide a response in the balancing services market. It is a BAU solution rolled out to 78% of our applicable substations and two other DNOs have proposed deployment in RIIO-ED2. It has also influenced product design among technology providers.

A5 Value for money to customers: CLASS was delivered under budget, with the LCNF project costing £7,214k instead of the expected £8,098k and the extension costing £465k instead of £622k. Robust governance processes and leveraging our existing assets and knowledge ensured that CLASS spending was efficient.

A6 Relevance and timing: CLASS has changed the balancing services landscape, and Ofgem has approved the CLASS demand side response use case. Finding low carbon alternatives to conventional balancing services at a reasonable cost is necessary for net zero but is a significant challenge – CLASS provides an affordable, zero carbon option.

A7 Methodology robustness and project readiness: the robust methodology developed for CLASS and our significant efforts have provided Ofgem with the confidence to allow CLASS to bid into the balancing services markets. Several aspects of the CLASS methodology have been adopted by other DNOs and innovation projects.

A8 Other: CLASS increases security of supply by reducing the need for automatic disconnection as part of the OC6 buffer and provides grid side demand response "invisible" to customers, where no complex changes are needed in behaviour or markets.

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

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

Reward criterion C – exceptional effort to ensure CLASS exceeds the expected delivery outcomes and the learning is maximised for the good of all DNO customers.

C1 Delivered more learning than expected: CLASS achieved more learning than expected with respect to the voltage/demand relationship, which had a positive, cascading effect for technology providers. We also took exceptional effort to gain confirmation from Ofgem to apply the learning to provide a new service to the ESO.

C2 Additional learning due to exceptional effort: we put in exceptional effort to gain additional learning through increasing the number of test sites to produce a larger and richer data set for analysis. We took exceptional efforts to engage our customers to ensure they did not perceive any changes to their supply quality. To further assure our learning we discussed follow-on research and funding with Ofgem, who accepted our proposal, enabling our delivery of the CLASS extension project.

C3 Exceptional capture and dissemination to maximise value for customers: CLASS was the first Second Tier LCNF project to harness the various forms of communications technology for pushing information to stakeholders, including using social media and webinars. We held bilateral discussions with other GB DNOs and invited them to visit us to see the technology and discuss its implementation with the project team.

Reward criterion A

A1 – Aspects of the Carbon Plan that have been facilitated

The deployment of CLASS reduces carbon emissions by displacing carbon intensive technologies that would otherwise be used for balancing services and by deferring embedded emissions in assets used for reinforcement. Our analysis in this section focuses on the former as it represents the primary carbon savings benefit from the deployment of CLASS.

CLASS has delivered larger carbon emissions reductions in the response and reserve balancing markets than anticipated in our LCNF submission. Using the Government's latest carbon values, the projected carbon savings from CLASS alone are sufficient to cover the cost of its deployment in a medium rollout scenario where it is deployed in three of the six DNOs.

CLASS was conceived as an opportunity to investigate whether the application of innovative voltage management technologies could be used to reduce peak demand and provide demand response services to the ESO. Both of these objectives meet the requirements of the Sixth Carbon Budget which outlines a need for "An increasingly flexible system, including from demand-side response (with 20% of demand being flexible in 2035)", see page 115, and the Clean Growth Strategy which calls for "Delivering clean, smart, flexible power" and for customers to "benefit from a smarter, more flexible power system to keep down costs", see pages 15 and 98. CLASS also aligns with Government ambitions in more recent publications including the Net Zero Strategy which, in turn, joins up with the second edition of the Smart System and Flexibility Plan. The Government's British Energy Security Strategy (April 2022) further underscores and encourages all forms of flexibility. All these strategies call for greater power system flexibility and demand side response for the ultimate goal of reducing carbon emissions.

The learning from this project has been adopted by various parties for different purposes, and perhaps the most salient are Ofgem's decision to endorse CLASS for the provision of balancing services and Ofgem's "minded to" position, which supports its continued use in RIIO-ED2. Table 6 on page 25 of Ofgem's Impact Assessment on the regulatory treatment of CLASS in RIIO-ED2 confirms that CLASS meets or is expected to meet the requirements for a range of balancing services. This new form of demand response has been successfully proven and accepted by the ESO as compliant with balancing services specifications. Subsequently it has been incorporated into the regulatory framework for RIIO-ED2 and can be deployed commercially at scale.

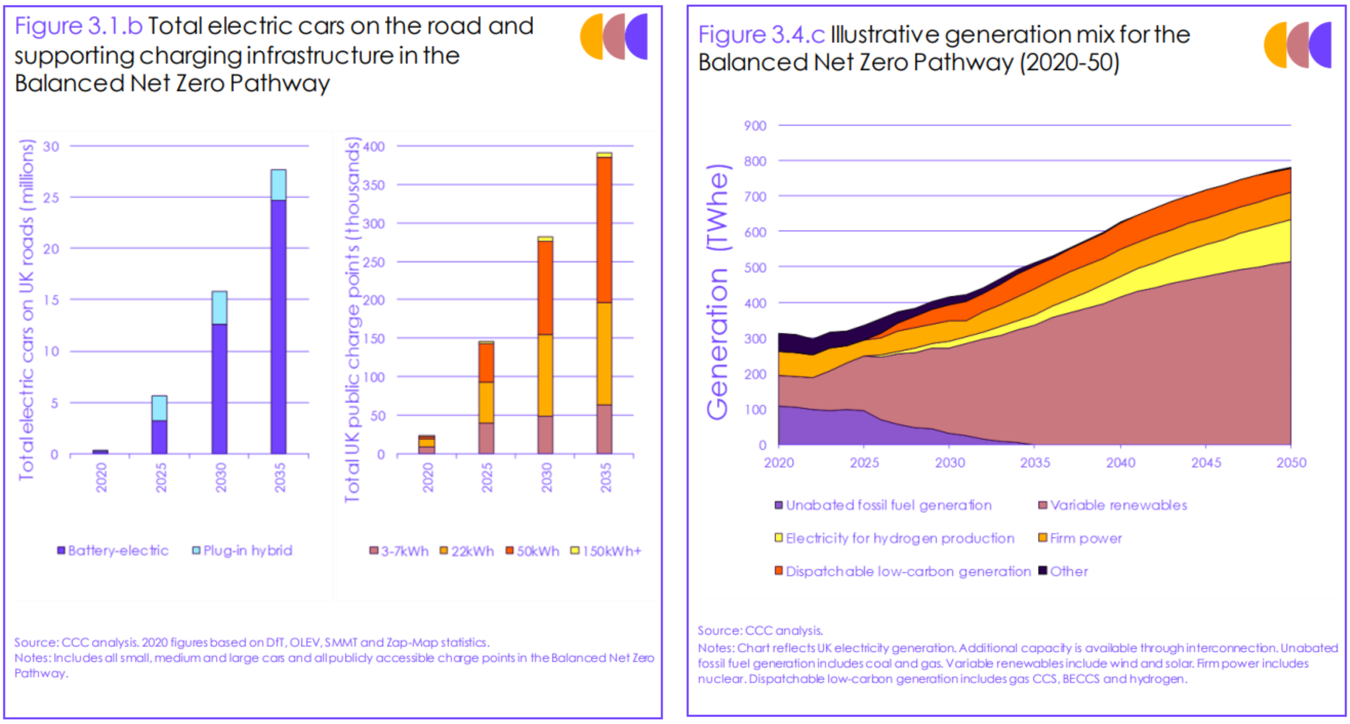
As GB moves towards a low carbon future, electricity demand and the level of renewable and low carbon distributed generation is expected to increase. This will introduce several network issues for GB electricity network operators:

- Increases in demand from the electrification of heat and transport will reduce network spare capacity.
- Excessive voltage levels can occur when high distributed generation outputs coincide with low local demand.
- The mis-match between demand and supply as a result of intermittent renewable generation can lead to constraints for which the solution is curtailment. However, curtailment decreases efficiency, increases carbon emissions and increases costs for customers.
- A generation mix with more intermittent renewable generation will result in lower inertia. As a consequence, there will be a greater need to use system reserves to

maintain system stability and avoid outages. Conventional spinning reserves carry both a high financial and carbon cost.

Addressing these network issues will help promote the objectives of the Sixth Carbon Budget, which calls for increases in Electric Vehicles (EVs), distributed generation and renewable energy generation (see Figure 3 taken from pages 98 and 136), as well as help [decarbonise the GB power system by 2035](). CLASS provides a method to address these challenges.

Figure 3: EV and renewable generation growth projections from the Sixth Carbon Budget



Carbon reduction in support of the Carbon Plan and the Clean Growth Strategy

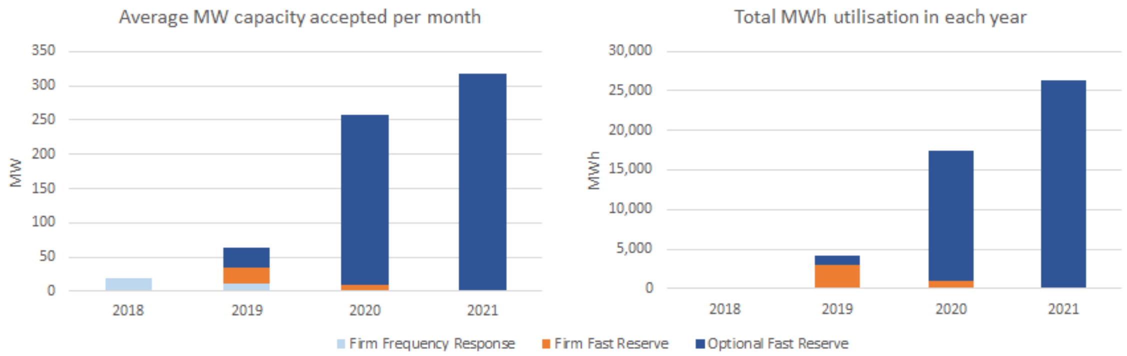
On page 12 of our [LCNF submission]()we estimated that the deployment of CLASS could reduce carbon emissions by 2,288tCO_2e per year when it is deployed across our area and used to offer reserve and frequency response services to the ESO. If it was deployed across GB, we estimated it would reduce carbon emissions by 29,637tCO_2e. The carbon savings were estimated assuming CLASS displaced current providers in the Fast Reserve and Firm Frequency Response markets and that CLASS was activated for one hour each day.

In addition, we highlighted that CLASS could be deployed to provide reactive power services to help manage energy flows across the transmission system. The ESO procures reactive power services through various market mechanisms or by installing compensation equipment, such as Static Synchronous Compensators (STATCOMs). STATCOMs typically have an active power loss of 0.5% to 0.75% of the reactive power output, resulting in carbon emissions when they are used.[1] In contrast, the provision of reactive power services using the tap staggering method available from CLASS does not increase carbon emissions. Based on these observations, the Tyndall Centre estimated the deployment of CLASS across Electricity North West could reduce carbon emissions by 25,845tCO_2e per annum by avoiding the need to install and operate STATCOMs with their associated power loss, see page 12 of our LCNF submission.

[1] As per Haghighat & Canizares 2010

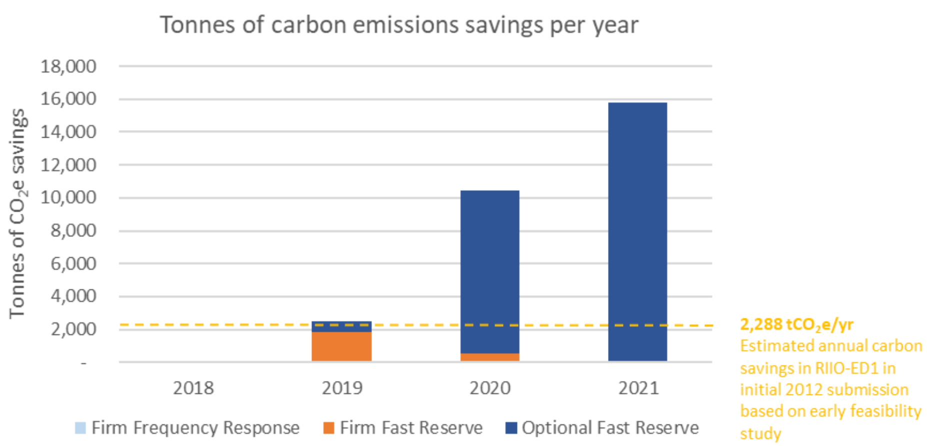
To date, we have used CLASS to offer reserve (Firm Fast Reserve and Optional Fast Reserve) and response (Static Secondary Fast Frequency Response) services to the ESO. CLASS was first bid into the balancing services market in February 2018. Since then, it has provided between 19 and 319MW of capacity per month to the ESO and has been used for a total of 47,800MWh. Around 90% of the deployment of CLASS has been for Optional Fast Reserve, as shown in Figure 4.

Figure 4: Capacity accepted and utilisation of CLASS



We have recalculated the emissions savings from the use of CLASS to provide a like-for-like comparison between out-turn carbon savings and those estimated in our LCNF submission. Assuming CLASS displaced gas generation and pumped storage it delivered 28,760tCO_2e savings over the period of 2019 to 2021 (see Figure 5). This is several times larger than originally expected and is primarily because CLASS has been activated more frequently than originally anticipated, demonstrating its exceptional value as a balancing service. Whilst over time the expectation is that batteries will become the marginal service provider, it has historically been fossil fuel-powered generators and pumped storage units that have provided reserve and response.

Figure 5: Carbon emission savings from CLASS

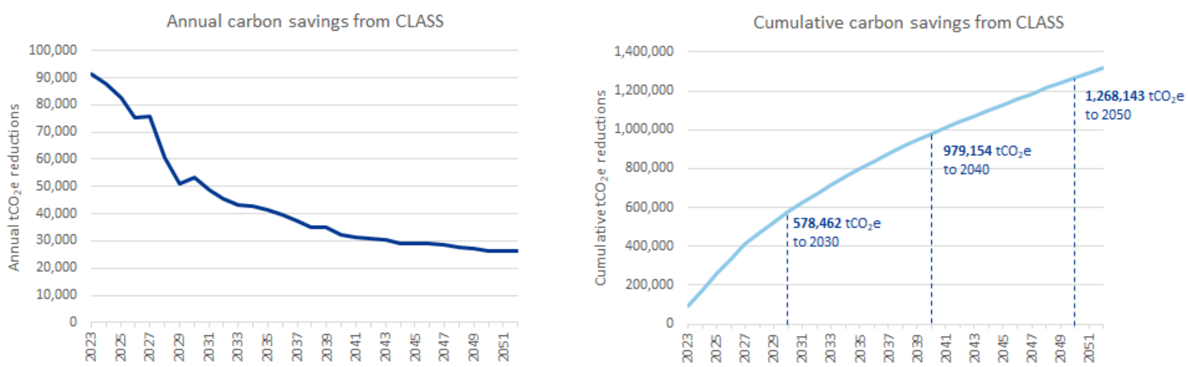


CLASS has not been deployed to provide reactive power services to date. However, the CLASS trial demonstrated that configuring CLASS to set different tap positions on each transformer could provide significant reactive power services. Table 6 in Ofgem's Impact Assessment on the regulatory treatment of CLASS in RIIO-ED2 confirms that CLASS meets, or is expected to meet, the requirements for a range of reserve, response and reactive power services.

The deployment of CLASS by other DNOs provides the opportunity to deliver additional carbon savings in the longer term, beyond those already realised by Electricity North West. Several DNOs have committed to rolling out CLASS in their RIIO-ED2 business plans (see criterion A4 for further details). Considering the relative size of each DNO, and that our deployment of CLASS provides 150-300MW of response, we expect the future deployment of CLASS for balancing services to provide around 1.3GW. This is within the range of the 795MW to 1,591MW of estimated response available in a medium rollout scenario based on Ofgem's analysis of the RIIO-ED2 plans, see page 25 of the Ofgem Impact Assessment on the regulatory treatment of CLASS in RIIO-ED2. The actual level of deployment could be higher if other DNOs commit to deploying CLASS following the conclusion of the consultation on its regulatory treatment in RIIO-ED2.

The deployment of 1.3GW of response for balancing services would save between 50,000 and 90,000 tonnes of CO_2 per year in the 2020s (see Figure 6) assuming CLASS displaces batteries that charge at the grid-average carbon intensity. The carbon savings will fall steadily over time as the carbon intensity of the grid reduces with the deployment of more low carbon generation. Our analysis is conservative and attributes only the carbon associated with the efficiency loss from the charging cycle of the battery (c.8%) and not the full carbon emissions from the production of the electricity. Further details of our analysis can be found in the June 2021 Assessment of the Impacts of CLASS deployment Baringa report previously shared with Ofgem.

Figure 6: Annual and cumulative forecast carbon savings from CLASS



In the analysis referred to above, the carbon savings were estimated to be equivalent to £76m in present value terms (2020/21 prices). We have updated this to reflect the deployment of CLASS in other DNOs from RIIO-ED2 onwards and updated emissions factors to align with Ofgem's Impact Assessment on the regulatory treatment of CLASS for RIIO-ED2. This results in the present value benefit rising slightly to £83m to 2050 (see Figure 7). On page 29 of Ofgem's Impact Assessment the carbon savings are quoted as £14m (2020/21 prices). Our understanding is that the underlying carbon savings in the Ofgem assessment are similar, but in converting this to a monetary value Ofgem has subtracted the UK Emission Trading Scheme (UK ETS) price from the carbon benefits value to avoid double counting carbon costs included in balancing service bids.

Applying the Government's latest net-zero consistent carbon values to our estimate of carbon savings would result in the investment in CLASS being justifiable on the carbon savings it delivers alone. In September 2021, the Government announced a step change in its carbon valuation approach to align the carbon values used in policy appraisal with net zero commitments. The carbon valuation approach recognises that additional measures will be needed in the traded sector beyond the UK ETS and therefore the £/tCO_2e figures applied should be significantly higher than used previously. For example, the Government's carbon value for 2023 in its latest publication is £252/tCO_2e whereas the previous analysis we shared with Ofgem used a value of £34/tCO_2e for that year[2]. Using the latest carbon values would result in CLASS delivering £367m of carbon savings in present value terms (2021/22 prices) to 2050 under in a medium rollout scenario (see Figure 7). This demonstrates the high value of CLASS in supporting net zero by helping to decarbonise electricity supply.

Figure 7: Estimated carbon savings from deployment of CLASS for reserve and response in medium rollout scenario

	2020 carbon values	UK Government latest carbon values
To 2030	£27m	£267m
To 2040	£58m	£353m
To 2050	£83m	£367m
Whole-life	£87m	£369m

A2 – Releasing network capacity

Demand reduction at peak loads leading to significant release of network capacity

CLASS provides a quickly deployable technique for releasing network capacity through voltage reduction at times of peak loading to reduce peak demand. This provides benefits to customers by deferring reinforcement, and the associated savings are passed onto customers through a reduction in bills.

In our LCNF submission, we expected the primary benefit of CLASS to come from releasing network capacity. Following the CLASS extension and demonstration of the commercial value of CLASS for balancing services, this latter use case took precedent. However, the value CLASS provides from deferring reinforcement is still of significant benefit to customers and is, in fact, larger than we originally expected after adjusting for changes in expected load growth, thus demonstrating the exceptionality of CLASS.

On page 11 of our LCNF submission we forecast that CLASS would release 69MVA of network capacity if deployed across all of our primary substations. This assumed that CLASS would deliver a 1.5% reduction in voltage, which would translate into a 1.5% reduction in peak demand – a one-to-one relationship. The reduction in peak demand would defer reinforcement of fourteen primary substations and the associated £6.7m reinforcement costs. In addition, we highlighted that the implementation of CLASS could be done 57 times faster and 12 times cheaper than traditional reinforcement.

The actual capacity released from CLASS exceeded our expectations in two respects:

1. *The reduction in demand for a given percentage reduction in voltage was higher than expected.* The CLASS trials demonstrated that a 1% voltage reduction at a primary substation produces a seasonal average real power reduction of between 1.3% and 1.36%, which is greater than the one-to-one relationship that was previously assumed, see page 33 of the closedown report. In addition, the project has produced significant learning for DNOs, academics and global industry on the relationship between demand and voltage. Analysis of the trial results by UoM has

[2] Annex 1 of the Valuation of greenhouse gas emissions: for policy appraisal and evaluation

shown that the demand response changes both seasonally and daily and has quantified the relationship between voltage and demand for different load compositions. We have proactively disseminated the learning to industry and are applying them in our BAU activity.

2. *The maximum voltage reduction that can be achieved by CLASS was higher than assumed in the benefit calculation for the LCNF submission.* The CLASS trials demonstrated that voltage reductions of 3% and 5% could be achieved through two and three tap changes, respectively. As part of Trial 2 – peak demand reduction – we tested whether customers perceived any changes in their power supply under these larger voltage reductions. Our detailed monitoring of customers determined that the percentage of customers reporting a change in their power quality actually fell between the baseline surveys conducted prior to the CLASS trials and the surveys conducted during the trials (21% compared to 15%). Further analysis showed that only a small percentage of power quality issues reported during the trial could have conceivably been associated with CLASS. These were thoroughly investigated and, in each case, it was proven that these power quality issues were unrelated to CLASS, see page 21 of the closedown report. At the same time, overall satisfaction amongst the survey population remained relatively high, with 90% of customers giving us a score of 8 out of 10 or higher. This showed that even where customers perceived a change in power quality, their overall satisfaction with their supply was unaffected.

The increased sensitivity of demand to voltage changes and the larger reduction in voltage achievable has increased the network capacity released by CLASS. On page 11 of the LCNF submission we forecast a capacity release of 69MVA, whereas, as stated on page 4 of the closedown report, the deployment of CLASS across Electricity North West releases:

- 57MVA (summer minimum) to 163MVA (winter maximum) for a 3% voltage reduction
- 94MVA (summer minimum) to 271MVA (winter maximum) for a 5% voltage reduction

Scaled up to GB, CLASS has the potential to unlock 1.2GW (summer minimum) to 3.3GW (winter maximum) of demand response. To demonstrate the scale, this is equivalent to two combined cycle gas turbine power stations, facilitating the deferral of a significant proportion of reinforcement. This would be in addition to benefits delivered through use of CLASS for balancing services.

The immediate benefits to customers from this network capacity release are lower than originally expected due to slower than expected load growth over the period. However, with the anticipated rise in connections of LCTs over the 2020s, which will increase the utilisation of assets, the benefits are anticipated to grow.

A3 - Delivering financial benefits

CLASS delivers financial benefits by:

- *Displacing more expensive technologies used for balancing services:* an independent review conducted by NERA (2022)[3] and commissioned by Ofgem identified savings of £883.4m, which is additional (exceptional) to the base case as balancing services was not included as a use case in the LCNF submission.

[3] Impact Assessment for CLASS – Supporting Annex

- *Releasing capacity and deferring the need for reinforcement:* the CLASS method can be implemented 12 times cheaper and 57 times faster than traditional reinforcement. A 5% voltage reduction would create 3.3GW of capacity resulting in deferred reinforcement costs of £78m.

Displacing balancing services

The largest benefit delivered to date from the deployment of CLASS is the avoided cost of alternative balancing services providers. If CLASS provides balancing services, then the electricity system will require lower provision from other technologies. The system will then either avoid the direct costs of deploying and operating the more expensive alternatives, or the opportunity cost of the capacity not being available to provide other services. Historically, CLASS has displaced fossil fuel generation technologies or pumped storage. However, in future, CLASS is expected to displace batteries, which are currently more expensive than conventional balancing services, resulting in higher financial savings when looking over a longer time horizon.

As described in A1, we have used the functionality provided by CLASS to offer reserve (Firm Fast Reserve and Optional Fast Reserve) and response (Static Secondary Fast Frequency Response) services to the ESO. CLASS was first bid into the balancing services market in February 2018. Since then, it has provided between 19 and 319MW of capacity per month to the ESO and has been used for a total of 47,800MWh. The price of bids accepted for CLASS have been materially lower than other accepted bids, with the availability fee (£/MW/hr) being 28%, 52% and 5%[4] lower than the average successful bid for Fast Frequency Response, Firm Fast Reserve and Optional Fast Reserve, respectively.

As well as avoiding the costs of more expensive balancing services, CLASS redistributes the benefits to customers. The revenues generated by CLASS are shared between the DNO and its customers as it is a Directly Remunerated Service. Between 2019 and June 2022, CLASS provided total savings of around £11.08m, of which £5.22m was a direct benefit passed through to customers (see Figure 8). Our estimates are likely to underestimate the financial benefits delivered as they are based on the average successful bid rather than the marginal unsuccessful bid, which would have been accepted in the absence of CLASS. However, these figures still demonstrate the exceptional value CLASS has provided and that it is a highly competitive service which provides direct benefits to customers.

Figure 8: Total financial savings from use of CLASS as a balancing service

	2019	2020	2021	2022 (up to June)	Total
Total financial benefits	£0.65m	£1.44m	£4.04m	£4.95m	£11.08m
Benefits passed through to customers	£0.37m	£0.74m	£2.03m	£2.08m	£5.22m

The financial benefits from CLASS in the future are expected to be higher, as CLASS is rolled out by more DNOs and it starts to displace more expensive balancing services needed to meet emissions reduction targets (i.e. batteries). Baringa (2021) and Ofgem (2022) have quantified the value of displaced balancing services under a medium rollout

[4] Paragraphs 6.50, 6.59 and 6.64 of the Ofgem Impact Assessment

scenario in which three of the six DNOs deploy CLASS. We have updated the Baringa (2021) analysis so that it assumes CLASS is deployed at this scale from the start of RIIO-ED2 (see Figure 9). Both analyses show the net savings are exceptional, ranging from £883m to £1,172m, with a financial benefit to cost ratio of 12.6 to 14.8. The fact the analyses are based on different assumptions in some areas demonstrates the robustness of the results.

Figure 9: Value of avoided balancing service costs (excluding societal benefits)

	Baringa (2021)			Ofgem (2022)		
	Costs	**Financial benefits**	**NPV**	**Costs**	**Financial benefits**	**NPV**
To 2030	£85m	£574m	£489m	-	-	-
To 2040	£85m	£988m	£903m	-	-	-
To 2050	£85m	£1,222m	£1,137m	-	-	-
Whole-life	£85m	£1,257m	£1,172m	£75m	£944m	£883m

Deferring reinforcement

The CLASS trials provided robust evidence that a reduction in voltage leads to a reduction in demand and could therefore defer reinforcement. Over the course of RIIO-ED1, load growth has been lower than anticipated and therefore CLASS has not been required to provide this benefit. However, as more LCTs are connected to the network and demand grows, the use case associated with deferring reinforcement is expected to materialise.

On page 37 of our closedown report we estimated that a 1.5% voltage reduction from CLASS across the whole of our network could release 12.8MVA of network capacity and defer the reinforcement of five primary substations with an associated expenditure of £2.8m for up to three years. A 5% voltage reduction would create 3.3GW of capacity resulting in deferred reinforcement costs of £78m. In both cases, this reinforcement would be deferred by around 3 years, providing savings to customers from the time value of money and providing the option to defer reinforcement further, or avoid it altogether, should the expected load growth not materialise. During RIIO-ED2 we will maximise the benefits CLASS provides to our customers as load growth materialises and we use CLASS to defer reinforcement.

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

CLASS learning has far-reaching impact across the DNO, GB and beyond. CLASS is an innovative and disruptive approach that has led to lots of industry debate and challenge and instigated changes to the regulatory framework. It is a ground-breaking innovation recognised by European Utility Week, which awarded CLASS the Energy Revolution award. It is the first disruptive innovation to be fully deployed, providing benefits to customers.

We now offer CLASS to the ESO as a first of its kind and unprecedented application for use in balancing services. CLASS is now a BAU solution rolled out to 78% of our applicable substations. Two other DNOs have proposed deployment through RIIO-ED2. Original partners and technology providers have benefited from CLASS learning by improving their off-the-shelf equipment and intellectual property creation.

Within Electricity North West: the original anticipated CLASS benefit was capacity release, but project findings pointed towards the widest possible benefit coming from using CLASS as a new, ground-breaking balancing service. CLASS is now a BAU solution, having been rolled out to 257 (78%) of our applicable primary substations, and there are plans to roll it out to all remaining applicable substations. In addition, we plan to rollout to sites where only the demand reduction function of CLASS can be used; for example, single transformer sites, which were previously deemed inapplicable. CLASS' exceptionality resides in how it is being used today.

Today, we actively bid CLASS into the ESO balancing services market, which is unprecedented and exceptional, providing between 19 and 319MW of capacity per month to the ESO. CLASS has been used for a total of 47,800MWh, providing £5.22m in financial savings to customers and delivering 28,760tCO_2e in carbon savings.

There are no other known similar innovations developed through the LCNF, the Network Innovation Competition or elsewhere that could be used instead of CLASS for ESO balancing services. Regarding implementation, CLASS was the first to implement the voltage management technology at the primary substation level.

Across other DNOs: CLASS has significantly changed industry attitudes. Prior to CLASS, it was unheard of for a DNO-deployed network technology to participate in the balancing services market, and now the ESO is regularly using CLASS as a low cost and reliable provider of balancing services. This involved taking the learning from Trial 3 – frequency response by demand management – and requesting an extension in scope and timescales, using the remaining funding from the original LCNF budget to demonstrate how the CLASS technology can be deployed commercially by DNOs into the GB electricity market. Ofgem approved this extension. However, as CLASS was a new, ground-breaking innovation, there was uncertainty and ambiguity as to whether or not it could be meet the performance requirements for ESO balancing services and compete with other providers. To address this uncertainty, in January 2016 we took a further step and requested that Ofgem confirm the regulatory treatment of costs and revenues associated with network voltage control for network management services procured by the ESO, then National Grid Electricity Transmission. Ofgem approved the use of voltage control for balancing services in March 2016.

CLASS in DNO RIIO-ED2 business plans

Further evidence of CLASS' continued legitimacy can be seen in Ofgem's request that all DNOs address, in their RIIO-ED2 business plans, how they will use CLASS. Of the other five DNOs, four have mentioned CLASS. Of these four, two have proposed deployment. The other two hesitate due to regulatory uncertainty surrounding the Ofgem consultation on the regulatory treatment of CLASS as a balancing service in RIIO-ED2, which has closed but is awaiting decision. See Figure 10 for the Ofgem analysis of CLASS deployment scenarios based on RIIO-ED2 business plans.

Figure 10: Ofgem analysis of deployment scenarios for CLASS based on RIIO-ED2 business plans

Scenario	Number of CLASS enabled sites	Aggregate MW response
A. Conservative rollout in Electricity North West only	260	150 - 300
B. Medium rollout covering 3 of 6 DNOs	1,378	795 – 1,591
C. Large-scale rollout across all DNOs	2,497	1,441 – 2,881

On page 51 of its RIIO-ED2 Distribution System Operator Strategy, SSEN has proposed to deploy CLASS to provide ESO services when regulatory certainty is provided. It has already identified around 300 primary substations with 680 transformers across its network that it believes would be suitable for CLASS deployment. SSEN said:

> *"Irrespective of […] uncertainties we recognise the benefits of CLASS and its potential to reduce costs for the ESO and subsequently Customers' bills. We are "minded to" deploy CLASS to provide ESO services but will not be putting it into our baseline plan until clarity is provided on regulatory treatment."*

NPG has also proposed to implement CLASS to provide ESO services on page 86 of its RIIO-ED2 Distribution System Operator Strategy, alongside other voltage optimisation upgrades. It has identified 156 primary substations and 100 supply point substations for potential deployment. NPG said:

> *"As we anticipate widespread demand increases on the network we see large benefits in expanding the use of network flexibility. We are proposing to perform several new functions including […] implementation of CLASS (including tap-staggering for (reactive power) voltage support and voltage adjustments to provide (active power) frequency support) to provide services to the ESO and the whole system deliverable WS4.3 distribution asset-based ancillary services to ESO."*

Wider impact on GB

CLASS' learning and application has reverberated across GB, from influencing engineering standards and future innovation projects to project partners' technology and product development.

Electricity Engineering Standards: Independent Review: Frazer Nash highlighted CLASS' contribution to quantifying the benefits of reducing load levels on the network through voltage management in its Electricity Engineering Standards Review Technical Analysis of Topic Areas prepared for BEIS.

Northern PowerGrid – Boston Spa Energy Efficiency Trial (BEET): the Network Innovation Allowance project, BEET, explicitly builds upon CLASS and its learning. On pages 12-14 of its literature review, BEET cites the results of CLASS trials as providing the proof of concept and quantification of the relationship between voltage and demand, which is a foundation of the BEET trial.

Electricity North West – QUEST whole-system voltage optimisation: the Network Innovation Competition project, QUEST, uses learning from CLASS to develop software alongside intelligent substation devices to co-ordinate CLASS and other voltage control techniques including Smart Street and Active Network Management. QUEST is based upon the premise that reductions in voltage reduce demand, and the project cites CLASS as proving this relationship. By 2050, QUEST is expected to release over 2,237MW of capacity with a financial benefit of £267m, reduce losses to save £65m, and reduce consumption to save customers £12.6bn across GB, as per pages 13–16 of the QUEST LCNF submission.

Across technology providers: CLASS has been hugely influential among project partners and technology providers. Siemens was an original project partner who provided the substation controller. Siemens gained learning from the project and staff turnover meant that it was cross-fertilised to Fundamentals, which upgraded its SuperTAPP SG relay to be CLASS-ready. That is to say that the capability is a built-in, default feature of the relay, which would just need to be switched on.

Since the conclusion of the CLASS project, we have contracted with Schneider Electric (SE) to provide our Network Management System (NMS), which used the learning from the project to develop the CLASS dashboard within its product. It is this SE dashboard that we use in our BAU operation of CLASS.

A5 - Value for money to customers

The CLASS project has successfully delivered an ambitious programme of work and has produced significant learning for all stakeholders by increasing the understanding of the voltage/demand relationship. In addition, it has demonstrated how innovative voltage management technologies can be utilised to provide demand response for the benefit of GB. The combined output from the project has more than fulfilled the commitments made. The project has proven the use of a technology that can provide significant savings to customers through reductions in whole system costs, in addition to delivering significantly under budget and returning money to customers. We have provided evidence on the three areas covered under the criteria below for delivering value for money for customers – minimising costs, the efficient use of funds and the effective use of funds.

- *Minimised costs:* The CLASS LCNF project was delivered under budget, for £7,214k instead of the expected £8,098k. The CLASS extension was also delivered under budget, for £465k instead of £622k. The CLASS LCNF and CLASS extension projects were both delivered within the CLASS LCNF budget.
- *Efficient:* robust governance processes and leverage of existing assets and knowledge.
- *Effective:* all project hypotheses were proven.

Minimising cost

The initial CLASS project was delivered at a total project cost of £7,214k, significantly under the budget of £8,098k, resulting in an efficiency saving of 11%. The CLASS extension was delivered at a cost of £465k, also significantly under the budget of £622k, resulting in an efficiency of 25%. The CLASS extension was funded from the savings from the initial budget of £8,098k, meaning there was no additional funding sourced. These efficiency savings were achieved through effective project management and the use of robust financial controls throughout the life of the CLASS project.

An essential part of our approach to CLASS was to engineer out the delivery risk, as much as possible, prior to LCNF submission stage. At the bid development stage, a strong consortium of project partners with proven delivery credentials were assembled. The

CLASS project partners were identified through an open competitive process and were selected based on their prior experience, whether their involvement represented value for money to customers, and their commitment to Electricity North West, the CLASS 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 agreed in advance. This approach provided the foundation for delivering the project for the lowest possible cost while minimising risk through collaboration with market-leading experts in their relevant fields.

Efficient use of funding

Once the project started, efficiencies were delivered through a range of channels as a result of robust governance processes and the team's focus on delivering value for money for customers. Examples of these efficiencies include, but are not limited to:

- Using spare communications capacity in existing remote terminal units (RTUs) where assessed to be viable, delivering a saving of £154k on RTU installation costs.
- Using internal resource instead of contractors for the installation of the substation controllers, delivering a saving of £112k.
- Drawing on previous development work completed for another LCNF project to support the configuration of the dashboard, delivering a saving of £52k.

As described in sections A1, A2 and A3 of this application, the outputs delivered by CLASS are exceptional when compared to the scale of funding.

As a result of the efficient use of funding in the initial stages of the project, we were able to deliver an extension to the CLASS project within the original envelope of funding. The purpose of the extension was to explore the potential commercialisation of CLASS services that could be deployed by other DNOs. In November 2015, Ofgem agreed to the extension and issued a revised project direction.

Effective use of funding

The objectives of the CLASS project were to test five hypotheses to prove that a DNO is able to deploy CLASS functionality without difficulty using existing network assets and without adversely affecting customers or stakeholders. The project delivered, and in some cases exceeded, the intended outcomes, demonstrating the effective use of funds for the project.

The lasting legacy of the CLASS project is the capability afforded to the ESO and to the DNOs in efficient management of the whole GB power system. The tools, techniques and methodologies delivered by the CLASS project will deliver benefits to customers for years to come and form a blueprint for potential distribution system operator services.

The results have shown the potential to provide frequency response services and reactive power services to the ESO, unlocking up to 3.3GW of demand response, equivalent to two combined cycle gas turbine power stations, and up to 2GVAr of reactive power absorption across the whole of GB from the distribution network. Figure 11 summarises the hypotheses stated in the LCNF submission and the way that these have been proven as a result of the project.

Figure 11: CLASS hypotheses and associated outputs

Hypothesis	Finding
The CLASS method creates a demand response and reactive absorption capability through the application of innovative voltage regulation techniques	**Proven:** The CLASS Method showed that by operating existing primary transformer circuit breakers and on-load tap changers in a coordinated and novel way, a meaningful and significant demand response and reactive power absorption capability can be obtained.
Customers within the CLASS trial areas will not see/observe/notice an impact on their power quality when these innovative techniques are applied	**Proven:** Robust customer engagement work has demonstrated that the CLASS Method is not noticed by customers.
The CLASS method will show that a small change in voltage can deliver a very meaningful demand response, thereby engaging all customers in demand response	**Proven:** The CLASS trials have shown that a 5% change in voltage yields a typical real power demand change of between 4% and 8%. The variance is due to the mix of customer types, seasonal and daily variation.
The CLASS method will defer network reinforcement and save carbon, by the application of demand decrement at the time of system peak	**Proven:** CLASS has shown that using a 5% reduction in voltage will on average produce a 6% reduction in demand during a winter peak demand period. Based on load growth scenarios at the time of the Closedown report, this would defer primary transformer asset replacement by up to three years.
The CLASS method uses existing assets with no detriment to their asset health	**Proven:** Asset health studies showed that the impact of the CLASS trials on the transformer and tap changer are negligible.

A6 - Relevance and timing of project

CLASS has changed the balancing services landscape, and Ofgem has approved participation in balancing services markets. It was also well-timed, providing a low carbon source of valuable balancing services as the need for such services increases.

CLASS produced exceptional learning for DNOs, academics and the global industry. It has surpassed expectation in providing understanding of the voltage/demand relationship and how the use of innovative voltage management technologies can be utilised to provide demand response for the benefit of GB.

Efforts were taken above and beyond the minimum to ensure project relevance. CLASS re-wrote the landscape and exceptional efforts were taken to assure its learning and application could be leveraged to the benefit of customers.

When we compiled the LCNF submission the main benefit foreseen was the release of capacity on our network, but in reality there is greater value to GB customers through our participation in balancing services and we took exceptional steps to ensure this value could be realised.

These included:

- Using the learning from Trial 3 – frequency response by demand management – we requested an extension in scope and timescales within the original LCNF budget, to demonstrate how the CLASS technology can be deployed commercially by DNOs into the GB electricity market. Ofgem approved this extension.
- The extension project demonstrated how CLASS could be deployed commercially by DNOs. However, as CLASS was a new, ground-breaking innovation, there was uncertainty to its application as a form of balancing service.
- To address this uncertainty, in January 2016, we took a further step and requested that Ofgem confirm the regulatory treatment of costs and revenues associated with network voltage control for network management services procured by the ESO.
- Ofgem approved the use of voltage control for balancing services in March 2016.

- We engaged with the GB DNOs to share all the learning, allowing them to consider the use of CLASS in their RIIO-ED2 business plans.

CLASS outcomes continue to feature in business planning, notably RIIO-ED2 plans.

CLASS features strongly in DNOs' RIIO-ED2 business plans. No other innovation project has achieved learning and outcomes to the extent that Ofgem has asked each DNO, specifically, to consider how they will treat it in the next price control period. As mentioned in section A4, two DNOs have said that they would propose deploying CLASS on their networks. To re-summarise:

- SSEN has proposed to deploy CLASS to provide ESO services when regulatory certainty is provided. It has already identified around 300 primary substations with 680 transformers across its network that it believes would be suitable for CLASS deployment.
- NPG has also proposed to implement CLASS to provide ESO services in its RIIO-ED2 Distribution System Operator Strategy, alongside other voltage optimisation upgrades. It has identified 156 primary substations and 100 supply point substations for potential deployment.

Innovation ahead of need

The power system needs an increasing amount of balancing services, and low carbon solutions such as CLASS are particularly valuable. This project was scoped and formed in 2012 and took place over the course of two years and nine months from January 2013 to September 2015, which has hence proved very timely. This is demonstrated in three ways:

- This was before significant uptake in LCTs such as transport electrification and intermittent, renewable generation. See Figure 12.
- This timing is also well-aligned with dispatchable thermal plants coming offline. See Figure 13.
- The Net Zero Strategy and the 2035 Zero Carbon Electricity commitment have increased the urgency for low carbon solutions for balancing services. CLASS is already providing the ESO with this service.

Figure 12: National Grid FES forecast of EV and renewable uptake

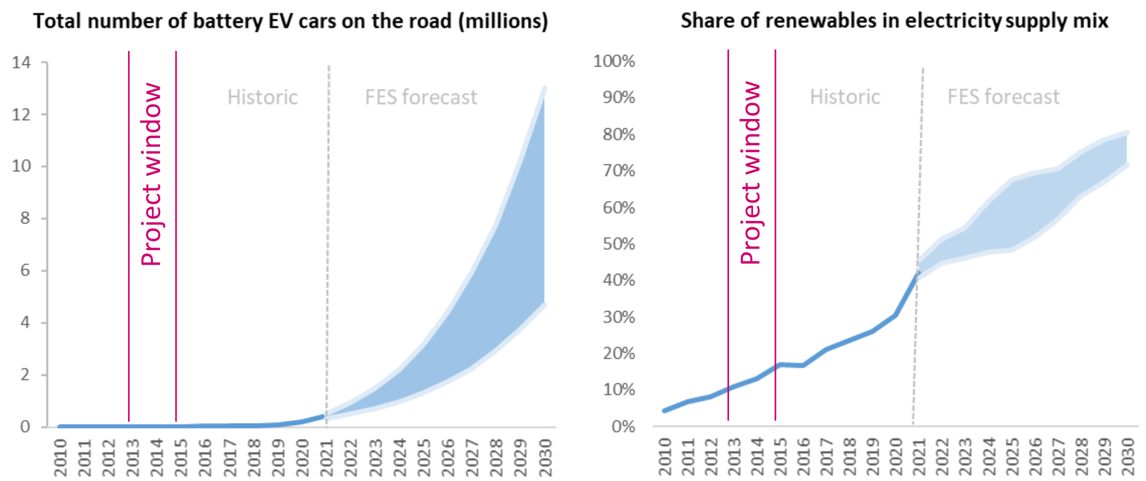
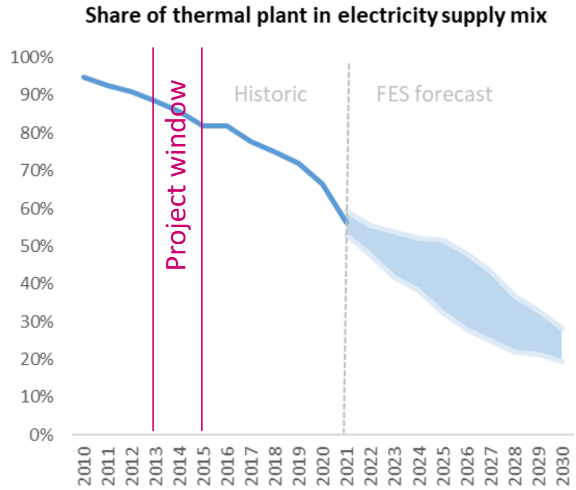


Figure 13: Historic and forecast of thermal plant decrement



A7 - Methodology robustness and project readiness

The CLASS trials adopted a robust methodology that provided a springboard for the technology being deployed at scale today. The use of strong governance procedures and industry best-practice project management principles ensured the project was delivered on time and to a very high quality. The project pioneered a new approach for innovation projects to customer engagement, improved industry understanding of the voltage/demand relationship and ultimately paved the way to the commercial deployment of CLASS as a balancing service.

The robustness of the methodology and exceptional efforts of Electricity North West are evidenced in three main areas:

- *CLASS extension:* following the conclusion of the initial project, we successfully made the case to Ofgem for the CLASS project to be extended to demonstrate how it could be deployed commercially into the GB electricity balancing services markets. The robustness of the trials and our significant efforts provided Ofgem with the confidence to issue a direction that CLASS could be offered in balancing services markets in RIIO-ED1 with costs and revenues recovered under Directly Remunerated Services. Ofgem has since published its consultation on the regulatory treatment of CLASS for RIIO-ED2 with the "minded to" position to extend the approval for CLASS to be bid into the balancing services markets. The extra measures Ofgem took to consider CLASS, and that CLASS prevailed positively under these reviews as well as CLASS' role in the balancing services market, is an ex-post affirmation of the project methodology.
- *Customer engagement approach:* the customer engagement approach to CLASS alongside another Electricity North West LCNF project, Smart Street, was unprecedented in scope and depth and set the benchmark for innovation projects. It involved setting up three ECPs, distributing leaflets to 485,000 customers in the trial area, completing 696 face-to-face and telephone baseline surveys and completing 1,357 monitoring surveys. This ensured statistically robust results were generated from the monitoring surveys undertaken during the project. The methodology was independently peer reviewed, as were the results from the customer surveys. Extra effort was made to ensure any customer queries that could have arisen as a result of CLASS were appropriately investigated and addressed.
- *Voltage/demand relationship:* the CLASS trials were designed in such a way as to provide robust data to inform the analysis of the voltage/demand relationship. Sites

were selected that enabled this relationship to be explored for different load types. Additional tests were undertaken during the trial, for example to better understand the reactive power absorption capabilities. Literature analysis was undertaken to complement the CLASS trial results. The result was market-leading research by our project partner, the UoM, which has supported a step-change in the industry's understanding of the voltage/demand relationship.

Throughout the project lifetime, we have made significant efforts to improve and refine the methodology of the CLASS trials and its subsequent rollout across the region. Several changes were made to the CLASS trials at the time of the LCNF submission which resulted in improvements in the methodology and cost savings:

- The number of primary substations where CLASS was deployed was reduced from 80 to 60 based on feasibility studies undertaken by UoM. These studies showed a statistically robust trial could be achieved with a lower rollout of CLASS, reducing the cost of the project.
- The focus of the trials was changed to Electricity North West only. In earlier versions of our LCNF submission, we expected to need to rollout CLASS across more than one DNO region to attain representative results. Feasibility studies by UoM showed this was not needed.
- The initial idea of involvement in the project by a passive retail energy supplier was not implemented. Discussions with energy suppliers failed to justify the resourcing expenditure needed in areas of their business. However, this was addressed through the development of the extensive customer engagement methodology.
- The approach to monitoring voltage at customer premises was revised. The decision was taken to monitor voltage at distribution substations rather than installing monitoring equipment at customer premises to avoid disrupting the smart meter rollout.

In addition, the following changes were made during the trials:

- We completed additional manual tests to provide UoM with sufficient data to quantify the reactive power absorption capabilities of CLASS.
- We revised our testing plan to overcome technical limitations, planned and unplanned outages, and best use of control room staff and time. The additional testing demonstrated that we could reduce the voltage further without customers noticing, enabling us to implement a 5% voltage reduction in BAU, rather than the 1.5% predicted on page 4 of our LCNF submission.
- We maintained flexibility in our customer engagement workstream, adjusting our approach when factors outside our control prevented a planned test to ensure the data generated remained representative.

The robustness of the methodology developed for CLASS has led to several other projects adopting its findings. Some examples are provided below:

- National Grid's DIVIDE project investigated how industry trends affected the sensitivity of the voltage/demand relationship. The project made extensive use of the data and modelling developed under the CLASS trials.
- In 2019, the UK Government commissioned an independent panel of experts to conduct an electricity standards review. The technical report by Fraser Nash used the CLASS trial results to help quantify the benefits of a reduction in demand on the network. With respect to CLASS, the report noted, on page 59, "The Panel believes these initiatives […] will be crucial to understand the opportunities and savings from the management of network voltages".

- Electricity North West's QUEST project has used the learning from CLASS to develop new software for relays to enable integration with the QUEST software module. QUEST is also using the voltage/demand relationship analysis developed through the CLASS trial and testing how that might change out to 2050.

A8 - Other benefits

CLASS provides further benefit above and beyond those already discussed by reducing the volumes of automated disconnection required under the OC6 buffer and providing Grid Side Demand Response "invisible" to the customer.

The project supports requirements under Operating Code No.6

Under Operating Code No.6 (OC6), and specifically OC6.6, the ESO can instruct DNOs to automatically disconnect customers in the event of low frequency events, thus reducing the requirement for the ESO to contract more frequency response. In response to Ofgem's consultation on CLASS in 2020, several stakeholders including the ESO noted that CLASS could be deployed to reduce the need to disconnect customers to meet OC6 obligations. In doing so it would operate somewhere between existing secondary response and the automatic Low Frequency Demand Disconnection (LFDD) scheme. This would provide direct benefits to customers who would otherwise be temporarily disconnected from the network.

The most recent event cited where CLASS could have supported the OC6 requirement is the 9 August 2019 event. Using the value of lost load metric (VOLL), Ofgem estimates that 620MWh of energy were lost during that event, with 931MW disconnected for a duration of around 40 minutes. This equates to a cost of £13.5m in lost load, based on the £22,000/MWh value of lost load used in RIIO-ED1 and ED2 (in 2020/21 prices). This disconnection may not have been necessary with wider deployment of CLASS.

The full economic impacts were larger, however, as the VOLL metric only captures the value that small and medium enterprises and domestic customers place on supply disruption and would not have accounted for the rail sector which saw thousands of rail passengers disrupted, with 371 trains cancelled, 220 part-cancelled and 873 trains delayed.

While most analysis to date has focused on the use of CLASS for balancing services, it could provide additional and significant benefit by avoiding the need for disconnections under OC6 where it is deployed at scale, thus demonstrating further exceptional use case for CLASS. Using a relatively conservative assumption that an event like the 9 August 2019 event would happen once every ten years and assuming there is sufficient capacity deployed by other DNOs, then using CLASS to support the OC6 buffer could provide a cumulative present value benefit of £24.4m by 2050[5]. See Figure 14 for details.

[5] Assumes 620MWh lost load every 10 years valued at a VOLL of £22,000 discounted at 3.5%

Figure 14: Cumulative benefits from the deployment of CLASS for meeting OC6 obligations

	Outturn benefits £m, 2021/22 prices	**Benefits projected in LCNF submission** £m PV, 2021/22 prices	**Latest projection of benefits** £m PV, 2021/22 prices
To 2021	CLASS has not been used for meeting OC6 obligations to date	The use of CLASS for OC6 was not identified in the LCNF submission	£0m
To 2030			£9.5m
To 2040			£18.2m
To 2050			£24.4m

CLASS provides grid side demand response "invisible" to the customer

The Smart System and Flexibility Plan (SSFP 2021) aims to facilitate a future where, instead of generating electricity to meet inflexible demand, demand must become more flexible to coincide with periods when renewable generation is most abundant.

To bring about this behavioural shift and response from the demand side, or everyday customers, policymakers will rely on price signals. Specifically, the SSFP (2021), on page 88, identifies a hurdle to demand response as "Network and policy costs are not passed on in a way that incentivises the optimal flexible behaviour among network users."

The challenge to achieving this, however, is significant and threefold:

1. It is difficult to repackage these costs into market incentives and price signals.
2. It is not clear that customers are flexible enough to respond to those signals even if they receive and understand them.
3. Even if customers understand them, changing behaviour is extremely difficult for which smart technology is often cited as a solution, but in reality is not a panacea. Ofgem research has found that "Nor can we assume that behaviour change will happen when new products and services come onto the market, even ones that are designed to make life easy for customers."

Instead, CLASS bypasses all these difficulties and unlocks up to 3.3GW of "invisible" demand response on the side of the grid at the low voltage level – equivalent to two combined cycle gas turbine power stations – without the need for network customers to change their behaviour or for policymakers to design and implement new, complex retail mechanisms.

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 funding and therefore offer no evidence against this criterion.

Reward criterion C

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

We achieved more learning than expected with respect to the voltage/demand relationship. This had a positive, cascading effect for Fundamentals, which enhanced its relay product, and SE, which developed new intellectual property, the CLASS dashboard. We also took exceptional effort to gain confirmation from Ofgem to apply learning as a new service to the ESO.

Our LCNF submission and business case for CLASS were based on achieving a 1.5% voltage reduction and an equivalent demand reduction without any noticeable impact to customers. These figures were based on a literature review where a reduction of 1.43% at peak time in winter and a 1:1 relationship between voltage and demand were quoted.

Our analysis of the trial data demonstrated that the relationship between voltage and demand is not linear and a voltage reduction of 1% could result in a demand reduction of between 1.3% to 1.36%, see page 4 of the closedown report.

The CLASS trials also demonstrated that 3% and 5% voltage reduction at peak time at all 60 primary substations could be achieved without any noticeable impact to customers, see page 31 of the closedown report. Additionally, there were no voltage violations recorded that could be attributed to the operation of CLASS.

This ability to reduce network voltage at times of peak load provides us the opportunity to defer asset reinforcement and if a 5% voltage reduction was applied across the GB network we potentially reduce demand by 3.3GW deferring reinforcement costs of £78m, see page 37 of the closedown report.

Using the CLASS methodology, the LCNF project proved that we could provide demand response services to the ESO, but there was no precedent for DNOs operating in this market. As a result of this learning, we submitted a change request to Ofgem to investigate the commercial mechanism for CLASS. This additional work was delivered as a short extension to the LCNF project, but within the original project budget. This extension recommended the mechanism by which CLASS could operate in the balancing services market and provide benefits back to customers. Based on this work, Ofgem confirmed the use of DRS8 and is currently consulting on a "minded to" position for RIIO-ED2 that will continue this practice.

During the project, it became apparent that the equipment deployed in the substation was not the best solution for rolling out into BAU. It would be preferable if the new functionality could be incorporated into the Automatic Voltage Control (AVC) relay rather than having to install extra control equipment. The learning from this project was then used by Fundamentals to enhance its SuperTAPP SG relay which is a commercially available product.

With the new BAU solution and evidence of the benefits CLASS could deliver for customers, we rolled out CLASS to 257 (78%) of our applicable primary substations. Alongside the rollout of the substation technology, we worked with SE, our NMS supplier, to use the learning from the project to develop the CLASS dashboard within its product. This dashboard now forms part of the core SE product.

Since the substation equipment and CLASS dashboard rollout was completed, we have been actively participating in the balancing services market to support the wider network and deliver benefits for our customers.

There are further opportunities for the CLASS method in reactive power services. The trials estimated that up to 167MVAr and 1.84GVAr could be absorbed during winter peak periods across our network and the GB network respectively, see page 5 of the closedown report. Therefore, if the market existed, we could provide the ESO with reactive power services in addition to demand response services.

Following the successful transition of CLASS to BAU and our deployment of other voltage control techniques, we applied for NIC project funding to co-ordinate the different solutions and boost the benefits for our customers. Our QUEST project will identify and trial novel methods to holistically integrate the techniques in use across the network into an overarching control system. It will explore co-ordinated operation to enable a reduction of the built-in operating margins, creating capacity for our customers.

The learning from CLASS has been shared widely with other GB DNOs and with network operators outside GB. See section C3 for more details.

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

We put in exceptional effort to gain additional learning through increasing the number of test sites from 14 to 60 to produce a larger and richer data set for analysis. To ensure that customers did not perceive any changes to the quality of their electricity supply, we took exceptional efforts to engage our customers, including applying an innovative and highly effective method for developing and refining the customer engagement documents through the use of an ECP. To further assure our learning, we discussed follow-on research and funding with Ofgem, who accepted our proposal and resulted in delivering three new reward criteria.

Our LCNF submission described the various types of CLASS sites including the modification of a legacy AVC scheme, although there was no commitment to install any of this type. During project delivery we felt that there was valuable learning on the limitations and cost comparison of modifying a legacy scheme when compared to a more modern solution. To enable this learning, we implemented the solution at eight sites. This proved that CLASS can be retrofitted to any AVC scheme for demand reduction, but due to the legacy AVC scheme we would be unable to implement the tap stagger function.

Following commissioning of the voltage regulation equipment, we saw that that the automatic tap stagger functionality could not provide the reactive power absorption levels required for the trials. We developed and carried out a series of manual tests to provide UoM with sufficient data to quantify the reactive power absorption capabilities.

As detailed in section 6 of the closedown report, the CLASS trial schedules were initially developed on a site-by-site basis to capture data as necessary for each trial. The voltage reduction tests were developed to cover the ‘time variation’ windows every day for 14 primary substations. The schedule was originally planned to carry out tests at single sites at different periods in the day. To increase the volume of tests and therefore data for analysis, we revised the test plan to carry out the voltage reduction tests at all 60 sites and to activate the test on a group basis rather than on an individual site basis. This revised strategy allowed us to still carry out testing and gather results even when there were planned or unplanned outages.

Our revisions to the planned test schedule overcame technical limitations, planned and unplanned network outages, and leveraged the best use of control room resource and time. This modified approach provided more tests and therefore more results to prove the hypotheses. This additional testing demonstrated that we could reduce the voltage further without customers noticing, enabling us to implement a 5% voltage reduction in BAU, rather than the 1.5% envisioned in the LCNF submission. This increase in voltage reduction will allow us to defer more reinforcement and provide a larger response to the ESO.

To ensure we could prove the hypothesis that customers did not notice any changes to their quality of supply, the customer workstream adopted a flexible approach to customer engagement activities. When factors outside of our control prevented a planned test from taking place, the customer engagement programme was flexible enough to be amended to ensure that a 50:50 balance of test and control interviews, representative of each test and sub-group, was maintained, enabling us to test the hypothesis robustly.

An ECP is not a conventional method for piloting a customer survey instrument. However, we felt that using this technique could be an effective way of optimising the survey before it was used in the large-scale customer surveys. The conversational nature of the ECPs allowed participants to share their understanding and any sensitivity about the questions and their responses. It also encouraged discussion around improvements to the questionnaire, for example changing the wording or the order of some questions. The ECP was also highly influential in the formulation of customer survey registration frequently asked questions, designed to assist in recruiting customers to take part in the survey. Piloting the survey instrument with the ECP provided valuable learning and helped us to ensure the customer engagement during the trial produced high quality results allowing us to confidently prove the customer hypothesis.

To maximise our customer engagement, we created and sent a CLASS leaflet to all 485,000 customers in the trial area, encouraging prospective participants to register their interest in taking part in the surveys. Over 3,000 customers pre-registered after the leaflet was distributed, which exceeded expectations, generating a considerably higher level of customer interest than anticipated. This response was far greater than the numbers needed for the baseline survey and enabled us to sign up enough customers to create a statistically robust sample.

Following the exceptional learning gained from the CLASS trials in proving the technical delivery of CLASS services, Electricity North West discussed with Ofgem the importance of the follow-on research work to understand the costs and benefits to DNO customers and the wider industry impact of the commercialisation of the CLASS services. This research activity had been included within the scope of the CLASS LCNF submission in the spring of 2012, but in discussions with Ofgem at the time was excluded in the final CLASS LCNF submission due to concerns over the costs and perceived benefits of the research to DNO customers.

We proposed to Ofgem that an expedient approach was to submit a change proposal to extend the scope and timescales of the CLASS project, especially as the CLASS project had delivered an underspend against the project budget. We drafted a change proposal for the CLASS project which outlined a standalone time-bound piece of research that could be easily accommodated within the original budget and as a simple extension to the scope and timescales of the original CLASS project. We estimated that the cost of extending the project was £622,000, and we would deliver three new Successful Delivery Reward Criteria (SDRC) and close down the extended project by 31 May 2016. Ofgem agreed to the change proposal and issued an updated project direction.

The outcome of this work established the framework by which DNOs could, for the first time ever, provide balancing services to the ESO. This proposed framework forms Ofgem's "minded to" position on the treatment of CLASS in RIIO-ED2, which was issued for consultation in March 2022.

This evidence represents our appetite to push the envelope and deliver industry-changing solutions which can benefit our customers.

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

CLASS was the first Second Tier LCNF project to harness the various forms of communications technology for pushing information to stakeholders. This was necessary as the knowledge dissemination landscape was becoming congested with dozens of active projects delivering a substantial body of knowledge.

We created a community of interested stakeholders, and by using different types of push communication techniques the project team provided knowledge in a manner that empowered them to decide whether to engage, either at that time or at a later time. For example, CLASS was the first project to use social media to update stakeholders on the progress of the project and to signpost key dates or key reports. We introduced the use of webinar technology to share bitesize pieces of the learning as the project progressed. We recorded each webinar as a permanent record which stakeholders could engage with at a time convenient for them.

Appendix A of the CLASS closedown report contains a full schedule of all the dissemination conducted during project delivery. In addition to the reports required as part of the SDRC, we also made the following reports available on our website to provide additional information on the use of CLASS and to encourage other DNOs to consider the solution for their network:

- Document explaining the functionality of the CLASS dashboard
- Summary of the key findings from the engaged customer panel
- An overview of the carbon impact assessment approach and findings of the CLASS method

Since the project has concluded, we have continued to disseminate the learning through discussions with other network operators worldwide and presentations at conferences:

- Innovative Voltage Management Techniques to derive active network services from existing assets. DPSP 2016
- A step-by-step data processing guideline for load model development based on field measurements. IEEE PowerTech 2015
- Practical aspects of developing load models at distribution network buses based on field measurements. CIRED 2015
- Distribution network supports for reactive power management in transmission systems. IEEE PES 2014
- A Monte Carlo Assessment of Customer Voltage Constraints in the Context of CVR Schemes. CIRED 2015

In addition to holding discussions with other GB DNOs, we invited them to visit our substations and control room to see the technology and discuss its implementation with the project team.

We also held discussions with network operators outside GB, including in Ireland and Australia, to share learning on the deployment of CLASS.

In preparation for RIIO-ED2, we held discussions with Ofgem to discuss how we are using CLASS and the benefits it delivers. We also held one-to-one sessions with the other DNOs to enable them to fully understand the solution so they could make the necessary provisions for rollout in their RIIO-ED2 plans.

In the CLASS LCNF project, the voltage control technology was provided by Siemens and the project learning showed that the use of a substation controller was not appropriate for BAU. Instead, the best approach would be to use a relay-based solution. Siemens was not looking to develop in this area, and therefore we needed an alternative supplier. Using the functional specifications produced by the project and the knowledge of the Siemens representative who had moved to Fundamentals, we explored alternative solutions with Fundamentals, which has now developed a relay-based solution that we have used in our BAU rollout, and that other DNOs can buy as an "off the shelf" product. Fundamentals is now developing this product further as a project partner in our QUEST NIC project.

There was a similar development path for the CLASS dashboard provided by GE in the CLASS project. Since the conclusion of the CLASS project we have contracted with SE to provide our NMS, which used learning from the project to develop the CLASS dashboard within its product. It is this SE dashboard that we use in our BAU operation of CLASS.