

## BOSTON SPA ENERGY EFFICIENCY TRIAL (BEET) – TECHNICAL FAQ

### What is BEET?

The Boston Spa Energy Efficiency Trial (BEET) is a Northern Powergrid innovation project to improve the energy efficiency of customers' appliances. It will use smart meter data in (near) real time to adjust network voltage to increase efficiency and reduce energy consumption of our customers' appliances. This should save customers money and reduce carbon emissions, without customers needing to do anything differently.

This energy efficiency trial will take place in Boston Spa (West Yorkshire), and the surrounding areas, including Wetherby, via the following 'primary' (i.e., large) substations:

- Audby Lane (which includes Boston Spa and Wetherby);
- Leeds Road (which includes Boston Spa and East Rigton); and
- Warren Lane (which includes Boston Spa and Bramham).

You can find out whether your house or business is served by one of these substations by using our interactive [Distributed Future Energy Scenarios map](#).



### When is the trial taking place?

We will start trialling the new technique once we have completed offline testing. Live trial dates are currently set for August 2022 to November 2023.

### **What is voltage?**

Voltage is electrical pressure measured in units known as volts (V). Northern Powergrid facilitates the delivery of electricity to customers connected to the low voltage network (mainly domestic customers) at 230V 'nominal' – this means that voltage can be provided to you within a range around 230V, from 216.2V to 253.0V.

### **Why a range, and not simply always 230V?**

The voltage varies within the range of 216.2V to 253V through the day as customer demand on the system changes.

The UK network used to run at 240V nominal, with the European network running at 220V nominal. This meant appliances had to be designed separately for each market, creating a trade barrier. The European Commission resolved this in 1995 with voltage 'harmonisation', which standardised network voltage across the UK and Europe at 230V (nominal). Because no infrastructure was updated, what this meant in practice was that both networks were to operate within a crossover range around the harmonised level. The BEET trial aims to understand the optimum operating point – 220V, 230V or 240V? In its own £9m 'voltage optimisation' trials, Electricity North West found the 'sweet spot' was between 220V and 230V.

### **What is voltage optimisation?**

Typically, because of how we operate the network, customers receive a voltage above 240V. Optimising this voltage means simply turning it up or down, but the how and why we will do this is a combination of:

1. The relationship between voltage and energy efficiency.
2. How the voltage is managed on our network at present – i.e. voltage compliance.
3. How new innovative voltage optimisation techniques can provide benefit to our customers.

*We will now explore these three areas in more detail...*

### **The relationship between voltage and energy efficiency:**

Generally, the higher the voltage, the higher the energy consumption. Overall, the relationship between voltage and energy efficiency is that a one per cent reduction in voltage should result in a one per cent reduction in energy consumption.

There are several important pieces of evidence to support this relationship, which are detailed within our literature review undertaken as part of BEET.<sup>1</sup> Of note is the learning from Smart Street. Smart Street was an innovation project undertaken by Electricity North West (ENW), the Distribution Network Operator (DNO) for the North West of England. Smart Street concluded from two years of trials that there is typically a one-to-one relationship between voltage and energy consumption. Other evidence in our literature review identified a higher benefit than this (typically 50 per cent higher), however, we have aligned our assumptions to ENW's Smart Street

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1. See our literature review at: <https://www.northernpowergrid.com/asset/0/document/5985.pdf>.

conclusions. We believe that this provides a conservative benefit, based on a robust trial undertaken that provided a similar level of voltage optimisation to that of BEET.

The University of Sheffield is one of our project partners, and we will leverage its expertise to undertake a robust statistical analysis of the data created during BEET to better understand and quantify the relationship between voltage and energy efficiency.

#### **How the voltage is managed on our network at present – i.e. voltage compliance:**

The voltage on our network is actively controlled at ‘primary’ substations. A primary substation typically feeds thousands of customers via hundreds of kilometres of network. For example, in our trial area, the Audby Lane substation powers roughly 10,000 homes.

The voltage received by each property is dependent on the route its electricity takes through the network and the amount of power flowing through that route. Generally, the voltage reduces as it moves away from the primary substation. It also reduces at a steeper rate as more power is flowing through the circuit. This means that the actual voltage received by each customer is slightly different, and it depends on what is happening in real time (i.e. how much power is flowing to meet customer demand).

This complex task of ensuring customers receive a voltage in the compliant range is made more difficult because we also need to cater for network outages.

Therefore, to ensure that we always provide a compliant and safe voltage to all customers, and cater for network outages, we typically provide customers with a voltage at the upper end of the range. This approach can be thought of as voltage compliance.

#### **How innovative voltage optimisation techniques can provide benefit to our customers:**

Traditionally, we have achieved voltage compliance by supplying customers with a voltage that is at the higher end of the allowed (compliance) range. This is to cater for any potential network outages, as mentioned, but also because we have not previously had access to real-time data about the voltage our customers receive, or the ability to respond to this information.

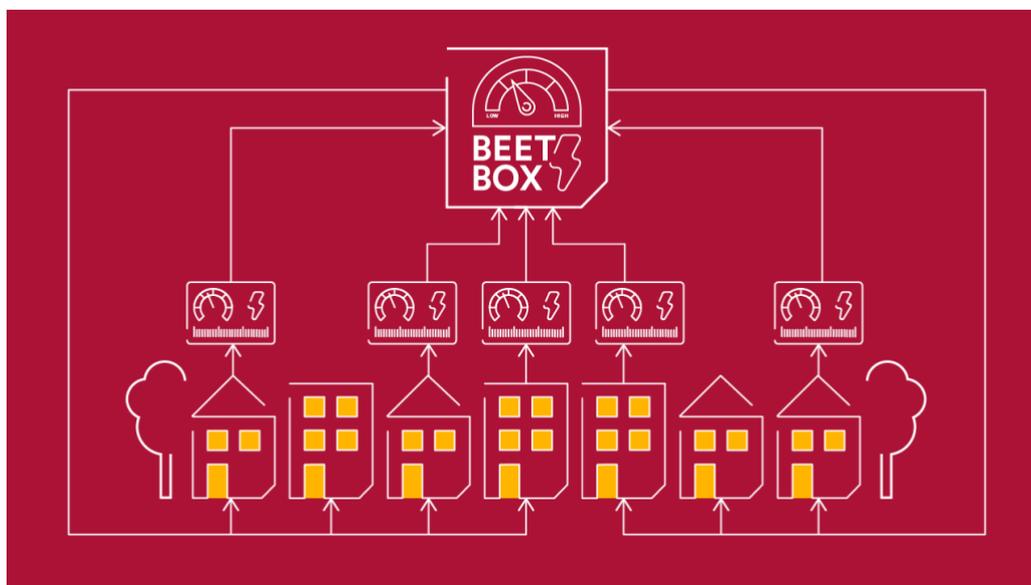
Smart grid investment and smart meters change that. Smart grids are technologies and capabilities that let us respond to network data in real time, enabling us to actively manage the network. Smart meters provide the essential data needed for us to provide voltage optimisation.

#### **What will happen during the trial?**

The trial will use a special platform developed by Northern Powergrid, known as the BEET-Box, which will analyse smart meter data to optimise the network voltage every half hour – in other words, to safely turn up or turn down the voltage to ensure appliances have a suitable voltage and to lower customer bills. The amount of voltage is to be optimised to maximise your energy efficiency. To maximise our learning and to ensure the proposed future roll-out is enhanced, we will monitor, adjust and improve the way in which the BEET-Box functions.

### How does the BEET-Box work?

Smart meter voltage data feeds into the BEET-Box, which applies an optimisation algorithm, developed by Fundamentals Ltd in conjunction with Northern Powergrid, to smart meter data, to determine the level of voltage adjustment required, and sends this information to the network management system (NMS), which in turn adjusts the voltage to customers' homes and businesses:



### Will BEET affect my power supply?

In short, no. There are statutory voltage limits under the Electricity Safety, Quality and Continuity Regulations (ESQCR) and the BEET-Box algorithm is designed to have real-time knowledge of the network and calculate appropriate voltage targets so that these are adhered to. We will only begin the trial once we are confident the BEET-Box will function as required. Customers shouldn't notice any discernible difference to their supply.

### Are you sure I won't notice anything?

No, it shouldn't significantly affect your everyday life apart from helping you save money and energy. If the average voltage optimisation achieved is four per cent, appliances with motors, such as fridges and washing machines, will continue to deliver the same levels of performance, but will be more energy efficient when they operate. Kettles may take fractionally longer to boil: for example, instead of taking 30 seconds they could take 32.5 seconds.

### How much is the BEET project costing Northern Powergrid?

The trial is a £1.3m investment, and we estimate a full roll-out across our region would be about £11m. This is part of our wider investment plan to create a greener energy system as the region, and the UK, decarbonise. Once BEET is rolled out at scale, the savings for customers are expected to significantly outweigh this investment: the annual saving for each household is anticipated to be £10-40 – typically we expect it to be £20,<sup>2</sup> with vulnerable customers and those who are fuel-poor likely to feel the benefits the most.

<sup>2</sup> Calculations based on several factors, including our regulator Ofgem's definition of typical electricity usage, and assumed unit costs of £0.17 per unit.

### **What benefit will I see?**

The benefit to you as a customer is estimated at £20 per household every year, because you should use less energy – and therefore pay for less. Using less energy will also lower your carbon footprint. And this happens without you having to do anything.

### **What will it cost me?**

We do not seek any direct payment from households benefiting from the trial. This project is already part of our investments set out in our business plans for 2015-23 and the wider roll-out of the technology is part of our proposed 2023-28 plan which will be submitted to our regulator Ofgem on 1 December 2021.

Customers pay for the services we provide through network-related charges which appear as part of their bill from their chosen electricity supplier. For the average domestic customer this is around 25p a day and it covers everything we do to manage, maintain, innovate and invest in the network that powers our customers' lives.

Given the benefits, this project is vastly in favour of customers and – if successful – will later benefit most customers living in our area and potentially the whole country.

### **How will BEET reduce carbon emissions?**

We know from research that voltage optimisation reduces energy use and that this in turn is directly linked to carbon emissions. A one per cent voltage reduction would deliver at least a one per cent energy consumption reduction, and therefore, in turn, a one per cent carbon reduction. Potentially, on average, we believe voltage could be reduced by up to four per cent – saving 12kg-48kg of CO<sub>2</sub> emissions per household. We predict the average annual CO<sub>2</sub> saving to be 27kg per household (the equivalent to driving more than 100km). Across the UK, this could potentially save between 200,000 and two million tonnes of CO<sub>2</sub> annually – like taking up to 200,000 cars off the road for a year.

### **Why optimise the voltage?**

There is a broad industry consensus that a one per cent voltage reduction can produce a one per cent electricity consumption reduction – therefore reducing customer bills and carbon emissions.

The potential benefits of voltage optimisation include:

- lowering customers' electricity bills;
- reducing carbon emissions (because less energy and infrastructure is needed);
- increasing capacity to connect to the network (to support low carbon technology uptake, such as installing solar panels or getting an electric vehicle); and
- providing Northern Powergrid with network voltage insight, enabling us to proactively resolve problems before they become complaints (thereby improving customer satisfaction).

### **How far can Northern Powergrid optimise the voltage?**

There is the potential that, on average, our BEET team could safely reduce voltage by up to four per cent – which could provide an annual saving of £10-40 per household and reduce 12kg-48kg

of CO<sub>2</sub> emissions per household. We anticipate the average annual CO<sub>2</sub> saving to be 27kg per household (the equivalent to driving more than 100km).<sup>3</sup> This prediction errs on the conservative side, but means that we have high confidence that the four per cent is achievable.

### **How can the same benefits be provided across the UK?**

BEET is part of Northern Powergrid's overall goal to decarbonise regionally and nationally, and secure net zero. It is our aim to ensure that the technology is shared with all the UK DNOs so they can use it with minimal investment. Assuming the same benefit could be provided across the UK, this could provide annual national customer savings in the region of £0.5bn and between 200,000 and two million tonnes of CO<sub>2</sub> emissions annually – the equivalent of taking up to 200,000 cars off the road for a year.

### **What evidence does Northern Powergrid have that this will work?**

The benefit to our customers of receiving an optimised voltage has been explored by several innovation projects within the industry, such as:

- Electricity North West's [Customer Load Active System Services](#) (CLASS) and [Smart Street](#);
- Western Power Distribution's [LV Network Templates](#), and [Voltage Reduction Analysis](#);
- Scottish Power Electricity Networks – [Flexible Network for a Low Carbon Future](#);
- National Grid – [DNO Investigation into Voltage Interaction and Dependency Expectation](#) (DIVIDE);
- Powerstar's [voltage optimisation technologies](#); and
- Northern Powergrid's own ongoing 'level bar reduction' initiative, plus the research [Phase 1 of the BEET project](#), which was completed in December 2020.

### **Have you done anything similar before?**

Yes, to date we have:

- Carried out a significant piece of analysis that resulted in us lowering the voltage at the majority of our substations by roughly two per cent. We are close to completing this action, and the benefits of this work were assessed statistically to identify significant energy efficiency benefit.<sup>4</sup> This action also created network capacity to connect more solar panels to the network.
- Applied intelligent techniques to optimise voltage in real time based on local measurements as part of our Customer-Led Network Revolution (CLNR) innovation project. It is because of CLNR we started an £83m smart-grid enablers programme that is nearing completion. The learning and technical capability from this work has formed the building blocks for BEET.

### **Why hasn't voltage been optimised before?**

It's only now that we have the learnings from the smart-grid enabler investments – together with recent work by Electricity North West's Smart Street project – that we know the tangible benefit

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3. Note that as the electricity system decarbonises, the annual CO<sub>2</sub> saving will fall – because the average unit of energy produced will be generated from increasingly lower carbon sources as we move towards net zero. Two million tonnes is therefore the upper bound.

4. See Northern Powergrid's [HV Conservation Voltage Reduction Impacts Study](#).

voltage optimisation can provide to customers. And we need the tools to implement this knowledge – visibility of what’s happening to voltage at our customers’ locations. The smart meter roll-out is the final piece of the puzzle: smart meters measure the voltage across the network where it really matters – where our customers are located. They can provide regular voltage readings that can be used to optimise the voltage for all customers. As we move to an increasingly digitalised network, we’re discovering exactly what data such as this can do, and exploring more possibilities to increase efficiency, save customers money, and reduce carbon emissions – over and above what our regulator Ofgem requires. Because once we know we can do something, and we have the tools to do so, it’s the right thing to do.

### **Do I need to have a smart meter to have my voltage optimised?**

No – the BEET-Box will read smart meter voltage data and feed it back to Northern Powergrid, who can then optimise the voltage for all customers. The sample readings across the network should provide enough information for the BEET-Box to ensure that the whole network is receiving the optimal voltage. The same voltage applies to thousands of customers, so it will never be entirely ‘bespoke’, which is why you don’t have to have a smart meter to benefit from the trial – we’re supplying the optimum voltage for your village or community overall, rather than for each individual customer. However, the more smart meters there are on the network, the more successful the project will be, because we will have more data and thus a ‘bigger picture’ of how the network is working in real time.

### **I’ve read a lot about the energy system changing, and an increase in electricity use from things such as heat pumps (HPs) and electric vehicles (EVs). How can you guarantee this saving when we’ll all be using more electricity in the future?**

We are expecting to see more HPs and EVs as the UK progresses towards net zero, and it’s true that these (likely) won’t benefit from voltage optimisation. This is because devices such as EV charging equipment have ‘power electronics’, which are relatively immune to voltage fluctuations. The cost savings and reduced carbon emissions are based on existing use of the network, which is not expected to change over the next 10 years, despite people consuming more electricity each year if they buy an EV. We will be carrying out robust statistical analyses both during the BEET trial, and in future alongside any roll-out, to ensure the ongoing benefit is quantified.

### **Why is Northern Powergrid planning to pass on the cost savings to me and not take them as profit?**

Energy suppliers pay us network charges for using our equipment to transport electricity to their customers – rather like a delivery charge. Customers, as part of their bill from their chosen supplier, pay their supplier their share of the network-related charges and pay for the actual amount of electricity they use. This means that any cost savings on electricity use are yours – not ours. BEET does help us to ‘deliver more for less’ and offers wider social benefits, but its biggest impacts are carbon footprint reduction and financial benefits – which will be felt most by those in our region who are vulnerable or fuel-poor.

### **Then what’s in it for Northern Powergrid?**

We have set commitments to facilitate decarbonisation ahead of the UK government’s target of 2050 – it’s in our 2023-28 business plan as the Planning Scenario, which aims to facilitate

regional decarbonisation by the mid-2040s. Innovation is one of the main drivers to reach this goal, and BEET is a prime example of how digitalisation and technology can provide energy and carbon savings with minimal investment. This is one such benefit to us, but others include:

- providing improved customer service (which benefits everyone);
- improved efficiency across the network;
- improved reputational excellence; and
- increased capacity to connect.

### **Why do I need to know about BEET if I won't notice it taking place?**

The success of BEET depends on support from our communities and regions, because the project:

- is driven by community engagement;
- requires the use of community-located assets (smart meters – these belong to suppliers, but we need access to the voltage data they contain, at the point of supply in the community);
- potentially requires community support to assist with increasing smart meter installations where required;
- ultimately benefits the community by reducing customers' consumption, thus saving the community money and reducing the carbon emissions associated with their electricity supply; and
- contributes to improvements in energy efficiency – a key factor in helping communities, regions and the UK reach net zero by 2050.

### **Who are the project partners?**

BEET came from an initial idea by Boston Spa community member Keith Jackson, and is a collaborative project led by Northern Powergrid with the support of:

- Keith Jackson – project board member and Boston Spa community member;
- the communities in and around Boston Spa, where we will be trialling this innovative voltage optimisation technique;
- WSP – project managing the trial;
- Fundamentals – designing the BEET-Box and an algorithm to determine the most efficient voltage to supply on the network;
- Gutteridge Haskins & Davey (GHD) – system studies to support development of the BEET-Box;
- The University of Sheffield – which will provide statistical analysis expertise;
- Siemens/Northern Powergrid smart metering team – creating the smart meter interface with the BEET-Box;
- GE Digital – providing a software platform that will provide the data to effectively and efficiently manage network operations to interface with the BEET-Box; and
- Greenhouse Communications – community and stakeholder engagement and communications.

### **How will my smart meter data be kept safe?**

We take your data privacy seriously. BEET will not use energy 'consumption' data (which, under GDPR, is covered by our Data Privacy Plan: [northernpowergrid.com/privacy-policy](https://northernpowergrid.com/privacy-policy)). We will only use voltage readings, which don't tell us about your personal energy consumption and don't give insight into your personal data. All the BEET-Box will see is the 'big picture' of voltage across the network.

### **Are there any other benefits?**

Our principal driver behind BEET is to enable customers to reduce consumption by improving the energy efficiency of customers' appliances, in turn saving customers money and reducing carbon emissions. We do however envisage other benefits, including:

- lower electricity losses; and
- improved capacity to connect customers (including low carbon technologies), as voltage optimisation should improve the amount of new load or generation that can connect before a voltage compliance issue is encountered.

### **Are there potential detrimental impacts to voltage optimisation?**

We will be reviewing the potential impact on the power reduction from devices such as electric heaters to understand if any mitigations are required.

### **What do I need to do?**

Nothing! Though we encourage you to consider a smart meter if you don't already have one (and you can still benefit from BEET even if you don't), as this will provide valuable data to enhance the project. You can also get involved if you wish and provide us with your thoughts on this project.

### **What about historic appliances? I think I have electrical items in my home that pre-date the 1995 voltage harmonisation standards mentioned.**

Northern Powergrid does not plan to go below the lower limit of 216.2V, which has been in place since 1995. There shouldn't be any detrimental impact in terms of appliance safety, but if you are concerned you can contact our BEET team using the details below.

### **Can I share my thoughts or ask a question?**

Yes, we really encourage you to get in touch and tell us your view. We want to develop BEET with you.

- You can learn more about BEET at [northernpowergrid.com/beet](https://northernpowergrid.com/beet).
- If you'd like to share an idea, ask a question, or give feedback on BEET, you can arrange a conversation with our BEET team by emailing [yourpowergrid@northernpowergrid.com](mailto:yourpowergrid@northernpowergrid.com) or calling 0800 011 3332.
- Alternatively, you can write to us at: Stakeholder Relations, Northern Powergrid, 98 Aketon Road, Castleford, West Yorkshire WF10 5DS.

### **How can I get a smart meter?**

To find out more, visit [smartenergygb.org](https://smartenergygb.org). Contact your energy supplier to find out more about how to arrange a free smart meter installation. Your supplier is responsible for installation and

making sure it works properly. They should explain the process, show you how to use it and give you a copy of the instructions. You can find out more about requesting a free upgrade to a smart meter, find your supplier and their contact details, and more information about the national transition to smart meters, at [northernpowergrid.com/smart-metering](https://northernpowergrid.com/smart-metering).

### **What happens if I think my supply is not working properly?**

BEET shouldn't affect your power supply and we don't anticipate customers noticing any change during the trial. **We're always here for you 24/7, if your supply is ever interrupted now or in the future.** Visit [northernpowergrid.com](https://northernpowergrid.com) to view our power cut map or contact our team by calling **105**.

### **What happens if I already have a voltage optimiser?**

Voltage optimisers are rare and you will almost certainly know if you have one. If you don't know if you have one, it's almost certain you don't. Someone with their own voltage optimiser that is already optimising the voltage to a lower level than we're supplying may potentially find that their voltage drops even further, below statutory limits. In all likelihood, you would not notice an effect on your appliances, and would only become aware of the issue by looking at your optimiser. In this instance, you would not need to talk to our BEET team to resolve this – the simplest option is to arrange for a qualified electrician to remove your voltage optimiser. There is no data available on how many 'personal' voltage optimisers there are on the network, but our research suggests that they are most likely to be used by industrial customers on the high-voltage network. If you have concerns, please get in touch with our BEET team ahead of the August 2022 trial date by emailing [yourpowergrid@northernpowergrid.com](mailto:yourpowergrid@northernpowergrid.com) or calling 0800 011 3332 .

### **What are 'losses' and how is the BEET project and voltage optimisation going to lower them?**

Electricity losses are a natural occurrence across large-scale networks such as ours. In very simple terms, more electricity enters the distribution network than leaves it, because some of the energy is lost as it travels across the network.

Losses on our network are split into:

1. no-load (commonly referred to as 'fixed'); and
2. load (commonly referred to as 'variable').

Losses are best considered separately for the network below the primary substation (the power lines and cables that deliver electricity to your house or business) and above the primary substation (the power lines and cables that deliver electricity from the generation source to the primary substation).

#### **1. No-load/fixed losses**

These losses occur generally in the transformer core. The transformer is a piece of electrical equipment that we use to turn the voltage up or down and is central to the running of the network. The no-load electricity losses occur due to the energy lost in magnetising the transformer, which is what causes the change in the voltage. A lower voltage applied to a transformer will reduce the no-load losses.

Below the primary substation: the hundreds of local 'secondary' substations will benefit from lower transformer losses due to lower voltages.

Above the primary substation: the voltage is not being adjusted, so there is no losses impact.

## 2. Load/variable losses

Load, or variable, losses occur on overhead power lines and underground cables and increase as the current increases through the network – when the current doubles the load losses quadruple. It is important to consider the impact of voltage optimisation on current before reviewing the impact on load losses.

Current is linked to power and voltage (where power = current x voltage). The current flowing through our network is a combination of the current required for both '**active**' and '**reactive**' power.

**Active power** is the power customers pay for and 'consume'. Where losses are concerned, a one per cent voltage reduction proportionally reduces active power consumption by one per cent, resulting in current staying the same – because it gets divided by a factor of one. This would mean that load losses would not be impacted.

It is however slightly more complicated than this, because the one per cent proportional relationship is on the conservative side, and therefore, in reality, we will expect a slight reduction in current, and thus losses.

**Reactive power** is slightly different. It supports the electric and magnetic fields of our network and customers' appliances. Reactive power demand has been shown to reduce more significantly than active power demand when voltage is reduced, and therefore when considering both active and reactive power, the total current on the network is expected to decrease with reduced voltage.

- Below the primary substation: the slight reduction in current will result in slightly lower load losses.
- Above the primary substation: the full extent of the power reduction at the primary substation (e.g. four per cent) will translate into a corresponding reduction in current. The load losses will therefore be lowered by reducing the voltage.