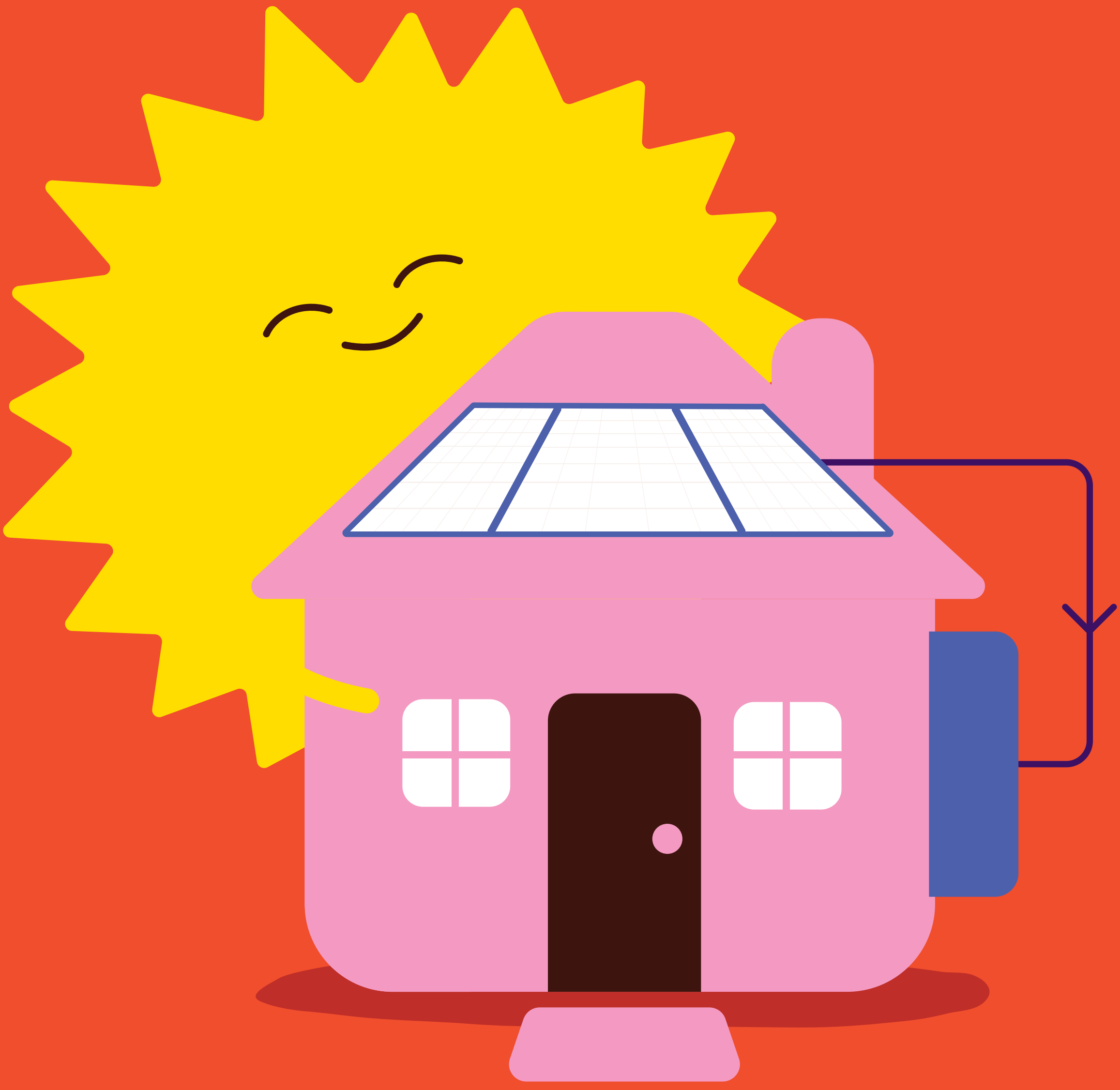
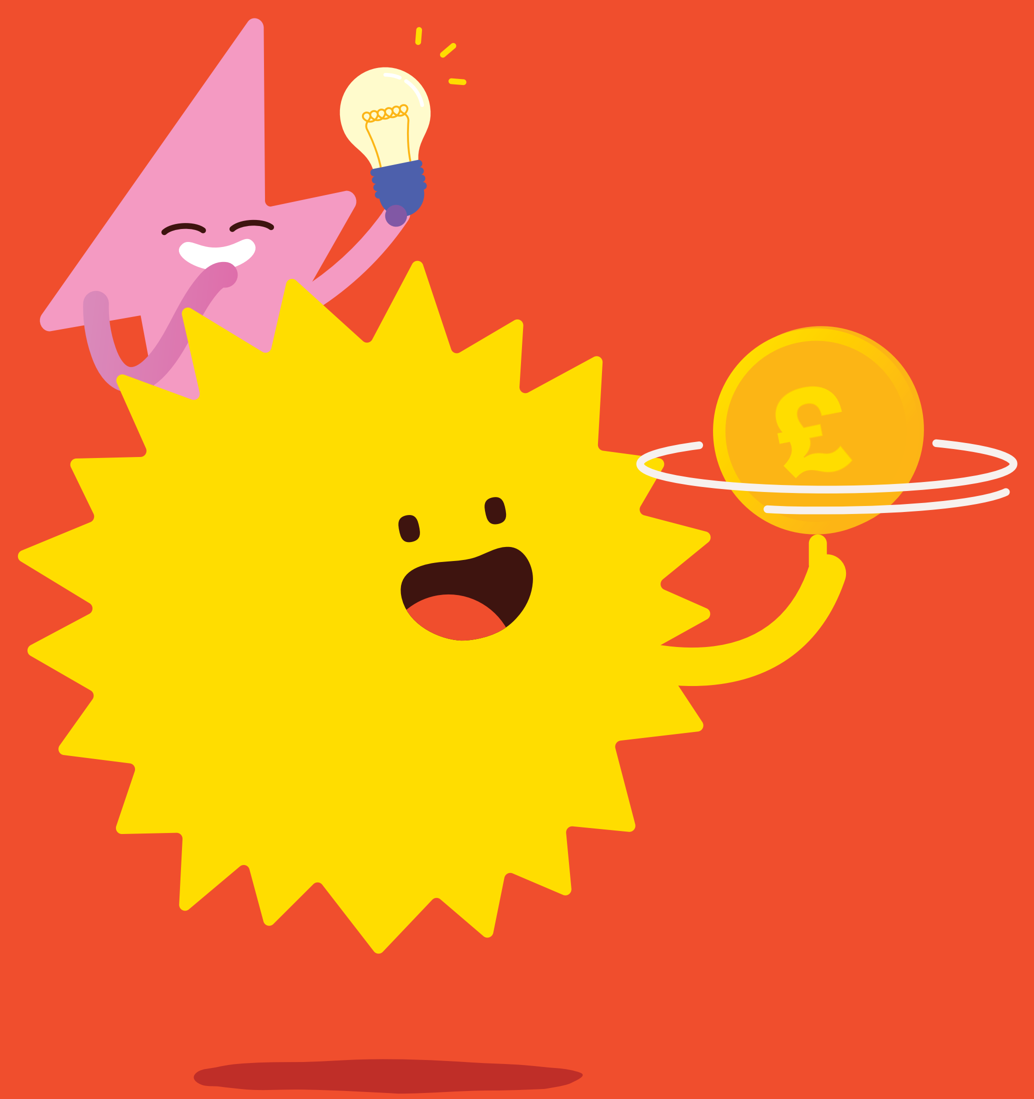
How batteries can reduce fuel poverty and limit burgeoning grid costs





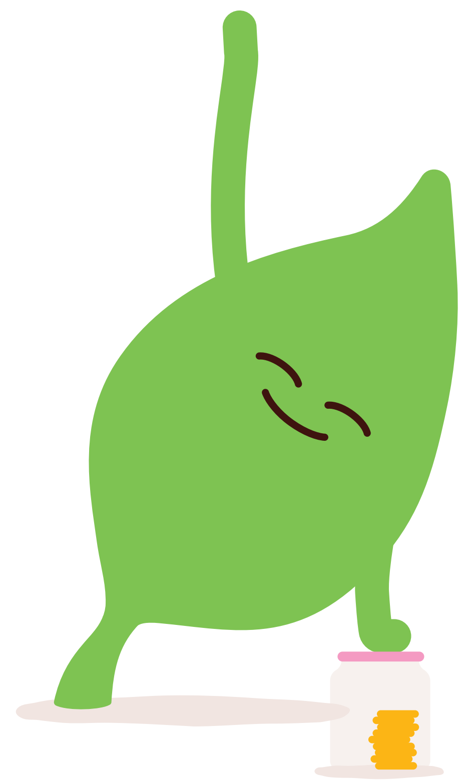
Foreword

The electricity system is fundamentally changing. Since 1991 when the UK's first commercial onshore windfarm turned on, renewables have been steadily reshaping our generation mix. Throughout this transition consumer demand has remained largely passive, but that is now changing. Today, households and businesses are increasingly needed to respond to system needs through flexible consumption, storage, and smart technologies — with the prospect that doing so will save costs overall. These fundamental changes to how we generate and consume electricity will place a growing strain on electricity grid infrastructure at both national and local levels.

The shift means we must rethink how we design costs and incentives across the system. Flexibility offers many opportunities across the electricity grid, and batteries specifically can provide significant advantages. E.ON's pilots in Coventry and Glasgow are demonstrating how we can move from welfare support to permanent solutions. By installing free home batteries and placing customers on flexibility tariffs, we are providing direct bill relief well above that provided by the Warm Homes Discount, while simultaneously easing local grid constraints.

Additionally, our Battery Boost pilots in Starbeck and Crowle explore a different funding approach using flexibility budgets from the Distribution Network Operator (DNO) to address local system needs such as delivering earlier grid connections, supply chain optimisation, and deferral of network investments.

To fully unlock the potential for batteries we need to shift from individual upgrades to area-based rollouts, allowing low-income and able-to-pay customers alike to participate in flexibility markets and realise the benefits for both themselves and the system. These batteries are both individual consumer assets as well as components of a Virtual Power Plant which can help NESO with transmission system operation, react to wholesale price changes, support the capacity market and help DNO's to meet their system requirements. This paper focusses on the latter.



Introduction

The fundamental changes to how we generate and consume electricity will place a growing strain on local electricity grids. Analysis by Oxera[1] indicates that, on top of planned grid reinforcement work[2], some 1,400 local substations will need to be upgraded by 2035 with a projected total headroom gap[3] of 3.7GW **(see Figure 1)**.

The need to radically upgrade local distribution networks comes at a time when UK electricity bills are already some of the highest in Europe, having grown 60%[4] in the last five years. We expect network charges, the fixed costs associated with building and operating the grid, to grow from an already high proportion of 21%[5]. By some estimates, even if wholesale electricity prices were zero in 2030, the total electricity bill may still be as high as today's, due in-part to rising grid charges[6]. Any further increase to electricity bills is becoming politically intolerable and the public is demanding a new, affordable approach to the transition.

Flexibility is an alternative. By turning down local demand at peak times, headroom at substations can be created enabling lower costs for distribution network operators and lower bills for all.

Our proposed Battery Boost approach is a flexibility-based solution. By installing batteries in social housing at no upfront cost, we can help address both network upgrades and fuel poverty at the same time. Modelling by Oxera suggests that Battery Boost could meet 77% of the expected 3.7GW headroom gap in 2035 using social housing alone, while delivering direct bill reductions to 480k households.

If implemented, we estimate DNOs would have the option to reduce their gross capital expenditure by £3.3 billion[7] in reinforcement costs over the 5-year period between 2028 and 2033 (increasing to £4bn[8] when including all housing types). This saving is £1bn more than the entire DNO upfront reinforcement allowances for the previous 5-year period[9]. As flexibility would only be used where it is cost effective, this would reduce electricity bills via lower network charges over the lifetime of the network assets. Additionally, participating social households would be directly saving £106m per year by 2035 (£220 per year per household).

In this paper, we assert

01 **distribution flexibility is good for customers**

02 **the current distribution flexibility market is not delivering**

03 **we have developed an innovative solution benefitting social houses, and**

04 **barriers we face to scaling the opportunity can be overcome**

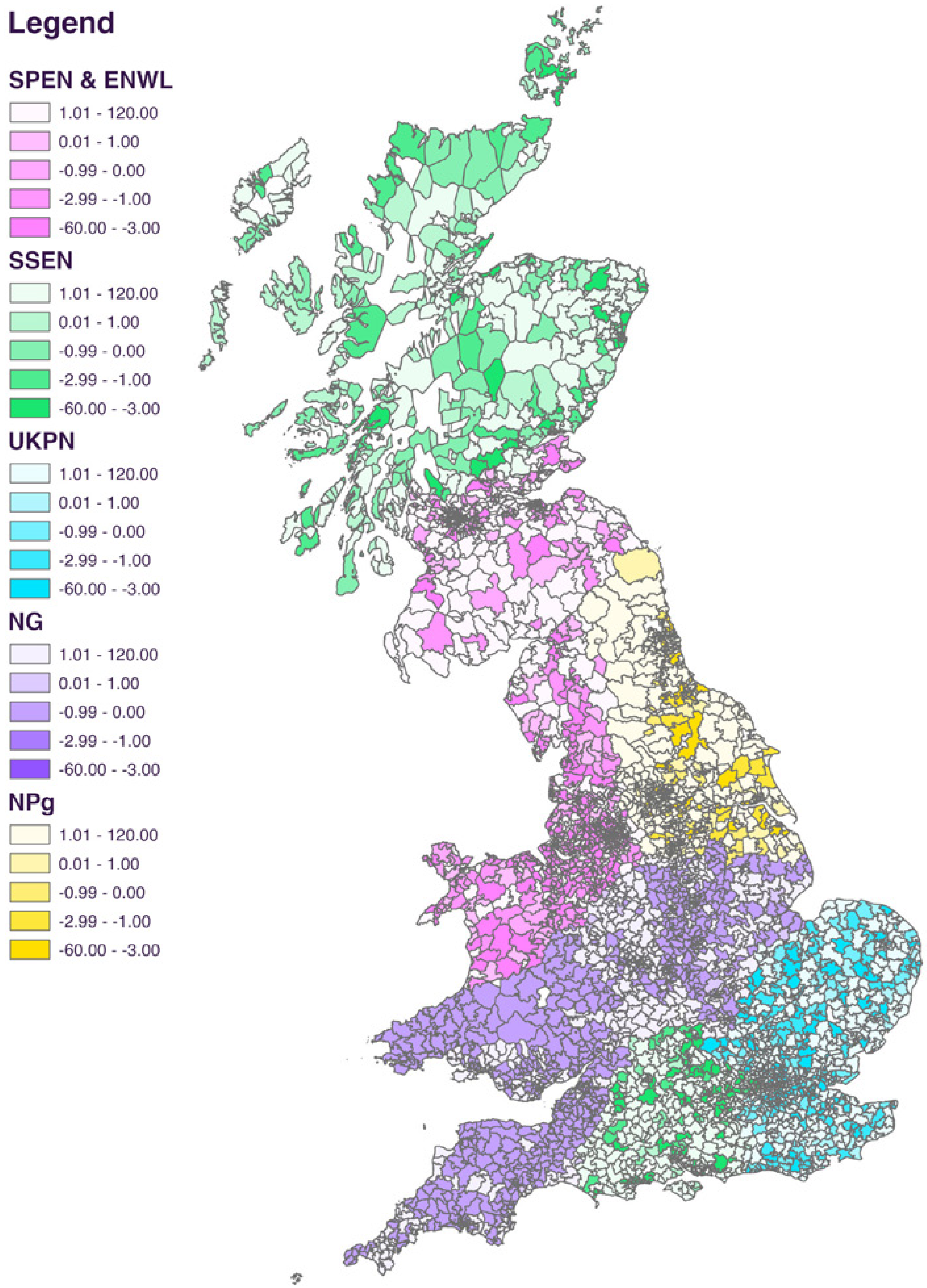


Figure 1: Projected 2035 headroom gap by Licence Area (MW)

01 Distribution flexibility is good for customers

1.1 Distribution flexibility can lower bills...

By limiting local grid reinforcement costs

We recognise that significant investment in distribution networks is needed, but reinforcing local grids at the scale we are expecting (1,400 additional substation upgrades by 2035[10]) will be very expensive and cause upward pressure on electricity bills. Estimates vary, but the capital cost of upgrading the GB distribution network for net zero is anticipated to be between £1.4bn and £3bn annually to 2050[11].

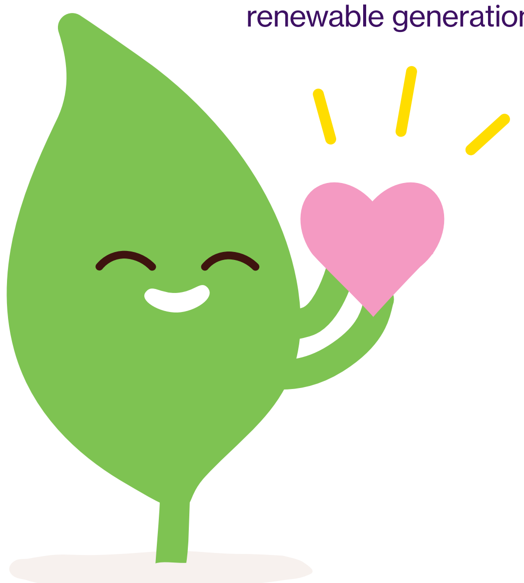
By using local flexibility, the peak capacity of a substation can be increased without the need for expensive upgrade works. Flexibility can create headroom at local substations by turning down local demand at peak times and offering network operators the ability to strategically time their investments. In some cases, physical upgrades can be removed entirely.

By strategically timing investment, increases to bills can be delayed or eliminated. Together with a reduced overbuild risk (described below), this creates vital breathing room for stretched billpayers as they are simultaneously required to pay for large investments in other areas of the energy transition including transmission networks, renewable generation and energy storage.

By reducing network overbuild risk

To plan the reinforcement of local electricity grids, DNOs rely on forecasts for how electricity demand will grow in any one area. These forecasts include assumptions on the expected uptake of electric vehicles, heat pumps and rooftop PV and are often highly uncertain, especially over the longer term. DNOs tend to adopt a conservative approach. By overestimating levels of electricity demand that may not materialise and reinforcing grids accordingly, DNOs could end up building new infrastructure that ultimately isn't needed.

Distribution flexibility reduces the likelihood that unnecessary infrastructure is built by ensuring substation capacity remains available until forecasts become more certain. Where forecasts change (as they regularly do) such that demand is lower than previously expected and upgrades are not needed, flexibility solutions mean that high-cost interventions have been entirely avoided.



The need to radically upgrade local distribution networks comes at a time when UK electricity bills are already some of the highest in Europe

1.2
Distribution flexibility builds resilience...

By ensuring capacity is available

As nations rush to upgrade their electricity networks for a new electrified world, global supply chains are becoming increasingly stretched. Transformers, a vital component in electricity grids, have increased in price by 30% in recent years while average lead times have grown to 18 months[12]. Prices for cables, another key component, have nearly doubled in the last five years as demand surges[13].

But growing lead times for components is not the only problem – the skilled labour essential to carrying out grid works is also very limited. Skills shortages for cable jointers and overhead line workers are particularly acute, with fierce competition from other sectors of the economy.

Supply chain constraints may create a scenario where local substations are not reinforced when needed. By using distribution flexibility to create headroom in less severely constrained areas, network operators can instead target limited resources on the most important upgrades and strategically time upgrade works to manage their supply chain challenges. This will ensure local grid capacity is there when it is needed.

By accelerating grid connections

Many new distribution connections are delayed because the local distribution grid lacks capacity. Where local networks are already operating close to their limits, DNOs routinely need to schedule reinforcement to enable new connections. This work can take anywhere between six months and four years[14], often leaving projects and customers in a connections queue and ultimately delaying the energy transition. While these wait times remain far shorter than those on the transmission network, there has been a steady increase in recent years.

Distribution flexibility can be used to manage local constraints so that new connections don't have to wait for physical reinforcement. DNOs may procure local flexibility to manage their local constraints while in parallel, customers can accept non firm (flexible) connections that allow them earlier but time-restricted grid access.

By helping to avoid outages

Distribution flexibility enables DNOs to rapidly shift load or turn up generation to maintain supply when parts of the local network become unavailable.

For sudden unplanned outages, rapid response flexibility (2 min & 15 min operational utilisation products) procured ahead of time can be deployed to curtail demand or dispatch local generation to stabilise the network until normal configurations are restored. For planned outages, DNOs can schedule flexibility during maintenance windows to keep customers on supply and avoid costly, disruptive reinforcement while assets are out of service.

In both cases, distribution flexibility improves resilience and enables better customer outcomes by minimising supply interruptions.

By reducing curtailment

As renewables penetration increases in our generation mix there are more regular occurrences when power supply exceeds demand. Where this happens, renewables are curtailed and the potential generation is wasted. Distribution flexibility can play a role in minimising this by turning up local demand at times of renewable abundance.

1.3
Distribution flexibility supports wider investment

The UK Government's Clean Power Action plan seeks to bring more than 10GW of consumer-led flexibility by 2030, a huge increase on today's 1.6GW[15] capacity. There are many hurdles to achieving this, but a core enabler will be ensuring that there is enough value available to flexibility service providers such that they make investments.

The distribution flexibility market provides a valuable route to market and revenue stream for flexible assets, which can be stacked with wider revenue streams from wholesale, balancing and NESO markets to create viable flexibility business cases. Distribution flex is often the most straightforward revenue stream for demand flexibility to access with many NESO services still inaccessible or with high barriers, despite years of NESO market-access initiatives.

By providing an accessible and valuable route to market, Distribution flexibility enables the critical investment needed for the UK to reach its wider consumer flexibility goals. In doing so, distribution flexibility plays a key role in realising the Clean Power 2030 mission at an affordable price.

Distribution flexibility enables the critical investment needed for the UK to reach its consumer flexibility goal

02
The current distribution flexibility market is not delivering

Despite the significant benefits offered by distribution flexibility, DNOs have consistently failed to procure the capacity they need to manage local constraints **(see Figure 2)**. In many zones, flexibility market participation is very low and DNOs often receive no bids at all.

There are several explanations for this trend

- flexible assets (such as EVs) are often not present in the locations that DNOs need;
- bids are higher than DNOs can pay; and
- contract terms are too short to allow bidders to make flexibility investments or suppliers to reflect the revenues in their tariff rates;

Even where DNOs have been successful in procuring the flexibility they need, they cannot always rely on the capacity they have under contract. Real life uncertainties, such as an EV that is left unplugged or a battery that has been drained, impacts the available flex capacity. Penalties on flexibility service providers for non-availability are minimal and do not provide any meaningful incentive to ensure capacity is there.

What's more, the procurement of flexibility is time-consuming and resource intensive for DNOs. Multi-stage tendering, stakeholder engagement and extensive analysis all create a time and cost burden on DNOs for often unsuccessful outcomes.

We believe the failure of the current DNO flexibility market has resulted in significant lost benefit to UK billpayers which may in-part be corrected by a different approach.

Figure 2: Flexible capacity tendered and contracted by GB DNOs by year[16]

03
We have developed an innovative solution for social households

We have developed an innovative solution that seeks to unlock the considerable benefits of distribution flexibility, address the difficulties faced by DNOs and provide direct relief to those struggling with energy bills.

Our solution: Battery Boost

We have been trialling a solution in partnership with Northern Powergrid (NPg), a UK DNO, that involves installing batteries free of charge in customer homes. This trial focused on locations where NPg has a substation constraint[17].

These DNO-centric batteries are controlled remotely to deliver DNO flexibility when required and otherwise used to earn money from the wider system by charging during electricity abundance and discharging during scarcity. While DNO required flexibility is prioritised, the batteries pay for themselves by stacking several flexibility revenue streams.

While the battery works silently in the background, the customer is offered a guaranteed bill credit for hosting it without any requirement to change their behaviour. For customers in fuel poverty, this bill credit provides immediate, tangible support to reduce their cost of living.

There are approximately 4.1 million social houses in the UK and modelling by Oxera indicates that 1.6m of these will be located near constrained substations by 2035.

Reliable, firm flexibility where it is needed

Our solution directly solves two key challenges for DNOs by installing dedicated batteries in homes:

01 **Firm flexibility** – Batteries are never unplugged, nor are they being prioritised for other purposes. Because the batteries are prioritised for DNO flexibility, DNOs can rely on them to deliver the flexibility they have been contracted for.

02 **In the right place** – By targeting DNO constraint zones, batteries will always be installed in locations that DNOs need flexibility. DNOs don't need to hope that EV or solar & battery penetration will organically grow in their constraint zones, flexibility will be in the places they need.

We estimate that we could install 480k batteries, free of charge, and meet 77% of the DNO headroom gap by 2035

Social households benefit

Social households, and those in fuel poverty, are sections of the population that face the greatest risk of being left behind in the energy transition. Low carbon technologies that enable bill savings, improve comfort and provide convenience have typically been accessible only by those with greater means.

By matching constrained substation locations and headroom gaps with social housing, we estimate that we could install 480k batteries, free of charge, to meet 77% of the DNO headroom gap by 2035. For those participating, we expect a typical social household to achieve direct bill savings of £220 per year.

In aggregate, we estimate that our Battery Boost solution could directly reduce the bills of participating social households by £106m per year, all while supporting DNOs to manage their constraints and indirectly reducing electricity bills for all.

We expect our approach to complement the Warm Homes Plan which also seeks to support lower bills for low-income households by leveraging low carbon technologies.

Participating households could save £220 a year, with no behaviour change needed

All billpayers benefit

If implemented, we estimate this would provide DNOs with the option to reduce gross capital expenditure by £3.3 billion[18] in reinforcement costs over the 5-year period between 2028 and 2033 (increasing to £4bn[19] when extended to all housing types). This saving is £1bn more than the entire DNO upfront reinforcement allowances for the previous 5-year period[20]. Flexibility would only be used where cost-effective, so these savings could be translated to lower customer bills through reduced network charges over the 2028 to 2033 period.

While these reinforcement capital costs are not eliminated by our Battery Boost solution they could be significantly delayed by periods exceeding 5 years and, in some cases, 10 years. Taking this into account, we estimate deferred capex savings of £681m[21] (increasing to £970m[22] when extended to all housing types). We recognise that to achieve these savings, DNOs do incur costs to procure the flexibility and thus the present value of these costs should be netted off the DNO capex savings to give system savings.

On top of DNO capex savings we expect Battery Boost to reduce the grid balancing requirement of the wider system. We forecast reduced balancing costs of £50m per year[23] by 2030 (increasing to £70m[24] when extended to all housing types), with these savings directly reducing bills.

A complementary model

Battery Boost complements the enhanced co-ordination role we expect DNOs to take in ED3 as well as many of the possible expanded responsibilities being consulted on at time of writing. While our approach mobilises private capital to reduce the burden on bill payers, it would work well alongside an expanded area-based DNO role seeking to minimise system costs.

DNOs could reduce their gross capital expenditure by £3.3 billion in reinforcement costs between 2028 and 2033[18]

04
Barriers we face to scaling the opportunity can be overcome

We see huge potential for our solution but face barriers to being able to make significant progress. These can be overcome.

01

Flex contracts need to be longer – at present, DNO flexibility contract lengths are limited by the fixed 5-year price control period. While batteries can be re-contracted, a maximum term of 5 years (the average being closer to 2.5 years) is not sufficient to underpin upfront private investment. Regulatory certainty that would allow DNOs to make longer term arrangements with flex service providers is needed.

02

ED3 incentives need to optimise long term build with flexibility – In ED3, DNOs should continue to be strongly incentivised to contract flexibility, taking a long-term view on network needs and considering the significant potential for flexibility to reduce near- and medium-term bills. Incentivisation shouldn't be limited to operational use cases with flexibility treated as complementary, not competing with network build.

03

DNOs should co-ordinate a market-based solution – All DNOs should play a co-ordination role for the installation of low carbon technologies (incl. batteries), working with local authorities and the private sector to maximise the benefit of flexible assets on the distribution network.

04

Regulatory and competitive frameworks need to account for the full range of financial and non-financial benefits – This should include the potential for DNO flexibility to support alleviating fuel poverty and recognising this with targeted regulatory incentives.

05

DNOs need freedom to enter bilateral flex contracts – DNOs should be given freedom for how they procure flexibility. Rather than forcing a focus on headline price, DNOs should be able to fully evaluate flexibility service provider offers against a wider range of criteria including reliability and delivery risks.

References

1 An independent consultancy
2 Infrastructure upgrades planned in ED2 (2023 – 2028)
3 Headroom gap is the amount that peak demand exceeds capacity at a substation (expressed in GW)
4 A household consuming 3.1MWh in 2020 paid £607 for their electricity. This rose to £963 by 2025 (+59%).
5 TNUoS, DUoS & BSUoS accounted for £207 of the annual bill (£963) for a household consuming 3.1MWh in 2025.
6 Based on latest cost forecasts at end of January 2026, non-commodity costs rising by £80/MWh between 2025 and 2030, approximating to the 2025 wholesale only rate
7 Based on removing the reinforcement costs of 599 primary substations at £5.5m per substation from the DNO ED3 capital programme, by instead installing batteries in social housing. This is the value of capex that could be deferred. To understand system savings, the cost of procuring DNO flexibility should be subtracted.
8 Based on removing the reinforcement costs of 735 primary substations at £5.5m per substation from the DNO ED3 capital programme, by instead installing batteries in all house types
9 The total upfront reinforcement allowances across networks in ED2 was £2.3bn in 2024/25 prices
10 In addition to the infrastructure upgrades planned in ED2 (2023 – 2028)
11 Electricity Distribution Network Capacity Analysis, Regen Nov 2024 estimates annual costs between £1.4bn and £1.8bn.Electricity networks strategic framework Appendix I: Electricity Networks Modelling, DESNZ and Ofgem 2022 estimates annual costs between £2.3 and £3bn.
12 National Infrastructure Commission Electricity distribution networks: Creating capacity for the future, Feb 2025
13 Building the Future Transmission Grid, IEA, Feb 2025
14 National Infrastructure Commission Electricity distribution networks: Creating capacity for the future, Feb 2025
15 2024 capacity. Sourced from: Clean flexibility roadmap, DESNZ, July 2025
16 DSO flexibility procurement reports over 2022/23 to 2024/25, excluding UKPN (due to inconsistent data reporting for 2022/23. The data sourced from SPEN, ENWL and NGED's annual Flexibility Services Procurement Reports.
17 Note that alleviating substation constraints is only one of many DNO use cases for flexibility
18 Based on removing the reinforcement costs of 599 primary substations at £5.5m per substation from the DNO ED3 capital programme by instead installing batteries in social housing
19 Based on removing the reinforcement costs of 735 primary substations at £5.5m per substation from the DNO ED3 capital programme, by instead installing batteries in all house types
20 The total upfront reinforcement allowances across networks in ED2 was £2.3bn
21 £681m is our central estimate, in a range between £0.71bn and £2.3bn. The central estimate is based on deferring reinforcement capex at 599 substations (92% for 5 years and 8% for 10 years) at a cost of £5.5m per substation. While our Battery Boost solution would reduce the headroom gap across 737 substations, we only see complete deferral as a viable option at 599 of them. Savings are in NPV terms.
22 £970m is our central estimate, in a range between £0.49bn and £1.56bn. The central estimate is based on deferring reinforcement capex at 735 substations (71% for 5 years and 29% for 10 years) at a cost of £5.5m per substation. Savings are in NPV terms.
23 Based on our Battery Boost solution reducing the need for NESO to take balancing actions for thermal constraints at an average cost of £125/MWh and assuming batteries discharge 12 kWh per day for 325 days a year (days in which they are not suppling DNO flexibility) across 599 substations.
24 By increasing the no. of batteries deployed to 145,600 by 2030 across 735 substations