Realising the value of domestic energy efficiency in GB electricity distribution

Saving energy in the home can mitigate network constraints and prepare electricity distribution networks for net zero.

- Domestic energy efficiency is a valuable complement to flexibility in avoiding or mitigating network constraints caused by rapidly increasing demand on the distribution system.
- For electrically heated homes, the network value of energy efficiency measures such as thermal insulation can be £1,000 or more.
- However, current regulatory and commercial models do not appropriately reward this important system service.
- To establish the evidence base for action to realise the system value of energy efficiency, we recommend a series of large-scale trials.
- Successful trial schemes should:
  - Reflect local technical, social and housing conditions,
  - Meaningfully involve stakeholders from across society in collaborative co-creation,
  - Place consumers' concerns and values at the heart of decisions,
  - Innovate through experimentation,
  - Gather and disseminate high-quality data.

Going forward, it is essential that Ofgem provides clarity on the proposed funding route for trial schemes, whether through the Strategic Innovation Fund (SIF) proposed in the 2023-2028 electricity distribution price control (RIIO-ED2), or via some other mechanism.

The electrification of heating and transport is projected to double GB domestic electricity consumption between now and 2050, to an annual total of 195 TWh. This rapidly rising demand will make managing the electricity system more complex, increasing the prevalence and severity of network constraints and requiring potentially costly remedies. The impact of this growing congestion will manifest most acutely in the low-voltage distribution networks that supply people's homes.

In addition to greater flexibility in how and when energy is used, simply reducing the amount of electricity consumed in the home through domestic energy efficiency will significantly reduce the cost of ensuring resilient, low carbon distribution networks.

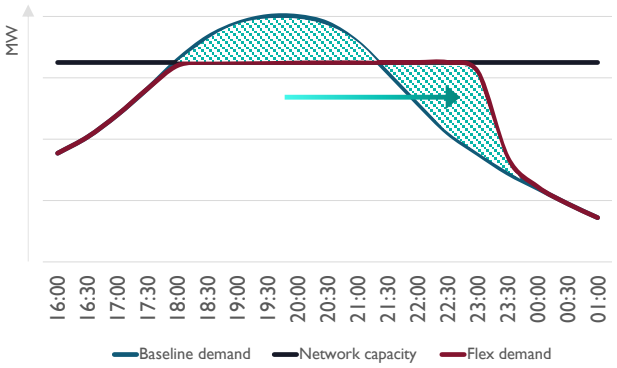
In this briefing paper, we show how energy efficiency can play a greater role in managing distribution network constraints. We also present modelling results that illustrate the magnitude of the untapped value and highlight the challenges that need to be addressed through large-scale trial schemes. Finally, we propose five design principles for implementing trial schemes.

1. How home energy efficiency contributes to distribution system management

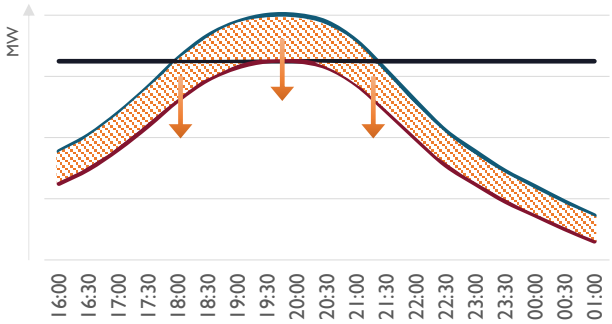
Changes in domestic energy consumption can reduce the prevalence and severity of network constraints in two distinct yet complementary ways.

- **Flexibility** allows home energy usage to respond to appropriate signals, shifting energy consumption outside of peak times. Flexibility is ideal for ensuring that non-time-specific consumption does not unduly contribute to network constraints – for example, charging electric vehicles at times of ample network capacity.
- **Energy efficiency** delivers permanent changes to consumption patterns, reducing rather than shifting demand. Energy efficiency has the greatest network value when applied to consumption for which significant shifts in time are difficult, or where efficiency can act as an enabler for flexibility. An example is the growing demand for electrical heat in homes during winter evenings, which energy efficiency can permanently reduce and can also enable to be shifted, helping homes to act as thermal stores.
- Flexibility and energy efficiency are complementary, and their combined effect may be required where network constraints are most severe.

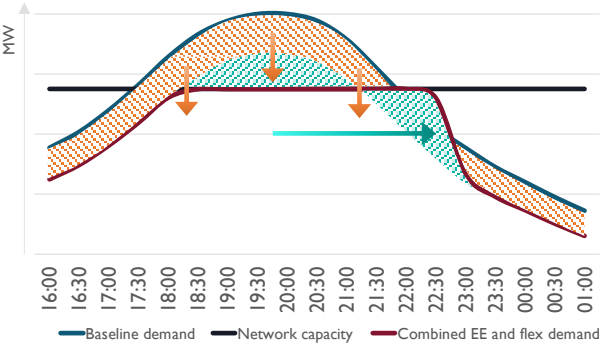
Flexibility protects against network constraints by shifting demand to off-peak times



Energy efficiency can provide the same result by reducing demand at all times



For the most severe network constraints, the combined effect of both flexibility and energy efficiency may be needed



Energy efficiency for low-carbon constraint alleviation

Using flexibility to shift electricity consumption does not change how much energy is consumed and therefore does not have a significant, direct contribution to carbon savings. Future Flex project analysis shows that using domestic flexibility to manage distribution networks constraints results in between 7 and 109 grams of *additional* CO_2e per kWh, albeit this is below conventional flexibility technologies.

In contrast, energy efficiency can contribute to network management while simultaneously reducing electricity consumption. Therefore prioritising energy savings from key sources of demand will help meet DSO requirements for network alleviation while also contributing to distribution system decarbonisation.

2. Valuing the network benefits of saving energy

Coping with network constraints comes at a cost, through either short-term active management or long-term investment in infrastructure reinforcement. By mitigating constraints, energy efficiency avoids some of this cost and therefore has a network value additional to the energy savings experienced by the consumer.

To calculate the system value of energy efficiency, the Future Flex project used real-world empirical data from the National Energy Efficiency Data Framework (NEED). Data showing the effect of household energy efficiency improvements on electricity consumption allowed the creation of efficiency-adjusted half-hourly domestic demand profiles. Mapping the adjusted profiles against WPD's known constraint alleviation costs provided an estimated energy efficiency system value for each profile. The modelling was led by Everoze and checked by WPD, based on data from BEIS and Flexible Power[1].

Three key findings emerge from the analysis:

Key finding 1: energy efficiency could deliver an overall network value of up to £1,000 per home

The results of the modelling exercise show clear network benefits from energy efficiency improvements. However, the findings also reveal that the system value of energy efficiency is highly locational and varies widely depending on homes' energy usage profile and local network conditions.

The principal drivers of the scale of savings are the severity of local network constraints, the duration of the constraint, and the type of heating system installed in a home.

- Installation of energy efficiency measures in areas with **severe network constraints** realises approximately **seven times** more value than in areas with moderate constraints.
- Energy efficiency delivers **five times** more value in zones with **chronic network constraints** (5-year) than in regions with short-term (1-year) constraints.
- Among homes with electrified heating, the value of energy efficiency varies by **heating type**, with heat pumps or conventional electric heating delivering **three times** more value than storage heaters.

"In zones with severe and prolonged constraint issues, the installation or improvement of thermal insulation could have a network value of almost £1,000 over its lifetime."

Key finding 2: the size of home and type of energy efficiency measure are secondary factors

- Improving the energy efficiency of homes with higher underlying electricity consumption realises greater network value.
- The type of energy efficiency action also has an impact, with cavity wall insulation and solar PV having the most significant effect, based on the limited data available at present.
- However, these factors have a less significant influence than the severity of the network constraint, its longevity and the type of heating installed.

"In very large houses, the network value of installing solar PV and improving thermal insulation could double to more than £2,000."

[1] A unified portal for the advertisement, procurement and operation of flexibility services across five UK DNOs: Western Power Distribution, SP Energy Networks, Scottish and Southern Electricity Networks, Northern Powergrid and Electricity North West.

Key finding 3: homes with the greatest energy efficiency network value are uncommon but geographically clustered

- Currently, a minority of homes are located in areas with severe network constraints, but the prevalence of constraints is expected to increase.
- Network constraints are inherently local phenomena and can be addressed only from within a precisely defined area.
- Patterns also exist in the geographic distribution of heating types, according to local housing stock.

"The greatest potential exists in local areas with both severe, chronic network constraints and homes with heat pumps or conventional electrified heating."

3. Delivering on the energy efficiency opportunity

Saving energy in the home offers a low-cost, low-carbon approach to mitigating network constraints that strongly aligns with broader policy and regulatory goals to meet net zero and protect vulnerable consumers. Given these advantages, we suggest that realising the distribution network value of energy efficiency should be an urgent priority for regulators, network operators, and other stakeholders in the GB electricity distribution system.

But at present, there are barriers to accessing this value. Future Flex has uncovered several key challenges to designing and implementing commercial and regulatory models that fully reflect the network value of domestic energy efficiency.

- **The existing funding landscape is complex:** There is a wide range of active schemes for domestic energy efficiency providing funding at a national, regional and local level. However, these schemes are difficult to navigate for the customer, are poorly integrated, and subject to frequent changes. They also fail to join up the efforts of the many motivated participants in the energy efficiency sector.
- **The benefits of energy efficiency are dispersed:** Energy efficiency benefits many different parties, presenting a challenge in how to draw diverse beneficiaries together into relationships that combine the value received by each and convert this into a single customer incentive.
- **Network services are designed around the DSO:** DSOs typically frame service procurement around their own technical requirements and timescales. This approach is suitable for dedicated flexibility assets but not for people's homes, where provision of DSO services is not a primary concern. DSO-centric processes contribute to the low consumer engagement in domestic flexibility reported by Future Flex workshop participants.
- **It is unclear how best to incentivise efficiency**: Future Flex has piloted a domestic incentive scheme that is agnostic to flexibility and energy efficiency in hundreds of homes. The findings of our 'Sustain-H' pilot and supporting work show that both operational payments and direct grant funding have their merits for energy efficiency, but there is no clear winner in all situations. Domestic energy efficiency solutions require a deep understanding of people and their homes, suggesting that a successful approach will be local and customer-focused, not centralised and technocratic.
- **The available data is insufficient:** To date, energy efficiency grant schemes have focused on collecting data to illustrate annual reductions in energy consumption. But to fully evaluate the system benefits of energy efficiency described here, high-resolution time-series data showing the impact of energy efficiency improvements over the course of the day is needed.

4. Our recommendations

Given the challenges outlined above, we believe that the first step towards realising the value of domestic energy efficiency in GB distribution networks is a series of large-scale trials to establish the evidence base for future commercial and regulatory arrangements.

We support the recommendation made by Sustainability First that DNOs should establish partnerships to deliver major 'beacon' energy efficiency schemes with a focus on vulnerable customers over the next five years. Going forward, it is essential that Ofgem provides clarity on the proposed funding route for trial schemes, whether through the Strategic Innovation Fund (SIF) proposed in the 2023-2028 electricity distribution price control (RIIO-ED2), or via some other mechanism.

Well-designed trial schemes will provide the networks, industry, local authorities, energy suppliers, and customers the opportunity to develop and implement the necessary changes before network constraints become more acute, widespread, and costly.

To contribute to what we hope will become a major theme of network innovation, we have established five principles for successful energy efficiency trials in the distribution system:

1. Tailored by location

The network value of domestic energy efficiency is highly location-specific. Therefore, we must tailor trial schemes to the technical specifics of distribution network constraint issues, to local demographics, housing tenure and housing stock. This means that trials must draw on expertise held by local communities, local authorities, not-for-profits and businesses to achieve effective engagement.

2. Collaboration and coordination

Energy efficiency solutions cannot be isolated from the broader energy system. They have technical, market, regulatory, and social impacts involving many stakeholders from across society: value is shared between multiple actors. Successful trial schemes will therefore require DSOs to work collaboratively and take a whole-systems approach that builds on existing efforts, rather than starting anew. This includes integrating with existing energy efficiency activity supporting vulnerable customers.

3. Consumers at the centre, always

The energy system exists for energy consumers, not the other way around. Future Flex engagement has shown that focusing on industry needs rather than people deters participation. Successful trials will be guided by the interests, concerns and values of energy consumers rather than those of the DSO.

4. Commitment to experimentation, learning and innovation

Future Flex has examined the relative merits of various commercial arrangements and found no universally satisfactory model. Optimal approaches to realising the network value of domestic energy efficiency will be innovative and potentially novel. Therefore, trials should be open to the full range of commercial possibility, including, for example, the valuation of energy efficiency's social and strategic benefits.

5. Data, data, data

There is a deficit of public-domain, high-resolution, real-world data on the effects of energy efficiency improvements on energy demand in homes[2]. To make better decisions, we need a stronger understanding of the relative merits of different solutions for energy efficiency and how they interact with other technologies and practices, such as flexibility. High-quality data gathering and dissemination should be a core aim of all trials.

[2] This finding is supported by the Final Report – Phase 2 of the Smart Meter Energy Data Public Interest Advisory Group.

5. A final word

This paper outlines the rationale for a greater focus on home energy efficiency's role in preparing GB's electricity distribution system for net zero. There is a clear and urgent case for exploratory trials to inform future decisions about how to value and reward this overlooked system resource.

Developing the innovative approaches needed to accurately and fairly value the contribution of energy savings to network management will not be easy. It will take collaboration and a new, shared understanding of problems and solutions. It will take innovation and commitment.

For DNOs this means working in new and unfamiliar ways: seeing homes, not houses; taking account of the local sociocultural context; partnering without necessarily being in the driving seat. It likely demands a more granular approach to customer segmentation than DNOs have previously been required to consider.

But we don't have a choice. Rapid decarbonisation to net zero means seizing all low carbon options for addressing network constraints. We must use energy flexibly, but we must also use it sparingly. Energy efficiency should be our first priority, not an afterthought.

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