SP ENERGY NETWORKS

DOMESTIC DEMAND SHIFT TRIAL

for local network management and distributed generation avoidance

Phase 1 - 2022

Executive Summary

Renewable energy capacity in the UK is set to grow by 26 GW and this growth in renewable energy generation is critical to reach the decarbonization objectives set out for the Net-Zero ambitions. As renewable capacity increases, the cost of curtailment is also set to increase and the consumers in Scotland and England may face an extra cost which is estimated to be over £1 billion per year through curtailment payments.

The most cost-effective outcome would be to help grid operators manage network stress while increasing the amount of utilised renewable energy. Domestic demand is an untapped resource which could pose a potential solution. Prior work has explored the potential for households to provide reliable support to the network through aggregated energy flexibility (demand shifting, and load turn up).

This paper outlines the demand shift trial conducted by SP Energy Networks (DNO) and Octopus Energy (Retailer) in the Dumfries, Galloway and Ayrshire area electricity distribution network which is constrained with high Distributed Energy Resources (DER) penetration.

Introduction

The energy landscape is changing fast as the way our customers generate, use, and interact with energy evolves. This means that our role – how we plan, design, and operate the network for our customers – must evolve with it. To tackle the climate emergency and deliver Net Zero carbon targets, distribution networks will enter a new era in its development and usage.

With the UK Government targeting carbon-free power generation by 2035, within a relatively short period of time, it is forecasted that a significant proportion of transport and heating will be electrified. We also anticipate five-fold increase in DER connected to our networks. Coupled with the rapid rise of digitalisation, this will precipitate a revolution in how both domestic and commercial customers interact with the electricity distribution system.

These changes will result in higher distribution network utilisation, more dynamic and volatile power flows, more complexity in network operation, and a greater need for whole system coordination.

Figure 1 depicts the transformation of the present distribution networks from being passive and predictable to more dynamic and complex networks.

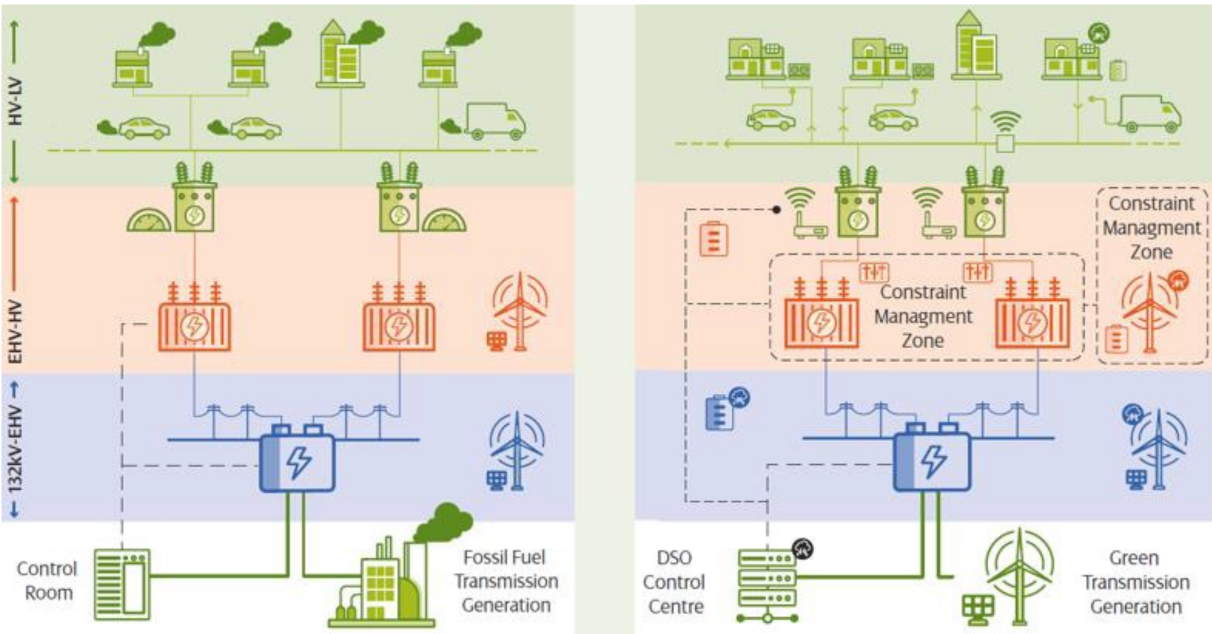

Figure 1. Transformation of distribution networks

DER penetration and growth

In the next ten years, the generation and storage capacity on our network is likely to triple and by 2050 we anticipate a five-fold increase in generation [1] to be connected on our distribution networks.

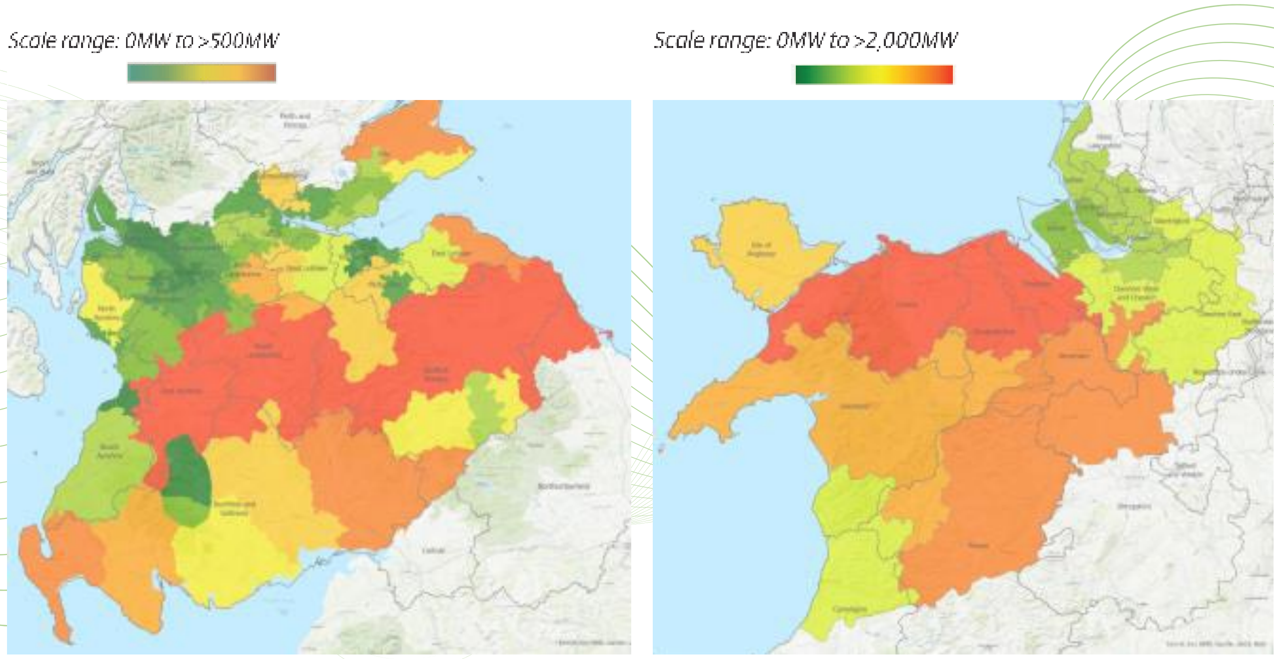

Figure 2. Forecasted DER penetration by 2050 in SP Distribution (SPD) and SP Manweb (SPM) licenses.

Figure 2 shows that significant growth is expected across our network licenses, the growth will be particularly from renewable generation. The majority of the increase in capacity is expected to come from wind, solar PV, and storage. Given that wind and solar PV generation output is weather-dependent, it is unlikely to always occur at the same time as periods of high demand. This means that the distribution network may need intervention to accommodate wind and solar PV generation capacity. It also means that there may be a greater export of power from the distribution network up onto the transmission network, and greater transfer of power across the transmission network, at times when generation output is high, and demand is low.
To accommodate renewable generation growth, we have delivered new technologies, such as Active Network Management (ANM) [2], to offer quicker and lower cost connections and accommodate renewable generation growth.

Curtailment and demand side flexibility

The level of renewable generation curtailed across Great Britain (GB) in 2020 due to network constraints was a total of 3.5TWh [3] with an estimated curtailment cost of £299m. These costs increased to £507m in 2021, mainly due to the impact of high gas prices at the back end of 2021. Renewable generation from Scotland represented most of these curtailments and associated costs.

As renewable capacity penetration increases, the cost of curtailment is also set to increase and the consumers in Scotland and England may face an extra cost which is estimated to be over £1 billion per year through curtailment payments.

Demand Side Flexibility

Studies have found that demand-side flexibility can be used to reduce renewable generation curtailment by better matching demand with supply. The International Energy Agency (IEA) has found that demand response and storage could reduce the need for curtailment of renewables in the EU from 7% to 1.6% in 2040, leading to 30MtCO2e emissions reductions in 2040 [4]. Another study from the National Renewable Energy Laboratory (NREL) shows that renewable energy curtailment in low demand-side flexibility scenarios has a rate of 6% to 9% compared to scenarios with high demand-side flexibility with curtailment rate of 2% to 3% [5].

Domestic demand is an untapped resource which could provide a potential solution. Prior work has explored the potential for households to provide reliable support to the network through aggregated energy flexibility (demand shifting, and load turn up).

Demand shift impact assessment

Dumfries & Galloway and Ayrshire region has over 3GW connected and contracted DER against a local demand of around 500MW. The cumulative firm capacity of Gird Supply Points (GSPs) in the region is around 1.8GW due to which significant proportion of generation capacity would need to be curtailed during certain network operating scenarios. To assess the impact of shift in domestic demand, this region was chosen for the demand shift trial.

SPEN in association with Octopus Energy reached out to customers in the Dumfries & Galloway and Ayrshire region and sought interest from over 8,500 domestic customers who were willing to participate in the trial. The cumulative capacity secured from the customer was 10.6MW.

Network modelling

SP Energy Networks (SPEN) have developed Engineering Net Zero (ENZ) model which comprises a full connectivity of complete LV network combined with HV and EHV network connectivity model. The ENZ Model allows for complex modelling and is a significant advancement on vectorised geographic information systems (GIS). It has been designed to operate with large data sets and provides access to full asset data including conductor types, ratings etc. It enables us to trace the network and aggregate demand, including the effects of demand diversity at any point in the network.

We used our ENZ Model which can run comprehensive programme of power flow analysis for every half hour for every forecast scenario – 175,000 iterations per network asset. This systematically identified the location, magnitude, and timing of every network constraint in our network.

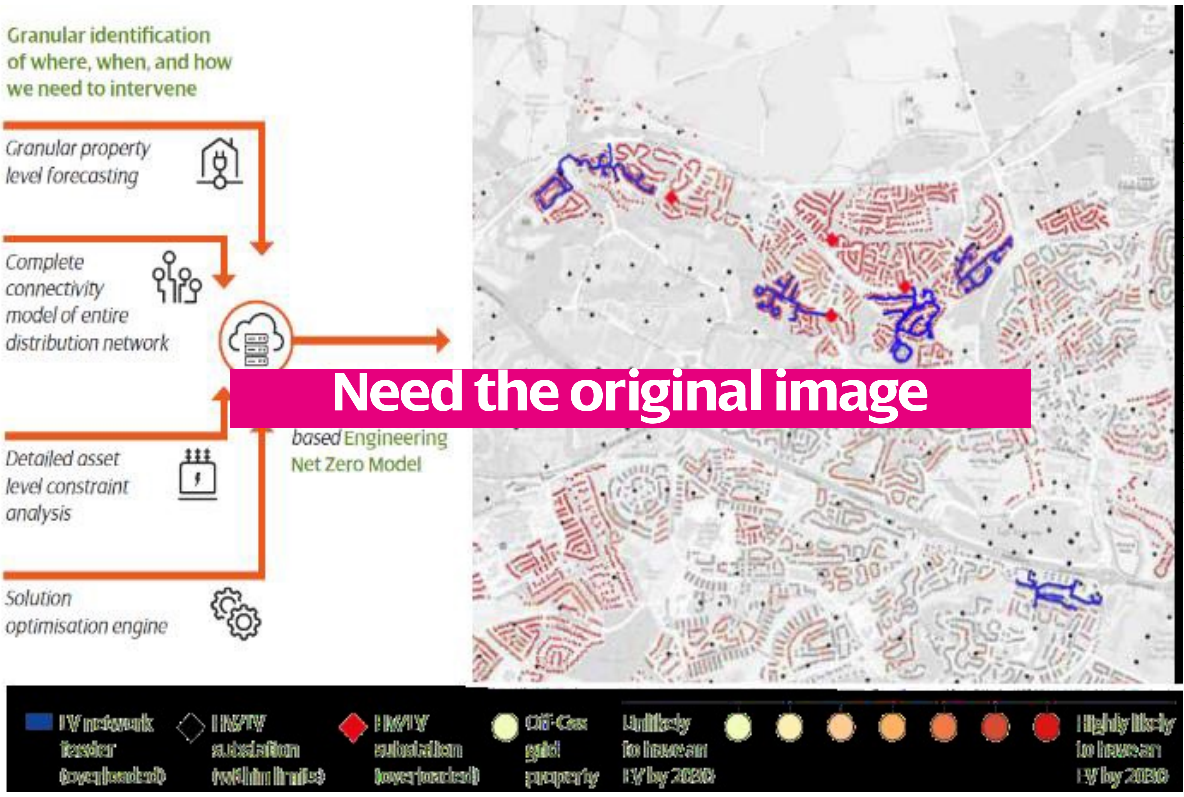

Figure 3: Enhanced forecasting combined with our ENZ Platform

This precise knowledge meant we could reach out to our domestic customers to enable demand side flexibility for every constraint. This identified the optimum approach for providing the required network capacity.

Impact Assessment

For the demand shift trial impact assessment, we used the ENZ model to determine network performance and number of constrained customers. The base data considered within the study area is shown below:

Table 1: Data for demand shift trial

Customers in Trial		8,692
Affected HV/LV substations		2,011
Affected primary substations		62
Total customers supplied within study area		212,278
Total Demand Shift Commitment (MW)	1	0.6

Network impact assessment from ENZ model-based system studies indicated considering the existing network operational scenario the anticipated 10MW shift in customer demand does not cause any adverse impact on the network. However, with the forecasted Electric Vehicle and Heat Pump uptake by end of regulatory price control period (2028), the anticipated shift in customer demand at the time of peak would lead to overloading of 3 secondary substation transformers above the cyclic rating.

A detailed sensitivity study considering time profile based half-hourly data and 17,520 simulation was performed to determine the opportunity for demand shift during considering seasonal and time of the day variations which is show in Figure 4.

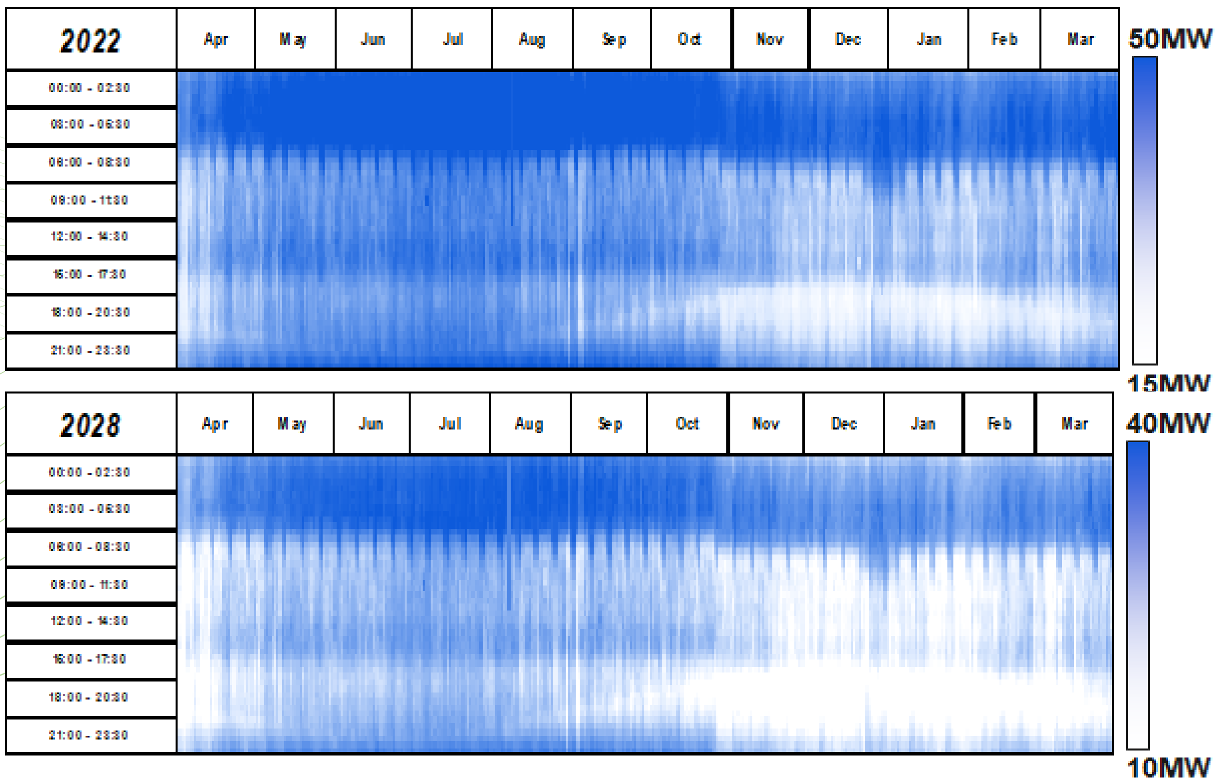

Figure 4: Time -profile based demand shift opportunity assessment for the year existing and future network operating conditions

The assessments indicated that the demand shift opportunity ranges between 15-50MW for the existing network without triggering a network constraint and the demand shift capacity erodes by 10MW with future LCT uptake.

Demand shift trials

With extensive engagement with Octopus Energy, we developed six separate events that lasted for two hours between either 5:30 am – 7:30 am or 7:30 pm – 9:30 pm covering weekdays and weekends.

The dates for the trial were determined based on consumer behavior and their usual trends. For the events between 7:30 pm to 9:30 pm, we tried to observe if the domestic customers were able to shift their usual peak consumption to later in the evening. The morning 5:30 am to 7:30 am on the weekends was chosen due to the lower demand and high generation period.

Trial process

The trial process can be divided in three steps:

– Pre-Event: Octopus Energy emailed participating customers in the Dumfries & Galloway / Ayrshire area with the trial information and an opt-in request. The customers, both smart and non-smart customers, who accepted the opt-in request became part of the "trial group".

– Event: In each of the six events the process was as follows:

- SPENs control room conducted assessments identifies the networks needs day-ahead of each event.
- Once confirmed that there are no constraints in the network, SPEN sends an email to Octopus Energy confirming the viability of the event.
- Octopus Energy sent a day-ahead reminder email to all domestic customers in the trial group with their turn up target.

– Post-Event: Octopus Energy calculated the demand shift response as the difference between the actual and forecasted demand. Customers who successfully reached the 10% increase target were deemed to have participated in the trial and were rewarded with free electricity / double the credit if they turned up by 100% of their usual consumption.

Trial results

The outcome of the six trials indicated that domestic customers turned up a total of 20MW with maximum turn-up per event recorded at 2.84 MW and an average turn up per even being 1.7 MW.

The pre-trial and post-trial results are shown in Figure 5.

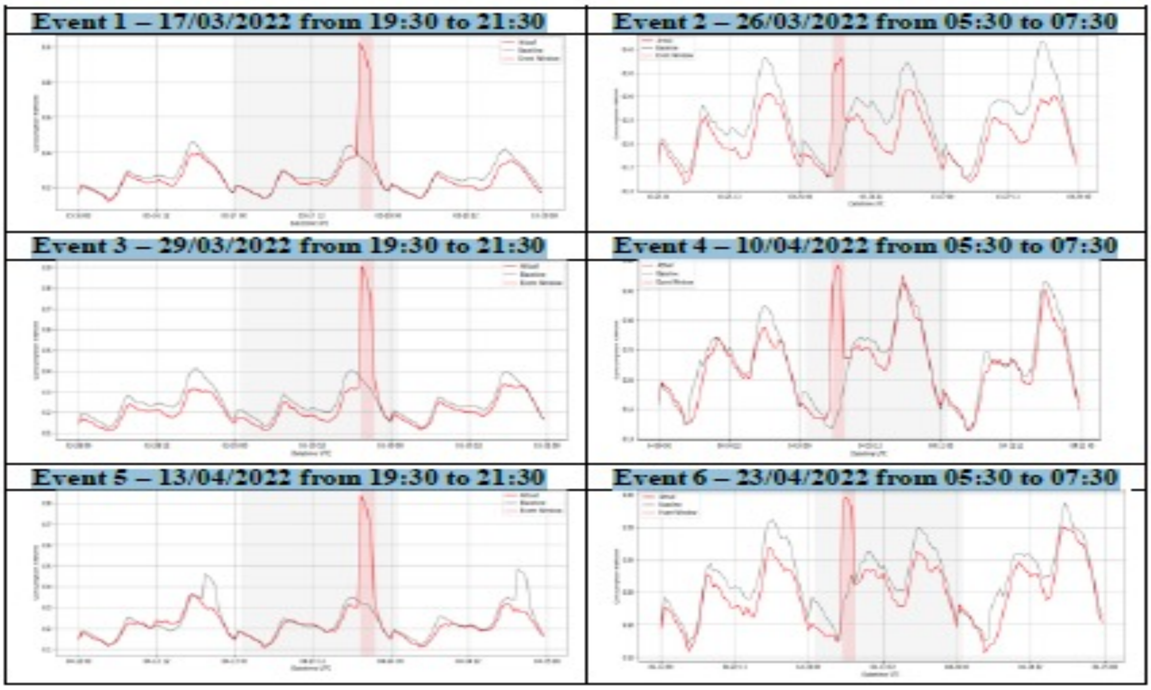

Figure 5: Pre and post-trial response from customers

Figure 6 shows the percentage of consumers who increased their consumption by more than 10% in the trials period.

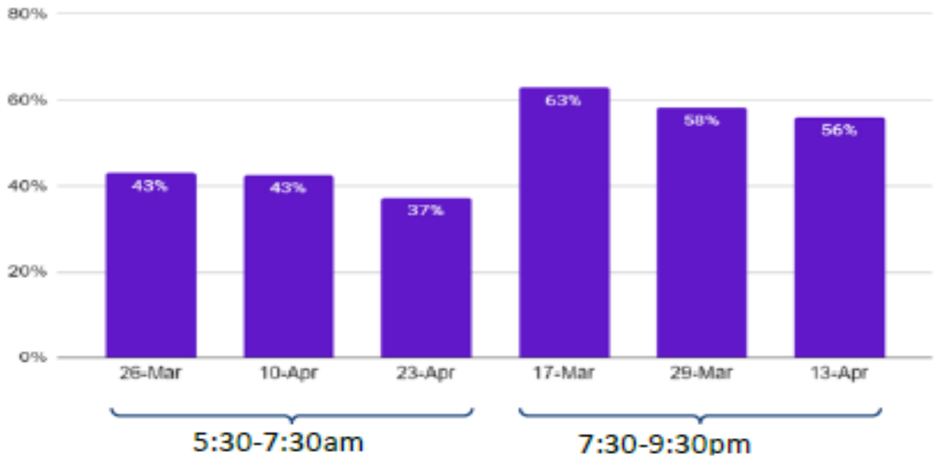

Figure 6: Customer participation per event

As anticipated, the evening events the consumption is higher with a participation of around 20% more than in the early morning events. This greater participation and in turn almost double the consumption leads us to confirm the hypothesis that it is important to determine when the best moment is to carry out the event.

The detailed assessments indicated that demand shift participation and customer response was highest in the Thornhill (DG3) and Moffat (DG10) postcode areas. Figure 7 below shows the demand turn up participation from each post code area with the trial region.

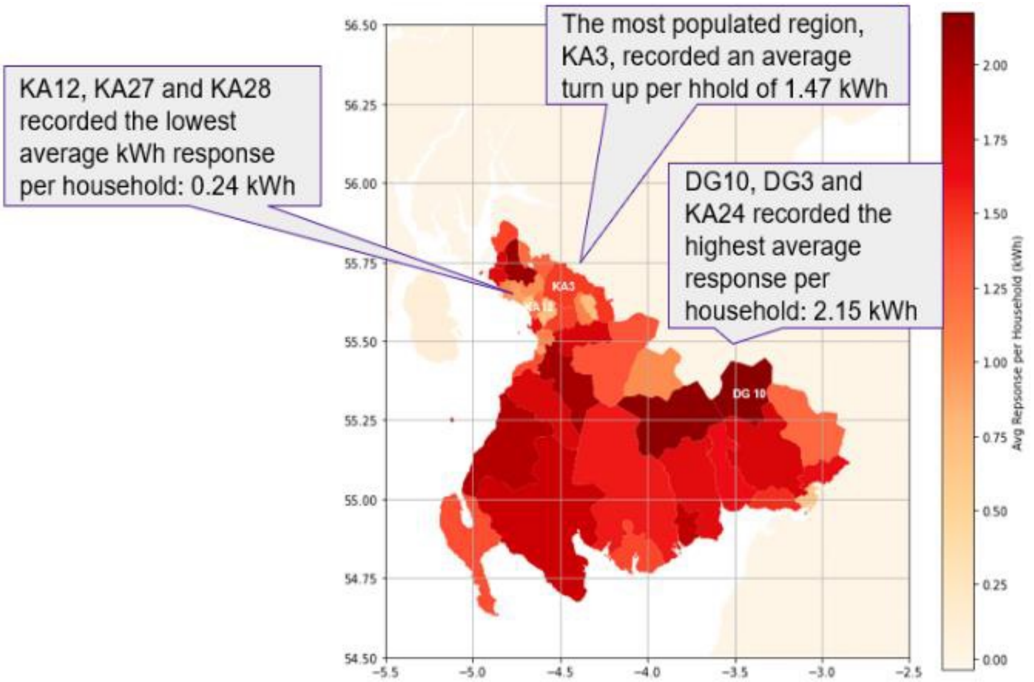

Figure 7: Customer participation by post code area

Customer survey

Octopus Energy carried out a satisfaction survey and 71% of the customers were happy with the participation and with over 46% indicated that they would been keen to participate 5 days a week.

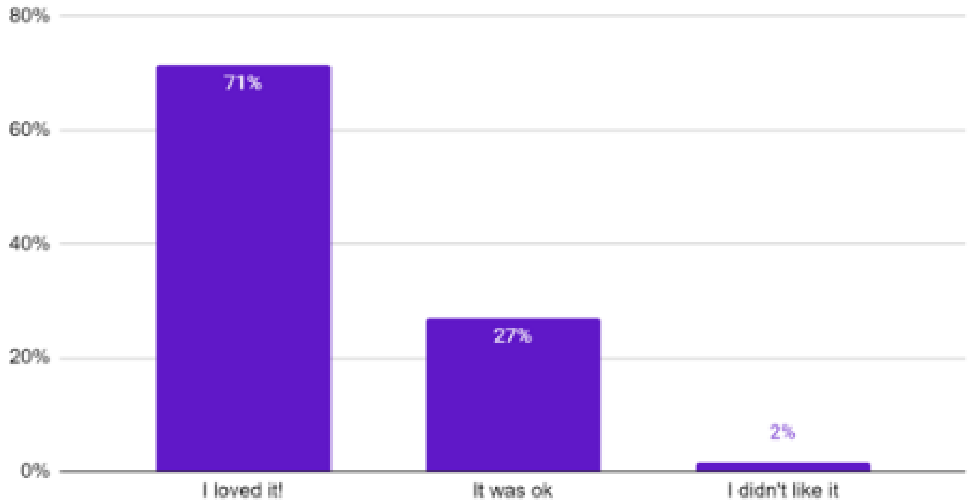

Figure 8: Customer satisfaction survey

CONCLUSION

Renewable energy capacity in the UK is set to grow by 26 GW and this growth in renewable energy generation is critical to reach the decarbonization objectives set out for the Net-Zero ambitions. As renewable capacity increases, the cost of curtailment is also set to increase and the consumers in Scotland and England may face an extra cost which is estimated to be over £1 billion per year through curtailment payments.

Studies have found that demand-side flexibility can be used to reduce renewable generation curtailment by better matching demand with supply.

Octopus Energy customers across Dumfries and Galloway participated in the six-week trial. Customers were instructed to power up their usage when green energy supply was highest, households used more energy across the six two-hour trial windows. Trials concluded that a total of 20MW demand response was secured with maximum response per event recorded at 2.84 MW and an average turn up per even being 1.7 MW.

Households who increased their usage by more than 10% were credited back all the energy they had used during the two-hour timeframe. Those who used more than 100% extra were credited double the amount they had used. Participating customers were rewarded with an average of £5 of free energy, with some saving up to £73.
Domestic flexibility methods like this trial will support the move towards a greener energy system – balancing the grid and bringing down costs for everyone by reducing the need for expensive grid rebalancing interventions.

REFERENCES

[1] SP Energy Networks Distribution Future Energy Scenarios (DFES).
[2] SP Energy Networks RIIO-ED2 business plan, Annex 4A.3 – DSO Strategy.
[3] Renewable curtailment and the role of long duration storage report for DRAX, May 2022 by Lane Clark & Peacock LLP.
[4] https://iea.blob.core.windows.net/assets/b1e6600c-4e40-4d9c-809d 1d1724c763d5/DigitalizationandEnergy3.pdf
[5] NREL Study, Electrification Futures Study: Operational Analysis of U.S. Power Systems with Increased Electrification and Demand-Side Flexibility, May 2021.