CrowdFlex: Alpha

November 2022

D4 - Trial Services

Strategic Innovation Fund

ESO

Contents

1. Context and aims

1.1. Shortlist of "trial services"

Much of the work in CrowdFlex has focused on identifying the system needs of National Grid Electricity Supply Operator (ESO) and the Distribution System Operators (DSOs) and the suitability of domestic flexibility to alleviate these system challenges through the participation of flexibility services. Following a range of interviews with Subject Matter Experts (SMEs) from ESO, National Grid Electricity Distribution (NGED), and Scottish and Southern Electricity Networks (SSEN), we have translated the shortlist of system needs and respective flexibility services into "trial services" for CrowdFlex. By this we mean the system needs/flexibility services that CrowdFlex will focus on to understand the technical capabilities and potential for the large-scale deployment of domestic flexibility to help address the challenges the electricity system faces as it decarbonises.

We propose that CrowdFlex design two new **ESO "trial services"** to investigate the large-scale potential of domestic flexibility:

1. Entry of portfolios of domestic flexibility into the **Balancing Mechanism** to provide "real-time" energy balancing for the ESO Control Room.
2. Long term trial of a Day-Ahead locational domestic flexibility service that provides **Thermal Constraint Management** on the transmission network via demand turn down and demand turn up.

We also propose that CrowdFlex should trial these services alongside the commercial product that exists from Winter 23/24 as a result of this year's **Demand Flexibility Service**, providing Day-Ahead scheduled demand turn down through domestic flexibility during system stress events.

Alongside the ESO services, CrowdFlex should trial two use cases for domestic flexibility **DSO "trial services"**, which will have utility across multiple DSOs:

1. Provision of NGED's **Sustain-H** service in CMZs, mitigating constraints on the distribution network, stacked alongside other flexibility services.
2. Provision of **LMA Secure** service, a variant of the Secure service to ensure diversity of electric heat demand for SSEN in historic Load Managed Areas (LMAs).

The requirements for these services are summarised in Table 1.

Table 1: Summary of "trial service" to be explored in CrowdFlex Trial.

System Operator	Trial Service	Local/National Response	System Need	Dispatch Notice	Response Duration
ESO	Balancing Mechanism	National	ESO Frequency	<1-hour	~30 mins
ESO	Thermal Constraint Management	Local	ESO Thermal	Day Ahead	<4 hours
ESO	Demand Flexibility Service[1]	National	ESO Adequacy	Day-Ahead	1-2 hours
DSO	Sustain-H	Local	DSO Constraint Management	Contract Stage	4 hours
DSO	LMA Secure	Local	DSO Constraint Management	Day Ahead	24 hours

[1] Our proposal is that CrowdFlex does not attempt to design a service that provides demand turn down during system stress events, as the Demand Flexibility Service does, but stack the other CrowdFlex "trial services alongside the output of the DFS in Winter 23/24.

A SIF CrowdFlex Trial would be building off pervious trials and analysis conducted by the CrowdFlex consortium with regards to the response of consumers to the introduction of time-of-use (ToU) tariffs that reflect Wholesale prices and to one off demand turn up/down signals. Our trial should ensure it accounts for these forms of flexibility incentivising. Specifically, layering the "trial services" above with Wholesale influenced ToU tariff.

1.2. Layering of domestic flexibility services

Given the number of services that should be tested in CrowdFlex, it will be important to determine, in all cases:

- What represents the consumption baseline, for evaluation of the level of response,
- If and how the services should be added / stacked to deliver a compound response to several incentives.

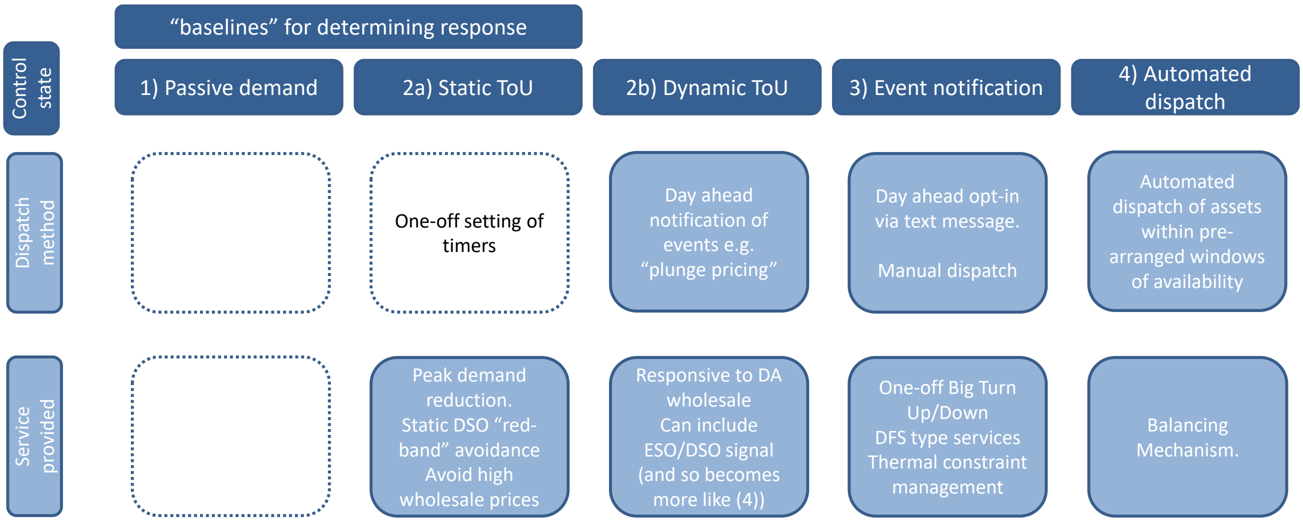

Figure 1: Baselines and flexible services

The approach is shown in the graphic above. Each asset can be under one or more of the control states 1-4. All of the "trial services" described previously can be aligned to one or more of these control states. The control states may be superimposed on one another. For example, starting with a baseline of passive demand (e.g., without any demand response), an asset may be put under a static (S) or dynamic (D) ToU tariff. In addition, the asset may respond to a one-off event such as a "big turn up" notice, akin to a Day-Ahead service. Finally, the asset might be under automated control, responding to "real-time" (i.e., sub-Day-Ahead) services such as the Balancing Mechanism.

In all cases, a passive state represents a de-facto baseline. However, a SToU tariff could also represent an appropriate baseline (e.g., SToU is assumed as being in the baseline for ESO Future Energy Scenarios).

Combinations of instructions will be as follows:

- All assets should be subject to a ToU tariff,
- In addition, assets may be subject to "Day-Ahead" instructions that can be executed manually, or "real-time" dispatch via automation,
- The project should test the combined impact of assets responding to "Day-Ahead" and "real-time" instructions in operation simultaneously (i.e., combining a ToU tariff, one off instruction and entry into the BM).

1.3. Baselining

As domestic flexibility is a demand side response service, it must be measured relative to a baseline which aims to describe how either a portfolio of or individual consumers would have behaved should they not have been dispatched or incentivised to alter their behaviour to provide domestic flexibility.

The image below presents one major challenge regarding the calculation of baselines in a residential setting to reward domestic consumers for providing flexibility. Ideally, a baseline should be highly accurate, but to achieve this will require the use of a greater amount of consumption data for a particular household. As this requires going back further in time, there is a greater risk that historical data becomes less relevant to current/imminent consumption levels.

Existing guidance (e.g., P376) attempts to bridge this gap with features such as:

- Accepting historical data up to 60 days old, but restricted to using data from “similar days” (matching weekdays)
- Applying a within day correction to reflect recent changes (perhaps due to weather, holidays etc).

There are problems with this approach; for example, if there is routine SToU dispatch in the historical data, that will form the baseline and so the apparent magnitude of any ongoing SToU dispatch will be artificially reduced (potentially to zero). There may also be unexpected effects from consumer behaviour in response to messaging.

There are also opportunities for CrowdFlex to provide useful learning outcomes. A work package will need to be designed in Beta to confirm these opportunities and desired working outcomes. However, our initial research indicates that CrowdFlex should:

- Implement P376 as a base case but evaluate alternatives to deriving baselines. Alternatives for evaluation should include statistical evaluation on a per-household level, or across the portfolio.
- Identify and categorise non-routine changes to demand (including but not limited to weather, holidays, acquisition/disposal of smart tech)
- Determine and test which are explainable/predictable and thus amenable to being modelled explicitly (such as weather impacts), and which are best predicted via a machine learning approach.

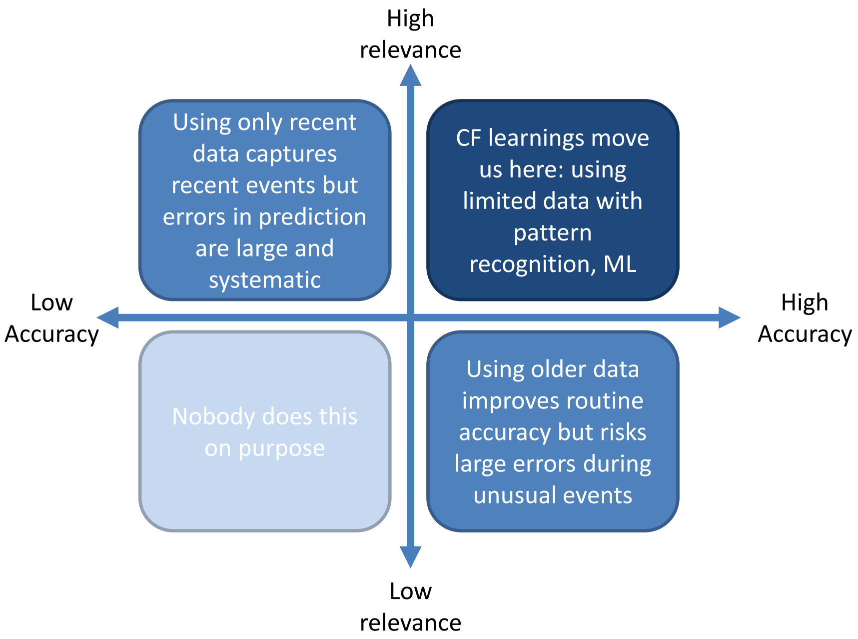

Figure 2: Tension between relevance and accuracy in the determination of residential baselines

2. Deep dive into ESO "trial services"

2.1. Energy Balancing via the Balancing Mechanism

2.1.1. Entering domestic assets into the Balancing Mechanism

Feedback received from interviews with SMEs within the Control Room at the ESO have made it clear that the most powerful way to demonstrate the potential of domestic flexibility to be a viable, large-scale source of low carbon flexibility in the future would be to enter it and have the Control Room dispatch it in the Balancing Mechanism (BM), alongside BAU Balancing Mechanism Units (BMUs). As such, this section lays out the way in which a "trial service" that explores domestic flexibility's capacity to provide energy balancing via entry of aggregated domestic portfolios into the BM.

For each Settlement Period, the BM comes into operation at Gate Closure, which occurs 1 hour before the start of the Settlement Period and continues to operate until the end of that second period (see Figure 3, taken from the ENA Open Networks Project[2]).

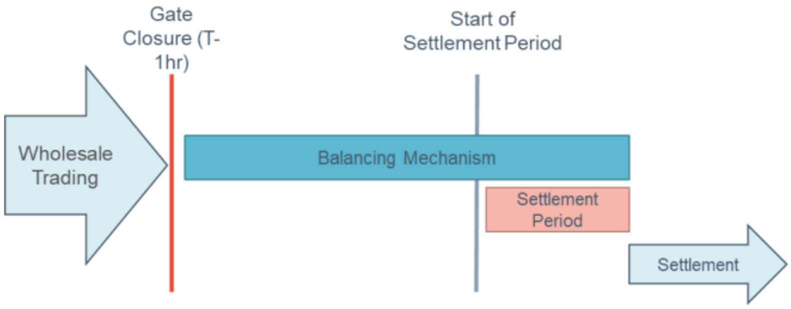

Figure 3: Timings of Balancing Mechanism dispatch.

Therefore, the maximum notification period for a BM dispatch instruction is one hour. However, for some use cases, responses to dispatch instructions are required to meet the system need (on the order of ~1 minute). Due to these relatively short dispatch instructions, our recommendation for CrowdFlex is that this "trial service" be aimed at automated domestic assets (including, but not exclusively, EVs and electric heating).

The BM is rewarded on a utilisation basis, i.e., BMUs are paid in £/MWh of energy they deliver on a pay-as-bid basis. This means for BM participation, no declaration of available capacity ahead of time is required, except for the settlement periods the BMU wishes to participate in. In this case, should a bid/offer be accepted (known as a Bid Offer Acceptance (BOA)), and the BMU fails to deliver the declared response in the BOA, this is met with non-delivery charges.

However, contrary to this, this work proposes that domestic customers will likely have to be incentivised to participate in the BM through an availability payment rather than a utilisation payment. This is because the BM requires dispatch of assets to be automated (dispatch signals for BM dispatch will be sent by the flexibility provider separate from ToU tariff incentives). Aside from initial "sign-up", there is no human involvement in the participation of domestic flexibility in the BM. Because of this, there will be no price elasticity of automated domestic assets. Therefore, instead of sending the utilisation price to consumers that reflects the participation of their automated flexible asset, an availability payment that spreads the expected revenue from BM participation over a given time period would be more appropriate to engage consumers in BM participation by incentivising the "sign-up" of their flexibility. Effectively, the trial needs to encourage consumers to "sign-up" to an energy balancing service that enables flexibility providers to enter their automated asset into the Balancing Mechanism.

As such, an important output for BM participation will be to determine the price discovery for domestic consumers to sign up their assets to participate in the BM. That is to say, what availability payment is required for different consumer groups to engage in flexibility for energy balancing. However, the project will provide price discovery of this new asset class in the BM. Flexibility providers will need to understand the costs associated with obtaining a flexible capacity from their customers, while National Grid ESO will need to understand the cost of an asset class participating alongside BAU technologies. While this is not a

[2] Energy Networks Association, Open Networks Project – DNO Flexibility Services Revenue Stacking, 2020.

measurement of price elasticity specifically, it will give an indication as to the strategy that flexibility providers should pursue when entering bid/offers into the BM, as the discovery price indicates the cost to flexibility suppliers to have access to domestic consumers' assets.

2.1.2. Applying the statistical nature of domestic flexibility in the Balancing Mechanism

In Deliverable 1.2 CrowdFlex identified the market value of an asset whose peak output is not constant; rather it may vary over time and so is best described statistically, i.e., the power output (capability) is a statistical distribution with a mean (expected) value and a standard deviation. For example, a residential flex portfolio might have a mean value of 10MW and a Standard Deviation of 2MW.

The statistical asset can also be described as pairs of values (power output and likelihood/confidence level). For example, the 10MW asset can provide:

- at least 4.5MW with 99.7% confidence level (essentially a "firm" capacity),
- at least 10MW at 50% confidence level,
- at least 11.35MW at 25% confidence level.

In a BAU version of energy markets, only the "firm" capacity can be declared, so despite the (statistical) potential to provide significantly more flex power, the asset has to declare this derated capacity of just 4.5MW, and value is lost.

D1.2 identified how the full value can be recovered in a fair manner by making the market value of the energy output at each level proportional to the confidence at that level. So, if the market value of 10MWh of firm energy was £100, then for the above statistical asset, it would be able to declare 10MWh statistically, at a value of 100*50% = £50. The lower value represents the cost to the counterparty (in the case of the BM this is NG-ESO) in having to procure energy should it not be generated.

As such, a method such as this would require a derogation to the BM. An alternative approach has therefore been evaluated, where the asset owner declares the market output levels that are low confidence (50% say), and accepts they will be fined during periods when output does not reach that level. The result of this is shown below: 100 market experiments are made, based on the statistical asset described above, and the cumulative revenue is compared for both the statistically declared approach, and alternatively for when a capability is declared e.g. (50%), and fines are accepted. As can be seen, the results are almost equivalent, with the statistical approach being more consistent across the 100 market experiments. At this time, we have not evaluated this result across other levels of capacity declaration, but it does suggest that declaring beyond the "firm" capacity of an asset, and accepting fines, is a valid way to enter the asset to the BM, without the need for a derogation.

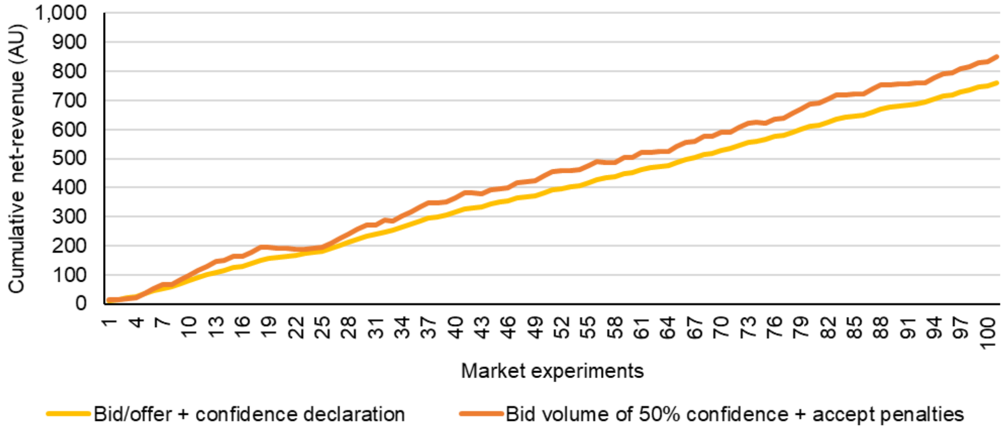

Figure 4: Comparison of cumulative net-revenue from two market models of statistical assets over 100 market experiments.

2.1.3. Value

The value available through the Balancing Mechanism is greatly variable, dependent primarily on the System Imbalance Volume for a given settlement period. As mentioned above, the BM is paid on a pay-as-you-bid basis. Therefore, the revenue generated by a BMU is dependent on their bidding strategy. However, to give an indication of the value available from BM participation, we can look at the System Imbalance Price (SIP). Figure 5 shows the average System Imbalance Price as the Net Imbalance Volume (NIV) varies for 2021.

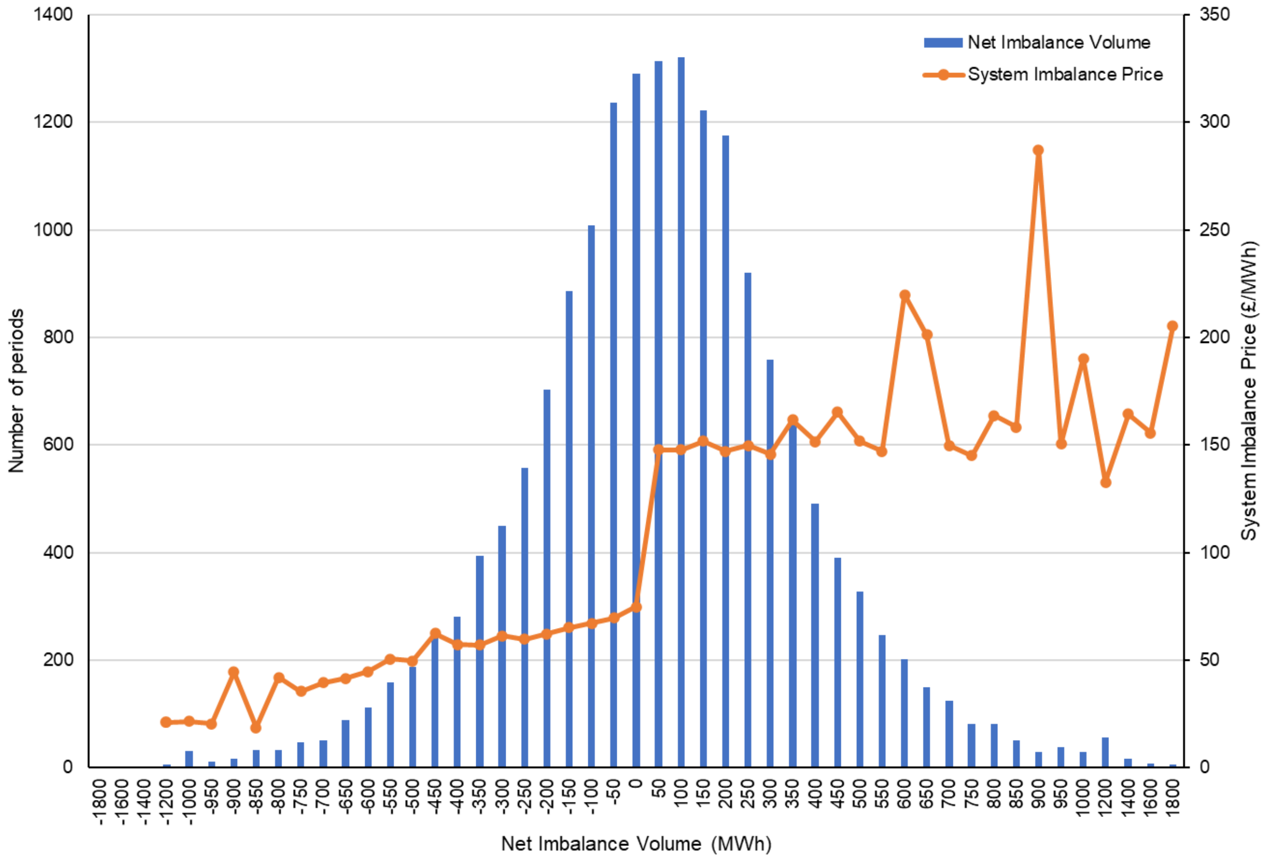

Figure 5: Frequency of Net Imbalance Volume settlement periods in 2021 and the associated average System Imbalance Price.

Figure 5 can be divided into two halves, the left-hand side (NIV<0) when the system is long (i.e., there is too much generation on the system) and the right-hand side (NIV>0) when the system is short (i.e., there is not enough generation on the system. If the system is long, ESO normally accept bids to reduce generation/increase demand (i.e., normally the participant pays ESO to reduce generation/increase demand). If the system is short, ESO normally accepts offers to increase generation/decrease demand (i.e., normally the ESO pays the participant to increase generation/increase demand).

Over the year, the average system sell price when the system was long was £64/MWh and the average system buy price when the system was short was £153/MWh[3], giving an indication of the value that can be generated from BM participation. Extreme events demonstrate occurrences where domestic flexibility could capitalise on the value available in the BM, but also reduce the cost for National Grid ESO by competing with the marginal plants. The minimum system sell price was -£71/MWh. This illustrates a settlement period where the system was long, forcing National Grid ESO to pay for the reduction of generation/increase in consumption. The maximum system buy price in 2021 was £4,038/MWh, which could have provided a payment of £4/kWh for domestic customers that turned down demand during this settlement period when the

[3] The system sell and buy prices are closely related to the maximum bid and offer prices accepted in their respective settlement periods. They are the 'cash-out' or 'Energy Imbalance' prices, used to settle the difference between contracted generation, or consumption, and the amount that was actually generated, or consumed, in each settlement period.

system was short. These events represent clear opportunities for domestic flexibility and should be targeted in CrowdFlex to assess how domestic flexibility can alleviate (and capture) some of these extreme imbalance events.

This section only provides a small indication of the value available from entering domestic assets into the BM to provide energy balancing. A full operational analysis of the value from the BM will be completed in D6.1.

2.1.4. Provision of Reserve

An important goal for domestic flexibility is for it to be a viable alternative to traditional thermal generation. This would divert future investment away from dispatchable generation (which is currently thermal fossil fuel generation), creating significant system savings and helping to further Net-Zero goals. There are two types of capacity that ESO consider, the total capacity on the system and the daily capacity available to ESO for balancing actions. The total system capacity is defined in the Capacity Market (CM). The daily capacity available to ESO is procured via Reserve.

To understand how domestic flexibility could replace total system capacity in the CM, please see Section 2.3 below on the Demand Flexibility Service. However, for the replacement of daily generation capacity by domestic flexibility, an essential output for CrowdFlex will be to understand the capacity and capability of residential flexibility, and how this varies through the day and across seasons.

Following discussions with ESO SMEs, the study has been advised that, until the firm capacity of domestic flexibility has been demonstrated, it will be too challenging to enter it into live Reserve products alongside BAU assets. Therefore, we propose that the CrowdFlex Trial explore energy balancing via entry of domestic flexibility into the BM and ensuring that trial calls cover a range of times and events. These must be sufficient so that following the trial, analysis can be completed by CrowdFlex to identify what the time-dependent capacity and capability of domestic flexibility is to participate in energy balancing, and therefore, in future Reserve products.

This analysis should consider two methods for capacity determination. The first is the BAU declaration of firm capacity, identifying the potential for domestic flexibility to provide Reserve in the form that it is currently procured, with 99.7% confidence in delivery. The second method is via the statistical declaration and dispatch of portfolios of domestic flexibility. This method continues to guarantee that the total confidence in the delivery of Reserve is 99.7%, but enables non-firm domestic portfolios to participate, taking advantage of the full potential of domestic flexibility. This method is outlined in detail in D1.2.

2.2. Thermal Constraint Management on the Transmission Network

One of the largest system challenges for ESO is managing thermal constraints on the transmission network. This challenge arises from the huge volumes of energy that must be redispatched due to thermal constraints. As well as representing one of the largest costs for the ESO, it can also be carbon intensive as it often involves curtailing wind generation and redispatching thermal fossil fuel generation.

ESO have recommended CrowdFlex investigate both export and import constraints:

- Export constraints (generation driven): net generation exceeds the capacity of the network (e.g., the Scotland-England constraint).
- Import constraints (demand driven): net demand exceeds the capacity of the network (e.g., London).

A CrowdFlex service would look to dispatch groups of aggregated domestic portfolios in paired and asymmetric responses either side of the constraint to mitigate the requirement for ESO to curtail renewable energy and redispatch thermal generation.

For an export constraint, on the Scottish Export (SCOTEX) constraint group on the England-Scotland border for example, this would include:

- One (or more) consumer group in Scotland (behind constraint) will be asked to turn up demand to reduce the need to curtail wind generation.
- A second (set of) consumer group in England (outside of constraint) will be asked to turn down demand to reduce the need to redispatch thermal generation in England.

These two requests will likely be unequal in size (asymmetric) due to the expected differences in response from the consumer groups.

For an import constraint on the Southeast Import (SEIMP) constraint group around London, this would include:

- One (or more) consumer group in London (behind constraint) will be asked to turn down demand to reduce the need to redispatch thermal generation behind the constraint.
- If dispatched in real-time, a second consumer group outside of the constraint will be asked to turn up demand to balance the system. This however has caveats:
  - An alternative balancing action (e.g., turn down generation) may be more cost effective for National Grid ESO (see Section 2.2.3 for more detail).
  - If the system (outside the constraint) is short, then a dispatch instruction for demand turn down to balance the system would supersede a thermal constraint management turn up instruction.
  - If dispatched ahead of gate closure, flexibility providers could position their portfolio outside the constraint in the market to avoid demand turn up. This will be discussed further in Section 2.2.4.

2.2.1. Duration of service

Due to the nature of domestic flexibility assets, the duration of turning up/down demand may be measured in hours. For example, a grid responsive heating system could be delayed by an hour without the customer noticing an interruption in service delivery – more if the house is well insulated. Charging an EV can be shifted by several hours, and with sufficient planning and knowledge of the consumer's regular use patterns, EV charging events could be shifted from (for example) a Monday to a Thursday in a flexibility event. Even within these time constraints, domestic assets can be a valuable source of flexibility. Therefore, domestic flexibility could be a valuable resource for **short-duration** constraint management (i.e., peak constraint periods that last up to ~4h in duration).

Analysis of day-ahead constraint limits and flow on the Scottish Export (SCOTEX) constraint group on the England-Scotland border between 2019-2022[4] has demonstrated that the average constraint is 7.5 hours in duration[5], with 68% of all constraints being shorter than 8 hours in duration where domestic flexibility is most useful. The distribution of constraints across SCOTEX is illustrated in Figure 6. The result of this analysis is that a significant number of thermal constraints across the SCOTEX constraint group are short in duration (<4 hour – the dotted line in the figure below). Therefore, thermal constraints across export constraints are a useful use case for a domestic flexibility Thermal Constraint Management service.

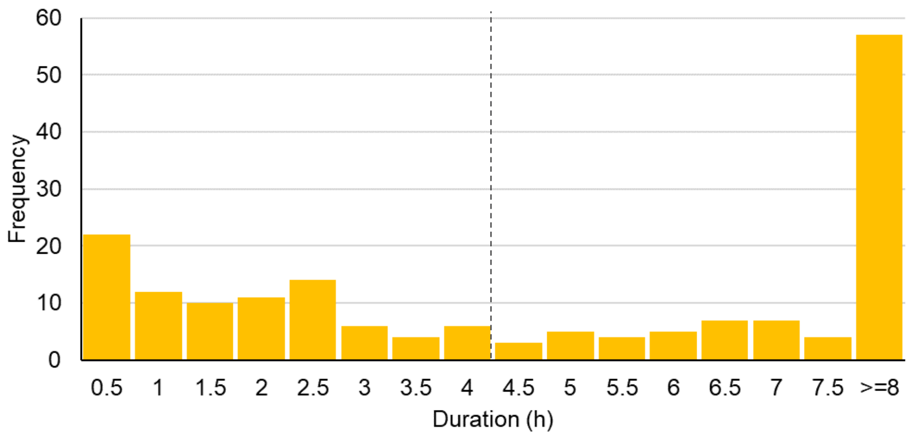

Figure 6: Distribution of Thermal Constraint durations across the SCOTEX constraint group 2019-2022.

[4] National Grid ESO, Day Ahead Constraint Flows and Limits, https://data.nationalgrideso.com/constraint-management/day-ahead-constraint-flows-and-limits, Accessed Nov 2022.

[5] The duration of a constraint is defined by the number of settlement period where the flow over the constraint group is greater than the constraint group limit. If the magnitude of the flow is greater than the magnitude of the limit during one settlement period is less than 8 settlement periods (or 4 hours) of another event, then it is considered part of the same constraint.

However, domestic flexibility can also be of use in managing these long duration constraints. This is through the participation of domestic flexibility in Thermal Constraint Management of export constraints during periods of high winds, specifically targeting the peak period of wind speed when generation is at its maximum. This period is when Thermal Constraint Management is at its greatest cost to National Grid ESO as the greatest quantity of MW of wind generation must be curtailed and thermal generation redispatched. Analysing UK generation data in 2021-2022 in Figure 7, we can see that when wind output was at 85% of the peak wind output it was 5 hours in duration. Domestic flexibility could be well placed to "flatten" these peaks in constraint management, to reduce system costs for ESO.

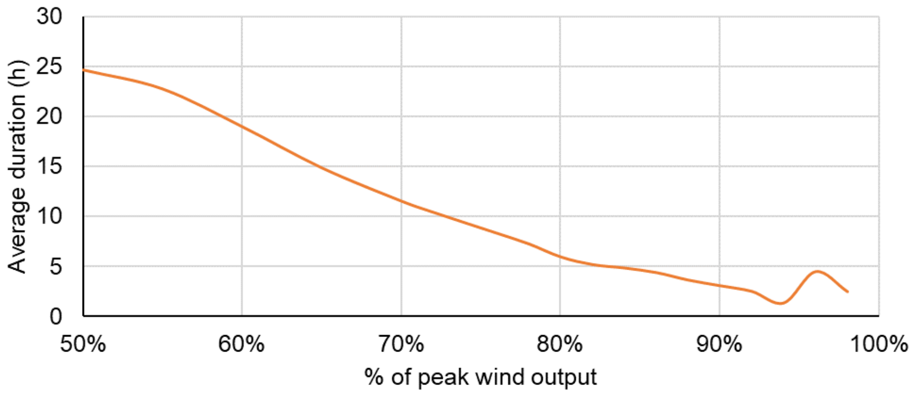

Figure 7: Average duration of wind generation events between 2021-2022[6]. The events are defined by the wind generation output being greater than a % of the peak wind generation output of the period.

Import constraints are often demand-driven[7]. Therefore, they have durations that align very closely to that of the duration of domestic flexibility. As shown in Figure 8, analysis of day-ahead constraint limits and flow on the Southeast Import (SEIMP) constraint group around London between 2019-2022[8] has demonstrated that the average constraint is 4.9 hours in duration with 67% of constraints being less than 4 hours in duration. As such, domestic flexibility is well suited to help manage these constraints.

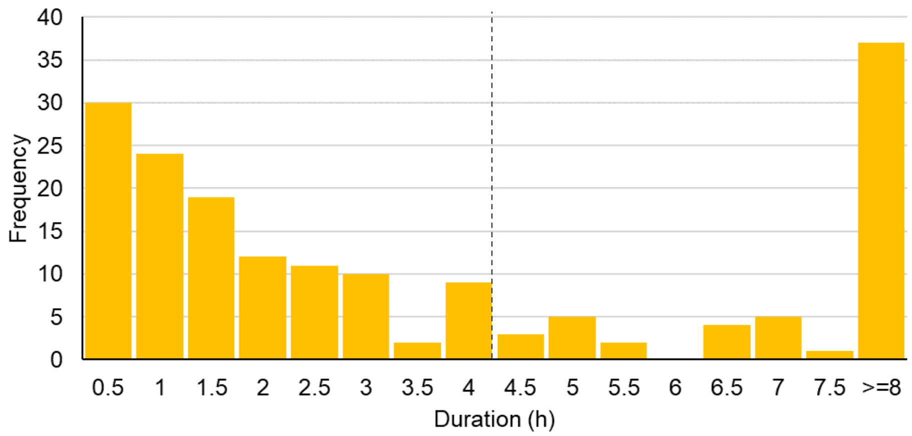

Figure 8: Distribution of Thermal Constraint durations across the SEIMP constraint group 2019-2022.

[6] Elexon & Sheffield University, Gridwatch, https://www.gridwatch.templar.co.uk/index.php, Accessed October 2022.
[7] Although not exclusively. Direct generation to interconnectors is another common cause of import constraints on the Transmission Network.
[8] National Grid ESO, Day Ahead Constraint Flows and Limits, https://data.nationalgrideso.com/constraint-management/day-ahead-constraint-flows-and-limits, Accessed Nov 2022.

The UK aims to be a net exporter of energy by 2040[9]. Therefore, import constraints will increase in prevalence as interconnectors become more utilised. This will likely increase the duration of constraints when interconnectors are exporting for long periods of time. However, the signal of domestic demand will remain short in duration. So, as we have proposed for flattening the peaks of export constraints, domestic flexibility can potentially flatten import constraints as well, even if interconnector-led constraints become more prevalent.

CrowdFlex will aim to provide clarity on the daily and seasonal capability of domestic flexible assets to provide flexibility to the system.

2.2.2. Value

In the past year constraint management has reached an all-time high for ESO. This is the result of two factors. Firstly, with the growing capacity of variable renewable energy on the network, constraints occur increasingly often and hence curtailment and redispatch occur more regularly and in greater quantities. The second factor is, following the unprecedented rise in gas prices, redispatch of thermal generation has become increasingly expensive.

Taking constraints in Scotland as an example, over the course of the 2021/22 financial year, constraint management cost ESO £788m in BM actions[10] (36% of the total cost of its BM actions over the same period). This results in an average price of £301/MWh to provide Thermal Constraint Management in Scotland.

It is highly likely that CrowdFlex could demonstrate that it could provide Thermal Constraint Management at a lower cost than £301/MWh, generating potential system savings for ESO (and therefore consumers) when managing constraints, their single greatest balancing cost.

2.2.3. Thermal Constraint Management via the Balancing Mechanism

We have identified two approaches to providing a Thermal Constraint Management service, which differ primarily in the notice time associated with their dispatch and hence the technology that can be involved in the service. The two approaches are:

- "Real-time" thermal constraint management via BM dispatch
- "Day-ahead" thermal constraint management via instructions issued to consumers as part of a "trial" service

The "real-time" approach involves a short notice period, dispatching Thermal Constraint Management via the Balancing Mechanism. This is the approach through which the vast majority of constraints on the Transmission Network are currently managed. An example of this is in the case of an export constraint where wind generation behind the constraint is instructed to turn down via the BM and dispatchable thermal generation in front of the constraint is instructed to turn up via the BM, ensuring the system stays in balance.

The full dispatch process and required derogations to enable domestic flexibility to participate in this service would be identical to that described in section 2.1. SMEs engaged with this topic as part of this trial design have highlighted that the dispatch period associated with Thermal Constraint Management is short, on the order of a few minutes. Additionally, they highlighted the need to have visibility of asset's location to a Grid Supply Point (GSP) level, so that the Control Room can ensure that the dispatch of domestic flexibility would not cause new constraints on the Transmission Network.

Due to the short notice periods, this approach to providing Thermal Constraint Management with domestic flexibility would mean that only automated assets would be able to participate in such a service. This would limit the magnitude of response that consumers could provide and, therefore, the benefit to both ESO and to consumers taking advantage of demand turn up events.

However, domestic flexibility would be able to be dispatched to manage "real-time" thermal constraint within settlement periods via this approach, to manage live thermal constraints on the Transmission Network. Therefore, the dispatch of domestic flexibility via the BM enables it to be precise in its ability to manage thermal constraints.

The other major advantage of CrowdFlex dispatching Thermal Constraint Management via the BM is that it could allow the Control Room to take a whole system approach to dispatching domestic flexibility. This means

[9] BEIS, UK government takes next steps to boost domestic energy production, 2022.
[10] National Grid ESO, Monthly Balancing Services Summary, Accessed Oct 2022.

CrowdFlex could understand the benefits of dispatching domestic flexibility in the place of other technologies that traditionally provide Thermal Constraint Management in the BAU scenario. This would allow CrowdFlex to identify the scenarios for which domestic flexibility is the optimal source of Thermal Constraint Management in the Control Room and where alternatives might benefit the system more.

For example, in an approach that only considered domestic flexibility, for an import constraint across the SEIMP constraint group around London, domestic flexibility behind the constraint would be dispatched to turn down, this would likely be the optimal action. However, outside of the constraint, domestic flexibility would be dispatched to turn up demand to ensure the system remains in balance. While this is a valid action, taking a whole system approach would allow (in the case of an import constraint) the Control Room to instead accept a bid from a thermal generator to reduce generation outside of the constraint. This would achieve the same objective (to balance the system), while providing additional system savings to instructing demand turn up in this example and both the reduce the carbon intensity of the grid and provide true system savings for consumers.

However, as the domestic assets would just be one amongst many other assets in the BM, the control room would not have any visibility of these residential assets nor of their capability. This would inhibit the generation of valuable learning outcomes related to the daily and seasonal capability of the asset to contribute to the BM.

2.2.4. Thermal Constraint Management via a “trial” day-ahead service

The alternative approach is to provide Thermal Constraint Management via a “trial” day-ahead service that schedules and instructs domestic flexibility to provide demand turn up/demand turn down on a locational basis a day-ahead of delivery based on day-ahead forecasts of Transmission Network thermal constraints[11]. This approach is similar to that of the Local Constraint Market product that National Grid ESO intend to take live in 2023. However, the service that we propose to trial in CrowdFlex is distinct in that, in addition to creating a day-ahead service that provides demand turn up behind an export constraint (as the Local Constraint Management product does), CrowdFlex also intends the service to provide the capability for the opposite response – turning down demand – outside of the constraint via a day-ahead service. We think that this is a vital addition to the CrowdFlex trial as it explores the potential for domestic flexibility to replace carbon intensive thermal generation, which provides Thermal Constraint Management in the BAU scenario.

CrowdFlex will also explore the management of import constraints via the same mechanism, focusing on providing demand turn down behind the import constraint. In this case, we do not recommend instructing a demand turn up outside of the constraint, as the system would be better placed to reduce the generation outside of the constraint. This could be achieved by positioning the flexibility provider’s portfolio to reflect their expected demand accounting for the demand turn down behind the constraint.

Given a day-ahead notification period both automated and manual technology would be able to participate in this service, increasing the magnitude of response that ESO could generate for constraint management. This pre-commercial trial service would collect data on the broad potential for domestic consumers to provide location-based flexibility. Establishing key metrics such as the price elasticity of consumers to participate in demand turn up/turn down events, the capacity of domestic flexibility, and the times at which it is available.

As a service that includes both manual and automated response, a crucial factor for this service would be understanding consumer behaviour around both incentives and information. Trial arrangements for this service would be similar to the DRST/DFS and therefore, the arrangements for this trial service should take into account the learnings from the DFS following its initial running period over Winter 22/23.

The limitation of this approach compared to the BM approach is that instructions would have to be based on day-ahead forecasts of constraints rather than real-time instructions. This means that the responses scheduled day-ahead may not always align with real-time constraints, forcing National Grid ESO to take alternative (and more costly) actions to manage the constraint.

Nevertheless, given CrowdFlex already intends to trial the entry of portfolios of domestic flexibility to the BM to provide energy balancing, the recommendation is that the trial for Thermal Constraint Management focuses on this day ahead trial service. This will allow CrowdFlex to trial the broad capability and potential of day-ahead, location-based, demand turn up and turn down flexibility.

[11] National Grid ESO, Day Ahead Constraint Flows and Limits, https://data.nationalgrideso.com/constraint-management/day-ahead-constraint-flows-and-limits, Accessed Nov 2022.

2.3. Participation in the 2023/24 Demand Flexibility Service

2.3.1. The Demand Flexibility Service

The Demand Flexibility Service (DFS) is an existing commercial product procured by National Grid ESO to ensure system adequacy through requesting demand turn down a day ahead of time during peak winter days. This new service, launched in November 2022, builds on the previous phases of CrowdFlex and the Domestic Reserve Scarcity Trial to leverage domestic consumers as a large-scale source of flexibility during system stress events. As such, CrowdFlex will **not** design a demand turn down service to provide adequacy during system stress events, as it would be repeating the work done to develop this commercial product. However, understanding the ability of domestic consumers to provide reliable flexibility at and near system peaks must be an essential output of any large-scale trial into domestic flexibility, especially as the literature review completed in CrowdFlex found that previous trials recorded that domestic flexibility tends to zero on the coldest day (a proxy for the system peak).

Therefore, CrowdFlex will include an experiment to measure the capacity of domestic flexibility at and near system peak and compare this to the flexibility offered/provided at other times. We propose that this is through participation in the outcome of the Winter 2022/23 DFS (e.g., a 2023/24 evolution of the DFS). As stated, as it is already a commercial product, CrowdFlex will not design this service, but it will ensure that trial participants who are participating in CrowdFlex “trial services” are also participating in the future variant of the DFS (though, for clarity, not via CrowdFlex).

Determining the firm capacity of domestic flexibility at the system peak facilitates understanding of how domestic flexibility could reliably mitigate infrastructure investment in the future. This could be through future iterations of the DFS that procures capacity statistically (as outlined in D1.2) or through the entry of domestic flexibility to conventional system adequacy markets, such as the Capacity Market. The second output of interest from participating in the DFS alongside CrowdFlex “trial services” is to understand how such a service that provides demand turn down during system stress events stacks with other services.

The DFS is a very high value service, offering customers a utilisation payment of £3/kWh on a “pay-as-you-generate” basis. Therefore, for DFS events, it is likely that the DFS will offer the most value compared to the other “trial services”. CrowdFlex will need to understand how the ability of consumers to participate in the DFS is limited by participation in other services and how this might impact consumer engagement in flexibility during the system peak.

2.3.2. Potential addition of a summer minimum service

Feedback with ESO SMEs has highlighted the appetite for a service similar to the DFS in the summer that could provide a demand turn up to help ESO secure system Stability and provide Adequacy at times when demand is low and solar generation is high. This would be via a national Day-Ahead demand turn up service that could be run in a very similar way to the DFS, but asking consumers to turn up demand rather than turn down during a pre-defined period.

Such a service could be dispatched through the same mechanisms as the Thermal Constraint Management service that CrowdFlex intends to trial, but at a national rather than a local level. As such, CrowdFlex could trial such events without significant additional effort.

3. Deep dive into DSO "trial services"

3.1. Constraint Management on the HV & LV Distribution Network

3.1.1. Constraint Management Zones

National Grid Electricity Distribution (NGED) has recommended that the most valuable "trial service" CrowdFlex could investigate from its position as a DSO is constraint management on both the high voltage (HV) and low voltage (LV) distribution network through demand turn down. The locations on the network where DSOs require this type of service are designated Constraint Management Zones (CMZs). Formally, a CMZ is defined as a geographic region served by an existing network where network requirements related to network security of supply are met using flexible services, such as Demand Side Response, Energy Storage and stand-by generation[12]. The primary objective of CMZs is to delay or mitigate the requirement of infrastructure upgrades on the distribution network through the provision of flexibility services. Given the pressure on the network that the increasing roll-out of domestic Low Carbon Technologies (LCTs) are likely to cause, any flexibility provided by domestic consumers would be valuable to the DSOs.

CMZs are only designated in areas where a constraint on the distribution network has been identified. As such, CMZs are highly localised and temporal. For a CMZ on the HV network this will mean that a service will only be available to the few thousand domestic consumers that are connected to this part of the network. For LV networks, this will be hundreds of domestic consumers. Furthermore, CMZs will only be required until demand on the network increases to the point where it is economically beneficial to reinforce the network rather than delay this infrastructure further with DSO services. Therefore, CMZs will not exist in the same locations indefinitely. Nevertheless, given the increasing roll-out of domestic LCTs and the high cost of network reinforcement for many parts of the distribution network, the prevalence of CMZs is only likely to increase as the electricity system decarbonises.

CrowdFlex would not be the first trial that assessed the capability of domestic flexibility to participate in DSO flexibility services providing flexibility in CMZs. The CrowdFlex Trial would aim to build on the learnings of these previous studies, whilst investigating how the stacking of DSO services alongside ESO services impact their viability. CrowdFlex aims to also collect better data on the capacity of flexibility throughout the year to help inform system operators on the reliability of domestic flexibility, particularly at times of system stress like the system/network peak.

3.1.2. Sustain-H

NGED have already completed a trial, Future Flex, that looks into the ability of domestic flexibility to provide demand turn down and alleviate constraints on the HV & LV Distribution Networks in Constraint Managed Zones (CMZs). The output of this trial was a new service, Sustain-H, which brings the pre-existing DSO flexibility product, Sustain, to domestic consumers. NGED define Sustain-H as a Scheduled Constraint Management service that requires providers to deliver a pre-agreed change in demand over a defined period of time. Procured months in advance (seasonally), Sustain-H is a pre-fault service to prevent a network going beyond its firm capacity, and thereby ensuring all loads remain secure following any subsequent fault. Participants in Sustain-H (suppliers or aggregators) are requested to reduce their domestic portfolio demand to a target demand (set by the flexibility provider) for a 4-hour delivery period. This is illustrated in Figure 9.

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[12] SSEN, Constraint Managed Zones.

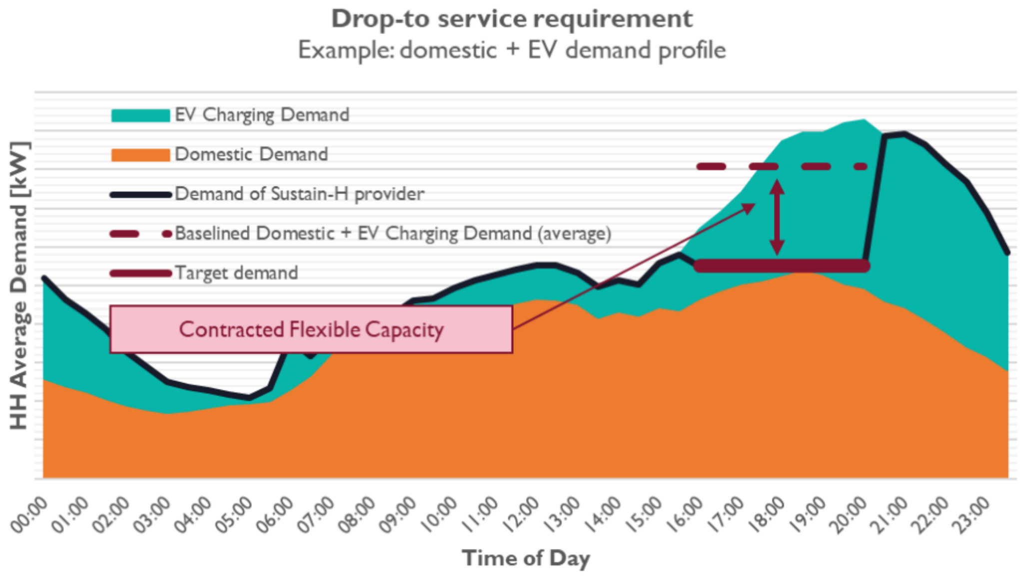

Figure 9: Example domestic and EV charging demand profile showing the target demand, baseline demand, and the contracted flexible capacity. This example was taken from the Future Flex: Sustain-H Trial Design[13].

For simplicity, the Sustain-H service is contracted for all weekdays in the month over two periods: Daytime (08:00-12:00) and Evening (16:00-20:00). Participants can choose which delivery periods to enter. Delivery assessment is based on actual demand reduction achieved relative to the pre-defined baseline demand for a portfolio. For each delivery day, service delivery is assessed on the highest half-hour (HH) metered demand over the contracted delivery period for that day. This means if a portfolio exceeds its target demand for a single HH period in the constrict delivery period, delivery assessment for that day is based on that HH period. While participants fix their portfolio for the entire season, NGED allow them to update their portfolio once per month if necessary. The contracted flexible capacity of a portfolio must remain constant, so it is the target demand that changes in this instance.

Sustain-H was designed for domestic flexibility and therefore requires HH metering for participation. As such, CrowdFlex should encounter no issues in participating in this service.

3.1.3. Baselining

The baselining approach adopted for Sustain-H is based on predefined values determined for Extra High Voltage (EHV) network modelling and planning. The baselining methodology proposed for the Sustain-H service thus considers what consumers were expected to do based on the DSO's network planning assumptions, rather than what consumers did do. To be specific, the baseline for Sustain-H looks at what NGED would have assumed would have occurred in its network planning without a flexibility service This approach differs from the approach taken by ESO, which looks at historical demand for baseline purposes. For example, the Sustain-H baseline assumes passive charging behaviour in its baseline. However, if there is a consumer smart charges, then the ESO will use a smart charging baseline based on historical consumption, as per the P376 baselining methodology.

This highlights the difference between ESO markets, which have high liquidity and can access flexibility from numerous sources, and DSO markets, where very localised flexibility is a key feature in network planning decisions. We will assess how ESO and DSO baselines interact and the pros and cons of the two approaches in CrowdFlex: Beta, as well as how CrowdFlex can help inform DSO baseline demand for network planning going froward by improving understanding surrounding consumer responses to ToU tariffs.

3.1.4. Value

It is expected that three tariff bands will be offered for each procurement season. Tariffs (tentatively) based on the 2022 CMZ data are as follows:

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[13] Everoze, Sustain-H Service: Guidelines for Participants, 2020.

- Red / high value band: £8 /kW/month
- Amber / medium value band: £2.50 /kW/month
- Green / low value band: £1 /kW/month]

These tariff bands are contracted over the 6-month delivery period.

The three bands relate to the value of constraint services in the CMZ the service is procured for. The high tariff band includes the top 20% of the CMZs that season in service value, the medium band the next 30% and the low band the bottom 50% of the CMZs. NGED will review the fixed tariff for the red-amber-green bands periodically and update as appropriate.[14]

3.2. Replacement diversity for Load Managed Areas switching

3.2.1. Load Managed Areas

LMAs are a legacy system used by SSEN to manage network capacity in the SHEPD licence area and avoid network constraints. LMAs reduce the maximum demand on circuits and at substations by controlling customer space heating and water heating load at different times during the day and night via Long Wave Radio Tele-Switching (RTS). In effect this smooths demand from electric heating over the 24-hour period. However, SSEN has agreed to the phase out of LMAs, replacing RTS meters with smart meters, removing the Distribution Network Operator's (DNO's) ability to control the demand of storage heaters. This is because LMAs are becoming misaligned with the direction of travel of DNOs (in providing rewards for the provider of flexibility they inadvertently obstruct access to competitive market supply), specifically in areas including:

- Relying on static tariffs rather than dynamic tariffs that can respond to market signals
- No reward for the customer for providing a flexibility service
- Creates barrier to switching supplier, which can force customers onto specific tariffs
- Creation of a two-tiered location-based customer experience
- Undermines the opportunity for market provision of alternative flexible solutions

There are approximately 87,000 customers in LMAs. Should the DNO lose the ability to control these customers' heating demand then it could cause constraints on large areas of the network. As DNOs transition to DSOs, they have committed to pursuing a "flexibility first" solution to avoid network constraints before considering network upgrades. Given that the presence of flexible assets (storage heaters) in LMAs were the reason why the network has remained unconstrained in the past, if correctly incentivised, the DSOs should be able to mitigate the vast majority of network upgrades.

Currently, the way that LMAs operate is that they randomly instruct storage heaters / water heaters to turn on at different times, diversifying demand. This diversified demand is not required on the network every day, but is necessary during times of network stress. SSEN have advised CrowdFlex that a service which notifies storage heaters of the need to provide diversity a day ahead of time during days that SSEN have forecasted potential constraints on the network would be of interest to trial. Section 3.2.2 lays out a service that would fulfil these criteria, closely resembling a Secure service. Such a service, initially rolled out for LMAs, could in fact help provide flexibility for other CMZs if extended to other DSOs.

3.2.2. LMA Secure service

Secure is a DSO service, designed to manage peak demand on the distribution network, in which the flexibility provider agrees in advance their availability to deliver a change in demand at specific times. Based on forecasts closer to the event, the DSO may or may not instruct the change[15]. Generally, the availability of a flexibility provider to provide Secure is agreed at the contract stage and then it is instructed 24 hours ahead of time. For providing Secure, flexibility providers are paid an availability payment (£/kW/h) for the capacity they make available for Secure and a utilisation payment (£/kWh) for the energy they shift when Secure is dispatched. Following discussions with SSEN, this could provide a viable alternative to LMAs.

[14] Everoze, Sustain-H: A Scheduled Service for Homes, 2021.
[15] SSEN, Flexibility Services, https://www.ssen.co.uk/our-services/flexible-solutions/flexibility-services/, Accessed Nov 2022.

Diversity in demand from storage heaters in LMAs is not a daily requirement, but rather a requirement during network stress events. Therefore, a service that contracts the availability of the flexible capacity of storage heating, but only pays to dispatch it when it is required by the DSO would be the most appropriate solution for LMAs.

The variation from the standard Secure service is that during days where flexibility is dispatched in an LMA, the DSO would require the flexibility provider to dispatch storage heaters randomly throughout the 24-hour period to provide similar diversity to what has historically been achieved through RTS. An advantage of only requiring this on days when flexibility is called is that on other days, households with storage heaters can maintain their flexible capacity to participate in ESO flexibility services.

As the phase down of LMAs is still in its very early stages, SSEN does not yet have a valuation for a replacement service to replace LMAs. CrowdFlex: Beta should explore the discovery price for which consumers would opt-in to this new service.

4. Flexibility service stacking and primacy rules

4.1. Context

The Energy Networks Association (ENA) Open Networks Project has done a lot of work to understand how the ESO and DSOs should interact when flexible assets connecting to the distribution network participate in flexibility services for both the ESO and the DSOs. The ENA break this down into primacy and stacking rules. Primacy rules understand what occurs if two contradicting signals are sent to the same asset (or two separate assets on the same part of the distribution network), i.e., which signal gets primacy. Whereas stacking rules refer to which services you are allowed to participate in simultaneously (in the same delivery period), sequentially (in different delivery periods), or not combine at all. Section 4 will focus on our interpretation of the stacking and primacy rules specifically associated with the CrowdFlex "trial services". For the full details on stacking and primacy, please see ENA's publications[16,17].

4.2. CrowdFlex Trial Services

4.2.1. Primacy

Focusing on just the trial services, we can build a clear set of primacy rules based on the ongoing work of the ENA Open Networks Project. Figure 10 lays out which service takes precedence if multiple, conflicting services are called for the same delivery period.

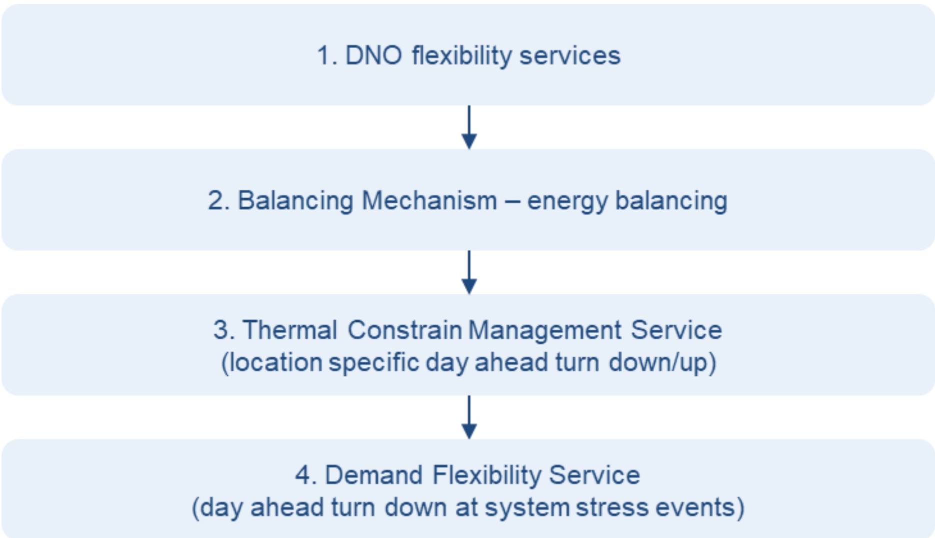

Figure 10: High-level diagram of CrowdFlex trial services primacy rules.

The high-level recommendation from the Open Networks Project is that in any case where a flexible asset is called to provide a DSO flexibility service (such as Sustain-H or a Secure product), it is the DSO service that takes primacy. It is sensible that DSOs receive primacy for domestic flexibility as DSO services seek to manage constraints on very specific areas of the distribution network. As such, they have a limited number of assets that they are reliant on to provide flexibility in CMZ. Meanwhile, the ESO operates in markets with much great liquidity, therefore, having to cede primacy to the DSO should not affect its ability to provide a response. Therefore, we propose to give DSO actions primacy in CrowdFlex over ESO actions.

The ESO services that we intend to trial include two Day Ahead services, which dispatch actions based on day-ahead forecasts of ESO system requirements, and one "real-time" service that is set to provide energy balancing via the Balancing Mechanism based on the requirements of Control Room operations. As the Day Ahead services are based on day ahead forecasts, they might not completely align with the "real-time" actions that the Control Room needs to take to operate the system. As such, "real-time" energy balancing actions via

[16] ENA, Open Networks Project – DNO Flexibility Services Revenue Stacking, 2020.
[17] ENA, Open Networks Project – Primacy Draft Rules Increment 1, 2022.

the Balancing Mechanism will have primacy over Thermal Constraint Management or the DFS, although the two can stack simultaneously.

An example of this is if domestic assets outside of an export constraint are instructed to provide demand turn down to manage a thermal constraint, but the system is in Surplus, a BM action to turn up demand outside of the constraint would take precedence. It is also worth noting that, in its current form, the DFS is an enhanced action. Therefore, it will only be dispatched if the Control Room are confident that all possible BM actions will be exhaustive. As such, we do not foresee an occasion where an instruction from the DFS must be overridden by a conflicting BM action.

4.2.2. Stacking

Our assessment from the ENA Open Networks Project is that all of the trial services are simultaneously stackable with one exception, for which two services can only be stacked sequentially. This is summarised in Table 2. Simultaneously stackable means that it is possible to participate in both services in the same time period. Sequentially stackable means that services can only be stacked in different time periods, not in the same time period. Stackability does not indicate how a flexible asset should be rewarded for the provision of flexibility for separate, but stacked services. This would be defined by the baseline.

Table 2: High-level summary of CrowdFlex stacking laws.

	Wholesale (via ToU tariff)	DSO flexibility service	Balancing Mechanism	Thermal Constraint Management	Demand Flexibility Service
Demand Flexibility Service	Simultaneous	Simultaneous	Simultaneous	Simultaneous	
Thermal Constraint Management	Simultaneous	Simultaneous (DTD) Sequential (DTD+U)	Simultaneous		
Balancing Mechanism	Simultaneous	Sequential			
DSO flexibility service	Simultaneous				
Wholesale (via ToU tariff)					

In addition to taking primacy, while there is no regulatory barrier, DSO services are designed in a way that prevents simultaneous stacking with the Balancing Mechanism and other “real-time” ESO flexibility services. For example, DSO services, such as Sustain, require dispatching to a set profile during the delivery period. Therefore, a flexible asset could not flex its output in response to a BM action during the delivery period of a DSO service. Therefore, we do not intend to enter domestic flexibility from CMZs into the BM during the same delivery period when they are contracted to provide Sustain-H[18].

However, CrowdFlex is interested in understanding how participation in day-ahead demand turn down for ESO system stress events impacts the ability of domestic assets to provide constraint management for the DSOs. Therefore, we propose that domestic flexibility in CMZs also participates in demand turn down only events simultaneously to DSO services (and demand turn down and up events sequentially). In this case CrowdFlex analysis will focus on the additional turn down mobilised by the additional incentive from the ESO service to supplement the DSO service payment. Future work on baselining and customer segmentation will be essential to understand how consumers are rewarded for these events.

We do not foresee any other stacking conflicts with our trial services, and these should all stack simultaneously, dispatched as per the primacy rules.

[18] D6.1 will indicate the financial implications of this decision. However, early analysis displayed in Section 5 suggests that this will be economically sensible for flexible assets.

5. Trial service deployment scenarios

Use cases for each individual trial service have been outlined in their respective scenarios. They are summarised in Table 3 below.

Table 3: Description of scenarios for which trial services would be called.

Service	Flexibility scenario	
	Demand turn-down	Demand turn-up
Balancing Mechanism	System is short following gate closure	System is long following gate closure
Thermal Constraint Management	a) Outside an export constraint b) Behind an import constraint	a) Behind an export constraint b) N/A
Demand Flexibility Service	System stress event e.g., system peak.	N/A
DSO flexibility – Sustain-H	4-hour evening peak each weekday in winter	N/A
DSO flexibility – LMA Secure	Distribution network stress event	N/A

The full operational profile of these calls will be assessed in detail in D6.1. Here we will consider a high-level approach to the impact that stacking these services has on the potential these services have to provide flexibility and the value they create.

This high-level model has broken the 24h day into 5 distinct sections: Overnight (00:00-06:00), Morning (06:00-12:00), Afternoon (12:00-16:00), Peak (16:00-19:00), Evening (19:00-00:00). We then assign experimental revenue values (£/kW/h) to the after-diversity flexibility potential (kW) of three domestic technologies: EVs (1kW in overnight period assuming smart charging baseline), HPs (2kW in winter), and whitegoods (0.12kW). The scenario we explored was the provision of services in Scotland behind a transmission network thermal constraint with and without a CMZ. The primary aim of these scenarios is to understand the impact that DSO services have (which take primacy over the other services and can only be stacked sequentially) on the value of the provision of flexibility services; exact values will be explored in CrowdFlex: Beta.

Figure 11 explores the value available per household per year for the scenario behind a transmission network constraint, exploring the value available when DSO flexibility services both are and are not available. The total annual value of flexibility for a household providing DSO flexibility services is approximately £190/household/yr, while a household in an area of the network which does not have DSO services has a value of £150/household/yr.

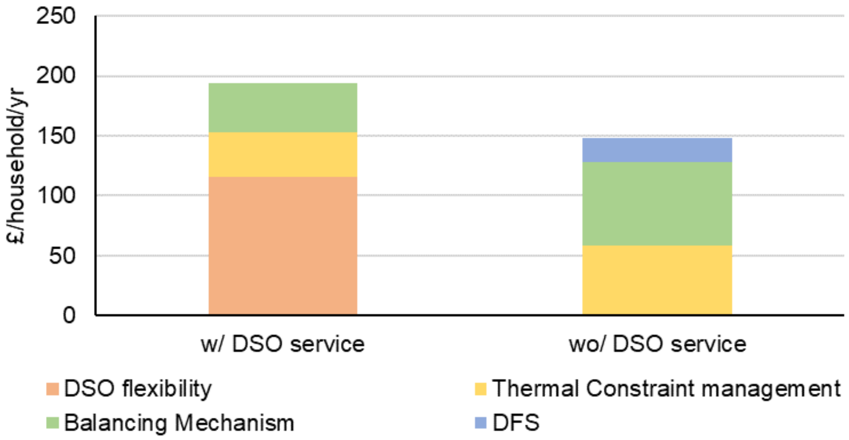

Figure 11: Value of flexibility per household per year for scenario behind a transmission network constraint, exploring the value available when DSO flexibility services both are and are not available

The key feature is that being exposed to the high payments from DSO services (assuming a red band Sustain-H service area, i.e., £8/kW/month) means that the key source of value from domestic flexibility can be found in providing constraint management on the distribution network. However, there is still significant value to be found by providing ESO services. Utilising domestic flexibility to turn down during the evening peak for DSO services means that some of the flexibility is depleted and cannot be deployed for ESO services in surrounding periods (afternoon/evening). A key feature is that households providing DSO flexibility are unlikely to be able to benefit from the DFS as their baseline will already show a demand profile with demand turn down flexibility exhausted. Therefore, they will be unlikely to generate an additional turn down during DFS events. Whether the additional incentive could encourage new flexible capacity from consumers should be explored in the CrowdFlex trial.

6. Summary & recommendations

6.1. Trial design

Understanding ToU tariffs and their impact on domestic flexibility will be an important outcome **of CrowdFlex**. This will include the **impact** on **consumer flexible capacity to respond to ESO signals, the extent to which consumers fulfil ESO needs without additional incentivisation through ToU** tariffs**, and the consumer behaviour elements associated with ToU tariffs (e.g., price sensitivity)**.

Challenges exist around devising the best **baselining methodology that captures both the accuracy and relevancy of consumer behaviour, whilst appropriately rewarding consumers** for providing domestic flexibility. This should be revisited at the start of CrowdFlex: Beta ahead of the CrowdFlex Trial.

6.2. Trial Services

We propose that CrowdFlex design two **ESO "trial services"** to investigate the large-scale potential of domestic flexibility:

1. Entry of portfolios of domestic flexibility into the **Balancing Mechanism** to provide "real-time" energy balancing for the ESO Control Room.
2. Long term trial of a Day-Ahead locational domestic flexibility service that provides **Thermal Constraint Management** on the transmission network via demand turn down and demand turn up.

- We propose that CrowdFlex should trial these services alongside the commercial product that exists from Winter 23/24 as a result of this year's **Demand Flexibility Service**, providing Day-Ahead scheduled demand turn down through domestic flexibility during system stress events. For clarity, participation in DFS will not be via CrowdFlex; though trial service 2 may be used to test a national summer turn up trial similar in operation to DFS.

Alongside the ESO services, CrowdFlex should trial two **DSO "trial services"** for domestic flexibility**:**

3. Provision of NGED's **Sustain-H** service in CMZs, mitigating constraints on the distribution network, stacked alongside other flexibility services.
4. Provision of **LMA Secure** service, a variant of the Secure service to ensure diversity of electric heat demand for SSEN in historically LMAs.

6.3. Statistical procurement of domestic flexibility

Provision of energy balancing through the **BM should include bid/offer pairs, accompanied by a confidence rating** to assess the value that can be captured by considering the statistical nature of domestic flexibility.

This "trial service" should also be conducted so that post-trial analysis can be completed to determine the **capacity that domestic flexibility could replace in the provision of Reserve**, either as a firm asset or statistically, as described in Alpha D1.2.

Day-Ahead ESO "trial services" should be conducted on a pay-as-you-deliver basis. However, as for Reserve, post-trial analysis must determine the capacity domestic flexibility could replace in the future.

6.4. Stacking & Primacy

Where there is conflict, **DSO services must have primacy over ESO services** due to the limited liquidity available to DSO CMZs.

"Real-time" ESO dispatch instructions should override Day-Ahead instructions as they more accurately reflect the Control Room's requirements to operate the system effectively.

ESO

CrowdFlex should **assess the impact of simultaneously stacking services**, with the exception of DSO services & the BM, which cannot be stacked. DSO services must only be stacked simultaneously with demand turn down ESO services to avoid primacy conflicts.