Public

The Demand Flexibility Service

Smart Meter Data Evaluation

Winter 2022/23

NESO
National Energy System Operator

Contents

NESO National Energy System Operator

Executive Summary

Introduction

This work evaluates the household-level response to the first year of the Demand Flexibility service (DFS), launched by ESO (now NESO) in winter 2022/23. Throughout this report we rely on a sample of ~139,000 domestic customers from Utilita, EDF, and EON who opted-into DFS year 1 (Y1). This dataset was cleaned by the research team at ERM and evaluated against a set of research questions co-developed by Environmental Resources Management (ERM), the Centre for Sustainable Energy (CSE) and NESO. These questions deliver quantitative insights into consumer responses to the DFS at a household level, supplementing the system-wide results and reporting published in August 2023.

Certain metrics were then extracted from the cleaned smart meter data and linked to the dataset resulting from the DFS Household engagement survey (undertaken in summer 2023) for the participants that opted in to this further research. The analysis of the linked survey-smart meter data is designed to understand how different types of energy consumers participate in the DFS, and whether certain characteristics of the person or their home correlate to different experiences.

The results for the Full smart meter dataset are summarised first followed by insights from the Survey-linked data subset

Thank you to Utilita, EDF, and EON for supporting this research and to the many households who engaged with our survey and with the Demand Flexibility Service as a whole.

Executive Summary

Response to the DFS across the full dataset

Full smart meter dataset

82% of the consumers in our full data sample opted into at least one event and a small number (just over 1%) opted into every event.

Out of the 113,648 consumers who opted-into at least one event, 52% of those consumers reduced their demand relative to the baseline during the event window for those events.

Across events in our sample, the delivered volume per participating consumer (i.e. those who reduced demand during the event) was 0.39 kWh.

In aggregate, the 124 MWh of flexibility delivered across the households and events in our dataset represents just under 4% of the total downturn (3.3 GWh) reported through the DFS over winter 2022/23.

DFS event date	Average delivered volume per participating consumer (kWh)	Total delivered volume (MWh)
15/11/2022	0.31	2.0
22/11/2022	0.32	2.4
30/11/2022	0.35	5.3
01/12/2022	0.36	5.3
12/12/2022	0.72	10.1
21/12/2022	0.42	4.8
23/12/2022	0.45	5.0
17/01/2023	0.36	3.4
19/01/2023	0.37	12.7
23/01/2023	0.39	10.5
24/01/2023	0.52	13.5
31/01/2023	0.37	3.9
13/02/2023	0.38	11.7
16/02/2023	0.45	0.2
21/02/2023	0.36	10.8
14/03/2023	0.39	0.10
15/03/2023	0.36	12.0
23/03/2023	0.32	10.3
All Events	**0.39**	**123.9**

Table ES1: Delivered volume from our sample for DFS Y1

NESO National Energy System Operator

Executive Summary

Understanding the role of the baseline in our analysis

Full smart meter dataset

Across full the dataset we saw reduction in demand during the event window for DFS events. The baselining methodology used in DFS Y1, which included an in-day adjustment (removed from subsequent iterations of the service), did often mask consumer intent to reduce demand to some extent.

The in-day adjustment mechanism shifted the baseline based on event day demand during an in-day adjustment window compared to an average baseline. Lower demand during the window resulted in a down-shifted baseline, reducing the measured volume of demand reduction.

77% of customer-events incurred a downshifted baseline, due to consumers reducing their demand before the event. The data suggests that people acted differently from the start of an event day, not just during the event, or during the in-day adjustment window immediately before it. The downshifted baseline will have limited the rewards received by households that made an effort to shift and may have impacted consumer understanding.

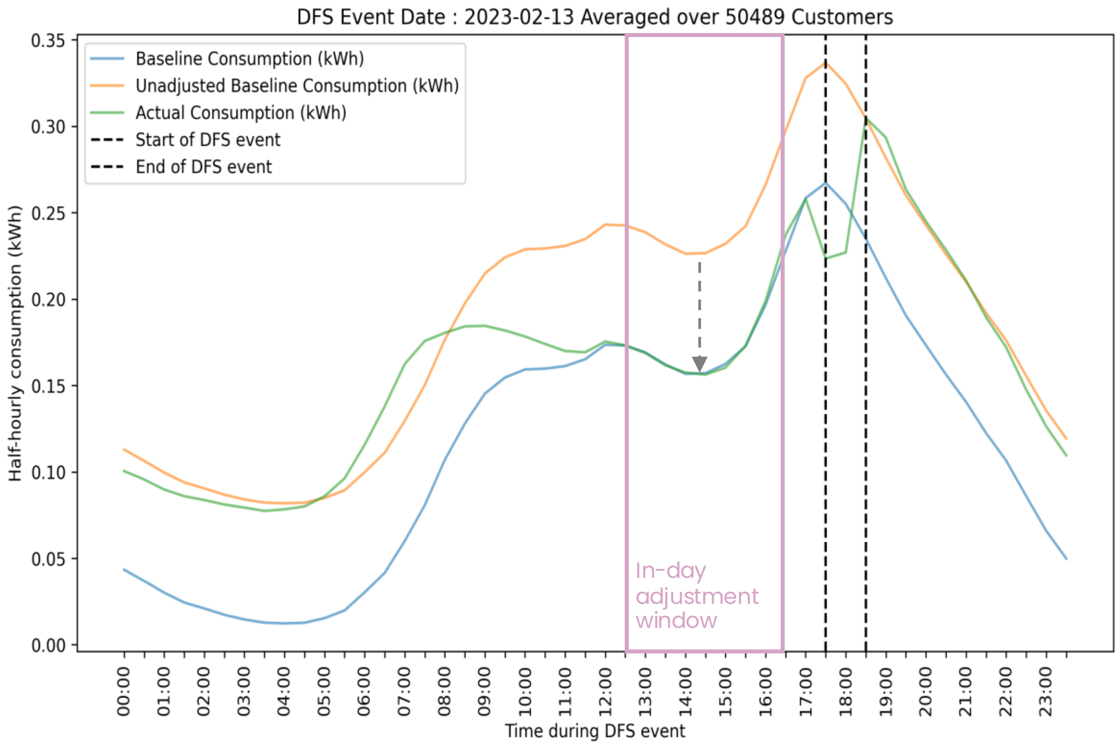


Figure ES1: Average profile with in-day adjustment

Executive Summary

Observed demand shift across the full dataset

Full smart meter dataset

To better assess the types of response across the full dataset we separated consumers into different groups based on the delta between their adjusted baseline and the consumption throughout the day of a DFS event.

For many consumers, we found that their actual consumption throughout the day was higher than their adjusted baseline due to the in-day adjustment downshifting their baseline. As discussed elsewhere, this adjustment makes it difficult to unpick consumer behaviour. Despite this, 33% of consumers across events were able to reduce demand relative to the adjusted baseline over the event day.

Across events, we found that anywhere from 78-92% of households have a secondary peak after an event. For 14 of the 18 of the events in our sample, this post-event turn-up in the hour after the event is greater than both the adjusted and unadjusted baselines and outweighs any turn-down during the event.

This indicates that there is a consistent increase in demand in the hour directly after the event regardless of the baseline used, possibly due to customers shifting demand during the event window.

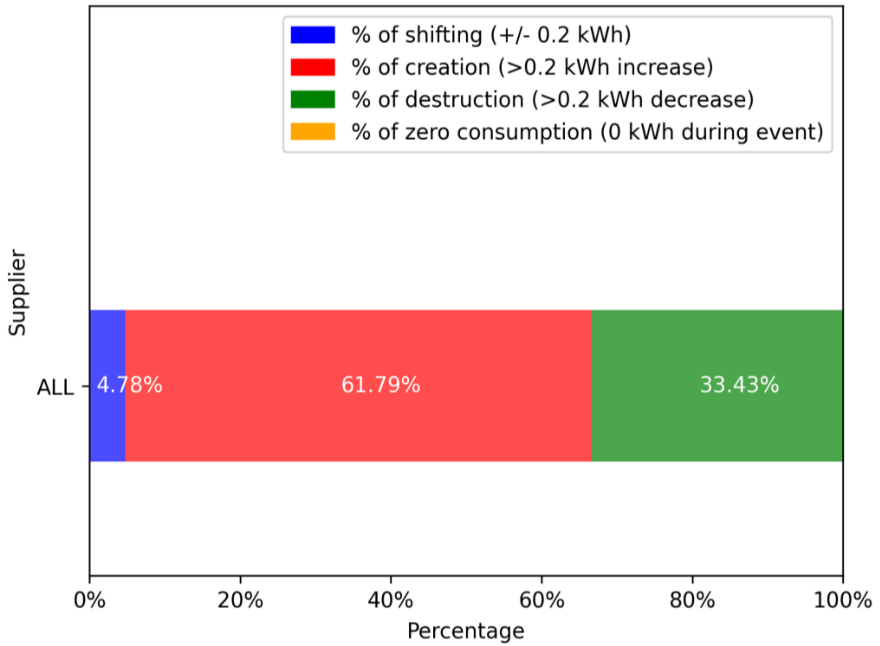


Figure ES2: Observed demand shift across DFS Y1

Executive Summary

Approach to the survey-linked dataset

Survey-linked data subset

Over 7,000 people that took part in the DFS Household engagement survey in spring 2023 consented to be contacted about using their smart meter data for further research. Of these, 723 participants went on to provide valid MPANs. Smart meter data for these households was provided by their suppliers and certain metrics extracted following the same process used for the full smart meter dataset. These metrics were then joined to the household engagement survey data for these 723 participants.

There are, however, some limitations to note for this research:

- The multi-staged process of providing MPANs to be linked to survey responses may have led to a selection bias in the survey-linked sample. (Representativeness is discussed further in the introduction to the report).
- The baselining method creates some complexity in understanding actual consumer behaviour during events.

Executive Summary

Headline findings from the survey-linked dataset

Survey-linked data subset

To establish patterns and findings between participant's survey responses and their smart meter demand profiles, CSE undertook group comparisons and outlier analysis.

Comparing those households that that opted in and successfully turned-down with those that opted in but did not actively participate, we found little difference in trial experiences (ease of participation, likelihood of participation), effort (number of events, shifting strategy) and household characteristics.

There were no significant differences in the average amount of demand turn-down provided by households between different low carbon technology ownership groups, between vulnerable groups, or between different tenures.

Looking at group differences in average rewards earned per event, we found that those with an EV charger earned significantly more than those without any LCTs.

We found that the incentive offered did have some impact on trial experiences. Those with lower incentives (under £3 kWh) appear to have taken part in fewer events, were more likely to report dissatisfaction with the overall experience (compared to the medium and high incentive groups), and were least likely to report that they would participate again.

Executive Summary

Conclusions

Full smart meter dataset | Survey-linked data subset

The results presented show clear intent to reduce demand across the dataset with 124 MWh of flexibility delivered by the ~139,000 consumers in our sample. This translates to an average reduction of 0.39 kWh across events for each household that was able to reduce demand during the event window.

This is, at times, obscured by the in-day adjustment mechanism which often shifted the household baseline downwards, reducing the measured demand reduction and any rewards received by consumers.

As a world-first initiative to use domestic flexibility to balance a grid at a national scale, the DFS was expected to encounter initial difficulties with implementation. Following feedback from industry, NESO removed the in-day adjustment mechanism from subsequent iterations of the DFS and the service continues to evolve and mature.

The large amount of variation in demand reduction, combined with the baselining method obscuring customer behaviour, means there were few observable group differences or patterns in the survey-linked data subset.

Introduction

Background on the Demand Flexibility Service

The Demand Flexibility Service (DFS) launched in winter 2022/23 as a contingency tool to shift peak electricity demand. During its first operational period from November 2022 to March 2023, it proved highly successful, with over 1.6 million households and businesses participating through 31 providers across 22 service events. The service was one of several enhanced measures implemented by NESO (then ESO) to ensure security of supply throughout winter 2022/23.

During its first two years, DFS served as a supplementary measure to the regular electricity market, helping reduce demand during high-demand periods, especially on critical winter days. The program encouraged both households and businesses to reduce or adjust their electricity usage voluntarily through flexibility providers and made flexibility markets more accessible to consumers. The initiative's success was recognised with two major industry awards in 2023.

In May 2023, NESO commissioned Environmental Resources Management (ERM) and the Centre for Sustainable Energy (CSE) through the Network Innovation Allowance (NIA) to evaluate the first year of the Demand Flexibility Service to understand more about how consumers participated and the impacts on energy use and behaviour. This evaluation has combined social research and smart meter data analysis. The overarching goal of this work was to share insights that can be used by NESO and energy system actors to improve the design and delivery of new flexibility services targeting domestic and eligible non-domestic consumers (i.e., micro/ small businesses with smart meters).

This report contains the results of the smart meter data analysis which complements the household engagement evaluation completed by CSE in 2023.

Introduction

Methodology and scope of this work

The results presented here are based on analysis of a smart meter dataset comprising ~139,000 domestic consumers[1] from Utilita, EDF, and EON who opted-into DFS Y1 over the winter of 2022/23. Not all DFS providers were able to provide smart meter data to feed into this work (due to resourcing or consent constraints). The analysis does not include any non-domestic consumers as no data was available from this group.

A further set of DFS providers have undertaken their own evaluation studies or published the results of their schemes. Relevant findings have been included in this report where possible.

The raw data provided by suppliers has been cleaned by the data team at ERM and then queried through a set of research questions co-developed by ERM, CSE and NESO. These questions assess the response to the DFS events alongside their impact on electricity consumption outside of the event window to evaluate the first year of the service.

Certain metrics were then extracted from the cleaned smart meter data and joined to the DFS Household engagement survey dataset for the participants that opted in to this further research. Relevant patterns and findings between survey responses given by participants and their actual smart meter demand profiles are presented throughout this report.

While we do present or comment on the results for distinct suppliers at points, this evaluation does not compare the flexibility delivered by one provider's customers to another provider's customers.

1 This is the number of consumers after anomalies were removed from the raw dataset. The cleaned dataset represents 87% of the consumers in the raw dataset. More information on the cleaning methodology can be found in Appendix 1.

NESO National Energy System Operator

Introduction

Methodology and scope of this work

Details of the DFS

DFS Year 1
Winter 2022/23

Key information:
- Registered provider list
- Participation guidance
- Communication principles

Evaluation of the service

DFS Year 1 Household Engagement report published May 2023

DFS Winter 2022/23 Review published August 2023

DFS Year 1 Smart Meter Data report published April 2025

Datasets

23,717 participant survey responses

Supplier breakdown: E.ON Next: 69%; EDF: 23%; Hugo: 3%, Utilita: 2%, Other: 3%

136,000 participant smart meter data records

Supplier breakdown: E.ON Next: 81%; EDF: 18%; Utilita: 1%

723 linked survey responses and smart meter data records

Supplier breakdown: E.ON Next: 73%; EDF: 26%, Utilita: 1%

This analysis is focused on the first iteration of the DFS over winter 2022/23. Given this we have used the baseline methodology used during the first year of the service and any results should be reviewed in the context of the Y1 service terms and procurement rules.

Scheme design changes:

- Removal of the in-day adjustment for the baseline
- Shift from an enhanced action service to an in-merit based margin tool
- Removal of the guaranteed acceptance price aligned with the shift to an in-merit margin tool

NESO National Energy System Operator

Introduction

Overview of our data sample

Customer count	DFS events	DFS customer events	Average daily consumption
138,998	18	522,338	7.98 kWh

Table 1: DFS dataset overview

Our dataset includes 18 DFS events out of the 22 events run over winter 2022/23. These 18 events include both the live events[2] and two consecutive one-hour test events run on 12 December 2022 which we treat as a single event.

Across the ~139,000 consumers and 18 events in the sample we have ~522,000 customer-events. The number of customer events is the sum of the total opted in available customers for each event. On the whole, the dataset represents 19.5 hours of demand turndown requests sent by the ESO *(now NESO)*.

The dataset also includes consumption leading into winter 2022/23 and consumption between events (16 to 18 months of data depending on the supplier). Average daily consumption across our dataset is broadly aligned with GB average domestic consumption at just under 8 kWh per day.[3]

2 "Live" DFS events included a competitive auction to set the reward per MWh of flexibility. These two live events were held on 23 and 24 January 2023

3 Average gas and electricity usage | Ofgem: 4.93 kWh (low), 7.40 kWh (medium), and 11.23 kWh (high)

Introduction

Overview of our data sample

The geographic spread of DFS consumers spans much of the country with highest concentration in the East Midlands, Yorkshire & Humber, and the North West. Our dataset is limited in that we do not have DFS consumer data for portions of north-west Scotland.

Figure 1 shows a heat map of the locations of consumers in our sample broken down by grid supply point group[4] (as indicated by the grey borders). The number of consumers within each GSP group is indicated by the colouring on the map. This gives us an indication of the coverage of our dataset.

The [aggregated delivery totals for DFS 2022/23](#) show a similar spread of consumers geographically with a high concentration of consumers in the south and the midlands and limited engagement in the north of Scotland. This suggests some of the low coverage in certain areas may be due to low consumer participation in the DFS in those areas rather than under-representation in our sample.

Geographic DFS consumer spread

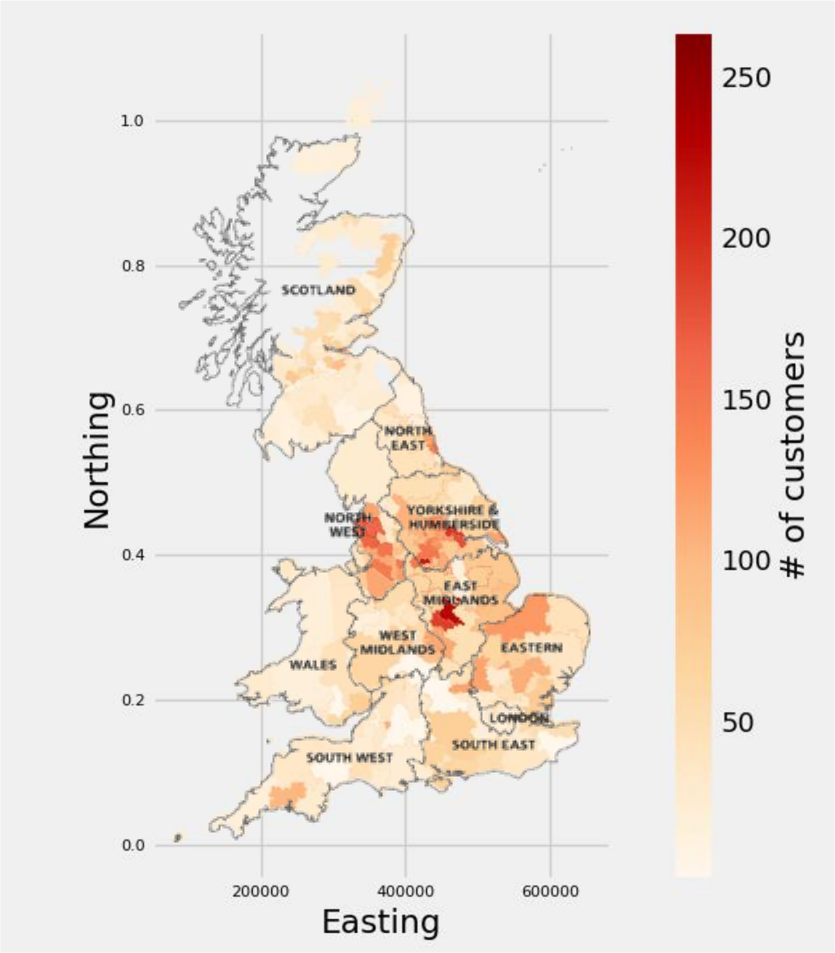


Figure 1: Consumer location heat map

4 These 14 [GSP groups](#) also correspond to the 14 licenced Distribution Network Operators and their licence areas.

Introduction

Overview of our data sample

Figure 2 shows the average weekly profiles for our cleaned dataset. The shape of these profiles is broadly similar to that of any diversified profile in GB suggesting that our sample is not significantly skewed by LCT ownership or other non-typical usage.

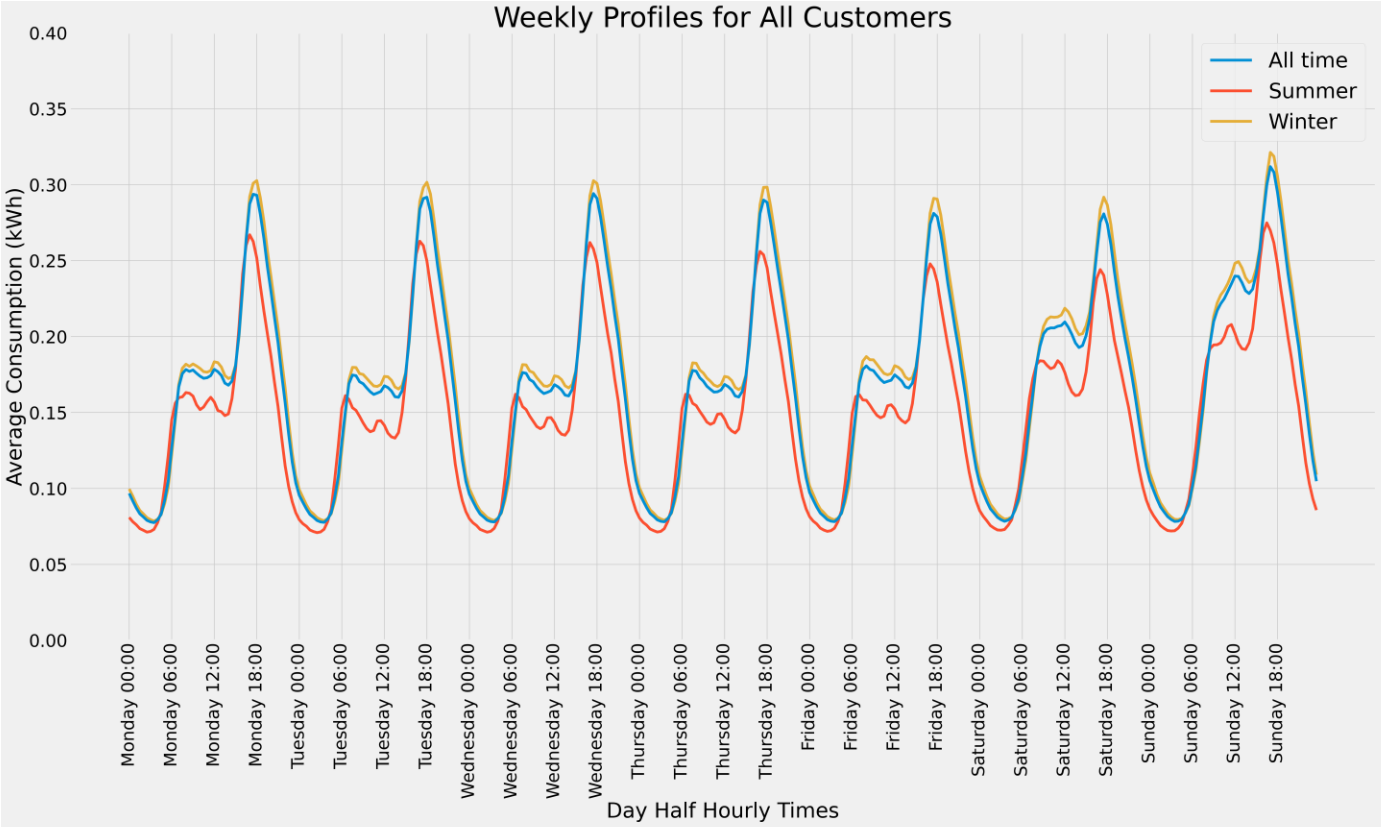


Figure 2: Weekly average profiles for consumers in our dataset

N.B. bank holidays have been removed from the dataset prior to any analysis or graphical presentations.

Introduction

Overview of the linked survey-smart meter data sample

Supplier	Customer count	DFS events	DFS customer events
EDF	191	8	902
EON	532	13	3223
Utilita	8	5	40
Total	**731**	**17**	**4125**

Table 2: DFS survey dataset overview by supplier

The survey-smart meter linked dataset includes 17 DFS events out of the 22 events run over winter 2022/23.

Over 7,000 people that took part in the DFS evaluation survey consented to be contacted about using their smart meter data for further research. Of these, 723 participants went on to provide valid MPANs. Smart meter data for these households was provided by their suppliers and certain metrics extracted following the same process used for the full smart meter dataset. These metrics were then joined to the household engagement survey data for these 723 participants.

E.ON Next customers made up the bulk of the linked survey-smart meter dataset with 532 of the 723 participants, compared to 191 for EDF, and 8 for Utilita.

Introduction

Overview of the linked survey-smart meter data sample

Group	Characteristics	Count	%	DFS Household engagement survey %	Group	Characteristics	Count	%	DFS Household engagement survey %
Tenure	Owner occupied	600	82%	79%	**Heating fuel**	Mains gas	568	78%	80%
	Private rented	57	8%	9%		Electricity	73	10%	10%
	Social rented	51	7%	10%		LPG/Oil	73	10%	7%
	Shared ownership	18	2%	3%		Wood or solid fuel	10	1%	2%
Building Type	Detached	261	36%	31%		Communal	7	1%	1%
	Semi-detached	219	30%	33%	**Age band**	20-34	29	4%	6%
	Terraced	116	16%	19%		35-54	179	24%	33%
	Purpose-built flat	68	9%	8%		55-64	182	25%	25%
	Converted flat	16	2%	2%		65+	341	47%	36%
Sex	Female	264	36%	52%	**Ethnicity**	White British	694	95%	92%
	Male	466	64%	47%		BAME	37	5%	8%

Table 3: Household characteristics: linked survey-smart meter dataset and DFS Household engagement survey dataset

A majority of the participants in the linked survey-smart meter dataset were in owner-occupied dwellings (82%) and were in detached (36%) or semi-detached (30%) buildings. 78% of the households used mains-gas, with 10% using electricity and 10% using LPG/Oil as their main heating fuel. Nearly half of the participants were over the age of 65 years old, while only 4% were between the ages of 20 and 24 years old. Men made up a majority of the participants (64%), and 95% of participants were white British.

The table also shows characteristics of participants in the DFS Household engagement survey. In comparison to the sample of respondents to the survey, there was a significant difference in social renters, women and younger people. 1% of the participants were on pre-payment meters (all of whom were the 8 Utilita customers), compared to 2% in the first DFS Household engagement survey. It should be noted that the process of providing MPANs for this research involved several additional steps following on from completion of the first survey, and may have led to a selection bias in the linked survey-smart meter data sample.

Introduction

Overview of the linked survey-smart meter data sample

The analysis of the linked survey-smart meter data is designed to understand how different types of energy consumers participate in the DFS, and whether certain characteristics of the person or their home correlate to different experiences. To do this, we have defined three broad groups:

- **Households that may be vulnerable in the energy market because of their circumstances** – this includes those reporting financial insecurity, households that include somebody with a long-term health condition, and people of pensionable age. We have aligned this grouping broadly with Ofgem's definition of vulnerability and the Priority Services Register eligibility criteria.

- **Households that may face barriers to demand shifting** – this includes those reporting financial insecurity and those living in rented homes.

- **Households that may have enablers for demand shifting** – this includes those that own low carbon technologies which can enable easier or more effective demand shifting. Examples of such technologies include electric vehicles (EVs) and EV chargers, heat pumps, batteries.

Introduction

Overview of the linked survey-smart meter data sample

	Group	% of sample	% of GB population	Difference
Participants in vulnerable circumstances	Health condition	28%	6%	+22%
	Over-65s	47%	19%	+28%
	Financially insecure	9%	Unknown	N/A
Participants with barriers to demand shifting	Social rented	7%	17%	-10%
	Private rented	8%	18%	-10%
Participants with enablers to demand shifting	EV + charger owners	7%	5%	+2%
	Battery owners	5%	1%	+4%
	Heat pump	3%	1%	+2%
	Solar PV	15%	2%	+13%

Table 4: Vulnerabilities, barriers and enablers in the linked survey-smart meter dataset and in GB

LCT-ownership was high relative to that for the GB population, ranging from 2% for solar thermal installations to 15% for solar PV installations.

Vulnerabilities were also high, with 28% of participants having a long-term health condition (likely related to the dominance of the older-age brackets in the sample). 9% of participants considered themselves financially insecure (responding that they are finding it ‘quite’ or ‘very’ difficult financially).

Participants with barriers to demand shifting (social and private renters) were both underrepresented relative the GB population.

NESO
National Energy
System Operator

Introduction

Overview of the linked survey-smart meter data sample

We also analysed responses according to the NESO consumer archetypes. The consumer archetypes were developed by NESO and CSE in the Consumer Building Blocks project, part of NESO's Future Energy Scenarios work. They use demographic data alongside information about a household's heating system and low carbon tech to build a picture of different energy consumers and their interaction with the energy system, helping to model consumer behaviour within different pathways towards decarbonisation.

Archetype	Count	%	% GB population	% of Original DFS Survey sample	Definition
D	6	1%	3%	1%	District or communal heating network
EO/ER/ES	56	8%	7%	9%	Electric radiators/storage heaters/electric other
G10	63	9%	14%	8%	Mains gas, 1 adult
G10p	105	15%	11%	13%	Mains gas, 1 adult (65+ years old)
G11	9	1%	3%	2%	Mains gas, 1 adult & 1 child
G12	7	1%	3%	1%	Mains gas, 1 adult & 2+ children
G20	109	15%	19%	20%	Mains gas, 2 adults
G20p	120	16%	12%	14%	Mains gas, 2 adults (65+ years old)
G21	17	2%	8%	3%	Mains gas, 2 adults & 1 child
G22	22	3%	12%	4%	Mains gas, 2 adults & 2+ children
L/O	59	8%	5%	5%	LPG (liquified petroleum gas) or Oil
SF	8	1%	Unknown	1%	Wood, or solid fuel
V	25	3%	Unknown	3%	Electric vehicle, no solar PV
VX	14	2%	Unknown	1%	Electric vehicle AND solar PV
X	97	13%	1%	9%	Solar PV, no electric vehicle
Unallocated	6	1%	3%	4%	Mains gas / Don't know

Table 5. Number and % of participants in the linked survey-smart meter dataset, and of the GB population for comparison, in each NESO archetype.

GB population comparisons

- X (solar PV) strongly over-represented in sample
- G10p and G20p (pensioner households) over-represented
- G10, G21 and G22 largely under-represented in sample

- Distribution of archetypes in the linked survey-smart meter data sample is similar to that of the original DFS survey sample.

NESO National Energy System Operator

Response to the DFS

This section explores:

- How many consumers opted into each DFS event? How many participated and reduced consumption?
- Is there an observable shift or change in demand within the DFS event?
- Do we see a turn-up during the event (instead of turn down)?

Response to the DFS

Overview of how we quantify the response to DFS events

Throughout this reporting we analyse the response in the smart meter data with regards to the number of households who have opted-into an event and those who have participated by reducing demand during the event window.

For consumers, opting-into a DFS event involves responding affirmatively to an event notification from a DFS supplier. Opting-into an event does not necessarily guarantee that a household will be able to reduce demand during the event, but it does suggest a level of engagement with the service. In our analysis, any consumer who opts-into an event and then reduces demand during the event window is considered a participant.

The data presented here is additionally only a subset of the 1.6 million households and businesses who participated in service over winter 2020/23.

NESO
National Energy System Operator

Response to the DFS

Who participated in DFS 22/23?

Across DFS events studied, roughly 80% of those eligible for the event opt into the session. This is highlighted in Table 6 which provides an overview of the consumers who opted into each event alongside the share of the consumers who opted-in and reduced demand during the event.

Roughly only 60% of the group who opt in to any given event are able to participate (i.e. reduce their consumption during the event). On the whole, this translates to 50% of the total consumers eligible for each event delivering demand reduction off the back of an invitation to participate in a session.

On average, Octopus Energy found a higher share of their customers reduced demand across their events, with an average of 75% of those who opted in reducing demand across their events.[5]

DFS event date	Opted-in percentage	Share of opted-in consumers who reduced demand
15/11/2022	78%	52%
22/11/2022	69%	52%
30/11/2022	78%	57%
01/12/2022	80%	59%
12/12/2022	81%	53%
19/01/2023	84%	77%
23/01/2023	84%	57%
24/01/2023	83%	54%
13/02/2023	84%	62%
16/02/2023	74%	73%
21/02/2023	81%	62%
14/03/2023	44%	64%
15/03/2023	83%	58%
23/03/2023	94%	57%
ALL EVENTS	**83%**	**60%**

Table 6: Opt-in and participation data for DFS Y1

5 Centre for Net Zero. (2024) The Impact of Demand Response on Energy Consumption and Economic Welfare.
N.B. Some suppliers were unable to provide opt-in data, and not all consumer data is included in the analysis of opt-in rates. For these 25,342 consumers the number of opted in consumers is based on the set of available consumers, less any consumers for which data points were missing.

Response to the DFS

How many consumers opted into every DFS event? How many participated and reduced consumption?

Table 7 shows the count of consumers who opted into all events for which they were eligible compared to the count of consumers who participated and reduced demand for each of those events.

1,845 consumers in our dataset opted into every event with 1,151 of those consumers (62%) delivering demand reduction in every event. These groups represent roughly 1% of our dataset.

The social evaluation of DFS Y1 found that only 4% of survey respondents took part in all or close to all the events that ran in 2022/23.

Consumers who opted-into every event	Consumers who participated in every event	Share of those who opted-into every event that reduced demand for every event
1,845	1,151	62%

Table 7: Breakdown of consumers who opted-into every DFS event over winter 2022/23

N.B. Some suppliers were unable to provide opt-in data, and not all consumer data is included in the analysis of opt-in rates. For these 25,342 consumers the number of opted in consumers is based on the set of available consumers, less any consumers for which data points were missing.

Response to the DFS

How many consumers opted into at least one DFS event? How many participated and reduced consumption?

Table 8 below shows the count of consumers who opted into at least one event over the course of winter 2022/23 compared to the count of consumers were able to participate and reduce demand for at least one event.

As expected, a significantly larger share of consumers opted in to at least one event – 113,648 consumers, which is 82% of the dataset.

This leaves roughly a fifth of consumers (25,350 or 18% of the total dataset) who signed up to DFS but did not opt into any events.

Consumers who opted-into at least one event	Consumers who participated in at least one event	Share of those who opted-into at least one event that reduced demand for at least one event
113,648	59,426	52%

Table 8: Breakdown of consumers who opted-into at least one DFS event over winter 2022/23

N.B. Some suppliers were unable to provide opt-in data, and not all consumer data is included in the analysis of opt-in rates. For these 25,342 consumers the number of opted in consumers is based on the set of available consumers, less any consumers for which data points were missing.

NESO National Energy System Operator

Response to the DFS

Demand response during DFS events

Table 9 to the right shows the total measured demand reduction or the delivered volume of flexibility across our sample for each DFS event compared to the official baseline.

Across events in our sample, the delivered volume per participating consumer (i.e. those who reduced demand during the event) is 0.39 kWh. Reviewing data from Octopus Energy customers, the Centre for Net Zero found a slightly lower average demand reduction of 0.31 kWh.[6] Our average reduction is slightly skewed by a particularly high response (0.72 kWh) by some households on 12 December 2024.

The total delivered volume across our sample of 124 MWh represents just under 4% of the total response (3.3 GWh) reported across DFS 2022/23.

DFS event date	Average delivered volume per participating consumer (kWh)	Total delivered volume (MWh)
15/11/2022	0.31	2.0
22/11/2022	0.32	2.4
30/11/2022	0.35	5.3
01/12/2022	0.36	5.3
12/12/2022	0.72	10.1
21/12/2022	0.42	4.8
23/12/2022	0.45	5.0
17/01/2023	0.36	3.4
19/01/2023	0.37	12.7
23/01/2023	0.39	10.5
24/01/2023	0.52	13.5
31/01/2023	0.37	3.9
13/02/2023	0.38	11.7
16/02/2023	0.45	0.2
21/02/2023	0.36	10.8
14/03/2023	0.39	0.10
15/03/2023	0.36	12.0
23/03/2023	0.32	10.3
All Events	**0.39**	**123.9**

Table 9: Delivered volume from our sample for DFS Y1

6 Centre for Net Zero. (2024) *The Impact of Demand Response on Energy Consumption and Economic Welfare*.

Response to the DFS

Demand upturn during DFS events

Some events resulted in a significant amount of demand turn up in our dataset when compared with the official baseline (which is discussed in more detail on the next slide). In each event anywhere from 20% to just under 50% of the consumers who opted in increase their demand during the DFS window. Notably, for the events on 15 and 22 November 2022 nearly half of opted-in consumers increased demand over the course of the event relative to the official baseline. When compared to the delivered volume (demand turn down) in Table 9, the delivered volume outweighs any turn up for 16 of the 19 events in our sample.

The social evaluation does not explicitly comment demand turn up, but only 50% of participants expressed dissatisfaction with having received no reward (which would have been the case for those who increased demand during an event). This could indicate low effort and therefore low expectation. The evaluation cites previous work[7] which found that households may opt-into non-punitive mechanisms (like the DFS) without intent to shift demand.

DFS event date	Proportion of consumers who increased demand during the event	Average demand turn up per consumer (kWh)	Total demand turn up (MWh)
15/11/2022	48%	0.44	2.6
22/11/2022	48%	0.45	3.1
30/11/2022	43%	0.43	4.9
01/12/2022	41%	0.43	4.4
12/12/2022	47%	0.80	10.0
21/12/2022	33%	0.35	2.0
23/12/2022	31%	0.36	1.8
17/01/2023	46%	0.43	3.5
19/01/2023	21%	0.32	2.9
23/01/2023	40%	0.44	7.9
24/01/2023	43%	0.58	11.1
31/01/2023	42%	0.40	3.1
13/02/2023	38%	0.42	8.1
16/02/2023	27%	0.43	0.1
21/02/2023	38%	0.39	7.1
14/03/2023	36%	0.44	0.1
15/03/2023	42%	0.39	9.7
23/03/2023	43%	0.38	9.3
All Events	**40%**	**0.44**	**91.4**

Table 10: Demand turn up across our sample for DFS Y1

7 Johnson, C. (2020) *Is demand side response a woman's work? Domestic labour and electricity shifting in low income homes in the United Kingdom*, ERSS.

Response to the DFS

Understanding the typical response and the baseline

The demand shifting discussed throughout this reporting is in reference to a standard baseline[8] created for each consumer who opted-into an event. The first step in creating the baseline is to define an unadjusted baseline, which was calculated as the end consumer's average usage over the previous 10 eligible working days.

For domestic consumers, the baseline included an adjustment to account for the impacts of weather on day-to-day demand patterns. This "in-day" adjustment vertically translates the unadjusted baseline based on the difference between their usage in the period from 4 hours to 1 hour before the delivery period, and the unadjusted baseline.

The profile shown in Figure 4 highlights the in-day adjustment period and how the unadjusted baseline was shifted down to better match demand within that window. This is the case for 402,913 customer-events (roughly 77% of the dataset) which have a downshifted baseline. As the profile shows, in these instances we see a reduction in demand early in the event day (i.e. pre-event), resulting in the downshifted baseline. After the event, demand reverts to something closer to the unadjusted baseline which registers as an increase in demand compared to the downshifted adjusted baseline.

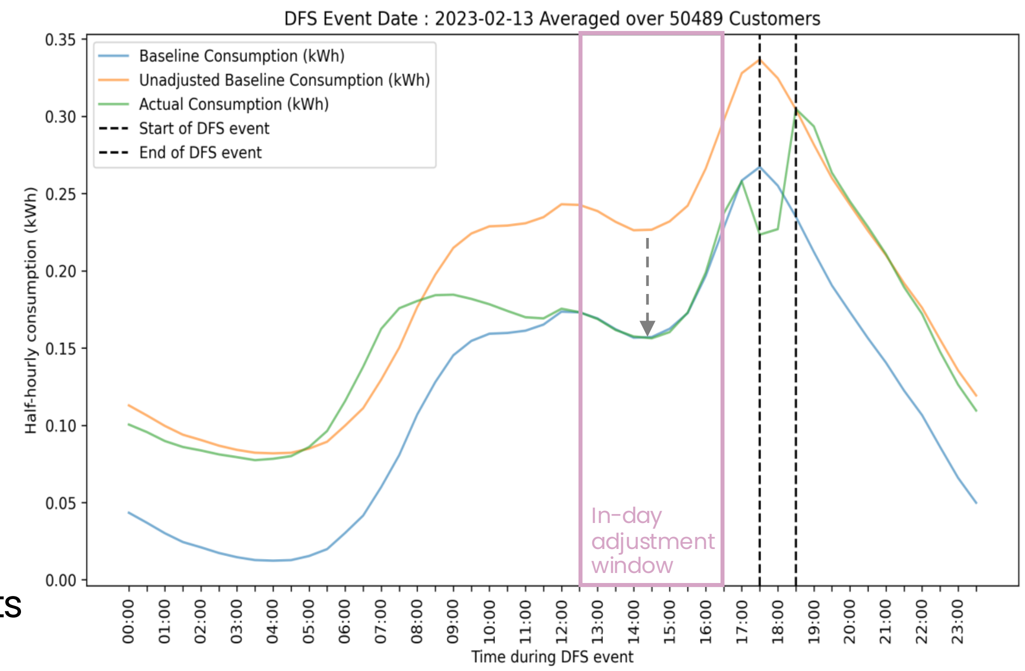


Figure 4: Average profile with in-day adjustment

8 Further guidance on the baseline can be found in the DFS Participation Guidance Document.

Response to the DFS

Impact of a downshifted baseline on measured response

We do see some instances where the adjusted baseline has been shifted so far down that it may no longer accurately represent consumption during the event.

Figure 5 shows the average baseline and actual demand and baseline for our dataset on 17 January 2024.[9] Lower consumption during the in-day adjustment period shifted the baseline down for the day. The actual consumption for the day shows a clear intent to reduce demand during the event, but baseline is shifted so far down that the net result is a "demand increase".

This phenomenon is also visible in the individual profiles for consumers and reinforces NESO and Ofgem's decision to remove the in-day adjustment from the second iteration of the DFS over winter 2023/24.[10]

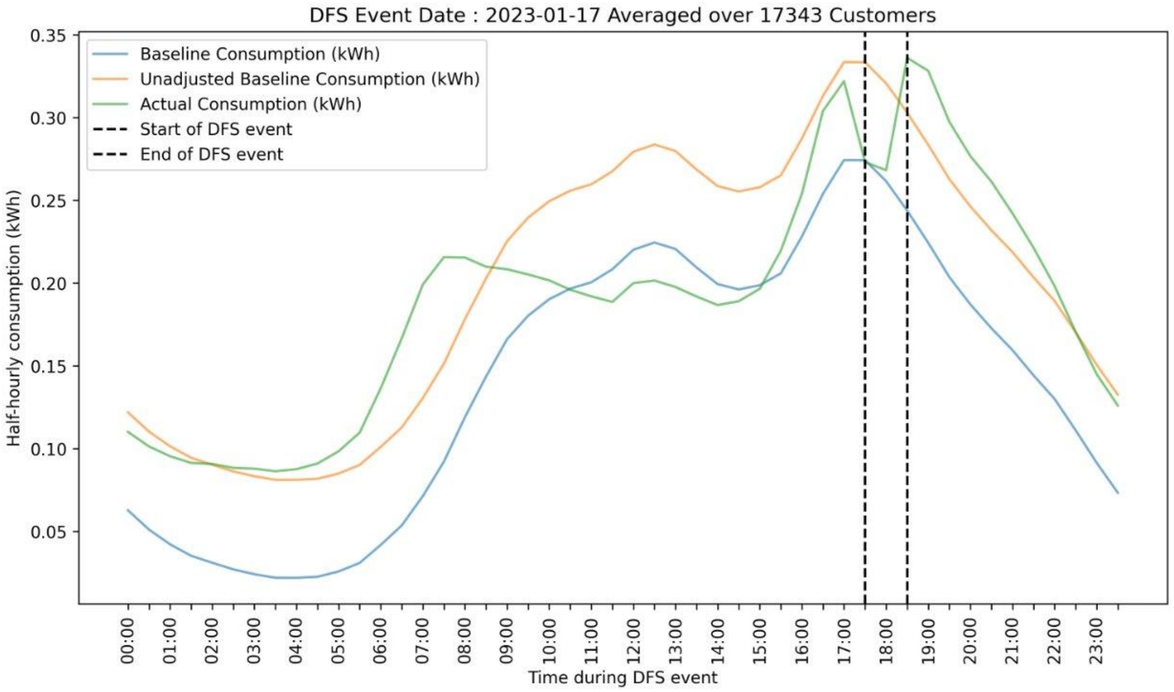


Figure 5: Sample average profile with downshifted baseline

9 Profiles for all 18 DFS events analysed here can be found in Appendix 2.
10 Ofgem. (2023) Decision on the Demand Flexibility Service in relation to an update to the Terms and Conditions related to Balancing.

Response to the DFS

Consumer behaviour and downshifted baselines

77% of customer-events resulted in a downshifted baseline, meaning that on these event days consumers reduced their demand in the hours before the event. Figure 5 above provides an example and shows a downward turn in actual consumption that starts at around 7am. Most events (see appendix 2) show this downward trajectory starting in the morning. This suggests that people acted differently on event days, not just during the event, or in the 4 hour window immediately before it. The DFS consumer survey raises several possible reasons for this.

- **Increased awareness of energy use on event days**. Event days could make people more conscious of their consumption, leading them to use less. Around a quarter of survey respondents reported that they had learnt more about energy use at home and were more able to manage their energy use generally as a result of participating in the DFS.
- **Shifting use around the event**. Planning usage around events was the shifting strategy most commonly reported by survey respondents, while reducing demand was the second most common strategy. It is likely that some households' strategies were broader than just activities carried out during the event window. Staying at work later, going to the gym, eating out for example, could mean that consumption was lower. This would align with the findings from CNZ's analysis.
- **Targeting of the in-day adjustment** (IDA) to improve rewards. Households that wanted to inflate their demand before an event to counter the in day adjustment may have shifted their demand from both earlier in the day as well as the during the event window to create the highest baseline possible in the hours immediately before the event. However, amongst survey respondents, awareness of the IDA was relatively low: only 16% reported that they specifically attempted to shift all of their electricity usage into the 1-4 hours before an event. This includes households who did not know about the IDA and households legitimately using the IDA to earn rewards.
- **Confusion or lack of awareness about how to participate effectively**. Though only 3% of survey respondents said that they didn't understand what to do to participate, comments made by some suggested that they understood the DFS as a general energy-saving scheme rather than specifically aimed at demand shifting during critical peaks.

The downshifted baseline will have limited the rewards received by households that made an effort to shift and may have impacted consumer understanding. Clearer communication around the calculation of results was a common theme in qualitative survey feedback.

Appendix 2 provides profiles of all events studied and shows a large variety between the baseline, the adjusted baseline and actual consumption. Future research could explore the factors associated with these differences and the impacts for different types of consumers. Understanding the extent that baselining methods impact consumers differently will be key to supporting effective participation in domestic flexibility services.

Response to the DFS

Separating measured response from consumer behaviour

The baselining method creates some complexity in understanding actual consumer behaviour during events. In some cases the measured response leads some consumers to be classified as turning up their demand during events, despite the data suggesting an intent to turn down demand. To address this in the linked survey-smart meter dataset, we classified the turn-up and turn-down signatures in the data into the three participant groups:

1. **Non-participation:** Those that opted in to an event, but did not appear to participate resulting in an observed turn-up signature in their smart meter data - greater consumption during the event relative to their adjusted baseline. 245 participants were in this group. These participants will not have received a reward, but did not actively reduce their demand during the events.

2. **Baseline issues:** Participants that opted in to an event, and appear to have made an effort to turn-down, but baselining issues meant that their baseline was calculated as negative, resulting in a turn-up signature in their smart meter data as any amount of consumption will look like they have turned up relative to a negative baseline. 9 participants were in this group. These participants will not have received a reward, despite actively participating in events.

3. **Participation:** Participants that opted in to an event, and appear to have made an effort to turn down, and their baseline was correct resulting in the expected turn down signature. 445 participants were in this group. These participants will have received a reward.

We allocated according to typical measured response. This means there will be some events that households in the 'non-participation' group did participate in, and vice versa. The numbers suggests that a majority of the event window turn-up signatures observed in the data were due to non-participation despite opting in, rather than baselining issues.

NESO
National Energy System Operator

Response to the DFS

Participation during DFS events

Group	Characteristic	Non participation (n = 245)	Participation (n = 445)
Vulnerability	Financially insecure	6%	9%
	Long-term health condition	24%	29%
	65+ years old	45%	47%
Barrier	Private renters	7%	8%
	Social renters	8%	6%
Enabler	Smart controls	44%	43%
	Solar PV	14%	16%
	Battery	4%	5%
	Heat pump	2%	4%
	EV charger	9%	4%

Table 11. Percent of participants in the event participation groups that had vulnerabilities, barriers and enablers.

Table 11 shows the characteristics of households that opted in but did not participate and those that opted in and turned-down (suggesting successful participation in demand reduction). For example, 9% of those in the turn-down group were financially insecure, while only 6% of those in the non-participation group were financially insecure.

In the survey-smart meter linked dataset, the group that opted in and participated but experienced a negative baseline contains just 9 households and has not been reported due to the small sample size.

NESO National Energy System Operator

Response to the DFS

Household experiences across participation groups

When comparing across households that typically participated in events and those that didn't, we see little difference in their trial experiences. They report using similar strategies, taking part in similar number of events, and show similar levels of ease and enthusiasm for taking part. This indicates some of the complexity in using smart meter data signatures to determine consumer behaviour. Although some households were clearly more effective in their participation, as evidenced by their smart meter data, even households that were less effective and less active in participation had positive experiences.

The 9 households that experienced baseline issues reported slightly different experiences. For example, over 40% of these participants (4 households in total) moved their electricity usage to 1-4 hrs before the event, and over 80% (8 household in total) reported shifting their demand. This suggests they did attempt to shift, however baselining issues may have resulted in their turn-up signature rather than turn-down. The small size of the group and the nature of the baseline issues make it difficult to interpret the experiences and outcomes for this group.

There is little difference in trial experiences (ease of participation, likelihood of participation), effort (number of events, shifting strategy) and household characteristics between households that did and did not actively participate in events.

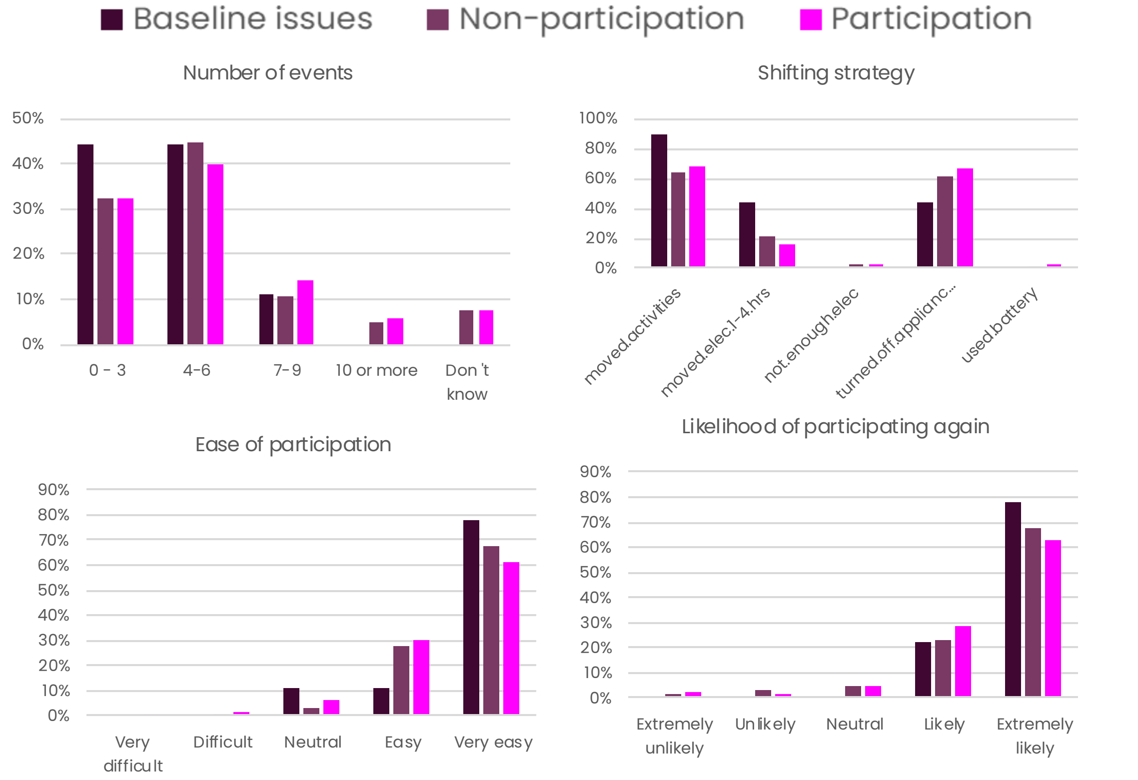


Figure 3: Proportion of turn-up (with positive and negative baselines) and turn-down households that responded to questions related to trial experiences

Response to the DFS

Calculating the secondary peak and absolute peak from DFS consumption data

For this analysis we set the secondary peak as the point in the day where we see the greatest positive difference between the day's actual consumption and the adjusted baseline. The consumption value at that time is presented as the secondary peak consumption throughout this section.

This metric allows us to evaluate when consumers are increasing their consumption outside of their normal or anticipated routine (which is represented by the adjusted baseline). As noted in previous sections, comparing against the adjusted baseline may inflate a consumer's daily consumption and the size of this secondary peak. We use this baseline in our reporting as this was the official baseline for the first year of the DFS.

At times, including for this event, we find that this secondary peak is also the day's absolute peak (the maximum consumption observed at any point in the day).

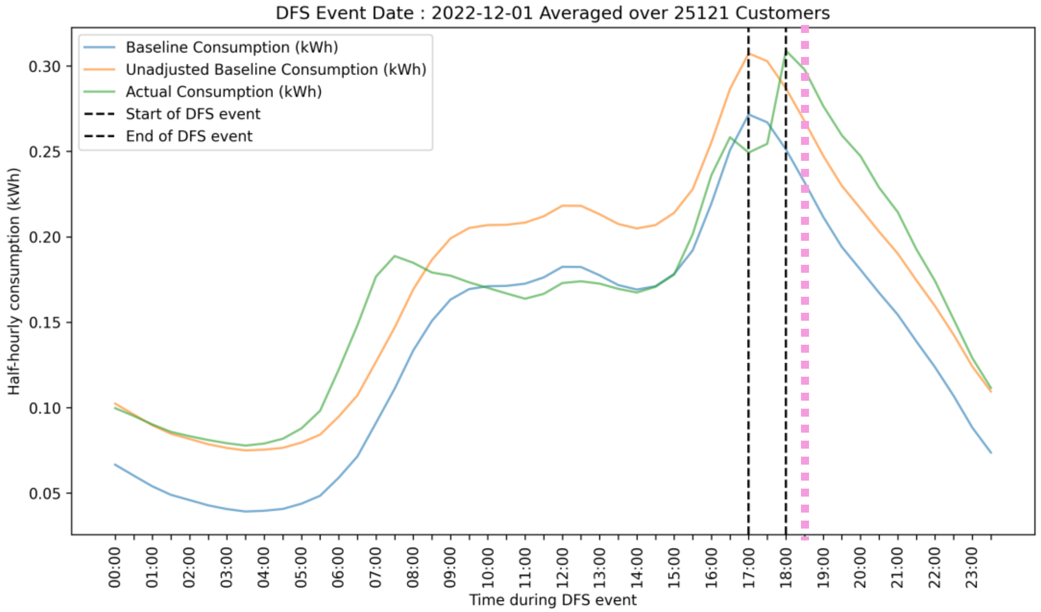


Figure 6: Secondary peak for a sample DFS event

The pink dotted line shows the secondary peak for the event on December 12 across our larger dataset which is larger than both the adjusted and unadjusted baselines.

Response to the DFS

Timing of the secondary peak across DFS events

Figure 7 shows the time delta between the secondary peak and each DFS event. This delta is the number of hours between the secondary peak time and the DFS event period (positive values relative to the DFS event end time and negative values relative to the DFS event start time). The most common case, across all DFS events is that a secondary peak occurs immediately following an event (i.e. increased demand is seen in the half hour following the end of a DFS event).

There is no correlation for how this changes as the events progress in the timeseries.

This suggests that, across DFS events, consumers are shifting demand to the half hour immediately following an event.

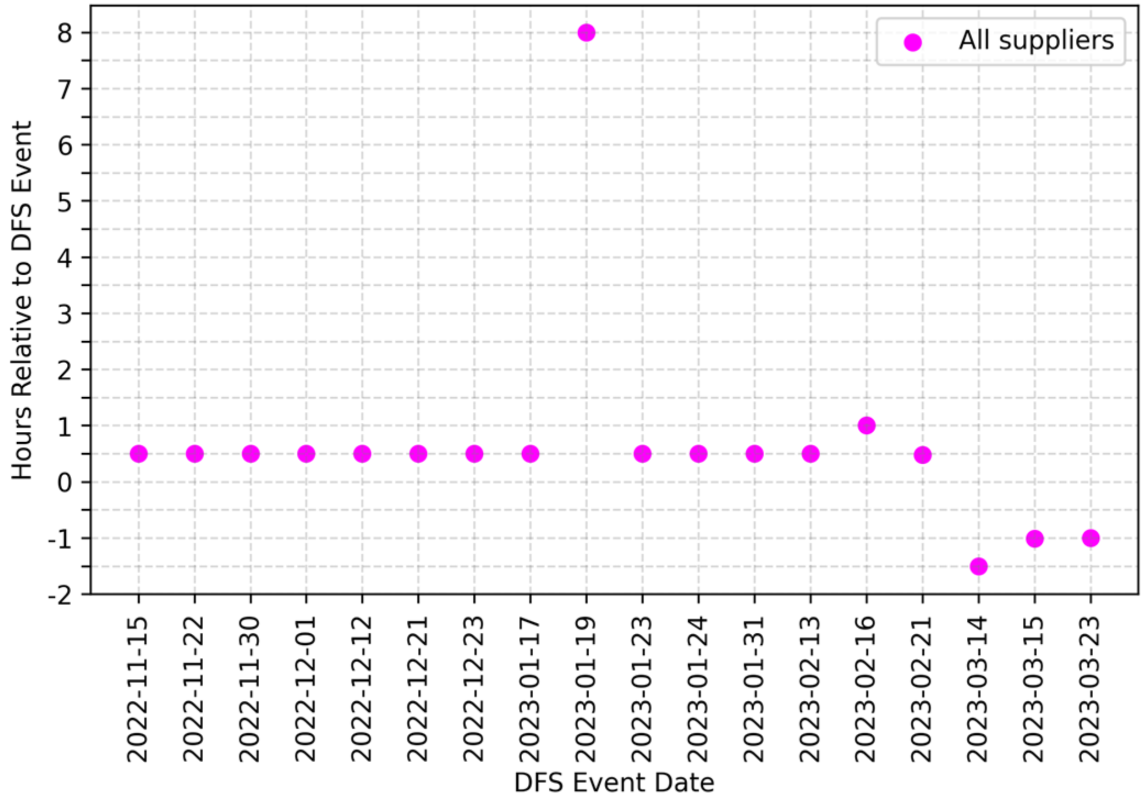


Figure 7: Time delta for occurrence of secondary peak

Response to the DFS

Does the DFS event lead to a larger peak around the DFS event compared to the baseline?

Figure 8 shows the average delta between the adjusted baseline and event-day actual consumption at the secondary peak time for each DFS event date. The average relative demand increase at secondary peak time varies between ~0.6 kWh to ~0.85 kWh.

Paired with the typical demand reductions (and potential upturns) for the half hours during each DFS event we can see that in most instances the demand increase for this secondary peak outweigh the reductions seen during the event. This contributes to the high proportion of demand creation (over the day as a whole) that we see in the dataset.

For fourteen of the eighteen DFS Y1 events, the average consumption at the secondary peak is greater than both the adjusted and unadjusted baselines at the secondary peak time, which usually immediately follows an event (i.e. within 1hr after the event end). This indicates that there is a consistent increase in demand after an event regardless of the baseline used.

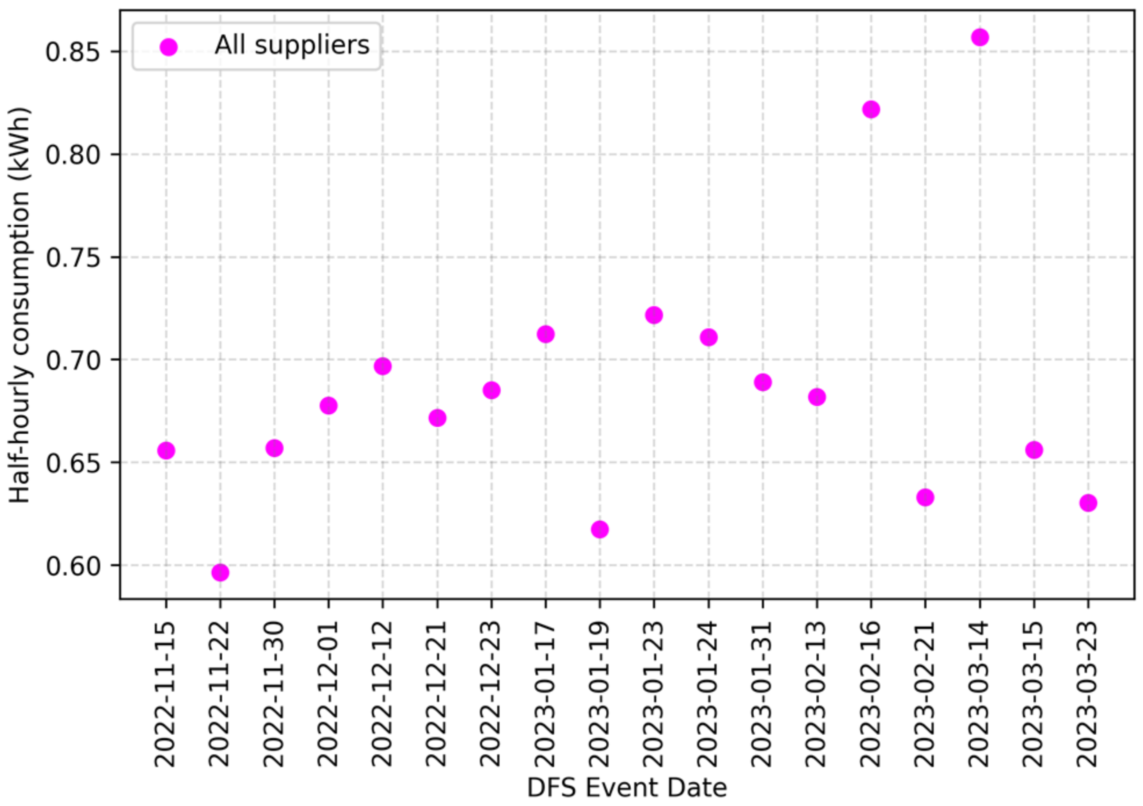


Figure 8: Average demand increase relative to baseline at secondary peak time

NESO National Energy System Operator

Response to the DFS

How quickly were consumers able to respond to DFS events?

Investigating the ramp rate provides an indication of how quickly consumers are able to respond at the start of an event. This metric can help establish how reliable the DFS is in reducing demand quickly for a given 1-hour period. This may be particularly relevant as the programme moves into an in-merit margin service in line with the normal electricity market for its third iteration over winter 2024/25.[11]

As Figure 9 shows, the average ramp rate across all 1-hr events was negative for both half-hourly periods, for all suppliers.

This indicates that on average, participants decreased their demand compared to the immediate half hour before the event start and maintained a continued ramp down during the event as well.

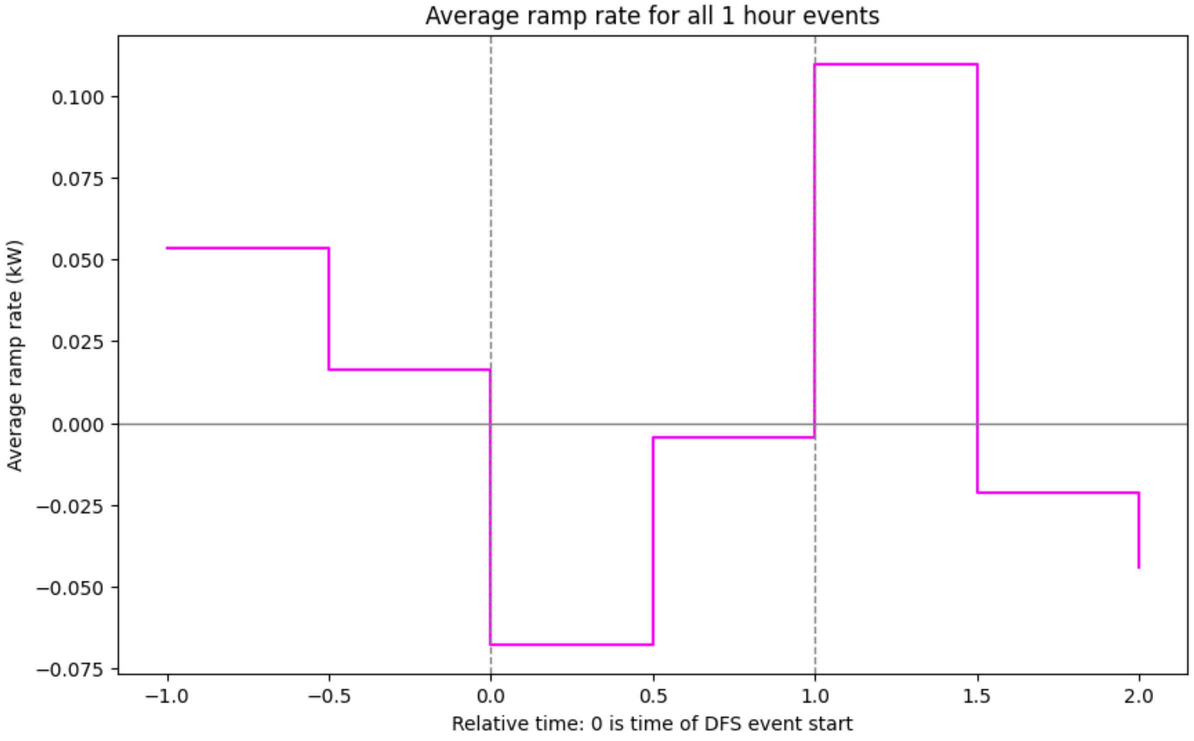


Figure 9: Average ramp rate for all 1-hour events

11 *Ofgem. (2024)* Decision on the Demand Flexibility Service in relation to an update to the Terms and Conditions related to balancing.

Observed Demand Shift

This section explores

- What strategies we observe in the smart meter data for moving demand
- Is there any evidence of disconnection during an event?
- Is there any evidence of leveraging the in-day-adjustment mechanism to inflate rewards?

Observed Demand Shift

Demand response patterns across consumers

The social evaluation of DFS Y1 found that both demand shifting (planning usage around the event) and demand destruction (reducing usage during event) were popular response strategies amongst those surveyed. Shifting demand to other times of the day or week was the most popular strategy selected by respondents (41%) and demand destruction during events was the second most popular strategy selected by 31% of respondents. From the survey results it was unclear if the reported prevalence of demand destruction was a reaction to the cost-of-living crisis. Respondents may have also mischaracterised their actions.

In their review of Octopus Energy's customer participation in the DFS, the Centre for Net Zero found no evidence of demand increase relative to the baseline in the hours just before and after DFS events (as would be expected if consumers shifted demand).[12] Instead, they found evidence of demand destruction across their sample. This analysis used a custom baseline created with a control dataset of customers who did not opt-into the DFS or who were never invited to opt-in. This baseline did not include the same in-day adjustment that was used to calculate rewards for DFS Y1 (which is also used throughout our analysis to quantify the response the DFS events).

As discussed earlier, the in-day adjustment of the baseline often shifts the baseline down and reduces the level of demand response measured across the event day, potentially obscuring consumer intent to reduce demand. In this section we group consumers based on the observed change in demand over the DFS event day compared to the baseline. These groupings do not necessarily reflect consumer intent, but they do broadly reflect outcomes in terms of rewards and measured demand response as calculated for this DFS Y1 analysis. The in-day adjustment has since been removed from subsequent iterations of the DFS.

12 Centre for Net Zero. (2024) The Impact of Demand Response on Energy Consumption and Economic Welfare, pp.29.

Observed Demand Shift

What are the specific demand response patterns observed when looking across total consumption on a DFS event day?

We separate consumers into different groups based on the delta between their adjusted baseline and the consumption throughout the day of a DFS event for all consumers who opted-into an event.

Any change less than ±0.2 kWh across the event day is treated as shifting; any larger positive change is classified as creation while a decrease >0.2 kWh is classified as destruction. This 0.2 kWh threshold was chosen to establish a clear delineation between demand response groups without considering small noise fluctuations as demand reduction.

The largest share (62%) of the observed behaviour is the creation of demand – i.e. consumers increase their demand across the whole DFS day relative to the adjusted baseline. It is worth noting that the prevalence of demand creation could be tied (at least in part) to the downshifting of the adjusted baseline, which inflates the consumption relative to this new lower baseline.

Demand destruction (reducing demand) accounts for 33% of the total consumer count. Demand shifting (i.e. demand staying roughly the same) accounts for 5% of the total consumer count. We see no evidence of 'zero consumption' during any event.

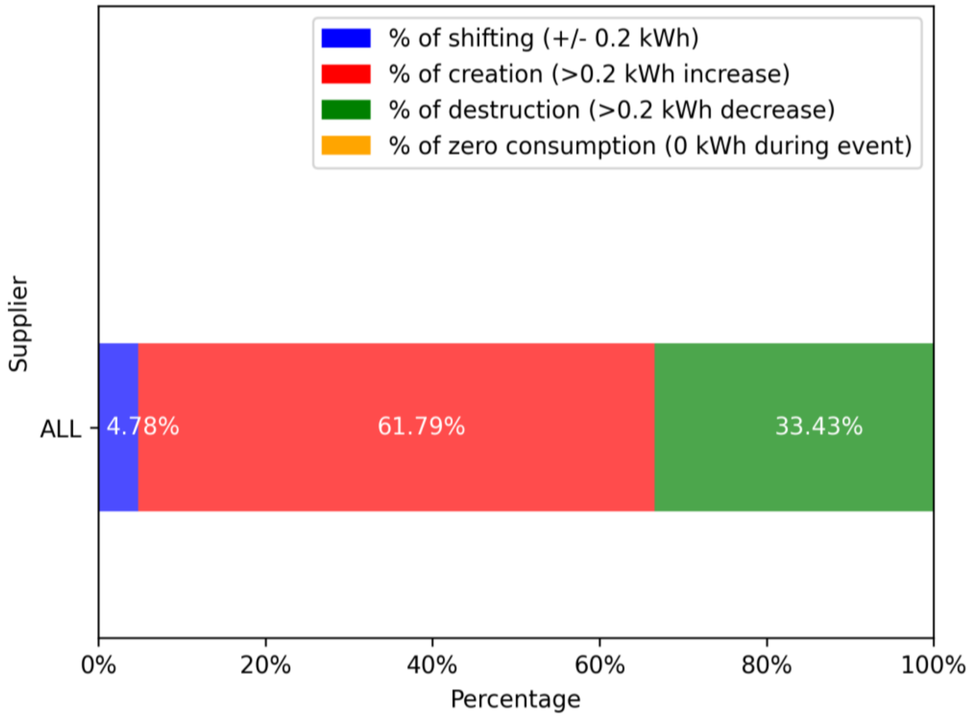


Figure 10: Observed demand shift across DFS Y1

Observed Demand Shift

What are the specific demand response patterns observed when looking across total consumption on a DFS event day?

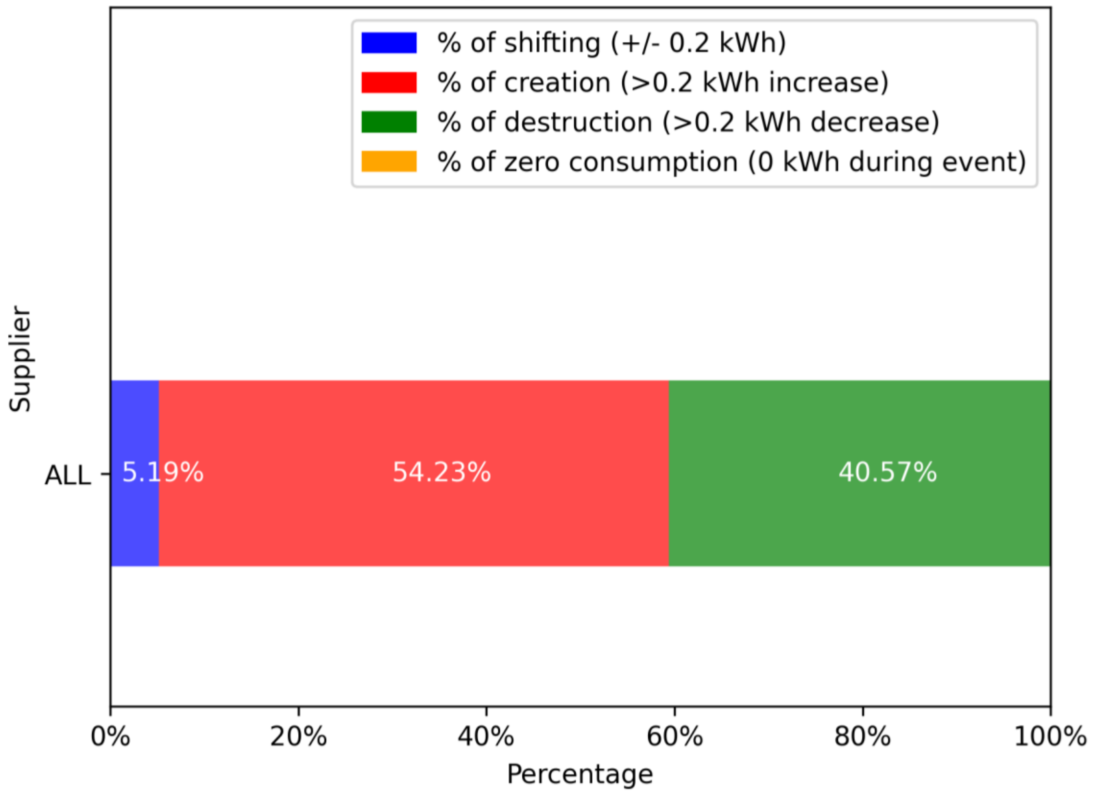


Figure 11: Shifting strategies for those who reduced demand during the event window for DFS Y1

In Figure 11 we present the same split between shifting strategies but only for consumers who participated and reduced demand during the DFS event window.

We see a slight increase in demand destruction (+7.1%) and shifting (+0.4%) for this subset of consumers when compared to the full set of consumers who opted into events (which includes some consumers who did not reduce demand during the event window).

There is still a large amount of demand creation across this group, again likely due in part to the downshifted baseline which inflates the relative change in consumption across the DFS event day.

We find no evidence of zero-consumption across the DFS event window.

NESO National Energy System Operator

Observed Demand Shift

Who are the participants in the demand destruction, creation, and event-day shifting groups?

The three event-day shifting groups (defined on page 41) were mapped to the survey data to analyse the household characteristics present in each group. Table 12 shows only the characteristics that differ between the groups. Apart from the characteristics presented below, the distribution of household characteristics and trial experiences was similar for the three groups. Similarly for shifting behaviours – though we would expect reported shifting behaviour to be different for the three groups, there were no significant differences observed.

Destruction (n = 196)	**Creation (n = 474)**	**Shifting (n = 20)**
Mostly 65-74 years old. 16% are 75+.	Mostly 65-74 years old. 15% are 75+	Mostly 35–44-year-olds. 10% are 75+
Archetypes: G20p, G10p, G20 (Mains gas) 6% V (EVs) and VX (EVs & Solar PV) 11% EO/ER/ES (electric heating)	Archetypes: G20p, G10p, G20 (Mains gas) 5% V (EVs) and VX (EVs & Solar PV) 7% EO/ER/ES (electric heating)	Archetypes: 50% G20 and G20p (Mains gas) No V or VX (i.e. no EVs) No electric heating archetypes No G21 or G22
39% detached, 29% semi-detached	36% detached, 30% semi-detached	55% Semi-detached
8% financially insecure	9% financially insecure	No-one financially insecure
Each LCT represented	Each LCT represented	No solar thermal, heat pumps, or batteries
86% 'fairly' or 'very' concerned about climate change	91% 'fairly' or 'very' concerned about climate change	100% 'fairly' or 'very' concerned about climate change
62% broadband & mobile data internet access	59% broadband & mobile data internet access	40% broadband & mobile data internet access

Table 12: Characteristics of participants who were in the different event-day strategy groups. Archetype definitions can be found on page 21.

NESO National Energy System Operator

Observed Demand Shift

Demand reduction of the event-day destruction, creation, and shifting groups

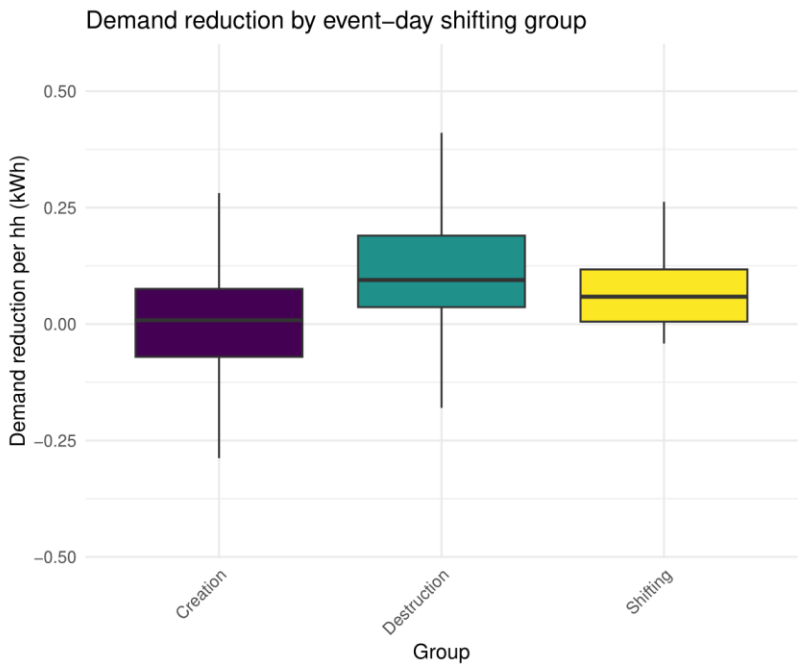


Figure 12: Amount of event-window demand reduction of the different event-day shifting groups. Each box represents the interquartile range (IQR), the horizontal lines indicate the median and whiskers extending to 1.5 times the IQR.

The event-day consumption behaviour of participants had a significant impact on the amount of demand reduction during the event window.

As expected, those that destroyed demand over the event-day had greater event-window demand reduction compared to the demand creation group (Figure 12).

Because of the significant variation of event-window demand reduction caused by the event-day creation/destruction/shifting group difference, any other differences related to factors like LCT ownership, vulnerability, and barrier groups may be obscured. Splitting up further demand-reduction analysis by the 3 groups in Figure 12 would allow any differences in LCT ownership, vulnerability, and barrier groups to become more evident.

Observed Demand Shift

Observed shift in demand across consumers

Figure 13 shows the demand reduction per consumer during each DFS event (any increase in demand is shown as a negative value) and in the hours immediately before and after the event. Almost always, significant levels of additional demand are seen post-event, with varied levels throughout the timeline.

Minor turn-up is also usually seen within an hour before an event.

For 14 out of 18 events, the post-event turn-up in the hour after the event outweighs any turn-down seen during the event when compared to the adjusted baseline.

This aligns with the secondary peak we see in the aggregated profiles (which often falls in the half hour after an event) and suggests that consumers are primarily shifting (or in some cases creating) demand.

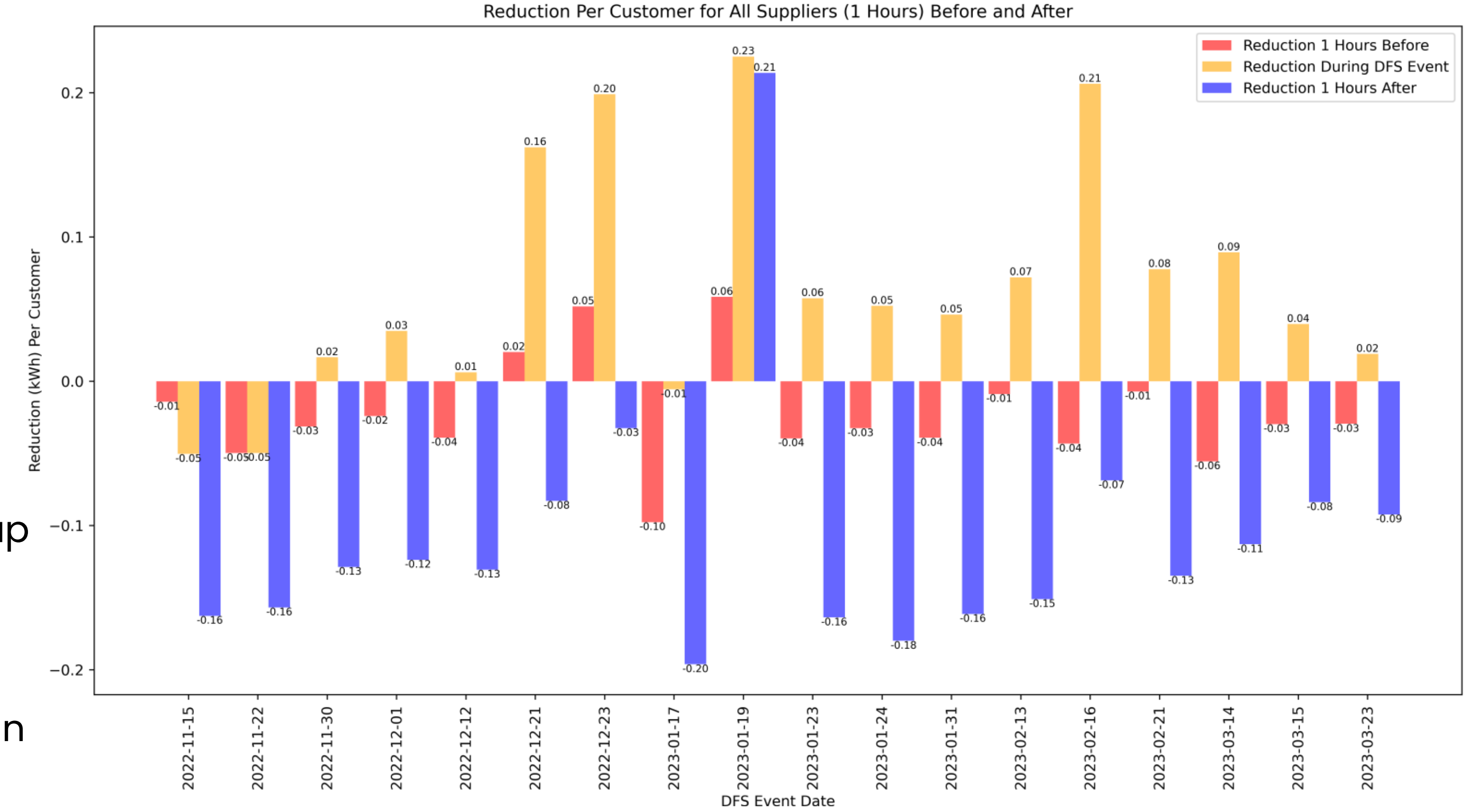


Figure 13: Reduction in the hour before and after DFS events

NESO National Energy System Operator

Observed Demand Shift

Evidence of total demand shut-off

A concern raised in the media over DFS 2022/23 was that DFS might incentivise households to turn off all power and heating for very minimal reward savings.

The DFS 2022/23 survey found limited evidence of demand shutoff with 7% of survey respondents selecting this as either their primary or secondary shifting strategy. These people were more likely to live on their own and rent their property than those who selected other strategies. These respondents were also slightly more likely to report that they were struggling financially.

Our analysis has found no evidence of total demand shutoff in our dataset and there were no instances of a zero-consumption value over the DFS events for our set of consumers.

NESO released a set of detailed communication principles for providers during DFS Y1 which underscored the importance of accompanying the service with safe and responsible information for consumers around what is appropriate to turn down as part of the service. These may have played a role in helping providers aciculate the value of the DFS without encouraging consumers to put themselves into unsafe situations to participate in the service.

Observed Demand Shift

In-day baseline adjustment and perverse incentives

In the survey of participants from DFS Y1, the social evaluation found that some respondents were familiar with the in-day-adjustment mechanism and reported using that fact to inform their shifting strategy and increase their rewards. Only 14% of survey respondents selected this as their shifting strategy (moving their consumption to the 1-4 hours before an event). Only a handful of respondents explicitly mentioned the in-day-adjustment at other points in the survey. Shifting demand to before an event can be a rational and effective way turn down during an event, rather than a strategy designed to artificially inflate a household's baseline.

There is no observable trend of leveraging the in-day-adjustment within our dataset. There is some shifting of demand to the three hours before an event but most of this demand is not concentrated at a time where it is likely to influence the in-day adjustment.

While we have found very high event-level rewards for a select few households (between £50 and £80) this does not translate to a trend across the dataset .

Understanding more about these outliers can help to understand more about how households interpret the Demand Flexibility Service and what effective demand shifting is.

Observed Demand Shift

Who are the top and bottom 1% of event-window demand turn-down?

In the survey-linked smart meter data there was considerable variation in the amount of demand reduced during the event for all groups, and considerable outliers. Table 13 explores the characteristics of these outliers to see what types of households were able to provide the most and least turn-down demand shifting.

Top 1% of turn-down (n = 7)	Bottom 1% of turn-down (n = 5)
Mostly 35-44 years old	Mostly 65-74 years old
Archetypes: G20p & G20 ES/ER/EO (electric heating) X (Solar PV) L/O (LPG/Oil)	Archetypes: G20p & G20 ES/ER/EO (electric heating)
Detached & Semi detached (No converted flats)	Mostly detached and semi-detached, but also with purpose-built flats in shared house
Not financially insecure	20% financially insecure
14% long term health condition	No one with long-term health conditions
29% 65+ years old	80% 65+ years old

Table 13: Characteristics of participants who were in the top and bottom 1% for providing demand turn-down

Observed Demand Shift

Who are the top and bottom 1% of demand shifters (turn down)?

Top 1% of turn-down (n = 7)	Bottom 1% of turn-down (n = 5)
57% have no vulnerabilities	No households with no vulnerabilities
14% have battery and solar PV	No LCTs owned
43% reported having smart controls vs 57% having none	80% reported having smart controls vs 20% having none
Very concerned with climate change	Very concerned with climate change
Local area energy discussions are common	Local area energy discussions are not common
Mostly higher managerial/professional/administrative	Mostly intermediate managerial/professional/administrative
29% turned off appliances to flex 60% moved electricity consumption 1-4hrs before the event	80% turned off appliances to flex 0% moved electricity consumption 1-4hrs before the event

Table 13 continued: Characteristics of participants who were in the top and bottom 1% for providing demand turn-down

60% of the high demand shifters targeted the baselining by moving their energy consumption to 1-4 hours before the event. This can be interpreted negatively as specifically targeting the in-day-adjustment or positively as evidence of high engagement with the DFS, as these people took the time to understand the principles of the DFS events, and successfully implemented their shifting strategy. The high demand shifters also had few vulnerabilities (57% had none) and had enablers to participation (LCTs). They are also in areas where local area energy discussions are common, which was not the case for the lower demand shifters.

Observed Demand Shift

Group differences in demand turn-down

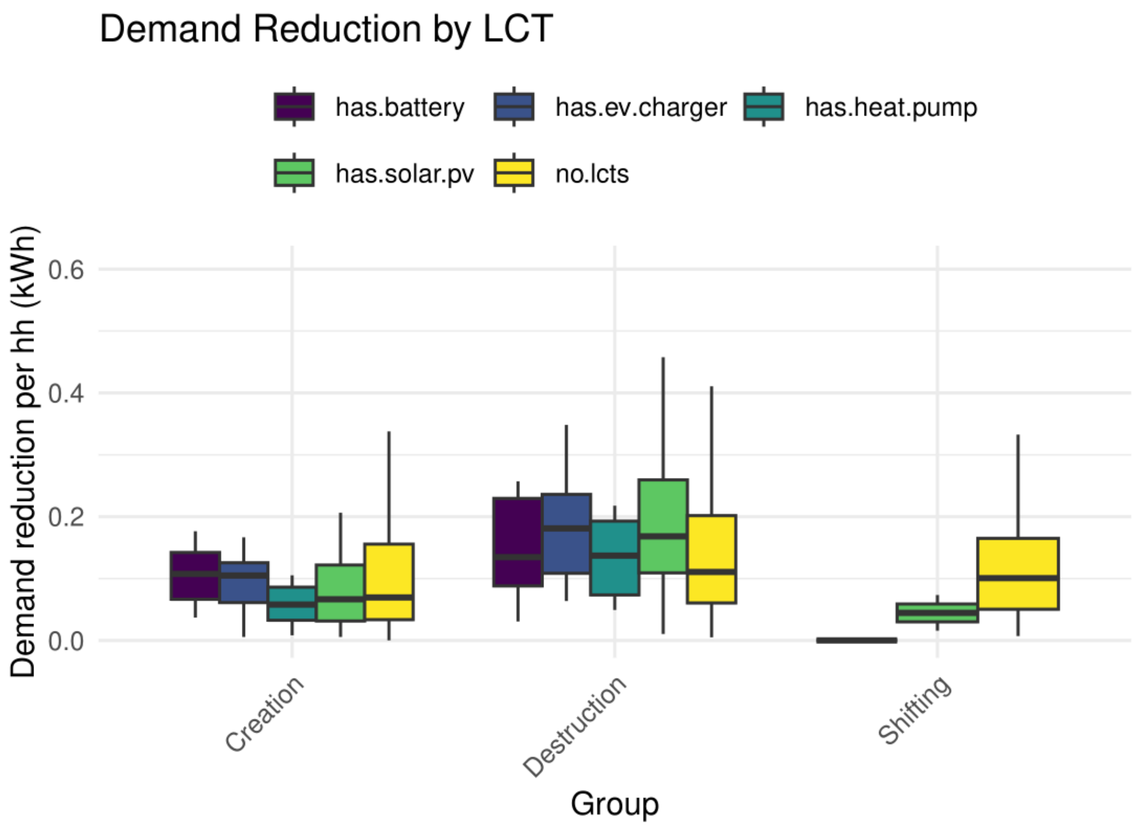


Figure 14: Demand reduction response of LCT owners by event-day shifting group (turn-up data excluded). Each box represents the interquartile range (IQR), the horizontal lines indicate the median and whiskers extending to 1.5 times the IQR.

There were no significant differences in the average amount of demand turn-down provided by households between different LCT ownership groups. This is contrary to expectations, given that it's thought that LCTs enable participation in flexibility services. There were also no differences in LCT ownership groups for demand creation.

Unexpectedly, there were also no significant differences in demand reduction between vulnerable groups, or between different tenures (see Figure 15). Both of these categories were expected to have some effect as these groups might be assumed to have some barriers to demand shifting.

The lack of group differences here may be due the large amount of variation in demand reduction throughout the data as a whole, rather than consumer behaviour.

Observed Demand Shift

Group differences in demand turn-down

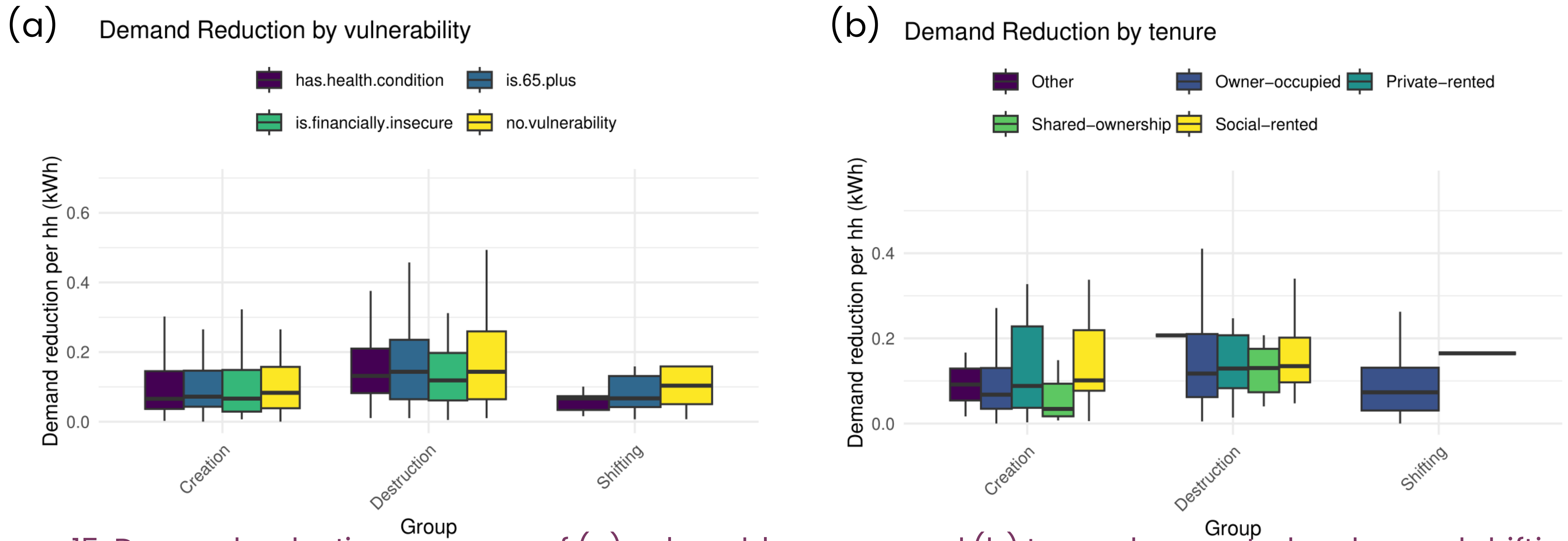
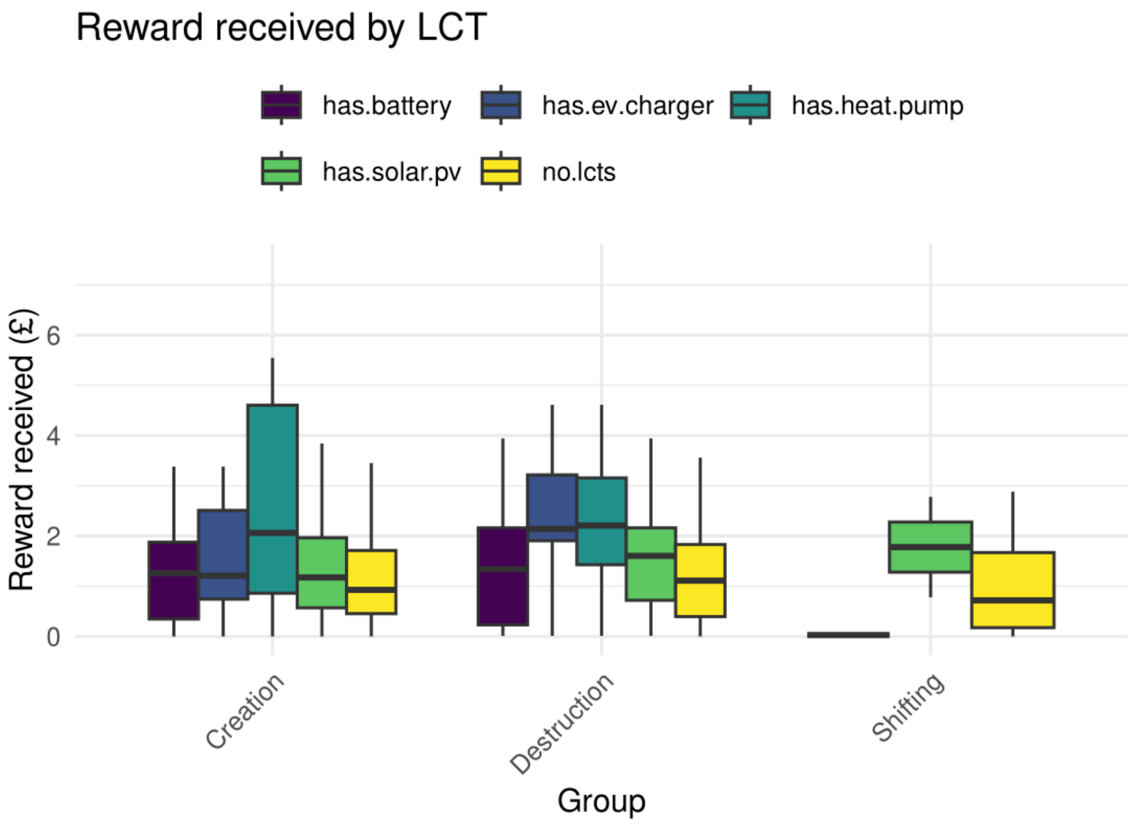


Figure 15: Demand reduction response of (a) vulnerable groups and (b) tenure by event-day demand shifting group (turn-up data excluded)

Observed Demand Shift

Group differences in average rewards earned per event



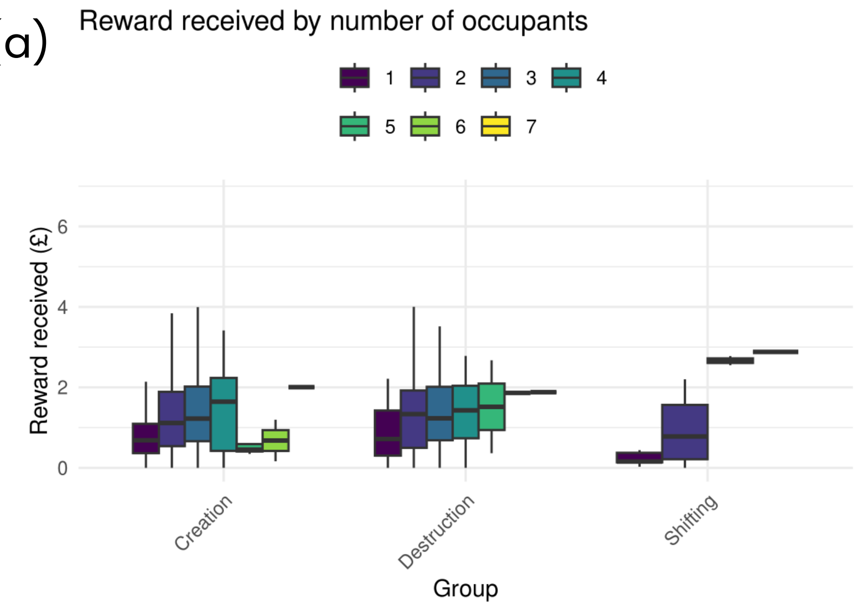
Those with an EV charger earned significantly more than those without any LCTs in both the event-day demand creation group (~£1.01 greater average rewards) and the event-day demand destruction groups (£1.14 greater average rewards). Heat pump owners had the greatest range of rewards received in both the event-day demand destruction and the creation groups. No other group differences were statistically significant.

Figure 16: Amount of reward received for LCT owners by event-day demand shifting group (turn-up group data excluded) Black horizontal lines in the boxes show the group median.

Observed Demand Shift

Group differences in average rewards earned per event

(a)



(b)

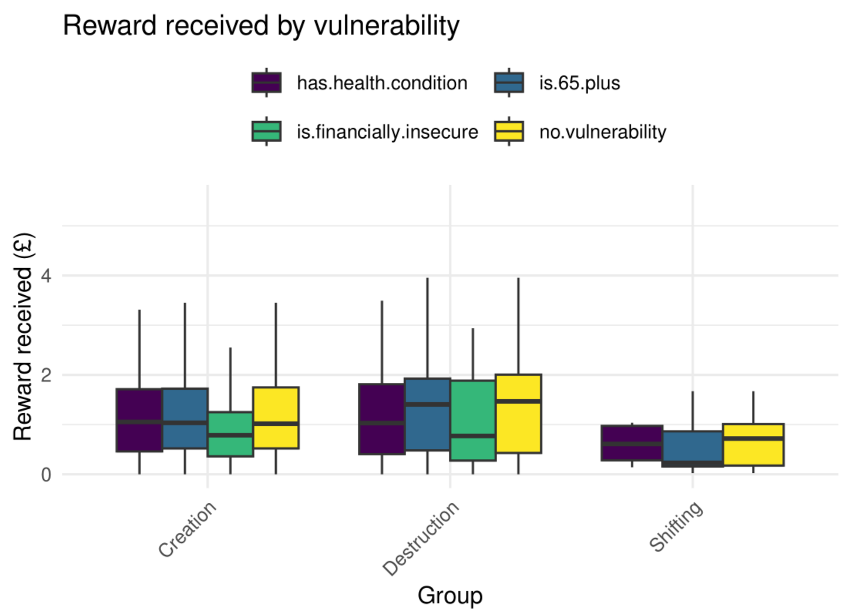


Figure 17: Amount of reward received for (a) household size and (b) vulnerable groups by event-day demand shifting group (turn-up data excluded)

In the shifting group, households with 3 to 5 occupants earned significantly more rewards than those with 1-2 occupants. In the creation group, 2 occupant households earned more than 1 occupant households. No other differences were found, however in the destruction group there appears to be a trend of increasing reward with increasing household size. No differences were found in the amount of reward received for households with different vulnerabilities.

Incentives

This section explores

- How does the level of incentive offered change the response to a DFS event?

Impact of Incentive Structure

How were consumers rewarded for their participation?

The incentives studied here vary across suppliers and events. Utilita's incentives spanned £1/kWh - £3/kWh, EON's incentives were all between £3/kWh - £4kWh. EDF is the only supplier who provided a significantly higher incentive for the two test events (i.e. £6/kWh).

The overall weighted average incentive across all consumers and events[13] was £3.25/kWh. Removing the EDF events where they offered £6/kWh, the weighted average reduces to £3.10/kWh.

This average of ~£3/kWh aligns with expectations and with the guaranteed acceptance price of £3,000/MWh offered to suppliers in test events. This price represents a maximum threshold price for suppliers bidding into the service over winter 2022/23. For the 20 test events any supplier bid priced at £3,000/MWh or lower, was guaranteed to be accepted.

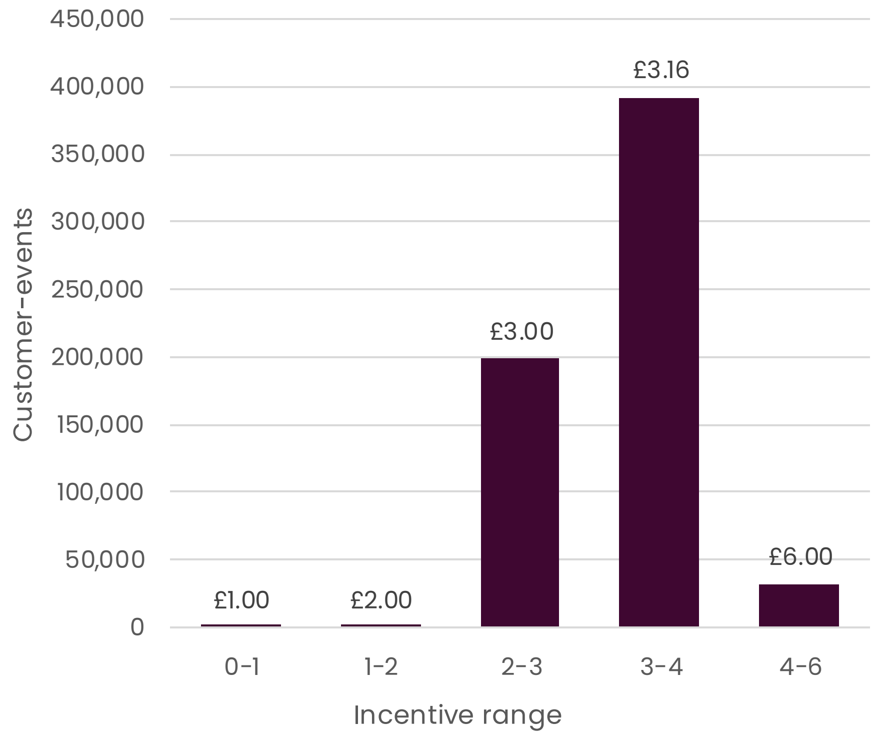


Figure 18: Incentives across events

13 The number of consumers presented consists of DFS incentives for participants over multiple events. e.g. EON ran 12 events, of which 2 of them had an incentive of £3/kWh; across these 2 events, the average participation rate was 41% (i.e. an average of 47K consumers participating in each of two events or a total of 93K customer-events over both events)

Impact of Incentive Structure

How were consumers rewarded for their participation?

The data from our sample shows average reward per consumer per event of £1.19 and a maximum reward of £83 for a single event. The majority of consumers (61%) received a reward between £0-£1, with 82% receiving a max reward of £2.

As shown in Figure 19 the total rewards received have a long tail with very few outliers (~1%) receiving over £8 in rewards for a single event.

This average figure is broadly consistent with other reporting. EDF reported an average reward of £1.35 per event and Octopus reported a higher reward of 90p per half hour of participation in DFS.

When surveying participants of DFS 2022-23, the social evaluation of DFS Y1 found that respondents self-reported similar levels of rewards. 61% of respondents selected that they had received less than £5 in rewards across all events. Only 4% received above £25 in rewards.

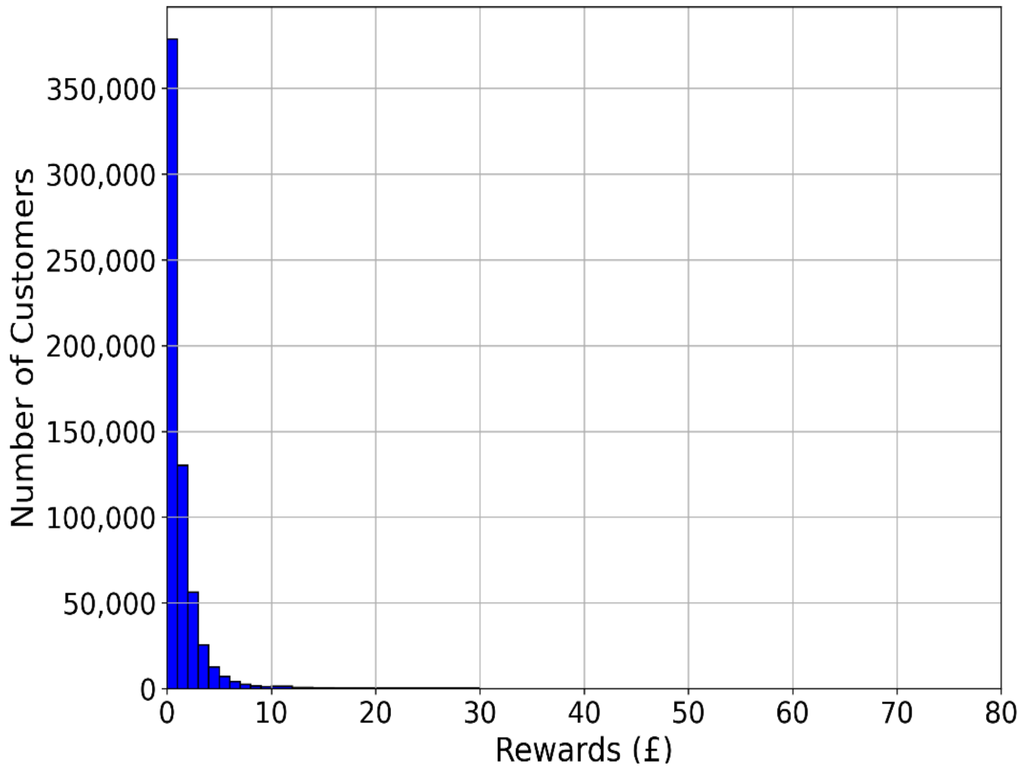


Figure 19: Single-event reward across DFS Y1

Impact of Incentive Structure

Incentives and participation in DFS

Figure 20 to the right shows the share of eligible consumers in our dataset who opted-into and those who opted-in and reduced demand (participated) in each DFS event at different incentive levels. As most incentives were clustered around £3.00 per kWh we are not able to draw many firm conclusions on the impact of incentives on flexibility delivery through the DFS.

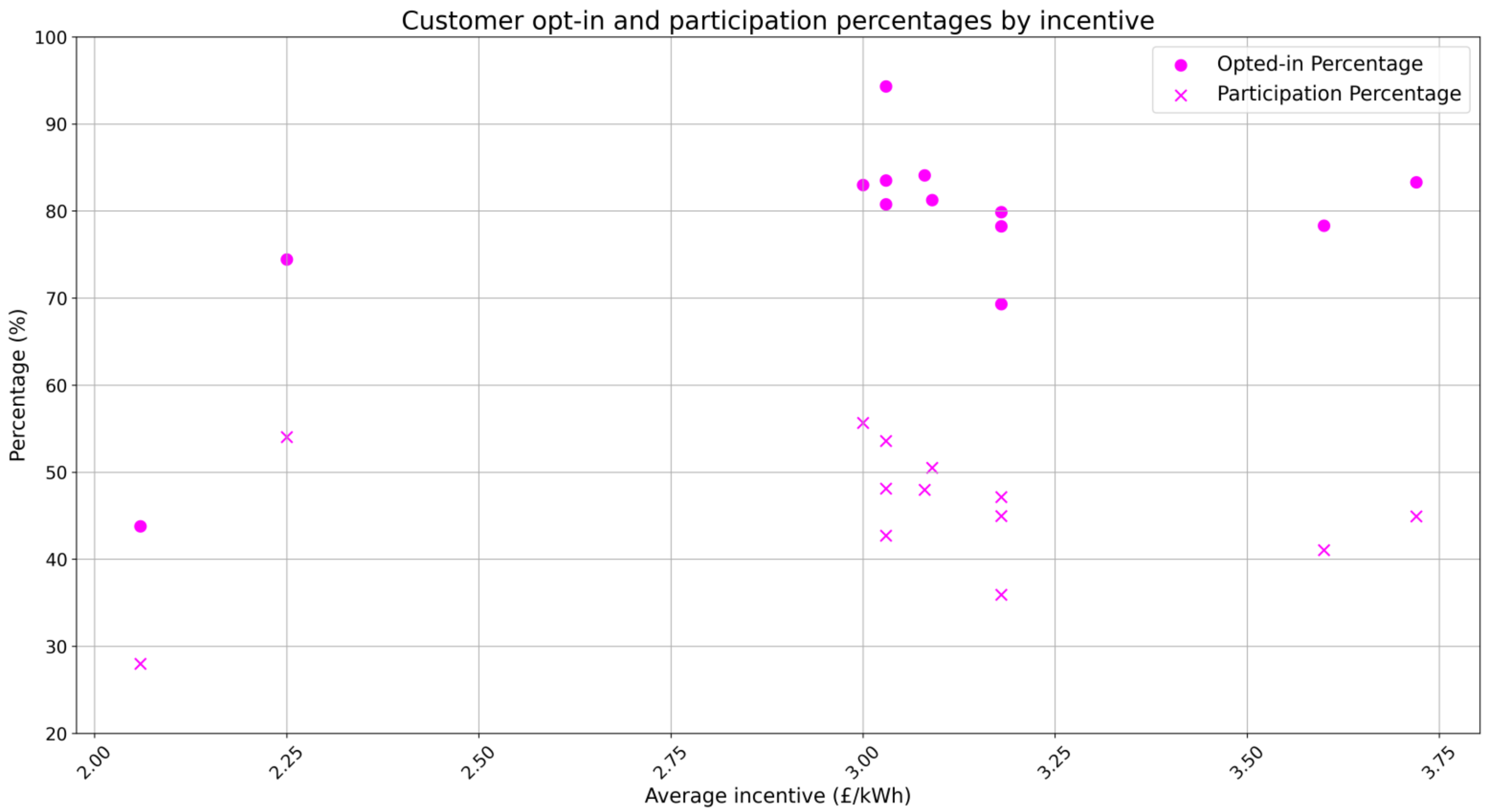


Figure 20: Consumer opt-ins and participation by incentive

NESO National Energy System Operator

Impact of Incentive Structure

Impact of incentive offered per kWh on trial experiences

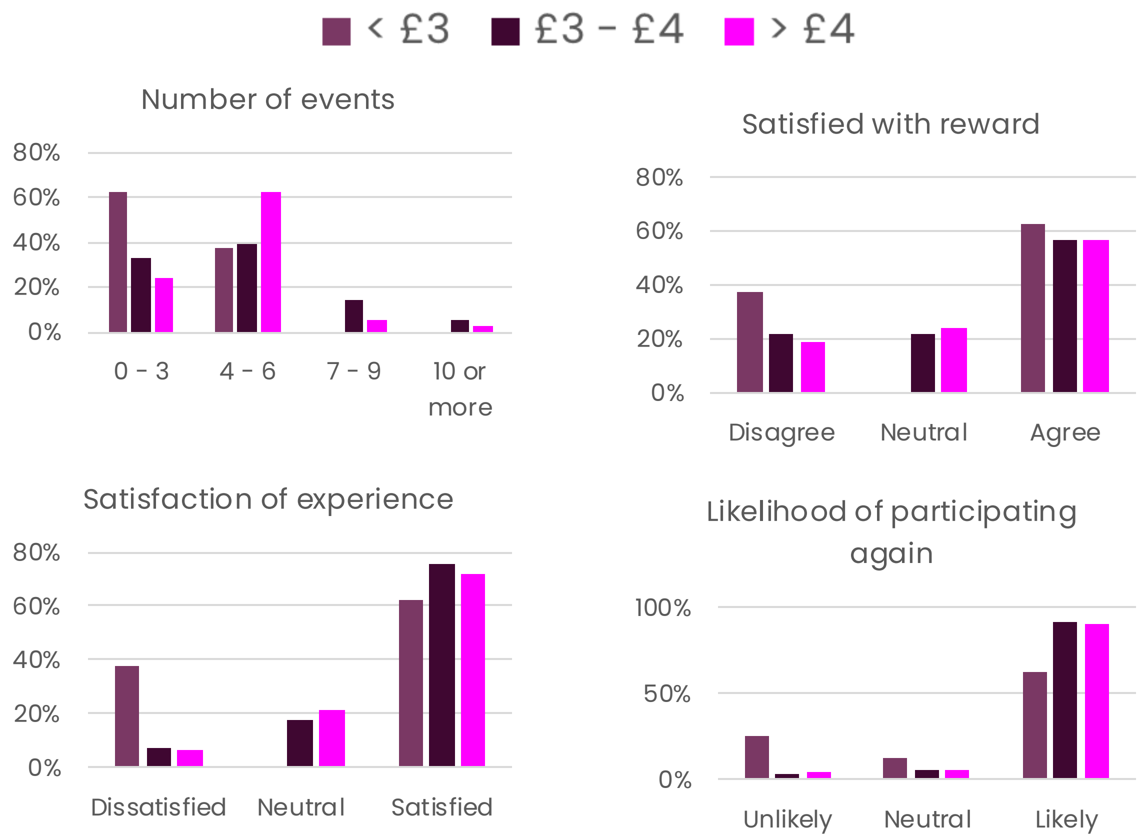


Figure 21: Consumer experiences and perceptions broken down by incentive reward band. (Event groupings are taken from the evaluation survey).

Those that received a low incentive (< £3 per kWh) had the high prevalence of those that only took part in 0-3 events. Those that received high incentives (> £4 per kWh) had highest prevalence in the 4-6 events group.

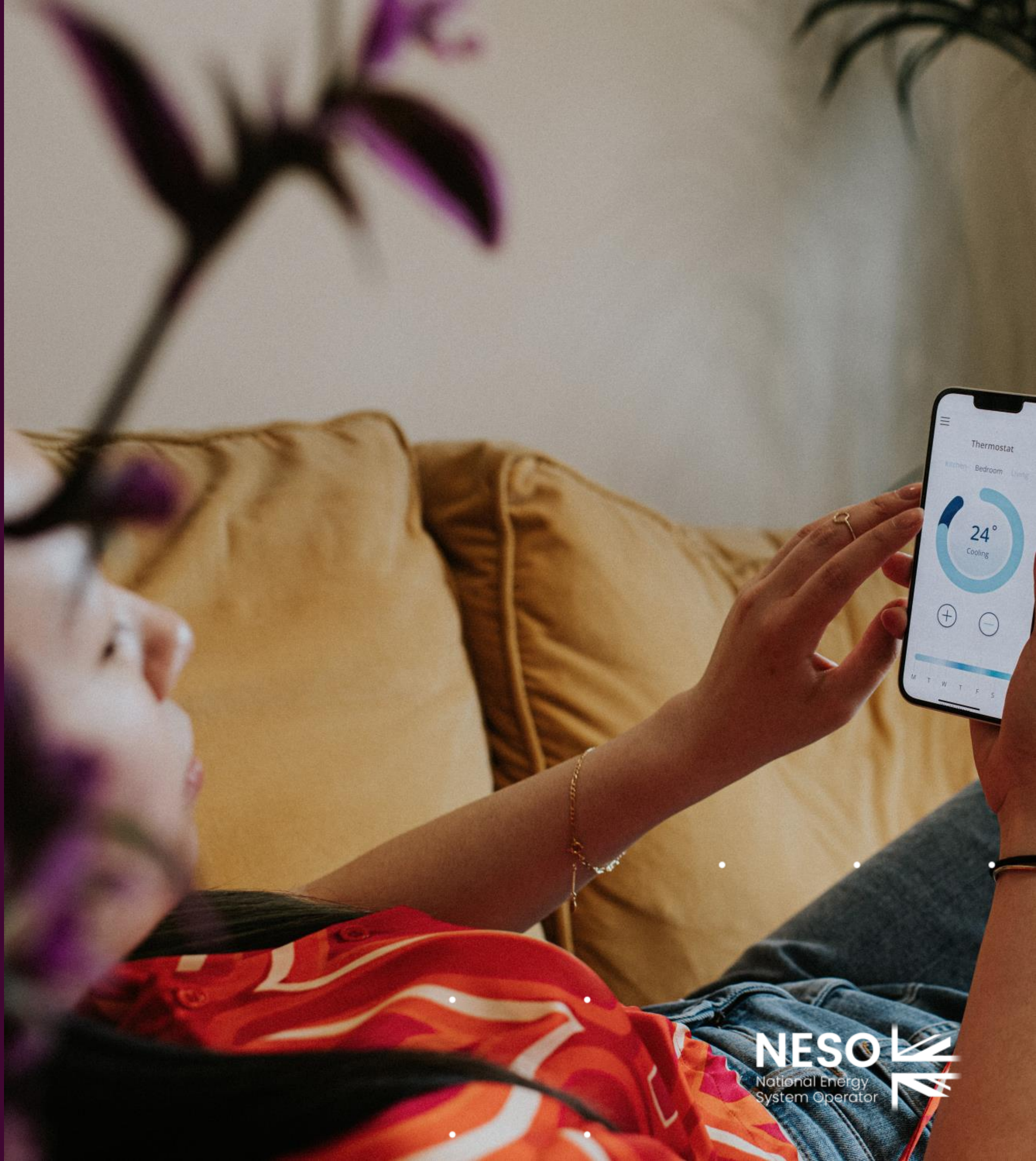
Those that received the lowest incentive reported the highest level of dissatisfaction with their reward, but also slightly higher levels of satisfaction with rewards, compared to the medium to high incentive groups. Nearly 40% of the low-incentive group did however report to be dissatisfied with the overall experience (compared to just 7% for the medium and high group), and were least likely to report that they would participate again.

There was no significant differences observed in the demand shifting response of different groups to different incentives. This was likely because there was not enough data for each incentive level to do a robust analysis, and there was an unequal spread of incentives.

Event Timing

This section explores

- How does the placement of an event in the winter change the response?
- Is there some level of observable participation fatigue?



Event Timing

How event timing has influenced participation

To check for any evidence of participation fatigue or learning over the winter, Figure 22 plots the share of consumers who have opted-in and the share of consumers who have reduced demand for each event over time. For this dataset, opt-in percentages generally hover above ~70% across all the events in the timeseries and show a slight correlation of increasing opt-ins over time.

Participation values generally are between ~40% and 60%, again showing a slight correlation of increasing participation over time.

There is no observed correlation between participation and the proximity to previous DFS events across our dataset.

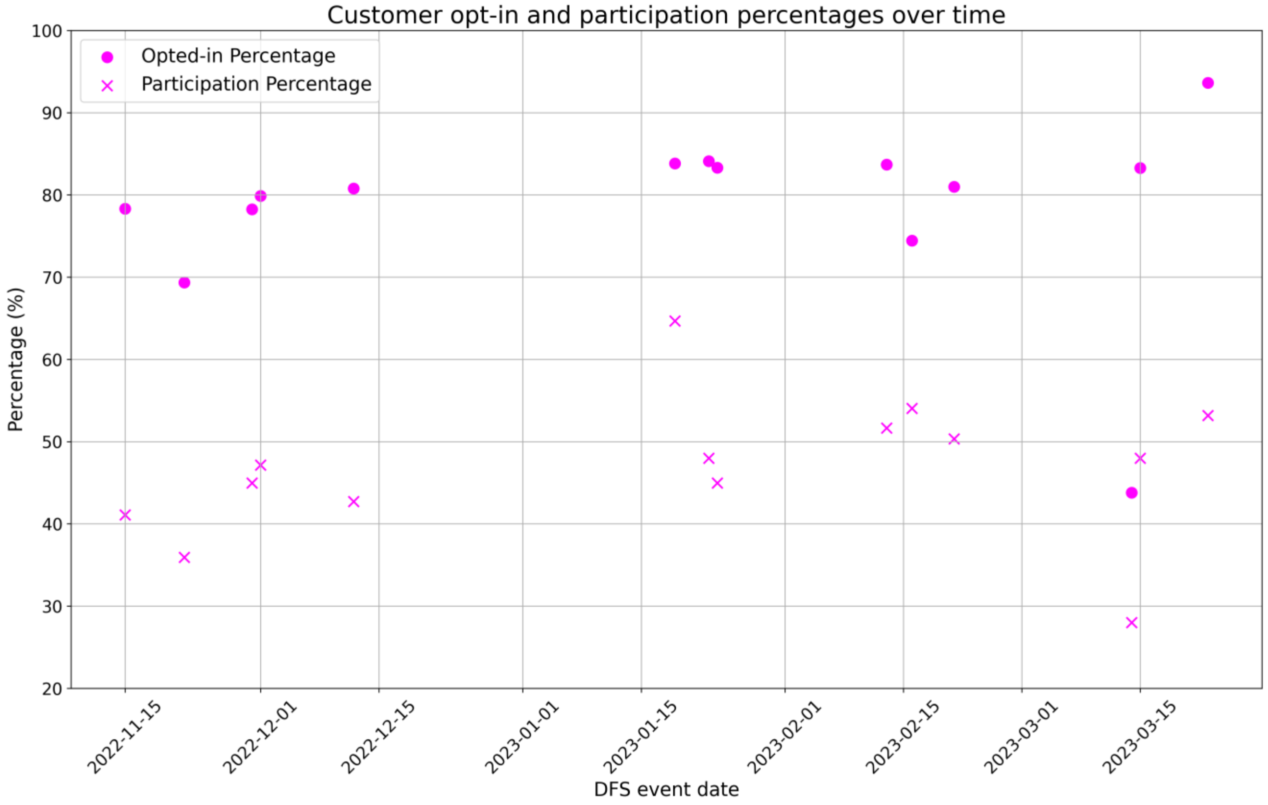


Figure 22: Opt-ins and participation over time

Event Timing

How did timing impact the delivery of flexibility

Figure 23 shows the average reduction per household for each event. There is no clear pattern shown across all consumers apart from the correction to always shifting demand downward after the first two events (apart from the outlier on 17 January 2023).

We found no relationship between the proximity of events and response, again showing no evidence of participation fatigue in the data.

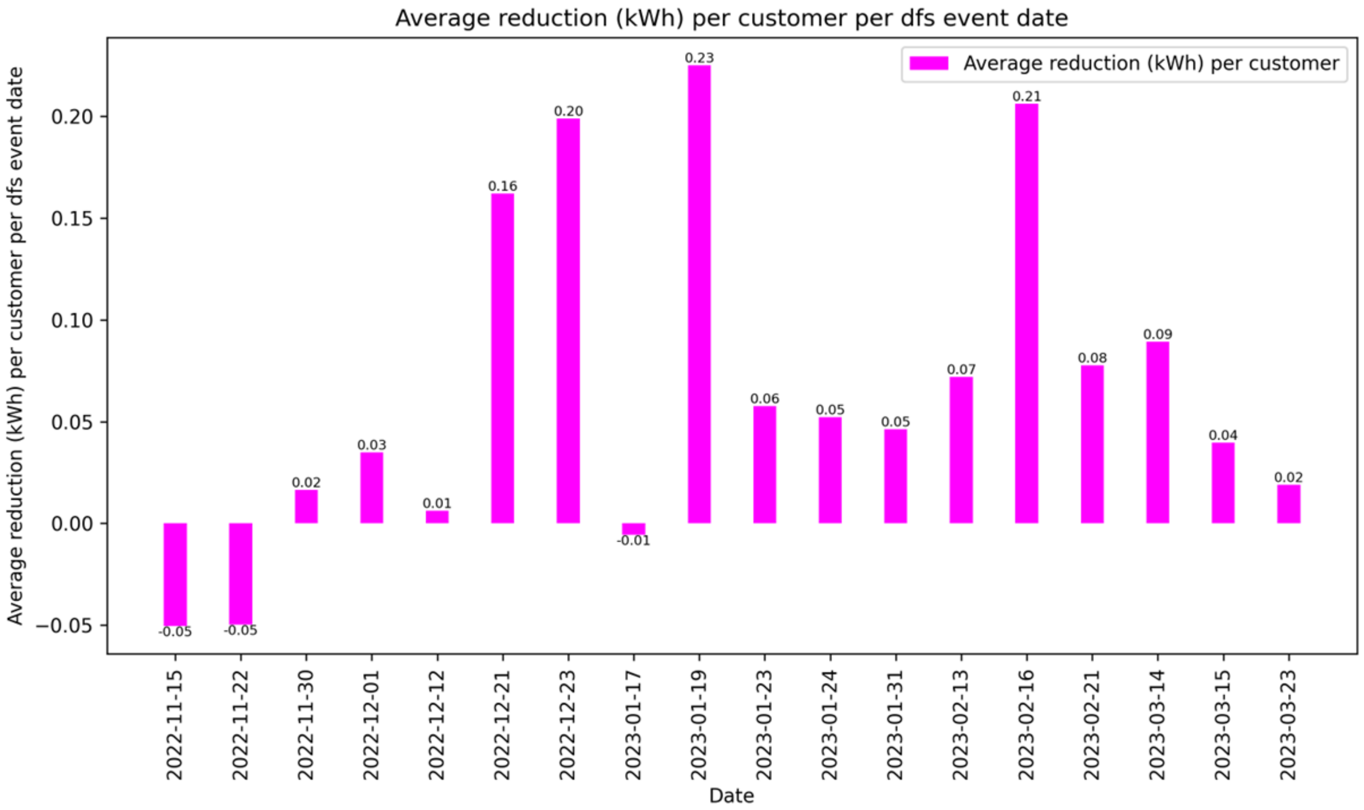


Figure 23: Average reduction by DFS event date

NESO National Energy System Operator

Perceived vs actual outcomes

This section explores

- How do participant's perceived experiences of participation in the DFS compare to their actual outcomes
- This will highlight any mismatches between participants issues in participation and their performance, showing how well demand flexibility principles are understood.

Perceived vs actual outcomes

Did ease of participation correlate with shifting performance?

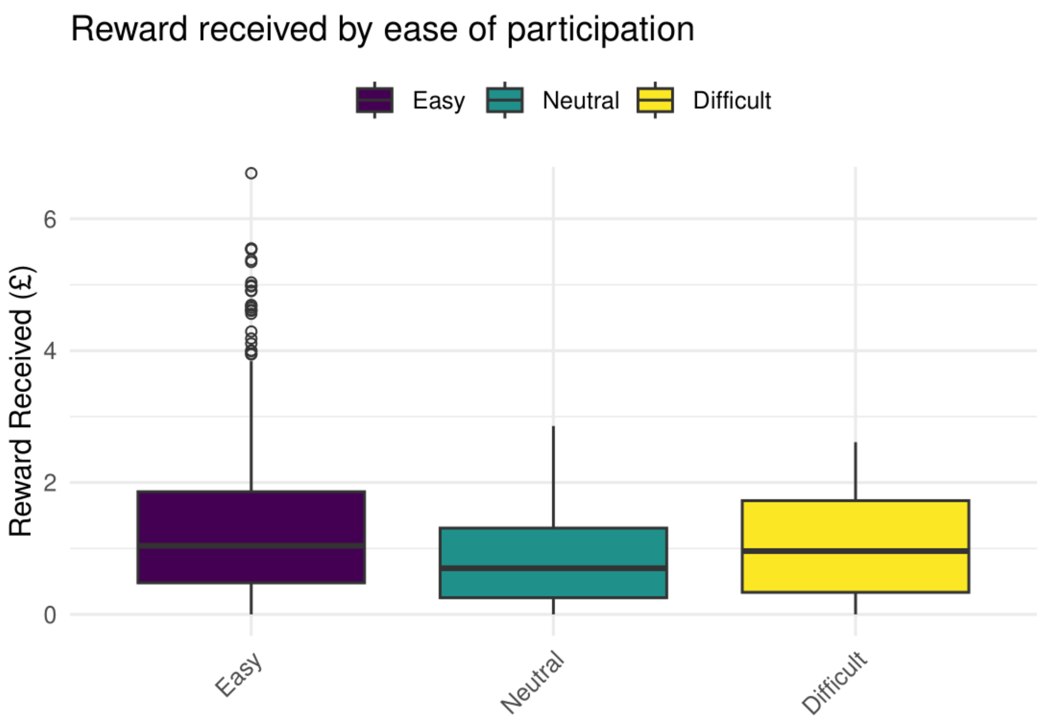


Figure 24: Reward received by how easy participants found shifting their demand, Black horizontal lines represent the median.

Participants that reported finding it easy to shift their demand had a significantly higher average amount of reward received compared to those that reported neutrally, but not significantly different to those reported it to be difficult.

However, the highest reward earners – the outliers in Fig 24 - were all in the 'Easy' group for ease of demand shifting, where their rewards ranged from £4 to £7, compared to no more than £3 and £2.50 for the 'Neutral' and 'Difficult' groups.

Perceived vs actual outcomes

Did ease of participation correlate with shifting performance?

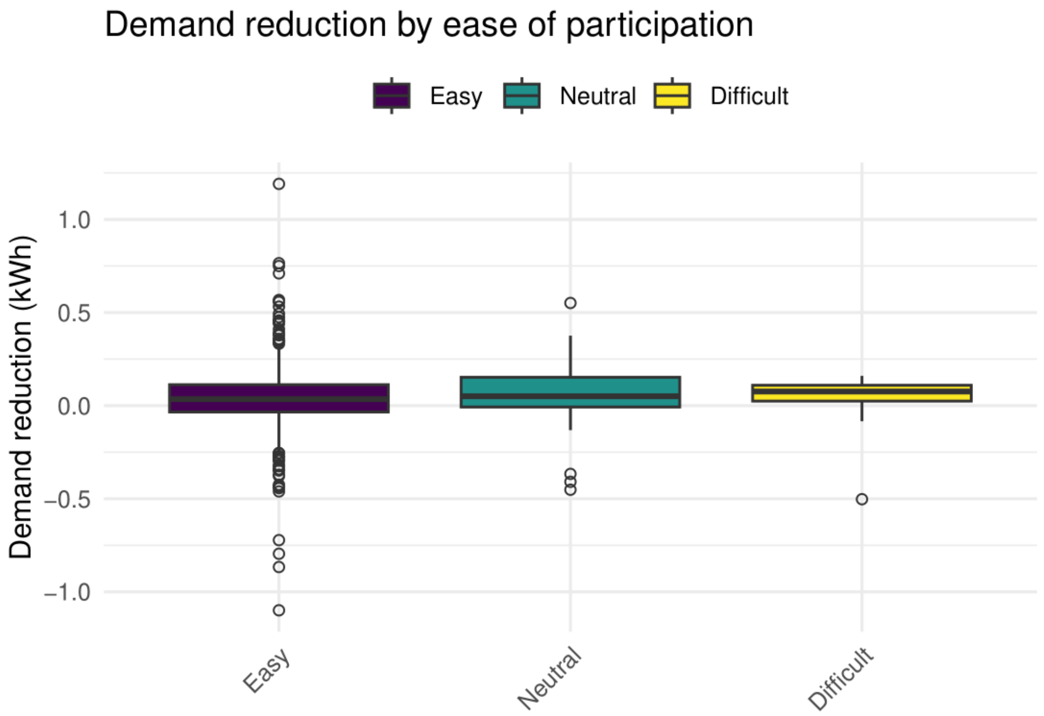


Figure 25: Demand reduction by how easy participants found shifting their demand

Similarly, looking at the range of the amount of demand reduction produced per household, we see that those that found demand shifting easier had the highest amount of turn-down (evidenced by the outliers). However, this group also had the highest amount of turn up.

We would expect those that find demand reduction easy would actively reduce their demand during events and not show a 'turn up' signature. However, as shown in page 34, generally positive experiences of the DFS are spread across households despite levels of active participation. This provides more evidence that the turn up signature in the smart meter data, should not be interpreted as consumer actively increasing their demand, but that the baseline approach obscures some consumer behaviour.

Perceived vs actual outcomes

Did the self-reported reward received correlate with the actual reward amount they received?

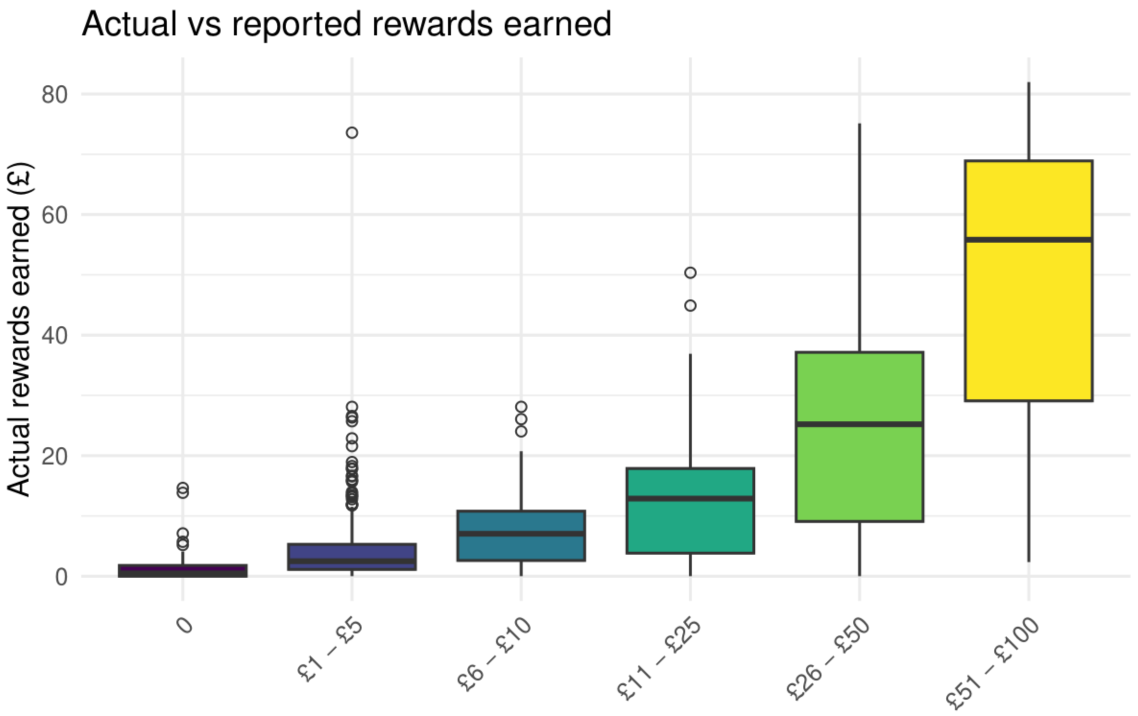


Figure 26: Total reward actually received with the self-reported reward received from the evaluation survey

In general, there was good agreement between the actual amount of reward that was earned by DFS participants, and the self-reported amount of reward earned by the participants.

However, there was still significant variation in the amount of actual reward received and the self-reported reward bandings from the evaluation survey.

This suggests an overall good understanding of the reward structure of the DFS, but that there is still room for improvement.

NESO National Energy System Operator

Conclusions

Summarising our findings in the smart meter data analysis

Our key findings from the smart meter analysis for DFS Y1 show that consumers were generally able to reduce consumption during the events, despite some evidence of increased consumption outside of the window leading to a secondary peak. However, challenges with in-day baseline adjustments can make it difficult to accurately account for the true extent of demand shifting behaviour.

Response to the DFS: Across the DFS events we saw some evidence of demand creation but on the whole, there is a clearly observed reduction in consumption during DFS events. The in-day-adjustment was also shown to typically downshift the baseline to a level where intention to shift demand during an event could result in either (i) a lower magnitude reduction or possibly (ii) a relative increase in demand depending on the level of baseline shifting observed.

In the survey-linked dataset, there is little difference in trial experiences (ease of participation, likelihood of participation), effort (number of events, shifting strategy) and household characteristics between households that showed turn-up signatures and those that showed turn-down signatures.

Impact of the in-day-adjustment: As the downshifting of consumer baselines must have impacted rewards received, we would expect this to result in negative consumer experiences. However, although it is a small sample in the survey-linked dataset, the group that appear to have encountered these baseline issues still reported that they were extremely likely to take part in the DFS again.

Households that opted-in but did not appear to participate also report positive experiences. A majority reported finding it very easy to participate and a majority said they were very likely to participate again. This suggests that some households participate with a ‘low effort, low reward’ approach in mind. Although they did not appear to shift in many events, they were happy to opt in, and were happy to support research around the DFS by providing their data for this analysis. This approach may shed some light on why only 50% of respondents that received no financial reward at all expressed dissatisfaction in the original feedback survey.

NESO National Energy System Operator

Conclusions

Summarising our findings in the smart meter data analysis

Observed demand shift: We found significant evidence of demand creation outside of the event window leading to a secondary peak after the event window. Some of this is likely due to the downshifting of the baseline as discussed above.

In the linked survey-smart meter data, we found very little evidence of between-group differences in the amount of demand shifted due to very high variation in the data, skewed by outliers. However, those with EV chargers earned significantly more rewards than those without, and vulnerable households with no LCTs were more likely to be in the bottom 1% of demand turn-down compared to other household types. Households that shifted their demand into the 4-hour window before the DFS were more likely to be in the top 1% of demand turn down indicating high engagement levels from some households and suggesting they made some effort to learn about the DFS and plan their energy use accordingly.

Incentives: The spread of incentives in our dataset was too limited to establish a correlation between the incentive offered and differential responses of different consumer groups to the event. However, those that received a low incentive of less than £3 participated in fewer events, were less satisfied with their overall experience and were less likely to want to participate in future events.

Event timing: We found little evidence of participation fatigue across the dataset.

Perceived vs actual outcomes : There was good alignment between the reported and the actual amount of rewards received.

Future work

Additional analysis for DFS Y2 and beyond

Table 14 shows potential research questions to further this analysis for the next winter of the DFS:

Research Area	Research Questions
Baseline	What impact does removing the in-day adjustment have on rewards and observed demand response? Do other baselining methods better represent consumer behaviour? Do baseline methods impact different consumer groups differently?
Consumer Archetypes	How can the data be split into reasonable archetypes using demographic indicators and/or consumption data? Can machine learning be applied to the dataset to group consumers using clustering algorithms? Can we deduce (or leverage data on) LCT ownership to better understand demand response during DFS events? Can we leverage demographic or consumer-level data (e.g. building type, age, income, etc.) to better understand the response delivered?
Location	Do we see different archetypes and/or usage patterns by location?
Weather	How does weather impact the response observed in the dataset? Do colder areas of GB show a consistently different response to events than warmer areas? What are favourable conditions for demand response delivered through the DFS? What are unfavourable conditions?

Table 14: Future research into the DFS

NESO National Energy System Operator

Future work

Additional analysis for DFS Y2 and beyond (continued)

Table 14 shows further potential research questions to further this analysis for the next winter of the DFS:

Research Area	Research Questions
Control group	How does our sample set compare to control data of those who did not opt-into the DFS or who were not invited to the DFS? Are baseline profiles different between the control group and those who opted-into DFS events? Is our sample representative and how scalable are our findings?
Supplier forecasting	How does the response compare to supplier forecasts? How doe suppliers forecast demand response during events? How might this methodology be improved? What are the key variables needed for robust forecasts of demand response?
Other response-based observations	Does time of day affect response? How does timing of notification affect response?
Consumer behaviour	Do event days raise energy salience and lead to a general reduction in demand / destruction on the day? This could be inferred from the 'actual consumption' plots in the appendix, but is masked by the baselining method. Does event participation create a form of 'rebound' which leads to overall increase in consumption / creation? Evidence here suggests so but assumed to be an artefact of the baselining method and worth testing. How can more effective demand shifting be achieved by households and by flexibility services?

Table 14: Future research into the DFS (continued)

NESO National Energy System Operator

Appendix 1

High level cleaning methodology

Consumers with incorrect meter readings

- Removes consumers with either too little or too many data points based on the expected number of meter readings (based on the minimum and maximum timestamp of their demand data).

Consumers with very 'peaky' data

- Removes consumers who have max consumption values which are significantly higher than the rest of the population (i.e. above the 95th percentile).

Consumers with outlier levels of average demand

- Removes consumers who have either significantly higher or lower average consumption values (i.e. below the 5th percentile and above the 95th percentile).

Consumers with outlier levels of maximum daily total consumption

- Removes consumers based on outliers in the overall distribution of max daily consumption (capped at 150 kWh max daily total consumption).

Consumers with outlier average daily total consumption

- Removes consumers based on outliers in the overall distribution of average daily consumption (capped at 25 kWh average daily total consumption).

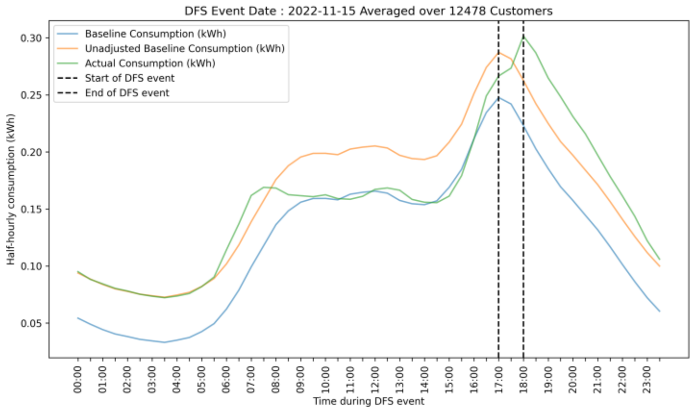
Consumers with extreme half-hourly values

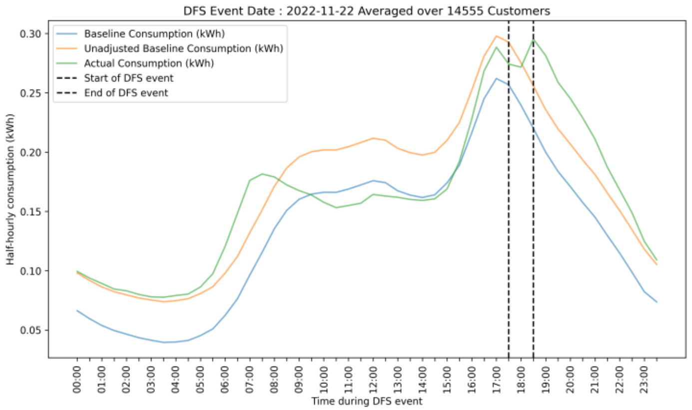
- Removes consumers based on a physical upper limit of 11.5 kWh applied in any half-hour time bin.

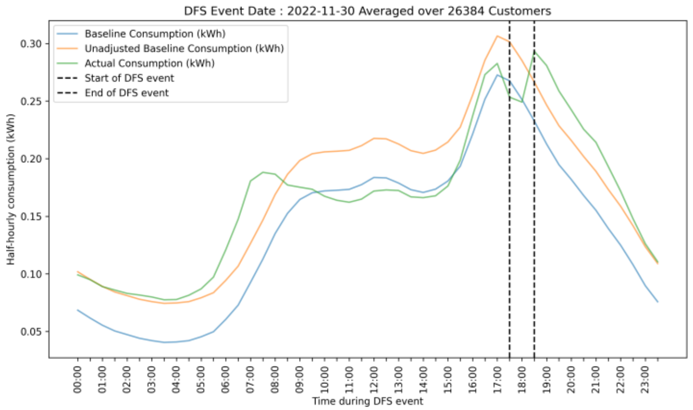
Appendix 2

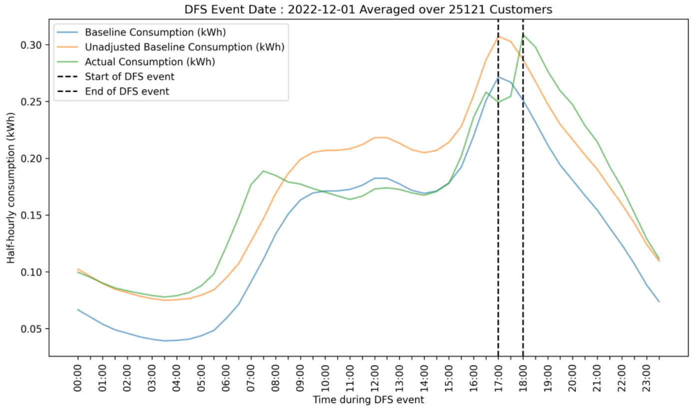
Profiles for all DFS events studied

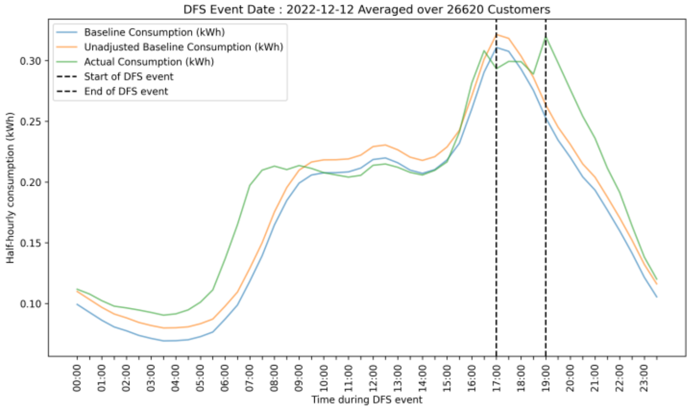
N.B. each plotted point signifies the kWh consumption in the following half-hour period - e.g. a 0.20 kWh value noted at 17:30 denotes that an average of 0.20 kWh was used by each consumer across all consumers in the given event between 17:30 – 18:00.

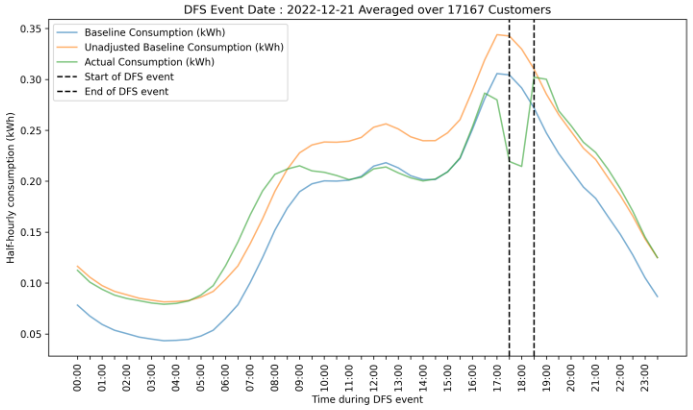










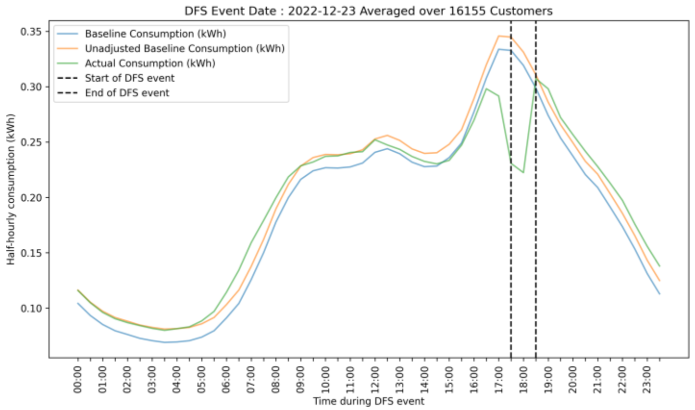


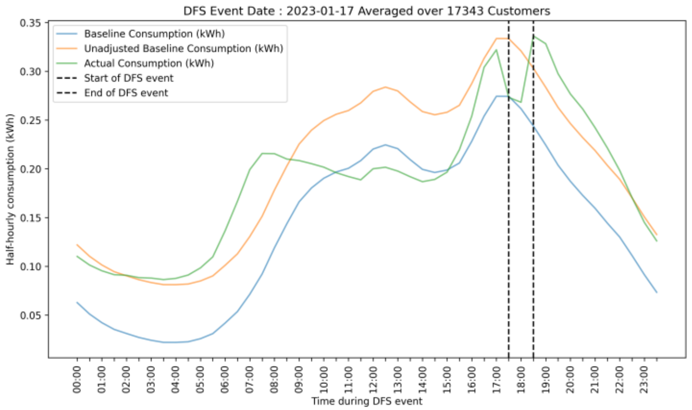
NESO National Energy System Operator

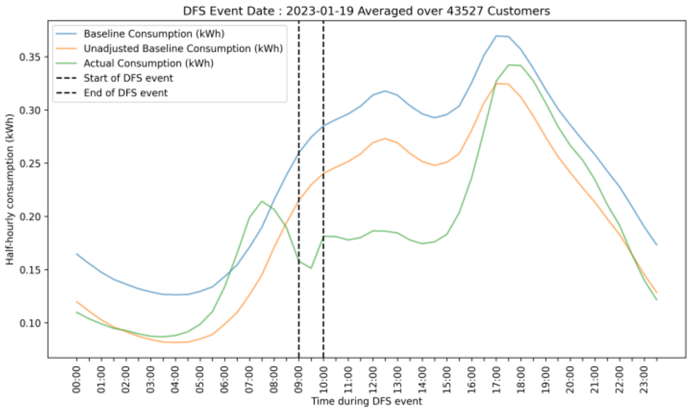
Appendix 2

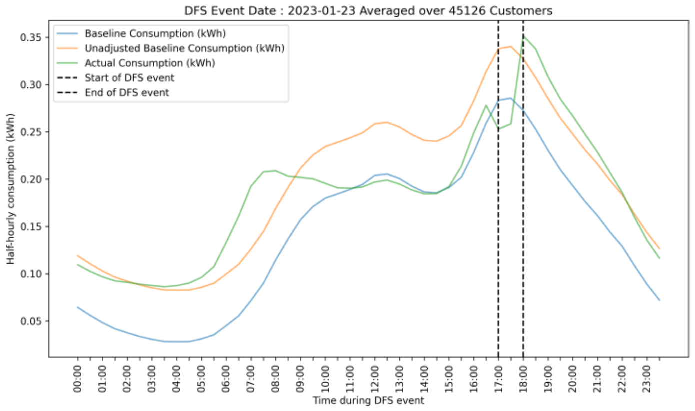
Profiles for all DFS events studied

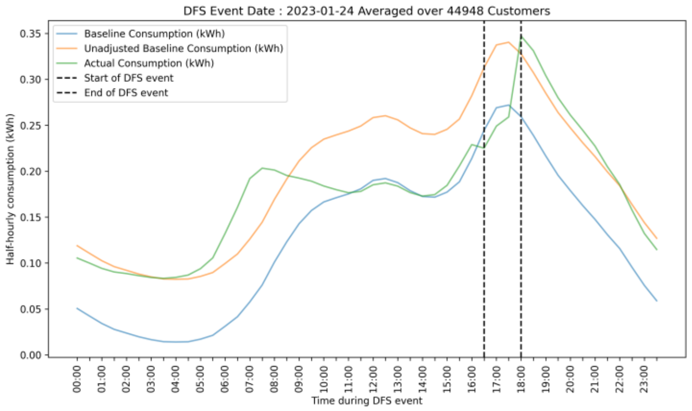
N.B. each plotted point signifies the kWh consumption in the following half-hour period - e.g. a 0.20 kWh value noted at 17:30 denotes that an average of 0.20 kWh was used by each consumer across all consumers in the given event between 17:30 – 18:00.

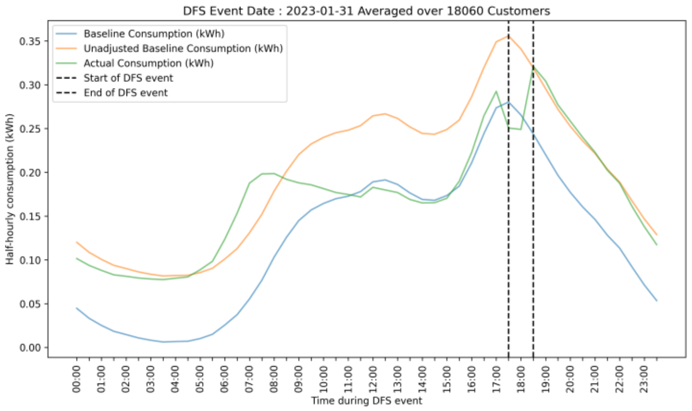










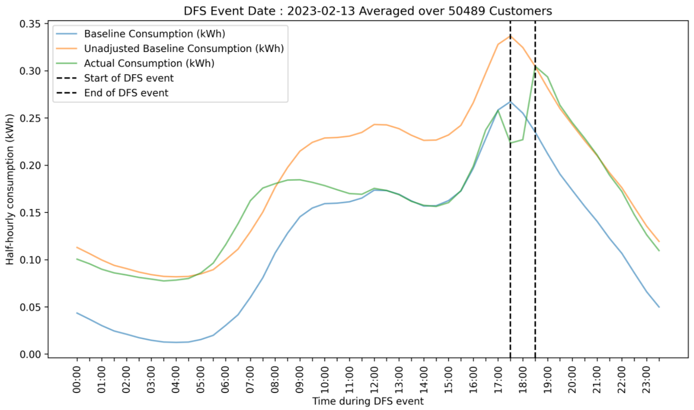


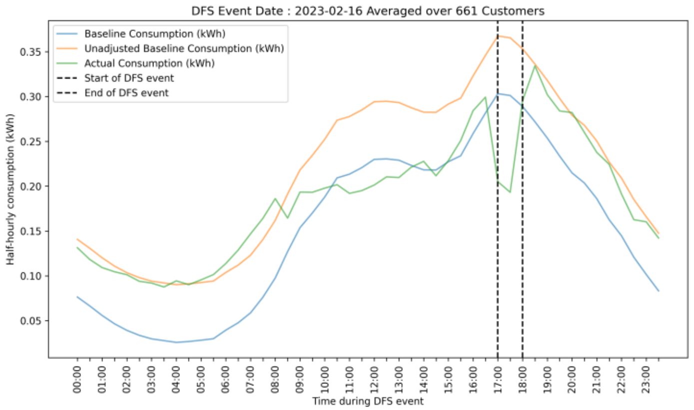
NESO
National Energy System Operator

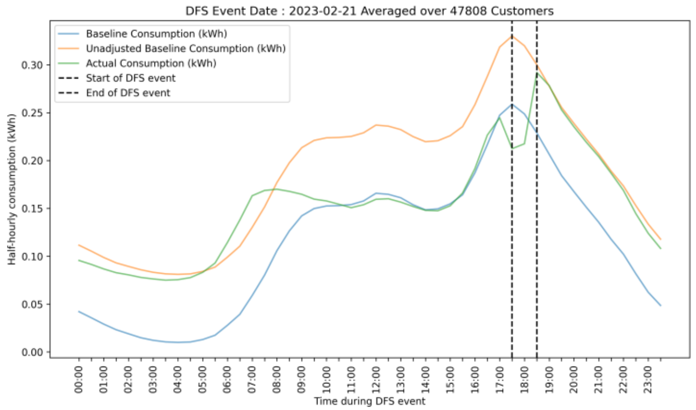
Appendix 2

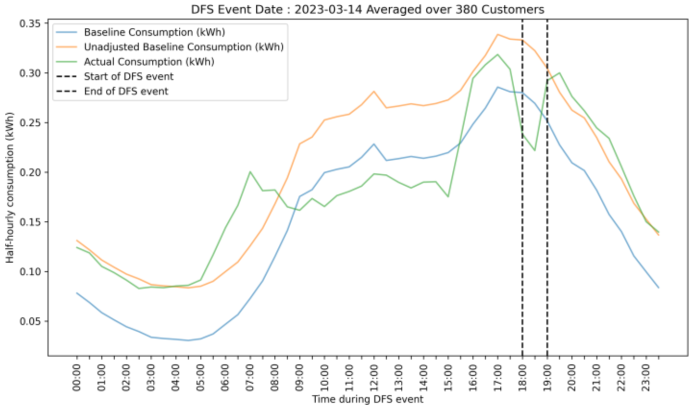
Profiles for all DFS events studied

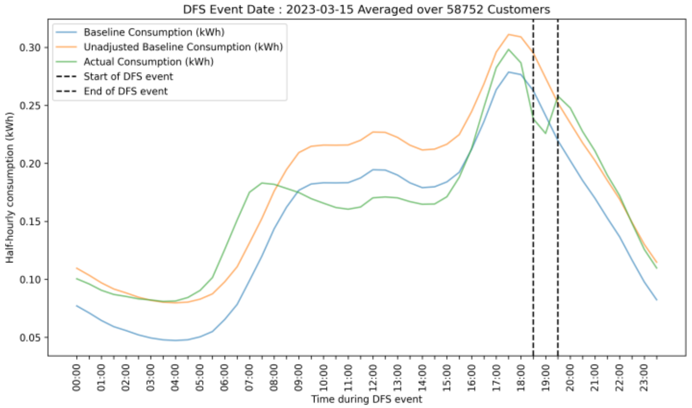
N.B. each plotted point signifies the kWh consumption in the following half-hour period - e.g. a 0.20 kWh value noted at 17:30 denotes that an average of 0.20 kWh was used by each consumer across all consumers in the given event between 17:30 – 18:00.

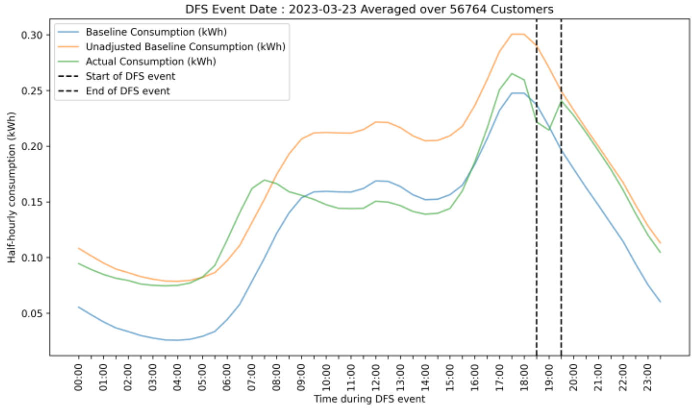












NESO
National Energy System Operator

Appendix 3

Key definitions

Absolute peak - The point in the day with the highest consumption.

Absolute peak consumption – The consumption value at the time of the absolute peak.

Adjusted baseline – This is the final baseline used to measure a consumer's demand reduction. This is an adjusted version of the adjusted baseline to account for the impacts of weather on day-to-day demand patterns. This "in-day" adjustment is based on the difference between their usage in the period from four hours to one hour before the delivery period, and the unadjusted baseline.

Unadjusted baseline - The end consumer's average usage over the previous ten eligible working days which is used as the first step in calculating a consumer's adjusted baseline.

Secondary peak - The point (i.e. half-hour time stamp) in the day where we see the greatest positive difference between the day's actual consumption and the adjusted baseline.

Secondary peak consumption - The consumption value at the time of the secondary peak.

NESO
National Energy
System Operator