The welfare effects of demanding short-term energy flexibility
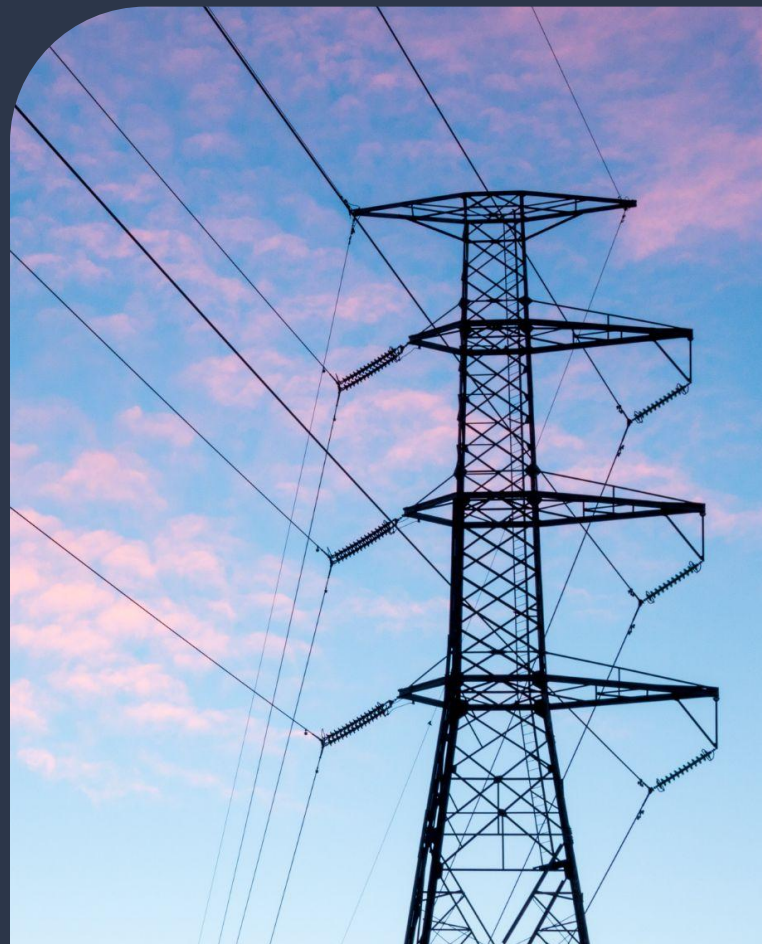
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Centre for Net Zero
Powered by **Octopus Energy**

THE DEMAND FLEXIBILITY SERVICE
ASKED CUSTOMERS TO TURN DOWN DURING SHORT 1-2 HOUR PERIODS

From November 2022 - March 2023, National Grid ESO rolled out its Demand Flexibility Service (DFS)

Households were paid a fixed incentive which varied between events (from £2/kWh to £4/kWh of electricity, five to ten times the unit price of energy).

31 utility providers participated. Octopus Energy was the largest in terms of number of customers involved and total demand reduced.

Octopus called its events **'Saving Sessions'**. We focus on the 13 DFS events that Octopus Energy participated in.

Two stages of selection: sign-up, and opt-in

Sign-up	Opt-in
Octopus invited 1.4 million of its smart meter customers to sign-up. 700k did so – i.e., 400k before the first Session in November, and the rest over the course of the winter.	91% of Octopus Energy households who signed up to Saving Sessions opted in to reduce demand in at least one event. 55% opted in for at least six sessions. 7% for all 13 sessions.

With **Saving Sessions, you could earn up to £100 by using less electricity at peak times** this Winter - and get the chance to win mystery prizes too.

Sign up, and from November to March you'll be invited to join at least twelve 1 – 4 hour sessions.

You'll earn rewards called OctoPoints that can be redeemed **for £££'s on your account**, prizes or donations – you'll earn them for every unit of power you **don't** use during Saving Sessions, compared to your normal use.

Are you in?

Sign up for Saving Sessions

You'll earn 1800 OctoPoints – **that's £2.25 worth** – per kilowatt hour for any electricity you cut down between 5:30 PM and 6:30 PM on 30th November.

Opt in now on your dashboard to save power and earn rewards in this Session. You'll go into a draw to win an extra 400,000 OctoPoints – that's £500 worth! – just for opting in.

Opt in in two clicks

Important: **you need to opt in on your Saving Sessions dashboard before each Session starts** if you want to earn rewards.

Research question 1: How much did customers reduce their demand?

Demand reduction is the difference between actual consumption and the consumption that would have happened had they not.

GB energy industry uses a modified pre-post calculation ('P376'). We worried about potential biases.

Using difference-in-differences strategies, we aimed to estimate the causal impact of Saving Sessions on energy demand.

Our difference-in-differences strategies rely on three counterfactual groups

Early sign-up versus never signed up

1) 332k customers who signed up before first event 15/11/2022 **versus** 654k invited customers who never signed up

Early sign-up versus later signed up

2) 332k customers who signed up before first event 15/11/2022 **versus** 12k customers who signed up after 01/02/2023

Octopus versus Bulb (a 'natural' counterfactual group)

3) 1.137m invited Octopus customers **versus** 198k Bulb Energy smart customers who allow half-hourly recording ('Octopus versus Bulb')

In each of our strategies, we use a two-period difference-in-differences approach
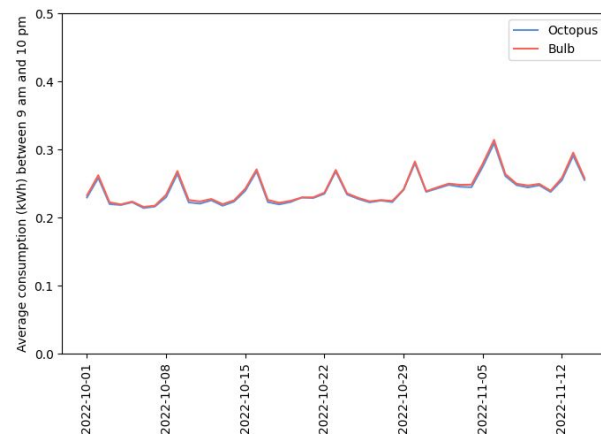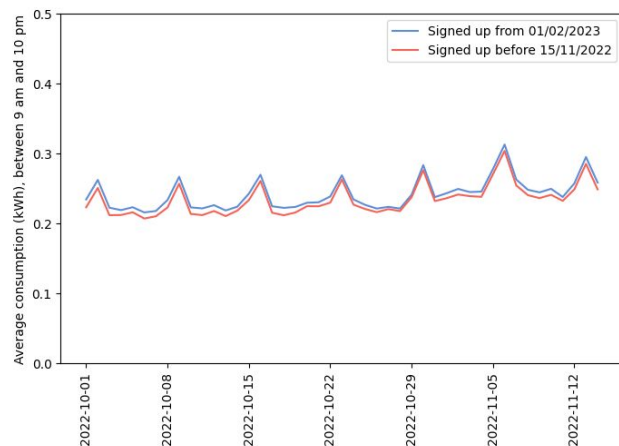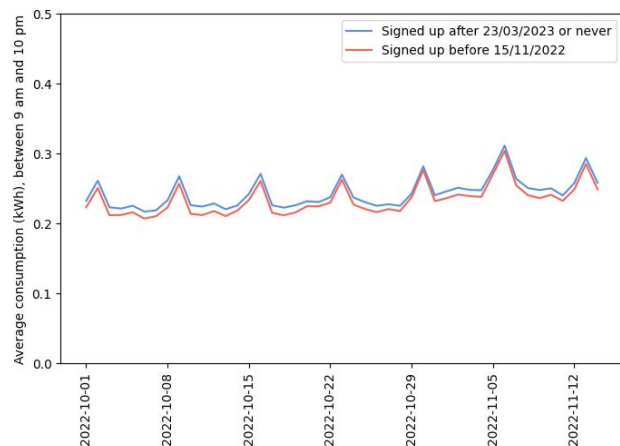
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"Pre" period (all strategies): average consumption during weekday half-hours 9am-10pm in October and first half of November, 2022

"Post" period: average consumption during the 29 Saving Sessions half-hours

"Post" period: average consumption during the 21 half-hours of the first nine Saving Sessions

"Post" period: average consumption during the 29 Saving Sessions half-hours

We regress average half-hourly consumption on "post", "treatment", and average heating degree days during the period.

Difference-in-differences: Signed up customers reduce demand by ~26%, opted in customers by ~40%

Effect sizes much higher than we usually see in energy consumption analysis:

DiD approach	Mean kwh per half-hour during SS	ITT as % of mean	LATE on *signup* as % of mean	LATE on *opt-in* as % of mean	ITT	LATE on signup	LATE on opt-in
Signed up early *versus* **signed up never**	0.376	-23.88%		-37.94%	-0.0897 (0.0003)		-0.1425 (0.0006)
Signed up early *versus* **signed up later**	0.373	-26.05%		-39.74%	-0.0972 (0.0018)		-0.1483 (0.0029)
Octopus invited *versus* **Bulb smart**	0.383	-9.43%	-26.67%	-43.59%	-0.0361 (0.0005)	-0.1021 (0.0014)	-0.1669 (0.0022)

ITT: Intention-to-treat analysis
LATE: local average treatment effect
Blue: Impact of sign-up
Green: Impact of opt-in

Interestingly, Sessions cause small but meaningful demand reduction in hour just before and after, too

	The hour just *before*			The hour just *after*		
DiD approach	**ITT as % of mean**	**ITT**	**Mean kwh per half-hour**	**ITT as % of mean**	**ITT**	**Mean kwh per half-hour**
Signed up early *versus* **signed up never**	-2.44%	-0.0079 (0.0005)	0.324	-2.45%	-0.0089 (0.0005)	0.363
Signed up early *versus* **signed up later**	-2.15%	-0.0067 (0.0018)	0.312	-3.10%	-0.0114 (0.0018)	0.367
Octopus invited *versus* **Bulb smart**	-1.04%	-0.0034 (0.0003)	0.326	-3.35%	-0.0125 (0.0003)	0.373

Across OE's customer base during those half-hours, these effects are comparable to a small CCGT plant

Saving Session	LATE on Octo vs Bulb sign-up (kWh per half-hour) (SE)	Half-hours	Signed up	Total MWh
15/11/2022 17:00 - 18:00	-0.1137 (0.0027)	2	409,075	-93
22/11/2022 17:30 - 18:30	-0.1424 (0.0030)	2	427,265	-122
30/11/2022 17:30 - 18:30	-0.1250 (0.0029)	2	445,850	-111
01/12/2022 17:00 - 18:00	-0.1033 (0.0028)	2	449,321	-93
12/12/2022 17:00 - 19:00	-0.1481 (0.0030)	4	468,547	-278
19/01/2023 09:00 - 10:00	-0.0664 (0.0023)	2	518,095	-69
23/01/2023 17:00 - 18:00	-0.1536 (0.0026)	2	605,440	-186
24/01/2023 16:30 - 18:00	-0.1172 (0.0022)	3	615,279	-216
30/01/2023 09:00 - 10:00	-0.0541 (0.0017)	2	627,495	-68
13/02/2023 17:30 - 18:30	-0.0838 (0.0025)	2	641,127	-107
21/02/2023 17:30 - 18:30	-0.0812 (0.0025)	2	658,527	-107
15/03/2023 18:30 - 19:30	-0.0830 (0.0027)	2	684,788	-114
23/03/2023 18:30 - 19:30	-0.0566 (0.0024)	2	692,792	-78

Research question 2: How much does changing notice period and incentive level change demand reduction?

Notice: Almost all Sessions featured day-ahead 'notice' for the Saving Session the next day, and customers tended to receive the notice around the same time for any given Session.

Incentive level: Although the incentive level somewhat varied between Sessions, it never varied between customers *within* a Session.

However, two Saving Sessions (on 13 Feb 2023 and 15 March 2023) featured different notice periods and incentives provided to customers, enabling rigorous analysis of these research questions.

We find that customers reduce demand more when they have more advance notice

We have two sources of evidence for this:

1. A natural experiment that transpired close to the 10th Saving Session (13/02/2023)
2. A field trial we conducted for the 12th Saving Session (15/03/2023)

You'll earn 1800 OctoPoints – **that's £2.25 worth** – per kilowatt hour for any electricity you cut down between 5:30 PM and 6:30 PM on 30th November.

Opt in now on your dashboard to save power and earn rewards in this Session. You'll go into a draw to win an extra 400,000 OctoPoints – that's £500 worth! – just for opting in.

Opt in in two clicks

Important: **you need to opt in on your Saving Sessions dashboard before each Session starts** if you want to earn rewards.

Super Saver Bonus challenge: Did you opt in to Session 2? **Continue your streak** by opting in to Session 3 and you'll automatically get...

- 100 extra OctoPoints (worth 12.5p)

Our natural experiment concerns a discontinuity in when customers were sent their opt-in notice

Legend: Day-Ahead Notice (Control Group) — Intra-Day Notice (Treatment Group) — Overnight Notice

Y-axis: Number of Octopus Energy Customers
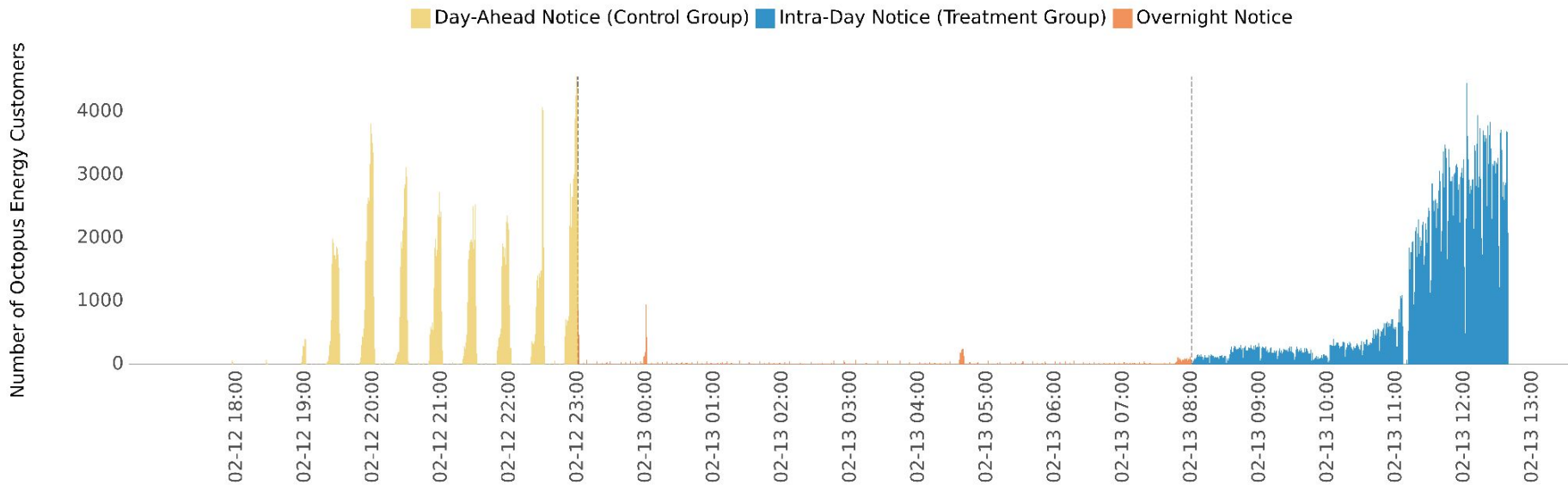
X-axis: "Sent" Timestamp for Earliest (Possibly Only) Opt-In Notice for 10th Saving Session (Feb. 13, 2023)

Opt-in notice send-time versus customer tenure

Number of OE Customers Sent Their First Notice In the Same 15-Min. Window (2nd, 3rd, and 4th Quartile Ranges)

● [0, 167]   ● (167, 1777]   ● (1777, 66664]

Average for OE Customers Notified in Same 15 Min Window

Account ID (Millions)

Tenure (Years Prior to 1st SS10 Opt-in Notice)

Beginning of Time Window (15 Min) In Which Earliest (Possibly Only) Opt-In Message Was Sent Before Saving Session
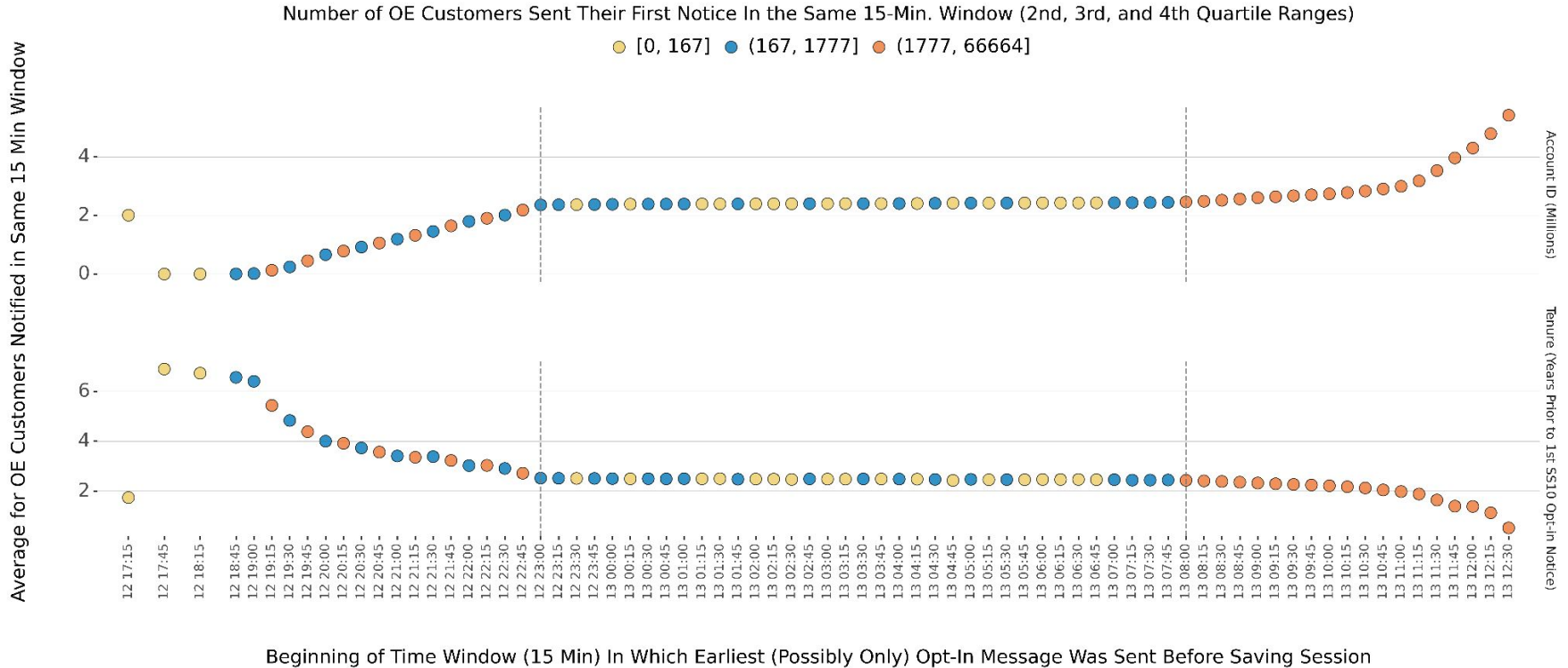
We find that intra-day notice increased in-Session consumption by ~10%, from ~0.6kWh to ~0.66kWh

Total Metered Consumption (kWh)

$\hat{\beta}$ Intraday Opt-in Notice [Ref Day-ahead] ÷ $\hat{\beta}$ Intercept

Probability of Opt-in

$\hat{\beta}$ Intraday Opt-in Notice [Ref Day-ahead] ÷ $\hat{\beta}$ Intercept

−20   −15   −10   −5   0   5   10   15   20

Mean Quotient of Posterior Parameter Values (Bar) + 95% Highest Posterior Density Interval (Line Range)

■ Baseline (MSE-Optimal Bandwidth)   ■ Extended (MSE-Optimal Bandwidth)   ■ Extended (MSE-Optimal Bandwidth; Flexible Scale)
■ Extended (MSE-Optimal Bandwidth × 1.5; Flexible Scale)   ■ Extended (MSE-Optimal Bandwidth × 2; Flexible Scale)

Our RCT for the 12th Session involved two treatment groups

Control Group (N = 627,155):
Intraday Opt-in Notice Only

Note that this was the only Saving Session where intra-day notice was the norm.

Treatment Group 1 (N = 19,182):
Intraday Opt-in Notice plus Day-ahead "Heads-up" Email

SAVING SESSIONS

Hi there,

Heads up: there may be a Saving Session tomorrow evening.

If the Session goes ahead, you'll be able to opt in as normal during the day tomorrow, and we'll send you a proper invite email with all the normal details then too.

Why are we sending you this email now? Saving Sessions is part of a wider project run by the National Grid. It's the biggest project of its kind in the UK to test how people can come together to balance the grid and avoid fossil fuels. We don't always know with loads of notice when the grid needs help.

As part of our testing in this project, we'd like to find out how readily people can get involved in a Saving Session with different amounts of notice. We suspect there might be a Session tomorrow. If there is, we'll only open opt-in's on the day. But we thought we'd give you a little pre-warning that there might be one coming up!
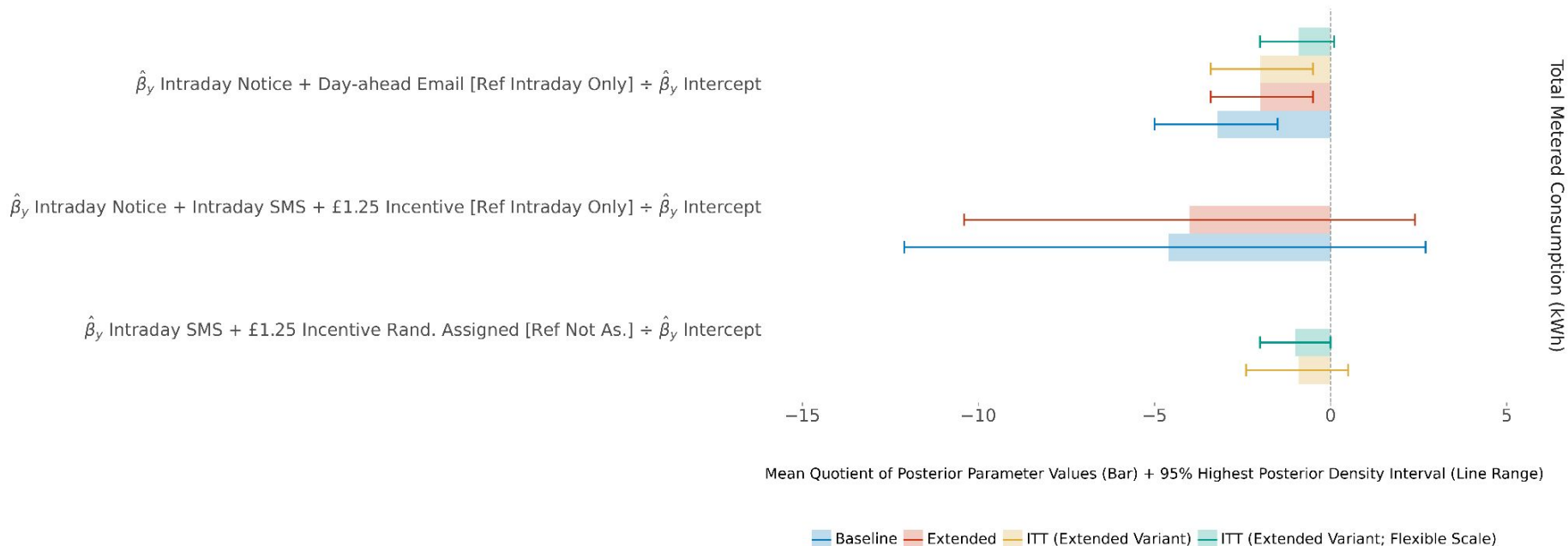
Keep your eyes peeled tomorrow, and get ready for a possible Session...

Thanks,
Pete

Treatment Group 2 (N = 19,220):
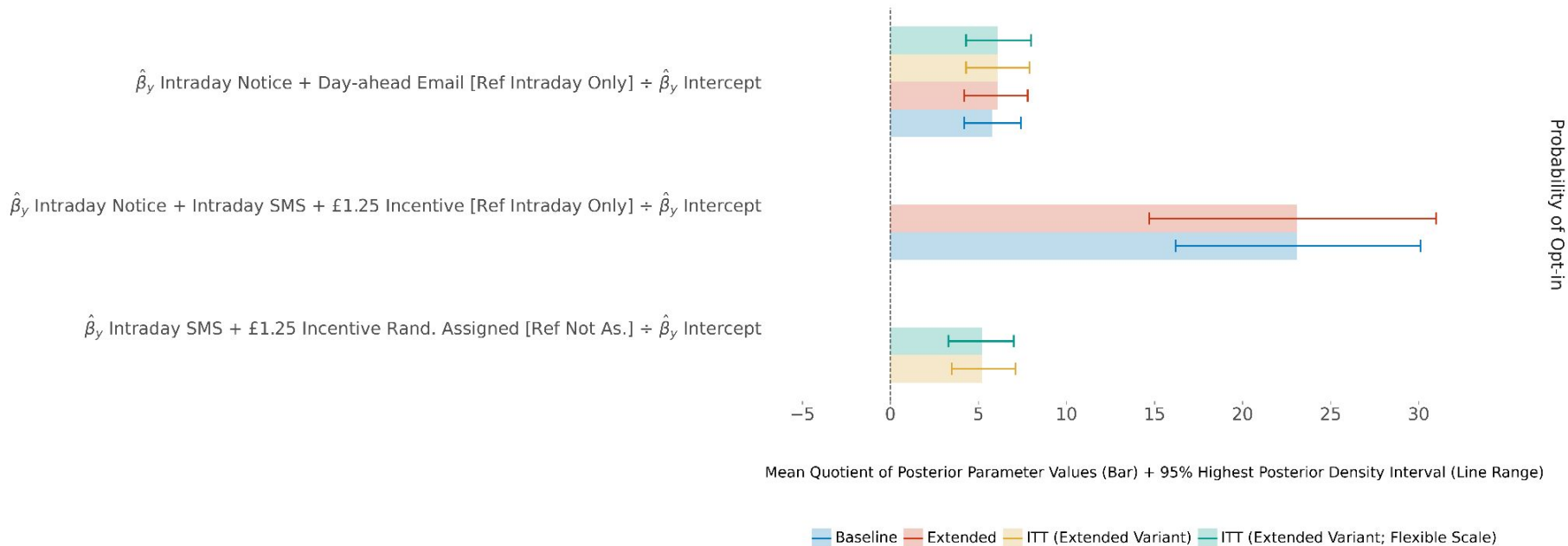Intraday Opt-in Notice plus Intraday "Reminder" SMS Text plus Eligibility for £1.25 Bonus

SAVING SESSION TODAY 1830-1930. SPOT PRIZE: Octobot has chosen you at random to win 1000 OctoPoints if you save energy in tonight's Session. Opt in before 1830!

Heads-up email decreases in-Session consumption by ~1-3%; extra incentive via day-of SMS is ~inconclusive but central estimate is notable

$\hat{\beta}_y$ Intraday Notice + Day-ahead Email [Ref Intraday Only] ÷ $\hat{\beta}_y$ Intercept

$\hat{\beta}_y$ Intraday Notice + Intraday SMS + £1.25 Incentive [Ref Intraday Only] ÷ $\hat{\beta}_y$ Intercept

$\hat{\beta}_y$ Intraday SMS + £1.25 Incentive Rand. Assigned [Ref Not As.] ÷ $\hat{\beta}_y$ Intercept

Total Metered Consumption (kWh)

Mean Quotient of Posterior Parameter Values (Bar) + 95% Highest Posterior Density Interval (Line Range)

Baseline   Extended   ITT (Extended Variant)   ITT (Extended Variant; Flexible Scale)

Heads-up email increases probability of opt-in by ~6%, while extra day-of SMS increases opt-in probability by ~23% (from baseline probability ~0.44)

Mean Quotient of Posterior Parameter Values (Bar) + 95% Highest Posterior Density Interval (Line Range)

Baseline — Extended — ITT (Extended Variant) — ITT (Extended Variant; Flexible Scale)

CO$_2$ equivalent reduction impacts

Saving Session	Half-hours	Signed up	Total MWh	CO$_2$-eq reduction (tCO$_2$-eq)
15/11/2022 17:00 - 18:00	2	409,075	-93	70.70
22/11/2022 17:30 - 18:30	2	427,265	-122	92.48
30/11/2022 17:30 - 18:30	2	445,850	-111	84.71
01/12/2022 17:00 - 18:00	2	449,321	-93	70.55
12/12/2022 17:00 - 19:00	4	468,547	-278	102.70
19/01/2023 09:00 - 10:00	2	518,095	-69	52.29
23/01/2023 17:00 - 18:00	2	605,440	-186	68.82
24/01/2023 16:30 - 18:00	3	615,279	-216	80.04
30/01/2023 09:00 - 10:00	2	627,495	-68	51.60
13/02/2023 17:30 - 18:30	2	641,127	-107	81.66
21/02/2023 17:30 - 18:30	2	658,527	-107	81.28
15/03/2023 18:30 - 19:30	2	684,788	-114	86.39
23/03/2023 18:30 - 19:30	2	692,792	-78	59.60
Total	29	692,792	-1,642	982.83

Welfare impacts

Saving Session	Total MWh	Marginal Value of Public Funds (MVPF)	MVPF (using Value of Lost Load of £6,000/MWh)
15/11/2022 17:00 - 18:00	-93	1.06	2.76
22/11/2022 17:30 - 18:30	-122	1.08	3.29
30/11/2022 17:30 - 18:30	-111	1.07	3.01
01/12/2022 17:00 - 18:00	-93	1.06	2.78
12/12/2022 17:00 - 19:00	-278	1.04	3.03
19/01/2023 09:00 - 10:00	-69	1.06	2.74
23/01/2023 17:00 - 18:00	-186	1.03	2.47
24/01/2023 16:30 - 18:00	-216	1.02	2.12
30/01/2023 09:00 - 10:00	-68	1.05	2.42
13/02/2023 17:30 - 18:30	-107	1.06	2.63
21/02/2023 17:30 - 18:30	-107	1.05	2.44
15/03/2023 18:30 - 19:30	-114	1.08	3.13
23/03/2023 18:30 - 19:30	-78	1.05	2.31
Total	-1,642	1.05	2.63

Conclusions

1. Domestic consumers can provide meaningful demand side response.

2. Shorter notice period meaningfully reduces the magnitude of this response.

3. Welfare impacts are sensitive to the extent to which the response reduces the likelihood of lost load.

We will publish the full working paper in mid-October.

Please get in touch if you want to discuss the findings of this analysis in further detail **info@centrefornetzero.org**.

You can find out more about our range of ongoing research on our website.

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