Energy Savings from the OVO Community

September 2019

Executive Summary

OVO Energy is committed to making energy cheaper, greener and simpler. On our end, this means utilising smart technology to optimise energy management and facilitate the switch to green gas and electricity. But the onus is not entirely on us - our customers play a critical role in helping us to reduce our collective energy consumption in and around the home. This has the dual effect of driving down bills and safeguarding the planet for future generations.

In this paper, we look at various initiatives undertaken by OVO Energy to help our members do just this. We start by quantifying the effect of rolling out smart meters across the country. We hone in on what we consider to be a subset of ‘energy enthusiasts’, so-called because they have demonstrated a particular interest in their energy consumption. The effect of providing real-time feedback to customers on their energy usage directly to their smart devices is then examined. Finally, we consider the impact of providing a disaggregated view of electricity consumption via our online customer portal.

We conclude that direct feedback delivered to customers on aggregate energy consumption has a net positive effect on kilowatt hours saved on the order of 4%, rising only marginally with the addition of disaggregated feedback. Despite a positive response from customers, there appears to be a gap in understanding with regards to making full use of the disaggregated view.

Background

The rollout of smart meters in Great Britain is world leading, with energy suppliers required to take all reasonable steps to convert all domestic and small business customers to smart mode by the end of 2020. This applies to both electric and gas supplies, with the vast majority of UK domestic customers having both.

In addition to providing a foundation for a more flexible and resilient energy system forecast, smart meters are proffered to put customers firmly in control of their energy usage, helping to reduce consumption by improving visibility of energy usage, and bringing to an end estimated billing (Ofgem 2011; Department for Business, Energy & Industrial Strategy 2018). Once granted the appropriate permissions, it is up to the supplier to feed smart meter data back to the consumer in a way that delivers value, be it environmental or financial.

With more than 14.3 million smart meters already in operation in the UK as of March 2019 (Department for Business, Energy & Industrial Strategy 2019), there remains little indication in the public domain as to their efficacy in the context of reducing energy consumption. A systematic review by Kelly and Knottenbelt puts average electricity reduction from aggregated feedback at 3%, rising to 4.5% when supplemented with disaggregated feedback (Kelly & Knottenbelt 2016). However, this is caveated as a positively biased estimate due to the opt-in nature of the studies examined. These results are echoed by studies carried out in the Netherlands, Australia, Canada and the US (Van Houwelingen & Van Raaij 1989; Geelen & Mugge 2019; McKerracher & Torriti 2013; Arup 2014; Davis et al. 2013).

There is comparatively little literature available on the impact of feedback on gas usage. Geelen and Mugge discuss the use of apps, in particular, to communicate electricity and gas consumption data directly to users, concluding that there is no statistically significant difference in usage between app users and the reference group (Geelen & Mugge 2019).

Smart meter data can be accessed by OVO Energy customers in a number of ways. 78% of our customers request an In-Home-Display (IHD) free of charge at the time of booking, which displays household energy usage in kilowatt hours, pounds and pence, and carbon dioxide equivalent on a real-time basis, as well as historically. Customers can opt to batch submit meter read data automatically at half-hourly, daily or monthly resolutions via a secure network connection. This data can then be accessed online using a personal login, alongside additional features such as itemised spending by appliance category, with a lag of at least one day depending on the resolution selected.

In May 2017, OVO Energy launched a trial in which 18,000 customers opted in to receive a Consumer Access Device (CAD). A CAD differs from a standard IHD in that it also sends smart meter data to the cloud so that it can be accessed on any authenticated device with an internet connection, notably smartphones and tablets, in real-time. We consider this subset of customers to be our energy enthusiasts for comparison purposes in the ensuing analysis.

In September 2018, we invited a subset of energy enthusiasts to take part in a user testing exercise, in which we sought guidance on how they interpret their energy usage graphs and what actions they take in response to this new information (OVO Tech Blog 2018). We intentionally sampled customers who check their usage data online more frequently than average to learn about the advanced tasks that can be completed with energy usage data. Tasks fall on a spectrum of energy maturity, from seeking reassurance on one end to tuning appliances on the other end. We refer to this spectrum throughout this paper to explain some of the results.

Methodology

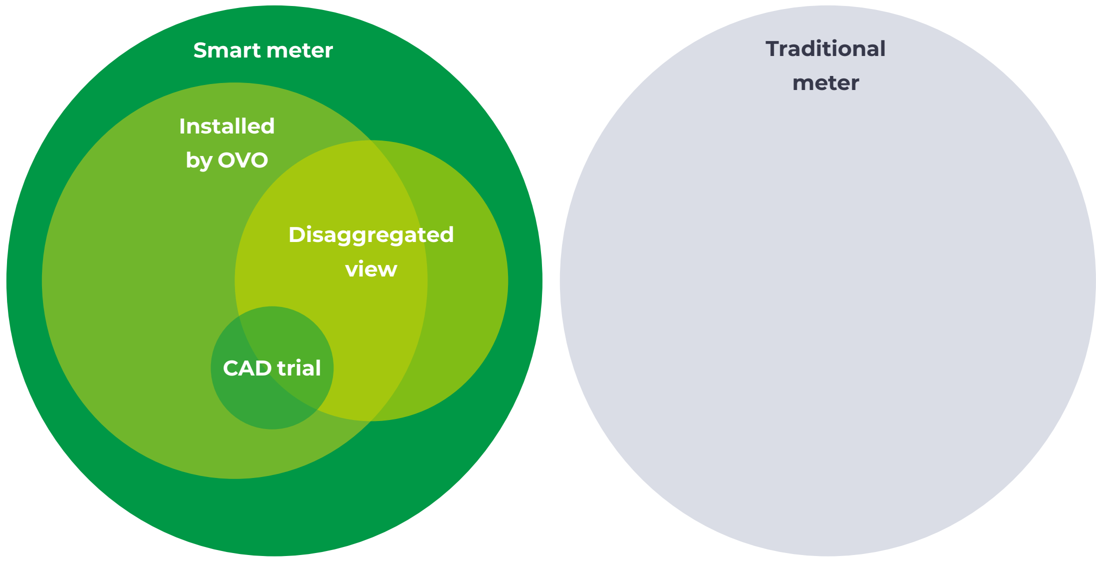
This is an observational study using existing data retrospectively to make inferences. It is not a randomised control trial, nor is it a designed experiment of any kind - potential sources of bias are considered at a later stage in this white paper. We have chosen this approach to make use of the vast amounts of data already collected pertaining to historic events, and because the long timescales required to detect statistically significant changes in consumption are limiting.

The study is restricted to electricity and gas credit customers, i.e. those who pay for their energy in arrears. In the case of electricity customers, only those in Profile Class 1 (Domestic Unrestricted) are included (ELEXON 2013). Combined, these represent 83% of our customer base. To understand the effect of feedback on consumption, we have studied customer behaviour in response to three initiatives, summarised in Table 1.

Table 1: Summary of initiatives employed to help reduce energy consumption

	Initiative	Description	Assumptions & Caveats
1	Smart meter exchange	Traditional energy meter replaced by OVO Energy with a smart meter and accompanying IHD displaying electricity usage in real-time and gas usage at half-hourly intervals; usage data also accessible via our online customer portal as standard	
2	Energy disaggregation	IHD supplemented with access to disaggregated feedback via the online portal	Requires opt-in to half-hourly meter reads; only available for electricity usage; available 5 months after meter exchange
3	CAD trial	IHD supplemented with a CAD, providing real-time access to energy usage (gas and electricity) via any authenticated device with an internet connection inside or away from the home	Due to the opt-in nature of this trial, this cohort of customers is considered to be our pool of energy enthusiasts

Figure 1: Venn diagram of customers affected by each of the initiatives adopted to help reduce energy consumption in the home (not to scale)



Measuring energy savings from each of these initiatives is not straightforward. Given the seasonal nature of energy consumption, annual data is required to compare usage pre- and post- implementation. Even then, weather adjustments may be required to account for a particularly cold winter or mild summer, for example. Furthermore, external factors such as more stringent regulations for new appliance efficiency, improved insulation for newbuilds and the systematic shift towards electric vehicles can cause energy consumption to trend one way or another.

In light of this, we opted to use weather-adjusted annualised meter advances to quantify changes in consumption. ELEXON and Xoserve are the settlement service providers for electricity and gas respectively. They are responsible for generating estimates of annual consumption by annualising meter advances using annual load profiles. More information can be found from the respective load profile guidance documentation (ELEXON 2013; Department of Energy & Climate Change 2014; Competition & Markets Authority 2015).

To quantify changes in electricity consumption from each of the initiatives described in Table 1, we use Estimated Annual Consumption (EAC) . EACs are calculated by ELEXON on receipt of meter reads as per Equation 1 (ELEXON 2013).

Equation 1: Suite of equations used to calculate EAC

$$AA = \frac{Meter\ Advance}{\sum_{read\ period} DPC}$$

$$W_{AA} = AA \times \sum_{read\ period} (DPC \times \alpha)$$

$$W_{EAC(old)} = EAC_{old} \times (1 - \sum_{read\ period} (DPC \times \alpha))$$

$$EAC_{new} = AA \quad if \quad \sum_{read\ period} (DPC \times \alpha) > 1$$

$$EAC_{new} = W_{AA} + W_{EAC(old)} \quad if \quad \sum_{read\ period} (DPC \times \alpha) < 1$$

where α is a smoothing parameter and DPC is the daily profile coefficient. The smoothing parameter is set to 2, which means that EACs are completely revised with a meter advance period greater than or equal to 6 months, and are a weighted average of previous estimates otherwise. Accordingly, we need to wait at least 6 months to measure the effectiveness of any given initiative to ensure that the annualised consumption post-implementation is more heavily weighted towards the post-implementation phase.

Gas consumption is tracked using Annual Quantity (AQ), an estimate of the consumption at a meter point for a 365-day year under seasonal normal weather conditions. The formula for calculating AQ is set out in the Uniform Network Code (Joint Office of Gas Transporters 2018). Xoserve takes the actual consumption between two reads, at least six months apart but ideally as close to a year apart as available, divides by the sum of the daily actual usage factors for the meter read period and multiplies by 365. An adjustment is applied to arrive at an AQ that is effectively weather-desensitised - the aim is to convert individual consumptions for differing read periods and durations into a value that is comparable across all meter points within a local distribution zone (LDZ). This also makes it possible to compare usage at the same meter point over different time periods.

Our methodology involves comparing the latest EAC and/or AQ revision prior to the initiative implementation date to the revision generated at least 6 months after. Anomalies were removed a priori by normalising the annualised quantities and using three standard deviations as an inclusion threshold either side of the mean.

Benchmarking

To start with, we need to check for any systematic change in consumption patterns over time which could artificially inflate or deflate the measured benefits of each of the initiatives studied. Table 2 shows average EAC and AQ computed for the past two years and split by utility and meter type. All of the combinations have small negative gradients, except for smart metered electricity, which has a more pronounced negative slope.

Both electricity and gas consumption are trending downwards, albeit by a small amount. Switching to smart metering has a measurable impact on electricity usage in particular, for which the gradient magnitude is higher. Understanding the complexities of what this means in the context of load profiling is beyond the scope of this discussion; however, all results quoted hereafter take into account this underlying trend.

Table 2: Demonstration of the systematic change in domestic energy consumption over the past 2 years

Utility	Meter Type	Mean Annualised Consumption (kWh)	Percent Standard Deviation	Gradient (kWh / year)
Electricity	Traditional	3,784	0.94%	-24.6
Electricity	Smart	3,762	1.56%	-73.7
Gas	Traditional	12,159	0.44%	-55.6
Gas	Smart	12,138	0.43%	-50.5

Results

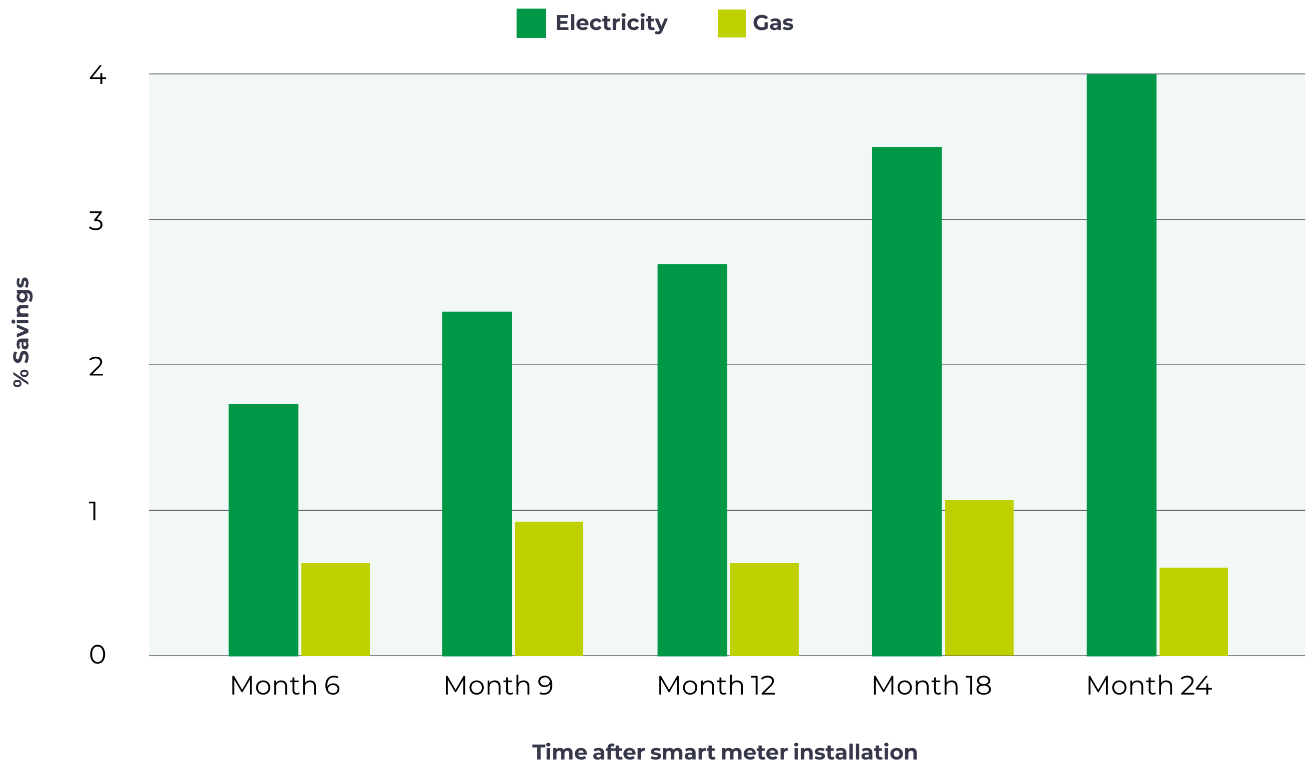
1. Smart Meter Rollout

The percentage change in annualised consumption for both electricity and gas following smart meter installation is shown in Figure 2. It is important to note that the horizontal scale is not linear and the number of customers included in each bin gradually decreases with time, i.e. only half of the smart meters involved in this study were in operation two years ago.

The percentage change in electricity consumption steadily increases with time following installation of a smart meter, with average savings of 4% achieved after two years. It is possible that early adopters of smart metering technology have a higher energy maturity than those who transitioned later on. As such, this may well be an upper bound for the general population. The measured effects on gas usage are statistically insignificant, with a one-tail p-value in excess of 0.05. Altering gas usage habits is likely to be more detrimental to personal comfort compared to electricity and this could explain the tendency for customers to revert back to old habits once the novelty has worn off.

Importantly, it is not possible to fully isolate the effects of aggregated and disaggregated energy feedback on consumption post- smart meter installation - a significant proportion of customers will have had access to disaggregated usage data at some point over the time period covered by this study. All we can say is that smart meter rollout is beneficial as far as electricity usage is concerned across the general population.

Figure 2: Percentage decrease in energy consumption following smart meter rollout

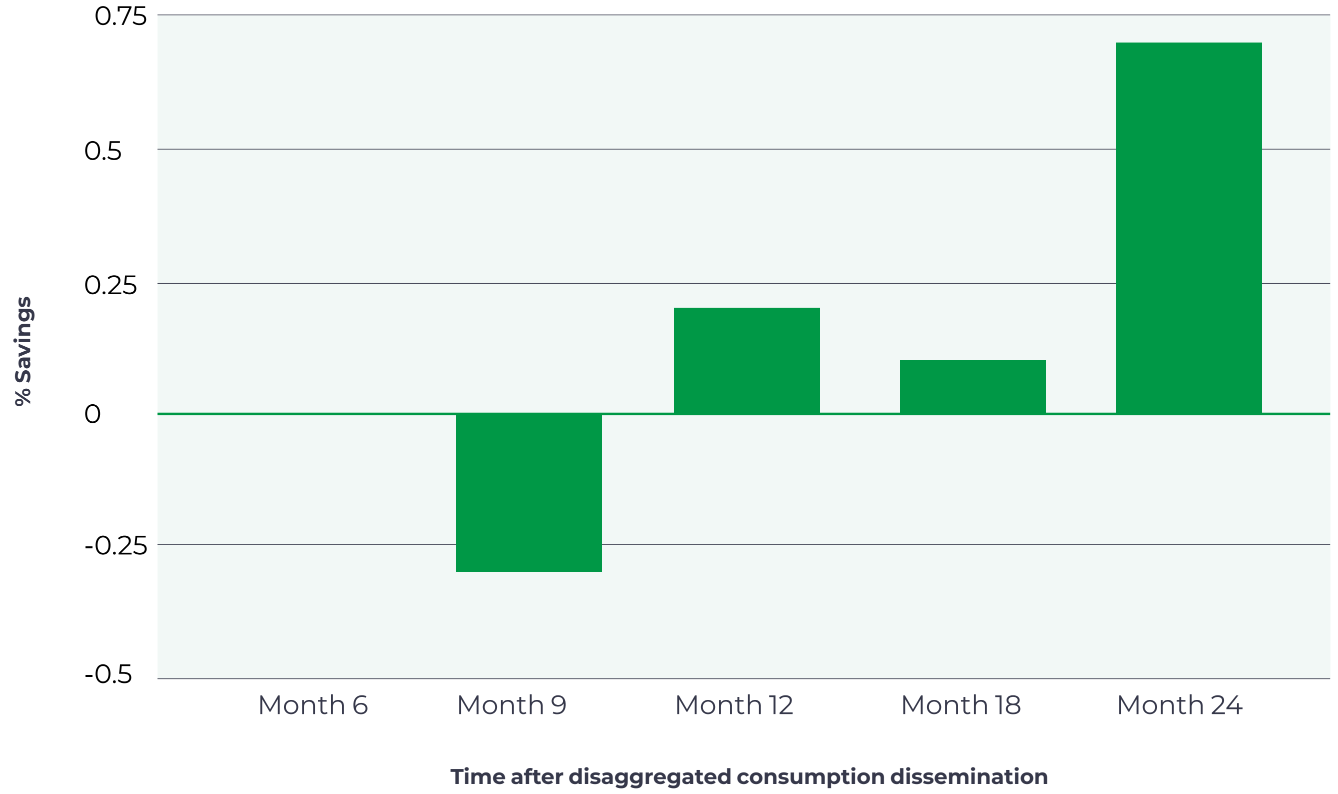


2. Energy Disaggregation

In July 2017, a new feature was added to the online customer portal, allowing credit customers access to a disaggregated view of their electricity (but not gas) consumption, i.e. on an appliance level. Customer access to this data is reliant on (i) having at least 5 months worth of smart meter data available as an input to the model, (ii) not having solar panels installed as electricity drawn from the panels is not captured by all smart meters, and (iii) a home not being empty for an extended period of time. There is also an option for customers to edit their profiles to improve the accuracy of the disaggregated view.

Figure 3 shows the effect of the disaggregation feature on electricity usage. Again, the horizontal scale is not linear and the number of customers included in each bin gradually decreases with time. Further, it is important to note that the horizontal axes in Figures 2 and 3 are in no way comparable. One customer may have had a smart meter for 5 months prior to gaining access to the disaggregated view; another may have had a smart meter for 18 months. This depends largely on whether or not it was installed prior to the July 2017 launch.

Figure 3: Percentage decrease in electricity usage following disaggregated consumption dissemination via the online customer portal



Despite largely positive feedback from customers on this feature, Figure 3 shows that there is no measurable benefit from having disaggregated data. Kelly and Knottenbelt suggest that disaggregated feedback is less impactful than aggregated feedback due to web apps being viewed less frequently than IHDs and because some users do not trust fine-grained disaggregation (Kelly & Knottenbelt 2016).

3. Real-Time Access to Energy Usage over the Internet

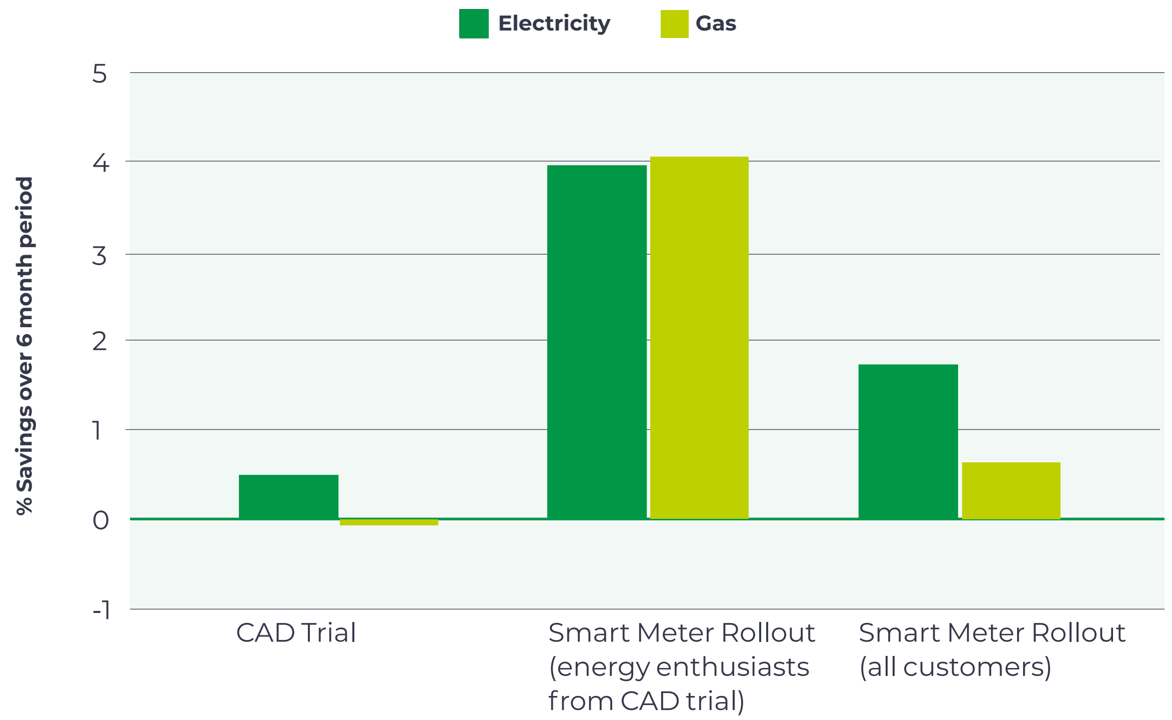
Finally, we look at the results from the CAD trial in which a subset of customers opted in to have a CAD installed alongside their regular IHD. The trial ran from May 2017 until February 2018, when it was discontinued. Due to the opt-in nature of this study, the participants are considered to be more interested in their energy usage than the general population. Therefore, identifying trends amongst this cohort of energy enthusiasts provides an upper bound on the types of savings that could be achieved through advanced energy maturity.

Figure 4 shows the percentage reduction in electricity and gas usage following CAD installation over a 6 month period. The trial in question overlaps with the launch of the disaggregated electricity feature, and so many of these customers will have had access to their itemised spending on electricity at some point during the trial also.

Access to real-time data on multiple devices does not have a statistically significant impact on energy consumption, with a one-tail p-value in excess of 0.05 for both gas and electricity. However, if we limit the analysis presented in Section 1 to our cohort of energy enthusiasts, their energy savings 6 months after access to smart meter data far exceeds those of the general population. Moreover, these gains exist for both electricity and gas.

Importantly, this is not to say that a widespread CAD rollout would be ineffective if offered to the rest of the customer base—it is possible that the CAD trial volunteers had already optimised their usage based on IHD data alone.

Figure 4: Percentage decrease in energy consumption following CAD installation - this is compared with the reduction achieved over the same time period following smart meter installation for (i) CAD trial volunteers (our energy enthusiasts) and (ii) all customers included in the smart rollout study detailed in Section 1



Sources of Bias

This is an observational study: external factors have not been controlled for and so there exists multiple sources of bias. These are detailed in Table 3. The likely skew associated with each source of bias is provided: a positive skew means that the source of bias tends to overstate energy savings; a negative skew implies the opposite.

We have tried to be conservative in our approach to calculating the effects of feedback on consumption; however, some adjustments may be required as we gather more data and delve deeper into the sources of bias outlined in Table 3.

Regardless, we can reliably assert that energy enthusiasts are able to draw more actionable insights from feedback delivered by virtue of having a smart meter installed, and thus are more likely to benefit from reduced bills.

We also now have a prior for Bayesian estimation of the energy savings that can be achieved by customers trying to reduce their consumption. This is an important result for predicting the effectiveness of future initiatives.

Table 3: Potential sources of bias

	Source of Bias	Type of Bias
1	Load profiles are calculated using a sample of half hourly meters in each of 12 grid supply points. The type of meter installed is not taken into account when calculating the daily profile coefficients and, therefore, any systematic change in energy consumption due to widespread rollout of what is potentially an energy-saving device is not accurately captured by the yearly load profile.	Positive
2	Settlement is not an exact science, merely a best attempt at forecasting demand.	Unknown
3	Annualised estimates are not available for all customers at 6, 9, 12, 18 and 24 month intervals. A customer may have only had their smart meter installed less than 24, 18, 12, 9 or 6 months in the past, or there may not be a data flow available for the particular month in question for operational reasons.	Positive, assuming early adoption of smart metering maps to advanced energy maturity
4	Some customers do not have access to their aggregate energy expenditure via an IHD due to misuse, malfunction, or not having requested one in the first place. We know the latter to be the case for at least 22% of our customer base.	Negative
5	It is unclear whether the reported gains in energy conservation are from curtailment (eg. switching off lights, reducing standby load) as opposed to investment in more efficient products (eg. appliances, insulation).	Unknown
6	The three results sections are not indistinct - there is overlap between all three and this cannot be reliably controlled for.	Unknown

Conclusion

This white paper has summarised the effects of aggregated and disaggregated feedback on electricity and gas consumption by OVO Energy customers. Customers have access to their smart meter data via an IHD which displays electricity and gas consumption in near real-time. This has an incremental effect on electricity conservation, on the order of 4% over a two year period, with savings steadily increasing from time of access. There is no statistically significant effect on gas usage. However, our cohort of energy enthusiasts achieve the same savings of 4% over a shorter period of 6 months for both electricity and gas. This provides us with an upper bound of the types of savings customers can achieve if they are really engaged.

There is no robust evidence that current forms of disaggregated energy feedback perform any better than aggregated feedback alone in helping to reduce energy consumption. This is probably due to a combination of lack of engagement with the web app and lack of trust in fine-grained energy disaggregation. Furthermore, granting customers access to their real-time usage via the internet, such that they may view their energy consumption statistics away from the home, has no statistically significant effect on either electricity or gas consumption.

Finally, we know from separate analyses of half-hourly data that there is scope for improvement. Excessive stand-by loads, inefficient lighting technology and habits, and sub-optimal heating settings are readily identifiable with the right disaggregation tools. Clearly, we need an innovative approach to communicate these missed opportunities to customers and close the loop by providing actionable recommendations to help our customers save energy and save money.

References

Arup (2014). Smart Grid, Smart City:Shaping Australia's Energy FutureExecutive Report. Retrieved from https://webarchive.nla.gov.au/awa/20160615070155/http://www.industry.gov.au/Energy/Programmes/SmartGridSmartCity/Documents/SGSC-Executive-Report-National-Cost-Benefit.pdf.

Competition & Markets Authority (2015). Energy market investigation: Gas and electricity settlement and metering. Retrieved from https://assets.publishing.service.gov.uk/media/5501b87c40f0b6140a00001e/Settlement_and_metering.pdf.

Davis, A., Krishnamurti, T., Fischhoff, B., Bruine de Bruin, W. (2013). Setting a standard for electricity pilot studies. Energy Policy, vol. 62, pp. 401-409.

Department of Energy & Climate Change (2014). Overview of Weather Correction of Gas Industry Consumption Data. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/369933/Overview_of_Weather_Correction_of_Gas_Industry_Data.pdf.

Department for Business, Energy & Industrial Strategy (2018). SMART METERING IMPLEMENTATION PROGRAMME: Progress Report for 2018. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/767128/smart-meter-progress-report-2018.pdf.

Department for Business, Energy & Industrial Strategy (2019). Smart Meter Statistics: Quarterly Report to end March 2019. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/804767/2019_Q1_Smart_Meters_Report.pdf.

ELEXON (2013). Load Profiles and their use in Electricity Settlement. Retrieved from https://www.elexon.co.uk/wp-content/uploads/2013/11/load_profiles_v2.0_cgi.pdf.

Geelen, D., Mugge, R. (2019). The use of apps to promote energy saving: a study of smart meter-related feedback in the Netherlands. Energy Efficiency, vol. 12, pp. 1635-1660.

Joint Office of Gas Transporters (2018). Uniform Network Code: Transportation Principal Document. Retrieved from https://gasgov-mst-files.s3.eu-west-1.amazonaws.com/s3fs-public/ggf/page/2019-07/Transportation%20Principal%20Document%20%28Consolidated%2C%20printable%20version%29.pdf

Kelly, J. & Knottenbelt, W. (2016). Does disaggregated electricity feedback reduce domestic electricity consumption? A systematic review of the literature. arXiv:1605.00962 [cs]. Retrieved from http://arxiv.org/abs/1605.00962.

McKerracher, C. & Torriti, J. (2013). Energy consumption feedback in perspective: integrating Australian data to meta-analyses on in-home displays. Energy Efficiency, vol. 6, no. 2, pp. 387-405.

Ofgem (2011). Smart metering - what it means for Britain's homes - factsheet. Retrieved from https://www.ofgem.gov.uk/sites/default/files/docs/2011/03/consumersmartmeteringfs_0.pdf.

OVO Tech Blog (2018). Discovering how people use their energy usage data. Retrieved from https://tech.ovoenergy.com/discovering-how-people-use-their-energy-usage-data/.

Van Houwelingen, J. & Van Raaij, W. (1989). The Effect of Goal-Setting and Daily Electronic Feedback on In-Home Energy Use. Journal of Consumer Research, vol. 16, pp. 98-105. Retrieved from https://doi.org/10.1086/209197.