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# Switching Off: Energy Saving Goals Outshine Incentives— Evidence from a Field Experiment

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## Abstract

Feedback interventions are a promising tool for promoting household energy conservation and addressing climate change. This study examines whether their effectiveness improves with incentivized energy saving goals through a field experiment involving 422 Singaporean households over eight months. All treatment groups received tailored feedback reports, energy saving goals, and tips. Two groups also received additional incentives: monetary rewards or environmental donations. Households receiving only feedback, goals and savings tips reduced electricity use by 16% compared to the control group, but those offered additional monetary or environmental incentives achieved no further savings. Notably the effects persisted marginally post-intervention in the goal treatment. These results indicate that low-cost behavioral strategies like feedback, savings tips and goal setting can be as effective as costly incentives, providing a scalable and economical pathway for energy conservation initiatives.

**Keywords** Energy conservation · Incentives · Feedback · Goal-setting · Field experiment

**JEL Classification** Q50 · Q40 · C93 · D91

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## 1 Introduction

More than two-thirds of anthropogenic global greenhouse gas emissions are linked to energy production and consumption (World Resources Institute 2020). As the impact of climate change is becoming more and more serious each year, residential energy conservation is an important factor in reducing greenhouse gas emissions and fighting climate change. Approximately 25 percent of the total energy usage is consumed by the residential sector (International Energy Agency 2020). Consequently, many scholars examine different interventions to increase residential energy conservation efforts.<sup>1</sup>

The most common behavioral intervention consists of feedback reports on a household's previous energy consumption with some kind of social comparison to similar homes (see e.g. Allcott 2011), mainly due to low implementation costs. Studies show that these kinds of interventions reduce household energy consumption by approximately 2–4 percent (Allcott 2011) or even less (Andor et al. 2020), so their impact is limited.

One way to enhance the effect of these feedback reports might be to combine them with specific and realistic energy savings goals and energy savings tips (Harding and Hsiaw 2014; Locke and Latham 2002; Loock et al. 2013).

Another possibility to improve the effectiveness of feedback reports may be to offer monetary incentives for reducing electricity consumption (see e.g. Abrahamse et al. 2005; Dolan and Metcalfe 2015; Goetz et al. 2024; Maki et al. 2016). The idea is that these incentives may provide an additional, extrinsic source of motivation, especially for individuals who would otherwise not reduce electricity consumption. However, monetary incentives may not be necessary among households that already have a high intrinsic motivation to save energy for environmental reasons. On the contrary, monetary incentives can even crowd out intrinsic motivation and warm glow benefits of pro-environmental behavior (Mellström and Johannesson 2008; Sudarshan 2017). While it may be difficult to boost the motivation of intrinsically motivated individuals with monetary incentives, it may be possible by rewarding (further) electricity saving efforts by offering additional incentives for the environment (Mellström and Johannesson 2008; Gosnell et al. 2020). Intrinsically motivated households could thus increase their pro-environmental impact beyond their individual impact through saving electricity when their effort is rewarded with additional benefit to the environment.

This study investigates whether combining consumption feedback with realistic goal setting and two types of incentives— either a monetary reward for the household or an environmental contribution in the form of a donation to an environmental organization chosen by the household— can more effectively reduce electricity consumption compared to feedback and goal setting without such incentives.

To this end, we conducted a randomized field experiment with 442 households located on the campus of Nanyang Technological University (NTU) in Singapore over eight months.

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<sup>1</sup> Examples for these kind of interventions include, e.g. social norms and peer comparison (Allcott 2011; Ayres et al. 2013; Costa and Kahn 2013; Myers and Souza 2020), home energy audits (Considine and Sapci 2016), provision of information (Allcott and Rogers 2014; Martin and Rivers 2018; Newell and Siikamäki 2014), real-time aggregated consumption feedback (Houde et al. 2013) or (real-time) appliances specific feedback (Attari et al. 2014; Brülisauer et al. 2020; Tiefenbeck et al. 2018), group-level incentives (Bekker et al. 2010; Katzev and Johnson 1984; McClelland and Cook 1980; Sintov et al. 2016), provision of information and goal setting (Goetz et al. 2024; Harding and Hsiaw 2014; Karp et al. 2016; McCalley and Midden 2002), feedback reports and monetary incentives (Dolan and Metcalfe 2015; Hayes and Cone 1977; Pellerano et al. 2017; Sudarshan 2017).

After a two-month pre-intervention period in which baseline consumption data were collected, households in our field experiment were randomly assigned to the control group (*CONTROL*) or to one out of three treatment groups. The first treatment group (*GOAL*) received monthly energy consumption feedback and the goal of conserving 10% of their electricity consumption for three months—relative to the average in the pre-intervention period and some energy savings tips to reach the goal. The treatment groups (*MONEY* and *DONATION*) received the same feedback, tips and conservation goal, but reaching the 10% conservation goal was additionally incentivized. At the end of the three-month intervention period, one out of the three months was randomly selected to determine goal achievement. If a household achieved the electricity savings goal in that particular month, it received S\$100 in cash. At a kWh price of around S\$0.2156 (SP Group 2018) at the time of our experiment and an average household-level consumption of 495 kWh this incentive is roughly equivalent to a monthly electricity bill of a household in our sample (of S\$106.72 on average).<sup>2</sup> Households in the *MONEY* group who achieved the energy savings goal received the monetary incentive for themselves. Households in the *DONATION* condition faced the same payout conditions, but the money was donated to an environmental organization of the household's choice.

Our results show that compared to the control group, monthly feedback combined with an electricity savings goal and energy savings tips significantly reduced electricity consumption by approximately 16 percentage points in the intervention period.

Moreover, we find that neither the individual monetary incentive in the *MONEY* treatment nor the monetary incentive for an environmental charity in the *DONATION* treatment increased households' electricity conservation efforts beyond the effect of feedback, goal setting and tips in the *GOAL* treatment. Furthermore, while in the treatment with feedback and goal-setting alone, post-intervention effects were marginally significant, they did not persist in the two treatment groups with additional incentives.

Consequently, feedback combined with goal setting was equally effective as when combined with additional (financial) incentives. Policymakers may benefit from our findings when designing interventions to reduce electricity consumption.

The remainder of the paper is organized as follows: Section 2 explains the experimental set-up, the identification strategy, and the data of our study. The results are presented in Sect. 3. We discuss our results and conclude in Sect. 4.

## 2 Experimental Set-up

### 2.1 Sample Selection and Data

Our field experiment was conducted with staff households at Nanyang Technological University (NTU) in Singapore in 2018. All apartments on campus have the same or very similar facilities and appliances, for example, the same fan and air-conditioning devices. This has the advantage that appliance-specific aspects that could influence the usage and energy consumption of these devices (Andor et al. 2019) can be excluded. Consequently, most of the variance in electricity consumption is related to behavioral aspects and observable char-

<sup>2</sup>At the time of the study, S\$100 (100 Singapore Dollars) were equivalent to US\$75.



acteristics of the households. Moreover, all households on campus are served by the same utility provider and pay the same tariff as any other household in Singapore.

The study was framed as a sustainability project of NTU contributing to a 35% reduction in energy, water, and waste intensity (compared to 2011) pursued by the university. All households were part of the study by default (opt-out design). Of the approximately 600 staff apartments on campus, approximately 20% were not occupied or under renovation. The accommodation office provided a list of the 484 occupied apartments, which were all invited to be part of the study before they were assigned to the different treatments (see Appendix D for the information letter sent out by NTU). Of the 484 households contacted, 32 opted out before the start of the intervention. Another 10 households moved away from campus during the intervention period, which led to a total sample size of 442 households. Monthly electricity data from all participating households was available (our research team read out the electricity meters located outside of the apartments every month at the same time.)

Moreover, we randomly selected 152 households for the installation of sub-meters that measure granular data on air-conditioning and fan usage (see Appendix E for the invitation letter and consent form). A roll-out in all households was not possible due to budget constraints. With these more granular data, we had originally hoped to gain additional insights in specific conservation behaviors regarding indoor cooling, which is the largest household electricity end use in Singapore, accounting for 38 percent of the residential electricity consumption (Energy Efficient Singapore 2020). Unfortunately, the deployment of these sub-meters resulted in a couple of problems, in particular possible interaction effects between intervention and installation of devices (see Appendix A.1 and A.2 for details). In particular, the Column (3) results of Table 7 in Appendix A.2 indicate that the installation of the devices already triggered behavior. Therefore, we focus our main analysis on the group of households without an installed sub-meter ( $N=322$ ) and report the results of the full sample in the Appendix.

## 2.2 Experimental Conditions

Our study design comprises four experimental conditions and three periods: a two-month baseline period (February 20 to April 20, 2018), a three-month intervention period (April 21 to July 20, 2018), and a three-month post-intervention period (July 21 to October 20, 2018). Assignment to one of the four experimental conditions (*CONTROL*, *GOAL*, *MONEY*, and *DONATION*) was performed randomly after the initial data collection in the baseline period.<sup>3</sup> Table 1 shows the timeline of the study and an overview of the different experimental groups.

At the end of the baseline period the three treatment groups (*GOAL*, *MONEY*, and *DONATION*) received information about their electricity consumption in the baseline period (i.e. the two previous months), a 10% electricity conservation goal relative to the household's electricity consumption in the baseline period (2-month average) and energy savings tips

<sup>3</sup>An alternative and potentially more suitable baseline period would have been the same months of the intervention period in the previous year to control for seasonality both in households' consumption patterns and weather. For reasons of data availability, a generally low variation in temperature across the year in Singapore, and to avoid potential year-over-year changes in occupancy of apartments, we opted for a baseline period immediately preceding the intervention period.

**Table 1** Overview of the experimental design

	Control group	Feedback + goal ( <i>GOAL</i> )	Feedback + monetary incentivized goal ( <i>MONEY</i> )	Feedback + environmentally incentivized goal ( <i>DONATION</i> )
Sample size	Total: 112 (79 without sub-meter, 33 with)	Total: 112 (82 without sub-meter, 30 with)	Total: 112 (84 without sub-meter, 28 with)	Total: 106 (77 without sub-meter, 29 with)
<b>Phase I: Baseline</b> (21 Feb- 20 April; 2 months)	No intervention			
<b>Phase II: Intervention</b> (21 April - 20 July; 3 months)	No intervention	Feedback, savings tips, 10% energy conservation goal	Feedback, savings tips, 10% energy conservation goal with <b>monetary incentive</b> (S\$ 100 conditional on achievement)	Feedback, savings tips, 10% energy conservation goal with <b>environmental incentive</b> (S\$ 100 donated to an environmental organization conditional on achievement)
<b>Phase III: Post-intervention</b> (21 July - 20 Oct.; 3 months)	No intervention			

helping to reach the goal. The households were encouraged to reduce their electricity consumption to or below the goal in the following three months (intervention period). In the *GOAL* treatment, there was no incentive to reach the 10% electricity conservation goal.

In the other two treatment groups, *MONEY* and *DONATION*, reaching the 10% conservation goal was additionally incentivized. The respective households were informed that at the end of the three-month intervention period, one out of the three months would be randomly selected to determine goal achievement. If a household achieved the electricity savings goal in that particular month, it received either S\$100 in cash (*MONEY*) or the S\$100 was donated to an environmental charity of the household's choice (*DONATION*); see Appendix D for the energy savings tips and the additional treatment descriptions).

At the end of each month, the households received reports mailed by post, informing them whether they had achieved the electricity savings goal in that month, reminding them of the conservation goal, and providing energy savings tips. While the reminders were otherwise identical between the treatments, households in *MONEY* and *DONATION* were additionally reminded about the monetary incentives for themselves or for charity. In addition, the households also received this information and the energy savings tips via e-mail every two weeks (see Appendix D). After the intervention period, no additional feedback reports were sent to the households.<sup>4</sup>

Households in the control group received neither information nor feedback about their electricity consumption or energy savings tips during the entire study period. However, they were aware of the ongoing energy challenge at NTU and all households on campus generally receive an electronic electricity bill with information about their current monthly and

<sup>4</sup>Two weeks after the intervention period, the households were informed which month had been randomly selected to determine goal achievement. The electricity consumption in that month was compared to their consumption in the baseline period. If they reached the goal, they were informed that they would receive the incentive (payment or donation). One month later, the incentives were paid out to the households (*MONEY*) or to the charity of their choice (*DONATION*).

historical electricity consumption and the amount to be paid. Thus, in principle, households in all conditions had access to information about their individual electricity consumption.

### 2.3 Identification Strategy and Descriptive Statistics

For the analysis, we use a differences-in-differences estimation strategy with monthly energy consumption as the dependent variable. Standard errors were clustered at the household level. Additional robustness checks, including regressions for the entire sample, are provided in Appendix C.

Table 2 shows the household characteristics of the experimental groups. Our sample (322 households without sub-meters) consists of 79 households in the *CONTROL* group, 82 in the *GOAL* group, 84 in the *MONEY* group and 77 households in the *DONATION* group, respectively. The majority (80%) of the households had three bedrooms, 18% had two bedrooms and only 3% had more than three bedrooms. As the study was conducted in academic staff housing, most households had one member that was a faculty (professor or post-doc). Thus, our residents are more educated than the average Singaporean population with an upper-medium income level. F-tests did not indicate significant differences between the different experimental conditions in terms of these characteristics.

As Table 2 shows, there are also no significant differences in the key dependent variable of monthly electricity consumption in the baseline period. On average, the households consumed 495 kWh per month during the baseline period.

**Table 2** Household characteristics

	CONTROL	GOAL	MONEY	DONATION	F-statistic
<b>No. of Bedrooms %</b>					
2 Bedrooms	0.18 (0.38)	0.17 (0.38)	0.20 (0.40)	0.14 (0.35)	0.797
3 Bedrooms	0.80 (0.40)	0.79 (0.41)	0.77 (0.42)	0.86 (0.35)	0.529
More than 3 Bedrooms	0.03 (0.16)	0.04 (0.19)	0.02 (0.15)	0.00 (0.0)	.
<b>Monthly electricity Use in kWh</b>					
Baseline	486.3 (298.7)	522.0 (326.0)	494.1 (303.8)	508.7 (378.1)	0.895
Intervention	471.8 (319.8)	439.4 (291.6)	422.2 (291.5)	443.3 (366.9)	0.357
Post-intervention	495.5 (292.2)	489.6 (300.0)	479.9 (295.5)	494.4 (385.9)	0.940
<b>Households</b>	79	82	84	77	

Notes: Means of key household characteristics, standard deviation in parentheses. Percentages add up to 100 within columns. The F-test column displays the p-value for the test

$$\beta_{GOAL} = \beta_{MONEY} = \beta_{DONATION} = 0$$

### 3 Results

Table 3 presents the results of the difference-in-difference regressions testing for the significance of our interventions. We find that all three treatment groups significantly reduced their monthly energy consumption between 51 kWh (13 percent) and 68 kWh (16 percent) compared to the control group during the intervention period (see coefficients related to intervention).<sup>5</sup> Thus, the results indicate that our intervention had a large and significant impact on the energy consumption of the treated households (see also Table 8 in the appendix for non-parametric tests and Table 9 for regressions including fixed effects). Figure 1 presents the results graphically. The treatment effect is sizable compared to previous studies (between 0% and 8%) that provided feedback on aggregated household electricity use (see e.g. Allcott 2011; Dolan and Metcalfe 2015).

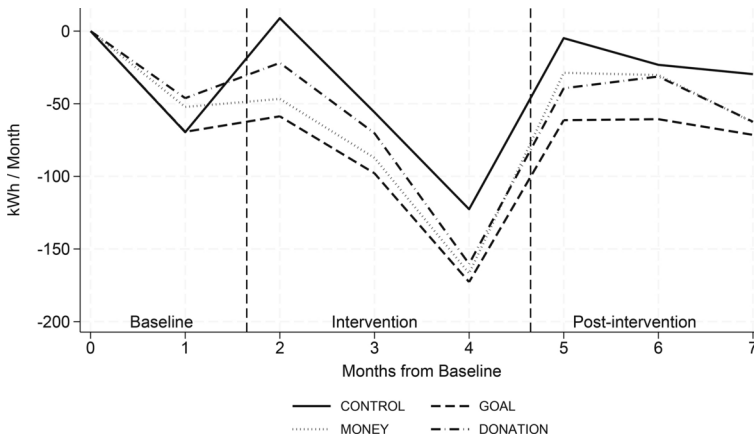
However, the effects of the different treatments are not statistically different from each other, as revealed by two-sided post-estimation Wald tests (*GOAL* vs. *MONEY*:  $F(1,321)=0.24$ ,  $p\text{-value}=0.62$ ; *GOAL* vs. *DONATION*:  $F(1,321)=0.57$ ,  $p\text{-value}=0.45$ ; *MONEY* vs. *DONATION*:  $F(1,321)=0.07$ ,  $p\text{-value}=0.79$  in the intervention phase, respectively). Panel A of Table 4 shows that only very few (between 13% and 17%) households in

**Table 3** Treatment effects on electricity consumption

	(1)	(2)	(3)	(4)
<i>GOAL</i>	35.63 (49.12)	17.43 (43.72)	0.12 (0.11)	0.08 (0.10)
<i>MONEY</i>	7.59 (47.08)	-1.24 (41.68)	0.04 (0.11)	0.02 (0.10)
<i>DONATION</i>	22.22 (54.49)	11.28 (48.92)	0.03 (0.12)	-0.01 (0.11)
<b>Intervention</b>				
<i>GOAL</i>	-67.99** (26.66)	-67.99** (26.71)	-0.16** (0.06)	-0.16** (0.06)
<i>MONEY</i>	-57.14** (27.40)	-57.14** (27.46)	-0.15** (0.06)	-0.15** (0.07)
<i>DONATION</i>	-50.67* (28.05)	-50.67* (28.10)	-0.13* (0.06)	-0.13* (0.06)
<b>Post-Intervention</b>				
<i>GOAL</i>	-41.55* (22.40)	-41.67* (22.32)	-0.11* (0.06)	-0.11* (0.06)
<i>MONEY</i>	-23.18 (22.40)	-23.18 (22.32)	-0.08 (0.06)	-0.08 (0.06)
<i>DONATION</i>	-23.35 (25.95)	-23.35 (26.00)	-0.09 (0.06)	-0.09 (0.06)
<b>Intervention</b>				
	-14.59 (22.08)	-14.59 (22.12)	-0.05 (0.05)	-0.05 (0.05)
<b>Post-Intervention</b>				
	9.16 (18.11)	9.16 (18.15)	0.05 (0.05)	0.05 (0.05)
<b>N</b>	2568	2568	2568	2568
<b>R<sup>2</sup></b>	.007	.193	.012	.208

Column (1) DiD on monthly electricity consumption in kWh without control, (2) with controls (number of bedrooms, housetype and job position), (3) in logs without controls, (4) in logs with controls. Coefficients are statistically significant at the \*10%, \*\*5%, \*\*\*1% level. Standard errors are clustered at the household level

<sup>5</sup>Note that the first three dummies *GOAL*, *MONEY* and *DONATION* correspond to differences at baseline between the control group and the three treatment groups, as shown in Table 2.



**Fig. 1** Monthly energy consumption over time by experimental condition

the treatment conditions never reached the goal in the three-month intervention period. This shows that the majority of the households that were part of our intervention reduced their electricity consumption in at least one month. Approximately 21 percent of the households in the three treatment conditions reached the 10% energy conservation goal in all three months. Panel B–D of the table show the goal achievement rate by month of intervention and the probabilities of reaching a goal in the second (third) month of the intervention period, conditionally on having reached the goal in the first (second) month of the intervention period. There is no statistically significant difference in the goal achievement rates between the three experimental conditions.

Compared with the control group, our treatment effects also persist in the post-intervention period in the *GOAL* group (see post-intervention coefficients in Table 3). We observe a significant reduction in monthly electricity consumption by 42 kWh (11 percentage points) between the baseline and post-intervention periods for households in this group compared to the control group. For the *MONEY* and *DONATION* groups, the coefficients are also negative in the post-intervention period, but the effects are not significant compared to the control group. Overall, our incentives (monetary and environmental incentives) do not seem to induce an additional boost in pro-environmental efforts for electricity conservation.

## 4 Discussion and Conclusion

Our study contributes to a growing body of empirical studies showing that feedback interventions can reduce resource electricity (and more generally: resource) consumption irrespective of (monetary) incentives (Tiefenbeck et al. 2019). Our findings thus complement the studies on Home Energy Reports (Allcott 2011; Allcott and Rogers 2014), which document the large-scale feasibility of feedback interventions with very large samples, yet with modest savings effects in the range of 0.7 to 2% (Allcott and Rogers 2014; Andor et al. 2020) of household electricity consumption. In those studies, it remains unclear to what extent the savings are driven by social norms, environmental considerations, monetary considerations (reducing the household electricity bill), or a mix thereof. Tiefenbeck et al. (2019), on the

**Table 4** Number of households reaching the 10% energy conservation goal in the intervention period

# of times the goal was achieved	GOAL	MONEY	DONATION	Total
<b>Panel A: Overall - All intervention months</b>				
Never	13 (15.85%)	11 (13.10%)	13 (16.88%)	37 (15.23%)
In one month	27 (32.93%)	27 (32.14%)	21 (27.27%)	75 (30.86%)
In 2 months	24 (29.27%)	28 (33.33%)	27 (35.06%)	79 (32.51%)
In all 3 months	18 (21.95%)	18 (21.43%)	16 (20.78%)	52 (21.40%)
<b>Panel B: 1st Intervention Month</b>				
1st Month only	28 (34.15%)	32 (38.1%)	30 (38.96%)	90 (37.04%)
Not Reached	54 (65.85%)	52 (61.9%)	47 (61.04%)	153 (62.96%)
<b>Panel C: 2nd Intervention Month</b>				
2nd Month only	25 (30.49%)	23 (27.38%)	20 (25.97%)	68 (27.98%)
1st & 2nd Month	19 (23.17%)	19 (22.62%)	18 (23.38%)	56 (23.05%)
Not Reached	38 (46.34%)	42 (50.00%)	39 (50.65%)	119 (48.97%)
<b>Panel D: 3rd Intervention Month</b>				
3rd Month only	16 (19.51%)	18 (21.43%)	14 (18.18%)	48 (19.75%)
2nd & 3rd Month	16 (19.51%)	19 (22.62%)	13 (16.88%)	48 (19.75%)
1st & 3rd Month	7 (8.54%)	8 (9.52%)	12 (15.58%)	27 (11.11%)
1st, 2nd & 3rd Month	18 (21.95%)	18 (21.43%)	16 (20.78%)	52 (21.40%)
Not Reached	25 (30.49%)	21 (25.00%)	22 (28.57%)	68 (27.98%)
<b>Total households</b>	82 (100%)	84 (100%)	77 (100%)	243 (100%)

In panel A, the table shows the number of months in which the households reached the goal in the 3-month intervention period. Panels B - D show conditional probabilities of reaching the goal of households in the 1st, 2nd and 3rd month of the intervention period, respectively

other hand, show in a study with hotel guests that feedback on resource consumption can yield large savings in the complete absence of monetary incentives. Our study complements these findings by showing that at least in our sample, the conservation effect achieved by feedback, goal setting and energy savings tips alone is not augmented by the additional provision of substantial (financial) incentives, neither in the form of direct monetary incentives for the household itself, nor in form of a donation to an environmental organization. Importantly, our monetary incentives are well above those used in other studies where incentives for energy conservation are often limited to the savings that accrue from the kWh saved (e.g., Allcott and Rogers 2014), or only participation is incentivized (typically by providing

an in-home-display for free), but no additional payouts for electricity savings are provided (e.g., Carroll et al. 2014; Mogles et al. 2017; van Dam et al. 2010).

In all three treatment groups, the effects are sizable compared to other feedback studies in the electricity conservation field. Most studies in which participants receive feedback on their consumption at the household level report reductions in the range of 0.7% (Andor et al. 2020) and 8% (Dolan and Metcalfe 2015). In fact, effect sizes in our study are more comparable to studies in which participants receive feedback on their resource consumption in energy-intensive end-uses such as air-conditioning or showering: For comparison, Brülisauer et al. (2020) report a 17% conservation effect on energy use for air-conditioning and Tiefenbeck et al. (2018) report an 22% average treatment effect on energy (and water) use in the shower.

One reason why electricity savings in our study may have been more substantial compared to similar interventions (providing feedback at the household level) is that our study was conducted in Singapore, a country with tropical climate conditions, and thus, high demand for indoor cooling. In that climate, the levers for electricity savings are much larger than those in moderate zones where indoor cooling does not make up for a large share in the electricity consumption of households. In other temperature zones like Europe, e.g., heating which is mostly does not rely on electricity is one of the drivers of resource use. Our results are therefore in line with the large effects reported by Brülisauer et al. (2020), whose study also took place in Singapore, albeit with an appliance-specific focus on air-conditioning. Conversely, Andor et al. (2020) report much smaller conservation effects when replicating the Opower studies (that Allcott (2011) had conducted in the United States) in European countries with a more moderate climate. These findings indicate that in countries where appliances account for only a small fraction of residential energy use, households have a smaller margin to realize substantial electricity savings, compared to households in hot, humid, or tropical climate zones. Moreover, from a self-efficacy perspective, it is more likely that individuals keep up their efforts when they realize that their actions actually make a meaningful difference (Bandura 2010). While the effect of cutting down on the use of air conditioning is likely to be noticeable on the monthly electricity bills, conservation efforts related to low-electricity-consuming appliances (e.g., switching off lights) hardly result in meaningful savings, which makes it less likely that individuals will maintain their efforts.

Another potential reason for the sizable effects observed in our study is that the pre-installed fans in the apartments offered a low-consumption alternative for indoor cooling that allowed households to maintain a similar, or at least adequate level of comfort. The availability of this alternative might have left the households' utility in terms of cooling relatively stable. Our analysis in Appendix A.1 supports this argument. When analyzing electricity consumption of households with sub-meters, our results suggest that at least some households substitute air conditioning with fan use.

We can also not rule out that our sample, given its fairly high income and education level, is more receptive to pro-environmental messages and less responsive to monetary incentives than the average population. Although our (financial) incentives were substantially larger than the mere cost savings through lower kWh consumption in other studies, it might be that our incentives (that benefited participants themselves or an environmental charity) were not sufficiently strong to serve as a meaningful source of motivation for additional conservation efforts beyond the effect already achieved by the *GOAL* treatment. Moreover, our study was conducted with staff households on an university campus. Therefore, there might be an

effect linked to participants' relationship with the university. For example, households may have been motivated to comply to impress their employer or to contribute to the university's research goals. This may contribute to our effect size and may explain why we do not see an immediate treatment effect beyond the *GOAL* treatment. Given the high level of education of our sample and our subject pool, caution is warranted with respect to the external validity of the findings.

However, there are also arguments suggesting that our effects actually represent lower bounds. For example, our experiment was conducted with university employees and spillover effects from treated to control households cannot be discarded. This would imply that we underestimate our effects. Similarly, our intervention period included the semester break where many households may have been absent. Effects could therefore be even more pronounced during another three month period during a year or with a different sample. Additional studies should try to investigate if the results can be replicated with a more representative sample.

Overall, our findings contribute to the understanding of residential electricity conservation interventions by showing that low-cost behavioral interventions may already be effective in inducing electricity-saving behavior. They can easily be scaled, as they do not necessarily need to be accompanied by additional monetary incentives (for oneself or as an additional incentive for the environment). Our results suggest that targeting behavioral interventions to high-electricity-consuming appliances is promising as an effective strategy to combat climate change. Moreover, our findings indicate that the availability of alternative appliances that consume less electricity may play an important role in the effectiveness of behavioral interventions. We conjecture that technological innovations and behavioral interventions may be a potent combination to combat climate change and reduce electricity consumption in the residential sector. However, more studies are needed to better understand the interplay between behavioral measures and energy-efficient technologies.

## **A: Additional Analysis Including Households with Sub-meter for Air-conditioning and Fan Usage**

### **A.1: Descriptive Data of Households with Sub-meters**

As outlined in Sect. 2, the original sample consisted of 484 households, out of which 152 households were randomly selected to have a sub-meter installed in their apartment. The goal was to collect more granular data in that sub-sample to better understand if participants would substitute the use of energy-intensive air-conditioning with fans as a much more energy-efficient alternative cooling technology. However, due to the methodological issues described in the following section (A.2), our main analysis focuses on the sample of households without sub-meters. Nevertheless, for transparency reasons, we also report the results of the households with sub-meters. To that end, we first provide additional information and descriptive data of the sample with sub-meters in this section and present the results of the households with sub-meters in the Sect. A.2.

The sub-meters were small white boxes that were (typically) installed in the kitchen or storage room at the end of the baseline period. Households were informed that the sub-



meters would collect high-resolution data regarding patterns of electricity consumption, but were not aware that the devices only monitored air conditioning and fan consumption. Out of the 152 households selected, 20 households either refused to receive a sub-meter or an appointment for installation was not possible due to a lack of availability. Another 12 sub-meters had to be uninstalled because of maintenance work in the houses during the intervention or had data connection issues. This led to a total of 120 households with working sub-meters in our dataset.

Table 5 shows the average monthly electricity consumption in the months before the installation of the sub-meter distribution. While there are some differences in monthly electricity consumption for households with and without sub-meter (e.g. the control group with sub-meter has a monthly electricity consumption of 388 kWh before the installation of the device, while the control households without the device have a monthly consumption of 455 kWh), these differences are not significant at conventional levels.

## A.2: Analysis of the Full Sample

Table 6 presents an extended version of the results presented in Table 3. It includes two additional columns (5 and 6) with the results of two additional fixed-effects regressions with daily electricity consumption for air-conditioning and fan usage as dependent variables on the sub-sample of households with sub-meters. The average daily electricity use for air-conditioning in households with sub-meters in the baseline period ranged between 3.7 and 4.4 kWh, depending on the experimental condition. Column (5) suggests that our intervention significantly decreased daily air conditioning usage by approximately 2 kWh. This corresponds to a very large reduction of approximately 50%, which would add up to approximately 60 kWh per month. Conversely, column (6) indicates that fan usage increased with the intervention. Average daily baseline fan consumption was between 0.49 kWh and 0.62 kWh depending on the experimental condition. This indicates that households may have substituted air-conditioning with fans as a more energy-efficient means of indoor cooling. Although the positive coefficients for the daily electricity consumption of fans are not significant at conventional levels, they indicate that (at least some of the) households intended to maintain levels of comfort by resorting to alternative (low consumption) appliances.

Table 7 shows the treatment effects depending on the sample restrictions. Column (1) of the table shows that the main treatment effects for our full sample in the in the intervention period and the post-intervention period are robust. They are smaller yet, sizeable compared to previous studies. Treatment effects for all households are smaller because of a limited impact of our interventions on households with installed sub-meters (see column (3)). Effects for households with installed sub-meter are smaller because of potential differences pre-experiment. Additional analysis controlling for time trends show a similar (directional) effect for all households (including and excluding sub-meters).

**Table 5** Average electricity consumption in September and November (2017) by sub-meter installation

	Pooled	Control	Goal	Money	Donation
Sub-meter	415.07	387.76	384.96	443.75	449.60
No sub-meter	445.94	455.12	442.00	433.70	454.08
T-test	0.31	0.21	0.31	0.88	0.95

Average electricity consumption in October and November 2017 (=three months before the start of our experiment) was provided to us by the management of the University

## B: Cost Calculation for Scale-up

The cost calculation for the scale-up is based on the assumption that all Singaporean households behave like the households in the *MONEY* group of our sample and that (like in our experiment) one out of the three intervention months is randomly selected. We calculate with 1.372.400 Singaporean households (Department of Statistics Singapore 2020). The goal achievement rates can be found in Table 4.

$$\begin{aligned} \text{Expected costs} &= 1.372.400 \text{ Households} \times 0.32 \times \frac{1}{3} \times S\$100 \\ &\quad + 1.372.400 \text{ Households} \times 0.33 \times \frac{2}{3} \times S\$100 \\ &\quad + 1.372.400 \text{ Households} \times 0.21 \times S\$100 \\ &= S\$73.653.133 \end{aligned}$$

**Table 6** Treatment effects on electricity consumption and indoor cooling

	(1)	(2)	(3)	(4)	(5)	(6)
<i>GOAL</i>	35.63 (49.12)	17.43 (43.72)	0.12 (0.11)	0.08 (0.10)		
<i>MONEY</i>	7.59 (47.08)	-1.24 (41.68)	0.04 (0.11)	0.02 (0.10)		
<i>DONATION</i>	22.22 (54.49)	11.28 (48.92)	0.03 (0.12)	-0.01 (0.11)		
<b>Intervention</b>						
<i>GOAL</i>	-67.99** (26.66)	-67.99** (26.71)	-0.16** (0.06)	-0.16** (0.06)	-2.30*** (0.58)	0.12 (0.12)
<i>MONEY</i>	-57.14** (27.40)	-57.14** (27.46)	-0.15** (0.06)	-0.15** (0.07)	-1.53*** (0.56)	-0.04 (0.13)
<i>DONATION</i>	-50.67* (28.05)	-50.67* (28.10)	-0.13* (0.06)	-0.13* (0.06)	-1.48*** (0.57)	0.05 (0.13)
<b>Post-Intervention</b>						
<i>GOAL</i>	-41.55* (22.40)	-41.67* (22.32)	-0.11* (0.06)	-0.11* (0.06)	-1.39 (1.02)	0.14 (0.14)
<i>MONEY</i>	-23.18 (22.40)	-23.18 (22.32)	-0.08 (0.06)	-0.08 (0.06)	-1.08 (0.86)	0.02 (0.17)
<i>DONATION</i>	-23.35 (25.95)	-23.35 (26.00)	-0.09 (0.06)	-0.09 (0.06)	-0.36 (0.86)	0.03 (0.14)
<b>Intervention</b>						
	-14.59 (22.08)	-14.59 (22.12)	-0.05 (0.05)	-0.05 (0.05)		
<b>Post-Intervention</b>						
	9.16 (18.11)	9.16 (18.15)	0.05 (0.05)	0.05 (0.05)		
<b>N</b>	2568	2568	2568	2568	28492	28492
<b>R2</b>	.007	.193	.012	.208	.026	.025

Column (1) DiD on monthly electricity consumption in kWh without control, (2) with controls (number of bedrooms, housetype and job position), (3) in logs (4) in logs with controls, (5) FE regression on daily AC consumption, (6) FE regression on daily fan consumption in kWh (both with months fixed effects). Kindly note that regressions (1), (2) (3) and (4) include only households without installed sub-meter and monthly values whereas regressions (5) and (6) are run on the sample with sub-meters only (N=120 Households) with daily consumption values. Coefficients are statistically significant at the \*10%, \*\*5%, \*\*\*1% level. Standard errors are clustered at the household level

**Table 7** Differences-in-Differences regression on monthly energy consumption in kWh - Households with and without sub-meter (SM)

	All HH	HH without SM	HH with SM
<i>GOAL</i>	17.17 (40.15)	35.63 (49.12)	-35.08 (66.84)
<i>MONEY</i>	13.86 (41.04)	7.59 (47.08)	29.52 (86.16)
<i>DONATION</i>	23.05 (44.19)	22.22 (54.49)	23.88 (73.16)
<b>Intervention</b>			
<i>GOAL</i>	-38.95* (22.70)	-67.99** (26.66)	32.43 (41.92)
<i>MONEY</i>	-36.86 (23.09)	-57.14** (27.40)	9.71 (41.00)
<i>DONATION</i>	-38.71 (23.87)	-50.67* (28.05)	-13.10 (43.76)
<b>Post-Intervention</b>			
<i>GOAL</i>	-41.29** (20.08)	-41.55* (22.40)	-38.25 (42.29)
<i>MONEY</i>	-29.29 (20.08)	-23.18 (22.40)	-47.57 (42.29)
<i>DONATION</i>	-25.31 (21.83)	-23.35 (25.95)	-30.45 (39.32)
<b>Intervention</b>			
	-38.11** (18.76)	-14.59 (22.08)	-94.41*** (33.89)
<b>Post-Intervention</b>			
	8.49 (16.73)	9.16 (18.11)	6.44 (36.85)
<b>N</b>	3524	2568	956
<b>R2</b>	.009	.007	.023

Column (2) *HH without SM* corresponds to the results presented in table 3, Column (1). Coefficients are statistically significant at the \*10%, \*\*5%, \*\*\*1% level. Standard errors clustered at the household level

Scaling up the financial incentives to one year would thus imply costs of  $S\$73,7M \times 4 = S\$294,612M$  (approximately US\$220 Million).

### C: Robustness Checks and Additional Analysis

#### C: Treatment Effects with Wilcoxon-Mann-Whitney-Test

**Table 8** Test for differences in monthly energy consumption between experimental groups

	(1)	(2)	(3)
Control vs. Goal	0.59	0.00	0.00
Control vs. Money	0.97	0.00	0.00
Control vs. Donation	0.81	0.01	0.00
Goal vs. Money	0.59	0.98	0.70
Goal vs. Donation	0.45	0.66	0.96
Money vs. Donation	0.81	0.82	0.80

P-values from Wilcoxon rank-sum (Mann-Whitney) test comparing differences of monthly energy consumption by experimental group. Column (1) average monthly electricity consumption at baseline, (2) difference in average monthly electricity consumption from baseline to intervention period, (3) difference in average monthly electricity consumption from baseline to post-intervention period. N=79 for *Control*, N=82 for *Goal*, N=84 for *Money* and N=77 for *Donation* in each period. Baseline consumption is 486.34 kWh for *Control*, 521.97 kWh for *Goal*, 493.93 kWh for *Money* and 508.56 kWh for *Donation*. Difference in electricity consumption intervention period to baseline -14.59 kWh for *Control*, -82.58 kWh for *Goal*, -71.73 kWh for *Money* and -65.27 kWh for *Donation*. Difference in electricity consumption post-intervention period to baseline 9.16 kWh for *Control*, -29.82 kWh for *Goal*, -14.02 kWh for *Money* and -14.19 kWh for *Donation*

## C.2: Fixed-Effects Regression

**Table 9** Fixed-Effect regression on monthly electricity consumption in kWh

	Effect on monthly kWh
Goal × Intervention	-67.99** (26.67)
Money × Intervention	-57.14** (27.42)
Donation × Intervention	-50.67* (28.06)
Goal × Post-Intervention	-40.93* (22.47)
Money × Post-Intervention	-23.18 (20.05)
Donation × Post-Intervention	-23.35 (25.96)
N	2568
R <sup>2</sup>	0.12

Coefficients are statistically significant at the \*10%, \*\*5%, \*\*\*1% level. Standard errors clustered at the household level. Months fixed effects included

## D: Study Information, Treatment Messages and Energy Savings Tips

Dear Sir/Mdm (Serial Number: **S700**),

NTU has set to achieve the goal of 35% reduction in energy, water, and waste intensity by 2020 as compared to the baseline of 2011.

To help NTU attain our sustainability goal, EcoCampus will be conducting a project to gain a better understanding of household electricity and water consumption on campus. This project should span 17 months, starting from January 2018 to May 2019.

As part of this project, your cooperation and understanding are needed in the following:

- (a) Monthly meter reading of the power and water meters, which are located outside your apartment, by the EcoCampus Team. Special care would be taken to ensure this process would be undertaken in a non-intrusive and respectful manner.
- (b) You might also subsequently receive more information regarding your household electricity consumption from NTU EcoCampus.
- (c) NTU EcoCampus, with the support of NTU HAS, will be installing a high-granularity electricity sub-meter in a subset of NTU faculty staff housings. If selected, we will contact you separately later.

While we value your participation, should you wish to remove your household from participating in this project, you may easily do so at any point in time. However, in order to help us to ascertain the number of households who would not mind participating, we invite those who do not wish to participate to opt-out by **8 December 2017**. Subsequently, those who wish to opt-out may still do so later.

To exercise the dropout option: Please visit <https://goo.gl/forms/YfZKZ75z0DtDfpZ62>, where you can indicate your preference to opt-out anonymously via the serial number shown above (next to "Dear Sir/Mdm"). We emphasise that the decision to participate in our project (or not) will have no impact to your existing relationship with the university or NTU EcoCampus in any way.

If you have any queries regarding this project, you may contact the Principal Investigator of the project, Mr Nilesh Jadhav, via [ecocampus@ntu.edu.sg](mailto:ecocampus@ntu.edu.sg).

Thank you.

**Mr Nilesh Y. Jadhav**

Programme Director, EcoCampus, Energy Research Institute @ NTU (ERI@N)

Email: [ecocampus@ntu.edu.sg](mailto:ecocampus@ntu.edu.sg) | [nilesh@ntu.edu.sg](mailto:nilesh@ntu.edu.sg) | Tel: (+65) 6908 1480

*This project was reviewed by the Institutional Review Board, Research Integrity and Ethics Office of NTU.*

*NTU-Institutional Review Board Research Integrity and Ethics Office*

*50 Nanyang Avenue, North Spine NS4-05-92A Singapore 639798*

*Email: [irb@ntu.edu.sg](mailto:irb@ntu.edu.sg) | Tel: +65 6592 2495*

Note: Information CONTROL + ALL treatments



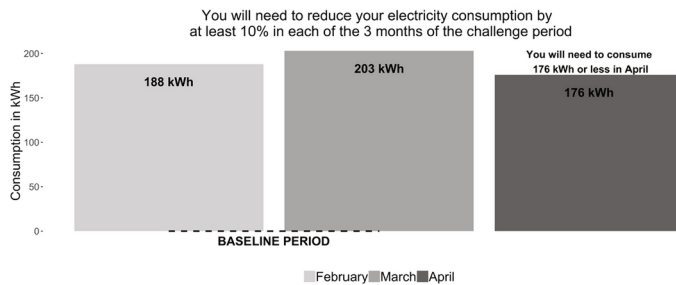
Dear XXX,

To demonstrate how easy it is to save energy, NTU-EcoCampus organises the "Energy Challenge", which starts on **25th March 2018**. The Challenge is a call to households at NTU campus to reduce their electricity consumption and contribute to a sustainable environment.

In this "Energy Challenge", we ask you to reduce your electricity consumption by **10% or more** in each of the three months of the "**Challenge Period**" (i.e. **April, May and June 2018**).

Your electricity consumption in each of the months of the Challenge will be compared with your average consumption in the "**Baseline Period**" (i.e. **February and March 2018**).

**Your average electricity consumption in February and March was 195 kWh. We ask you to reduce your electricity usage by 10% or more next month. This means that you need to consume 176 kWh or less. We will inform you at the end of next month whether you achieved this electricity reduction goal.**



- ✓ Reduce your energy consumption to 176 kWh or less in each of the three months of challenge

Sincerely,

NTU EcoCampus.

Disclaimer: The meter readings might be taken in different days than the ones from SP services, which can result in dissimilar kWh consumed in the month considered. If you do not wish to receive further information regarding your electricity consumption or have further queries, please contact [ecocampus@ntu.edu.sg](mailto:ecocampus@ntu.edu.sg).

Note: GOAL treatment



Dear XXX,

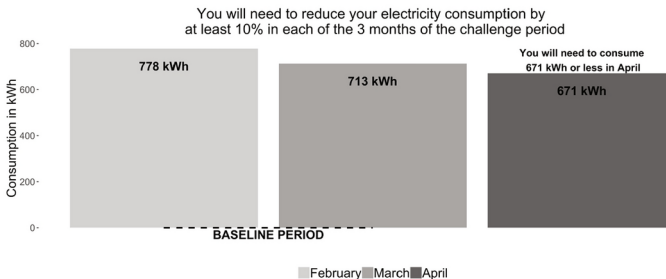
To demonstrate how easy it is to save energy, NTU-EcoCampus organises the "Energy Challenge", which starts on **25th March 2018**. The Challenge is a call to households at NTU campus to reduce their electricity consumption and contribute to a sustainable environment.

In this "Energy Challenge", we ask you to reduce your electricity consumption by **10% or more** in each of the three months of the "**Challenge Period**" (i.e. **April, May and June 2018**).

Your electricity consumption in each of the months of the Challenge will be compared with your average consumption in the "**Baseline Period**" (i.e. **February and March 2018**).

**At the end of the "Challenge Period", one out of the three months of the Challenge (i.e. April, May or June) will be randomly selected and if you achieved the goal in that particular month, you will be rewarded with a monetary payment of \$100 cash.**

**Your average electricity consumption in February and March was 746 kWh. We ask you to reduce your electricity usage by 10% or more next month. This means that you need to consume 671 kWh or less. We will inform you at the end of next month whether you achieved this electricity reduction goal.**



- ✓ If your consumption in any one of the next three months is 671 kWh or less
  - ✓ You stand a chance to win \$100 cash!
- ✓ The more months you achieve the goal, higher are your chances to win

Sincerely,

NTU EcoCampus.

Disclaimer: The meter readings might be taken in different days than the ones from SP services, which can result in dissimilar kWh consumed in the month considered. If you do not wish to receive further information regarding your electricity consumption or have further queries, please contact [ecocampus@ntu.edu.sg](mailto:ecocampus@ntu.edu.sg).

Note: MONEY treatment



Dear XXX,

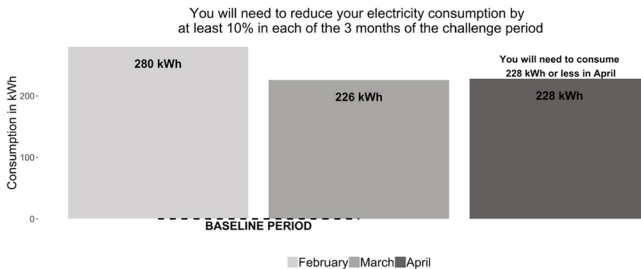
To demonstrate how easy it is to save energy, NTU-EcoCampus organises the "Energy Challenge", which starts on **25th March 2019**. The Challenge is a call to households at NTU campus to reduce their electricity consumption and contribute to a sustainable environment.

In this "Energy Challenge", we ask you to reduce your electricity consumption by **10% or more** in each of the three months of the "**Challenge Period**" (i.e. **April, May and June 2018**).

Your electricity consumption in each of the months of the Challenge will be compared with your average consumption in the "**Baseline Period**" (i.e. **February and March 2018**).

**At the end of the "Challenge Period", one out of the three months of the Challenge (i.e. April, May or June) will be randomly selected and if you achieved the goal in that particular month, you will be rewarded with a \$100 to be donated to an Environmental Charity of your choice.**

**Your average electricity consumption in February and March was 253 kWh. We ask you to reduce your electricity usage by 10% or more next month. This means that you need to consume 228 kWh or less. We will inform you at the end of next month whether you achieved this electricity reduction goal.**



- ✓ If your consumption in any one of the next three months is 228 kWh or less
- ✓ You can be rewarded with \$100 to donate to an Environmental Charity!
- ✓ The more months you achieve the goal, higher are your chances to win

Sincerely,

NTU EcoCampus.

Disclaimer: The meter readings might be taken in different days than the ones from SP services, which can result in dissimilar kWh consumed in the month considered. If you do not wish to receive further information regarding your electricity consumption or have further queries, please contact [ecocampus@ntu.edu.sg](mailto:ecocampus@ntu.edu.sg).

Note: DONATION treatment



## We share with you some energy saving tips to help you save energy and reduce your energy bill

To save energy is easier than you think by following the advices below!



If you use an air conditioner, **set the temperature at 25°C or higher**.  
You could **save up to \$25 a year for every degree you raise**.



Air-conditioners account for the bulk of a household's electricity bill.  
**A fan uses less than 1/10th the electricity of an air-conditioner!**  
This means you **save up to \$840 a year**.



Standby power can account for up to 10% of your home electricity use.  
**Don't leave electrical appliances on standby.**  
Switch them off when not in use and you can **save up to \$70 a year**.



Use more efficient lighting fixtures such as LED.  
**By choosing energy-efficient light bulbs, you can save up to \$30 a bulb per year.**



**Choose an energy-efficient appliance** (e.g. air-conditioner, refrigerator) by checking the energy labels. A 4-tick air-conditioner **saves you about \$450 in electricity bills a year** compared with a 1-tick model. A 4-tick refrigerator saves you about \$70 a year, when compared with a 2-tick model.



Note: Energy savings tips sent to all households in GOAL, MONEY and DONATION in all intervention months



Dear XXXXX,

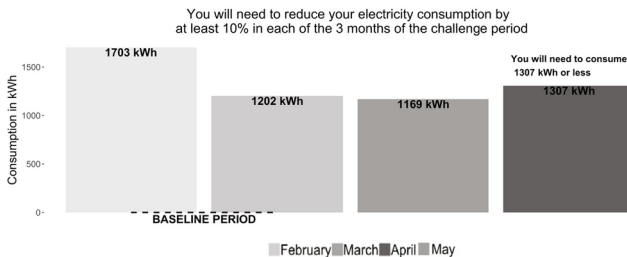
To demonstrate how easy it is to save energy, NTU-EcoCampus organises the "Energy Challenge", which started on **25th March 2018**. The Challenge is a call to households at NTU campus to reduce their electricity consumption and contribute to a sustainable environment.

In this "Energy Challenge", we ask you to reduce your electricity consumption by **10% or more** in each of the three months of the "**Challenge Period**" (i.e. **April, May and June 2018**) compared with your average consumption in the "**Baseline Period**" (i.e. **February and March 2018**).

**Your average electricity consumption in February and March was 1452 kWh. We ask you to reduce your electricity usage by 10% or more next month. This means that you need to consume 1307 kWh or less. We will inform you at the end of next month whether you achieved this electricity reduction goal.**

**Your consumption in April was 1169 kWh. WELL DONE!**

**Please, keep reducing your energy consumption during the next two months of the Challenge!**



- ✓ Reduce your energy consumption to 1307 kWh or less in each of the three months of the Challenge

Sincerely,

NTU EcoCampus.

Disclaimer: The meter readings might be taken in different days than the ones from SP services, which can result in dissimilar kWh consumed in the month considered. If you do not wish to receive further information regarding your electricity consumption or have further queries, please contact [ecocampus@ntu.edu.sg](mailto:ecocampus@ntu.edu.sg).

Note: GOAL treatment - First feedback: Goal achieved



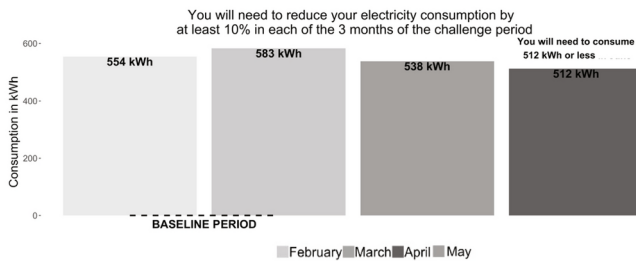
Dear XXXX,

To demonstrate how easy it is to save energy, NTU-EcoCampus organises the "Energy Challenge", which started on **25th March 2018**. The Challenge is a call to households at NTU campus to reduce their electricity consumption and contribute to a sustainable environment.

In this "Energy Challenge", we ask you to reduce your electricity consumption by **10% or more** in each of the three months of the "**Challenge Period**" (i.e. **April, May and June 2018**) compared with your average consumption in the "**Baseline Period**" (i.e. **February and March 2018**).

**Your average electricity consumption in February and March was 568 kWh. We ask you to reduce your electricity usage by 10% or more next month. This means that you need to consume 512 kWh or less. We will inform you at the end of next month whether you achieved this electricity reduction goal.**

**Your consumption in April was 538 kWh. Please, KEEP TRYING!  
You can achieve the conservation goal by reducing your energy consumption during the next two months of the Challenge!**



- ✓ Reduce your energy consumption to 512 kWh or less in each of the three months of the Challenge

Sincerely,

NTU EcoCampus.

Disclaimer: The meter readings might be taken in different days than the ones from SP services, which can result in dissimilar kWh consumed in the month considered. If you do not wish to receive further information regarding your electricity consumption or have further queries, please contact [ecocampus@ntu.edu.sg](mailto:ecocampus@ntu.edu.sg).

Note: GOAL treatment - First feedback: Goal not achieved



Dear XXX,

To demonstrate how easy it is to save energy, NTU-EcoCampus organises the "Energy Challenge", which started on **25th March 2018**. The Challenge is a call to households at NTU campus to reduce their electricity consumption and contribute to a sustainable environment.

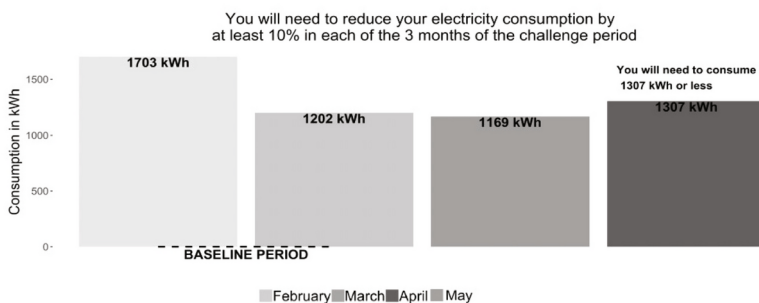
In this "Energy Challenge", we ask you to reduce your electricity consumption by **10% or more** in each of the three months of the "**Challenge Period**" (i.e. **April, May and June 2018**) compared with your average consumption in the "**Baseline Period**" (i.e. **February and March 2018**).

**At the end of the "Challenge Period", one out of the three months of the Challenge (i.e. April, May or June) will be randomly selected and if you achieved the goal in that particular month, you will be rewarded with a monetary payment of \$100 cash.**

**Your average electricity consumption in February and March was 1453 kWh. We ask you to reduce your electricity usage by 10% or more next month. This means that you need to consume 1307 kWh or less. We will inform you at the end of next month whether you achieved this electricity reduction goal.**

**Your consumption in April was 1169 kWh. WELL DONE!**

**Please, keep reducing your energy consumption in the next two months of the Challenge and increase your chance to win \$100!**



- ✓ Reduce your energy consumption to 1307 kWh or less in each of the three months of the Challenge
- ✓ You stand a chance to win \$100 cash!
- ✓ The more months you achieve the goal, the higher are your chances to win

Sincerely,  
NTU EcoCampus.

Disclaimer: The meter readings might be taken in different days than the ones from SP services, which can result in dissimilar kWh consumed in the month considered. If you do not wish to receive further information regarding your electricity consumption or have further queries, please contact [ecocampus@ntu.edu.sg](mailto:ecocampus@ntu.edu.sg).

Note: MONEY treatment - First feedback: Goal achieved



Dear XXX,

To demonstrate how easy it is to save energy, NTU-EcoCampus organises the "Energy Challenge", which starts on **25th March 2018**. The Challenge is a call to households at NTU campus to reduce their electricity consumption and contribute to a sustainable environment.

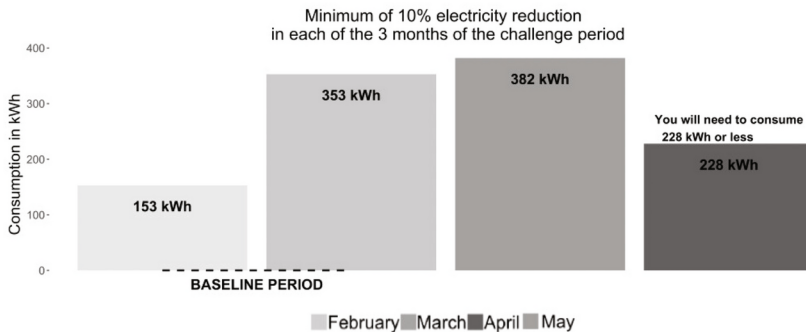
In this "Energy Challenge", we ask you to reduce your electricity consumption by **10% or more** in each of the three months of the "**Challenge Period**" (i.e. **April, May and June 2018**).

Your electricity consumption in each of the months of the Challenge will be compared with your average consumption in the "**Baseline Period**" (i.e. **February and March 2018**).

**At the end of the "Challenge Period", one out of the three months of the Challenge (i.e. April, May or June) will be randomly selected and if you achieved the goal in that particular month, you will be rewarded with a monetary payment of \$100 cash.**

**Your average electricity consumption in February and March was 253 kWh. We ask you to reduce your electricity usage by 10% or more next month. This means that you need to consume 228 kWh or less. We will inform you at the end of next month whether you achieved this electricity reduction goal.**

**Your consumption in April was 382 kWh. Please, KEEP TRYING! You still stand the chance to win \$100 cash by reducing your energy consumption during the next two months of the Challenge!**



- ✓ If your consumption in any one of the next three months is 228 kWh or less
  - ✓ You stand a chance to win \$100 cash!
  - ✓ The more months you achieve the goal, higher are your chances to win

Sincerely,  
NTU EcoCampus.

Disclaimer: The meter readings might be taken in different days than the ones from SP services, which can result in dissimilar kWh consumed in the month considered. If you do not wish to receive further information regarding your electricity consumption or have further queries, please contact [ecocampus@ntu.edu.sg](mailto:ecocampus@ntu.edu.sg).

Note: MONEY treatment - First feedback: Goal not achieved



Dear XXX,

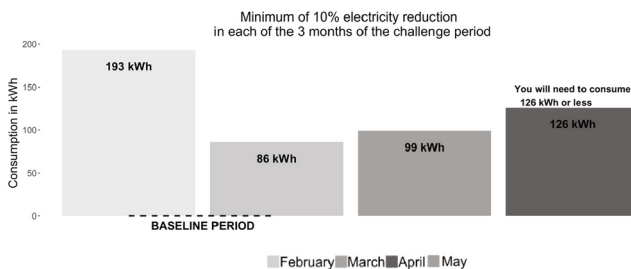
To demonstrate how easy it is to save energy, NTU-EcoCampus organises the "Energy Challenge", which started on **25th March 2018**. The Challenge is a call to households at NTU campus to reduce their electricity consumption and contribute to a sustainable environment.

In this "Energy Challenge", we ask you to reduce your electricity consumption by **10% or more** in each of the three months of the "**Challenge Period**" (i.e. **April, May and June 2018**) compared with your average consumption in the "**Baseline Period**" (i.e. **February and March 2018**).

**At the end of the "Challenge Period", one out of the three months of the Challenge (i.e. April, May and June) will be randomly selected and if you achieved the goal in that particular month, you will be rewarded with a \$100 to be donated to an Environmental charity of your choice.**

**Your average electricity consumption in February and March was 140 kWh. We ask you to reduce your electricity usage by 10% or more next month. This means that you need to consume 126 kWh or less. We will inform you at the end of next month whether you achieved this electricity reduction goal.**

**Your consumption in April was 99 kWh. WELL DONE!**  
**Please, keep reducing your energy consumption in the next two months of the Challenge and increase your chance to win \$100 for donation!**



- ✓ If your consumption in any one of the next two months is 126 kWh or less
- ✓ You can be rewarded with \$100 to donate to an Environmental Charity!
- ✓ The more months you achieve the goal, higher are your chances to win

Sincerely,

NTU EcoCampus.

Disclaimer: The meter readings might be taken in different days than the ones from SP services, which can result in dissimilar kWh consumed in the month considered. If you do not wish to receive further information regarding your electricity consumption or have further queries, please contact [ecocampus@ntu.edu.sg](mailto:ecocampus@ntu.edu.sg).

Note: DONATION treatment - First feedback: Goal achieved



Dear XXX,

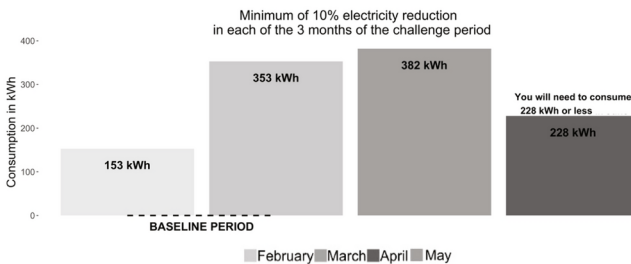
To demonstrate how easy it is to save energy, NTU-EcoCampus organises the "Energy Challenge", which started on **25th March 2018**. The Challenge is a call to households at NTU campus to reduce their electricity consumption and contribute to a sustainable environment.

In this "Energy Challenge", we ask you to reduce your electricity consumption by **10% or more** in each of the three months of the "**Challenge Period**" (i.e. **April, May and June 2018**) compared with your average consumption in the "**Baseline Period**" (i.e. **February and March 2018**).

**At the end of the "Challenge Period", one out of the three months of the Challenge (i.e. April, May and June) will be randomly selected and if you achieved the goal in that particular month, you will be rewarded with a \$100 to be donated to an Environmental charity of your choice.**

**Your average electricity consumption in February and March was 253 kWh. We ask you to reduce your electricity usage by 10% or more next month. This means that you need to consume 228 kWh or less. We will inform you at the end of next month whether you achieved this electricity reduction goal.**

**Your consumption in April was 382 kWh. Please, KEEP TRYING! You still stand the chance to win \$100 for donation by reducing your energy consumption during the next two months of the Challenge!**



- ✓ If your consumption in any one of the next two months is 228 kWh or less
- ✓ You can be rewarded with \$100 to donate to an Environmental Charity!
- ✓ The more months you achieve the goal, higher are your chances to win

Sincerely,

NTU EcoCampus.

Disclaimer: The meter readings might be taken in different days than the ones from SP services, which can result in dissimilar kWh consumed in the month considered. If you do not wish to receive further information regarding your electricity consumption or have further queries, please contact [eccampus@ntu.edu.sg](mailto:eccampus@ntu.edu.sg).

Note: DONATION treatment - First feedback: Goal not achieved





Dear XXX,

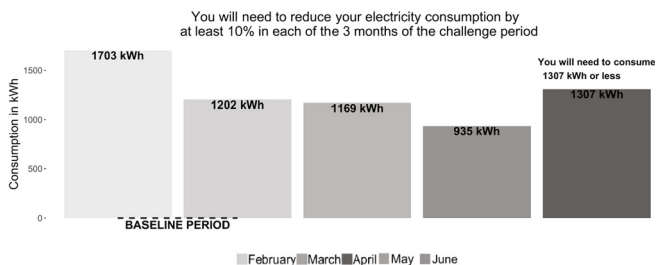
To demonstrate how easy it is to save energy, NTU-EcoCampus organises the "Energy Challenge", which started on **25th March 2018**. The Challenge is a call to households at NTU campus to reduce their electricity consumption and contribute to a sustainable environment.

In this "Energy Challenge", we ask you to reduce your electricity consumption by **10% or more** in each of the three months of the "**Challenge Period**" (i.e. **April, May and June 2018**) compared with your average consumption in the "**Baseline Period**" (i.e. **February and March 2018**).

**Your average electricity consumption in February and March was 1452 kWh. We ask you to reduce your electricity usage by 10% or more next month. This means that you need to consume 1307 kWh or less. We will inform you at the end of next month whether you achieved this electricity reduction goal.**

**Your consumption in May was 935 kWh. WELL DONE!**

**Please, keep reducing your energy consumption in the remaining month of the Challenge!**



- ✓ Reduce your energy consumption to 1307 kWh or less in each of the three months of challenge

Sincerely,

NTU EcoCampus.

Disclaimer: The meter readings might be taken in different days than the ones from SP services, which can result in dissimilar kWh consumed in the month considered. If you do not wish to receive further information regarding your electricity consumption or have further queries, please contact [ecocampus@ntu.edu.sg](mailto:ecocampus@ntu.edu.sg).

Note: GOAL treatment - Second feedback: Goal achieved





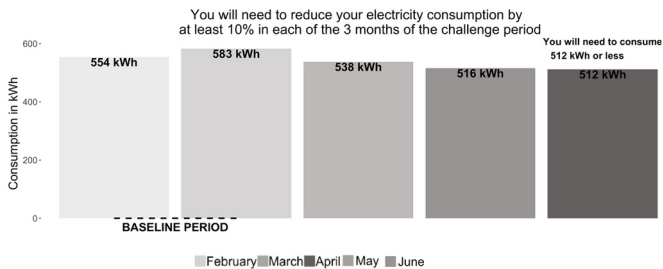
Dear XXX,

To demonstrate how easy it is to save energy, NTU-EcoCampus organises the "Energy Challenge", which started on **25th March 2018**. The Challenge is a call to households at NTU campus to reduce their electricity consumption and contribute to a sustainable environment.

In this "Energy Challenge", we ask you to reduce your electricity consumption by **10% or more** in each of the three months of the "**Challenge Period**" (i.e. **April, May and June 2018**) compared with your average consumption in the "**Baseline Period**" (i.e. **February and March 2018**).

**Your average electricity consumption in February and March was 568 kWh. We ask you to reduce your electricity usage by 10% or more next month. This means that you need to consume 512 kWh or less. We will inform you at the end of next month whether you achieved this electricity reduction goal.**

**Your consumption in May was 516 kWh. Please, KEEP TRYING! You can achieve the conservation goal by reducing your energy consumption in the remaining month of the Challenge!**



- ✓ Reduce your energy consumption to 512 kWh or less in each of the three months of challenge

Sincerely,

NTU EcoCampus.

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Note: GOAL treatment - Second feedback: Goal not achieved



Dear XXX,

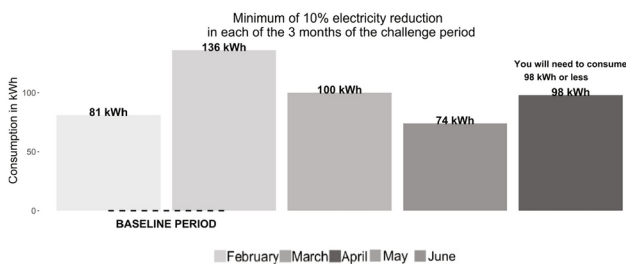
To demonstrate how easy it is to save energy, NTU-EcoCampus organises the "Energy Challenge", which started on **25th March 2018**. The Challenge is a call to households at NTU campus to reduce their electricity consumption and contribute to a sustainable environment.

In this "Energy Challenge", we ask you to reduce your electricity consumption by **10% or more** in each of the three months of the "**Challenge Period**" (i.e. **April, May and June 2018**) compared with your average consumption in the "**Baseline Period**" (i.e. **February and March 2018**).

**At the end of the "Challenge Period", one out of the three months of the Challenge (i.e. April, May or June) will be randomly selected and if you achieved the goal in that particular month, you will be rewarded with a monetary payment of \$100 cash.**

**Your average electricity consumption in February and March was 109 kWh. We ask you to reduce your electricity usage by 10% or more next month. This means that you need to consume 98 kWh or less. We will inform you at the end of next month whether you achieved this electricity reduction goal.**

**Your consumption in May was 74 kWh. WELL DONE!**  
**Please, keep reducing your energy consumption in the remaining month of the Challenge and increase your chance to win \$100 cash!**



- ✓ If your consumption in any of the three months of the Challenge is 98 kWh or less
  - ✓ You stand a chance to win \$100 cash!
- ✓ The more months you achieve the goal, higher are your chances to win

Sincerely,

NTU EcoCampus.

Disclaimer: The meter readings might be taken in different days than the ones from SP services, which can result in dissimilar kWh consumed in the month considered. If you do not wish to receive further information regarding your electricity consumption or have further queries, please contact [ecocampus@ntu.edu.sg](mailto:ecocampus@ntu.edu.sg).

Note: MONEY treatment - Second feedback: Goal achieved



Dear XXX,

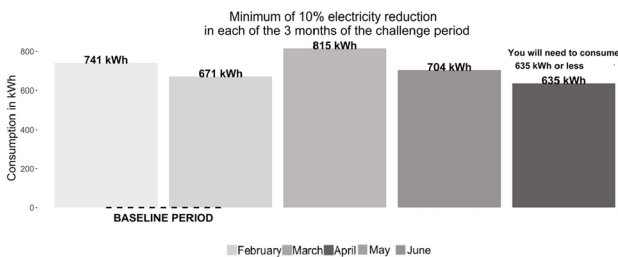
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In this "Energy Challenge", we ask you to reduce your electricity consumption by **10% or more** in each of the three months of the "**Challenge Period**" (i.e. **April, May and June 2018**) compared with your average consumption in the "**Baseline Period**" (i.e. **February and March 2018**).

**At the end of the "Challenge Period", one out of the three months of the Challenge (i.e. April, May or June) will be randomly selected and if you achieved the goal in that particular month, you will be rewarded with a monetary payment of \$100 cash.**

**Your average electricity consumption in February and March was 706 kWh. We ask you to reduce your electricity usage by 10% or more next month. This means that you need to consume 635 kWh or less. We will inform you at the end of next month whether you achieved this electricity reduction goal.**

**Your consumption in May was 704 kWh. Please, KEEP TRYING!  
You still stand a chance to win \$100 cash by reducing your energy consumption in the remaining month of the Challenge!**



- ✓ If your consumption in any of the months of the Challenge is 635 kWh or less
  - ✓ You stand a chance to win \$100 cash!
- ✓ The more months you achieve the goal, higher are your chances to win

Sincerely,

NTU EcoCampus.

Disclaimer: The meter readings might be taken in different days than the ones from SP services, which can result in dissimilar kWh consumed in the month considered. If you do not wish to receive further information regarding your electricity consumption or have further queries, please contact [ecocampus@ntu.edu.sg](mailto:ecocampus@ntu.edu.sg).

Note: MONEY treatment - Second feedback: Goal not achieved



Dear XXX,

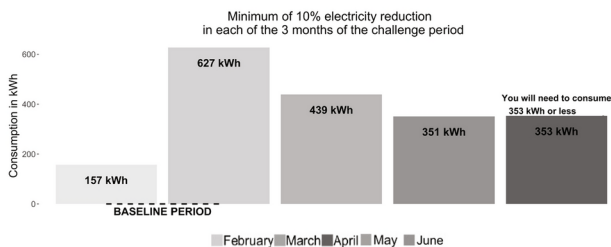
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In this "Energy Challenge", we ask you to reduce your electricity consumption by **10% or more** in each of the three months of the "Challenge Period" (i.e. **April, May and June 2018**) compared with your average consumption in the "Baseline Period" (i.e. **February and March 2018**).

**At the end of the "Challenge Period", one out of the three months of the Challenge (i.e. April, May or June) will be randomly selected and if you achieved the goal in that particular month, you will be rewarded with a \$100 to be donated to an Environmental charity of your choice.**

**Your average electricity consumption in February and March was 392 kWh. We ask you to reduce your electricity usage by 10% or more next month. This means that you need to consume 353 kWh or less. We will inform you at the end of next month whether you achieved this electricity reduction goal.**

**Your consumption in May was 351 kWh. WELL DONE!**  
**Please, keep reducing your energy consumption in the remaining month of the Challenge and increase your chance to win \$100 for donation!**



- ✓ If your consumption in any of the three months of the Challenge is 353 kWh or less
  - ✓ You can be rewarded with \$100 to donate to an Environmental Charity!
  - ✓ The more months you achieve the goal, higher are your chances to win

Sincerely,

NTU EcoCampus.

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Note: DONATION treatment - Second feedback: Goal achieved



Dear XXXX,

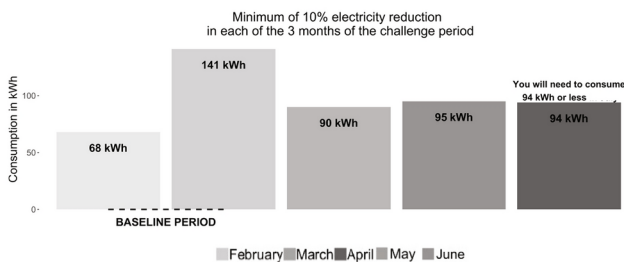
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In this "Energy Challenge", we ask you to reduce your electricity consumption by **10% or more** in each of the three months of the "**Challenge Period**" (i.e. **April, May and June 2018**) compared with your average consumption in the "**Baseline Period**" (i.e. **February and March 2018**).

**At the end of the "Challenge Period", one out of the three months of the Challenge (i.e. April, May or June) will be randomly selected and if you achieved the goal in that particular month, you will be rewarded with a \$100 to be donated to an Environmental charity of your choice.**

**Your average electricity consumption in February and March was 104 kWh. We ask you to reduce your electricity usage by 10% or more next month. This means that you need to consume 94 kWh or less. We will inform you at the end of next month whether you achieved this electricity reduction goal.**

**Your consumption in May was 95 kWh. Please, KEEP TRYING!  
You still stand the chance to win \$100 for donation by reducing your energy consumption in the remaining month of the Challenge!**



- ✓ If your consumption in any of the three months of the Challenge is 94 kWh or less
  - ✓ You can be rewarded with \$100 to donate to an Environmental Charity!
  - ✓ The more months you achieve the goal, higher are your chances to win

Sincerely,

NTU EcoCampus.

Disclaimer: The meter readings might be taken in different days than the ones from SP services, which can result in dissimilar kWh consumed in the month considered. If you do not wish to receive further information regarding your electricity consumption or have further queries, please contact [ecocampus@ntu.edu.sg](mailto:ecocampus@ntu.edu.sg).

Note: DONATION treatment - Second feedback: Goal not achieved



Dear XXX,

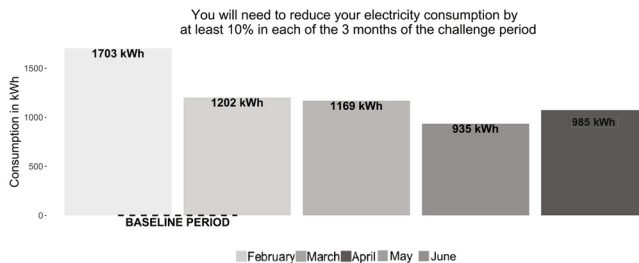
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In this "Energy Challenge", we ask you to reduce your electricity consumption by **10% or more** in each of the three months of the "**Challenge Period**" (i.e. **April, May and June 2018**) compared with your average consumption in the "**Baseline Period**" (i.e. **February and March 2018**).

**Your average electricity consumption in February and March was 1452 kWh. We ask you to reduce your electricity usage by 10% or more each month. This means that you need to consume 1307 kWh or less. We inform you at the end of each month whether you achieved this electricity reduction goal.**

**Your consumption in June was 985 kWh. WELL DONE!**

**Thank you for participating in the Energy Challenge!**



- ✓ Reduce your energy consumption to 1307 kWh or less in each of the three months of challenge

Sincerely,

NTU EcoCampus.

Disclaimer: The meter readings might be taken in different days than the ones from SP services, which can result in dissimilar kWh consumed in the month considered. If you do not wish to receive further information regarding your electricity consumption or have further queries, please contact [ecocampus@ntu.edu.sg](mailto:ecocampus@ntu.edu.sg).

Note: GOAL treatment - Third feedback: Goal achieved



Dear XXX,

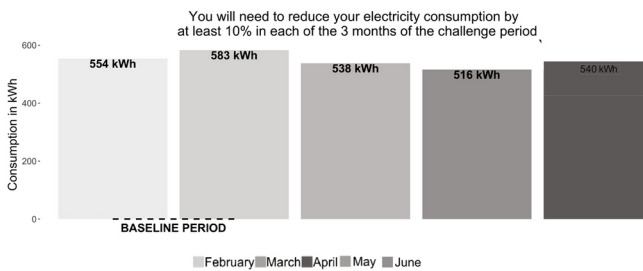
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In this "Energy Challenge", we ask you to reduce your electricity consumption by **10% or more** in each of the three months of the "**Challenge Period**" (i.e. **April, May and June 2018**) compared with your average consumption in the "**Baseline Period**" (i.e. **February and March 2018**).

**Your average electricity consumption in February and March was 568 kWh. We ask you to reduce your electricity usage by 10% or more each month. This means that you need to consume 512 kWh or less. We inform you at the end of each month whether you achieved this electricity reduction goal.**

**Your consumption in June was 540 kWh. Please, KEEP TRYING!**

**Thank you for participating in the Energy Challenge!**



- ✓ Reduce your energy consumption to 512 kWh or less in each of the three months of challenge

Sincerely,

NTU EcoCampus.

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Note: GOAL treatment - Third feedback: Goal not achieved



Dear XXX,

To demonstrate how easy it is to save energy, NTU-EcoCampus organises the "Energy Challenge", which started on **25th March 2018**. The Challenge is a call to households at NTU campus to reduce their electricity consumption and contribute to a sustainable environment.

In this "Energy Challenge", we ask you to reduce your electricity consumption by **10% or more** in each of the three months of the "**Challenge Period**" (i.e. **April, May and June 2018**) compared with your average consumption in the "**Baseline Period**" (i.e. **February and March 2018**).

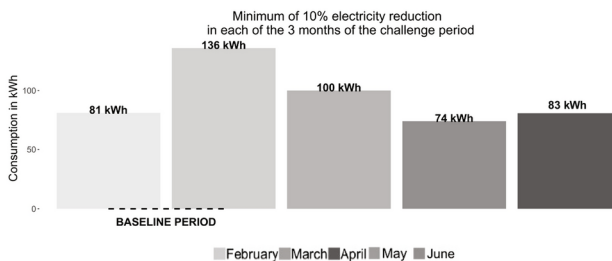
**At the end of the "Challenge Period", one out of the three months of the Challenge (i.e. April, May or June) will be randomly selected and if you achieved the goal in that particular month, you will be rewarded with a monetary payment of \$100 cash.**

**Your average electricity consumption in February and March was 109 kWh. We ask you to reduce your electricity usage by 10% or more each month. This means that you need to consume 98 kWh or less. We inform you at the end of each month whether you achieved this electricity reduction goal.**

**Your consumption in June was 83 kWh. WELL DONE!**

**Thank you for participating in the Energy Challenge!**

**We will reach out to you in a few days to let you know if you have won the \$100 cash.**



- ✓ If your consumption in any of the three months of the Challenge is 98 kWh or less
  - ✓ You stand a chance to win \$100 cash!
- ✓ The more months you achieve the goal, higher are your chances to win

Sincerely,

NTU EcoCampus.

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Note: MONEY treatment - Third feedback: Goal achieved





Dear XXX,

To demonstrate how easy it is to save energy, NTU-EcoCampus organises the "Energy Challenge", which started on **25th March 2018**. The Challenge is a call to households at NTU campus to reduce their electricity consumption and contribute to a sustainable environment.

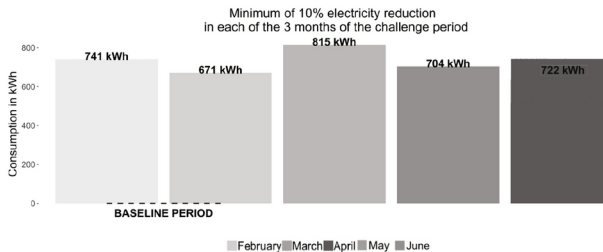
In this "Energy Challenge", we ask you to reduce your electricity consumption by **10% or more** in each of the three months of the "**Challenge Period**" (i.e. **April, May and June 2018**) compared with your average consumption in the "**Baseline Period**" (i.e. **February and March 2018**).

**At the end of the "Challenge Period", one out of the three months of the Challenge (i.e. April, May or June) will be randomly selected and if you achieved the goal in that particular month, you will be rewarded with a monetary payment of \$100 cash.**

Your average electricity consumption in February and March was **706 kWh**. We ask you to reduce your electricity usage by **10% or more** each month. This means that you need to consume **635 kWh** or less. We inform you at the end of each month whether you achieved this electricity reduction goal.

**Your consumption in June was 722 kWh. Please, KEEP TRYING!**

**Thank you for participating in the Energy Challenge!**



- ✓ If your consumption in any of the months of the Challenge is 635 kWh or less
  - ✓ You stand a chance to win \$100 cash!
- ✓ The more months you achieve the goal, higher are your chances to win

Sincerely,

NTU EcoCampus.

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Note: MONEY treatment - Third feedback: Goal not achieved



Dear XXX,

To demonstrate how easy it is to save energy, NTU-EcoCampus organises the "Energy Challenge", which started on **25th March 2018**. The Challenge is a call to households at NTU campus to reduce their electricity consumption and contribute to a sustainable environment.

In this "Energy Challenge", we ask you to reduce your electricity consumption by **10% or more** in each of the three months of the "**Challenge Period**" (i.e. **April, May and June 2018**) compared with your average consumption in the "**Baseline Period**" (i.e. **February and March 2018**).

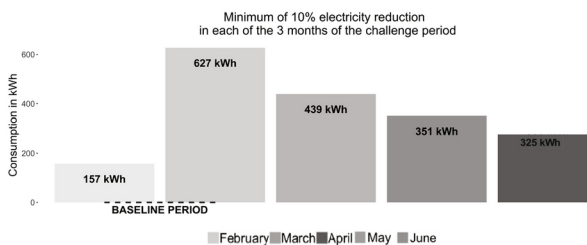
**At the end of the "Challenge Period", one out of the three months of the Challenge (i.e. April, May or June) will be randomly selected and if you achieved the goal in that particular month, you will be rewarded with a \$100 to be donated to an Environmental charity of your choice.**

**Your average electricity consumption in February and March was 392 kWh. We ask you to reduce your electricity usage by 10% or more each month. This means that you need to consume 353 kWh or less. We inform you at the end of each month whether you achieved this electricity reduction goal.**

**Your consumption in June was 325 kWh. WELL DONE!**

**Thank you for participating in the Energy Challenge!**

**We will reach out to you in a few days to let you know if you have won the \$100 for donation.**



- ✓ If your consumption in any of the three months of the Challenge is 353 kWh or less
  - ✓ You can be rewarded with \$100 to donate to an Environmental Charity!
  - ✓ The more months you achieve the goal, higher are your chances to win

Sincerely,

NTU EcoCampus.

Disclaimer: The meter readings might be taken in different days than the ones from SP services, which can result in dissimilar kWh consumed in the month considered. If you do not wish to receive further information regarding your electricity consumption or have further queries, please contact [ecocampus@ntu.edu.sg](mailto:ecocampus@ntu.edu.sg).

Note: DONATION treatment - Third feedback: Goal achieved



Dear XXX,

To demonstrate how easy it is to save energy, NTU-EcoCampus organises the "Energy Challenge", which started on **25th March 2018**. The Challenge is a call to households at NTU campus to reduce their electricity consumption and contribute to a sustainable environment.

In this "Energy Challenge", we ask you to reduce your electricity consumption by **10% or more** in each of the three months of the "**Challenge Period**" (i.e. **April, May and June 2018**) compared with your average consumption in the "**Baseline Period**" (i.e. **February and March 2018**).

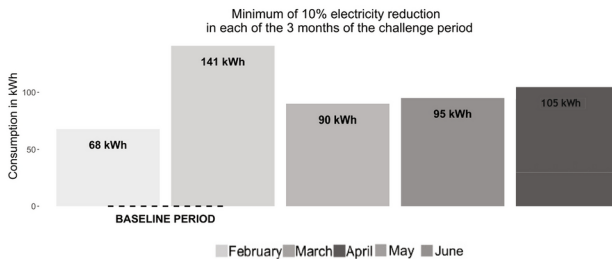
**At the end of the "Challenge Period", one out of the three months of the Challenge (i.e. April, May or June) will be randomly selected and if you achieved the goal in that particular month, you will be rewarded with a \$100 to be donated to an Environmental charity of your choice.**

**Your average electricity consumption in February and March was 104 kWh. We ask you to reduce your electricity usage by 10% or more each month. This means that you need to consume 94 kWh or less. We inform you at the end of each month whether you achieved this electricity reduction goal.**

**Your consumption in June was 105 kWh. Please, KEEP TRYING!**

Thank you for participating in the Energy Challenge!

We will reach out to you in a few days to let you know if you have won the \$100 for donation.



- ✓ If your consumption in any of the three months of the Challenge is 94 kWh or less
  - ✓ You can be rewarded with \$100 to donate to an Environmental Charity!
  - ✓ The more months you achieve the goal, higher are your chances to win

Sincerely,

NTU EcoCampus.

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Note: DONATION treatment - Third feedback: Goal not achieved

## E: Sub-meter Households: Invitation and Consent Form



### INFORMED CONSENT FOR THE INSTALLATION OF ELECTRICITY SUB-METER

Dear Sir/Mdm (SN: HE01 – e.g.),

NTU has set to achieve the goal of 35% reduction in energy, water, and waste intensity as compared to the baseline of 2011 by 2020.

To help NTU attain our sustainability goal, EcoCampus will be conducting a project to better understand household electricity and water consumption on campus. The aim of the project is to study the electricity usage patterns in the staff-housing at NTU and your participation will help us to identify them. This project should span 18 months, starting from November 2017 to May 2019.

As part of this project, your apartment unit has been chosen for the installation of a high-granularity sub-meter that can give precise information regarding patterns of electricity consumption. You are not required to perform any particular task after the installation of the device. The device is not intrusive and does not involve any risk for your household.

All data collected will be anonymised and kept strictly confidential. The data will be only used for the purposes of our project to understand household electricity and water consumption patterns at NTU.

The participation in this study is voluntary and you have the right to refuse the installation of the device in your apartment. Besides, you have the right to drop-out of the study at any moment during the duration of the study even after the installation of the device.

To exercise the drop-out option is very simple: Please visit <https://goo.gl/forms/NiTaX29O42LPqTwB3>, where you can indicate your preference to drop-out anonymously via this serial number HE01 – e.g.

After which, EcoCampus will not consider your apartment as part of the study. We emphasise that the decision to either participate in our project or not will have no impact on your existing relationship with the university or NTU EcoCampus in any way.

If you have any queries regarding this project, you may contact the Principal Investigator of the project Mr Nilesh Jadhav (see contact information below).

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**Mr Nilesh Y. Jadhav**  
Programme Director, EcoCampus  
Energy Research Institute @ NTU (ERI@N)  
Email: NILESH@ntu.edu.sg  
Tel: (+65) 69081480



I affirm that I have read the above information and voluntarily gave my full consent for the installation of the meter described above by a licenced electrician. I understand my rights to refuse to participate or stop being part of the study by exercising my right of opt-out at any point during the study. I declare that the member(s) of the Research Team answered all my questions before signing this consent form. I may contact the Principal Investigator Mr Nilesh Jadhav to the number given above if I have further queries or questions about my right as a participant.

NAME:

SIGNATURE:

DATE:

THIS PROJECT HAS BEEN REVIEWED BY THE NTU-INSTITUTIONAL REVIEW BOARD RESEARCH INTEGRITY AND ETHICS OFFICE

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**Note: Consent form: sub-meters**

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