Under pressure! Nudging electricity consumption within firms. Feedback from a field experiment*

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Abstract

Energy consumption is a serious environmental issue due to global warming and pollution with public policies developed in this context. One such policy is the nudge, a form of policy aimed at changing individual behaviors without using financial incentives nor orders, for example by providing information to individuals so as to conduct behaviors in the direction desired by the policymaker. Interestingly "private nudges" can be imagined for companies. Many economists and psychologists have studied the impact of nudges on households' pro-environmental behaviors. Yet, studies focusing on nudging employees' energy use are rare. The objective of our paper is precisely to explore this issue, both from a theoretical point of view (with the help of an Agency model where peer pressure is introduced), and an empirical point of view with the help of a field experiment. Using a difference-in-difference methodology, the effects of three nudges on employees' energy conservation are tested. The first nudge, "moral appeal", stresses the responsible use of energy regarding environmental stakes. The second one, "social comparison", informs employees on the energy consumption of other firms participating in the experiment. Finally, the third nudge, "stickers", alerts employees about good energy conservation practices. The field experiment was conducted at 47 French companies's sites. Our results stress the complementarity of these nudges. When implemented alone, the three nudges have no significant effects on energy consumption. However, when the moral appeal and social comparison nudges are combined with the stickers one, they become effective.

Keywords: Energy demand management, Private nudges, Peer pressure, Field experiment.

JEL Codes: C93, D04, D91, Q41

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1 Introduction

The practical difficulties of implementing Pigouvian taxes on energy consumption and the development of behavioral sciences have raised interest for non-price energy conservation policies. Behavioral economics has made major contributions to the development of this literature assuming more realistic individual behaviors than the one usually supposed. In particular for the interest of this paper, agents are supposed to be motivated by a warm glow (Andreoni, 1995), a form of impure altruism, and assign an intrinsic value to the environment.

Within this field, the use of nudges has been prominent among policy proposals since the pioneering work of Schultz (1999). Nudges can be presented (Thaler and Sunstein, 2008) as rules of thumb modifying choice architecture to induce individuals to choose a wished course of action. Nudges can consist in choosing the right default option (taking advantage of the inertia generally characterizing individual behavior), delivering information to correct misperceptions, or providing information on what social psychologists call "descriptive norms" and "injunctive norms". Cialdini et al. (1990) define "descriptive norms" as specifying "what most others do", and "injunctive norms" as specifying "what most others approve or disapprove" of. Nudges based on the former exploit the property that individuals tend to behave in accordance with behavioral norms, whereas a nudge based on the latter uses the weight of moral motive in individual decisions.[1]

Several experiments have already been conducted at varying scales testing nudges on energy consumption and have generally focused on households' electricity consumption in residential sites.[2] Their results illuminated behavioral strategies to increase energy conservation (Asensio and Delmas, 2015). Allcott (2011), for example, showed that the effect of a social comparison nudge used by the company Opower in a very large randomized field experiment with households, was equivalent to a 11 to 20% short-run price increase. Allcott and Rogers (2014) focused on the persistence of the effects of Opower's program. They showed that the marginal effect of the program decreases because of habituation, but that long-term effects should not be underestimated because of the formation of a "capital stock" of habits and technologies facilitating energy economies.

Nudging behavior has also been considered in the relations between firms and their customers, and within organizations. Thaler and Sunstein (2008) surveyed a number of "private nudges" of this type. Egebark and Ekström (2016) conducted a field experiment in a Swedish public university comparing two types of nudges on the saving of paper by employees when printing. The first one took the form of a "green default option" to print on both sides of a sheet of paper (rather than one side). The second one was a "moral appeal" nudge consisting in sending messages to employees trying to convince them to reduce their use of paper. The authors found that the first nudge reduced the consumption of paper by 15%, whereas the second one had no effect. The field experiment we explore in this paper develops this issue by considering employees' energy consumption. Compared to experiments with households, experiments involving employees are original for several reasons. First, employees have no financial incentives to reduce their energy consumption, contrary to households who pay the bill, except if a part of their income is indexed to the firm's profit.[3] Even in this case, the pecuniary motive of energy usage is assumed to be small. Second, an employee's peers are his coworkers. They can share environmental values, especially when the firm has a Corporate Social Responsibility (CSR) policy or has received an environmental certification. The pride or guilt a worker can feel because of the amount (or lack) of his energy saving are thus directly linked to the pressure of his peers. In this context, studying energy consumption in the workplace, Handgraaf et al. (2013) observed the superiority of public rewards over private ones as well as the superiority of social rewards over monetary ones.

Peer pressure has been considered initially in labor economics (Kandel and Lazear, 1992; Barron and Gjerde, 1997; Mas and Moretti, 2009; Cornelissen et al., 2017) from both theoretical and empirical points of view. This literature explores the impact of peer pressure on productivity or income. From a theoretical perspective, these articles explore how peer pressure can complement pecuniary incentives to counter free-riding when employees' efforts are not observable (or when individual output is not contractible). The empirical findings confirmed that peer pressure should not be disregarded.

To our knowledge, examining the adoption of pro-environmental behaviors within firms by taking the peer effect into account has rarely been studied. Our study investigates this issue. More precisely, we explore the effectiveness of different nudges a manager can use to incite employees to engage in responsible energy consumption. To do so, in

[1] See Schultz et al. (2007) for the combination of the two norms.

[2] See for example Allcott (2011), Ayres et al. (2013), Houde et al. (2013), Sudarshan (2017), and Kendel et al. (2017).

[3] Delmas and Lessem (2014) study a comparable situation, nudging electricity consumption of students who do not pay the electricity bills in residence halls.

the empirical part of the paper, we focus on electricity consumption of companies in the French services sector, which accounted for 75% of the country's labor force. In 2013, 45% of the total consumption of electricity was attributable to the combined residential/service sector market sector.[4] The service sector alone had a heated surface of 957 million m^2 and mean annual consumption of 240 kWh/m^2.[5] Offices (i.e. the surfaces of interest in our study) represent 23% of this total heated surface. These data show the importance of offices as an area for the application for behavioral strategies to reduce electricity consumption.

Because of the innovative nature of this work, we first provide a conceptual framework to investigate the issue. Then, we empirically examine the question with the help of a field experiment. We focus more specifically on the complementarity of different environmental nudges. In this context, the results highlighted in our study have important implications for business strategies. They show that private environmental nudges have no significant impact on workers' energy conservation when implemented alone but become significant as soon as they are combined with the use of another nudge.

The structure of the paper is as follows. The next section presents a conceptual framework in which the nudges used in our field experiment are outlined and their effect on workers' energy conservation efforts are explained through peer effects. Section 3 then describes the experimental design of our field experiment. We present our results in Sections 4 and discuss them in Section 5.

2 Workers' electricity consumption and peer pressure: conceptual framework

We present a model of unobserved workers' energy conservation efforts. This framework intends to highlight the subsequent empirical analysis. From a theoretical point of view, it considers a traditional principal-agent perspective and introduces peer pressure as in Kandel and Lazear (1992). To fit with the empirical characteristics of the field experiment, we consider that workers' income is not significantly affected by energy consumption within the firm. As a consequence, instead of developing an "optimal contract perspective", we rather focus on private nudges that can be used by the principal to enhance workers' energy management efforts. We first describe a simple situation with no social interaction, where workers contribute to the firm's cost minimization by taking care of their electricity consumption (Section 2.1). We then introduce social interactions with peer pressure (Section 2.2) in this framework.

2.1 The situation with no social interaction nor nudges

The total electricity cost $E(e)$ borne by a firm is a function of N workers' energy conservation efforts e_i, where $e = (e_1, \cdots, e_i, \cdots, e_N)$, $\frac{\partial E}{\partial e_i} < 0$, and $\frac{\partial^2 E}{\partial e_i^2} > 0$.

This cost E is not separable in e_i because the employer cannot observe the individual energy consumptions nor individual efforts to manage consumption. As a consequence, individual contributions to energy conservation are not contractible. We assume that the best a manager can do in terms of monetary incentives is to implement a profit-sharing arrangement. In this case, workers' compensation is partly determined by the cost minimization. More precisely, we suppose that each worker receives an equal part α of the profit that depends on the total electricity cost E. In the literature on peer effects, the particular case where $\alpha = \frac{1}{N}$ is often considered. In the field experiment we developed, certain firms implement a profit-sharing arrangement (so that $\alpha = \frac{1}{N}$), while others do not (so that $\alpha = 0$). Note that even under a profit-sharing arrangement, αE may offer little monetary incentives since the cost reduction due to energy saving is generally small compared to the entire profit.

Furthermore, we assume that each worker can intrinsically (i.e. independent of any reward associated with his effort e_i) value energy conservation for environmental purposes. We denote $v_i^a \geq 0$ as the worker's intrinsic value for environmental conservation. Finally, since effort is painful, energy conservation implies a cost $C(e_i)$, where $C' > 0$, and $C'' > 0$.

When no social interaction is considered, worker i chooses his energy conservation effort e_i^* to maximize his utility:

$$U_i(e_i) = v_i^a e_i - \alpha E(e) - C(e_i). \tag{1}$$

[4] http://www.statistiques.developpement-durable.gouv.fr/indicateurs-indices/f/2090/0/consommation-finale-denergie-secteur.html

[5] http://www.energie.sia-partners.com/20161102/amelioration-de-lefficacite-energetique-du-parc-tertiaire-quels-leviers-reglementaires-et#_ftnref1

When every employee behaves this way, taking the effort of all other employees as given, a Nash equilibrium is characterized by the first-order conditions:

$$v_i^a - \alpha \frac{\partial E(e)}{\partial e_i} - C'(e_i) = 0. \tag{2}$$

The individual effort e_i^* solution of (2) is a positive function of both the worker's value v_i^a, and the incentive variable α: $\partial e_i^* / \partial v_i^a > 0$, $\partial e_i^* / \partial \alpha > 0$. The latter property highlights two important facts. First, when no incentive to develop energy conservation is given to a worker ($\alpha = 0$) his effort is at the lowest possible level. In this case, the decision is exclusively driven by the intrinsic value for environmental conservation (v_i^a), compared to the marginal cost of effort. Second, a free-riding situation appears in the Nash equilibrium when $\alpha = 1/N$, with the associated result that e_i^* is not an optimum. The individual effort is underdeveloped when the worker does not gain the entire benefit of his effort, whereas he bears its full cost.

To derive the first best level of energy conservation effort e_i^{FB}, we consider the maximization of the total surplus $S(e)$ requiring that each worker i obtains the entire benefit of his effort. Therefore, each worker chooses e_i^{FB} maximizing

$$S(e) = \sum_i v_i^a e_i - E(e) - \sum_i C(e_i), \tag{3}$$

satisfying the following first-order condition:

$$v_i^a - \frac{\partial E(e)}{\partial e_i} - C'(e_i) = 0. \tag{4}$$

Since $C'' > 0$, the effort e_i^{FB} derived from (4) is higher than e_i^* from (2). The proof is given in Appendix A. Note that when no profit-sharing is implemented ($\alpha = 0$), e_i^* is less than e_i^{FB} because of a lack of incentive, rather than because of free-riding.

So far, in this conceptual framework, workers choose their energy conservation effort e_i^* in ~~program~~ (1) without looking at what others do (i.e. being "isolated"). We now consider the situation where, on the contrary, each worker takes account of "peer pressure" when choosing his effort level.

2.2 Workers' energy conservation under peer pressure

Here, employees are supposed to take account of their peers when deciding on whether or not to adopt conservative consumption. Usually (see Brekke et al. (2003) for example), peer effect is introduced with the help of a reputation function inciting an individual to be as close as possible to the social behavioral norm. In a similar way, the peer effect on a worker i for responsible energy conservation is introduced as in Kandel and Lazear (1992) with the help of a function of peer pressure P depending on worker i's effort and on the efforts of his peers: $P(e) = P(e_i, e_j, ..., e_N)$, with $\frac{\partial P(e_i)}{\partial e_i} < 0$. The latter assumption implies that peer pressure forms a cost that a worker can alleviate by augmenting his energy conservation effort. In contrast to Kandel and Lazear (1992), we consider that workers differ in the weight γ_i they give to peer pressure. Under peer pressure, worker i chooses his energy conservation effort maximizing his utility function modified as follows:

$$U_i(e_i) = v_i^a e_i - \alpha E(e) - C(e_i) - \gamma_i P(e) \tag{5}$$

The level of effort e_i^P chosen in the Nash equilibrium satisfies the following first order condition:

$$v_i^a - \alpha \frac{\partial E(e)}{\partial e_i} - C'(e_i) - \gamma_i \frac{\partial P(e)}{\partial e_i} = 0 \tag{6}$$

Since $\frac{\partial^2 E(e)}{\partial e_i^2} > 0$, and $C'' > 0$, the effort level e_i^P solution of (6) is greater than the solution e_i^* of (2). The proof is given in Appendix A. Peer pressure goes therefore against free riding. Note however, that without further function specifications, since $\frac{\partial P(e)}{\partial e_i} < 0$, cases where the level of effort under peer pressure e_i^P is higher than the first best level e_i^{FB} cannot be discarded.

The originality of this conceptual framework is twofold. First, the responsible management of energy consumption is considered within the firm in an agency relationship. Contrary to traditional agency models in which workers are only motivated by selfish motivation, workers can spontaneously serve the interests of shareholders because of the intrinsic value v_i^a they attribute to environmental preservation. Second, a peer pressure that can somewhat align the efforts of employees and shareholders interest is considered.

Before presenting the introduction of nudges in this framework, note that in the pioneering work of Kandel and Lazear (1992), peer pressure exists because of profit-sharing $\alpha \frac{E(e)}{N}$ in (1). When a fraction of workers' remuneration comes from profit-sharing,[6] each worker's effort affect others' payments so that an incentive to exert peer pressure is created. Peer pressure would therefore mitigate free-riding. The general idea that individuals want to adhere to a norm can be extended to peer pressure within firms.[7] When environmental protection or energy conservation is considered, a strictly positive norm of effort is conceivable because individuals can have pro-environmental attitudes and derive utility from their environmental actions such as responsible energy management. The consideration of the intrinsic value v_i^a in (1) and (5) clearly introduces this environmental motive in workers' decisions regarding energy management efforts. Therefore, peer pressure can be explained by both profit-sharing and the wish to conform to a social norm in our model. As a consequence, even if α is zero, workers can exert pressure because of their pro-environmental attitude.

2.3 Nudging workers' energy management efforts

Three types of nudges ν_k ($k = 1, 2, 3$) are considered in our field experiment (see Section 3). Each nudge delivers information of a particular kind that can be used or not by employees. In that sense, information delivery does not change options for effort decision and is considered as a nudge. These nudges are delivered in a context where every worker knows that all others receive the same information. For this reason, we consider that the different nudges affect the weight a worker gives to peer pressure: $\gamma_i(\nu_k) P(e)$.

Stickers. Stickers simply provide information on good practices on energy consumption. The mere fact that such information is displayed in a company demonstrates that responsible energy management is considered as important.[8]

Weekly reports with peer comparisons of electricity use. The weekly reports are communicated each week using the following kind of message: "During week t, you did better than x_t% of your peers." We expect that this nudge ν_2 positively modifies individual energy conservation because of increased peer pressure.

Weekly messages expressing a moral consideration. These messages link energy consumption to the natural and human consequences of global warming.

To complete this conceptual framework, our empirical analysis seeks to determine whether $\frac{\partial e_i^P}{\partial \nu_k} > 0$ for the three nudges considered.

3 Experimental design

3.1 Design and procedures

We conducted a field experiment at 47 French companies' sites. This experiment aimed at measuring the effect of three energy saving programs. The field experiment sought to establish whether three type of nudges: stickers, moral appeal, and social comparison (the independent variables) would successfully decrease the level of energy consumption (the dependent variable). All participating companies were equipped with a Building Management System (BMS), thereby allowing us to obtain the daily energy consumption of individual equipment such as ventilation, lighting, power systems, heating, etc. Companies had neither labour contract with specific clauses about the employees' use of electricity, nor any mechanism of control. We also asked companies not to implement any parallel actions during the field experiment aimed at inciting energy conservation behavior among employees. A profit-sharing arrangement was implemented for employees on 37 sites. This arrangement links individual salaries to any cost saving. The impact of individual electricity conservation on the remuneration can be considered as very small as well as the resulting financial incentives.

[6] Or output sharing, as in Barron and Gjerde (1997).

[7] Mas and Moretti (2009) provide empirical results on workers' productivity in this perspective.

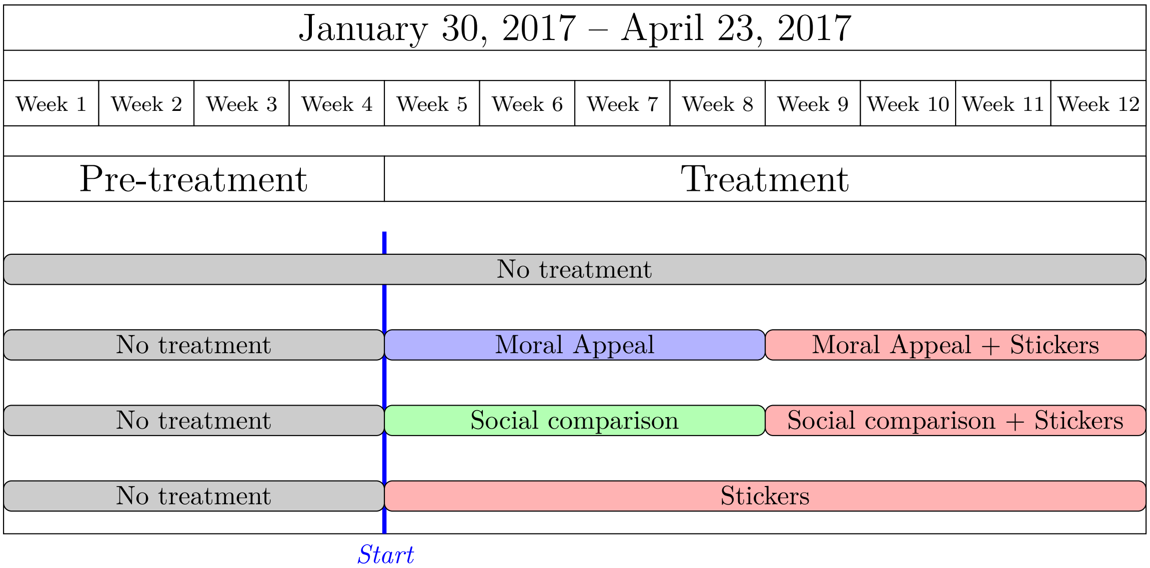
[8] We consider that delivering information with stickers forms a nudge. However, "assimilation" is very often discussed (Bovens, 2009). In all cases, stickers are an information or behavioral treatment from which we can expect effects.

Table 1: Group composition (by treatment)

Treatment	Number of companies	Baseline period	Experimental period
Benchmark	13	12 weeks	–
MAT 'Moral appeal treatment'	11	4 weeks	8 weeks
ST 'Stickers treatment'	12	4 weeks	8 weeks
SCT 'Social comparison treatment'	11	4 weeks	8 weeks

Each of the 47 companies was randomly assigned to either one of the three treatment groups (N = 11 or 12 for each group) or the control group (N = 13). Table 1 outlines the total number of companies within each group.

Figure 1: Experimental design



The experiment was carried out in three stages over 12 weeks (see Figure 1). The first stage was the pre-treatment, which lasted 4 weeks. The information collected during this period was important to understanding the energy consumption behavior of employees. This first stage also gave us a baseline. The second stage (Phase 1 of treatment) lasted 4 weeks and consisted in applying the different nudges (one per group) to the three treated groups. This phase allowed us to measure the effect of programs on the use of electricity by employees. During the last phase of 4 weeks (Phase 2 of treatment), all treated-groups were subject to the "visual prompt/stickers" program. This phase enabled us to measure the potential complementarity of the different nudges, in particular, the net impact of stickers with respect to the other nudges. These programs started for each sub-group of companies at different pre-defined periods. The phased implementation of programs within each group means that our experiment was a controlled case study.

The assessment of these nudges is made with regard to the economic characteristics of the employees identified in an *ex-ante* analysis (see in Appendix). The latter also allows us characterizing the behavior of the employees studied. Finally, an *ex-post* survey (see in Appendix) allows us verifying whether employees feel that they have been able to modify their behavior and, above all, to compare this estimate with the actual data observed.

3.2 The treatments

3.2.1 Moral Appeal

The first treatment, *moral appeal* (T1), consisted of sending messages by email encouraging employees to adopt environmentally friendly behavior by reducing energy consumption. This nudge was tested in a field experiment on printing using duplex copiers at Norwegian universities (Egebark and Ekström, 2016).

Table 2: Moral appeal text message

Week	Moral appeal message
5	Through our energy consumption, we contribute to global warming. **2016, record melting of arctic sea ice.** Be involved for change.
6	Through our energy consumption, we contribute to global warming. **One person moves every second for climatic reasons.** Be involved for change.
7	Through our energy consumption, we contribute to global warming. **The oceans will see "their acidity increase by about 170% compared to pre-industrial levels by 2100." Great coral reefs under threat!** Be involved for change.
8	Through our energy consumption, we contribute to global warming. **Between 2030 and 2050, it is expected that climate change will cause more than 250,000 additional deaths per year.** Be involved for change.
9	Through our energy consumption, we contribute to global warming. **Global warming decreases rainfall in the most arid regions and increases it in the most watered regions.** Be involved for change.
10	Through our energy consumption, we contribute to global warming. **Rise of the oceans: The pace is accelerating dangerously.** Be involved for change.
11	Through our energy consumption, we contribute to global warming. **Climate change threatens world food security.** Be involved for change.
12	Through our energy consumption, we contribute to global warming. **Ongoing climate change could cause the extinction of a sixth of all animal species.** Be involved for change.

Table 2 lists all the messages that were sent. Each message was sent to the employees by the directors of each company participating in the experiment. During the second phase of treatment (weeks 9 to 12), this message was coupled with stickers (see next sub-section). Moral messages were illustrated (see Appendices C.1 and C.2).

3.2.2 Stickers (Visual prompt)

The second treatment, stickers (T2), was based on visual messages that, in a playful way, provided information on several everyday actions that might reduce the individual and overall energy consumption of the company. For example, there was a sticker on the office thermostat indicating the recommended temperature level and explaining that reducing the temperature of each room of 1°C causes a decrease in individual energy consumption by 7%. We combined this kind of nudge with several gestures of everyday life. The 12 "good practices" communicated by the stickers are listed in Table 3.

Table 3: Stickers

	Sticker messages	**Sticker positions**
1	Reducing the temperature of each room of 1°C causes a decrease in individual energy consumption by 7%. Wearing a sweater guarantees just as much comfort.	Placed near the thermostats.
2	Opening a window, even for a few minutes to ventilate a room, for example, must be accompanied by a heating cut-off so as not to waste energy during the opening period.	Placed next to the windows.
3	Anticipation of the end-of-day heating cut: The inertia of buildings is generally sufficient to switch off the heating 1 to 2 hours before departure.	Placed either beside thermostats or heaters.
4	Standby at noon and turn off at night.	Placed on the computer screen or close to the computer
5	If the laptop battery is sufficiently charged, no need to connect the device. Connect the notebook only if the battery is low.	Placed next to the visible sockets commonly used to connect a laptop
6	Print only when necessary.	Placed on the printer.
7	Switch off equipment in case of absence and at the end of the day.	Placed on or near the printer or photocopier.
8	Do not leave a loaded device connected and do not leave a charger plugged into the socket because it consumes as long as it is plugged in.	Placed either near a plug, close to the office, or in the vicinity of a plug used to recharge phones or other devices.
9	Turn off lights in unoccupied rooms and in case of prolonged absence.	Placed close to light switches.
10	Do not use your desk lamp when daylight illuminates the room in which you work.	Placed near the desk lamps.
11	Be careful not to leave coffee makers switched on when not in use.	Placed on coffee makers.
12	Reheat only the amount of water you need.	Placed on kettles.

3.2.3 Social comparison

Finally, the third treatment, *social comparison* (T3), which was in the same vein as the study of Schultz et al. (2007), provided employees information on the overall energy consumption of their company compared to the consumption of other companies participating in the field experiment. This information was delivered with graphics as shown in Appendix C.4.

4 Results

4.1 *Ex ante* survey information

The survey distributed to employees before the implementation of the different nudges during the pretreatment period (see Figure 1) shed light on three different aspects: first, the importance attached to the environment in connection with energy consumption by employees; second, the adoption of energy conservation actions at home and work; and finally, employees' positions regarding the information delivered by the different nudges used in the field experiment.

On the first point, the survey's results show that an overwhelming majority of employees claim to attach importance to environmental preservation and think that energy conservation is directly linked to it. The evident attention paid to energy conservation measures in everyday life does not contradict this first observation.

Regarding the second point, simple actions such as switching off the light when leaving a room and those involving lowering costs like taking care of the energy consumption of lighting and appliances, are found to be the most adopted. More constraining or more expensive actions are less frequently adopted. Interestingly, a difference between the attention paid to electricity consumption at home and work is reported: 95% of the workers who answered the survey declared being aware of their consumption at home compared to 89% at work. The gap may be explained by several reasons: the ease with which the control of electricity consumption can be done at home and at work, the diversion of employees' attention, different financial incentives, etc. Regarding incentives, 79% of the respondents considered that indexing their salaries to their electricity consumption would incite them to reduce consumption. However, 64% of them are currently in that situation thanks to a profit-sharing arrangement. This difference can be explained by the fact that managing electricity consumption can only have a marginal effect on the profit or due to ignorance of the exact way remuneration is calculated within the firm.

On the third point, the *ex ante* survey provides us with insight about employees' opinions regarding the importance of the information delivered by the three nudges tested in the experiment. For instance, more information on the consequences of energy consumption on the environment was seen by 70% of the respondents as an element that would have a positive impact on their electricity consumption. The "moral appeal" nudge delivering such information should therefore be effective. In the same way, the information on everyday energy conservation gestures given by the "stickers" nudge was positively evaluated by 66% of the respondents. The information delivered by the "social comparison" nudge received 70% positive feedback. In view of these scores, the different nudges tested should impact employees' electricity consumption. The rest of the paper specifically addresses this question.

4.2 Descriptive statistics:

4.2.1 Main variables

The different statistics provided and the following econometric analysis consider electricity consumption by isolating heating ('heating') from the rest of the electricity consumption ('electricity'). Table 4 summarizes the general statistical characteristics of the main variables in our analysis. We see that the average of electricity consumption is equal to 157.58 KWhr, and the average for electricity consumption for heating is equal to 54.26 KWhr. In our experiment, the outdoor temperature varied from approximately 0 to 21 $^{\circ}C$.

Table 4: Descriptive Statistics

Variable	**Mean**	**Std.Dev.**	**Min.**	**Max.**	**N**
Site surface (m^2)	475.76	730.39	46	4812	4536
Nb Employees	18.65	28.19	1	120	4536
Days Worked	0.71	0.45	0	1	4536
Electricity consumption, (kWhr)	157.58	191.06	3	2024	4536
Heating consumption, (kWhr)	54.26	64.28	0.22	506	3696
Weather temperature, ($^{\circ}C$)	12.98	3.19	0.32	21.13	4536

Table 5 summarizes the descriptive statistics of both the electricity and heating consumption across the four treatments over all twelve weeks of the experiment. We can see that the group which consumed the least is the Baseline group (T0, no treatment), followed by the stickers-treated and the social comparison-treated groups. The moral appeal-treated group consumed more than the others.

Table 5: Statistics on electricity and heating consumption

	Electricity consumption, kWhr			**Heating consumption, kWhr**		
Treatment	**Nb. Obs.**	**Mean**	**Std.Dev.**	**Nb. Obs**	**Mean**	**Std.Dev**
Baseline (T0)	1680	96.15	70.89	1680	37.94	41.04
Moral Appeal (T1)	924	241.74	365.61	672	101.48	109.38
Social Comparison (T2)	1008	215.07	107.14	672	62.09	39.47
Stickers (T3)	924	122.41	72.12	672	40.01	43.06
Total	4536	157.58	191.06	3696	54.26	64.28

4.2.2 Evolution of the Electricity and Heating consumption during the experimental period

Figure 2 shows the average daily electricity and heating consumption in the four treatments. We observe that the average consumption in all treatments decreased. The trends observed for electricity and heating seem to tend the same way. These decreasing trends can be explained by an increasing temperature over the period (cf. Figure 3) and an increase in the hours of sunlight. The troughs in consumption appearing regularly correspond to Sundays. We note that even in

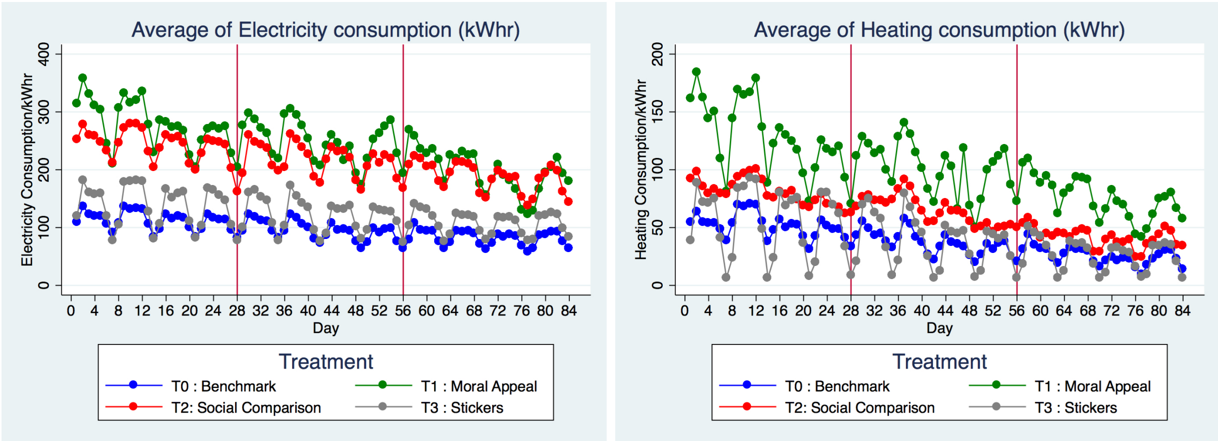


Figure 2: Mean daily Electricity and Heating consumption

these unworked days, positive consumption of electricity and heating is observed.

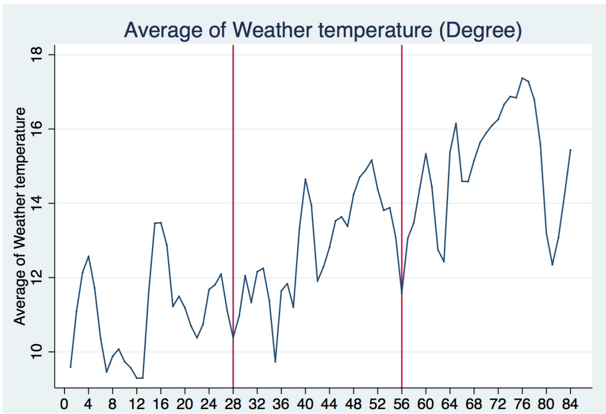


Figure 3: Daily Mean of weather temperature, $^{\circ}C$

The weekly electricity and heating consumption are shown in Figure 4 and contains additional information. Regarding the evolution of electricity consumption in the pretreatment period (the four first weeks), we can observe a little increase between the first and second week and a decrease thereafter. The treatment period (between week 4 and week 12) exhibits differences between treatments, except for the non-treated group and the stickers-treated group. This suggests that stickers have no effect on the consumption of electricity. The electricity consumption under the social comparison treatment and the benchmark seem to progress in parallel during the first period of treatment (between week 4 and week 8). However, this similarity is less clear during the second part of the treatment (between week 8 and week 12). Therefore, the data suggest a treatment effect in the second treatment period only. The moral appeal treatment fluctuates the most, which seems to suggest that this treatment has an impact on electricity consumption. Regarding heating consumption, the pre-treatment period exhibits similar fluctuations across the four groups. Stickers seem to have no influence, whereas consumption under the social comparison and moral appeal treatments appears to decrease more than what is observed in the non-treated group.

To complete this graphical analysis, we proceed to the Kruskal–Wallis equality-of-populations rank test, considering the average of the observations. As indicated in Table 6, we reject the null hypothesis that the consumption is the same for all treatments (p=0.001) except concerning heating between the non-treated and social comparison-treated groups (p=0.5734).

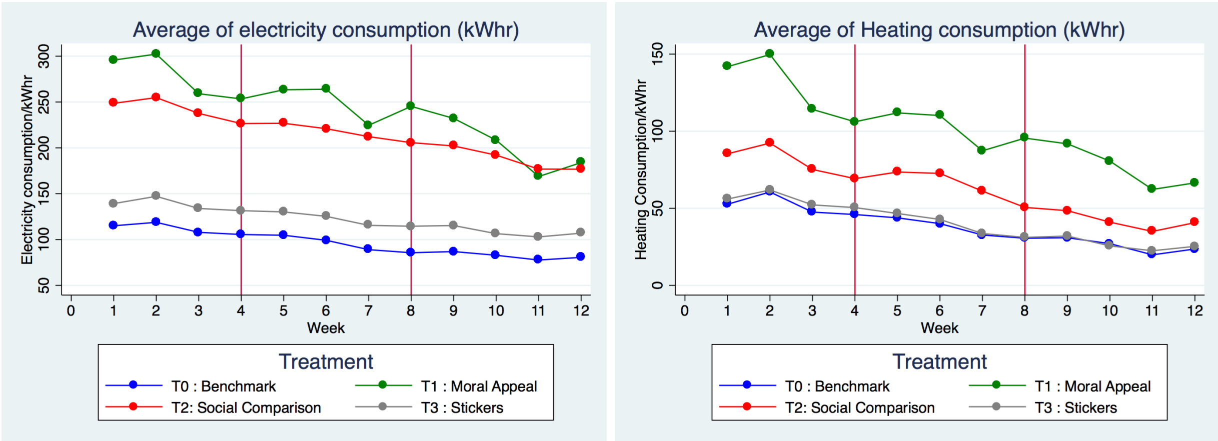


Figure 4: Mean of Electricity and Heating consumption by week

Table 6: Kruskal–Wallis test by treatment

Treatment	Electricity consumption	Heating consumption
Moral Appeal (T1)	$X^2(2) = 82.472$ p = 0.001	$X^2(2) = 246.912$ p = 0.001
Social Comparison (T2)	$X^2(2) = 1085.574$ p = 0.001	$X^2(2) = 256.795$ p = 0.001
Stickers (T3)	$X^2(2) = 109.772$ p = 0.001	$X^2(2) = 0.317$ p = 0.5734

4.3 Econometric analysis

To go further in our analysis, we proceed to an econometric analysis. We use panel data for the electricity and heating consumption of companies over 12 weeks (84 days). In order to estimate the impact of the nudges used in the field experiment on employees' energy consumption, we compare the performance of a sample of companies pre- and post-treatment relative to the performance of the control group at the same instant in time. Companies whose employees' electricity consumption is nudged in the treatment period represent the treated group (either T1, T2, or T3), while the non-treated companies in the sample form the control group (T0). In essence, variation in energy consumptions is explained across time and groups.

A difference-in-difference (DID) analysis is developed, which controls for external factors affecting both the sample and the control group between periods by using trends in the control as the baseline. The evolution in average consumption for non-treated companies over the same period represents the counterfactual, i.e. the evolution in energy consumption not observed for the treated but that would had been observed in the absence of the nudge. This methodology requires data measured in at least two time periods so as to estimate the expected difference in the outcome variable between the treated and benchmark groups. This means that even if the treated group had not been subjected to a nudge, this difference between the groups would still exist. This methodology is chosen to control time trend factors such as changes in weather temperature, socioeconomic characteristics over time, as well as behavioral factors directly or indirectly affecting energy consumption. These factors are assumed to affect both groups in the same way. This method reduces both the potential selection and temporal bias between treated and control groups (Wooldridge, 2007).

We present the following equation for the difference-in-difference estimation:

$$Y_{it} = \beta_0 + \beta_1 T_{it} + \beta_2 A_{it} + \beta_3 T_{it} A_{it} + \beta_4 B_{it} + \beta_5 T_{it} B_{it} + \epsilon_{it}. \tag{7}$$

Here, Y_{it} is the outcome variable of interest, i.e. the average daily energy consumption for company i at time t. T_{it} equals 1 if company i belongs to the group of companies treated (and 0 otherwise), and thus, β_1 captures the differences between the companies treated and those of the control group before the nudge treatment. A_{it} equals 1 in the first treatment period (from Week 5 to Week 8). Therefore, β_2 captures aggregated factors that would cause changes in energy use in the absence of treatment. The interaction term β_3 is the coefficient of interest for the first period of treatment (from Week 5 to Week 8 in Fig. 1) and equals 1 for companies treated by the first nudge after the intervention (and 0 otherwise). It represents the causal effect of treatment, i.e. the impact of the first nudge on energy consumption. B_{it} equals 1 in the second treatment period (from Week 9 to Week 12). Therefore, β_4 captures aggregated factors that would cause changes in energy use in the absence of this second part of treatment. The interaction term β_5 is the coefficient of interest and equals 1 for companies treated by the combination of two different nudges (and 0 otherwise). It represents the causal effect of treatment, i.e. the impact of the combination of two nudges on energy consumption.

The results of the DID regression for the changes in energy consumptions are reported in Table 7. The full set of statistical controls for observable characteristics include weather temperature, number of employees, days worked, company surface, and being an agency[9] open to the public. Our results are robust to various estimation strategies and specifications (Available in the Appendix, Table 9: the DID estimation by treatment with company-fixed effects, and Table 10: the DID estimation for all treatments with company-fixed effects).

Table 7: Difference-in-differences estimation results by treatment

	Moral Appeal (T1)		**Social comparison (T2)**		**Stickers (T3)**	
	Electricity consumption	Heating consumption	Electricity consumption	Heating consumption	Electricity consumption	Heating consumption
First period of Treatment (29-56 days)	-11.879**	-8.689**	-16.686**	-20.080***	-25.507***	-14.768***
Second period of Treatment (57-84 days)	-13.917*	-8.021*	-125.255***	-34.891***	-46.062***	-22.362***
Treated	84.546***	23.006***	63.126***	-0.541	26.109***	-3.783
First period of Treatment * Treated	-7.278	-7.937	-4.087	2.676	4.916	1.442
Second period of Treatment * Treated	-44.666***	-20.432**	-20.114*	-7.196	7.238	1.297
Days Worked	35.817***	17.588***	37.332***	7.247***	38.749***	21.694***
Weather temperature	-4.974***	-5.549***	-2.350***	0.671	2.466***	-2.229***
Company size (area)	-0.151***	0.006	0.074***	0.081***	0.1197***	0.085***
Nb Employees	17.039***	2.339***	1.376***	2.549***	3.121***	2.916***
Agency open to the public	447.631***		90.632***		121.04***	
Constant	-384.927***	92.277***	2.166	113.811***	-107.457***	27.849***
R^2	0.8574	0.6921	0.4894	0.4580	0.3224	0.4705
N	2016	1764	2100	1764	2016	1764

$* : p < 0.05, ** : p < 0.01, *** : p < 0.001.$

First of all, we note that for the third treatment, the consumption of electricity and heating is generally significantly positively affected by the days worked and significantly negatively affected by the weather temperature. These results are not surprising. We also introduce characteristic variables for companies (company surface, number of employees, agency open to the public).[10] The use of heating and electricity is more important during days worked (computer, light, heating off or on standby mode). Similarly, if the outdoor temperature is higher, the internal temperature (and brightness) will be improved, which can reduce the consumption of heating (and electricity). The interaction variable 'First period of treatment * Treated', representing the effect of the measure during the first part of the treatment, is not significant for any of the three treatments. This means that it does not affect electricity or heating consumption. Regarding the moral appeal treatment, we observe that the time of experiment (first and second period of treatment) significantly affect the consumption. As a consequence, a temporal effect is in play. Another interesting result concerns the interaction variable 'Second period of treatment * Treated', which represents the effect of the combination between two treatments during the second part of the experiment. We observe that this variable negatively impacts electricity and heating consumption.

[9]We expect that agencies open to the public have higher comfort standards, thereby implying more electricity consumption.

[10]The variable "Agency open to the public" is a binary variable. Thus the positive significance of this variable can be explained by the fact that a company that receives customers must respect some comfort.

The moral appeal treatment alone does not significantly impact the consumption of electricity and heating (even if it goes in the right direction). However, when it is coupled with the stickers-treatment, which provides information on good practices to manage electricity consumption, it then becomes effective. In other words, complementarity between the moral and stickers treatments seems to exist.

We observe the same trend for electricity consumption in the social comparison treatment: this treatment alone does not affect the consumption, but when it is coupled with the stickers treatment, it negatively affects the energy consumption. Finally, the stickers treatment alone does not affect energy consumption. Moreover, we can rank the effects of our treatments. Indeed the complementarity 'social comparison + stickers' is less effective than 'moral appeal + stickers'. When we applied the moral appeal treatment, the consumption of electricity decreased by 44,660 KWhr with a concomitant decrease in heating of 20,495 KWhr, while the corresponding decreases for the social comparison treatment were 20,631 KWhr for electricity and 7,358 KWhr for heating.

To know if "moral appeal" and "social comparison" treatments have an effect before the second part of the experiment (Weeks 9–12), and to see whether the effect of our treatments becomes more significant over time, we also perform difference-in-diffence calculations per week. The results of the coefficients of interest of these interaction variables are represented in Figure 5.

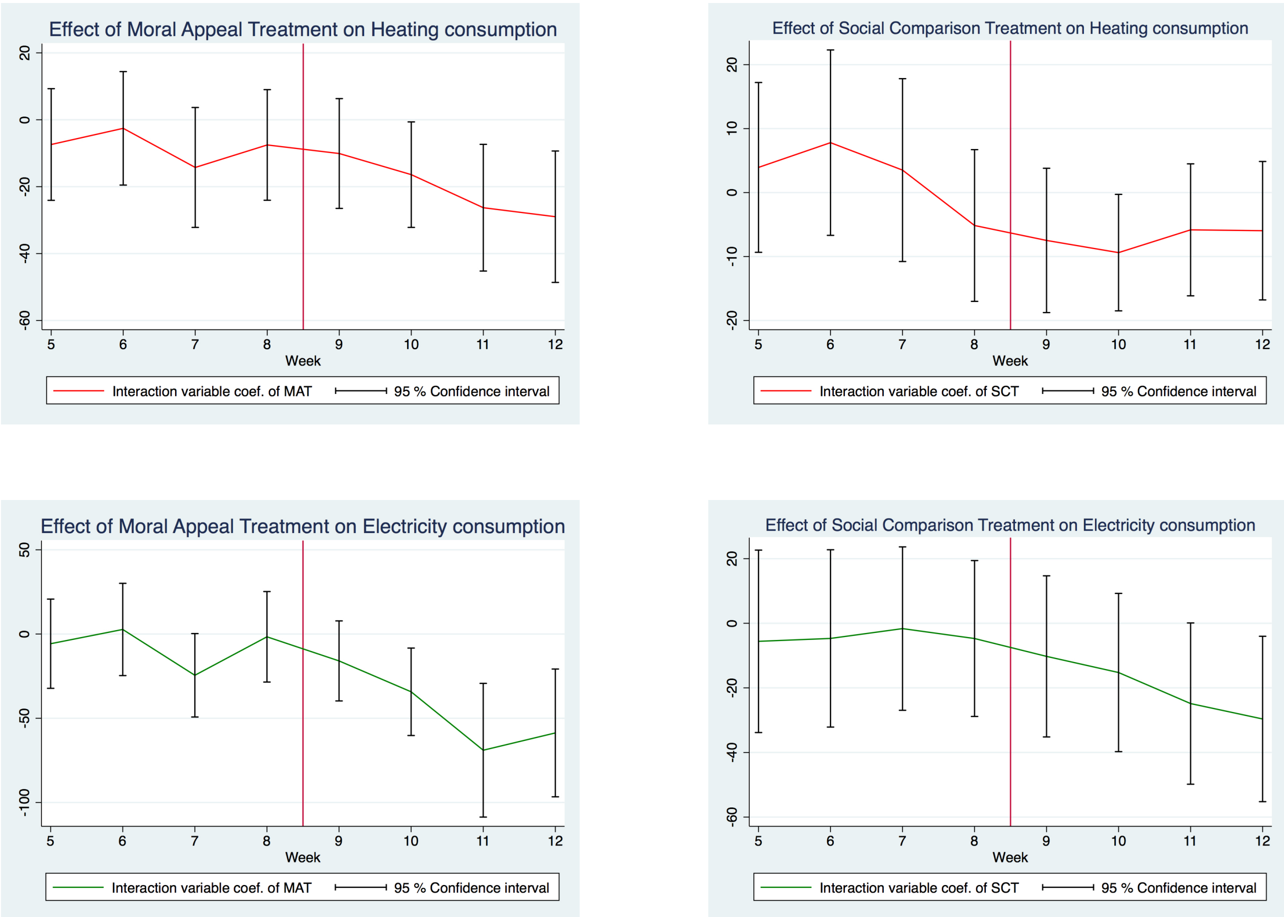


Figure 5: Effect of Moral Appeal and Social Comparison treatments on Electricity and Heating consumption by week

Regarding electricity and heating consumption for the "moral appeal" treatment, the graphs in Figure 5 show that the effect of treatment is significant only from the 10th week. Concerning the social comparison treatment, the graphs confirm the difference-in-difference results presented in Table 7: no effect for heating and a significant effect for electricity that appears from the 11th week. Moral appeal and social comparison therefore seem to take longer to impact behavior.

Regarding the global effect of the 'social comparison' treatment, we can test the effect of the quality of each message (see Table 8), given that we communicated four message levels (very positive, positive, negative, very negative) to the social comparison treated-group. The effect of these messages is different on heating and electricity consumption. We observe that only 'very positive' and 'positive' messages impact energy consumption. However, their respective effects are diametrically opposed: a 'very positive' message positively impacts heating consumption, while a 'positive' message induces a decrease in electricity consumption.

Table 8: Effect of messaging on consumption

	Social comparison (T2)	
	Electricity consumption	Heating consumption
First period of treatment (29-56 days)	-16.608***	-20.169***
Treated	62.705***	-4.25
First period of treatment * Treated * Very Positive Message	2.709	36.816***
First period of treatment * Treated * Positive Message	-50.617***	-8.593
First period of treatment * Treated * Negative Message	12.918	-10.328
First period of treatment * Treated * Very Negative Message	25.892	6.433
Company size (Area)	0.086***	0.119***
Nb Employees	1.649***	2.346***
Days Worked	40.171***	7.073**
Weather temperature	-2.393***	0.719*
Agency open to the public	134.419***	
Constant	-48.246	1.138
R-squared	0.4823	0.4911
N	1400	1176

$* : p < 0.05, ** : p < 0.01, *** : p < 0.001.$

The energy savings achieved during the field experiment concern only a small sample of companies in the service sector. The "moral appeal" treatment combined with stickers during one month allowed savings of 44.7 KWhr for heating and 20.6 KWhr for electricity. Extrapolations to the entire French service sector on a larger period of one year can be done to better grasp the consequences of this nudge. In 2013 in France, offices represented 23% of the total heated surfaces of the combined residential/service sector market, or 220 million heated m^2.[11] Half of the employees of the service sector, or 10 million people, work in this sub-sector.[12] Taking account of the heating period and an attenuating effect at the beginning and at the end of this period, we can thus estimate what would be the effect of the "moral appeal" treatment on heating consumption for the entire sector during a year. We can perform the same type of estimations for the annual electricity consumption for uses other than heating, taking account of 4 weeks off on average. Using the data for the office sector in France, the moral appeal treatment would lead to a potential annual energy savings of 7453 MWhr for heating and 9840 MWhr for electricity consumption. These total estimated electricity savings of 17.3 GWhr represent the average electricity consumption of 3600 French households.[13] Another way to illustrate the potential annual energy savings of the moral appeal treatment is to consider the electricity required for a particular use. The potential energy savings of 17.3 GWhr represents, for instance, the electricity needed for domestic hot water for a town of 21,500 inhabitants (the average electricity consumption per inhabitant is 880 KWhr per year).

5 Conclusions

How can managers nudge electricity consumption of employees in an agency relationship so as to align employees' effort to their cost minimization objective? This paper deals with this question from both theoretical and empirical points of view. The theoretical framework developed in Section 2 highlights the originality of the question. First, employees have no (or little) financial incentive to reduce their energy consumption since they do not pay the electricity bill. Second, values regarding energy conservation and environmental protection may be shared by peers within a company.

[11] http://www.energie.sia-partners.com/20161102/amelioration-de-lefficacite-energetique-du-parc-tertiaire-quels-leviers-reglementaires-et#_ftnref1.

[12] https://www.insee.fr/fr/statistiques/1906677?sommaire=1906743.

[13] The average consumption for a French household is 4710 KWhr. See source https://prix-elec.com/energie/comprendre/statistiques-consommation-france

Therefore, the guilt or pride linked to energy conservation may be linked to peer pressure. As a result, a manager can use nudges to modify peers' incentives to exert pressure. To our knowledge, few empirical studies have considered nudging energy consumption within firms. The field experiment we developed focuses on companies and therefore approached the question in an original way.

Our experimental results show interesting information regarding the three different nudges we used (information delivery, social comparison, and moral appeal). When implemented alone, the three different treatments have no significant effects. In other words, the three nudges do not significantly affect energy and heating consumption. This result seems to be in line with the information delivered by the *ex post* survey we did once the experiment ended. For example, of those respondents who followed the Internet links provided in company emails to obtain more information, 85% read the messages communicated with the "moral appeal" nudge, 72% considered them as non-intrusive, and 60% had their curiosity aroused. However, only 28% of them thought that these messages had any real effect on their electricity consumption. The same kind of figures hold for the other nudges: 98% of the respondents read the messages on social comparison, but only 36% estimate that it has changed their electricity consumption. Futhermore, 90% of the respondents noticed the stickers, but only 16% only estimated that they changed their electricity consumption as a result.

However, things are not so straightforward. When the moral appeal and social comparison treatments were combined with the stickers, they became effective. Therefore, complementarity of these two nudges each combined with the stickers seems to exist. We think that the moral appeal and social comparison nudges act more as means of creating awareness, while the stickers more likely act as a "reminder" of everyday actions for proper energy conservation. Indeed, the first two nudges raise individuals' awareness but do not necessarily give the means or the knowledge necessary to act and improve energy conservation. Regarding this comment, it is interesting to note that the *ex post* survey reveals that when coupled with stickers during Phase 2 of the treatment, 47% of the surveyed employees confronted with the moral appeal nudge and 32% of those subjected to the social comparison nudge estimated that stickers affected their electricity consumption. The importance attached to the moral appeal and social comparison nudges seems therefore to be stronger when coupled with stickers. Finally, regardless of the phase of treatment during the experiment, peer pressure is revealed to be a factor by the *ex post* survey. When respondents were asked if the change in behavior of their colleagues they observed following the nudge positively influences their own electricity consumption, they were systematically more likely to answer in the affirmative when they had talked about the nudge with their colleagues.

References

Allcott, H. (2011). Social norms and energy conservation. *Journal of Public Economics 95*(9 – 10), 1082 – 1095.

Allcott, H. and T. Rogers (2014). The short-run and long-run effects of behavioral interventions: Experimental evidence from energy conservation. *American Economic Review 104*(10), 3003 – 3037.

Andreoni, J. (1995). Cooperation in public-goods experiments: Kindness or confusion?. *American Economic Review 85*(4), 891 – 904.

Asensio, O. I. and M. A. Delmas (2015). Non price incentives and energy conservation. *Proceedings of the National Academy of Sciences 112*(6), 510 – 515.

Ayres, I., S. Raseman, and A. Shih (2013). Evidence from two large field experiments that peer comparison feedback can reduce residential energy usage. *The Journal of Law, Economics, and Organization 29*(5), 992.

Barron, J. M. and K. P. Gjerde (1997). Peer pressure in an agency relationship. *Journal of Labor Economics 15*(2), 234 – 254.

Bovens, L. (2009). *The Ethics of Nudge*, pp. 207 – 219. Theory and Decision Library Series A: Philosophy and Methodology of the Social Sciences, vol. 42. Dordrecht and New York: Springer.

Brekke, K. A., S. Kverndokk, and K. Nyborg (2003). An economic model of moral motivation. *Journal of Public Economics 87*(9-10), 1967 – 1983.

Cialdini, R. B., R. R. Reno, and C. A. Kallgren (1990). A focus theory of normative conduct: Recycling the concept of norms to reduce littering in public places. *Journal of Personality and Social Psychology 58*(6), 1015 – 1026.

Cornelissen, T., C. Dustmann, and U. Schonberg (2017). Peer effects in the workplace. *American Economic Review 107*(2), 425 – 456.

Delmas, M. A. and N. Lessem (2014). Saving power to conserve your reputation? the effectiveness of private versus public information. *Journal of Environmental Economics and Management 67*(3), 353 – 370.

Egebark, J. and M. Ekström (2016). Can indifference make the world greener? *Journal of Environmental Economics and Management 76*, 1 –13.

Handgraaf, M. J. J., M. A. Van Lidth de Jeude, and K. C. Appelt (2013). Public praise vs. private pay: Effects of rewards on energy conservation in the workplace. *Ecological Economics 86*, 86 – 92.

Houde, S., A. Todd, A. Sudarshan, J. A. Flora, and K. C. Armel (2013). Real-time feedback and electricity consumption: A field experiment assessing the potential for savings and persistence. *Energy Journal 34*(1), 87 – 102.

Kandel, E. and E. P. Lazear (1992). Peer pressure and partnerships. *Journal of Political Economy 100*(4), 801 – 817.

Kendel, A., N. Lazaric, and K. Marechal (2017). What do people 'learn by looking' at direct feedback on their energy consumption? results of a field study in southern france. *Energy Policy 108*, 593 – 605.

Mas, A. and E. Moretti (2009). Peers at work. *American Economic Review 99*(1), 112 – 145.

Schultz, P. W. (1999). Changing behavior with normative feedback interventions: A field experiment on curbside recycling. *Basic and Applied Social Psychology 21*(1), 25 – 36.

Schultz, P. W., J. M. Nolan, R. B. Cialdini, N. J. Goldstein, and V. Griskevicius (2007). The constructive, destructive, and reconstructive power of social norms. *Psychological Science (0956-7976) 18*(5), 429 – 434.

Sudarshan, A. (2017). Nudges in the marketplace: The response of household electricity consumption to information and monetary incentives. *Journal of Economic Behavior & Organization 134*, 320 – 335.

Thaler, R. H. and C. R. Sunstein (2008). *Nudge: Improving decisions about health, wealth, and happiness.* Yale University Press. New Haven and London.

Wooldridge, J. (2007). What's new in econometrics? lecture 10 difference-in-differences estimation. *NBER Summer Institute, available at: www.nber.org/WNE/Slides7–31–07/slides_10_diffindiffs.pdf, accessed April 9*, 2011.

Appendix A

Proofs

We first demonstrate that $e_i^{FB} > e_i^*$. e_i^{FB} is solution of (4) and e_i^* is solution of (2). We thus have:

$$C'(e_i^*) - C'(e_i^{FB}) = \frac{\partial E(e^{FB})}{\partial e_i} - \alpha \frac{\partial E(e^*)}{\partial e_i}$$

Assume that $e_i^* > e_i^{FB}$. Since $C'' > 0$, we would have $\frac{\partial E(e^{FB})}{\partial e_i} - \alpha \frac{\partial E(e^*)}{\partial e_i} > 0$, which would contradict the assumption $\frac{\partial^2 E(e)}{\partial e_i^2} > 0$ (implying, with $\alpha \in [0, 1]$, $\frac{\partial E(e^{FB})}{\partial e_i} > \alpha \frac{\partial E(e^*)}{\partial e_i}$).

We now demonstrate that $e_i^P > e_i^*$. e_i^P is solution of (6) and e_i^* is solution of (2). We thus have:

$$C'(e_i^*) - C'(e_i^P) = \alpha \left[\frac{\partial E(e^P)}{\partial e_i} - \frac{\partial E(e^*)}{\partial e_i} \right] + \gamma_i \frac{\partial P(e^P)}{\partial e_i}$$

Assume that $e_i^* > e_i^P$. Since $\frac{\partial P(e)}{\partial e_i} < 0$ and $C'' > 0$, we would have $\frac{\partial E(e_i^P)}{\partial e_i} - \frac{E(e_i^*)}{\partial e_i} > 0$, which would contradict the assumption $\frac{\partial^2 E(e)}{\partial e_i^2} > 0$.

Appendix B

Methodology used to compare energy consumptions in the "social comparison" treatment

To be able to quantify and compare the potential gains in terms of energy consumption caused by the nudges tested in our field experiment, it is necessary to normalize the different consumptions taking account of comparable units between the tested sites. In this context, two different indicators are used for heating and electricity (heating excepted) consumption. The consumption of electricity due to heating is weighted by the heated surface of the building. The calculation of this consumption is normalized per unified degree days during the period of observation. The unified degree days represent the temperature difference between a norm (of 22 $°C$ for office buildings) and the exterior temperature. Therefore, for each building, unified degree days express the required electricity consumption to reach the norm. The "social comparison" treatment uses these relative electricity consumptions for heating in relation to the unified degree days per square meter. The ranking of the different sites is made taking account of the variations of these relative consumptions each week. Regarding the electricity consumption for uses other than heating, the calculation is weighted by the number of employees working on the tested site. In a similar manner to what we do for heating, for the "social comparison" treatment, we calculate the variations of electricity consumption observed each week weighted by employees and rank the different sites according to these observations. This method permits energy consumptions, which are constant over time and over which employees have no control (such as the electricity consumed because of a server room, for example), to be neutralized.

Appendix C

C.1. Moral Appeal

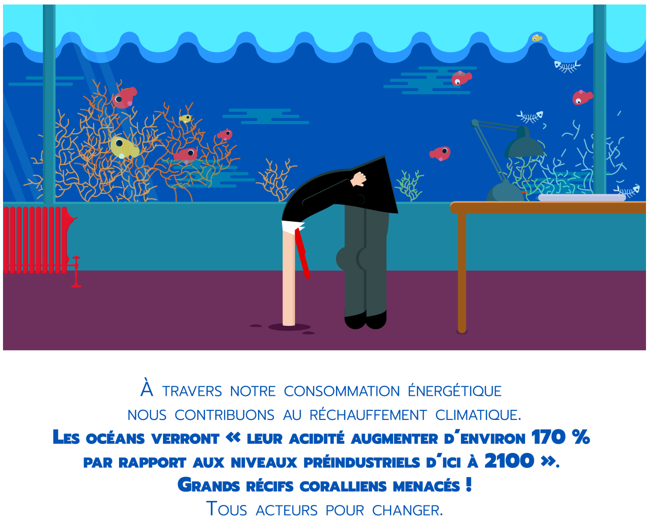
Figure 6: The four moral appeal messages sent **during the first phase**

Translation :
Through our energy consumption
we contribute to global warming.
2016, record melting of arctic sea ice.
Be involved for change.

First week message

Translation :
Through our energy consumption
we contribute to global warming.
One person moves every second
for climatic reasons.
Be involved for change.

Second week message



Translation :
Through our energy consumption
we contribute to global warming.
The oceans will see "their acidity increase by about 170% compared to pre-industrial levels by 2100"
Great coral reefs under threat!
Be involved for change.

Third week message

Translation :
Through our energy consumption
we contribute to global warming.
Between 2030 and 2050,
it is expected that climate change
will cause more than 250,000 additional deaths per year.
Be involved for change.

Fourth week message

C.2. Moral Appeal + Stickers

Figure 7: Four second step moral appeal messages sent

A TRAVERS NOTRE CONSOMMATION ÉNERGÉTIQUE
NOUS CONTRIBUONS AU RÉCHAUFFEMENT CLIMATIQUE.
AU MENU DU RÉCHAUFFEMENT CLIMATIQUE :
DIMINUTION DE LA PLUVIOMÉTRIE DANS LES RÉGIONS LES PLUS ARIDES
ET ACCROISSEMENT DES PRÉCIPITATIONS DANS LES RÉGIONS LES PLUS ARROSÉES.
TOUS ACTEURS POUR CHANGER.

Translation :
Through our energy consumption
we contribute to global warming.
On the cards for global warming:
decrease in rainfall in the most arid regions
and increase of precipitation in the most watered regions.
Be involved for change.

Fifth week message

À TRAVERS NOTRE CONSOMMATION ÉNERGÉTIQUE
NOUS CONTRIBUONS AU RÉCHAUFFEMENT CLIMATIQUE.
MONTÉE DES OCÉANS :
LE RYTHME S'ACCÉLÈRE DANGEREUSEMENT.
TOUS ACTEURS POUR CHANGER.

Translation :
Through our energy consumption
we contribute to global warming.
Rise of the oceans:
The pace is accelerating dangerously.
Be involved for change.

Sixth week message

A TRAVERS NOTRE CONSOMMATION ÉNERGÉTIQUE
NOUS CONTRIBUONS AU RÉCHAUFFEMENT CLIMATIQUE.
LE CHANGEMENT CLIMATIQUE MENACE
LA SÉCURITÉ ALIMENTAIRE MONDIALE.
TOUS ACTEURS POUR CHANGER.

Translation :
Through our energy consumption
we contribute to global warming.
Climate change threatens
World Food Security.
Be involved for change.

Seventh week message

A TRAVERS NOTRE CONSOMMATION ÉNERGÉTIQUE
NOUS CONTRIBUONS AU RÉCHAUFFEMENT CLIMATIQUE.
LE CHANGEMENT CLIMATIQUE EN COURS
POURRAIENT ENTRAÎNER L'EXTINCTION
D'UN SIXIÈME DES ESPÈCES ANIMALES.
TOUS ACTEURS POUR CHANGER.

Translation :
Through our energy consumption
we contribute to global warming.
Ongoing climate change
could cause the extinction of
a sixth of animal species.
Be involved for change.

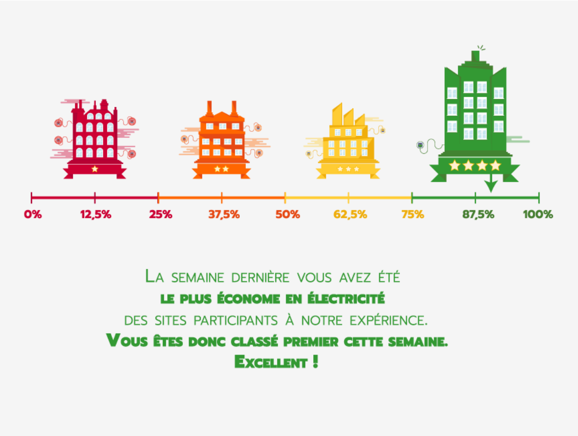
Eighth week message

C.3. Stickers

Figure 8: The twelve stickers

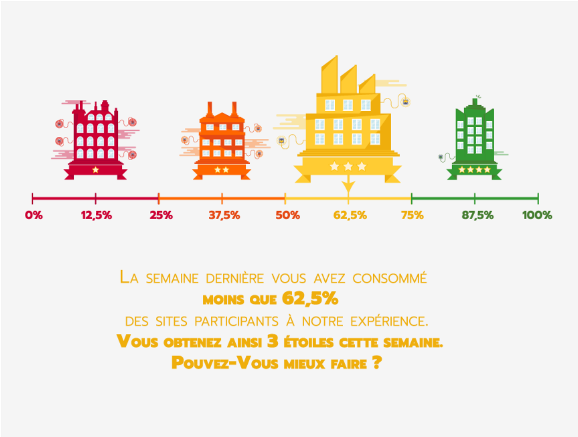
C.4. Social comparison

Figure 9: Four example of social comparison message



Translation :
Last week, you were the most energy efficient of the sites participating in our experiment.
You are therefore ranked first this week.
Excellent.

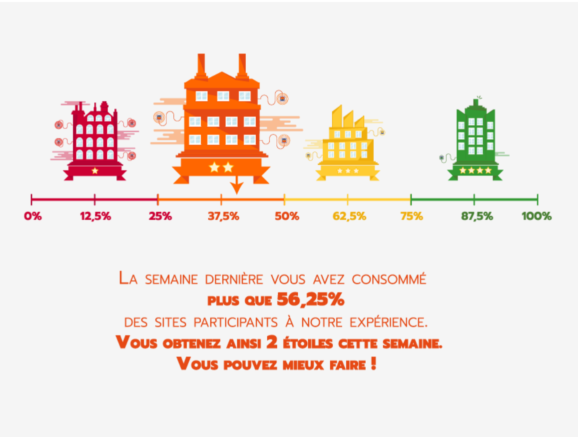
Very positive message



Translation :

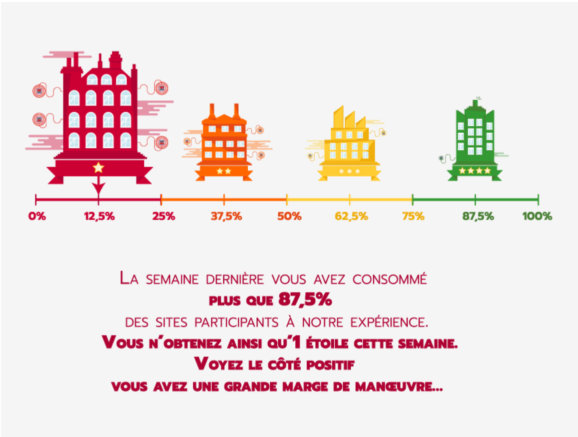
Last week, you consumed less than 62.5% of the participating sites in our experiment
You get three stars this week.
Can you do better?

Positive message



Translation :
Last week, you consumed more than 56.25% of the participating sites in our experiment
You get two stars this week.
You can do better!

Negative message



Translation :
Last week, you consumed more than 87.5% of the participating sites in our experiment.

You only get one star this week. See the positive side, you have the

most flexibility.

Very negative message

Appendix D

D.1. Ex-ante surveys responses

Question

Do you think it is important to control our energy consumption because it is an important part of environmentally friendly behavior? Not at all (0.35%) - Rather (14.58%) - Absolutely (85.07%)

Do you think your effort in energy efficiency meets individual responsibility towards society? 92.71%

Overall, do you pay attention to your energy consumption? At home (95.83%) - At work (89.24%)

At home, your heating consumption is? Individual (10.07%) - Included in collective charges (89.93%)

How often do you perform the following actions in your daily life? (%)

	Never	Occasionally	Often	All the time
Turn off the lights when leaving a room:	0.69	2.78	25.69	70.83
Lower the heating / air conditioning to limit your energy consumption:	4.17	18.06	40.97	36.81
Use the washing machine or dishwasher only at full load:	3.47	10.07	32.99	53.47
Use the sleep mode of appliances / electronics (computer, printer):	31.94	27.43	20.14	20.49
Dry clothes outdoors instead of in a dryer:	4.86	10.42	9.79	64.93

At home, in the past five years, have you installed any of the following (%)

	Yes	Already equipped	No	Unrealizable or Owner job
Energy-efficient appliances of the highest class:	59.38	23.26	15.28	2.08
Low-energy bulbs:	71.18	14.58	13.89	0.35
Energy efficient windows:	33.68	44.83	13.54	6.94
Thermal insulation of walls / roof:	23.26	34.03	29.17	13.54
Heat Thermostats:	21.53	28.82	37.50	12.15
Solar panels for electricity or hot water:	4.51	3.47	68.06	23.96

Do you think that your potential efforts to control energy consumption in companies have an impact on your remuneration? 26.04 %

Do the following factors encourage you to reduce your energy use in your professional activity? (scale 0 to 10)

	1	2	3	4	5	6	7	8	9	10
More information on practices to reduce your energy consumption at work (%):	9.03	2.08	3.82	2.08	17.01	8.68	12.85	23.26	7.64	13.54
More information on the impact of energy consumption on the environment (%):	8.33	2.08	4.51	3.12	14.93	5.21	12.15	21.53	12.5	15.62
More information on your individual energy consumption at work (%):	7.99	0.35	2.08	1.04	13.89	4.86	11.81	25.69	15.28	17.01
An increase in your earnings according to your company's energy savings (%):	6.6	1.39	1.74	1.74	9.03	3.12	5.9	14.93	8.33	47.22
Information about your company's energy consumption compared to other comparable companies (%):	8.33	2.78	2.08	1.74	14.93	5.56	15.28	19.79	13.19	16.32
Discover that your company consumes more energy than other similar companies (%):	10.42	3.82	2.43	1.04	14.58	3.82	12.85	20.49	12.15	18.40
An increase in the price of energy (%):	16.67	4.17	2.08	1.39	22.57	6.25	10.07	14.93	6.94	14.9

In company, do you control your energy consumption because
Your company has a pro-environmental commitment?: 63.89%
This seems important to your company's profitability?: 71.88%
You have a pro-environmental commitment?: 71.18%

Age (%)
18–24 years old: 4.86 / 25–34 years old: 20.83 / 35–49 years old: 35.76 / 50–64 years old: 38.19 / 65 and over: 0.35

Education (%)
Without diploma: 0.69 / 2 year degree after high school: 28.47 / Professional training (CAP, BEP, BP, etc.): 4.51
Bachelor's degree: 27.43 / High school degree: 6.25 / Master's degree or higher: 32.64

D.2. Ex-post surveys responses moral appeal treatment (MAT), social comparison treatment (SCT) and stickers treatment (ST)

Question	MAT	SCT	ST
Have you received emails encouraging your colleagues and yourself to adopt an environmentally friendly behavior by reducing your energy consumption? (% yes)	93.65	82.69	——
On a scale of 1 (not at all intrusive) to 10 (very intrusive), how did you perceive these emails?			
1 (not at all intrusive)	32.20	18.60	——
2	10.17	13.95	——
3	10.17	9.30	——
4	1.69	13.95	——
5	18.64	18.60	——
6	10.17	6.98	——
7	8.47	6.98	——
8	3.39	4.65	——
9	1.69	6.98	——
10 (very intrusive)	3.39	0	——
Have you read the emails? (% yes)	84.74	97.67	——
Did you click on the links? (% yes)	60.00	——	——
Do you think that these emails have affected your energy consumption? (% yes)	28.57	36.54	——
Do you think that these emails have affected the behavior of your colleagues? (% yes)	36.51	26.92	——
Have changes in the behavior of your colleagues affected your own behavior? (% yes)	34.78	42.86	——
Have you talked about these emails with your colleagues?(% yes)	39.68	32.69	——
If yes, has the change in behavior of your colleagues affected your own behavior?(% yes)	40.82	43.85	——
Was the content of these emails the subject of your company's external communication? (% yes)	23.81	3.85	——
Have you even communicated the content of these emails to people outside of the company? (% yes)	6.35	1.92	——
Your preference in terms of comfort temperature at work:			
A temperature above 24 degrees	3.17	5.77	47.92
A temperature between 22 and 24 degrees	53.97	61.54	47.92
A temperature below 22 degrees	38.10	32.69	0
It does not matter	4.76	0	4.17
When you feel cold, do you prefer			
To increase the temperature?	34.92	46.15	41.67
To dress more warmly?	52.38	48.08	50.00
To drink a hot drink?	12.70	5.77	83.33
Have you noticed the stickers encouraging you and your colleagues to behave in an environmentally friendly way by reducing your energy consumption? (% yes)	74.60	53.84	89.59
On a scale of 1 (not at all intrusive) to 10 (very intrusive), how did you perceive these stickers?			
1 (not at all intrusive)	40.42	21.43	18.60
2	8.51	21.43	16.28
3	8.51	3.57	4.65
4	0	7.14	2.32
5	21.28	28.57	32.56
6	8.51	7.14	4.65
7	4.26	0	6.98
8	4.25	7.14	9.30
9	2.13	3.57	0
10 (very intrusive)	2.13	0	4.65
Do you think these stickers have affected your energy consumption? (% yes)	47.12	32.14	16.28
In your opinion, did these stickers affect the behavior of your colleagues? (% yes)	31.75	32.14	16.28
If yes, have changes in behavior of your colleagues affected your own behavior? (% yes)	30.00	13.46	25.00
Have you talked about these stickers with your colleagues? (% yes)	49.21	43.72	68.75
If yes, Have the changes in behavior of your colleagues affected your own behavior? (% yes)	40.16	23.08	21.21
Age			
18-24 years old :	7.94	5.77	12.50
25–34 years old :	20.63	28.85	31.25
35–49 years old :	44.44	34.62	43.75
50–64 years old :	26.98	30.77	12.50
Education			
Without diploma:	0	0	2.08
Professional training (CAP, BEP, BP, etc.):	1.59	3.85	2.08
High school degree:	1.59	5.77	2.08
2 year degree after high school:	31.75	21.15	18.75
Bachelor's degree:	42.86	38.46	39.58
Master's degree or higher:	22.22	30.77	35.42

Appendix E

C.1. Robustness check regression

Table 9: Difference-in-difference estimation results by treatment with company-fixed effects.

	Moral Appeal (T1)		**Social comparison (T2)**		**Stickers (T3)**	
	Electricity consumption	Heating consumption	Electricity consumption	Heating consumption	Electricity consumption	Heating consumption
Treated	230.1***	11.313***	126.284***	-61.390***	74.946***	-18.977***
First period of Treatment (29–56 days)	-11.953***	-11.411***	-12.961***	-12.767***	-15.506***	-13.204***
Second period of Treatment (57–84 days)	-14.091*	-14.443***	-16.469***	-17.642***	-22.473***	-18.672***
First period of Treatment * Treated	-7.278	-7.923	-3.769	3.493	3.530	1.125
Second period of Treatment * Treated	-44.660***	-20.495***	-20.631***	-7.358*	2.793	0.560
Days Worked	36.341***	16.618***	37.415***	9.373***	40.030***	22.057***
Weather temperature	-4.934***	-4.062***	-4.383***	-3.322***	-2.994***	-3.083***
company-fixed effects	YES	YES	YES	YES	YES	YES
Constant	112.596***	116.955***	105.641***	113.811***	88.159***	102.069***
R-Squared	0.9200	0.8420	0.9143	0.7331	0.8260	0.6834
N	2016	1764	2100	1764	2016	1764

$*p < 0.05, **p < 0.01, ***p < 0.001.$

Table 10: Difference-in-difference estimation results for all treatment with company-fixed effects.

	Electricity consumption	Heating consumption
First period of Treatment (29–56 days)	-7.716	-6.557**
Second period of Treatment (57–84 days)	-6.537	-7.619**
Treated 1 (Moral appeal)	-44.068***	254.799***
Treated 2 (Social Comparison)	448.624***	-38.759***
Treated 3 (Stickers)	80.972***	-15.334**
First period of Treatment * Treated 1	2.082	-4.771
Second period of Treatment * Treated 1	-35.520***	-17.302***
First period of Treatment * Treated 2	-0.204	3.973
Second period of Treatment * Treated 2	-17.840**	-7.253*
First period of Treatment * Treated 3	2.688	-0.002
Second period of Treatment * Treated 3	0.117	-1.440
Days Worked	45.283***	21.848***
Weather temperature	-6.267***	-4.854***
company-fixed effects	YES	YES
Constant	119.881***	119.330***
R-squared	0.9140	0.8046
N	4277	3367

$*p < 0.05, **p < 0.01, ***p < 0.001.$